The Structure of Fibres, Yarns and Fabrics

E. A. Posselt

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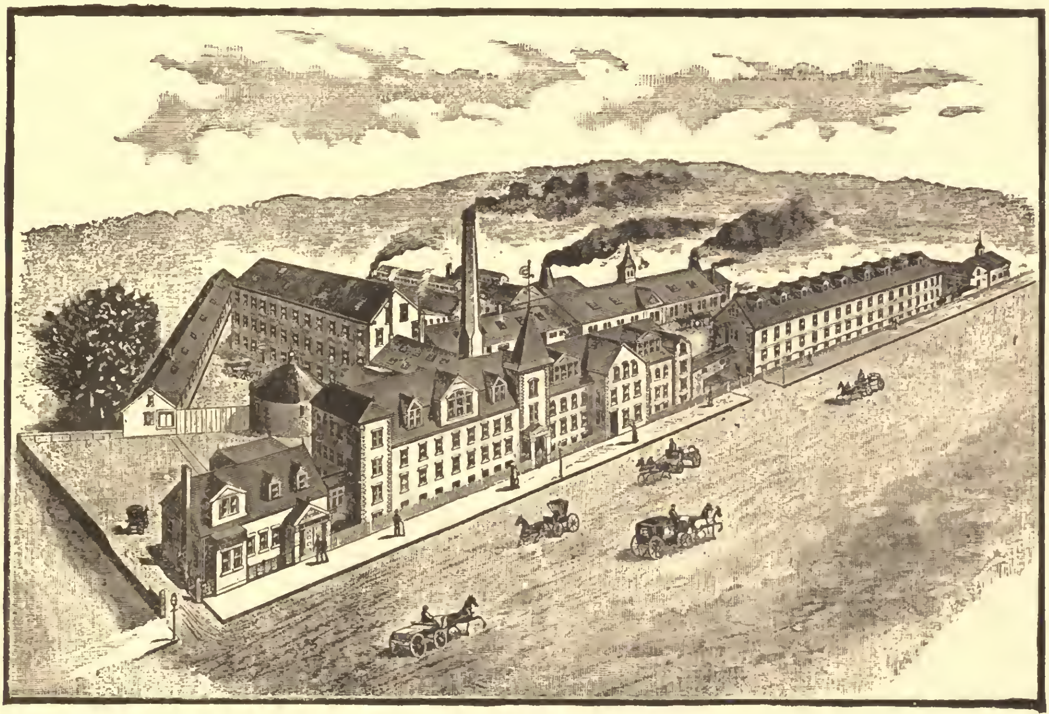

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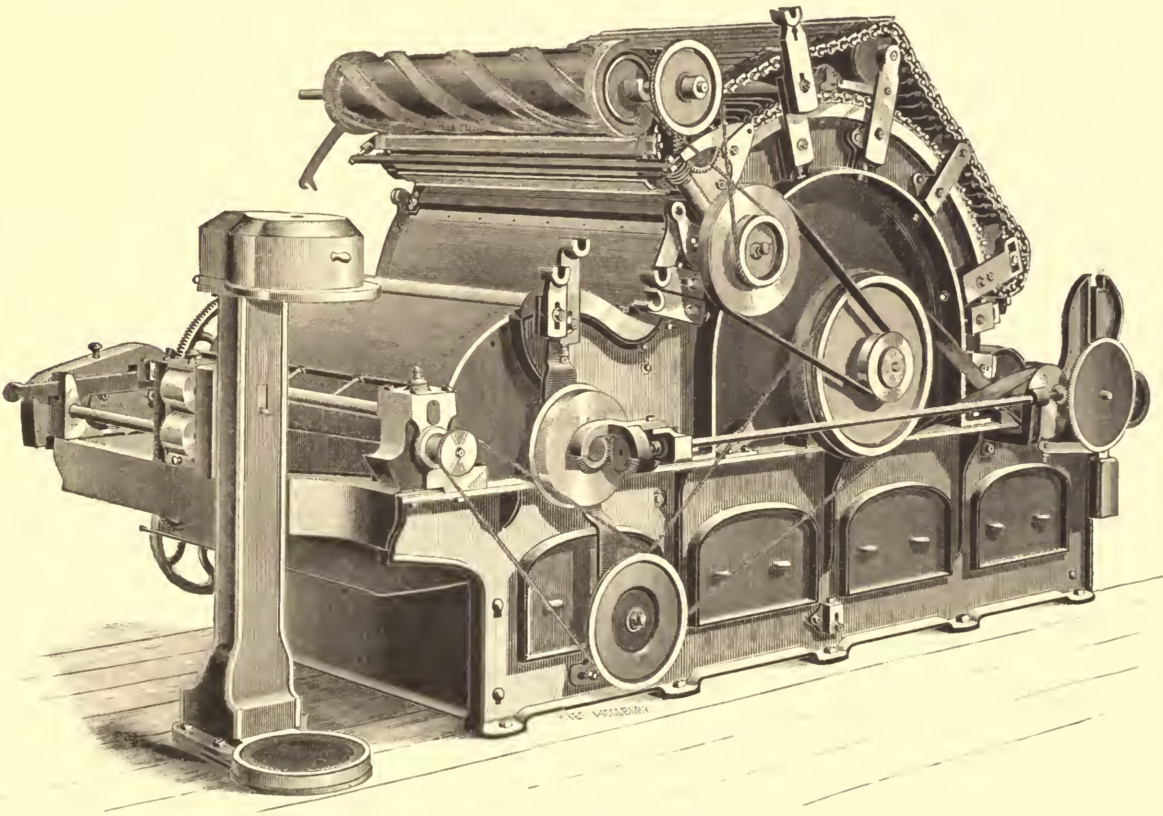
These Combs are illustrated on pages 163 and 166 of this work. Correspondence solicited.



(See Insi e Cover)

THE

STRUCTURE OF FIBRES, YARNS AND FABRICS.

Being a Practical Treatise for the Use of All Persons Employed in the Manufacture of Textile Fabrics.

IN TWO VOLUMES

VOLUME I.

Being a description of the growth and manipulation of Cotton, Wool, Worsted, Silk, Flax, Jute, Ramie, Chinagrass and Hemp.

VOLUME II.

Dealing with all manufacturers' calculations for every class of material, also giving minute details for the structure of all kinds of Textile Fabrics.

Containing also an appendix of Arithmetic specially adapted for Textile purposes, and a Glossary giving Explanations of the Most Frequently Used Technical Terms.

—BY—

E. A. POSSELT,

Head Master Textile Department Pennsylvania Museum and School of Industrial Art, Philadelphia, Pa.; Author and Publisher of "The Technology of Textile Design;" "The Jacquard Machine Analyzed and Explained, The Preparation of Jacquard Cards and Practical Hints to Learners of Jacquard Designing," etc., etc.

ACCOMPANIED BY OVER 400 ILLUSTRATIONS

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1891.

PHILADELPHIA
PRESS OF PENFIELD BROS.
1225-27-29 LEIPER ST.

PREFACE

The great success accorded to my Technology of Textile Design has induced me to prepare the present work. The same I divided in two volumes, of which the first volume treats of the structure of the various fibres used in the manufacture of Textile Fabrics and the entire subject of their manufacture into yarn. The whole of the various machines and processes have been considered fully, and the most important improvements described. The preparation of the drawings has been a laborious work, and no money has been spared to have the same well engraved.

Volume second deals with the manufacturer's calculations for every class of material, also giving minute details for the structure of all kinds of textile fabrics, and forms an advanced study to my former work on the art of designing and weaving.

The present work contains for its appendix a treatise on Arithmetic specially adapted for Textile purposes, also an Index and Glossary giving detailed definitions of over six hundred of the most prominent technical terms and which forms in itself a most complete Textile-Dictionary.

E. A. P.

Philadelphia, Pa.—1891.

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Cotton.

Cotton is a soft, downy substance, growing around the seeds of various species of cotton plant, *Gossypium, O. Malvaceæ.* The genus is indigenous to the American, Asiatic, and African continents, but has been spread by means of cultivation throughout all parts of the world, within the limits of 40° north and south of the Equator. Cotton plants vary in height according to the climate and soil, some reaching a height of sixteen to twenty feet, while others do not grow higher than two, three, or four feet. The leaves of the cotton plant grow upon stalks placed alternately upon the branches, most frequently being formed in the shape of a heart, and generally either three or five lobed, with the lobes sharp or rounded. The flowers are usually large and showy, and grow singly upon stalks in the axils of the leaves. The fruit of the cotton plant is a three or five called capsule, which bursts open through the middle of each cell when ripe, exposing the numerous seeds covered with the filaments known as cotton.

Fig. 1.

Amongst the different primary species of cotton plant we find:

Gossypium Barbadense, (see Fig. 1) which grows to a height of from six to fifteen feet. The flowers are yellow and its seeds black and smooth, being also quite deprived of the hair which characterizes, several other species. It is a native of Bardadoes, where it is and has been cultivated for a long time. It has also been introduced into other countries with good results. The most successful outgrowth of this specimen of cotton is what is known as our *Sea Island, or long-staple cotton,* (see Fig. 2) which was introduced into our country in 1785, and is grown on the low islands and sea coast of Georgia, Florida, and South Carolina. This is the most valuable kind of cotton in the world, and has a fine, soft, silky staple from one and one-half to two and one-quarter inches long, which can be separated easily from the seed. The long-stapled *Egyptian cotton* and the *Bourbon cotton,* belong, according to several botanists, also to this class. The average length of Sea Island, or long-stapled cotton, according to the place of growth, is as follows: Edisto Island, 2.2 inches; St. Helen Island, 1.8 inches; Bluff Island, 1.8 inches; Sea Island, 1.7 inches; Wadamalan Island, Wassa Island, Hutchinson Island, 1.65 inches; Johns Island, James Island, Florida Island, 1.6 inches; Bulls Island, Pinkey Island, Cat Island, 1.5 inches.

Fig. 2

During the great civil war in our country England introduced Sea Island cotton into her dominions in Australia, but with little success, however, since only small quantities are raised there and the crop is rather uncertain. The average length of the *Australian cotton* is from one and one-half to one and three-quarter inches. *East India Sea Island Cotton*—The introduction of the Sea Island plant into India by England has been more successful, but the staple as derived will be about 10 per cent. coarser than by the same plant grown in our country. Again, a new supply of original seeds is constantly required, owing to the more arid climate of India and the want of humidity. The average length of the staple of this kind of cotton is about one and one-half inches.

Gossypium Arboreum.—This is a perennial tree growing to a height of from fifteen to twenty feet. The flowers are reddish-purple, the seeds covered with a greenish-colored fur, enveloped in a fine, silky wool, being of a yellowish-white color. It is found in India, China, Arabia and Egypt, and produces a good quality of cotton yarn. In India the plant is considered sacred. It is grown and carefully preserved about the Hindoo temples, and furnishes the Brahmins with the sacred tripartite-thread, the emblem of the Trinity of their creed, and there bears the popular name of *Nurmah*, or *Deo Parati.* Gossypium Arboreum differs from the other Indian cottons principally by the color of the flower and that of the seeds, which are covered with a rich, green down or fuzz, resembling in this respect those of the American Uplands.

FIG. 3.

Gossypium Hirsutum, is a hairy, shrubby plant about six feet high, with pale-yellow, or almost white flowers. In this species we find the seeds numerous, free, and covered with firmly adhering green down, under the long, white wool. Is is believed that this is the original of the green-seeded cotton, now so extensively cultivated in our Southern States, forming the bulk of their cotton harvest. It is known under different names as Orleans, Mobile, Uplands, Apalachicola, Texas, Boweds, etc. The average length of fibre for these specimens of *Gossypium Hirsutum,* according to their classification in the market, are: New Orleans or Louisiana, average length of staple 1.1 inches; Mobile, Alabama, Mississippi, average length of staple 1.05 inches; Georgia, North and South Carolina, Apalachicola, (Uplands) average length of staple 1.00 inch; Tennessee, average length of staple 0.98 inches, and Texas, average length of staple 0.95 inches.

This species of cotton plant has also been introduced into India, but the same facts as given before, regarding the Sea Island raised in India, are also true of this kind; *i. e.*, the staple gets coarser, and original seeds must be constantly supplied.

Gossypium Herbaceum, (see Fig. 3) is an indigenous Indian species and yields the bulk of the cotton of that country, but also grows in Southern Europe, (see Fig. 4) Egypt, Asia Minor, Arabia, and China. The average height of this specimen of cotton plant is from four to six feet; its seeds are covered with a short, grey down, and the fibre it bears is classified as short-stapled, known in the market as *Surat-cotton.*

FIG. 4.

Gossypium Peruvianum, is the species of a cotton plant which produces the cotton exported from Brazil, Peru, and other parts of South America. It grows to a height of from ten to fifteen feet and bears a yellow flower. This specimen is seldom spun alone on account of its harshness and irregularity, both in length of staple and cleanliness. It is generally mixed with cotton of Egyptian and American growth. The average length of staple of the different kinds according to place of growth are Pernambuco cotton, 1.35 inches; Surinam and Peru, 1.3 inches; Maceo and Paraiba, 1.2 inches; Maranham, Aracate, and Ceara, 1.15 inches.

Our Orleans variety of cotton has been introduced with success in Brazil, and is now extensively cultivated there. The market name of this variety of cotton is *Santos,* and resembles in its staple closely the kind from which it is derived.

Gossypium Religiosum, is found in India and China. It is a low shrub of from three to three and a half feet in height. The cotton derived from this species has also for ages been devoted to the manufacture of clothing for the Brahmins, the religious caste of Hindoo society. It is of no value for commerce, since the yield is very small, and the filaments being close to the seed render it unfit for ginning; *i. e.*, it must be hand-picked.

Gossypium Tahitense is found in Tahita, the Society Islands, etc.

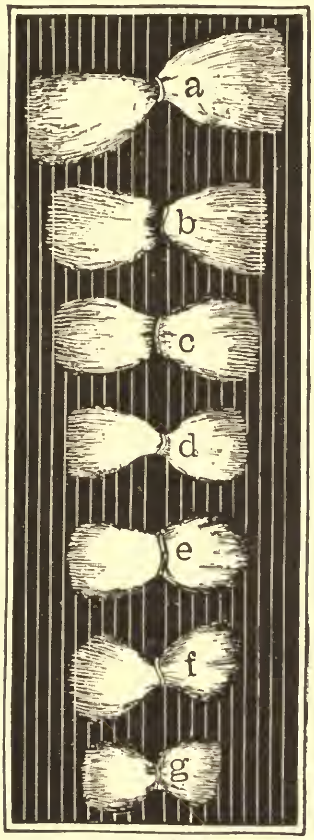

FIG. 5.

Gossypium Sandwichense is found in the Sandwich and adjacent Islands.

In commerce the different species of cotton are not designated by their scientific names, but by the names of those parts of the world where they are grown. To give an idea of the most prominent different kinds of cotton as to length of staple and diameter of fibres, the following table with reference to Fig. 5, is given.

Place of Growth	Name.	Average Length of Staple.	For illustration see Fig. 5.	Average size of Diameter.
United States,	Sea Island or Long Staple,	1.80	a.	$\frac{1}{1560}$
" "	Uplands or American,	1.05	e.	$\frac{1}{1290}$
South America,	Peruavin or Brazilian,	1.20	d.	$\frac{1}{1260}$
Egypt,	Egyptian,	1.40	c.	$\frac{1}{1320}$
India,	Native or Surat,	0.90	g.	$\frac{1}{1180}$
	From American Uplands,	1.10	f.	$\frac{1}{1200}$
	From American Sea Island, or from Egyptian (long staple.)	1.50	b.	$\frac{1}{1370}$

Examination of the Various Kinds Under the Microscope.—Examining cotton fibres under the microscope shows them to be spirally twisted bands, containing thickened borders and irregular markings on the surface. Fig. 6 shows Sea Island, Fig. 7 Upland, and Fig. 8 Surat cotton magnified. Upon this peculiar characteristic twist in the fibre, depends to a great extent the power which cotton possesses in forming strong threads of yarn, by means of the strands interlocking into the grooves of contiguous fibres. The spiral character of cotton fibre also explains the comparatively more elastic character of calico, as compared with linen cloth. The specimens of cotton differ as previously explained, in length and fineness of staple, and also in regard to amount of twist the fibres possess; but more or less this characteristic twist is found in every kind. This twist also assists the manufacturer to detect, by means of the microscope, cotton from any other fibre.

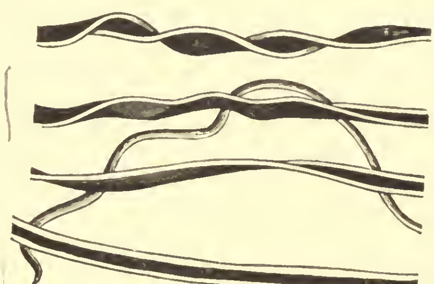

FIG. 6.

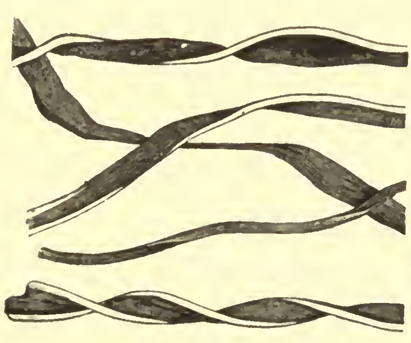

FIG. 7.

FIG. 8.

Ripe and Unripe Cotton.—In fully ripe cotton the twisted form is regular and uniform, compared to unripe or half-ripe fibres. For illustrating this subject Fig. 9 is given. *A* represents an unripe fibre; *B* represents a half-ripe fibre, having a thin cell-wall; *C* represents a ripe fibre, having a full twist and a properly defined cell-wall.

Examining by means of a microscope the transverse sections of the ripe cotton fibres, (see Fig. 10) shows them to be flattened tubes, having comparatively thick walls with a small central opening; whereas the transverse sections of unripe cotton (see Fig. 11) exhibits no central opening, hence no separation of the thin cell-walls has yet taken place. In half-ripe cotton fibres the central opening, as formed in ripe cotton, is only visible as a fine line; *i. e.*, the cell walls are yet closely pressed together; but such fibres will readily swell up if steeped in water, forming hollow tubes. Occasionally we find in cotton structureless fibres, as shown in Fig 12. If unripe or half ripe fibres be found in a lot of cotton, it will greatly depreciate its value, on account of its poor dyeing and spinning qualities.

A. B. C.
Fig. 9

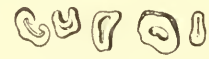

Fig. 10.

The Chemical Composition of the full-ripe cotton fibre is what is called *cellulose*, which is a combination of carbon, hydrogen and oxygen, $C_6H_{10}O_5$. There are generally about 5 per cent. impurities present, which explain the loss in weight when bleaching cotton, since the latter process has for its object the removal of these impurities. This 5 per cent., or about that amount of natural impurities, is, or can be, removed by boiling the fibres with a weak solution of caustic potash or soda, without injuring the fibres. Care must be taken not to expose the fibres during the operation to the air, otherwise the fibres will get tender. If steeping cotton in strong solutions of caustic alkalis (50° Tw. Sp. Gr. 1.25) and examining the same (after previously washing off the alkali) under the microscope, it seems to have lost its original appearance; *i. e.*, the fibres appear no longer flat and spirally twisted, but thick, straight and transparent. If examining in this state a transverse section of the fibres, their former structures, as shown in Fig. 10, has changed to be cylindrical, with the cell-walls considerably thickened and the central opening diminished to a mere point, as shown in illustration, Fig. 13.

Fig. 11.

Fig 12.

Fig. 13.

Sowing and Harvesting.—The time for beginning sowing in the different cotton-producing countries varies considerably, depending on the climate. In our country the same ranges from the middle of March to the middle of April; in Egypt, from the beginning of March to the end of April; in South America, from the end of December to the end of April; in India, from May to the beginning of August. In a similar manner, as the time for sowing, the time for harvesting varies. In our country the same begins in August and lasts until December.

Cleaning.—After being picked and dried, the cotton is forwarded to the gin-mill, to have, by means of a *cleaner*, sand, dust and other foreign substances, removed from the cotton, previous to separating the seeds from the fibres by means of the gin.

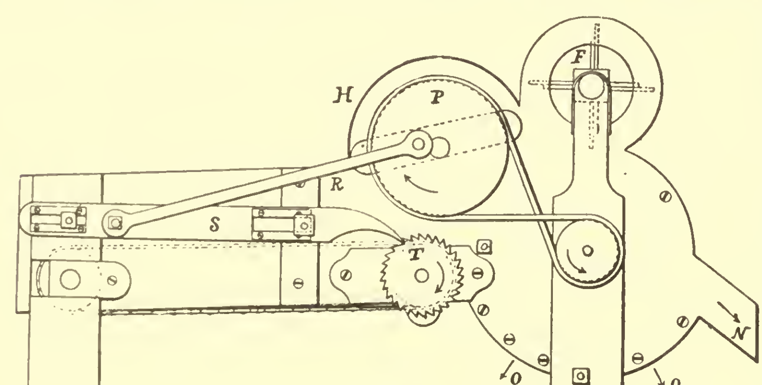

Fig. 14

Seed-Cotton Cleaner.—Before the cotton is submitted to the cotton-gin, for removing the seeds from the fibres, the same is first cleaned by means of a seed-cotton cleaner. Such a cleaner may be arranged to work independently, or in direct connection with the gin, permitting a continuous operation. A seed-cotton cleaner is very simple in its construction. The object in view is to free sand, dust and other foreign substances, by means of shaking and beating, creating at the same time a strong draft by means of a quick revolving fan. Figs. 14 and 15 illustrate such a seed-cotton cleaner. Fig. 14 is a side elevation of the machine, and Fig. 15 is a central longitudinal section made by a vertical plane. Letters of references in both illustrations are corresponding. The cotton to be cleaned is placed upon the *creeper M*, composed of slightly separated transverse slats, fixed upon two or more narrow belts revolving around the two rollers *J*, *J*, in direction of the arrow. In the side elevation

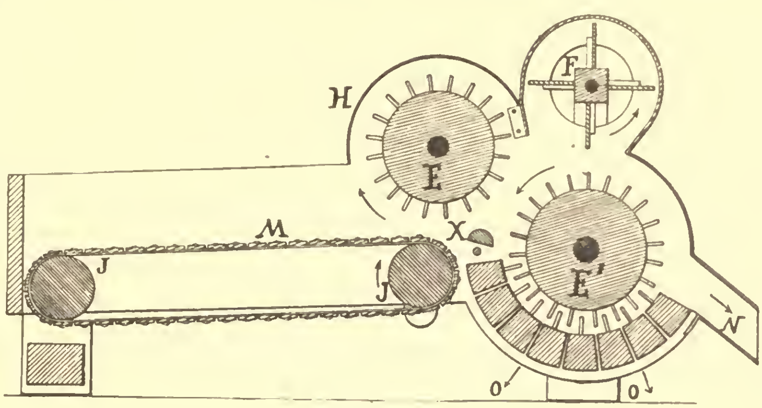

FIG. 15.

a peculiar mechanism is clearly visible; *i. e.*, pulley *P*, which serves as a crank plate, and in its revolutions imparts intermittent motion to the carrier *M*, through pitman *R*, sliding pawl *S* and ratchet *T*, the latter being fixed upon the same shaft as previously mentioned, drum *J*. The sudden movements imparted by the pawl shake the heavier foreign substances the cotton (as fed upon carrier *M*) contains through between the slats composing the creeper. As the cotton advances it is caught by the toothed cylinder *E*, and carried around beneath the netting *H*, the current of air from the fan *F*, blowing out meantime such impurities as may be thus dislodged. Thence it falls upon the cylinder *E'*, and guided by a bridge *X*, is carried into the toothed concave bed, where the combined action of the stationary teeth of the bed and the moving teeth of the cylinder, effectively loosen up all compact masses, and set free all remaining foreign material. The latter, by means of gravity and the force of the blast from the fan, passes out between the slats or bars *O*, and is conveyed away in any convenient manner, while the cotton now cleaned from foreign substances (except the seeds) escapes through the chute *N*, in excellent condition for being submitted to the gin.

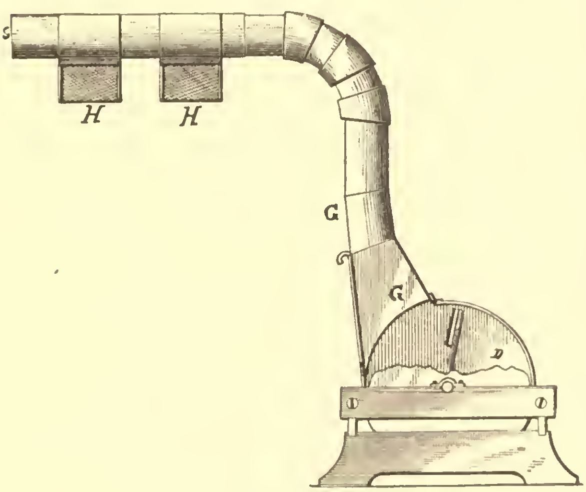

FIG. 16.

Another machine for cleaning seed-cotton from sand, dust, and other foreign substances, and the delivering of the cleaned cotton into a bin or other receptacle, or direct to the gin, is shown in Figs. 16, 17, and 18. Letters of reference are selected correspondingly for all three illustrations. Fig. 16 is an end view partly broken away. Fig. 17 is a vertical longitudinal section, partly in elevation. Fig. 18 is a detail of one of the discharge spouts or guides. The operation of the machine is as follows: When the cotton is placed in the hopper *A*, it immediately falls into the cylinder *B*, where it is caught by the spirally arranged arms, rapidly revolving; this agitates the cotton, and by centrifugal force presses the same against the meshes of the cylinder and

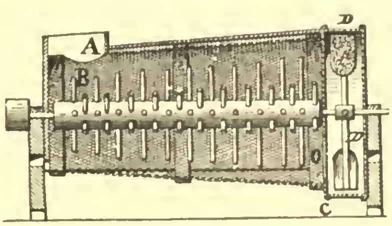

FIG. 17.

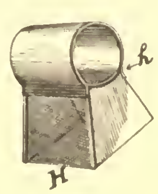

FIG. 18.

against the brushes. This agitation loosens the dirt and foreign matter from the cotton, and owing to the cylinder being entirely perforated or slatted, the foreign substance is ejected from the same between the meshes. The spiral arrangement of the arms carries the cotton down the inclined sides of the cylinder, and discharges the same through the opening *O*, in the cap *C*, into the drum *D*, where it is subjected to the blast caused by the fan blades which, owing to their soft elastic faces, gently gather the cotton and prevent the impact of the blades from injuring the fibres, but at the same time forces it up the tube *G*, and out the openings *h*, through the guides *H*, into the gins, or a bin. The wire sides of the guides permit the air and dust carried up the pipe to escape. When the cotton is to be discharged into a bin or other receptacle, the cap *S*, on the end of the pipe is removed and the discharge openings *h*, closed by turning the guides *H*, up.

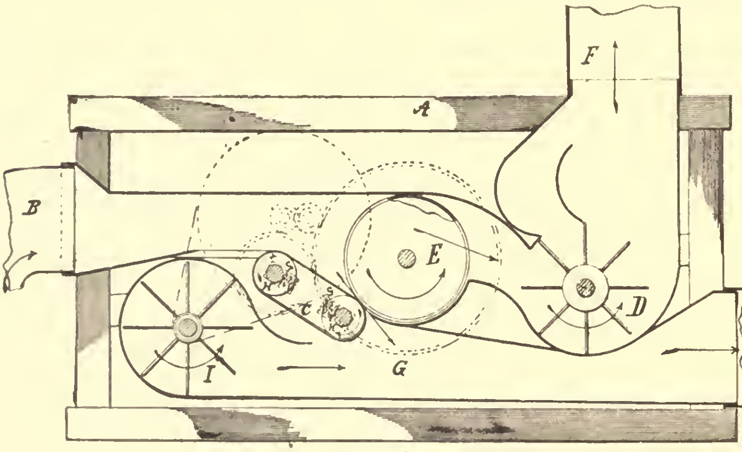

FIG. 19.

Another method of cleaning cotton from sand, dust and other impurities is shown in Fig. 19, representing the vertical sectional view of such a machine, and consists essentially in two fans, one for elevating and removing dust and other impurities, and the other fan for conveying the cleaned seed-cotton to the gins or storage bins. In the illustration, *A* represents the frame of the elevator, *B* is a suction pipe, bending downward at one end, (where it receives the seed-cotton from a wagon or bin) and bent at the opposite end, where it terminates in the discharging dust flue *F*. An exhaust fan *D*, is revolubly supported at the lower end of the flue. This fan has its suction and discharge at the periphery. *E*, is a revolving cylinder, covered with perforated sheet metal or wire cloth to permit the free passage of dust and motes through it, but at the same time arrests the passage of the seed-cotton, and by its revolution turns or deflects it downward, between its periphery and the endless belt *C*, into the discharge pipe *G*, below. The rollers *H*, upon which the belt is carried, are held yieldingly in position by small springs *S*, so as not to crush the seeds, and at the same time preserve an air-tight joint between the belt and cylinder. A fan *I*, is located in one end of the discharge passage, and is used to blow the cotton to the gin or storage bins. The various parts of the machine are driven by suitable belts, pulleys, and gears, as partly indicated by dotted lines in the drawing. Motion is communicated from the line-shaft by means of a belt running over a pulley on the shaft of either fan, as most convenient.

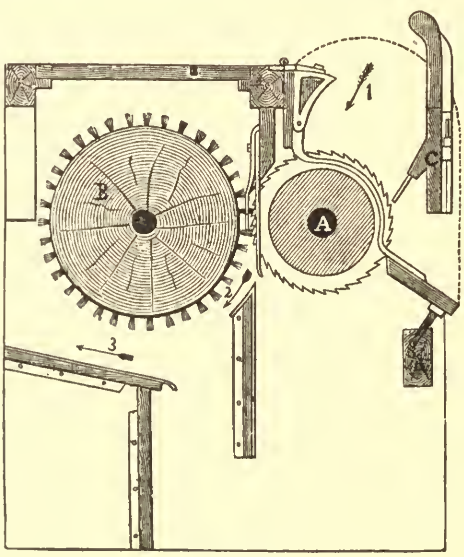

FIG. 20.

Ginning.—After the cotton is cleaned from sand, dust, and other foreign substances, by means of the cleaner, the same is forwarded either directly or indirectly to the cotton-gin to separate the cotton fibres from the husk, berry, or seeds, to which it most tenaciously adheres. Every ball of cotton has a berry inside resembling unground coffee. There are several kinds of cotton-gins built, amongst which we find: the saw-gin, the Macarthy-gin, the comb-gin, the Macarthy double roller-gin, the lock-jaw-gin, etc.

Saw-gin.—The same (see Fig. 20, sectional view), is the invention of Eli Whitney, of New Haven, Connecticut (1793), and consists of a series of circular saws *A*, forming a cylinder about the size of a loom beam. The teeth are cut out like a coarse saw, at equal distances from each other, from which it derives its name. These saws pull the cotton through an iron grating, having such narrow apertures that the seeds or gins cannot pass through. This grating has a horizontal inclination, and the cotton is thrown upon it by the person attending to the machine, when the teeth of the saws take hold of it, and pull it through the openings of the grate; the gins being pressed out, roll down the surface of the grating, escaping by an opening in the side of the machine. The cotton is thrown backward by the centripetal force of the cylinder, aided by a brush cylinder *B*, which also serves for cleaning the cotton from the saws. Arrows 1, 2, 3, clearly indicate the run of the cotton from entering up to leaving this saw-gin. This machine is mostly used for the short-stapled material, which it cleans superior to any other style, the saws of the saw-gin separating the seeds from the cotton more effectually than rollers, and at the same time give it a kind of teasing, which is of advantage to its fibres in spinning.

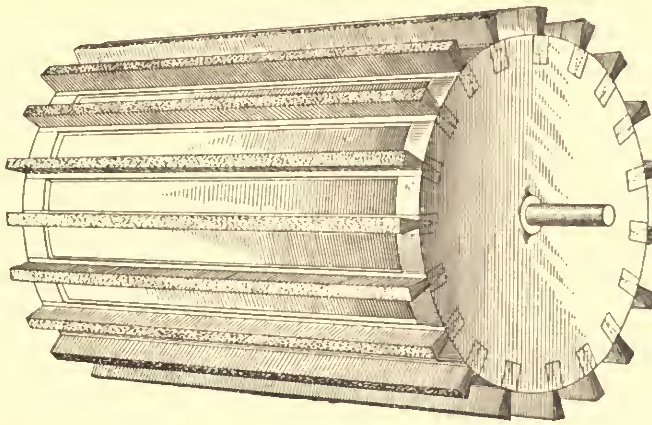

FIG. 21.

Fig. 20 represents a *single cylinder saw-gin.* There are also machines built having a double set of saws, and which are known as *double cylinder saw-gins.*

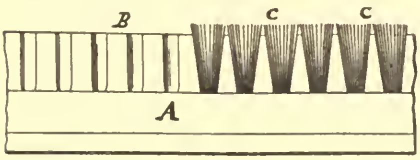

FIG. 22.

Improved Brush for Saw-gins.—In the use of either kind of saw-gins special care must be taken to keep the circular brush in good order, to remove the lint and gum from the saws. Fig. 21 illustrates a perspective view of the brush most frequently used. Figs. 22, 23 and 24 illustrate a useful improvement in these brush cylinders as used for cotton-gins. Fig. 22 is a view in inside elevation of a portion of a bristle-holder. Fig. 23 is a transverse section of it, and Fig. 24 is an end elevation of the brush cylinder (with one of the spaces for inserting one bristle-holder in cylinder left open). Letters of reference in all three illustrations are selected correspondingly. The bristle-holder *A*, consists of a long strip of wood, having a flange or lip *B*, made integral with it, and extending outward from one of its outer edges on one side, and nearly to the ends of the bristles *C*, which lie against it; and are thus reenforced and virtually stiffened. The bristles are made up in tufts and drawn into the holes formed in the holder, in which they are secured by a binding-cord. The bristle-holders are mounted in the periphery of the cylinder, rotating in the direction of the arrow shown on the drawing, Fig. 24. They are arranged singly, between groups of two or more bristle-holder *H*, carrying unsupported bristles. The bristles of a holder made in previously explained manner are so stiff that they readily clean the gum from the saws, and so make the gin run freely, easily, and do good work.

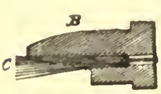

FIG. 23.

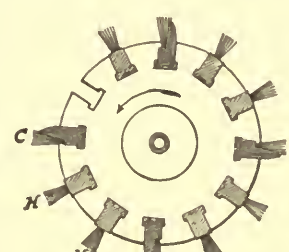

FIG. 24.

Automatic Oiling Saws.—To prevent the gin-saws as much as possible from gumming, mineral or coal oil may be applied. This, it is claimed, also improves the cotton thus manipulated, by means of less breakage of the fibre, and getting a greater average length of staple. The method of applying the oil to the gin-saws is illustrated in Fig. 25, showing in perspective view that portion of the cotton-gin with which the improvement is more immediately associated. *A* represents the grate-fall, *B* the series of saws, and *C*, a perforated tube arranged cross-wise in the machine above the saws. The oil is supplied to the tube from an elevated reservoir *D*, and it flows through the tube perforations *c* on the cotton grates and saws.

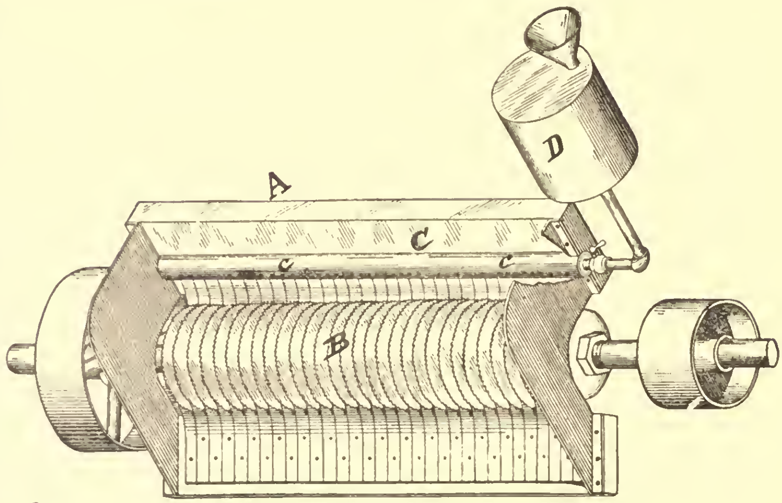

Fig. 25.

Improved Saw-Gin with Device for Grading.—Lately a unique saw-gin has been constructed and patented, whereby the material can be discharged in two or more grades of lint, varying in the length of fibres composing the same. This feature is accomplished by applying to an ordinary saw-gin an end-feed constructed of a suitable hopper, a barrel or trough, and a screw which is adapted to force the seed cotton horizontally into the cotton box at one end, and keep it moving straight across the saws, which may be closer together at the tail end, until the seeds pass out at the opposite end. The first saw with which the material comes in contact strips the blooms off all the long fibre, then passing on to the next, the shorter fibre is removed, and so on until reaching the other end of the machine, when the seeds are so well stripped that only the short lint remains, when by the aid of an agitator, the seeds are acted upon by the remaining saws. In connection with the gin, thus separating the long from the short fibres, a condensing roll is provided, having one or more separating bands of metal, which prevent the material from taking hold or clinging to previously mentioned roll at that point, and therefore delivers the ginned cotton in two or more grades. To give a clear understanding of the working of the machine, its perspective view is given in Fig. 26. Fig. 27 is a detail drawing of brush and condensing roll set a proper distance apart. Numbers of reference in both illustrations are as follows: 1, represents the hopper; 2, the barrel; 3, the screw feed-conveyor, and 4, the agitator, having radial arms. 5 represents the cotton box, having hinged cover, 6, and ribs, 7. Between these ribs project the saws, 8. 9 represents the brush, and 10 and 11 the condensing rolls, the former 10, which is provided with the metallic strip 12. When the fibre comes in contact with the condensing roll 10, to be passed forward thereby and between the outer rolls 11 for compressing it, it does not adhere to the metallic band 12, but is drawn by the currents of air to one side or the other with the fibre, which adheres

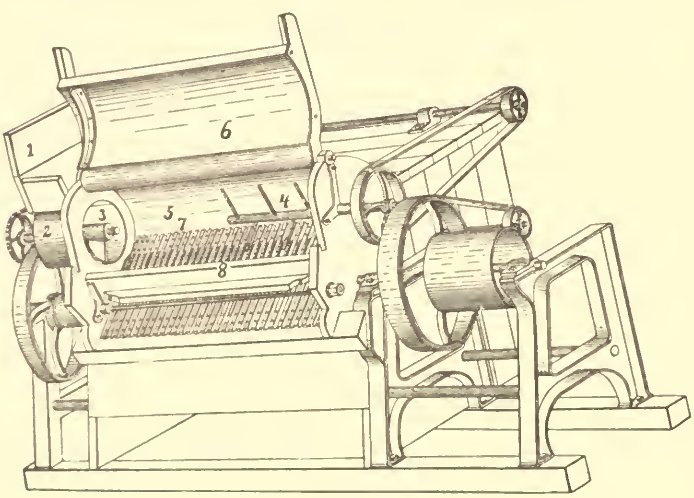

Fig. 26.

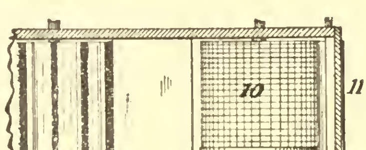

Fig. 27.

to the rough surface of the roller. Thus, the fibre may be delivered in two, three, or more portions by providing one, two, or more separating strips on the roller.

The Macarthy-Gin is illustrated in its section in Fig. 28. This machine is well adapted for cleaning the long-stapled cotton. Its method of operation is thus: The roller *B*, covered with strips of leather, draws the cotton in under the knife *C* (which is fixed so as to press gently upon the roller *B*), but the seeds being unable to get under the knife are held at its point, when the beater-blade *D* comes up close to the knife, which it passes slightly, and keeps tapping the seeds and loosens them, while the leather-covered roller is continually drawing the fibres through. From two to three times tapping each seed in this manner will denude it of the cotton, and the seed will fall through the grid under the gin.

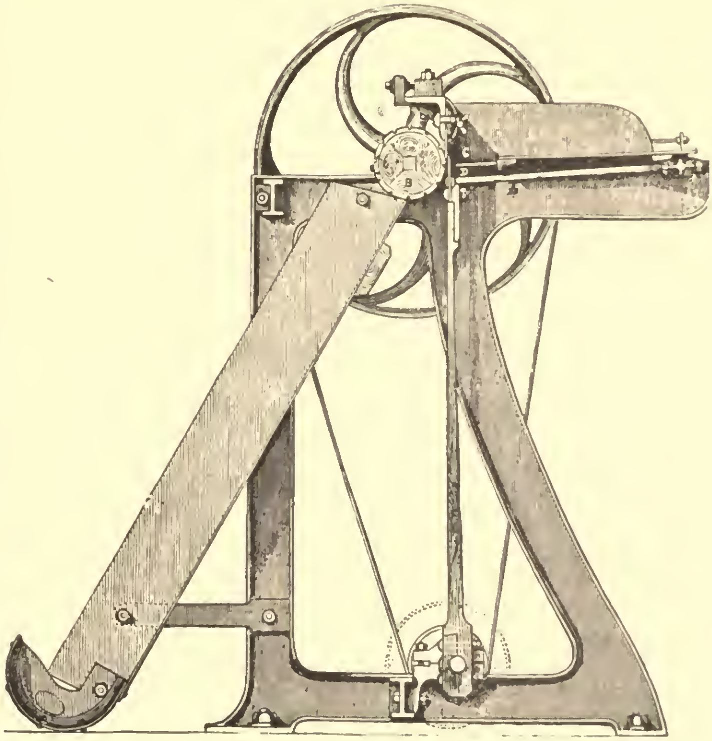

Fig 28.

Improved Macarthy or Comb-Gin.—This gin is an improvement upon previously explained gin and is illustrated in Fig. 29 in its perspective view, and in Fig. 30 in its section. The gin with reference to Fig. 30 works thus: *A* is a leather-covered roller, moving in the direction of the arrow, taking along the fibres of the seed-cotton as fed in the machine. *a* is the knife set close to the periphery of the first mentioned roller, and retains the seeds of the cotton which are detached from the fibres by means of two beater-knives *b* b^1, moving quickly up and down. The seeds thus liberated from the cotton find exit through the grid *i*. Beater-knives *b* b^1, are adjusted to the ends of the levers *c*, and receive motion from a crank-shaft by means of suitably situated connecting rods. The seed-cotton is placed upon a *creeper* moving around two tension rollers *r*. This creeper, or feed-apron, feeds the cotton below fluted roller *h*, from where it is thrown, by means of porcupine roller *s*, in the trough *H*. From there it is combed toward the leather-covered roller *A*, by means of comb *J*. The fibres, as fed from the seeds, are taken off from the leather-covered roller *A*, by means of fluted roller *G*. This gin, similar to the previously explained machine, is mostly used for long-stapled cotton.

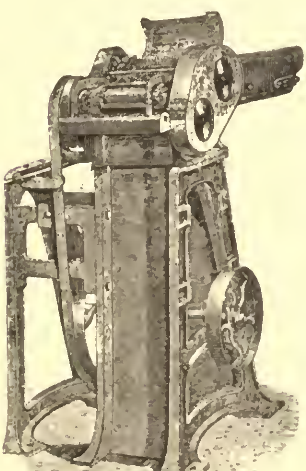

Fig 29.

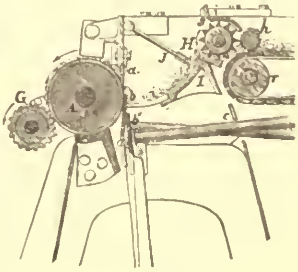

Fig. 30.

Macarthy Double Roller-Gin.—This machine is illustrated in Fig. 31 in its perspective view. Amongst the features of this machine we find that it is self-adjusting, the fixed knives being perfectly rigid and the rollers being pressed against the knives by weights; thus the machine can be instantly regulated for various lengths of staples as required. The fixed and moving beater-knives cannot enter into contact on the insertion of any extraneous matter as pieces of string, etc., the rollers receding from the knife, and allowing the obstruction to pass freely away. Other gins are the *Cowper lock-jaw-gin*, the *roller-gin*, and the *Scattergood needle-gin*, etc., but those illustrated and explained are the ones most frequently used.

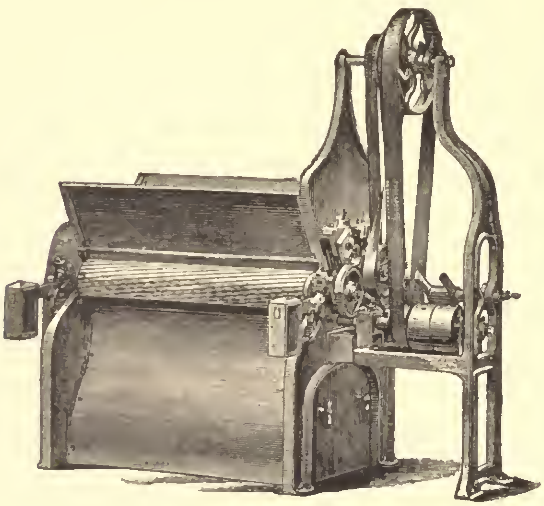

Fig. 31.

Feeders for Cotton-Gins.—An ingenious and practical feed for cotton-gins has lately been invented, and is illustrated in Figs. 32, 33 and 34. Fig. 32 is a vertical longitudinal section thereof. Fig. 33 a perspective view of the feed regulator (being special illustration of part *C* in Fig. 32) and Fig. 34 a similar view of the discharging roll of the feed-carrier (being a special illustration of part *I* in Fig. 32). This feeder for cotton-gins also cleans the seed-cotton from any foreign substances found in cotton through the carelessness of the pickers, as sticks, stones, clods of earth, etc., which if not previously run through a cleaner would endanger, to a more or less degree, the saws of a saw-gin. In Fig. 32 *A* represents the hopper for the reception of the seed-cotton. *B* the carrier for conveying the cotton to the throat of the gin. *C* is the feeding regulator to limit and control the quantity of material conveyed by carrier *B*. The slats of the carrier *B* are provided with short teeth projecting from the under surface of the carrier, in a plane slightly above the horizontal, when moving in chute *D*. The chute opens at its bottom into a trash box *E*, the bottom of which is hinged at *F*, so as to swing downward to discharge the contents. A movable pin *G*, projecting from the inner surface, holds the bottom of the box in normal position. The rotating feed regulator *C* is mounted in adjustable boxes, hence it may be adjusted nearer or farther from the carrier, to control the amount of cotton passing from the hopper to the carrier. The cotton is removed from the carrier by means of a revolving drum *H*, mounted in boxes, which consists of plates apertured at one end to receive the shaft, and slotted at the other to receive securing screws or bolts that pass into the sides of the enclosing case. To prevent, as far as possible, the passage of foreign substances to the under surface of the feeder, as well as to beat back loose locks of cotton that might chance to pass the regulator *C*, a second regulator *I*, comprising a small rotating roll having projecting flanges, is arranged near the bottom of the carrier *B*. This supplementary roller will beat backward loose locks of cotton, which by being entangled with the cotton upon the carrier teeth, may be dragged passed the first regulator *C*, but it will also prevent in a great measure the passage of foreign substances to the under surface of the carrier.

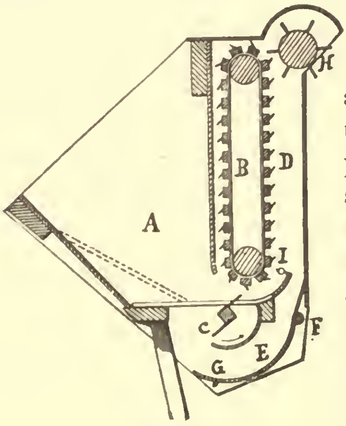

Fig. 32.

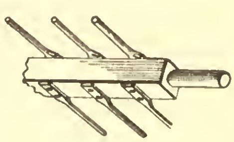

Fig. 33.

Fig. 34

Fig. 35 illustrates another kind of feed-regulator in a broken side elevation. The feeding of the seed-cotton from the hopper *A*, to the saw chamber *B*, is regulated automatically by the action of the cotton, as it falls into the saw chamber from the evener-cylinder, by means of a cord *C*, which is secured by a staple near the front end of the frame, and runs thence horizontally and taut through the saw chamber, to and through the guide staple *D*, at the left side of the frame, and thence upward, where it is attached to lever *E*. Whenever the cotton is fed to the saws *F* faster than they can dispose of, the over accumulation of cotton in the roll box causes an increase in the bulk of the roll and consequently presses against the cord *C*, and deflects it, which thus necessarily pulls upon and depresses the lever *E* at *I*, which raises the link *J*, and disengages the pawls from the ratchet *G* until the saws have disposed of the extra feed; when the pressure on the cord *C* is relieved the link *J* drops, the pawls resume their engagement with the ratchet-wheel and the feed-apron *H* again moves. The proper supply of cotton to the saw chamber is also regulated by the breast-board of the saw chamber as follows: The breast-board *K*, as shown, is hinged at *L*, and is provided with a projection at *O*. When the breast-board is raised to open, by means of too much cotton fed into the saw chamber, part *O* will press upon the front lever *E*, and also stop the feed until the board is lowered again to place. After the seed-cotton, by means of ginning, has been freed from its seeds and other impurities, it is packed by means of powerful hydraulic presses into bales, and ready for shipment to any part of the world.

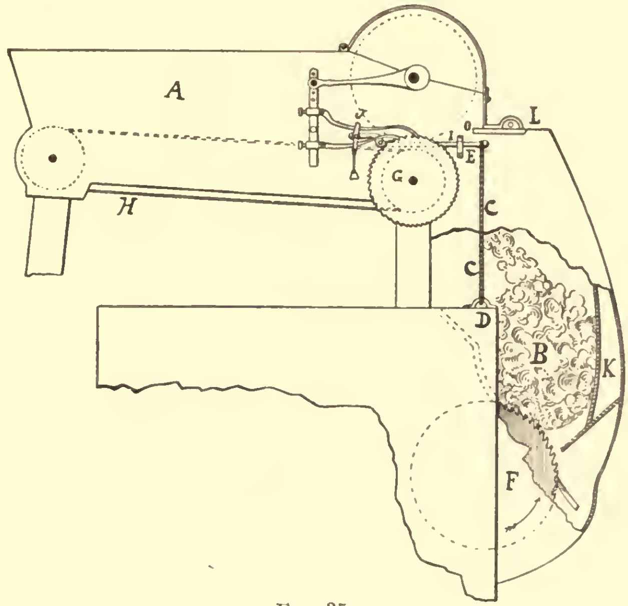

Fig. 35.

COTTON SPINNING.—Before the cotton fibre, as received at the mills in bales, is converted into the thread technically known as warp, or filling, it is subjected to the following processes:

1st. Mixing; 2d. Opening and picking; 3d. Carding (Combing); 4th. Drawing; 5th. Slubbing;

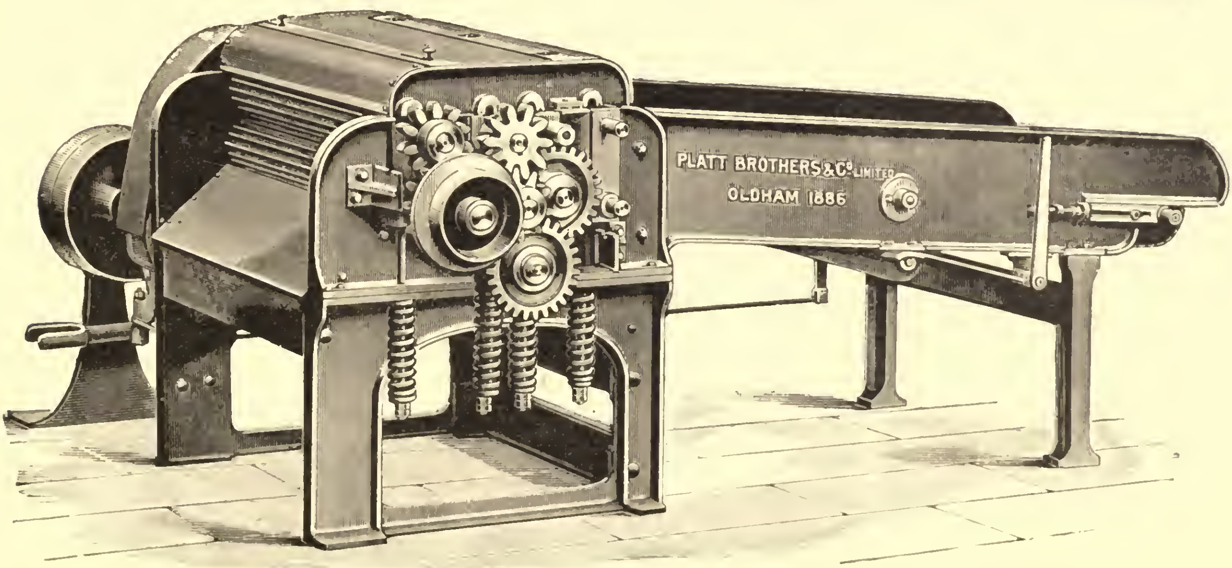

Fig 36

6th. Roving; 7th. Spinning; 8th. Doubling (Gasing and Polishing). All these operations are in a general way included in the one word, cotton-spinning.

Mixing.—Is a process of the greatest importance, yet frequently undervalued by manufacturers. It is the mixing of different qualities of cotton in order to secure economical production, uniform quality and color, and also threads of even counts. We may be compelled to mix a long-staple cotton with short-staple cotton to produce a stronger thread than if using the latter alone; again, the price of the spun yarn may be the main factor to indicate what and which qualities mix. Even if using only one quality or grade of cotton mixing is to some extent required, its object being to distribute any irregularities in staple and quality, as well as any possible improper classification by the planter or dealer, over the entire lot to be mixed. The larger the amount of cotton mixed the more uniform the yarn spun. The process of mixing is as follows: Open about eight bales, more or less, of cotton previously laid side by side, take alternately a quantity from each bale, and place upon the creeper-feed lattice of the *bale-breaker,* of which a perspective view is given in Fig. 36. By the action of the collecting roller, three pairs of breaker-rollers, and the lattice, the cotton is pulled and delivered on to the mixing in good condition for the next operation.

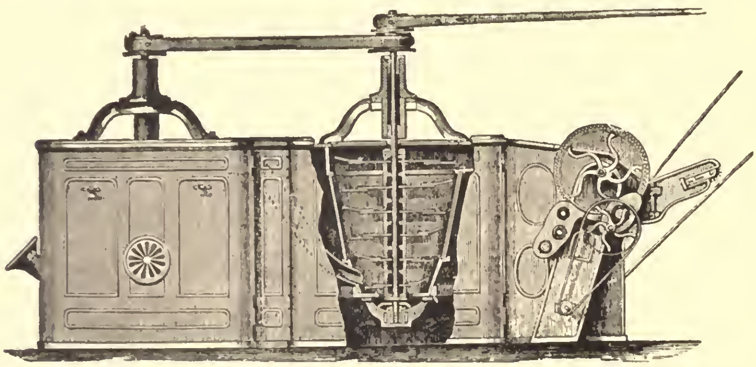
Fig. 37.

Opening has for its object the loosening of the fibres as matted by the heavy pressure the cotton had been subjected to during the packing, and also cleans or knocks out of the cotton heavy dirt, such as sand, seeds, etc. This opening process is carried on by machines known as willows, or openers, of which there are several kinds built. Amongst the best kind of openers in use we find the *Crighton Opener,* which is shown in Fig. 37 in its side elevation, and in Fig. 38 in its plan. As seen by the illustration Fig. 37, there are fitted in the interior of the frame work, side by side, two conical grids (beaters) with their small ends downward resting on a cross-rail a short distance from the bottom. (Only part of the frame is shown broken away, exposing only one of the conical grids; but the previous one not exposed is only a duplicate of this). The cotton to be opened is fed into the tube extending outside at the left of the illustrations, coming first in contact with the lower part of the first conical beater. By the centrifugal action of the beater-arms, as well as aid of the fan, the cotton is drawn upwards, thrown out at the top, when it passes down a pipe to the second beater (shown in our illustrations with sides of frame broken away) when the same process is repeated. The action of the beaters loosens the mass of fibre and drives foreign substances left by the cleaner, gin, or the breaker, if not too large, through the grid into the dust cavity (space between frame of machine and beater), and from there to the bottom. When the cotton rises to the top in the second beater it finally passes out to the lattice-creeper which conveys it away. The opener can be used either by itself, or as is mostly the case, directly in connection with the breaker-picker.

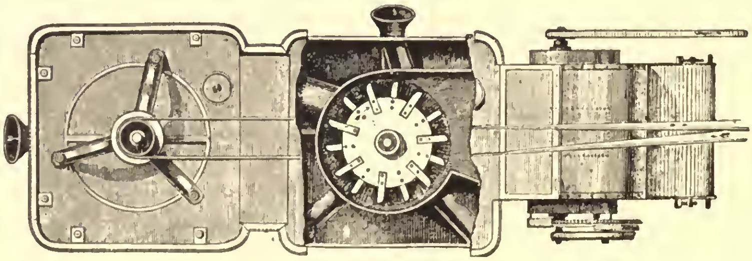
Fig 38.

Opening and First Picking.—Another make of machine for opening cotton is known as the *Exhaust Opener,* of which a perspective view is shown in Fig. 39, in connection with a breaker-picker. The cotton is taken from the mixing and spread on the lattice of the feeder, the feeder having collecting roller, two pairs of feed-rollers and cylinder, which delivers it to the dust trunks, over which it is drawn by the action of the exhaust fan into the cylinder of the opener; the loose dirt is deposited in the dust trunks, and the cotton enters the cylinder of the opener by tin pipes, and after passing the cylinder is spread level on the first pair of cages of the first division of the breaker-picker, by the action of two exhaust fans. It then passes around the cages and two pairs of feeder rollers, then undergoes the action of a three-winged beater; next subjected to the action of the second division of the breaker-picker, which is a duplicate of the first, and from here is made into laps. At the commencement of each lap, the rollers at the feeder are started a short time before the lap-part of the opener, and at the finish the feeder stops the same length of time before the lap-part. By this means the trunks and pipes are freed from cotton when the lap-part stops, and this obviates any irregularity arising from cotton remaining in the trunks. The connection between feeder and opener is automatic in its action. The feeder can be situated either over the blowing room, or on the same level, or in the room below.

Another exhaust opener in connection with a picker and lap machine is shown in Fig. 40. Similarly to the preceding one the inventor availed himself of the pneumatic principle, using a current of air to bring the cotton along tubes from the room above the machine. The operation of the machine is as follows: The cotton is fed from the mixing on the endless lattice *A*, which delivers it to two pairs

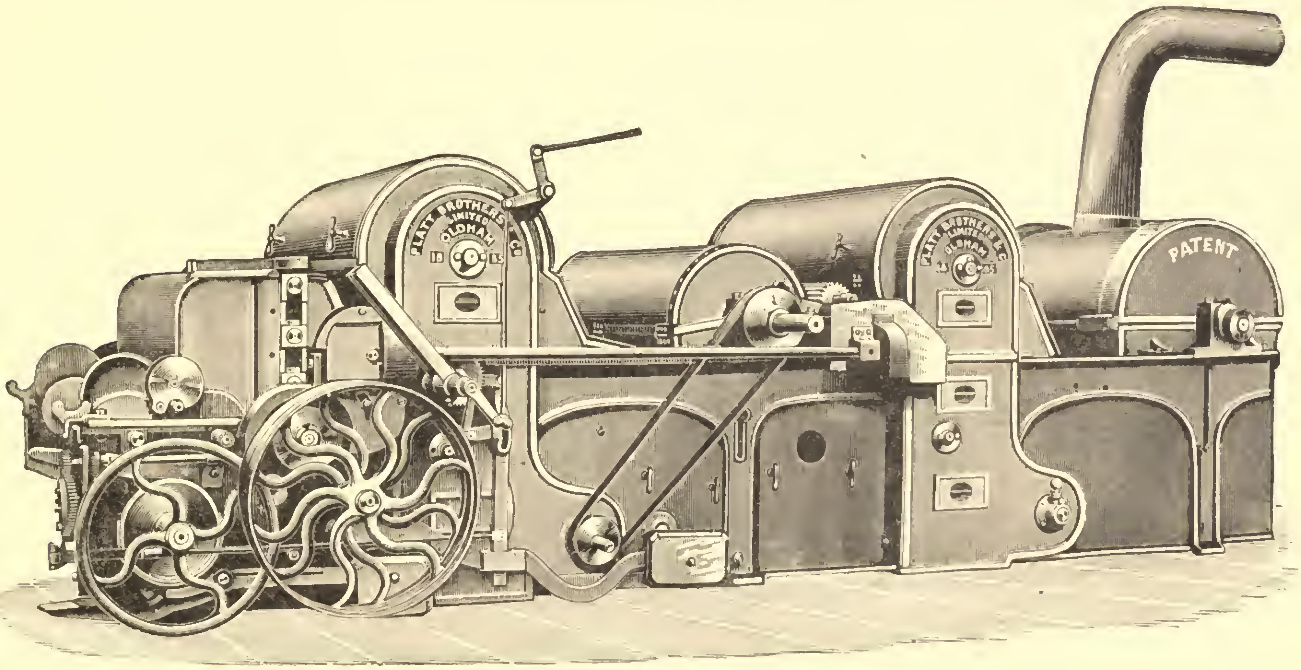

Fig 39.

of rollers *B*, the second pair of which revolve more quickly than the first. These convey the cotton to the tube, where it comes within the influence of the air current, and is forwarded to the opener *C*, consisting of a horizontal shaft carrying a series of accurately balanced arms, arranged radially on the shaft at several inches apart. The length of these arms is at the end nearest the tube about 18 inches, and increases gradually towards the other end, ending with a length of about 28 inches. When in operation the arms form a sort of cone (being the same as in the Crighton opener only that the shaft carrying the arms is placed horizontally in this opener, whereas in the Crighton they are placed vertically) and are surrounded by a conical grid. The bars of this grid are stationary at the delivery end, but capable of adjustment at the feeding end, in order to increase or diminish the distance from the beater, according to the nature or quality of the fibre to be opened. At the upper end of the beater is a powerful disc-fan, for drawing the cotton from the extremity of the feed-pipe through the beater to the first dust cages *D* of the picker. After passing through there the cotton is received by two small rollers, which deliver the same to the beater *E* of the picker, where it undergoes further opening and cleansing. From there it is forwarded to the second cages *F*, where it is formed at the same time in a continuous sheet, which is then compressed by the compression rollers, and then wound upon the lap-roller in the front, or head stock *G*, of the machine. In order to permit inspection of the interior of both dust cages the casing is glazed at places indicated by *H* and *I* in the illustration. For very low grades and also low counts of yarn the lap, as formed at the front of the breaker-picker, is delivered direct to the carding engine, whereas for better grades and finer counts of yarn, the laps as derived from the breaker-picker are subjected to the second or finisher-picker.

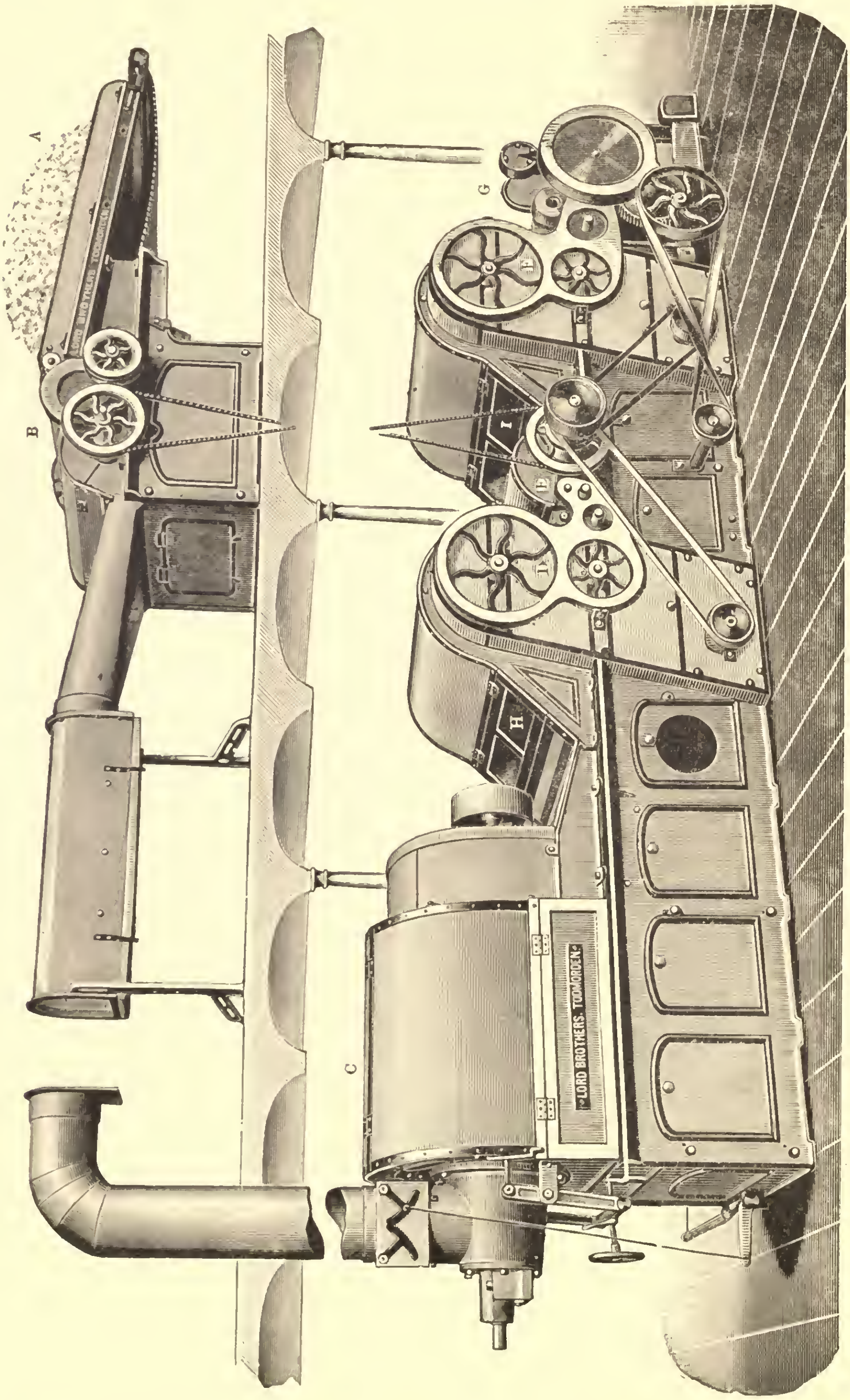

Fig. 40.

Principle of Picking. — Before explaining this finisher-picker (which is actually only a repetition of the first process with the machine built so as to do its work more perfectly all around; *i. e.*, produce laps as perfect as possible), we will give an application of the principle of the picking (or scutching, as sometimes called) process. Diagram Fig. 41 is designed to illustrate the principle of the operation. The cotton (for example taken in bulk from the opener) is spread upon an endless apron, from which it is fed between two pairs of grooved rollers *A*, when it comes within reach of the arms of the bea'er *B*, having either two or three blades. This beater is enclosed with a cylinder *C*, one-eighth of the circumference of which, extending from the feed-rollers to the bottom, is composed of a grid *D*. The average revolution of the beater is 1,000 turns per minute; hence, × by 3 blades in our diagram = 3,000 strokes per minute upon the cotton, which is slowly delivered to it and beaten down with great force from the roller against the grid *D*, causing any foreign substances, as broken leaves, motes, etc., still found in the cotton, to fall by means of their gravity through the grid (see *d*). Extending along the bottom of the cylinder is a passage leading to a dust cage *G*. This dust cage is also closed with an air-tight cover *F*, connecting closely to the one of the beater. Exhaust fans produce a strong current of air towards the dust cage, and the cotton from the beater is carried to the slowly revolving dust cage, on the exterior of which the same is deposited, forming the characteristic lap. The bottom of the passage along which the cotton has thus been brought consists of a grid *E*, to permit the exit of any impurities not previously removed at this stage by means of falling into the cavities by their greater specific gravity, compared to the cotton fibre. As previously mentioned, the loose cotton is carried by a current of air to the slowly revolving dust cage *G*, and at the same time evenly distributed over the surface. The interstices, between the wires of the cage, are sufficiently small to prevent the fibres from entering, but large enough to permit any impurities, as sand or dust yet adhering to the cotton, to enter; but this latter point is only of secondary consideration, since the cotton until now is pretty well cleansed of all impurities; so the point first alluded to, as to the collecting on its surface the cotton for forming the lap, is the main object to be accomplished. This lap is then removed by a pair of small fluted rollers *K*, which carry it to the compression rollers; when it passes to the lap-roller *M*, made of wood, upon which it is wound. The lap-roller rests upon two fluted rollers *L*, by contact with which the lap-roller is caused to revolve, and to wind up the cotton in a continuous sheet, until a thick roll, a *lap* is formed. To permit the lap to leave the dust cage readily, a shield *I*, is placed inside the cage, and opposite the two small drawing rollers *K*. This shield, fastened to a lever, is in turn balanced by weight *H*.

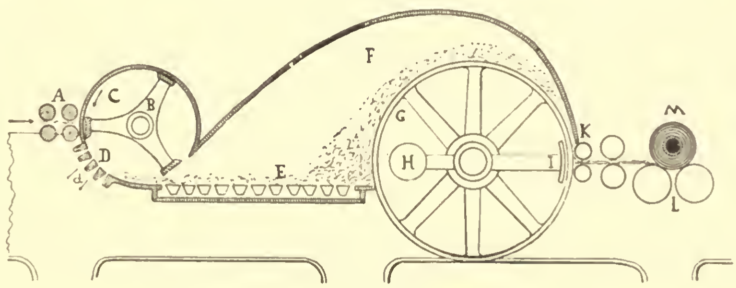

Fig. 41.

Finisher-Picker.—The laps on leaving the breaker-picker are weighed and forwarded to the finisher-picker, sometimes called finisher lap-machine where three to six of these laps are fed in at the same time. By thus combining three or more laps into a new lap any irregularity in either of the minor laps will be well balanced. The number of minor laps to be taken to form the new lap, when leaving the finisher lap-machine, is regulated by the weight of the latter required, as well as the weight of the minor laps used. The object of the finisher lap-machine is to produce a perfectly clean and even as possible sheet. Its working is the same as the first picker or scutcher, only that the different parts are arranged to work yet more perfectly. Fig. 42 illustrates, in perspective, such a finisher lap-machine. At the rear end of the machine the creel for holding the laps from the first picker (or scutcher) *A*, *B*, *C*, *D*, is clearly visible. All the laps as placed in the creel revolve by means of the lattice apron *E*, which revolves upon a roller at each extremity of the creel, and which thus delivers either a two, three, four, five, or six-fold sheet of cotton to the piano-feed arrangement, (see illustrations and explanations under this heading later on), which in turn delivers the two, three, or more fold sheet to the action of the beater placed in the beater case *F*, which has a grid in its bottom for the exit of any foreign impurities. From the beater case the cotton is passed over the longitudinal grid by the exhaust draught to the dust cages *G* and *H*. At *I*, the casing of the dust cages is glazed to permit inspection of the interior. The dust cages revolve slowly permitting the cotton to gather on their surface in the form of a sheet, which is then delivered to the compression rollers, from where it is wound upon the lap-roller in the front, *K*, or the head of the machine. The machine stops automatically when the lap is completed, which is then removed to make room for winding the next. From the finisher lap-machine, which is the last machine in the picking department, the laps are forwarded to the carding department.

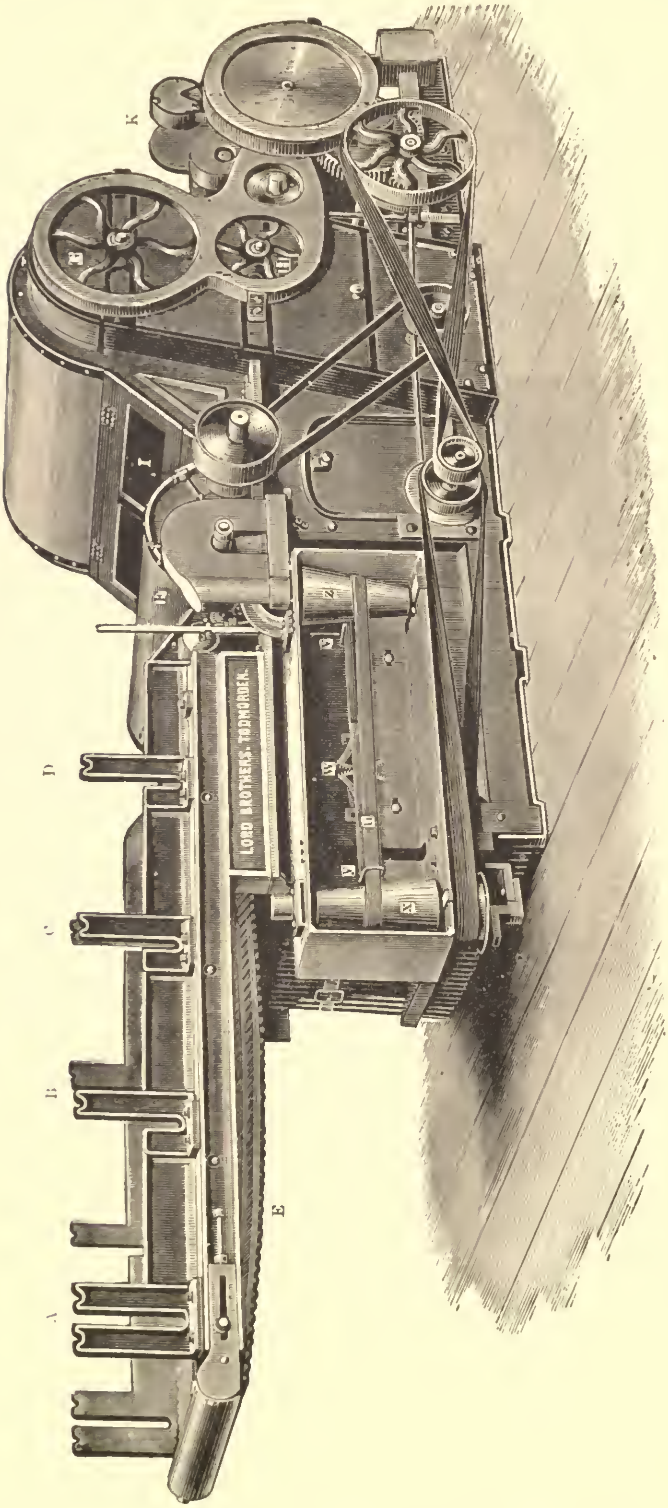

Fig. 42.

Piano Feed.—Also called Lord's Piano Feed, after the invention of this most ingenious method of regulating the feeding for either or all the different picking machinery so far explained. Illustrations in detail, Figs. 43, 44, and 45 are designed to illustrate the procedure. Fig. 43, section in detail; Fig. 44, rear view; Fig. 45, regulator. This feeding arrangement takes the place of the formerly used pair of fluted rollers, and has for its object to regulate automatically the supply for either machine, as will be seen by the following explanation. *a*, represents the common three-blade beater, (which may only contain two blades); *b*, the upper feed-roll revolving stationary in the frame of the machine; *c*, one of a series of bent levers extending across the frame. The short ends of these levers are occasionally slightly changed in their shape, and placed in the machine to suit the staple of the cotton to be worked. The ends of the longer levers terminate in a hook *d*, to which is attached a rod *g*. These rods increase in thickness at the bottom end, and are passed between two horizontal bars *e*, parallel to each other. Between the horizontal bars and the spaces between the rods small bowls *s*, are introduced. The rod situated at the right of diagram, Fig. 44, see *g'*, has a projection cast upon it, which forms with the other portion, a slot for the reception of a connecting rod attached to the levers, the second of which is connected with the strap lever *y*, seen between the cone drums in Fig. 45. Both strap levers, *y* and *v*, are geared together by means of sector wheels *w*, (see Fig. 42), while *x* and *z* in the same illustration, Fig. 42, as well as in Fig. 45, are cone drums, with *u*, the belt for transmitting motion. The method of operation of the feeder is thus: If any heavy spaces in the cotton (bulk or lap) by means of uneven feeding, go between the roller *b*, and the short part of the lever *c*, the latter is consequently pressed down, raising at the same time the longer part at *d*, pulling up the rod *g*, the thick end of which coming up between the bowls *s*, pressing the rods in the only direction they can move towards the slotted rod at the end, which through the connecting rod and levers previously described, moves the strap *u*, upon both cone drums, thus regulating the speed as required. Cone drum *z*, actuates the feed roller through worm *t* (see Fig. 45) on its shaft.

Carding.—Carding is the final stage of cleansing the cotton, as well as the process by means of which the fibres, which so far rest in all possible directions, crossways, against each other, are arranged side by side or parallel. Carding is the most important process in the entire system of cotton manufacture; in fact good carding is the backbone of good spinning or perfect yarn. Besides cleansing the cotton from all, either natural or foreign substances, all broken or nepped, as well as very short fibres, are also extracted during this process. Another purpose of carding is to distribute or change the heavy sheet of cotton forming the lap into a thin fleece, and contract this into a *ribbon* or *sliver* fitted for the next process. The final cleansing of the cotton from its natural foreign substances, not previously removed by means of cleaning, ginning, opening and picking, is accomplished by the rapid revolution of the cylinder and rollers working in connection with the former, and which, striking broken seeds, husks, dirt, or any other impurity, fix and retain the same in the teeth of their card clothing, from which they are removed by means of *stripping*. The short broken fibres, being of insufficient length to be held by the teeth of the card clothing, are ejected as *flyings*, or fall through the grating to the bottom.

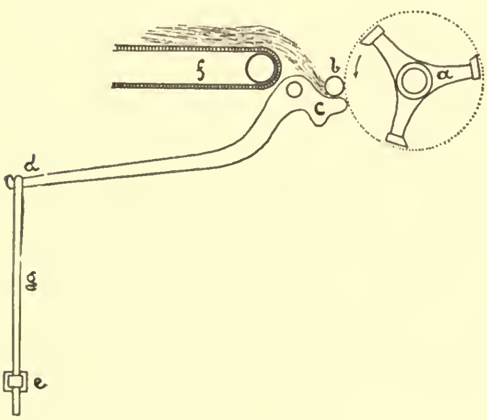

Fig. 43.

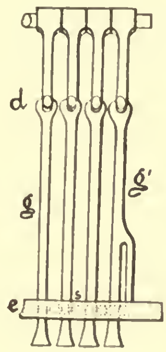

Fig. 44.

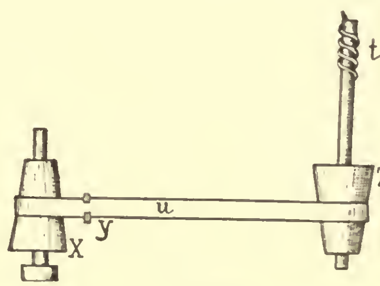

Fig. 45

Principle of Carding.—To illustrate the principle of the working of what is called card-clothing, diagram Figs. 46 and 47 are given. Card clothing consists of leather (see *a* and *d* in both illustrations) in which are inserted small staples of steel wire called *teeth*, and which have their projecting ends slightly bent in one direction, see diagram *I*, illustrating a pair of independent teeth; and *b* and *c*, in Figs. 46 and 47, showing the teeth set in the leather, forming the actual card clothing. The card clothing is fastened either to flat surfaces, wooden, or metal cylinders. The size of the steel teeth as used in the clothing are manifold, and are regulated according to the quality of raw material to be worked, as well as to the place or position they occupy in the carding engine; *i. e.*, the respective work they have to do, for the clothing with which the fibre, as fed in the engine from the lap, comes first in contact, has to perform harder or coarser work, compared to the clothing required at the last stage; *i. e.*, before the baird leaves the engine. The teeth for each different kind of card clothing must be uniform in size as well as set equal distances apart from each other. The teeth are adjusted in the leather, (which must be uniform in thickness) in pairs as shown in diagram *I*, and the leather must be pierced with twin ho'es at a distance apart from each other to correspond to those twin teeth, for otherwise the teeth would vary with the angle of inclination and the card clothing would be irregular on its working surface. The cotton to be carded is passed between the points of two sets of card clothing, and the method of operation with reference to our illustration is thus: In Fig. 46 the teeth are arranged, bent with their points in opposite directions, and if moving each clothing in the direction of its respective arrow (*a* and *d*) the tangled cotton as placed between the points will be seized by all the teeth, one set of teeth pulling them away from the other, or in the opposite direction. The procedure will divide the tuft of cotton, as placed between both sets of teeth, equally over both surfaces, at the same time disentangling the fibres from the tufts and place the same parallel. Fig. 47 illustrates two sets of clothing arranged with their points bent in the same direction. Having both sets of clothing filled with cotton, and moving only the lower set in the direction of the arrow *d*, all the cotton from the upper set will comb itself, (or is transferred) to the lower; again, if we keep the lower set stationary and move the upper, in the direction of arrow *a*, all the cotton will be transferred upon this set of teeth. Upon these two operations as explained and illustrated by Figs. 46 and 47 is based the entire system of carding cotton, as well as any other raw material—spun silk, tow, wool, etc.

Card Teeth.—Steel in place of iron wire is now generally used for card teeth, since the former permits a finer drawing, giving a greater number of points per square inch, carries a finer point, keeps sharp longer, requires less grinding and consequently increases production, besides producing better work. The wires should be kept clean, the points sharp, and set as close as possible to each other without touching. To illustrate the mode of making good card teeth, Figs. 48 and 49 are given. Fig. 48 is an enlarged view of a staple as it would appear before the grinding operation. Fig. 49 represents the staple after the grinding operation. In Fig. 48 the two limbs of the staple which are to constitute two dents of the card, are flattened at the back and front from about the bend at *a* to the

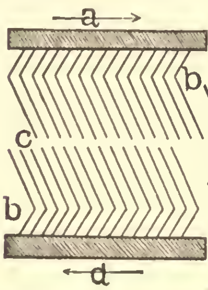

FIG. 46.

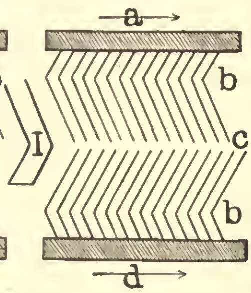

FIG. 47.

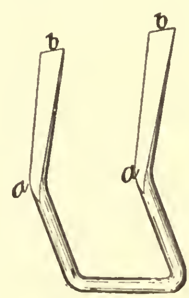

FIG. 48.

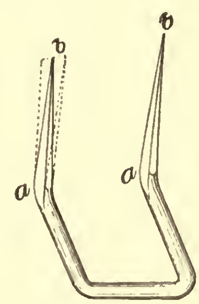

FIG. 49.

point *b*. This flattening is obtained by flattening the wire at the required places before it is bent into a staple, using pressing dies or rollers which act simultaneously with other ordinary parts of the card-setting machine employed for the purpose, but the staple thus formed has the flat places situated on the inside and outside of the limbs of the staple, instead of at the back and front, or in other words the flat places are at right angles to the flat places appearing in Fig. 49. This flattening of the sides of the dents, while increasing the clearance, has also the effect of increasing the breadth of the dent in the direction of its working movement, so that when ground ready for use, the points *b*, of the dents are chisel-shaped, or resemble the ends of knives rather than the points of needles. When the dents, flattened in the manner indicated in Fig. 48, are ground at the sides, the dents will have the form indicated in Fig. 49, each dent tapering at the back and front and at the two sides from *a* to *b*, or in other words the dents have four-sided tapering or pyramidal points, (technically called diamond points). The grinding of the sides of the dents is effected by means of revolving emery wheels or grinders, (of which a detailed explanation with illustrations is given later in a special chapter on grinding) which penetrate between the rows of dents. In Fig. 49, the metal removed in the grinding operation, is indicated on one side of the staple by dotted lines. Such dents or teeth when sharpened in the ordinary manner take very keen points.

Carding Engines.—Among the different makes of carding engines in use we find the *roller card*, the *revolving flat card*, the *top flat card*, and the *combination cards*.

The Roller Card.—This machine is illustrated in diagram Fig. 50, and is used mostly for low counts of yarn. Letters of reference in the illustration indicate as follows: *A*, the frame; *B*, the feed-rollers; *C*, the lap as produced on the lap attachment of the finisher-picker and which is now delivered to the previously mentioned feed-rollers, which move at a surface speed of from eight to twelve inches per minute. From the feed-rollers the cotton is delivered to the *licker-in D*, which runs at an average surface speed of 800 feet per minute. From the licker-in the cotton is taken away by the main cylinder or *swift E*, by means of double the surface speed of the latter (1,600 feet average surface speed

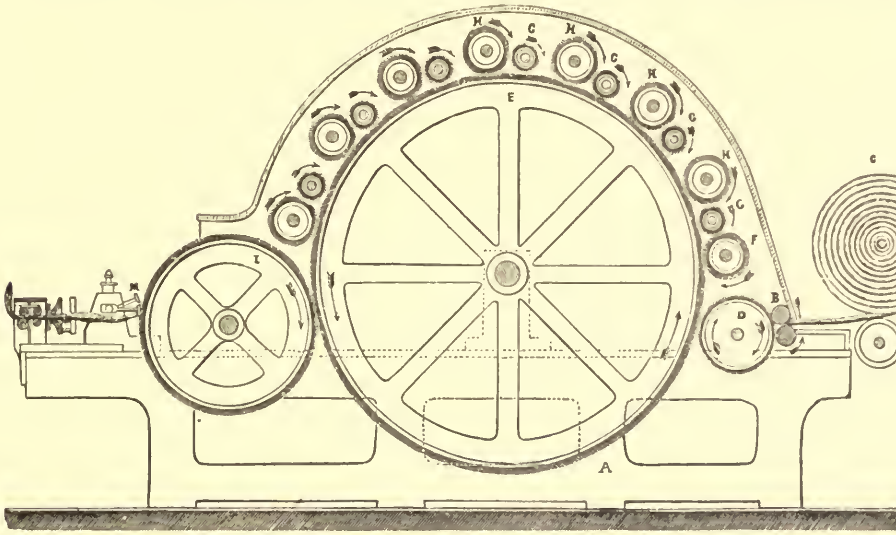

Fig. 50.

for main cylinder). From there the cotton passes next in contact with *dirt-roller F*, (average surface speed sixteen feet per minute) previous to being passed by the main cylinder to the *worker H*, which has a correspondingly smaller roller *G*, called a *clearer*, for its companion. The clothing of the worker is arranged inclined, the reverse of that of the main cylinder, hence by this means, as well as the comparatively slower speed (twenty feet surface speed per minute) the worker takes a portion of the tangled cotton from the main cylinder, and carries it to the clearer which runs at a higher speed (about 400 feet surface speed per minute), and having its teeth inclined in the direction of its motion (*i. e.*, the same direction as those of the main cylinder), strips the worker and returns the cotton to the main cylinder. Diagram, Fig. 51, is given to illustrate more clearly the workings of a worker and a clearer in connection with a swift. The cotton is successively carried from one pair of workers to the next, each one only taking hold of portions of the tangled cotton, until after being thoroughly straightened or carded, the same arrives at the *doffer I*, which also acts powerfully with regard to carding, by means of having its teeth set in the same direction as the workers. The average surface speed of the doffer is seventy feet per minute. The doffer then carries the fleece of the cotton about half way around itself, until reaching the *doffer-comb M*, which strips the thin fleece over a guide-plate, and passes the same through the trumpet shaped tube, where it is formed into the round untwisted sliver, and which is delivered coiled in the *sliver-can* or to the *railway-head*. The cotton which has been fed into the carding engine from the lap in its most tangled state, is now formed in a sliver having the fibres resting more parallel to each other.

Fig. 51.

Revolving Flat Carding Engine.—The principle of this method of carding, which on account of less expense, as well as better work produced, is superior to the previously explained method, is illustrated in its principle in Fig. 52. Letters of reference in illustration indicate as follows: The lap is put in the frame in front of the carding engine and its end passed under the feed-rollers *a*, and the machine started. The roller holding the lap slowly revolves, unrolling at the same time the fleece from the lap, which, by means of an endless apron, is conveyed to the feeding-rollers which carry it within reach of the *licker-in b*, running at a surface speed of about 800 feet per minute, which reaches the cotton in a downward direction from the feeding-rollers, and by its revolution carries the same to the main cylinder or *swift c*, which revolves at about 1600 feet surface speed, per minute, and in the opposite direction from the licker-in. The main cylinder, having about twice the surface speed compared to the licker-in, and owing to the position of the teeth in the clothing, receives and takes away the fleece of fibres from the latter. The upper part of the main cylinder is surrounded by the *flats d*, which are in the machine arranged in the form of an endless lattice. Such of the flats as are engaged in work rest upon semi-circular guide rollers fastened to the tops of the sides of the frame, and such of the flats as are not in action are arranged to travel over carrier-rollers, until in turn they come again face downwards or towards the main cylinder ready for work. The card clothing of the flats and of the main cylinder is of such an arrangement that the upper or end parts of the card-teeth, coming the nearest in contact toward each other, would form a straight line if sufficiently extended. The series of flats are operated in a slow, (about one inch, surface speed, per minute), traverse motion, As previously mentioned the cotton is delivered from the licker-in *b*, to the main cylinder *c*. When reaching or coming in contact with the card teeth of the flats the latter will (by means of its slow motion), take hold of the cotton fibres resting upon the surface of the main cylinder, and continually straighten out the fibres in a parallel position, in the direction of the revolution of the main cylinder, which is the chief object of the whole procedure of carding. The flats, after leaving the periphery of the main cylinder, move in turn against a stripping roller, which clears from them any accumulation of dirt. After the cotton has passed all the flats, the same is carried to the *doffer e*, whose card-clothing is arranged similar to the main cylinder, but has an opposite direction of revolution compared to the latter. The surface speed of the doffer is from 65 to 70 feet per minute, hence the main cylinder, in consequence of its higher speed, will deposit the cotton upon it. The doffer in turn carries the cotton half way round its surface where the film is combed off, (similar to previously explained carding engine), by the action of the doffer-comb fitted upon vibrating arms. The doffer-comb strips the doffer-cylinder during descending, and cleans itself when ascending, its motion being from 700 to 1000 strokes per minute, which can be regulated to suit the quality and counts of the yarn. The film of cotton being combed off the doffer-cylinder by its comb, is next passed over a guide plate and through a trumpet-shaped tube, in which it is transformed in a round, untwisted sliver, which, in its turn, by passing between the compression-rollers of the draw-box, is flattened into a ribbon, next either passed to the coiler and coiled in a *sliver-can* standing upon a revolving-plate, or conveyed by the sliver-trough to the *railway-head*. Examining illustration Fig. 52 we see the section of two other cylinders marked *f* and *g*. The larger cylinder (*f*), has the name *fancy*, and is covered with a longer and more elastic clothing than is used for the other cylinders, besides this, it is situated very close to the main cylinder, in fact its teeth extend some way into the clothing of the latter. The doffer cylinder, *e*, will receive only such of the fibres of the film as are situated in the top of the card clothing of the main cylinder, and such of the fibres as entered deeper in the clothing must be raised for future work, since otherwise the main cylinder would get filled up or clogged and unfit for good work. To raise those fibres is the object of the fancy. Some of those fibres get raised upon the circumference of the main cylinder, whereas others will be taken up

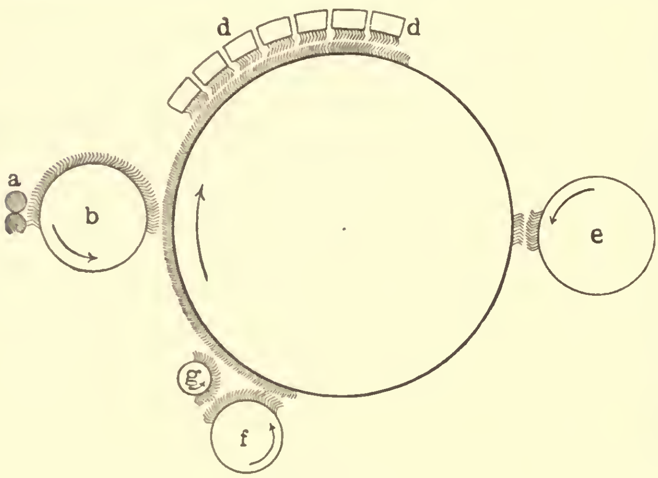

Fig. 52.

by the fancy upon its own clothing, and from there delivered to its *clearer g*, which delivers it to the main cylinder, ready to be worked again by the flats and successively taken off by the doffer. The work of the fancy is accomplished not only by its longer clothing, as previously alluded to, but also assisted by means of greater surface speed compared to the main cylinder. For the same reason the clearer *g*, moving slower than the fancy and the main cylinder, will take up the film from the fancy and deposit it on the main cylinder. In some machines the fancy is situated above (or before the film reaches), the doffer. In this instance the fibres must be sufficiently loosened so that the doffer can get all. In some cases it is omitted, but if so, a more frequent cleaning of the card clothing (stripping) is required. Fig. 53 illustrates in perspective the revolving flat carding engine as built by the Pettee Machine Company. This card is capable of carding for either high or low count yarn besides being also ahead in amount of production compared to the roller card, since the flats do not have to be taken off to be ground, as is the case with workers and clearers in the roller card. In the

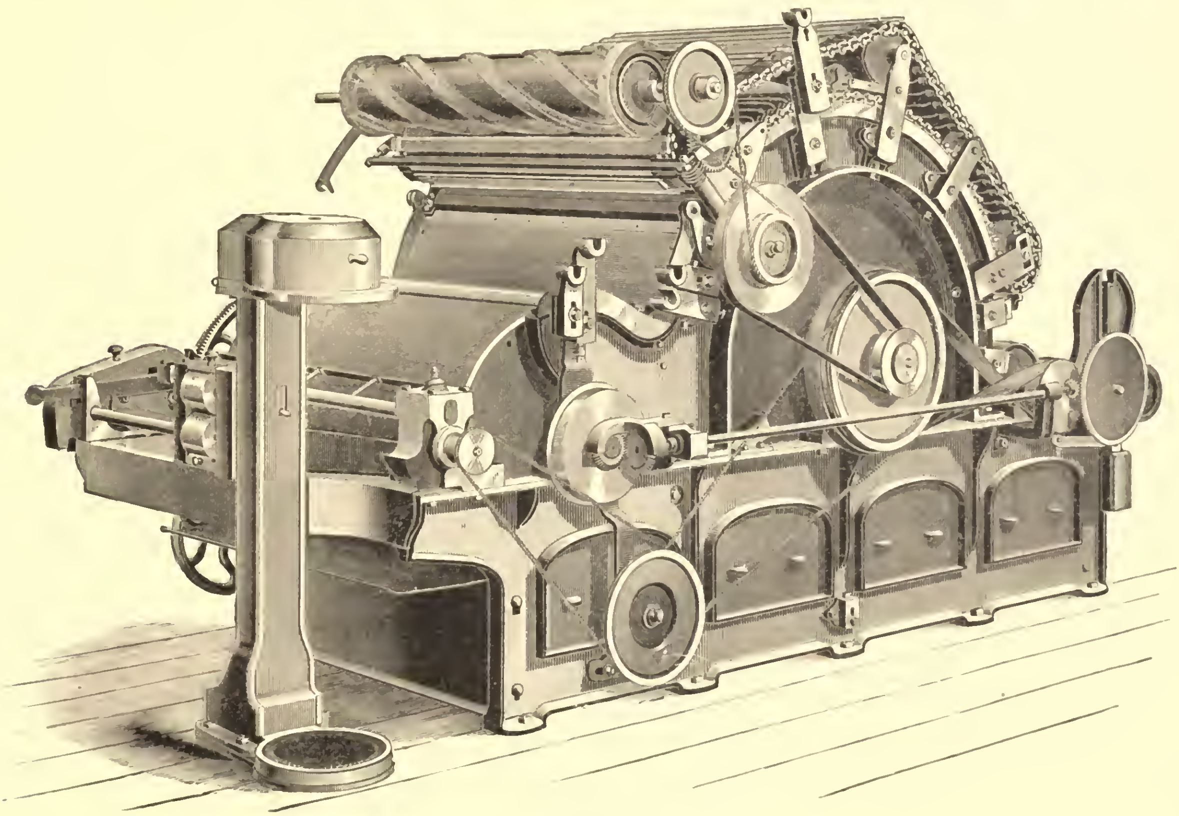

Fig 53.

revolving flat card the flats are stripped automatically on the machine during its working time, whereas in the roller card workers and clearers, and, in addition, a heavy wooden cover situated over the same, must be taken off the machine for stripping, during which time, (cleaning workers and clearers) the carding engine must be stopped. Fig. 54 illustrates the revolving flat carding engine as built by Howard & Bullough, and which closely resembles the previosly explained machine. A special feature of these machines are their *adjusting or setting arrangements*, of which one, (the others being exact duplicates) is illustrated in its details in Figs. 55 and 56. Fig. 55 shows the sectional view, and Fig. 56 the front view. Letters of reference indicate as follows: *A*, is adjusting screw on which is dial, *D*. *B*, is rigid conical bend. *C*, is flexible conical bend. *D*, is graduated adjusting dial. *E*, is pointing finger by which dial is set. The method of setting the flats by this arrangement is as follows: As the screw *A*, is worked one way or the other it moves the rigid cone *B*, in or out, thereby raising or lowering the corresponding flexible cone *C*. As the flats rest on the turned face of the flexible cone *C*, they are raised or lowered with it. One end of screw *A*, is the graduated adjusting dial *D*, each division of which raises or lowers the flexible cone *C*, and flats resting on it one thousanth part of an inch. Thus the adjustment of the flats to the cylinder is rendered easy and certain, as the dial is in full view of the carder, and the pointing finger *E*, tells him exactly how much he has lowered or raised the flats. Having adjusted the flats correctly at any one point, he has only to notice the figure to which the finger points on the dial, and set the rest of the dials so that the fingers point to the same figure. Each dial is made immovable after setting by simply tightening a check-nut.

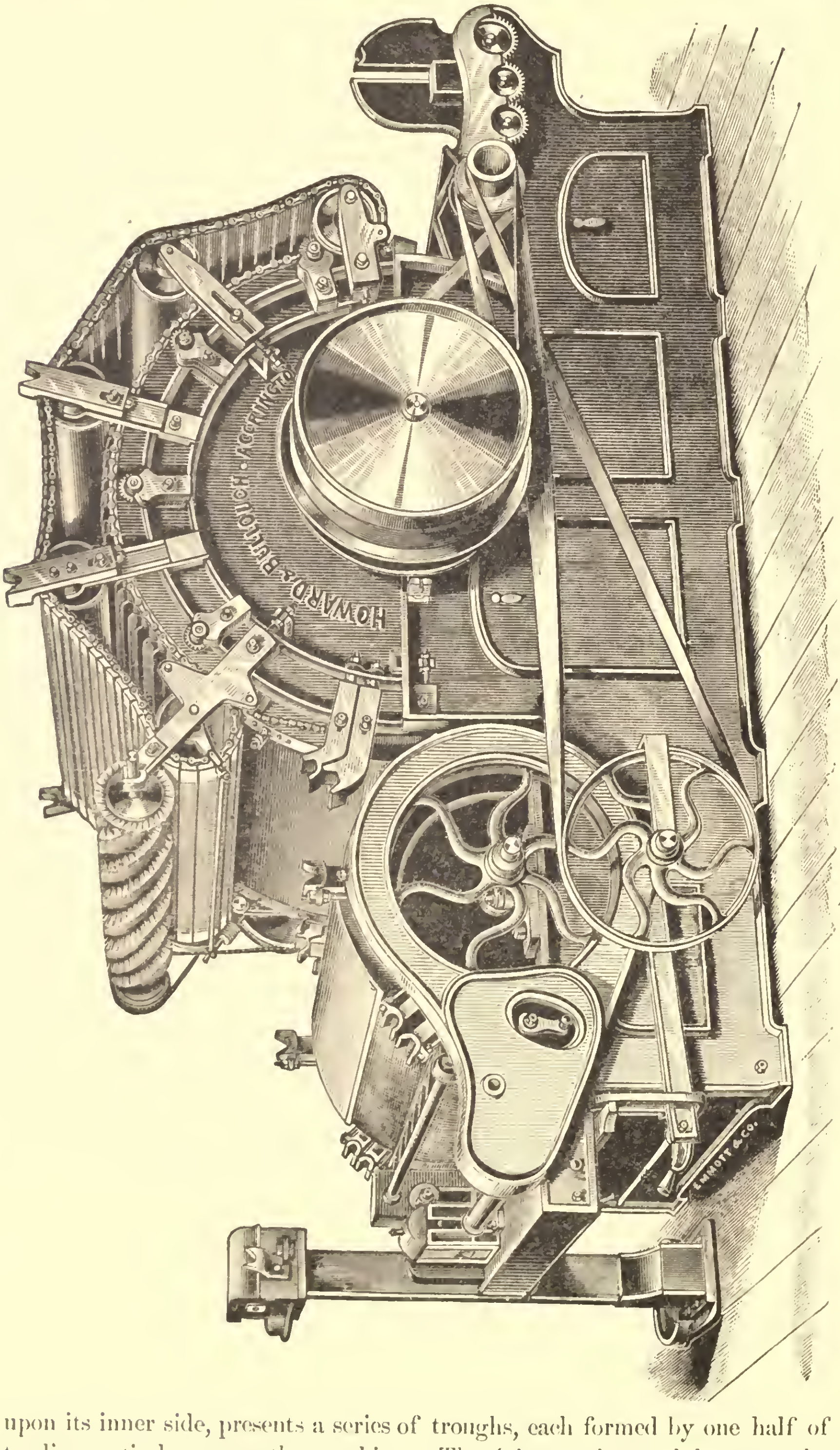

Fig. 54.

Revolving Flat Clearer for Revolving Flat Cards.—This is a device lately brought into the market by the Pettee Machine Works for cleaning the flats as they revolve over the cylinder. It is named after the inventor, the *Whitten Flat Clearer*. As previously mentioned the endless chain of flats is supported upon suitable driving and supporting rollers at the upper part of the carding engine. Each flat, upon its inner side, is provided with a central longitudinal stiffening frame or rib, so that the series of flats making up the endless chain, when viewed upon its inner side, presents a series of troughs, each formed by one half of two adjacent flats and extending entirely across the machine. The joint or interval between the adjacent flats, required to permit the bend called for in passing over the carrying-rollers of the endless chain, allows the loose cotton, dust, etc., arising from the operation of carding to pass into the interior of this endless chain.

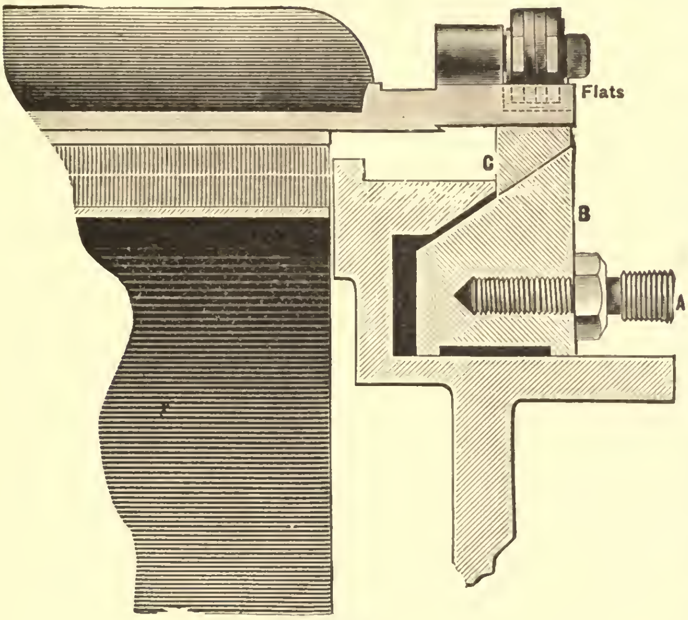

FIG. 55.

It there collects and gradually increases until it interferes with the operation of the machine and must be removed. Heretofore this has been done by means of a piece of hooked wire in the hands of a workman, with which he hooked or drew out of the machine as much of the collected lint or dirt as may be. This operation not only involved the stoppage of the carding engine for a considerable time, but was clumsy and rather inefficient. The new clearer has for its object the doing of this work automatically and without stopping the machine. It collects all the dust and flyings which gather on the flats, hence improves the quality of work, decreasing at the same time the amount of waste. Fig. 57 is given to illustrate this clearer in its perspective view, with such parts of the flats shown broken away as are necessary to illustrate the device and its working method. This cleaner (or brush) when in its place in the machine within the series of flats, will, as the chain of flats passes along under the series of brushes, permit one of them to drop into the trough, and in so doing wipe or clean that side of the rib past which the brush enters the trough. The continued sidewise motion of the flats cleans the bottom of the trough by carrying it sidewise past the brush, and finally the brush passes upwardly out of the trough and along the side of the next rib, thereby cleaning that, which forms the remaining portion of the trough. At the same time the brush being free to rotate on its own axis, is continually presenting a fresh surface to perform the cleaning operation; and furthermore, as one brush is about to leave the trough, having been cleaned by it, another brush is entering the next trough to clean it, the motion of the brushes toward and away from the central shaft, as before mentioned, allowing them to pass easily into and out of the successive troughs. The different sections of the cleaner may readily be cleansed when necessary by removing from the machine the

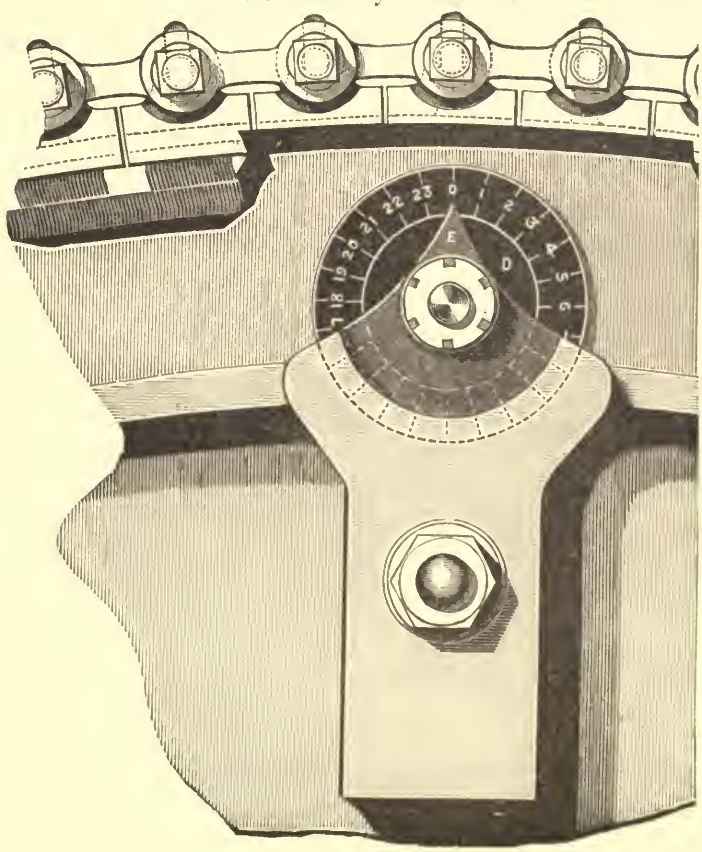

FIG. 56.

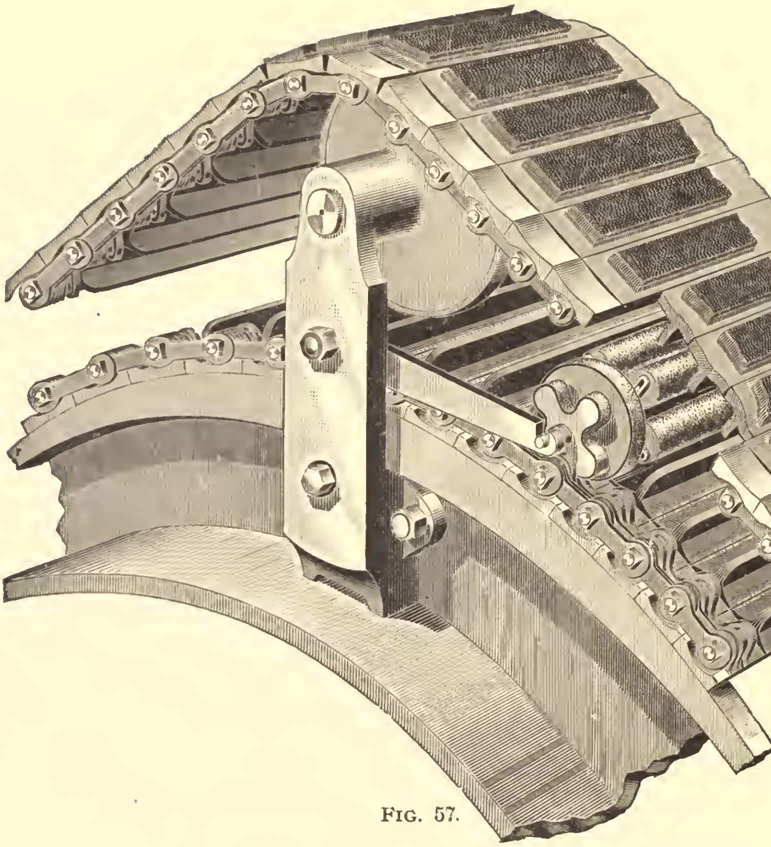

FIG. 57.

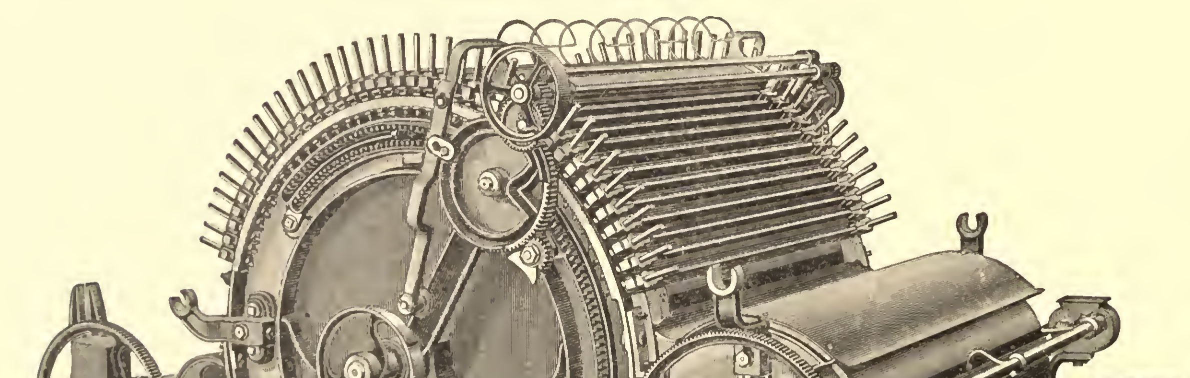

FIG 58.

shaft to which they are connected and taking from them the accumulated dust, fibre, etc. Another system of carding engines much in use in this country is the

Top Flat Card.—A specimen of this system of carding engines is shown in its perspective view with its flats removed, in Fig. 58 (built by the Lowell Machine Shop). The same is modelled from the Wellman Top Flat Card, but, taken altogether, is a different machine in many of its characteristics and superior to the card after which it has been modelled. The construction of the machine is as follows: Over the main cylinder are fitted, in adjustable brackets, a series of flats which are bent concentrical on their working surface so as to suit the main cylinder. The long arm extending upwards to the flats and moving around the main cylinder shaft, moves in both directions over all the flats, and carries at its extreme end the flat lifting and stripping apparatus, by means of which the flats are lifted from their respective brackets, and turned upwards with their face exposed to the action of the stripper-

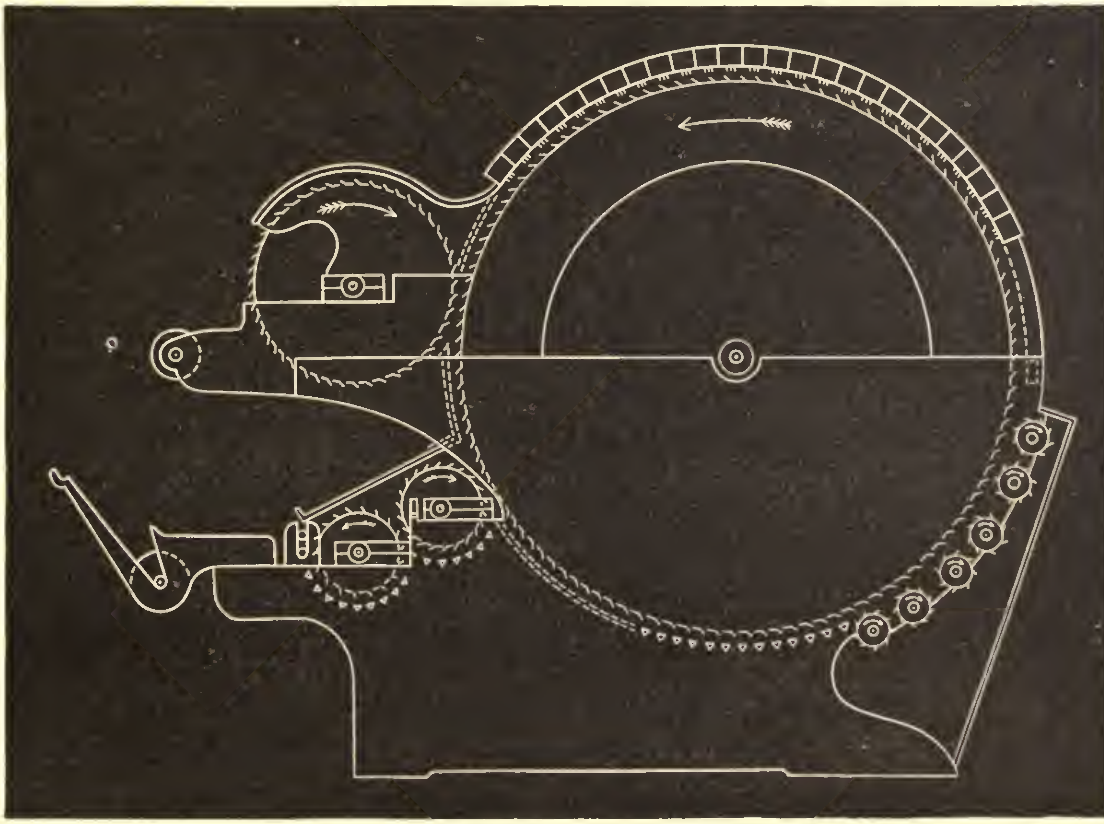

Fig. 59.

roller, which cleans the same and then restores them automatically to their proper place. In this manner one of the flats is cleaned after the other. This carding engine is also provided with the *Fall's Patent Double Rack,* which permits the stripper to go over the first half of the flats situated towards the licker-in twice, before cleaning the others as situated nearest to the doffer. This is a great help to the carder, since those flats nearest to the licker-in have to do the most work, and thus receive more impurities, as well as short fibres clogged in their clothing. The brackets extending from the frame out the machine toward the lap-holder and over the licker-in are for the reception of the grinding-roller for grinding the cylinder, and the brackets extending from the frame of the machine over the doffer are for the reception of the grinding-roller for grinding the doffer; hence both the cylinder as well as the doffer are ground without removing either out of its place. The flats are either of wood or iron; if using wood they are made of two pieces of pine, thoroughly seasoned and veneered on top with cherry. The card clothing is secured by a process avoiding the use of rivets, and which forms a continuous fastening at the edge of the clothing, and consequently can be ground on any ordinary grinder. The cotton in passing from the leader to the cylinder goes under a steel back-plate which fills up the space, is circular in shape, and adjustable in all directions, and can easily be removed and replaced without disturbing the adjustment. The space between the last flat and doffer is also closed up by a similar steel plate and equally adjustable. The cotton is removed from the doffer by a comb and delivered to calendar rolls and trumpet similar as in previously explained carding engines.

The Combination Card.—This is another form of a carding engine, and, as the name indicates, is a combination of the top flat card and the roller card. To illustrate this card, Figs. 59, 60, and 61 are given, representing the carding engine known as the *Pettee Combination Card.* Fig. 59 illustrates the diagram of the machine, on the top of which 26 flats are placed, where the workers and their com-

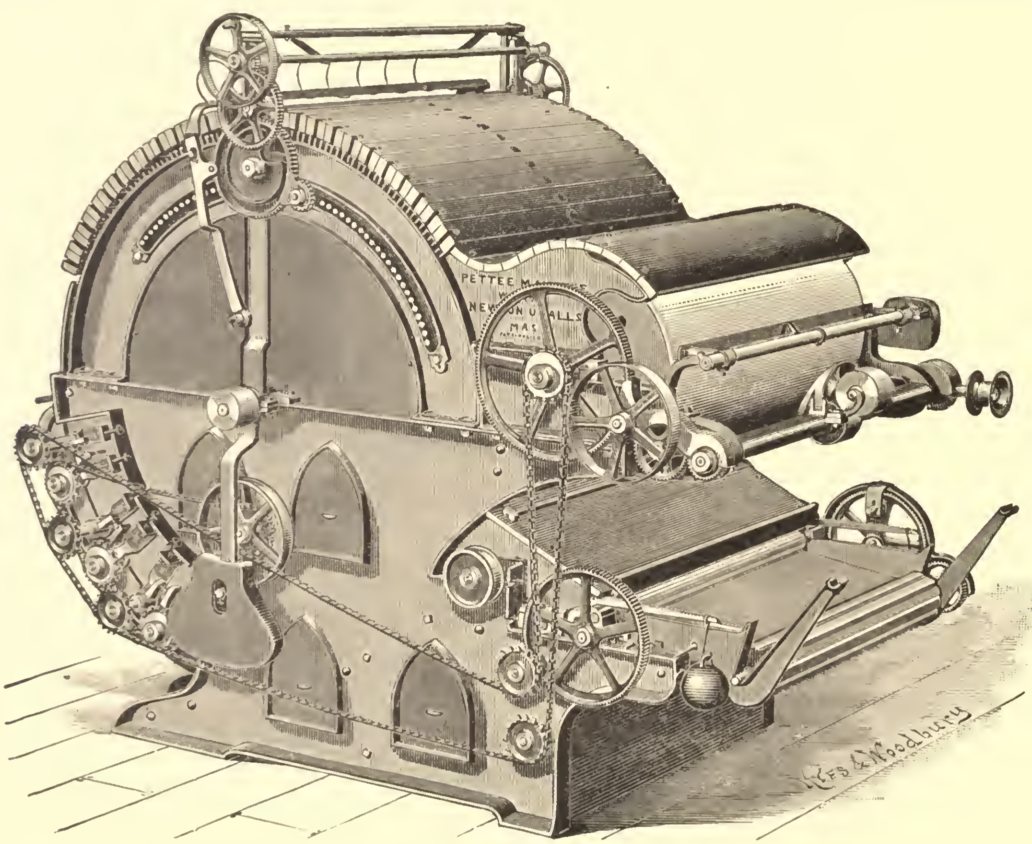

Fig. 60

panions, the cleaners, three of each, are shown in the lower back part of the machine. The doffer cylinder is found in this machine, on the same side and above where the lap is placed. Arrows in licker-in, workers, clearers, cylinder, and doffer, indicate their direction of motion, and as this card is only a combination of the top flat card and the roller card, no special explanation of the working of the different parts is necessary. Similar to the top flat card, the flats of this combination card are cleaned automatically by means of a stripper. The same is clearly visible in both of the perspective views (front and back) given in Figs. 60 and 61.

Double Carding Engines.—These are, nothing else but a combination of either of the previously explained single cards; either two machines of one system, or two machines, each of a different system united.

Amongst the most frequently used combinations we find:

Double carding engines, composed of *two roller cards.*

Double carding engines, composed of *two revolving flat cards.*

Double carding engines, composed of *one roller* and *one flat card.*

Consequently, in a double carding engine of either build are two main cylinders, the first being stripped by a doffer cylinder (termed *slow tumbler*), which in turn has the cotton taken from its surface by means of a clearer, and which transfers the baird to the second main cylinder. No doubt a double carding engine may be a saving to some extent in labor for the manufacturer, yet the item, if any, is very little, and the work produced will not be as perfect as if two single cards were used; therefore they are used very little in our own country, but extensively in some of the cotton manufacturing districts of England and other European countries.

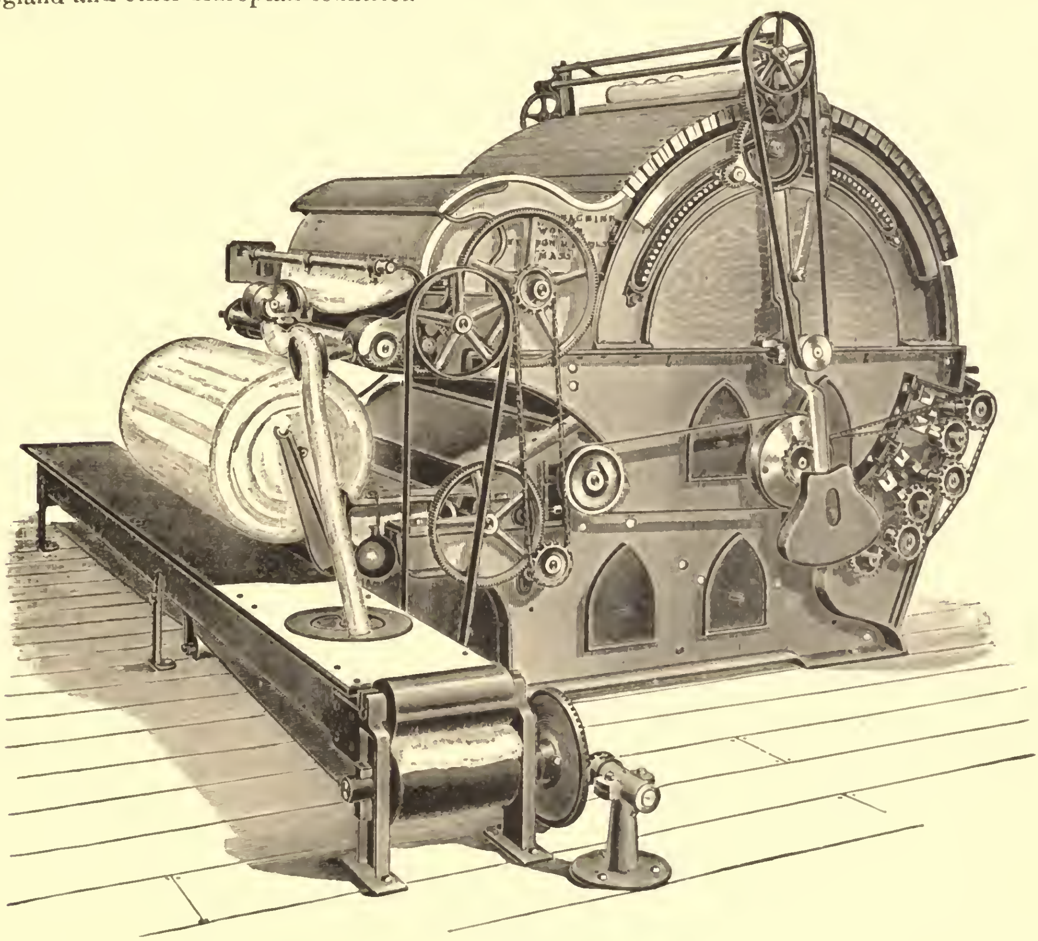

Fig 61.

Breaker and Finisher Cards.—For the common grade of cotton yarns the cotton is only put through one carding engine, but for the better grades two machines are brought into requisition. If so the first card is termed *breaker* and the second, *finisher* card.

Lap-Winder.—The sliver on leaving the breaker card is made into a lap on the lap winder, of which we give a perspective view in Fig. 62. This machine is arranged for self doffing, and will wind a compact lap weighing from thirty to forty pounds. The same can be used to wind laps from two lines of cards, or can be arranged in connection with a carrying frame, to make a lap from slivers coming from four or more lines of cards. The lap as made on this machine is then forwarded to the finisher card. Sometimes one carding engine is used for both cardings, but this method is inferior to that of using special cards for the first and second cardings, since the card clothing of the second or

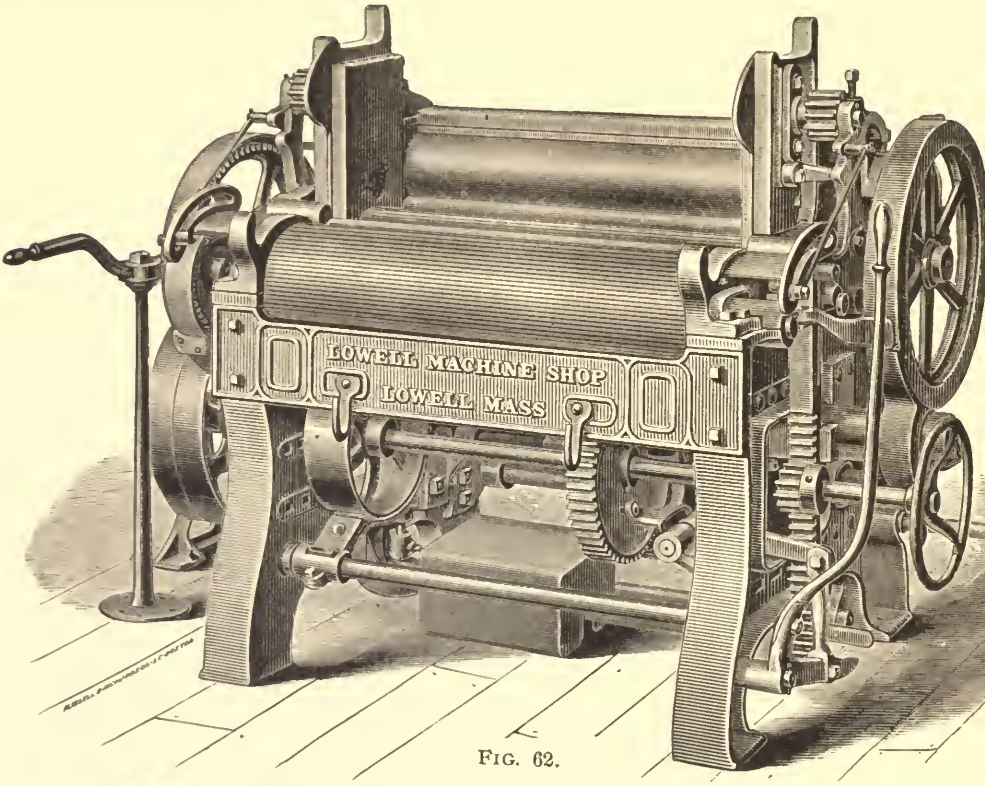

Fig. 62.

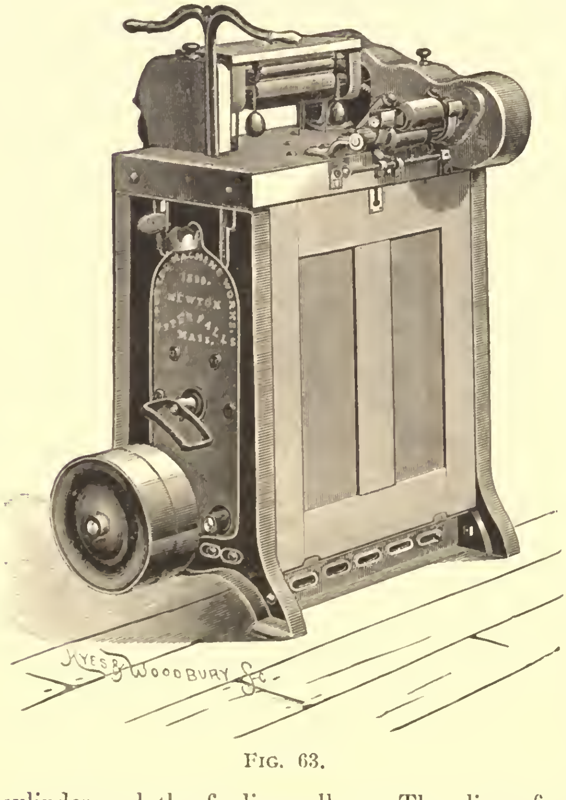

Fig. 63.

finisher card must always be finer than that used for first or breaker cards. Either one of the three (previously explained) principles of cards may be used for breaker and finisher. If using two kinds use the roller for breaker and top flat for finisher; or roller for breaker and revolving top flat for finisher; or top flat for breaker and revolving flat for finisher.

Railway-Head.—The purpose of this machine is to collect and double a number of card slivers, thus bringing them into a convenient form for the next machine. The number of carding engines put in a section must be in proportion to the railway-head draft and hank carding. The railway-head by means of its working also straightens out the fibres composing the sliver and must have a low draft regulated by the amount and quality of carding done; *i. e.*, mixed up position of the fibres in the sliver, since the more the fibres are entangled, the more difficult it will be found to draw the same. Every carding engine in a section is connected with the railway-head by a shaft which drives the doffer-cylinder and the feeding-rollers. The sliver from the card is conveyed to the railway-head by the *sliver-trough,* which extends throughout the entire length of the section, situated under the *calender-rolls.* The bottom of this sliver-trough consists of an endless belt, which collects all the card-slivers as it passes each carding engine in the section, and which in turn delivers them to the back-rolls of the railway-head. It will be readily seen that the *calender-rolls* of the cards in each section, *the sliver-belt,* and the *back-rolls* of the railway-head, must have corresponding surface velocity so as to prevent the slivers from sagging down or breaking, either point causing bad work. Fig. 63 shows in perspective the railway-head as built by the Pettee Machine Works.

A special feature of the modern railway-head is the *evening or regulating mechanism,* consisting of a pair of cones which drive the front-roll at a speed in proportion to the bulk of sliver passing the trumpet. Fig. 64, representing the Evans Friction Cone Company's railway-head is given to illustrate in detail our explanations; in the same, all the pull of cotton in the trumpets acts directly upon the arm *F,* which reverses the motion of pulley *C,* and screw *J.* Arm *F,* is so weighted that pulley *C,* will remain idle when the trumpet is at the medium or balancing point, half way between the maximum and minimum pull of cotton. This position can be maintained, when cotton flows even, by perfectly balancing with weights. In this case the trumpet stands in position to work reversely, according to the variation of the cotton. The slightest movement of the trumpet gives the friction-belt *H,* a quick jump to the proper diameter for the speed called for by the quantity of cotton drawn into the trumpet; for when the sliver comes heavy as soon as it strikes the trumpet, the extra bulk of sliver coming through the small end of the trumpet pulls it forward, whereas when the sliver comes in light, everything reverses by the trumpet falling back.

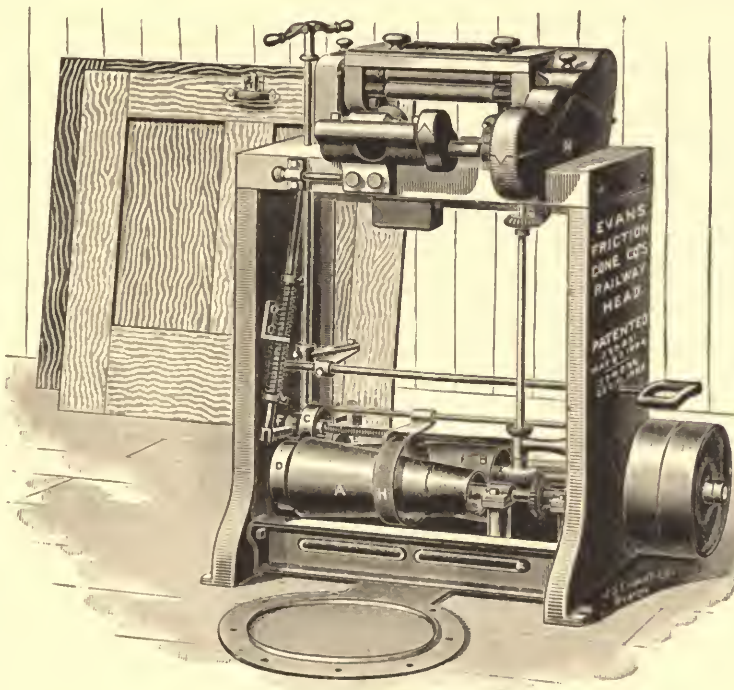

FIG. 64.

Card Clothing Mounting Machine.—It is of the greatest importance that all the cylinders in a carding engine are covered perfectly *true* with their clothing, so as to produce good work. To insure this, the clothing of cylinders is now done automatically by specially constructed card clothing mounting machines. A specimen of such a machine is shown in Fig. 65, representing Dornsfield's Patent Card-Mounting Machine, with Whiteley's Patent Tension Apparatus. The use of such a machine saves much labor, since half the number of men can put on the same amount of *fillets* at the same time as by the old *hand process,* besides producing with the use of the machine a uniform tension throughout entire lengths of fillets. Referring to letters of reference in illustration we find the slide-rest *K,* is fixed on the frame work of the carding engine, opposite the cylinder to be covered. Travelling on this is the tension apparatus, which can be moved to the right or left, either by hand when required by handle *M,* or as the fillet is being wound on by the chain, which turns pulley *L,* actuating the screw running through the length of the rest. The speed of traverse of the tension apparatus is adjusted to the various widths of fillets by change wheels. The rotating of the cylinder to be covered, and driving of the mounting machine are accomplished by turning handle of the jack Numbers used in illustration for reference indicate as follows: 1, carriage moving on planed bed; 2, cradle hinged to carriage; 3, barrel fixed on cradle, the former being quite smooth to prevent injury to card clothing; 4, trough for fillet; 5, hand-screw and regulating-spring; 6, presser plate; 7, tension spring, which is accurately adjusted, and remains at rest when the apparatus is not in use; 8, index showing tension of fillet in pounds; 9, index finger.

The apparatus is used as follows: The *card-fillet* should be carefully unpacked and put in a basket, in such a way that it will come out regularly and without twisting when drawn up to the mounting machine. In putting the fillets into the basket, see that all the teeth are pushed up to the foundation, so that when passing through mounting machine none of them will project; next pass the fillet, teeth upwards, through the trough 4, and around the barrel 3, and make its end fast to the cylinder to be covered. Then slowly turn the handle actuating the winding-on gear, and, as the cylinder begins to

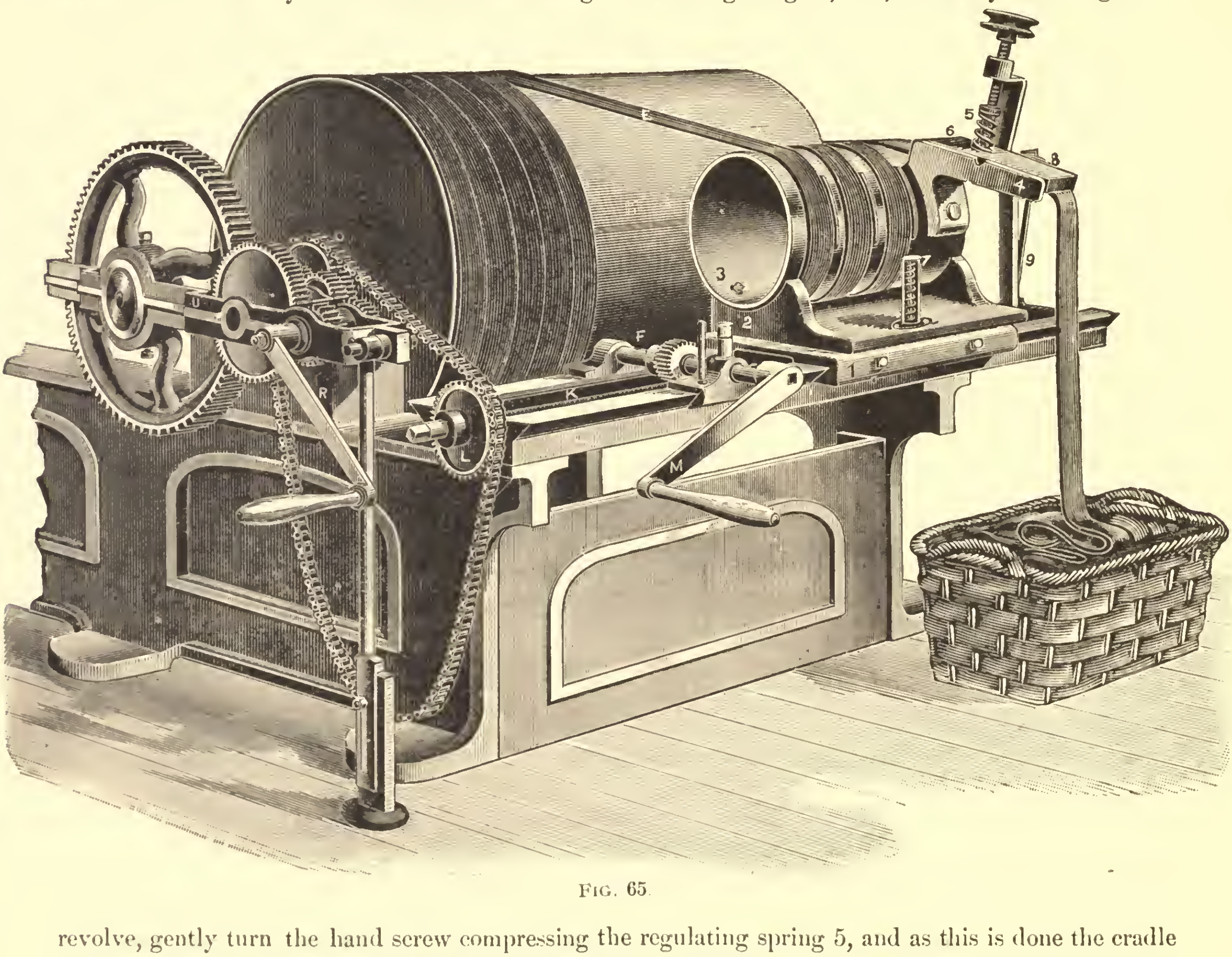

Fig. 65.

revolve, gently turn the hand screw compressing the regulating spring 5, and as this is done the cradle 2, will gradually be raised against the tension spring 7, which it compresses slightly. Continue slowly turning the hand screw 5, until the index finger 9, points to the desired tension on the index 8, and, as the fillet is passing through the trough 4, by adjusting the hand screw 5, so as to keep the index finger 9, pointing to the same place, the fillet will be put on with uniformity of tension from end to end.

Grinding.—For producing perfect work, good grinding of cards is of the greatest importance to a carder. Grinding of the clothing of the carding engine has for its object the keeping of the wires sharp and free from turning up at the points; *i. e.*, forming hooks. The first grinding of a newly covered carding engine is done in order to take out the inequalities remaining even after the most careful setting and covering up of a carding engine, besides producing the previously referred to sharp point. The grinding should not be done to excess, too fast nor too slow, for when grinding to excess, the clothing will be unreasonably worn down; if grinding too fast, the proper sharp point will not be obtained; and if too slow, time will be wasted uselessly. There are three methods for grinding in use: First—grinding with a *Grinding-roller* about eight to nine inches diameter covered with coarse emery and extending across the face of the cylinder, rollers or tops. This method of grinding produces poor results as the abrading action of the grinding roller is always brought more or less to bear upon the back of the card tooth, producing a wide, flat point similar to a fine chisel, from this fact it derived its technical term, *chisel-point*. This imperfection can be remedied to some extent by giving the grinding roller a short lateral transverse motion. Second—grinding with the *Traverse Emery Wheel Card Grinder*, an illustration of which is given in Fig. 66, and which is far superior to the above method. As the illustration clearly indicates, the grinding is done by means of a small drum or pulley, covered with emery, which is made to traverse to and fro across the card clothing surface by means of a double threaded screw placed inside the hollow shaft on which it moves. By this method the point to the wires is produced from three sides; *i. e.*, on back similar as the previously explained large grinder, and next on both sides by means of its to and fro traverse motion across the surface of the card clothing. It thus grinds all except the quarter part of each wire which forms the front and which it cannot touch.

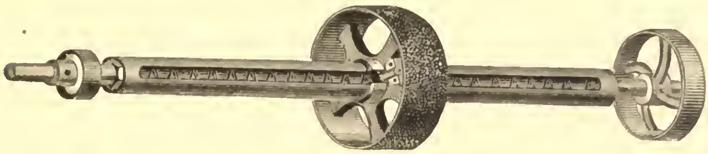

Fig. 66.

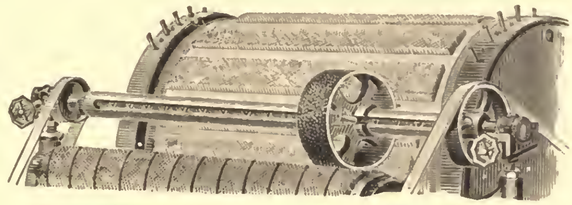

Fig. 67.

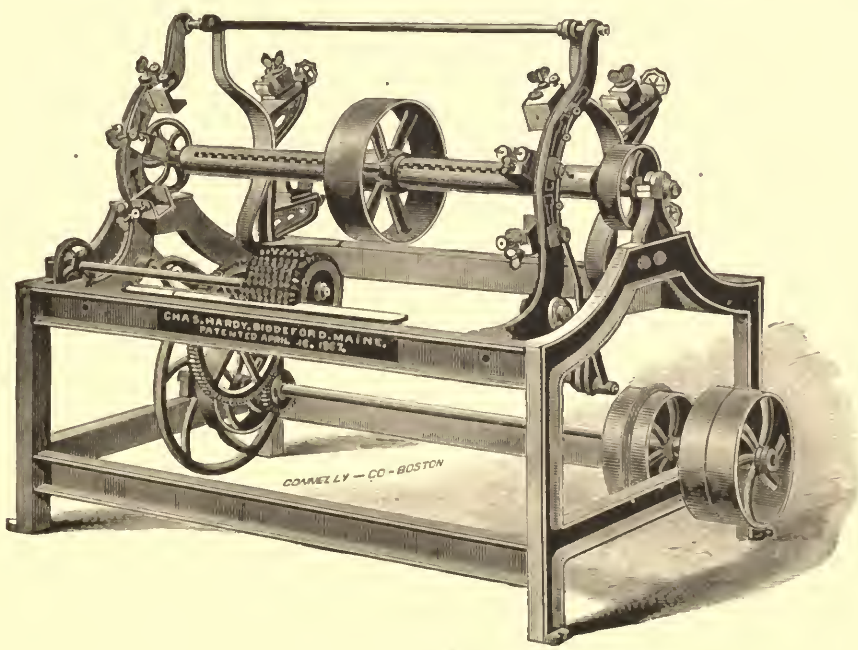

Fig. 68.

Fig. 67 shows this traverse emery wheel card grinder in position for grinding the doffer and main cylinder in a carding engine. Both can thus be ground either at the same time, or separately as preferred. For grinding workers, clearers or tops, they are taken to a *Grinding-frame*, of which an illustration is given in Fig. 68. The grinding-frame has a traverse emery wheel in its upper centre, and the rollers and tops to be ground are placed in circular shape around, so as to be operated on in unison. The machine, as shown in illustration, is adapted for grinding three tops and two rollers, (workers or strippers), at one time, but some of them are built to give place for two tops and three rollers, three tops and three rollers, three tops and one roller, two tops and one roller, etc., or, in fact, built according to the choice of the carder.

The third method of grinding is by the use of *Hand-strickle,* also called *Flexible-strickle.* By the proper use of it the best point, (diamond point or needle point), for carding purposes is derived, since a careful operator will thus grind round seven-eighths of the circumference of the wire forming the points of the teeth.

Stripping.—Some carders, when using diamond-pointed card clothing, consider stripping unnecessary. Too much of it, no doubt, is disadvantageous to the quality and quantity of the work, but no carder should dispense with reasonable stripping. In order to keep quality and counts of the yarn uniform, only one-half the cards in a section should be stripped at one time, whether stripping once or four times a day, as the case may be. The reasons for recommending the stripping of cards is based upon the fact that if this procedure were left undone the clothing would get completely filled with dirt and waste, which will, more or less, always adhere to the best of cotton, and in turn the elasticity of the wires (so greatly valued for good carding) would be arrested. Again, if stripping is not sufficiently done it will frequently become difficult to remove the dirt by a regular stripping process, since there is danger for having the same felted at the bottom. The old or common method of stripping is by means of hand cards, being a board with a handle having a piece of sheet card-clothing tacked on. The modern stripping is done by means of a revolving steel wire brush, which not only produces a better result, but also makes the work easier for the operator than if using hand cards.

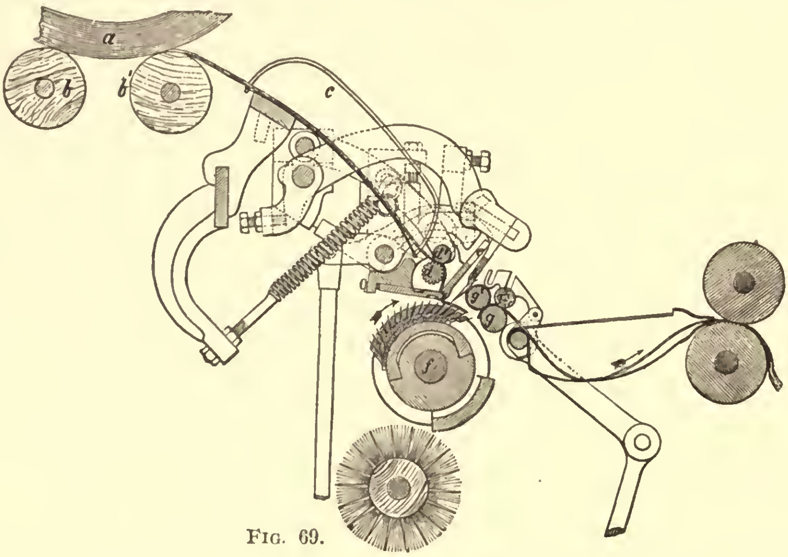

FIG. 69.

Combing.—For all yarns of extra high counts (from 80's to 200's and upwards) as well as such of the lower counts where an extra good thread is required, the lap as produced from the sliver of the breaker-card is *combed.* It is positively required to use the breaker-card for carding the cotton previously to combing the same, thus the latter mentioned process will only discard the second or finisher carding.

Heilmann Comb.—Combing is done on the machine known as a *comb,* which is the invention of *Mr. Heilmann, of Mülhousen, Germany,* and which machine first appeared on the market in 1851. Fig. 69 illustrates in section the working parts of this comb as invented by Heilmann. The method of operation was thus: The lap *a,* was unwound by the rollers *b,* and *b',* and the fleece passed down the inclined guide or conductor *c*, to the feed rollers *d*, and *d'*. After having fed a certain portion to the *nipper e*, the latter was closed and moved backwards till the protruding portion of the fleece was presented to the combs on combing cylinder *f*. These separated the waste from the front end of the fibres, and the nipper moved forward and opened and the combed ends were taken hold of by the top roller *g'*, which had by this time fallen into contact with the fluted part of the cylinder *f*. As they revolved together they drew out and separated from the fleece the long cotton, the short fibres or waste in the tail ends of the fibres being prevented from coming forward by the top comb *h*, which dropped amongst the fibres for this purpose. This completed the combing of one length of fibres, but the fibres previously combed required piecing up to the fresh ones that came forward, hence the motion of the roller *g*, was reversed and made to return those previously combed, so that the fibres which had just been combed were placed to overlap those immediately before, by means of which a continuous fleece or sliver was produced. There were six nippers in each comb, the action of each being simultaneous, a sliver coming forward from each, and which were united upon the plate in front of the machine, and passed along it through a drawing-head consisting of three pairs of drawing-rollers and a pair of calender-rollers, which strengthened the sliver to permit a ready lifting out of the can into which it was placed, either direct from the calender-rollers or through a coiling-motion.

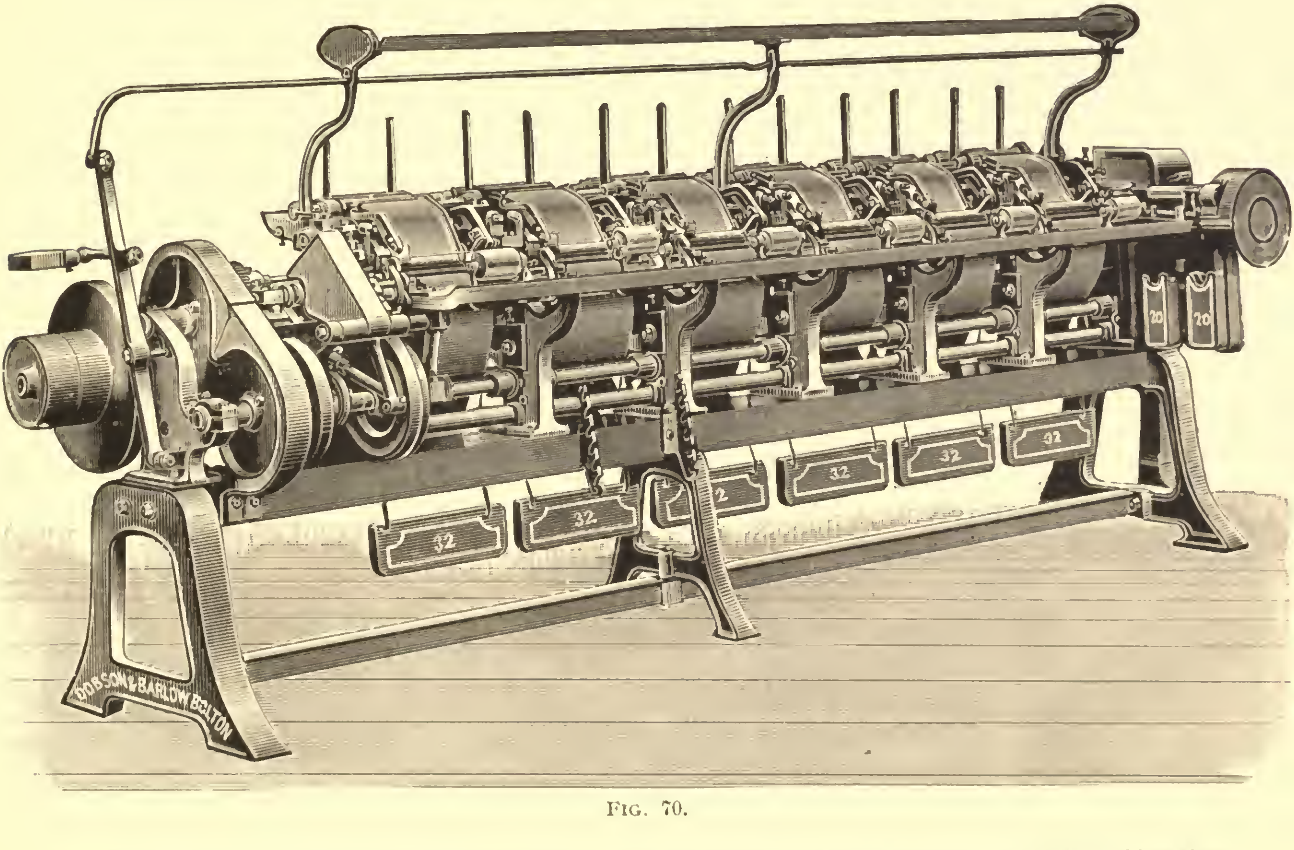

FIG. 70.

Dobson and Barlow's Comb.—Like any other machine the comb as previously described has since its invention been greatly improved, both with reference to simplifying the mechanism as well as increasing its production. Amongst the best combs built upon the Heilmann principle is Dobson and Barlow's Comb. In the original Heilmann comb, as previously explained, there were in each set of six nippers no less than 564 pieces, including such as belong to their fixings. These parts have been reduced by Dobson and Barlow to 216 parts. To set the nippers (being an operation requiring the greatest mechanical skill) in the original Heilmann comb required about ten hours, whereas in Dobson and Barlow's machine the operation is greatly simplified and can be done in half an hour, and by almost any carder of average skill. Fig. 70 illustrates in perspective the improved comb. Amongst the special features of this machine compared to the original Heilmann comb we find: The quadrant detaching motion substituted in place of the large detaching cam, the cradle, the notch wheel, the catch and its spring, the large spur wheel which drives the calender roller, and the internal wheels for the detaching roller shaft; a much simpler motion consisting of a smaller cam, a quadrant, and a clutch. Another improvement is that the positions of the knife and plate are reversed. The leather of the plate instead of being put on in the old way, is a piece of solid leather which is placed between two strips of steel attached to each side of the plate. This affords a perfectly true and accurate surface for the knife to impinge upon; it cannot sustain any injury, and will last three or four times as long as the old style of plate, thus saving repairs, waste, and increasing the product. With reference to the adjustment of the piecing-roll the connecting-rod is dispensed with and one joint saved. The joint that remains is at the foot of the levers that carry the roller, and has a special adjustment, so that one of the most important settings of the comb; *i. e.*, that of the piecing-roller, is rendered easier and more accurate. Further improvements in this comb are the treble-brush carrier-wheel, for driving the brush at three different speeds, and special arrangements to prevent *flocking*, improved bearings for piecing-roll, method of driving the calender-rolls, etc. Another combing machine is the

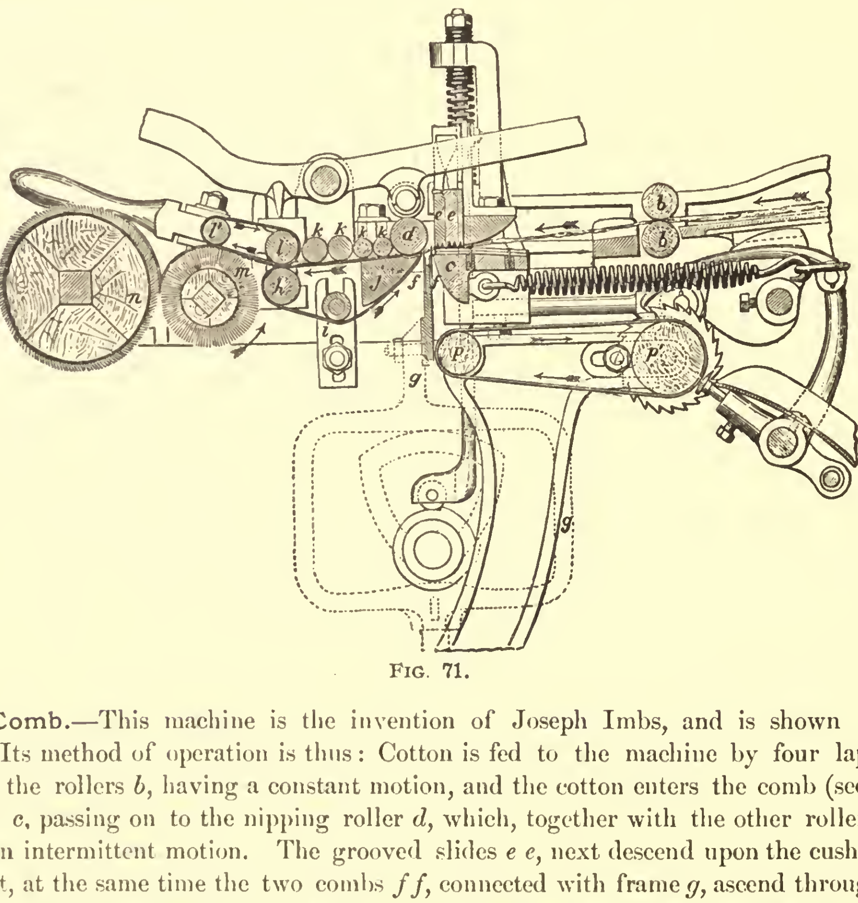

Fig. 71.

Imbs' Comb.—This machine is the invention of Joseph Imbs, and is shown in its section in Fig. 71. Its method of operation is thus: Cotton is fed to the machine by four laps, which are drawn off by the rollers *b*, having a constant motion, and the cotton enters the comb (see arrow) over cushion table *c*, passing on to the nipping roller *d*, which, together with the other rollers, brush and doffer, have an intermittent motion. The grooved slides *e e*, next descend upon the cushions and hold the cotton fast, at the same time the two combs *f f*, connected with frame *g*, ascend through the cotton, when immediately the cushioned table, together with the nippers, are drawn back, parting the web; the combs then descend, bringing along any motes or short staple contained in the length of web between the two combs. The slide next rises, the rollers having delivered another length, the table advances, piecing the web, which is taken hold of by the nipping roller *d*, and the combing repeated. The nipping roller rests on a leather strap to which motion is given, in the direction of arrows, by the roller *h*, and kept uniformly tight by the weighting roller *i*, from which it passes over the triangular metal bar *j*, which supports the nipping-roller *d*, and helps to form the nip, being hollowed out a little near its point to receive the nipping-roller. After leaving the latter roller, the combed cotton passes with the strap under the four small calender-rollers *k*, to the rollers *l* and *l′*, which also have a travelling belt moving in the direction of the arrows, when it comes in contact with circular brush *m*, and by it is deposited on the roller *n*, which is covered with card clothing. It is stripped from the latter by an ordinary doffing-comb, leaving like cotton from a carding engine, through a drawing-box and calender-rollers to a can. Any short fibres and motes are removed thus: When the combs *f*, descend they come in contact with the roller *p*, which has a belt of woolen cloth around it, and as this is moving in the direction of the arrow, it takes away the short fibres and motes to the roller *p′*, which is likewise stripped by an oscillating comb, and the waste thus obtained is delivered in a box.

The Heilmann comb or any other comb constructed upon its principle is more adapted for combing long-staple cotton, whereas the Imbs comb also works short-staple cotton successfully.

Lately an improvement in combing machines has been patented by Lever & Redford, which has for its object the increasing of the speed of the combing machines, and the doing away with sliding comb-carrying lags, providing the comb-cylinder with rocking or oscillating jaws or clamps, so mounted and operated that they are held open as the fixed jaw of the cylinder approaches the combed end of the lap, but as soon as the fixed jaw, in its rising movement comes under the down-turned combed ends of fibre at the end of the lap, and extending beyond the nippers and the said comb ends are made to fully cross and lie upon the fixed jaw, it continuing its rotation, the rocking or oscillating jaw is operated quickly toward the fixed jaw to clamp the combed end of the two laps, and thereafter the jaw pulls off a tuft and carries it around with the cylinder, delivering the tuft at the proper time upon the table to the action of the holder.

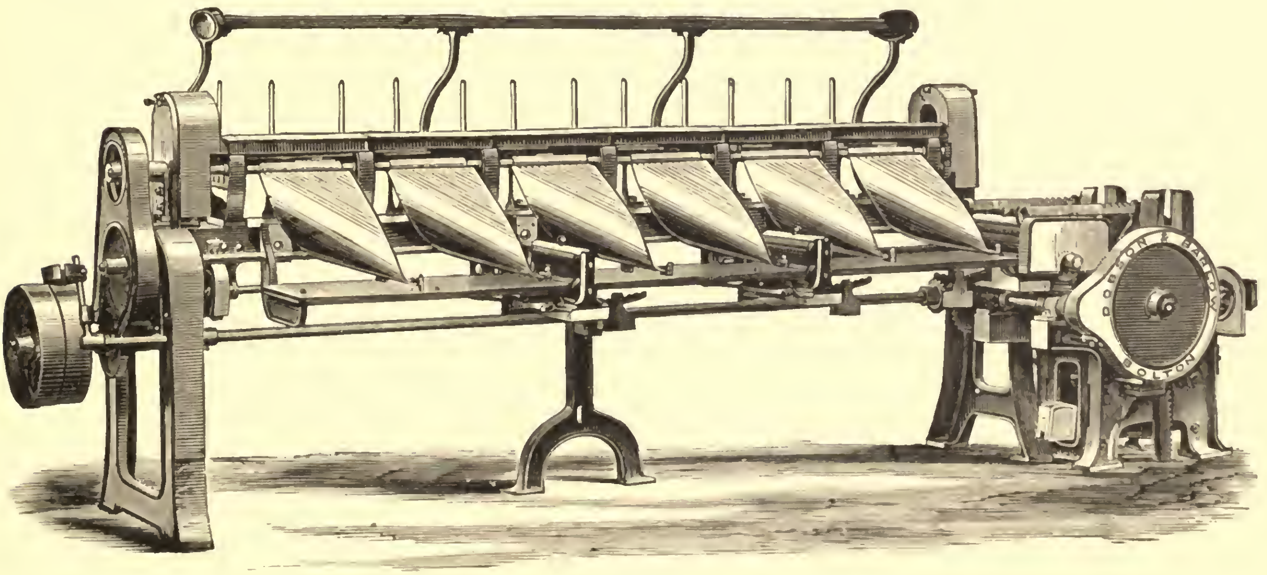

Fig. 72.

Ribbon-Lapper.—In connection with a comber is used frequently a machine known as a ribbon lapper, or draw-frame and lap-machine combined, for preparing laps for combs. The purpose of this machine is to do away with the old fashioned process of preparing comber-laps, since this old process makes a lap that consists of a series of slivers laid side by side and is not of one uniform thickness. It is obvious that the nipper of the comb cannot act as well upon this lap as if the thickness were uniform throughout, and further that where the thin places are, there is danger of good cotton passing through into the waste on account of the defective nip. Also where the thick places come, the pins are required to do too much work and the quality at once suffers. It is to obviate these difficulties that the ribbon-lapper has been so universally introduced. Fig. 72 illustrates in perspective this machine

When this machine is used the system is as follows: The ordinary style of drawing-frame is thrown out entirely and the card-slivers are doubled up into a lap directly on the small sliver-lap machine, then six of these laps are placed in a creel of the machine and are drawn through four lines of rollers in the form of a ribbon instead of a sliver, and by means of curved plates, are placed perfectly even and level on a polished table. Each machine is fed by six laps, which, having been drawn through four lines of rollers into six ribbons, are placed one upon the other with mechanical accuracy, and compressed by calender-rollers, which also assist to convey them to the lapping-machine, to be formed into a lap ready for the combing-machine. The laps made upon this machine, having all the fibres perfectly straight and the amount of cotton equally distributed, make less waste in the process of combing; the cotton is not injured or torn by the combs, nor are the teeth of the combs injured or broken in the effort necessary to straighten crossed fibres. The resulting lap is of a perfectly uniform thickness throughout, and is the most perfect lap to put up to a combing-machine. The nipper nips it evenly throughout, the combs all have an equal share of the work to do, waste is saved, and better combing is the result.

Drawing.—As previously explained the cotton leaves the finisher-card in the shape of a delicate narrow strip or ribbon, technically termed a *sliver*, which is either coiled automatically in a revolving tin can (sliver-can) or delivered to the sliver-trough, and from there, in connection with the slivers of the section, to the railway-head. The fibres constituting this sliver are now more or less parallel, but to further perfect this parallel position of the fibres forming the sliver, as well as to make the sliver uniform in its dimensions, the *drawing-frame* is brought into requisition.

The drawing-frame, as previously mentioned, takes the sliver from the cards or railway-head, as the case may be, and doubles and draws the same, at the same time laying the fibres parallel by the action of the front and middle rolls. When the sliver has been doubled and drawn on the last head there should be hardly any variation in it, provided the frames have been properly adjusted. The principle of the process of drawing is illustrated in Fig. 73, and is accomplished by means of different rates of speed at which the rollers *A*, *B*, and *C*, revolve. These rollers, equal in their diameters, as seen in our illustration, are situated equal distances apart and revolve in the same direction, but every successive pair (commencing with *A*) has a greater velocity. Supposing a sliver is fed between the first and second pair of rollers *A* and *B*. Since, as previously mentioned, the second pair of rollers *B*, have a greater speed than the first pair *A*, the sliver, as situated between both pairs of rollers, will get elongated or drawn out, hence rollers *B*, will deliver a finer sliver than fed to the rollers *A*. From the second pair of rollers *B*, the sliver is passed between the third pair of rollers *C*, and since the latter have a greater velocity than the second pair of rollers *B*, the method of operation as between *A* and *B*, is repeated; *i. e.*, the sliver when leaving the pair of rollers *C*, is more drawn out or finer in its dimension than when leaving the second pair of rollers *B*. The same process of drawing out the respective sliver may be repeated once or twice more, every time getting the sliver more and more reduced in its dimensions. In addition to reducing the sliver in its dimensions, it will be readily seen by the student that this drawing process must have a strong tendency to stretch or lay parallel the individual fibres composing the sliver. The amount of draft between the rollers must not be too great, otherwise the sliver would part, and this the sooner the poorer carding has been; *i. e.*, the more crossed up the fibres are in the sliver. Hence the drawing must be always less between the first and second pair of rollers, compared to the draft between the second and third pair, and so on. If using four pairs of rollers the speed for each pair may be stated approximately as follows: First pair, 100; second pair, 125; third pair, 175; fourth or front pair, 300 revolutions per minute. Hence the draft is mainly accomplished, or the main work is done, between pairs of rollers *C* to *D*; whereas between pairs of rollers *A* to *B*, only a small draft is exercised. Another point which regulates the amount of draft to use, is the length of the fibre; since a long-staple cotton will permit a greater amount of drawing out compared to the short-staple material.

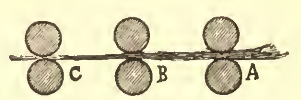

Fig. 73.

The sliver, as coming from the carding engine, is never perfectly equal in its dimensions, and if we would draw out only single slivers such imperfections would not diminish, but on the contrary, get more prominent. This, however, never happens since experience has long ago demonstrated the necessity of *doubling and drawing*, by means of which any imperfections in one sliver are balanced by others, for it would be impossible for several slivers from an equal number of cards to have all the heavy places in one sliver meet all the heavy places in the other slivers, and *vice versa*, light places in one sliver meet light places in all the other slivers. Thus it will be seen that the chances of irregularities falling together in a number of slivers are reduced in proportion to the increase of the number, and that doubling will produce a perfectly even sliver; hence this is the foundation of producing an even thread. Doubling, for which the textile industry is indebted to Arkwright, was commenced with two slivers, by and by three slivers were united, and so on until nowadays six to eight slivers are put up in the first passage through the drawing-frame. In most instances the draft and the number of slivers fed into the drawing-frame at the first drawing is equal; thus, if feeding six slivers and draw-

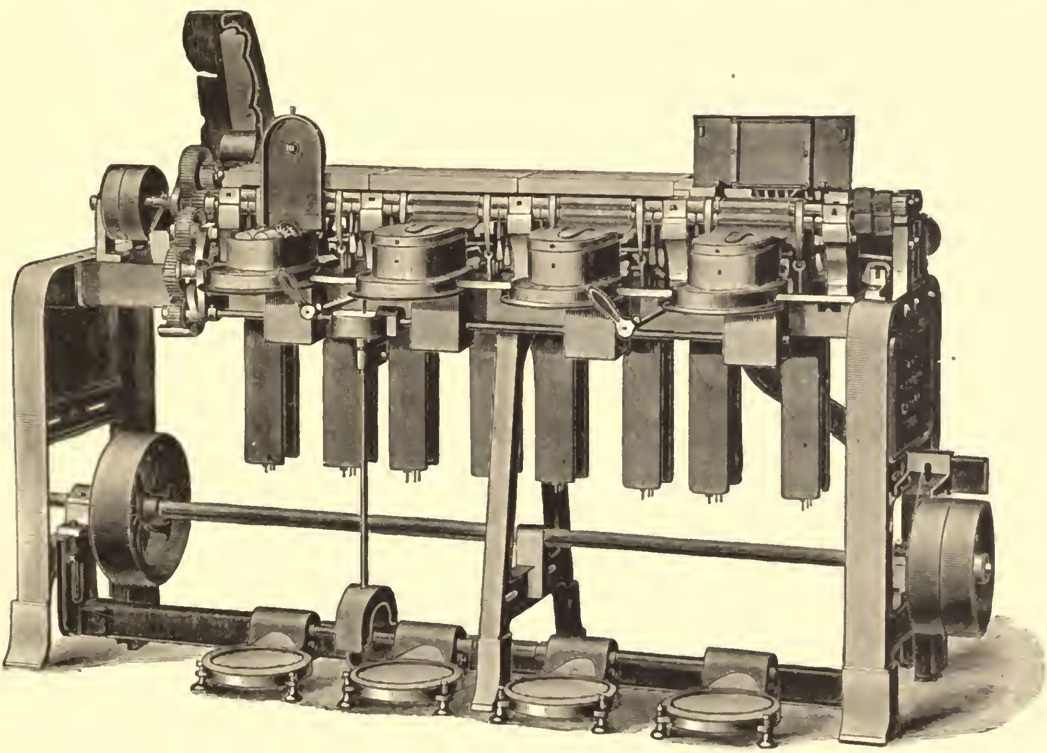

Fig. 74.

ing out each sliver six times its original length the combined sliver as leaving the frame should be exactly equal in dimension to either one of the minor slivers fed in, but in practice it will be found finer, which readily explains itself, since the fibres in the resulting compound sliver are placed more parallel.

While gradually more and more slivers were combined or doubled in the drawing process, the number of passages (through drawing-machine) were at the same time increased, until at present the material is generally put three times through the drawing-machine getting every time a resulting sliver more perfect as to its dimensions, and the fibres more and more perfectly parallel to each other.

Drawing-Frames.—Figs. 74 and 75 illustrate two different kinds of drawing-frames in their perspective view. Fig. 74 illustrates the John Mason drawing-frame, and Fig. 75 the drawing frame as built by the Pettee Machine Works. Both machines represent an oblong frame, in which is mounted a roller-beam, carrying four rollers extending the length of the frame. These are the bottom rollers and contain twice as many fluted bosses as there are heads to the frame. The top rollers, being double bossed, are only sufficiently long to do the work for one head, and are mounted in the same bearings, and rest upon the bottom rollers. The top rollers, besides having a plain surface, are first covered with cloth, and on the outside with leather and covered with a special varnish, so as to prevent the sliver from catching on and winding around. This gives the surface a chance to slide over such of the

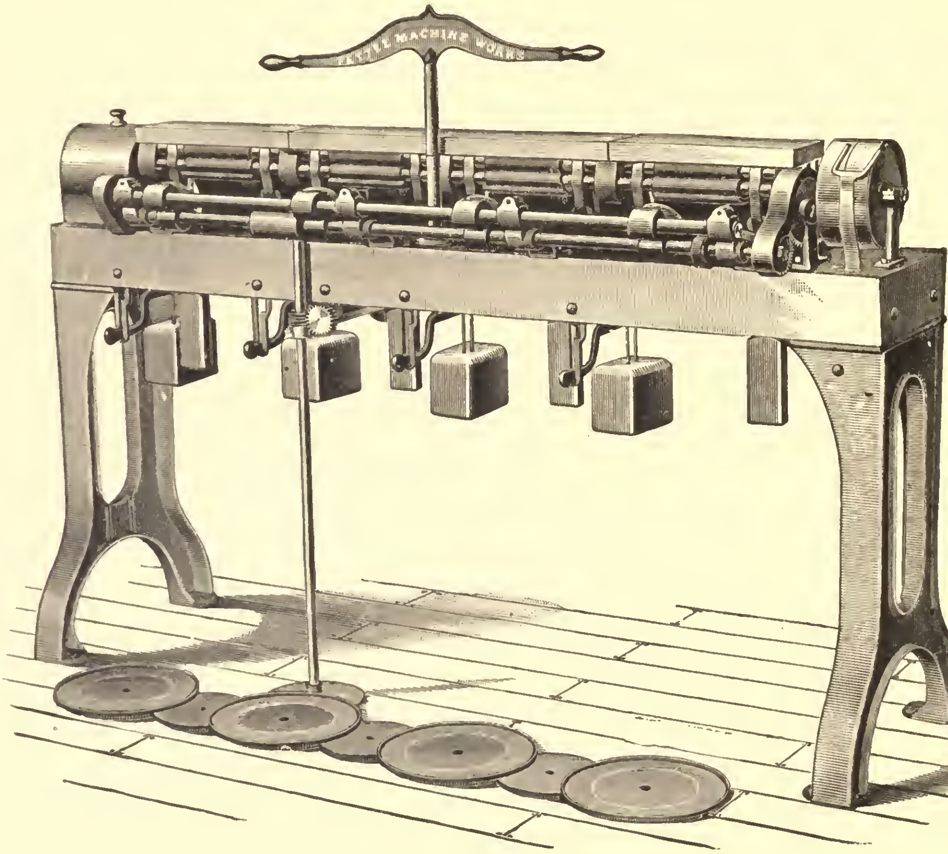

FIG. 75

fibres as are held too taut by the preceding rollers. When the slivers leave the drawing-frame they pass through a coiling disc into the can. This can is placed in a revolving dish and carried around with the latter, which causes the circles deposited by the coiler to extend in a ring of circles, or nearly like it, around the centre of the can. The coiling disc (see Fig. 74) consists of two compression rollers which take hold and guide the sliver. Below these rollers is a trumpet tube, which is fitted with a transverse arrangement in order to protect the compression rollers against unequal wear that would arise from the sliver strand always entering at one place. The weighting of the top rollers is done by levers and weights, arranged so that the top rolls can be relieved from any pressure when the frame is not running.

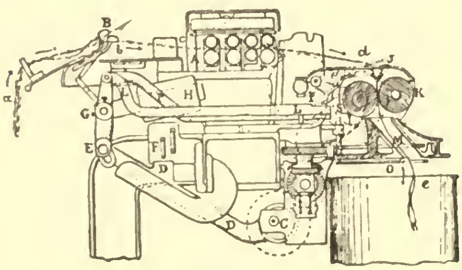

FIG. 76.

Stop-Motions.—All the modern built frames are provided with both front and back stop-motions, and on coiler drawing-frames a coiler and can stop-motion is applied; the former prevents the winding up of the calender-rolls, while the latter prevents the can from filling too full, and which can be set to stop the machine when any number of yards have been delivered. Diagram Fig. 76 is given to illustrate in its section the principles of the working parts of a drawing-frame, also front, back and can stop-motions.

The slivers *a*, after being fed in rear of the machine, over the tumblers *b*, to the drawing rollers c, are passed *d*, through a funnel-shaped guide between the calender-rollers, through coiler and false bottom to the can *e*.

The Back Stop-Motion.—The stopping of the machine if a sliver as fed in breaks, is as follows: The sliver passing over tumbler *B*, is seen broken, hence the weighted end of the latter drops, coming in contact with an arm projecting from the back of the shaft *G*, thereby arresting the rocking of the shaft. This arrests the motion of the stud *E*, and the rod *D*, continuing its reciprocating motion; the oblique slot causes the upper end of the rod to rise upon the stud, bringing the projecting arm close against the bar *F*, which, now being lifted and liberated from its notch, shifts the driving strap from the fast to the loose pulley and thus stops the machine.

The Front Stop-Motion.—The doubled and drawn out sliver after leaving the last of the drawing-rollers is then passed *d*, through (funnel) guide *J*, on to the calender-rollers *K*. The guide *J*, is adjusted to the front end of a lever, the back end of which *I*, is made heavier, consequently has a tendency to lift the guide (in oblique position as shown by dotted lines in illustration). The reciprocating-rod *L*, is connected with an arm on the oscillating shaft *G*, and has a notch in its front end. The tail *I*, of the guide-lever, when liberated by the breaking of the sliver, drops into this notch, arresting at the same time the motion of rod *L*, and consequently of shaft *G*, and stud *E*, which brings the stop-motion *D*, *F*, into action, immediately stopping the machine.

The Can Stop-Motion has for its object, to stop the frame when the front can is filled. It consists of the false bottom *O*, of the coiler-wheel *M*. The former is weighted above by a ring to suit, as to its weight, the hank sliver; *i. e.*, using a finer ring the finer the sliver, and a coarser ring the coarser the sliver. When the receiving can is sufficiently filled, the plate *O*, is lifted, the vertical stop *S*, is raised in front of the end of the reciprocating bar *P*, as connected with the oscillating shaft *G*, thus stopping the motion of the machine. A point of great value in favor of using this or a similar can stop-motion is that the same amount of sliver is put into each so that they will run out simultaneously when put to the second or third drawing. As previously mentioned the number of times the slivers should be drawn, as well as the number of slivers to be doubled is various; it is regulated by quality of cotton to be worked, and the purpose of the yarn. Sometimes two drawings are sufficient, other times three are required; again six slivers may be doubled for one yarn, whereas for the next yarn eight slivers may be united. No doubt the more doubling and the more drawing the better the yarn as produced; again too much drawing, or *over-drawing*, is equally hurtful.

Drawing-Frame with Electric Stop-Motion.—Fig. 77 illustrates Howard and Bullough's drawing-frame with *electric stop motion*. This stop-motion is of great delicacy, and is based upon the fact that cotton, when in a comparatively dry state, is a non-conductor of electricity. The slivers before reaching the drawing-rollers are passed between rollers (electric-rollers), the lower situated one of which is fluted, revolving in bearings attached to the machine frame. The top rollers are made short, allowing one for every pair of slivers, and revolve in plates secured to a plate (back-plate) which is electrically insulated from the rest of the machine. On the frame is a small electro-magnet, the stop-motion, and strap-fork. The top series of electric-rollers are kept from being in contact with the bottom one by means of a non-conducting cotton sliver, and the upper and lower rollers are insulated from each other by the non-conductors, the passage of the current is not possible, but if the sliver breaks, the rollers come into contact, thus completing the circuit and stopping the machine. A second trouble in a drawing-frame is that the slivers may wind on the drawing-rollers; both rollers (both top and bottom) are in electrical contact with the machine frame and are covered by the plates of the top clearers placed a short distance from them and attached to the insulated back-plate. Thus the top clearers are in electrical contact with one pole of the *magneto electric machine*, and the drawing-rollers in contact with the other. When the rollers work properly their distance is corresponding, but if the sliver winds itself around either one, the distance between the centres increases, thus raising the upper roller which then comes in contact with the projection from the top-clearer, producing the electrical contact and stopping the machine. In a similar manner the calender-rollers are insulated from each other. Where the sliver is passing properly they are separated, thus no current; but if the sliver breaks in one of the funnels, the rollers (having nothing to keep them apart) touch, completing the circuit, and the machine is again automatically stopped. The next operation where the electric mechanism comes in operation is when the cans are filled with the proper amount of sliver; in this instance the tube wheel is slightly lifted, completing the circuit and stopping the machine.

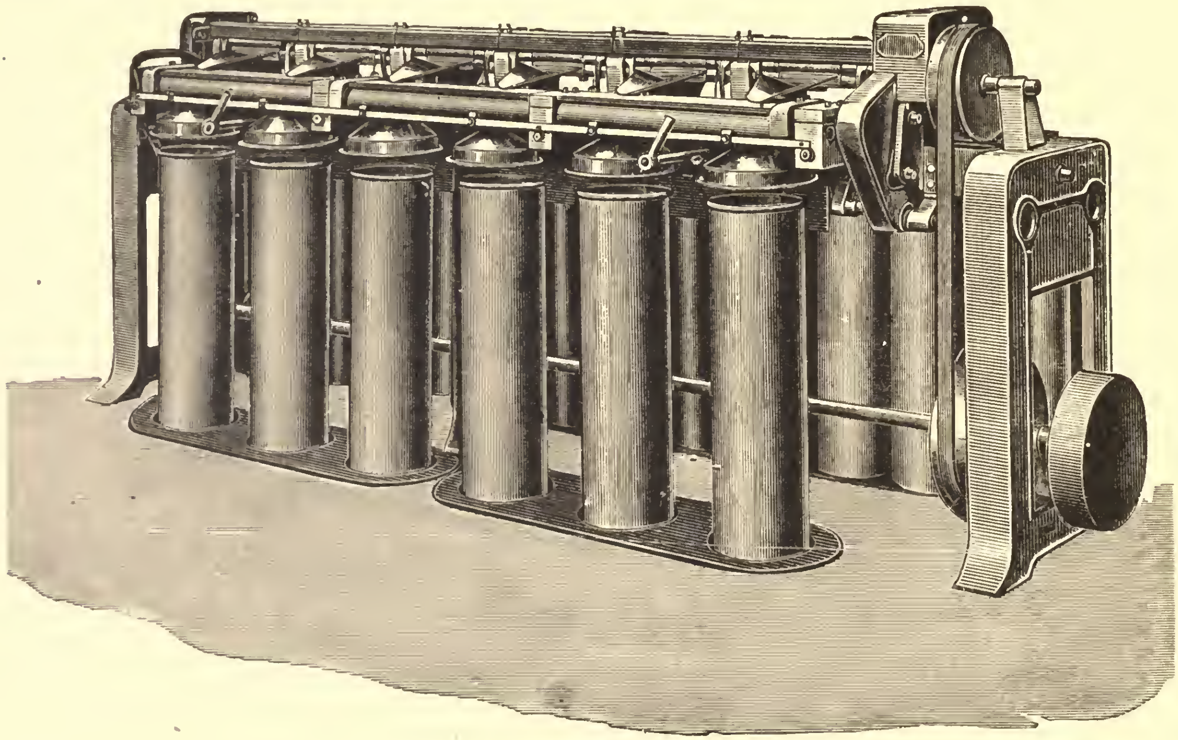

Fig. 77

Slubbing, Intermediate and Roving.—These are the next three processes to which the sliver after leaving the drawing-frame is subjected, and are produced on correspondingly named machines; *i. e.*, slubbing-frame, intermediate-frame and roving-frame. The process in all three machines, to some extent, resembles the previously explained drawing process (without doubling) and consists in drawing the sliver, step by step, into one of much smaller dimensions, imparting at the same time some twist to it. All three machines are, in their principles of working, alike, hence we will consider the same as briefly as possible.

Slubbing.—The slubbing-frame, commonly called *the slubber*, is the first machine to which the sliver after leaving the drawing-frame is delivered. The cans containing the slivers are placed in rear of the slubber and the end of the sliver passed between three pairs of rollers similar to those used in the drawing-frame and which attenuate the same; *i. e.*, reduce its dimensions. After leaving the last roller the *slubbing*, as the sliver is now called, is by means of a *flyer*, carried on a revolving spindle, wound upon a bobbin. Only a small amount of twist (sufficient to permit rewinding of the slubbing from the bobbin) is put in the slubbing, since this strand of fibres must be still more drawn out by the next processes, and too much twist would not permit this procedure. Fig. 78 shows a slubbing-frame (*fly-frame system*) in its perspective view; the last set of drawing-rollers, the flyers, bobbins and their slubbing-strands, are clearly visible. The cans containing the sliver from the drawing-frame are not shown in our illustration, being placed in the rear of the machine. The bobbins containing the slubbing are next put up in the creel of the

Intermediate-Frame.—This machine is a repetition of the previously explained slubbing-frame. The only difference being that more spindles are used in the same width of the machine, since this machine deals with a finer strand of fibres. For common class of yarns, say below 20's, this process is generally dispensed with and the slubbing put directly on the creel of the roving-frame; but for better yarns of these counts, as well as for all the higher counts, the use of this frame is essential. Its object is, to further reduce the slubbing strand in its dimensions by means of drawing out, previous to winding it again by means of a flyer, carried on a revolving spindle on a bobbin, which is then put on the creel of the roving-frame. Fig. 79 illustrates the intermediate-frame as built by the Lowell Machine Shop (*speeder system*), but which can also be used as a slubbing-frame by placing the cans containing the slivers from the drawing-frame in rear of the machine.

Fig. 78.

Roving-Frame.—This is the next machine to which the strand from the slubbing or the intermediate-frame is subject to, and is the same in principle as the two preceding. The only difference found, consists in arranging a shorter lift and using more spindles in the same width than in the slubbing and intermediate-frames, since the strand to be drawn out is correspondingly finer. The strand leaving this frame is now termed *roving*. Fig. 80 shows in perspective this frame as built by the Lowell Machine Shop (*fly-frame system*). Fig. 81 illustrates in perspective the roving-frame as built by Howard & Bullough (*flyer system*).

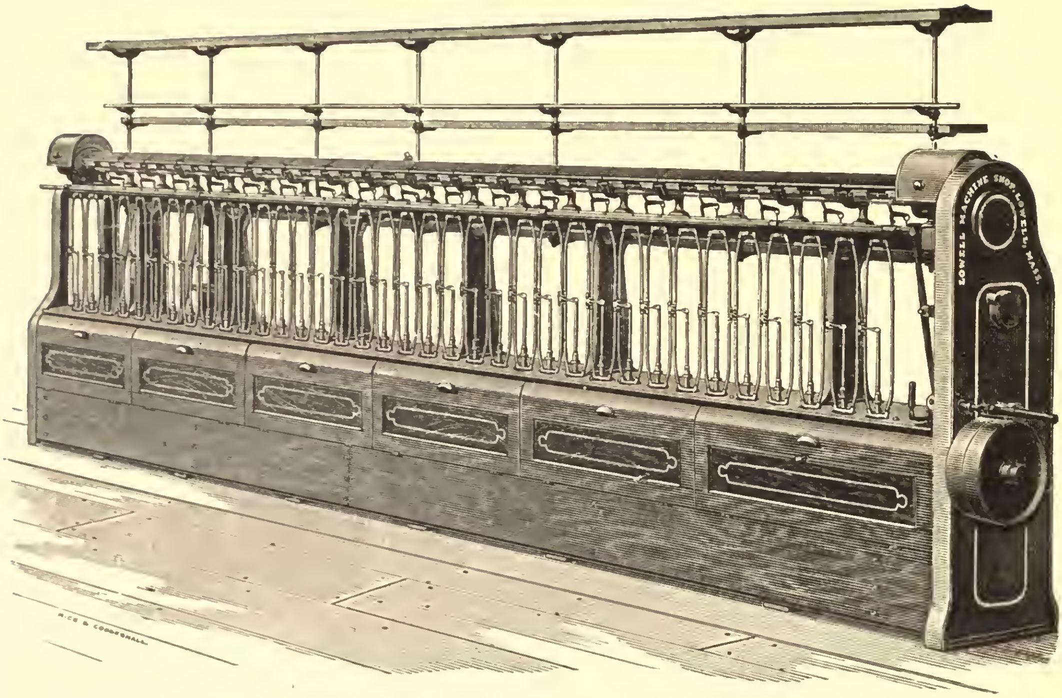
LOWELL MACHINE SHOP, LOWELL, MASS.

Fig. 79.

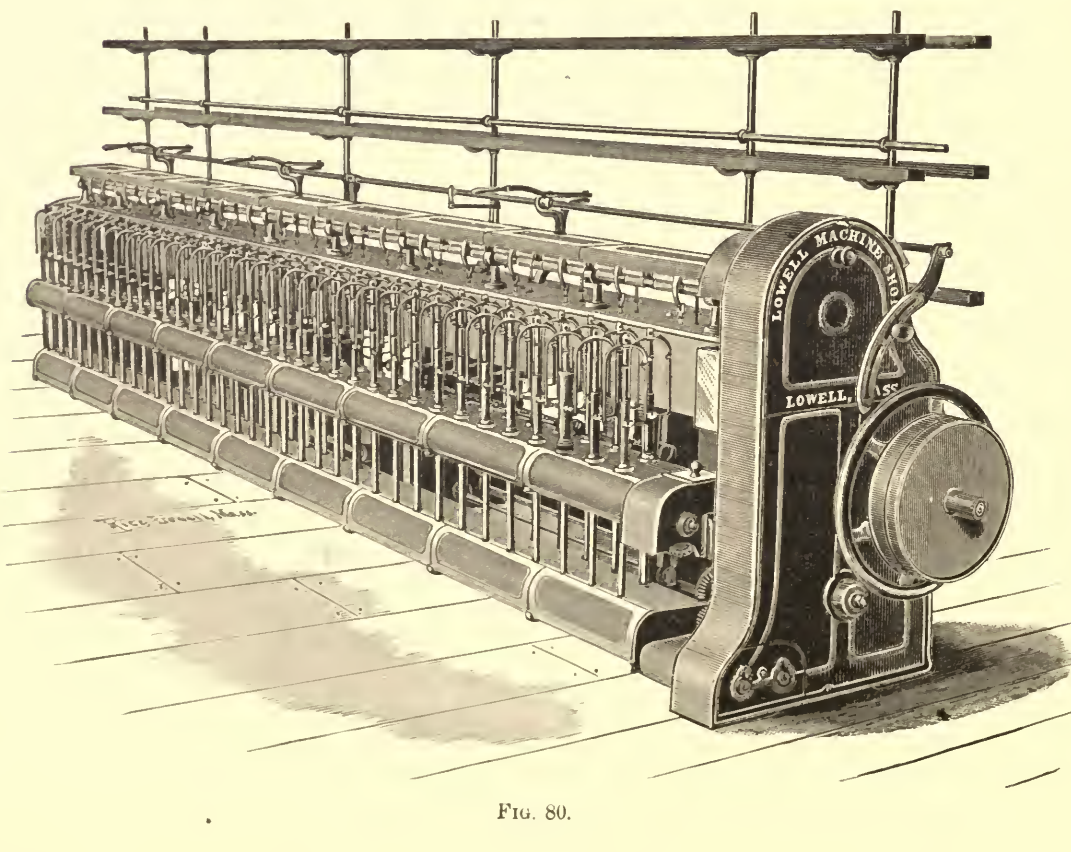
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Fig. 80.

Speeders, Fly-Frames.—Both systems are used for either slubbing, intermediate, or roving-frames. The difference between both is: The *fly-frame* has two rows of spindles, and the flyers are removed when the machine is doffed, whereas the *speeder* has usually but one row of spindles and is doffed without removing the flyers. Fig. 82 is an illustration in detail of the spindle and flyer of a speeder. In the same the flyer has the form of a flattened ellipse of about double the length of the bobbin, thus permitting, as previously mentioned, the removal of the bobbin without disturbing the flyer. Fig. 83 illustrates the flyer as used in frames constructed upon the fly-frame principle. The flyer being like an inverted U, is screwed to the top of the spindle, requiring to be unscrewed and as previously mentioned, replaced each time the bobbins are doffed. Letters of reference in this illustration indicate as follows: The strand leaving the front drawing-rollers, enters the flyer at its head *a*, and is then passed *b*, in the one arm of the flyer which it leaves again *c*, at its lower end, from where it is wound around the guide (presser-arm) *c*, *d*, previously to being passed to the bobbin. It will be readily seen that the strand of *elongated*

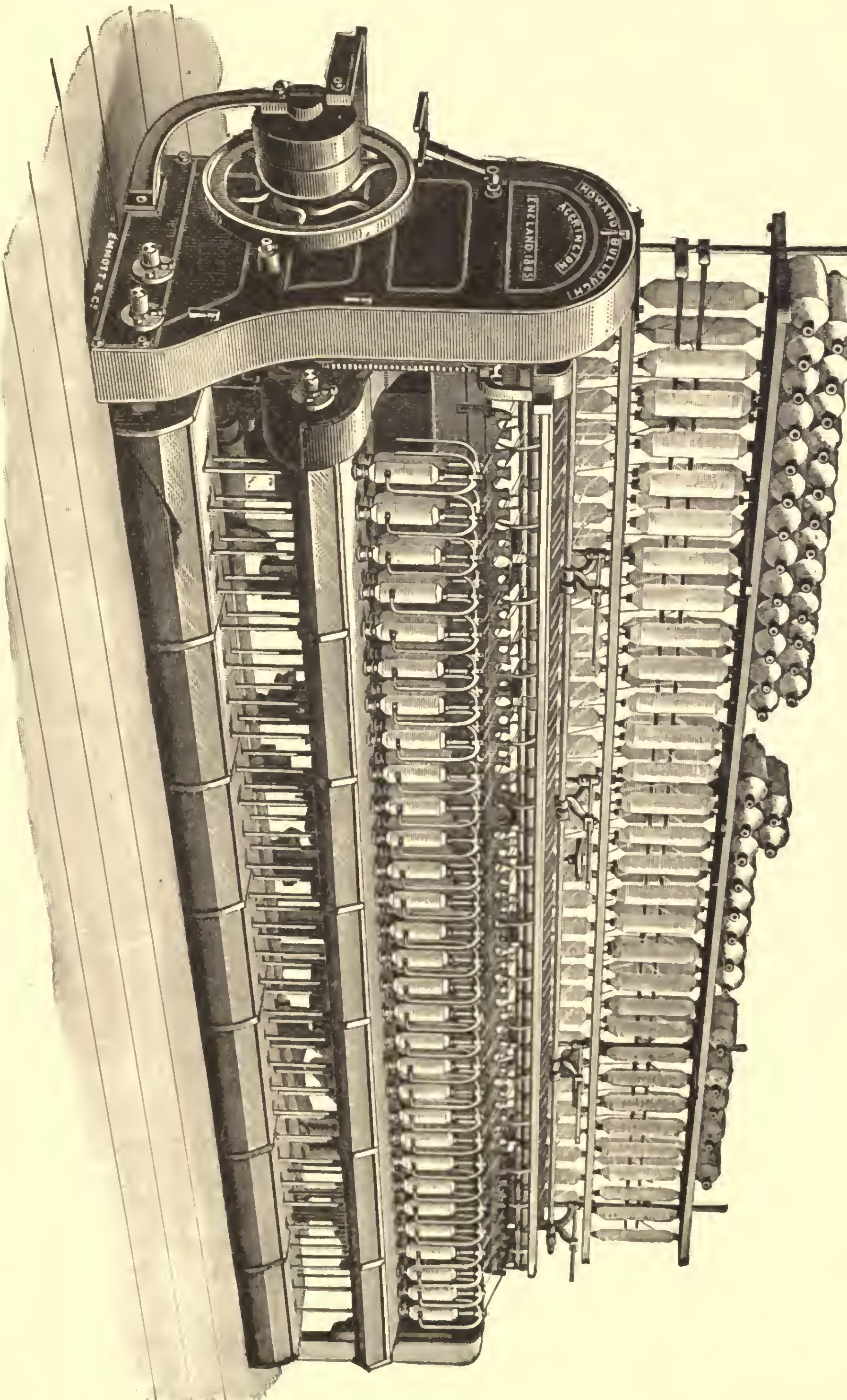


Fig. 81.

slubbing between the front drawing-rollers and the head of the flyer is turned once around its axis every time the flyer completes one turn. (Technically this is known as *one turn of twist,* and the number of turns of twist put in are expressed in proportion to one inch.) The end of the guide *c, d,* always rests on the bobbin, in fact, pressed slightly against the same. This requires the guide to be movable; *i. e.,* permitting a pushing back motion, since the bobbin, by means of the yarn wound around it, gets more and more fuller. To permit this motion the guide is movable at *c,* around axe *e, c,* and pressed against the bobbin by means of a spring in *e, c.*

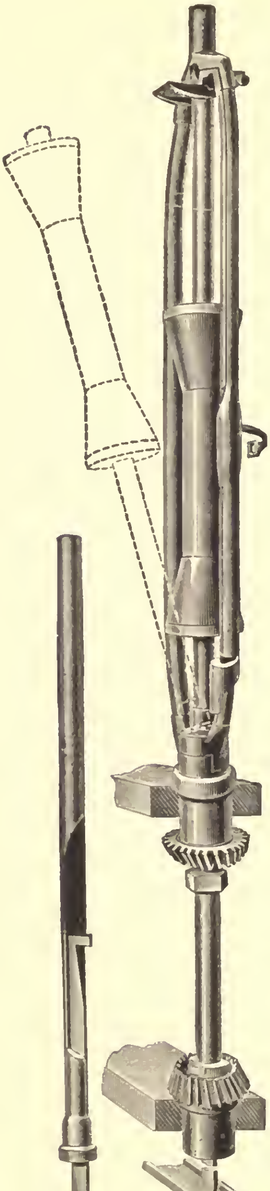


FIG 82.

Differential Motion.—The slubbing, intermediate and roving-frames were a great puzzle to early inventors. The attenuation of the sliver at the stage of the slubbing had proceeded so far that it was difficult to deal with in the sliver cans of the drawing-frame, which also occupied too much space. Yet the roving could not be wound upon bobbins, as inventors had not yet solved the problem of making a mechanical arrangement that should secure a uniform rate of winding on a circumference that was growing larger with the addition of every layer. That great genius, Arkwright, got over the difficulty by a slight modification of the drawing-frame, in which he made the receiving cans revolve on a central pivot, by which means the rove was coiled inside. These cans were furnished with a door extending from the top to the bottom in the manner of the old lanterns that were in general use before the discovery and adoption of gas as an illuminant. From this fact the frame received its name of the *lantern roving-frame.* When the can was full the rovings were removed by girls, carried to the winding department and wound upon bobbins. The machine made a good roving, but it was often much damaged in this winding process, which was also very expensive. The difficulties encountered in this way, amongst many other devices, led to the invention of the old *Jack-in-the-box,* or *Jack-frame,* a name which has been transmitted to the far more ingenious and perfect invention of H. Holdsworth, which made its public appearance in 1826. The old jack-frame consisted of the revolving can, as in the lantern frame, this giving the necessary twist to the roving. Inside the can a small cylinder was arranged horizontally, which was made to revolve at such a rate that its surface velocity was uniform with that of the front drawing-rollers. A flanged bobbin was imposed upon it and driven by friction, a transversing guide-wire upon the cylinder depositing the layers of roving evenly upon it. It will thus be seen that in this there was no differential movement at all of the bobbin. The mechanism was, however, very liable to get out of order, and consequently was unsatisfactory. In the early part of the century attempts were made, partially successful, to adopt the bobbin and fly-frame to the production of roving, and very complex arrangements were devised, in order to solve the differential winding problem. The first frame for this purpose contained four cone drums, the veritable results obtained from their action partially overcoming the difficulty, but they still left it necessary, in every change of the twist, to make a corresponding change in the speed of the bobbin; a change which was not proportional, but such as would preserve the difference between the motion of the spindle and the bobbin unaltered. For this purpose a large number of change-wheels were required, and to get at correct results, even with their aid, was found to be beyond the capacity of most overseers. It was rarely that they arrived at a correct result without spoiling a quantity of work.

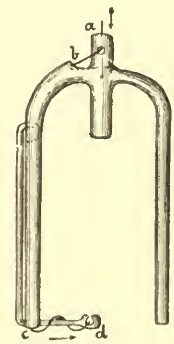


FIG. 83.

The idea of automatically accelerating or retarding the speed of the bobbin in relation to the spindle appears to have been first broached by a Mr. Green, who patented in England in 1823, a plan for that purpose. Though practicable it was so complex, cumbrous and destructive that it never got much beyond the stage of experimentation. The central idea, however, was taken up by Mr. Holdsworth, and after a couple of years' study he overcame all the difficulties that stood in the way by the invention of his differential system, one of the most beautiful examples of automatic equation that has ever been devised. Beyond the addition of a balance wheel this arrangement until lately has not been improved upon since it left the hands of its inventor sixty years ago, which proves the great merit of the invention and the high degree of skill with which it was wrought out. The differential motion works in connection with a regulator similar to the one explained in connection with the finishing picker.

Holdsworth's Differential Motion.—To make our explanation of this device more clear, Fig. 84 is given. In the slubbing, intermediate, and roving-frames, there are three main facts to deal with—namely, drawing-rollers, the spindle, and the bobbin. The two former revolve at a constant speed; the latter at a constantly varying one; that is with a bobbin-lead arrangement it commences at its maximum rate, which is slightly diminished every time a layer of the strand is deposited upon it, until the bobbin is filled, when its rate of revolution is very nearly reduced to that of the spindle. With the flyer leading this arrangement is reversed. As the delivery of the strand of fibres from the front rollers is at an unvarying rate it is required that the winding surface of the bobbin shall take it up in the same manner. This surface being a constantly enlarging one, it becomes necessary, in order not to stretch the strand, that its rate of revolution shall be retarded in exact ratio to its increased surface. Hence the requirement of the differential arrangement for driving. This is the problem Mr. Holdsworth had to solve, which he accomplished by the method shown in the illustration (Fig. 84), which we proceed to describe. It must be borne in mind that the power to drive all the parts of the machine is derived from its main shaft, which has a uniform and constant revolution. A proper train of wheels drive the drawing-rollers at a uniform speed; another train drive the spindles also uniformly from the wheel *P*, upon the main shaft *M*. These are what we may term the constants. We have now to get at the variants, the bobbin, and the mechanism which drives it. Power is taken from the main shaft through the wheel *Q*, to the top cone-drum, one of a pair, by the use of which the variant capability is brought in. From the top cone-drum, power is transmitted by means of a strap to the bottom cone, upon the axle or shaft of which is fixed a small pinion wheel gearing into the sun wheel *N*. Upon the wheel *N*, two lugs are cast to form bearing for the wheels *L*, *L'*, through the first of which the power is transmitted to the wheel *O*, whilst *L'*, is an idle or at most balance wheel. The bevel wheel *K*, is the main driver of the arrangement. Being fixed to the shaft and revolving with it in the direction indicated, it turns the wheel *L*, as marked, this again causing the bevel to which the wheel *O* is cast, to revolve in the direction shown, which, it will be observed is opposite to the revolution of the main shaft. The wheel *N*, and those connected with it, are necessarily loose upon the shaft *M*, to admit of their revolution and variable movement in the opposite direction. If the bottom cone pinion *P*, was not moving, the rate of revolution transmitted from the bevel *K*, through the wheel *L*, to the bevel attached to the wheel *O*, would be exactly equal to that of the shaft *M*, upon which it is fixed. Thus the wheel *O*, driving the bobbins would revolve at the same rate as the wheel *P*, driving the spindles, only the revolution of the two wheels would be in opposite directions; and spindles and bobbins as a consequence, would revolve exactly at the same rate, in which state no winding could take place. The power to diminish or accelerate the rate of revolution is derived from the cones. As the wheel *N*, driven by the cone-

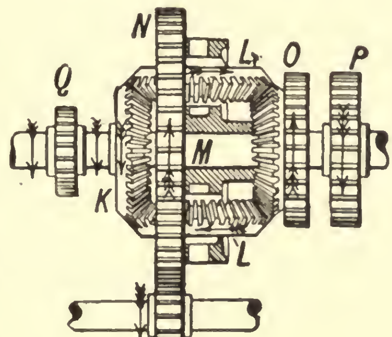


Fig. 84.

pinion revolves in the direction of its arrow, the speed of the wheel *L*, and its connection, the wheel *O*, are accelerated in exact ratio ; thus the excess speed of the bobbin over the spindle is obtained. At the commencement of a set the bobbin must run at its maximum rate, and the machine, therefore, begins its work with the cone-strap upon the largest diameter of the driving cone, and upon the smallest of the driven cones. With the deposit of every layer of rove upon the bobbin the strap is traversed a little distance from the largest diameter of the top cone and each successive change until with a full bobbin the minimum diameter is reached, giving the minimum rate of revolution to the bobbin. However, there is one defect in this device, which is that the whole of the differential mechanism revolves in a direction opposite to that of the shaft *M*, upon which it is carried. If we suppose that the shaft *M*, makes 450 revolutions per minute in the direction indicated by the arrow, and that the differential mechanism runs at the same rate in the opposite direction (as a fact it runs at a higher rate) the friction induced will be equal to that of a shaft running 900 revolutions upon a fixed bearing. This absorbs a great deal of power, exerts a severe strain upon the parts, and thus results in a great deal of wear and tear. The part to give way is necessarily the weakest link in the chain through which the power is transmitted. This is the cone-strap, and the trouble and difficulty experienced with it, is caused by its frequent stretching and slipping, producing inferior work as a result. Another cause of defective work

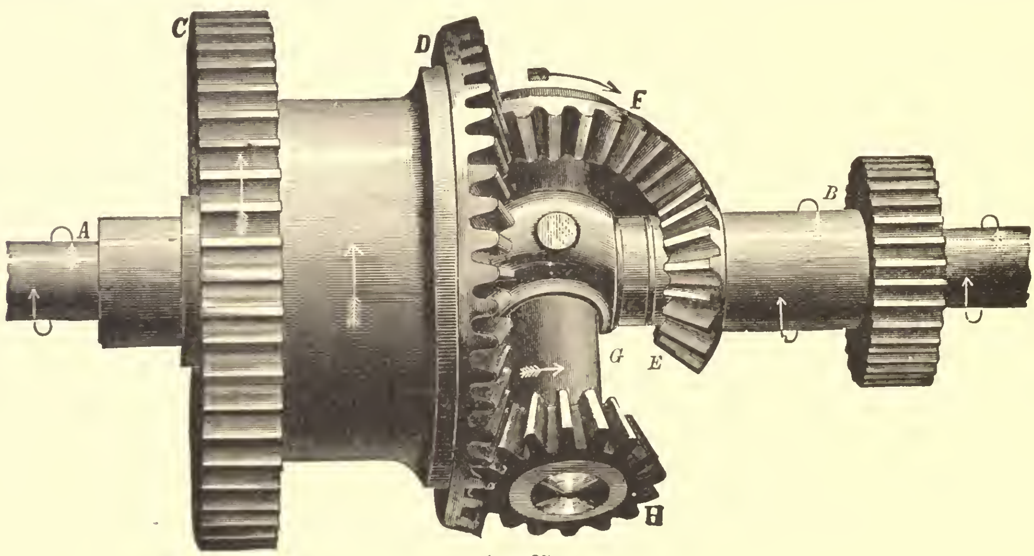


FIG. 85.

arises from the necessity of the jack-shaft being fixed in a position away from the centre of the lift, which causes the strand of fibres to become more slack at one end of the bobbin than the other; in order to prevent this it has been necessary to arrange the winding in such a manner that the strand is often stretched in the middle of the bobbin. An improvement over this device has lately been invented by Samuel Tweedale, of Howard and Bullough, and which is supplied by this firm to their slubbing, intermediate and roving-frames. (Figs. 78, 81.) It is known as the

New Differential Motion, and illustrated in its perspective view in Fig. 85. Letters of reference in this illustration indicate as follows: On the main shaft *A*, is cast a boss or cross-piece *G*, for the reception of, and to form a bearing for, the small cross-shaft carrying the bevel-wheels *F*, *H*. Loose on the shaft *A*, is the bell, or as it is sometimes called, the socket wheel *C*, which, through its connection, drives the bobbins. Attached to the wheel *C*, is the bevel wheel *D*. Beyond the cross shaft and loose upon the main shaft, is the wheel *B*, in connection with the lower cone-drum. Upon the extended boss of this wheel is cast the bevel wheel *E*, which gears into the bevel *F*. These constitute the parts of the new arrangement, the action of which is as follows: The shaft *A*, revolves in the direction indicated by the arrow, carrying the boss *G*, and the cross-shaft around with it. If no disturbing factor interfered, all the wheels geared together would, as we have also seen in Holdsworth's arrangement, revolve together, and no winding would take place, as the speed of the bobbins would be the same as that of the spindles. In this case, however, it is necessary to note that the revolutions of the various wheels are all in one direction, and thus entail no expenditure of power beyond that required to overcome the *inertia* of the various parts of the machine, and to maintain them in motion. We now, however, want the winding to be performed, and in order to do this the bobbins must revolve as before, faster than the spindles. As in the previous case, the differential power is obtained from the cone-drums, the bottom one of which through its connections drives the wheel *B*, which through its attached bevel *E*, working into the bevel *F*, on the cross shaft by means of the small bevel *H*, on its opposite extremity, accelerates through the bevel wheel *D*, the bell wheel *C*, driving the bobbins. This acceleration is to the extent of the motion it derives from the cones. With the commencement of a set, of course a bobbin starts at its maximum rate of revolution, whilst its rate is diminished by the shifting of the cone-strap in the usual way. It will be seen that in this arrangement the revolution of the shaft *A*, becomes a help to the cone-strap. The greatest strain put upon the strap is no more than is required to revolve the bobbin when at its maximum speed, about 100 revolutions per minute beyond those run by the spindles. The shaft helps to the extent of the number of revolutions it drives the spindles, the balance being the small burden of labor falling upon the cones, which is from 100 revolutions to nothing. It will be obvious that with such a light task the cone-strap will almost perfectly cease to be a trouble, or the cause of bad work. The new arrangement permits the jack shaft being placed in the centre of the lift, and so removing any defect in winding. The wheel upon the shaft of the bottom cone-drum has also been constituted a change wheel, which dispenses with all the bevel change wheels upon the top and bottom of the upright shaft in the old arrangement. The new wheel, being made of the same pitch as the twist wheel, enables a considerable reduction to be made in the number of change wheels required. The cones also are speeded, and a larger twist wheel has been introduced. Howard and Bullough have also embodied in their frames an improved method of lifting the cone-drum, by which it is locked in its working position, and all movement or vibration prevented. Connected with the same point is an improved method of tightening the cone-strap, by which the frequent relacing or buckling up of the strap is quite obviated. The cone-drums, by another improvement, can now be lifted and lowered from the front of the frame previous to winding back the strap, so that there is no necessity for the minder to go round to the back, as before.

Spinning.—The next process the roving undergoes is spinning; *i. e.*, reducing the dimension of the roving to the exact count required, besides putting in the proper amount of twist (warp or filling) to permit weaving. Three different systems of machinery for spinning are in use. The common *fly-throstle*, the *ring-frame* and the *mule*.

The Common Fly-Throstle.—This is the oldest system of spinning and was invented by Richard Arkwright. It is little used in this country, but very extensively in England and other parts of Europe. Fig. 86 illustrates the principle of this method of spinning. Letters of reference indicate as follows: *A*, spools containing the roving. From there the strand of roving passes over guide *B*, to and through the set of drawing rollers *C*, C^1 and C^2, where it is drawn out to the required counts. After leaving the front roller C^2, the strand of roving is passed to the *flyer D*, twined around one of its legs and passed to bobbin *E*, which rests upon the rail *F*, and has spindle *G*, passed through its centre. The flyer *D*, is fixed to the spindle; hence, when turning the latter, (*H*, section of tin roller extending from end to end and placed in the centre of the frame, and to which motion is imparted direct; *I*, spindle-band for transferring motion from roller to spindle) the flyer will turn correspondingly.

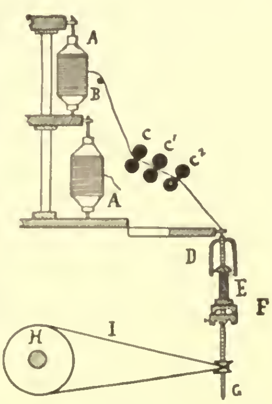


Fig. 86.

The bobbin *E*, only fits loosely around spindle *G*; hence no motion is imparted to it. When starting up the machine the roving after being drawn by the drawing-rollers to its required dimensions (counts) is next twisted by the flyer and wound on to the bobbin. The thread itself being of sufficient strength to bear the drag of the bobbin; the velocity of the bobbin is retarded by friction, which can be increased or decreased to any degree that may be required, and being thus held back, the thread by means of the motion of the flyer, drags the bobbin after it with a velocity equal to the difference between the speed of the flyer and the length of roving delivered by the front rollers. The rapid revolutions of the flyer puts the twist in the yarn. The bobbin *E*, resting on the rail *F*, is retarded by means of washers from revolving at the same speed as the flyers. The thread is wound on to the bobbin as fast as delivered from the front roller C_2 whilst the rail *F*, (*carriage*) raising and lowering by a regular alternate motion (*heart-motion*) fills the bobbin equally from end to end. The yarn produced by this method of spinning is very strong and smooth, and well adapted for warp yarns. The original name of this machine was *water-frame* from which is derived the name *water-twist* as still used nowadays for designating yarn spun upon the common fly-throstle.

FIG. 87.

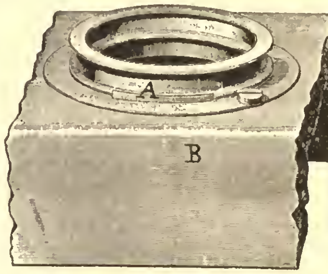


FIG. 88.

Ring-Frame.—This machine is an American invention and used for spinning warp yarns and less frequently for spinning filling yarns. England, and other manufacturing countries of Europe, take

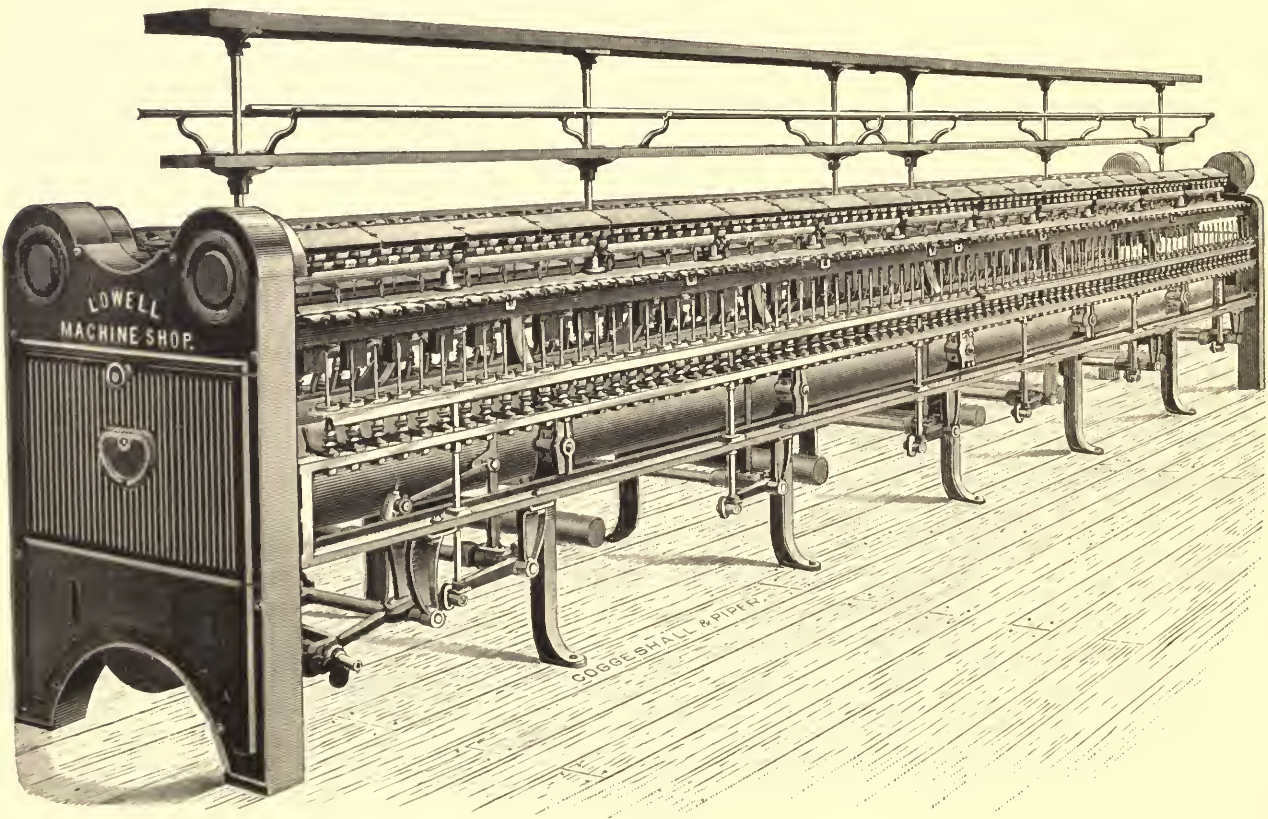


FIG. 89.

slowly to this system of spinning, hanging more or less to their old slow and expensive throstle spining explained in the previous chapter. The difference between the ring-frame and the fly-throstle consists in dispensing with the flyer and substituting a *ring* fastened in the *lifting rail*, which is made to traverse for the filling up of the bobbins. The drag, or the winding on, is produced by means of a small piece of flat steel wire, bent in a half circular shape with the ends turned in, as shown in Fig. 87, termed *ring-traveler* and which is dragged round on the top flange of the ring by the yarn passing between, on its way to the bobbins. Fig. 88 shows in perspective such a ring, *A*, as is fastened to the lifting rail (carriage) *B*. Ring-travelers are made of various sizes and used according to the counts of the yarn and the speed of the spindles. These travelers, as will be readily understood by the student, are subject to a great amount of wear, hence care must be taken to attend regularly to their lubrication. Fig. 89 illustrates the ring-frame as built by the Lowell Machine Shop.

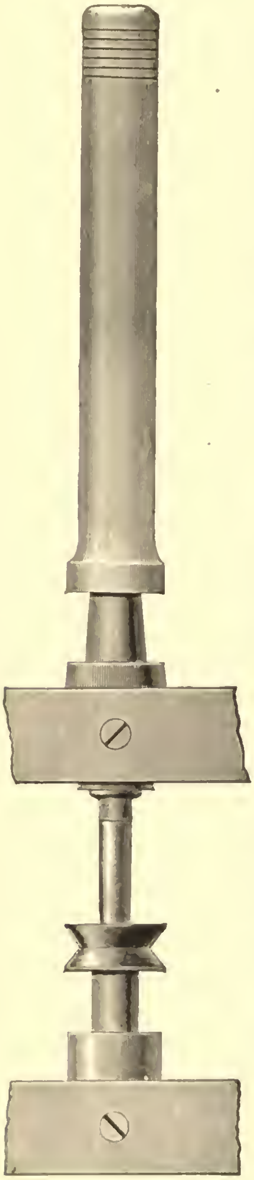


FIG. 90.

Spindles.—Of great importance for the manufacture of a good and evenly-twisted yarn is a good spindle. This has been ever since the invention of the ring-frame a constant study for the mechanics in the shops building this part of cotton machinery, as well as the overseers and their assistants of spinning mills. Patents by the hundred for spindles of all shapes and forms have been granted, most of the same not being worth the paper used for drawing up the description of the patent. The best and most widely known spindles used are the Sawyer and the Rabeth spindle; the latter which is built in several styles, each designated by a different name.

Sawyer Spindle.—This spindle was invented about eighteen years ago by J. H. Sawyer, of Lowell, and at the time of its introduction was regarded as a most important improvement in cotton manufacturing as Jenks' invention of ring spinning itself. It is gratifying to know that thus the entire ring spinning is a demonstration of American mechanics' skill. Fig. 90 is an elevation of the modern Sawyer Spindle, showing all the parts (bolster, step and bobbin) in working order. Fig. 91 shows all except the steel spindle itself in section. In the latter illustration letters of reference indicate as follows: *A*, is the spindle; *B*, the bolster, of bronze, screwed into the cast-iron bolster tube *C*, both tube and bolster being rifled so that when in operation oil is carried up from the oil-cup *D*, to lubricate the bolster bearing; *E*, the whirl, which is recessed on the lower side and forms a cover to the step *F*, in which the bearing for the foot of the spindle is of bronze.

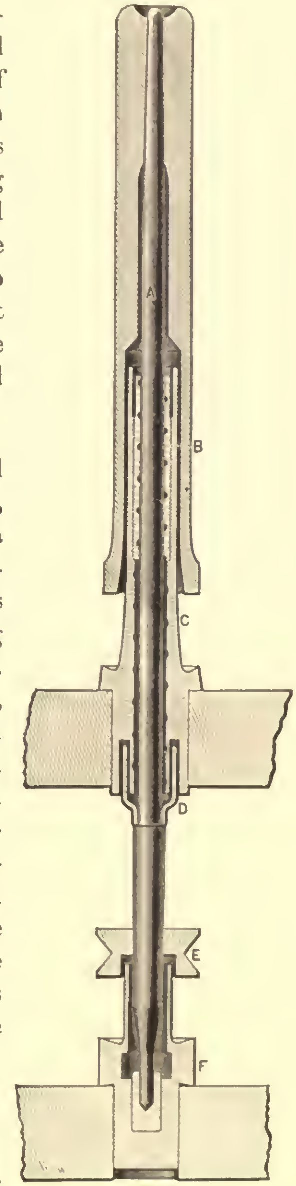


FIG. 91.

The Rabeth Spindle.—Is the invention of E. J. Rabeth, and came into public notice in 1878. Fig. 92 is an elevation showing all the parts in working order, and Fig. 93 shows all except the steel spindle itself in section. Both illustrations refer to the improved Rabeth spindle as built by George Draper and Sons, and known in the market as their No. 49 Rabeth spindle. This is a very light spindle for running at high speed, and is used very extensively in most of the mills.

The Sherman Spindle.—Fig. 94 is an elevation of it, and Fig. 95 is a section of all parts except the spindle. This is a form of the Rabeth spindle, and has a longer step set in a still longer bolster, which is hung or supported on an annular projection or shoulder in the bolster case. The bolster has sufficient play in its case to prevent any gyration of the spindle when it is running without the use of packing, and the bolster is locked at the top to prevent its turning around. The oil chamber is formed about and below the bolster and does not project as in the Rabeth spindle, but in other details the spindle is like it.

The Whitin Gravity Spindle.—This is another form of the Rabeth spindle and closely resembles the Sherman spindle, but having a longer step. The bolster is supported on a small piece of

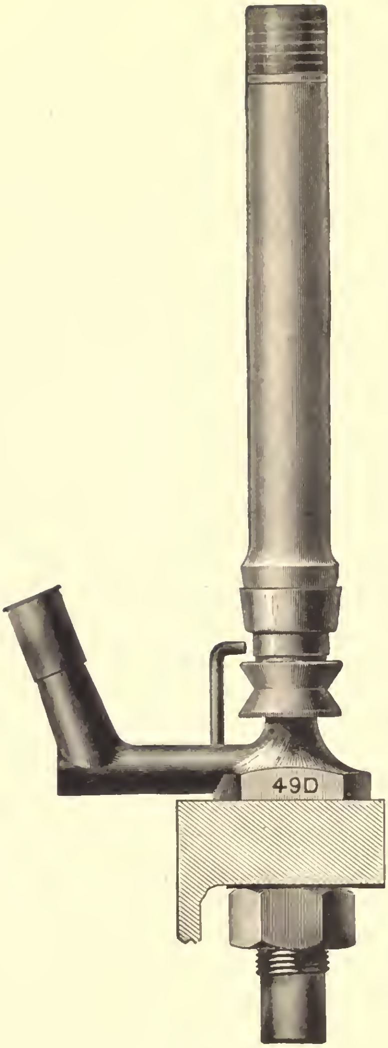


Fig. 92.

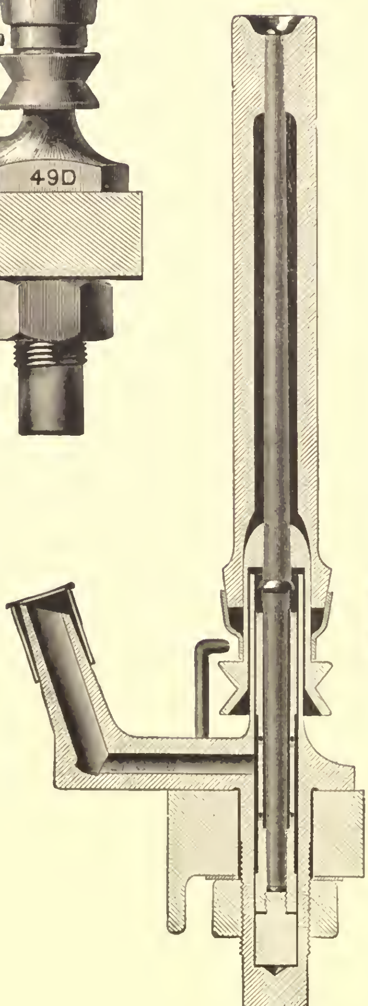


Fig. 93.

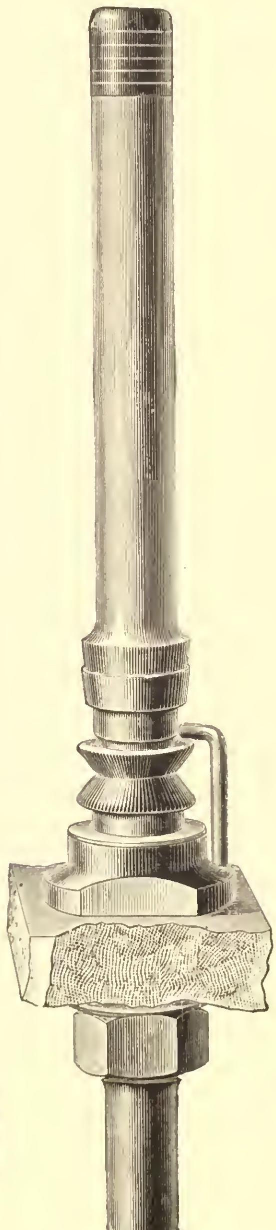


Fig. 94.

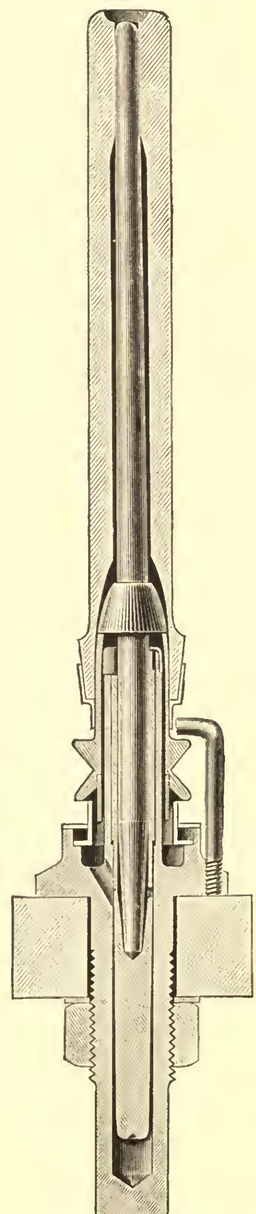


Fig. 95.

cork at its lower end; this cork support being designed to act as a cushion and prevent any jar or noise and further, to retard the movement of the base of the bolster when the spindle is running with an unbalanced load. An elevation of the complete spindle with filled bobbin is shown in Fig. 96, whereas Fig. 97 illustrates all parts except the spindle in section. Letters of reference in the latter illustration refer to the following parts: 1, bearing at top of bobbin (not to fit too tight); 2, adhesive bearing at lower end of bobbin; 3, centre of whirl and spindle bearing; 4, annular groove for oiling covered with a convex washer; 5, oil chamber; 6, space between bolster and bolster case (about $\frac{1}{500}$ part of an inch); 7, cork support; 8, chamber for dirt to settle in. All the four spindles thus explained are made by George Draper & Sons.

Fig. 96.

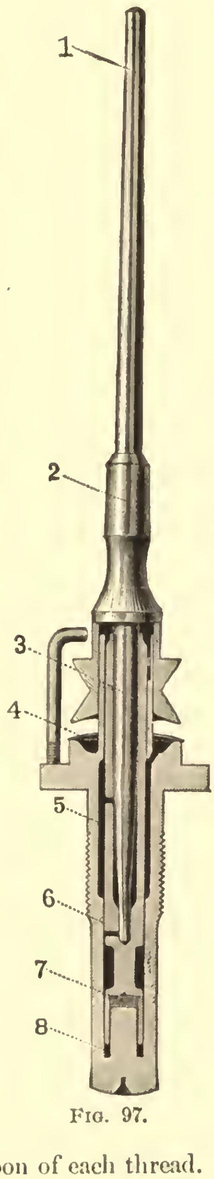


Fig. 97.

The Separator.—By means of the great velocity of the traveler in a ring-frame the roving-strand being twisted will by means of its centrifugal force *balloon* between the ring-rail and the guide. The faster the speed of the spindle, and thus also of the traveler, the wider the ballooning of the thread will be, and since the object or advantage of the ring-frame over the throstle is high speed, the ballooning of the threads will be such that each neighboring thread would meet and consequently break each other. To prevent this trouble the separator has been invented, its object being to keep under control; *i. e.*, keep separated the balloon of each thread. The most frequently used makes of this device are the *Doyle Separator* and the *Cummings Separator*.

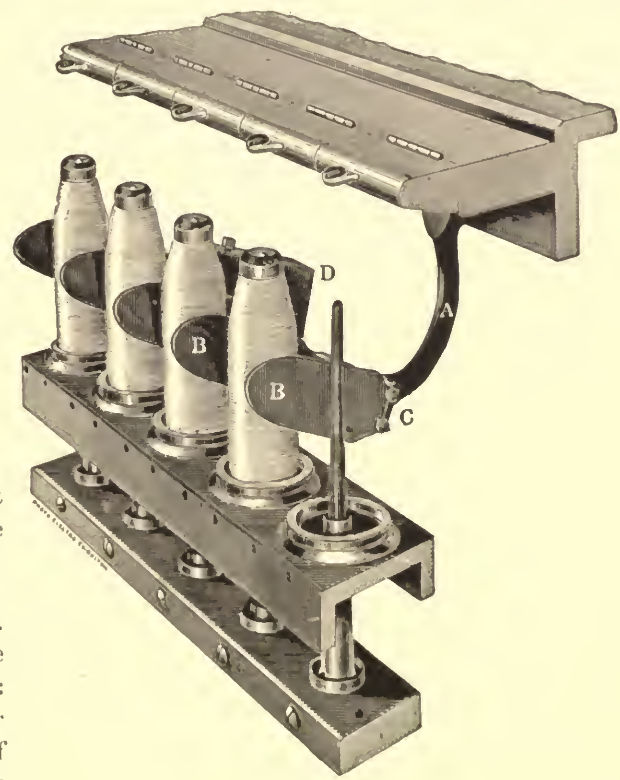


Fig. 98.

The Doyle Separator as shown in Fig. 98, is built by George Draper & Sons. The method of operating this device is as follows: Attached by bolts to the roller beam at proper intervals are stands *A*, supporting by means of hinged joints two parallel wires *C*, which carry the separators *B*. The latter are counterbalanced by means of weights *D*, so as to be easily moved by the rise of the ring-rail and thrown back under the thread board when the rail is at its highest point, and during doffing.

Cummings' Separator shown in Fig. 99, is built by the Lowell Machine Shop for either of their styles of ring-frames. The object of this invention is to obtain a separator for a ring-frame that shall prevent the ends from whipping together without putting any weight on the ring-rail. By referring to illustration it will be seen that the rails to which the separators are attached are connected by rocker-arms to a shaft. Motion is given to the separator rails by a cam attached to the end of the builder-shaft, and is so shaped that, while the separator-plates are always between the spindles when the ring-rail is so low that the ballooning of the threads would be sufficient to cause them to interfere with each other, if not prevented; the separator-plates themselves never come in contact with the ring-rail. It will readily be noticed that by the arrangement of the rods with the levers and the shaft, they cause the separator-plates on each side of the machine to move inward toward, and outward from the middle of the machine simultaneously, and by a single cam. When for any purpose it is desirable to remove the separator-plates from between the spindles, as it is in doffing, they are placed in their extreme backward position by means of the handle or otherwise, and retained there by the pawl that is

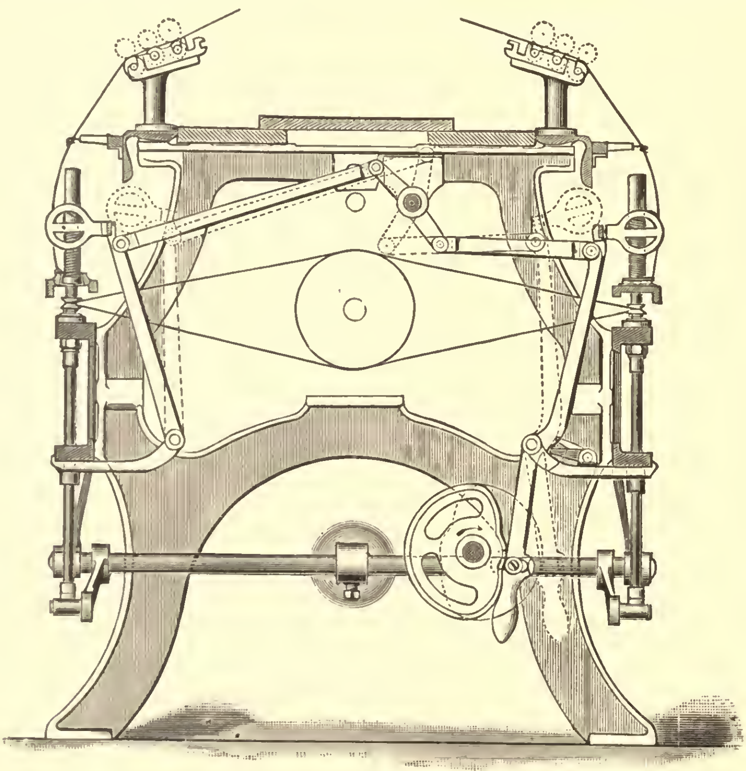


Fig. 99.

pivoted upon the pin, being raised to the position shown by the dotted lines. To replace the separator-plates in their normal position it is then only necessary to push the bar or any of its convenient attachments gently toward the middle of the frame, when the pawl drops into the position shown by the full lines, where it is entirely out of the way of the motion of the rocking-arm.

Stop-Motion for Delivery of Roving in Spinning Frames.—In spinning machines previously explained, the sliver passes to the feed-rolls, the drawing-rolls and delivery-rolls, and then through the guide-eyes to the traveler of the ring-frame or flyer of the throstle-frame. The partly twisted thread between the delivery-rolls and (cop, spool, or) bobbin frequently breaks, from various causes, and as the drawing-rolls continue to revolve, sliver is continually delivered, which cannot be spun or twisted, causing waste, as the so-delivered sliver has to be removed before piecing. The object of the stop-motion is to prevent this waste of sliver by severing the sliver back of the feed-rolls.

Our illustration, Fig. 100, is a sectional view of the drawing-roll portion of a spinning machine, showing the feed, the drawing and delivery-rolls, the guide-eye through which the sliver passes to the ring-traveler or flyer, and the automatic stop by which the delivery of the sliver is stopped when the end breaks. Referring to the drawing, letters of reference indicate as follows: *A*, the sliver; *B*, the feed-rolls; *C*, *D*, the drawing-rolls; *P*, guide-wire with the guide-eye through which the drawn-out sliver *E*, passes to the traveler of flyer. *F*, indicates a slightly over-balanced lever, pivoted on the rod or shaft *H*, and provided with the bent arm *I*, to which is attached the comb *S*, formed of a number of sharp-pointed pins, in two or more rows. The pins are formed of fine wire, bunched close together in alternate rows, so that the sliver cannot enter between the points, and one or more points must enter the sliver and the comb tear the same when it is presented to the moving sliver. The lever *F*, is provided with a finger *K*, which rests on the drawn-out sliver *E*, and supports the lever in its normal position. This finger may be either straight or hook-shaped. The operation of the device is as follows: To start up a frame the handle *M*, is moved in direction of the arrow *N*, partially revolving the rod *H*, to which levers *F*, and bent arm *I*, are properly secured, thereby elevating all the levers *F*, and with them all the fingers *K*, and depressing the bent arms *I*, carrying the combs *S*. Then the roving is passed through the feed-rolls *B*, thence through the drawing-rolls *C*, *D*, thence through the guide-eye *P*, to the ring or flyer, and then to the bobbins. The handle *M*, is then moved back to its normal position, when the device will assume the position shown in Fig. 100 in full lines, all the fingers *K*, resting upon the sliver *E*. When, now if one or more of the drawn-out slivers *E*, should break, the fingers *K*, will drop and with it the lever *F*, by reason of its being overbalanced, causing the bent arm *I*, to rise and with it the comb *S*, which will enter or break the roving strand *A*, so that no roving will be delivered to the rolls, hence no waste. The position assumed by the device when a thread or threads have been broken is clearly shown by broken lines in our illustration. In piecing up any individual breaks any one of the fingers *K*, can be individually raised by the operator and placed on the newly pieced sliver *E*.

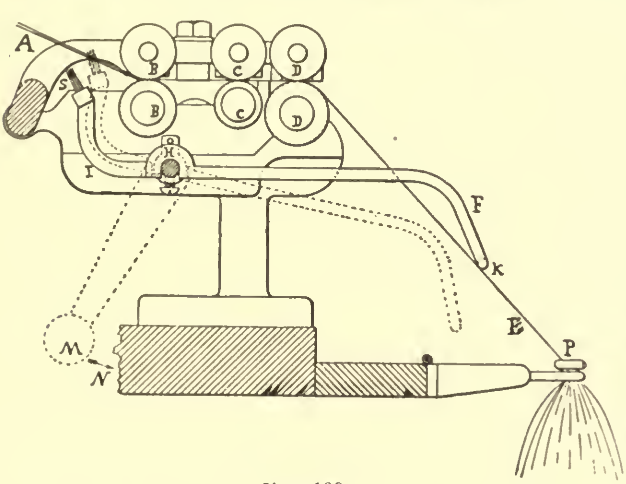


FIG. 100.

Tension-Regulating Device for Spindle-Driving Bands.—As mentioned previously, the spindles of the throstle and the ring-frame are driven (from a large tin roller extending in the centre throughout their entire length) by means of bands. If using separate bands for each spindle they will always stretch more or less (even if made of the best material). If some of these bands in a spinning-frame get slack, the respective spindles will consequently lose in speed by means of the slipping of the spindle band, producing in consequence soft bobbins. Again, if the entire set in a frame should get affected alike (by the weather, etc.,) the trouble would remain between the yarn spun with slack working driving bands and such yarn where the bands were tight. To prevent this trouble is the object of the present invention, its object being to provide tension regulating devices for all the driving bands in a spinning-frame. Fig. 101 is a plan view of a portion of a spinning-machine frame containing the spindles and driving-drum thereof, in which is shown an endless driving band applied to drum and spindles and the tension device arranged to act on the driving band. Fig. 102 is a perspective view of a portion of the frame and of the driving band and one band-tension device. The method of the operation of the tension device will readily explain itself by means of both illustrations. Letters of reference indicate as follows: *A*, portion of the frame of a common spinning-frame, supporting tin rollers, or driving-drum *B*, and spindles *C*. The driving band *D*, is an *endless band*; that is to say, it is a band of sufficient length to encircle the drum and all of the spindle whirls, and the ends thereof are united. It is made long enough to provide a slack portion, which is made to pass from each end-spindle of said machine under that portion of the band which drives the intermediate spindles, as shown in Fig. 101. The object in carrying this slack portion of the band under those parts extending between the drum and the spindles is to provide for a suitable engagement of the tension device therewith, whereby an even and regular tension is exerted upon the driving band. The tension device is constructed and attached to the frame of the machine as follows: In suitable proximity to the driving band is fixed by its lower end a vertical post, on which is placed a hollow post capable of a free reciprocating rotary movement. To the upper end of the latter post is rigidly secured one end of a horizontal arm, and to the opposite or free end of said arm is pivoted a pulley *S*, having a groove therein for engagement with the driving band of the spinning machine. The hollow post, previously referred to, and arm are actuated by a coil-spring applied to the hollow post. The lower end of the spring has an engagement with a fixed portion of the machine, having its upper end suitably extended and engaged with the arm which carries the pulley thereon, as previously mentioned. The action of said springs, as will be clearly understood, is such as to carry the periphery of the pulley with more or less force against the driving band. In practice, the coiled portion of the spring is made of such internal diameter that it fits somewhat loosely around the hollow post, in order that the tension of said spring against the arm may be varied by winding the spring around said post more or less in either direction, thereby varying the tension which is imparted to the driving band by the pressure of the pulley against it.

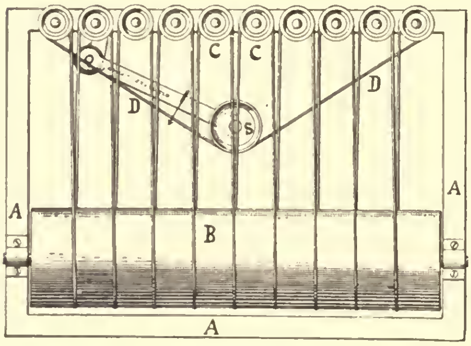


FIG. 101.

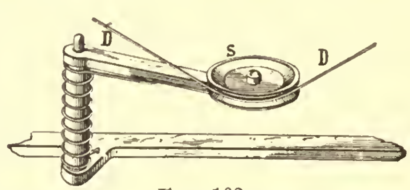


FIG. 102.

The Mule.—An illustration of this machine is given in Fig. 103. In this machine the roving *a*, as produced on the roving-frame is put up in a creel *b*, situated above and in the rear of the machine. The ends of the roving are then passed over guides to a series of sets of drawing-rollers *c*, and after passing the same on to the spindles *d*, which are placed upon open carriages *e*. This carriage runs (on tracks *g*), from the rollers *c*, while the thread is drawn out, stretched, and twisted and returns toward the rollers winding at the same time the thread on the bare spindle or tube as the case may be. This drawing and stretching principle of mule spinning produced in return a finer yarn, and on an average is more uniform in its counts than either the yarn produced by the throstle or ring-frame. The difference in the principle of spinning between mule spinning and ring or throstle spinning consists in that either of the two latter kinds of spinning exercises a continuous action upon the roving strand, drawing, twisting, and winding it upon the bobbin, whereas in mule spinning the mule draws and twists at one operation (during the *running-out* of the carriage) and then winds the entire length of the thus twisted yarn upon its spindles (during the *running-in* of the carriage). The roving as delivered by the rollers is frequently slightly thicker in some places than in others, and the thicker portions containing less twist in comparison to the finer places are consequently softer and will yield more readily to the stretching power of the mule; thus the twist becomes very equal throughout the yarn by means of mule spinning. The rollers delivering the roving are set for stopping to suit the staple of the cotton to be spun. The carriage travels from the rollers as fast as the drawn-out roving is delivered, the spindles during the movement revolve, imparting the twist to the yarn. The average speed of the spindles in the mule is 9,000 revolutions per minute on 30's yarn and higher counts, hence it will be readily seen that the spindle must be made of the best of steel and finished up with great accuracy. The amount of delivery of roving is regulated by the quality of the cotton, the size of the roving strand as well as the counts of the yarn required when spun. The rollers stop to deliver roving after a certain length has been given out, but the carriage continues to travel away from the rollers (according to staple of material), and the spindles go on revolving, even when the stretching is completed, and continue to revolve until the required amount of twist is put in the yarn. Only a small amount of twist is put in the thread

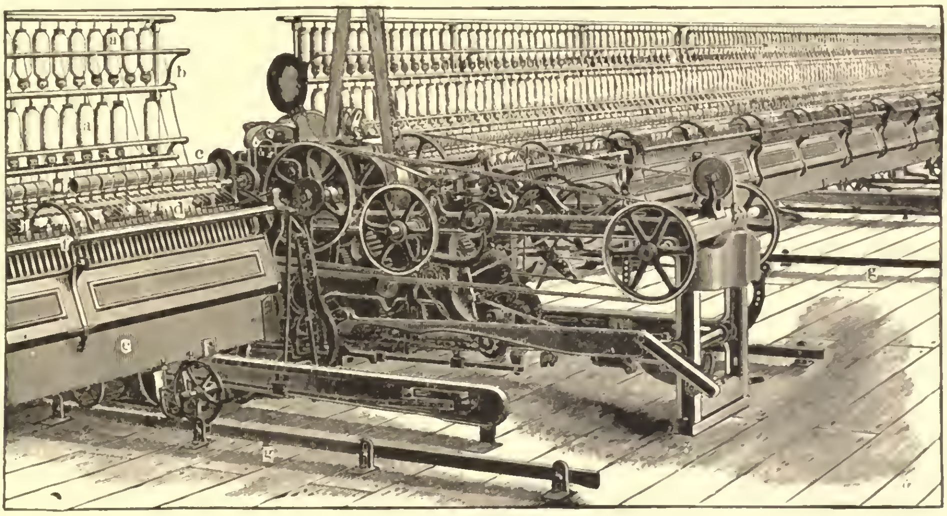


FIG. 103.

during the time the rollers deliver, just enough to keep the fibres united; thus a great amount must be put in after the rollers stop. The more we twist a thread, the shorter it will get, and if both ends of the thread are held during the operation, the more tension it will exercise upon itself. To reduce this tension toward the finish of the twisting operation the rollers are made to revolve slightly, thus delivering a small amount of roving (regulated according to amount of twist, count, and quality of yarn). When spinning long-stapled cotton, spinners frequently arrange the rollers to deliver about three inches roving during the travel of the carriage toward the rollers; *i. e.*, when the spun yarn is wound on the spindles (or tubes). This it is claimed greatly assists spinning as well as producing good yarn.

FIG. 104.

For guiding the threads to be wound on the spindles, or tubes in the shape (or building up) of *cops*, two movable guides known as *fallers*, see *f*, are brought into requisition. One is known as the under or *counter-faller*, with the wire beneath the yarn (about two and one-half inches below the spindle points), and the other is known as the upper or *winding-faller*, about one and one-quarter inches above the spindle points. The operation of these fallers is thus: When the carriage is run out to its outermost position, to the end of the *stretch*, and the required amount of twist is put in the thread, the driving strap of the carriage is automatically changed from the fast to the loose pulley, and the reversal of the tin roller causes the spindles to turn in an opposite direction, unwinding at the same time the spiral of yarn previously wound upon the spindle above the top of the cop thus far produced. The *backing-off* (running in) of the carriage now commences, at the same time the counter-faller rises, and the winding-faller is brought down, both wires coming in contact with the yarn, and acting against each other, regulating its tension and preventing it from slacking and thus from kinking. As already mentioned when the carriage runs in, the thread is wound upon the spindle or a tube, and this in the shape of what is known as a cop. The building up of the cop is done by the shaper. Fig. 104 illustrates the gradual building up of the cop. To allow for the increasing diameter of the cop, the successive layers of threads are wound in more open coils as the size increases (see broken lines in illustration) which is obtained by gradually increasing the range of the faller wires; at the same time the ends of the cop are made in the conical form shown in full lines in the illustration. In commencing to build up the cop on the bare spindle or tube the range of the fallers is such as to produce bobbins shown from *a* to *s*. The range then is gradually increased until the cop is built up to its full diameter, see *b*, *b*, when the range of the fallers is the widest building cop as shown by broken lines from *b* to *x*. From now the range of the fallers gradually diminishes until it arrives at a range corresponding to the building of bobbin shown in illustration from *c* to *o*.

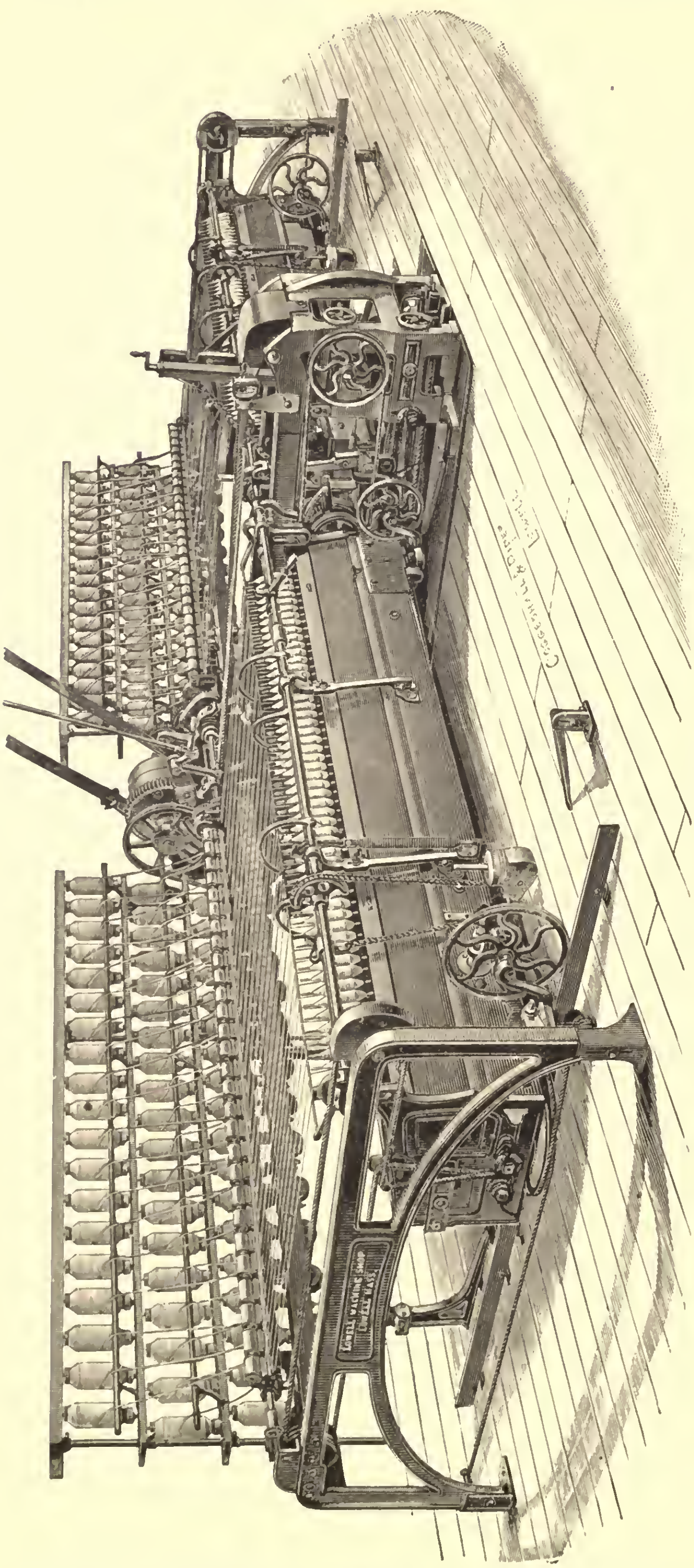


Fig. 105.

In Fig. 105 the mule as built by the Lowell Machine Shops is shown. Fig. 106 illustrates the *head-stock* of the mule built by Asa Lees & Co. This mule is technically known as *low head-stock*. Amongst the devices adopted in the construction of this mule we find: The *governing motion* for making the cop bottoms is self-acting; the quadrant nut ascends in the same ratio as the cop bottom increases in circumference producing an evenly wound bottom free from snarls. The *backing-off motion* consists of a cam shaped to imitate the spiral coils of yarn on the spindles. It brings down the faller wire in the same ratio as the yarn is unwound from the spindles, thus keeping it tight and free from snarls. The cam is governed by a loose incline on the *shaper* or *copping-rail*, which varies the backing-off as the building of the cop proceeds. *The backing-off chain tightening motion* is actuated from the copping-rail, and tightens the chain just previous to backing-off. As soon as the carriage commences to go in, it moves away from the tightening apparatus, and allows the chain to become perfectly slack at the unlocking. The patent connection of *drawing-out*, *taking-in* and *backing-off* levers prevents all possibility of two motions coming into gear at the same time. The act of putting the *taking-in motion* into gear disengages the *drawing-out motion,* and the putting of the latter into gear disengages the taking-in motion, and so forth, thus avoiding all breakages. The self-acting *belt-relieving motion,* is an ingenious arrangement for gradually moving the belt of the fast pulley as the outward run of the carriage is nearly completed; the belt by this means can be moved onto the loose pulley any distance before the long lever changes. The horizontal taking-in shaft is driven directly from the counter shaft by a rope (to which their patent tightening arrangement is applied) instead of by a range of wheels from the loose pulley. The self-acting *anti-snarling motion,* or *hastening motion* is automatic. It is actuated from

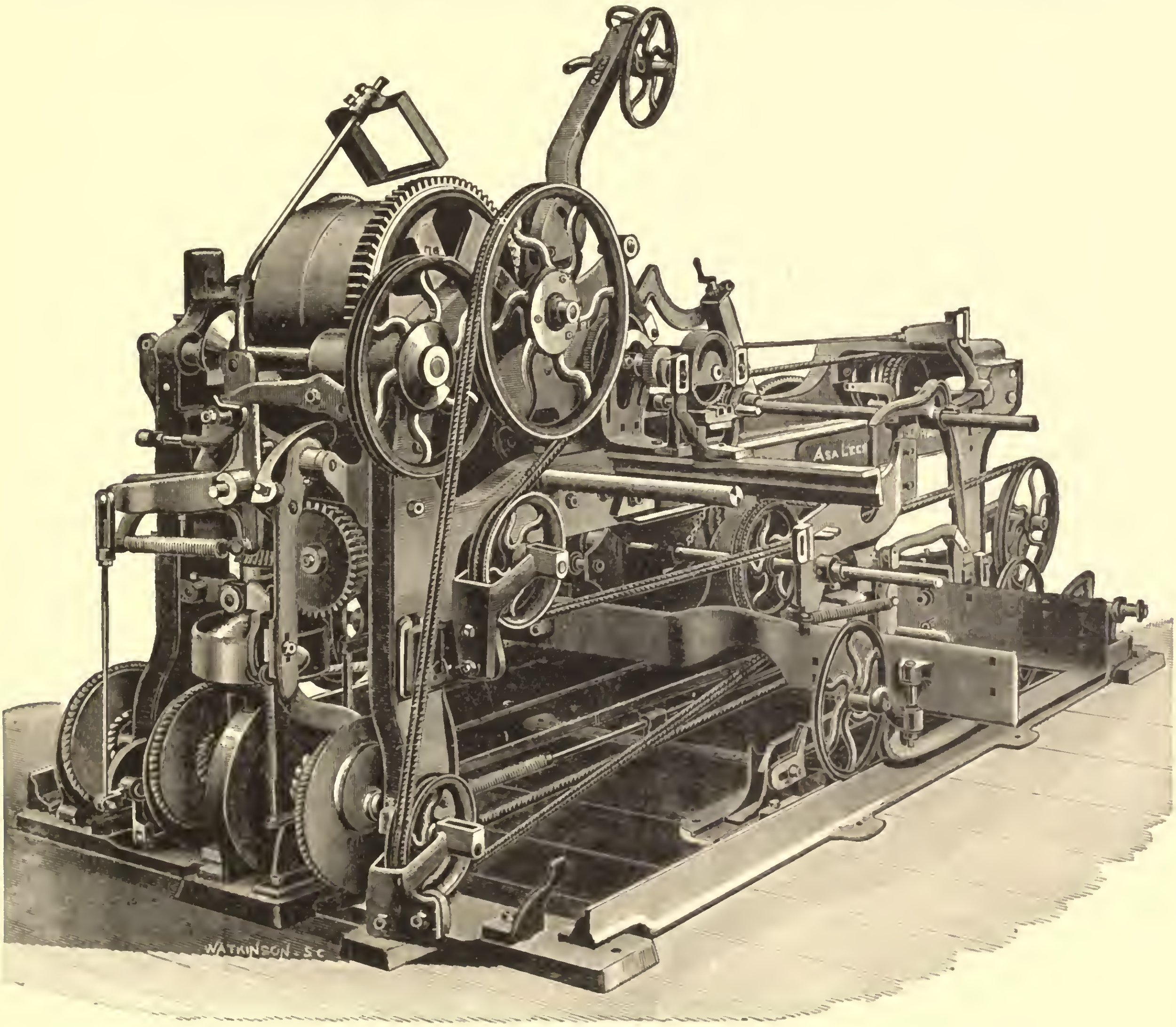


FIG. 106

the *copping motion,* and slightly increases the speed of the spindles at the end ot the draw. If a *snarl* is formed, this motion will throw the snarl onto the spindle point, when it will be taken out by the *drag.* The instantaneous *click-locking motion* operates with regularity upon the *winding-click* and puts it in gear, so that at the first move of the carriage the winding commences. This click although working simultaneously with the *faller-locking* is not connected with it, and consequently is never disturbed by the motion of the *boot-leg* as it commences to unlock. The patent full *cop-stopping motion* (which is of special value for spinning filling) stops the mule when the cops of any desired length are full, and then all the cops are always of the same size for which the *knocking-off* stud is set.

Table Showing the Square Root of the Various Counts from 1 to 200 with the Twist Per Inch for Different Kinds of Yarn.

Counts	√	Extra Warp Twist.	Warp Twist.	Extra Mule Twist.	Mule Twist.	Filling Twist.	Twist for Doubling.	Twist for Hosiery Yarn.
1	1.0000	**4.75**	**4.50**	**4.00**	**3.75**	**3.25**	**2.75**	**2.50**
2	1.4142	6.72	6.36	5.66	5.30	4.60	3.88	3.53
3	1.7321	8.23	7.79	6.93	6.50	5.63	4.76	4.33
4	2.0000	9.50	9.00	8.00	7.50	6.50	5.50	5.00
5	2.2361	10.62	10.06	8.94	8.39	7.27	6.14	5.59
6	2.4495	11.64	11.02	9.80	9.19	7.96	6.73	6.12
7	2.6458	12.57	11.91	10.58	9.92	8.60	7.27	6.61
8	2.8284	13.44	12.73	11.31	10.61	9.19	7.77	7.07
9	3.0000	14.25	13.50	12.00	11.25	9.75	8.25	7.50
10	3.1623	15.02	14.23	12.65	11.86	10.28	8.79	7.90
11	3.3166	15.75	14.92	13.27	12.44	10.78	9.12	8.29
12	3.4641	16.45	15.59	13.86	12.99	11.26	9.52	8.66
13	3.6056	17.13	16.22	14.42	13.52	11.72	9.91	9.01
14	3.7417	17.77	16.84	14.97	14.03	12.16	10.28	9.35
15	3.8730	18.40	17.43	15.49	14.52	12.59	10.65	9.68
16	4.0000	19.00	18.00	16.00	15.00	13.00	11.00	10.00
17	4.1231	19.58	18.55	16.49	15.46	13.40	11.33	10.30
18	4.2426	20.15	19.09	16.97	15.91	13.79	11.66	10.60
19	4.3589	20.70	19.62	17.44	16.35	14.17	11.98	10.89
20	4.4721	21.24	20.12	17.89	16.77	14.53	12.29	11.18
22	4.6904	22.28	21.11	18.76	17.59	15.24	12.89	11.72
24	4.8990	23.27	22.05	19.60	18.37	15.92	13.47	12.24
26	5.0990	24.22	22.95	20.40	19.12	16.57	14.02	12.74
28	5.2915	25.13	23.81	21.17	19.84	17.20	14.55	13.22
30	5.4772	26.02	24.65	21.91	20.54	17.80	15.06	13.69
32	5.6569	26.87	25.46	22.63	21.21	18.38	15.56	....
34	5.8310	27.70	26.24	23.32	21.87	18.95	16.03	....
36	6.0000	28.50	27.00	24.00	22.50	19.50	16.50	....
38	6.1644	29.28	27.74	24.66	23.12	20.03	16.95	....
40	6.3246	30.04	28.46	25.30	23.72	20.55	17.39	....
45	6.7082	31.86	30.19	26.83	25.16	21.80	18.44	....
50	7.0711	33.59	31.82	28.28	26.52	22.98	19.44	....
55	7.4162	35.23	33.37	29.66	27.81	24.10	20.39	....
60	7.7460	36.79	34.86	30.98	29.05	25.17	21.30	....
65	8.0623	38.30	36.28	32.25	30.23	26.20	22.17	....
70	8.3666	39.74	37.65	33.47	31.37	27.19	23.00	....
75	8.6603	41.14	38.97	34.64	32.48	28.15	23.81	....
80	8.9443	42.49	40.25	35.78	33.54	29.07	24.59	....
85	9.2195	43.79	41.49	36.88	34.57	29.96	25.35	....
90	9.4868	45.06	42.69	37.95	35.58	30.83	26.08	....
100	10.0000	47.50	45.00	40.00	37.50	32.50	27.50	....
110	10.4881	49.82	47.20	41.95	39.33	34.09	28.84	....
120	10.9545	52.03	49.30	43.82	41.08	35.60	30.12	....
130	11.4018	54.16	51.31	45.61	42.76	37.06	31.35	....
140	11.8322	56.20	53.24	47.33	44.37	38.45	32.54	....
160	12.6499	60.08	56.91	50.59	47.43	41.10	34.78	....
180	13.4164	63.72	60.37	53.66	50.31	43.60	36.89	....
200	14.1421	67.17	63.63	56.56	53.03	45.96	38.89	....

Doubling.—Doubling or twisting is the process by means of which two, three, or more threads are brought side by side and twisted in one thread. This work is accomplished on machines known as *twisters*, and which so closely resemble our spinning machines previously explained, that a special illustration is unnecessary. Thus we find twisters built: 1st, after the throstle-frame principle; 2d, after the mule-jenny; 3d, after the ring-frame.

Care must be taken that the direction for twisting two or more minor threads is in the opposite direction from the original twist the minor threads contain.

The rule for finding the (average) amount of twist to put in two or more ply twist is as follows: Extract square root for equivalent in single yarn, and multiply root thus obtained with 3¾ for warp twist, and 3¼ for filling twist.

Example.—Find amount of twist to put in 2/50's warp twist.

2/50 = 1/25; square root of 25 = 5. 5 × 3.75 = 18.75.

Answer.— 18¾ (practically 19) turns per inch.

Example.—Find amount of twist to put in 4/100's filling twist.

4/100 = 1/25 = 5, square root. Thus, 5 × 3.25 = 16.25

Answer.— 16¼ (say 16) turns per inch.

Example.—Find turns of twist required to put in 3/140's warp twist.

3/140 single 46.67's = 6.8313, square root. Thus, 6.8313 × 3.75=25.617375.

Answer.— 25.6 (say 26) turns per inch.

When the yarn as required twisted is wanted to curl it is usual to add about 20 per cent. Thus, using the last example, the answer would be found as follows:

25.61 original answer.
+ 5.12 (20 per cent. for curl).
30.73

Answer.— 30.73 (practically 31) turns per inch are wanted.

For *knitting yarns,* which are required to be soft, the amount of twist required is found by multiplying the square root of the equivalent counts in single yarn by 2½; for *crochet yarn,* and also for *embroidery cotton yarns,* multiply by 2. The result in each instance being the turns of twist required per inch.

Twister Built upon the Throstle-Frame Principle.—This twister is the throstle-frame modified by adding a creel for the reception of the bobbins containing the single yarn and exchanging the three or four pairs of drawing rollers for one large pair of rollers. On top of the frame (see illustration of wet spinning frame in chapter on flax spinning) is a zinc trough containing water which is heated by suitably arranged steam pipes. Through this hot water the single ends, (delivered from creel) are passed and then guided between the previously referred to pair of rollers which extract any superfluous water. As many ends as are required to be twisted into one thread are afterward run together under one section part of the upper roller, and from there passed to the respective flyer, and then to the bobbin. For wet doubling, the rollers are covered with brass, whereas for dry doubling the common rollers can be used. The legs on the flyer are drilled upwards and have each a brass wire curl soldered in the holes which can readily be changed when the curl is worn out.

Twisters Built upon the Mule-Jenny Principle.—These machines are known as *twiners* and the difference between yarn twisted upon such a machine, compared to the method previously explained, is about the same as spinning the single yarn either on the mule or the throstle-frame; *i. e.*, the thread twisted on a twiner will be more wooly in appearance. The twiner is, as previously mentioned, a modification of the mule, or actually a return to the principles of Hargreave's Jenny. It resembles a mule in which the carriage containing the spindles is fixed stationary the reverse way of a mule carriage, while the creel, containing the threads to be twisted, consists of a traversing carriage which retires from the spindle bank, while the length of yarn to the extent of its traverse is being twisted. After sufficient twist is put in the stretch the traversing carriage returns to its original position winding the twisted yarn during the *running-in* by means of *faller-guides* upon the spindle. Mules, when getting rather poor for good spinning, but still too good for breaking up, are frequently converted into twiners by substituting lead weights in place of the rollers, and placing a twiner creel at the back for fine yarns; or for coarse yarns, winding the yarn two-fold upon bobbins. Twiners are mostly used for twisting yarns in a dry state.

Ring-Frame Twister, or Ring-Twister.—This is the most frequently used twister in this country, and which is also growing more into favor in England and the European continent, in place of the previously explained two styles of twisters (throstle-twister and twiner). What is mostly in favor of the ring-twister, compared to the other styles of twisters, is the amount of production, and the even twist. The ring-twister is also modified after the ring-frame, simply adding the proper creel, as well as substituting for the three pairs of drawing-rollers one single pair of heavier rollers. Fig. 107 illustrates the ring-twister as built by the Hopedale Machine Company.

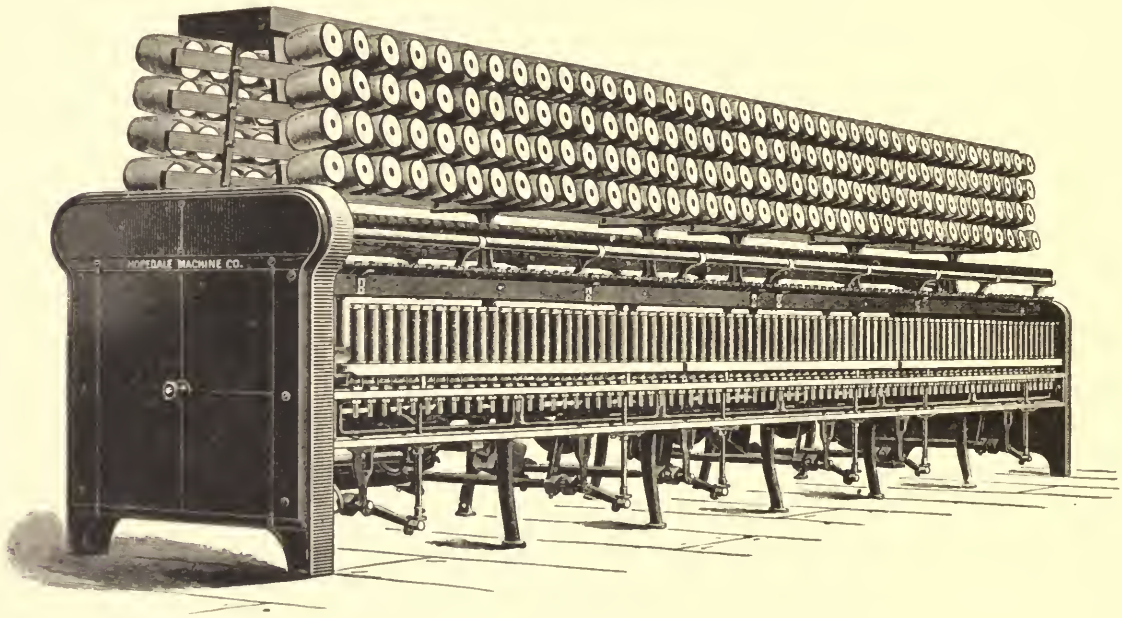


Fig. 107.

Gasing.—The object of gasing cotton threads, double or more ply, is to singe off all the loose fibres extending outside of the main thread, thus producing a very smooth yarn. The process is done on a *gasing machine*, which winds the thread from one bobbin to another; during the travel the thread passes through a very small jet of gas. The greatest uniformity of speed in winding these bobbins is required to produce perfect work; *i. e.*, not to burn the thread in some places nor to singe it insufficiently in others. When a thread breaks or a bobbin runs out, the corresponding gas jet is put aside automatically, and returns similarly when the running of the thread is arranged again.

Polishing.—In this process the yarn is automatically stretched in the *yarn-polishing machine*. When in this stretched position a size, made out of beeswax, starch and other ingredients, is applied. The yarn thus finished has a beautiful silk-like gloss, besides having increased both in length (by means of stretching) and in weight (by means of the size applied). Gasing and polishing are two processes, each of which is only used for special yarns, the regular yarns are not subjected to either process.

Wool.

Wool is the hairy covering of several species of *mammalia;* it is softer than the actual hair, also more flexible and elastic, besides having a wavy character. Many of the mammalian animals have both wool and hair in their covering and only in a few species (chiefly of the sheep) more wool than hair is found. Amongst the wool-producing mammalian animals besides the sheep are the Angora goat, the Cashmere goat, the Llama, the Alpaca, the Vicugna, etc. No doubt in its original wild state there has been less wool in proportion to hair in the covering of the sheep, but under the influence of domestication the hair has largely disappeared and wool has taken its place.

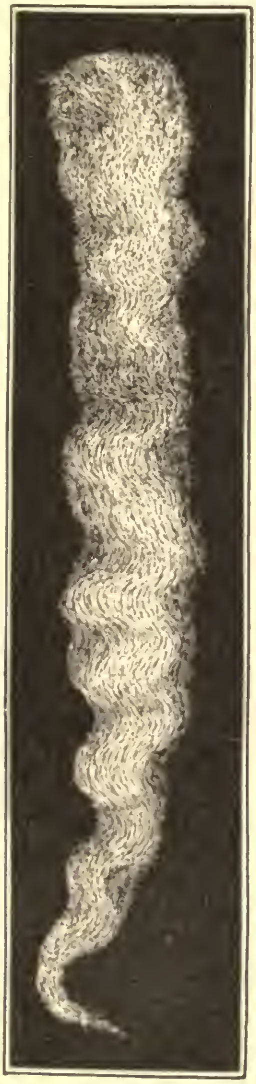


Fig. 108.

Fig. 109

Surface Structure.—Wool as compared to hair is characterized by the surface structure of the fibre which enables the former to be more readily matted together. To illustrate this peculiarity in the structure of the wool, Figs. 108 to 112 are given. Wool-fibres do not grow independently on the body of the animal bnt grow in little locks which is due to the curliness of the fibres. Fig. 108 illustrates such a lock of wool and shows clearly the previously mentioned wavy appearance. Diagram Fig. 109, illustrates a single fibre taken from the previously shown lock which readily shows the most regular series of curves technically known as the *wave of the crimp.* Diagram Fig. 110 illustrates such a single fibre greatly magnified. By means of this illustration we see that it is a cylinder whose surface is covered with imbricated scales or *serrations* pointing from the root to the tip, (as clearly shown in Figs. 111 and 112) an appearance similar to the edge of a saw. The serrated surface of wool was discovered by M. Monge and mentioned by him in *Annales de Chimie* in 1795. These scales or serrations are only attached by their bases which is demonstrated in Fig. 111, illustrating a fibre bent. The scales are free to about two-thirds of their length and to a certain extent turned partially outward. If placing two fibres near each other; *i. e.*, with their scaly cylinders arranged reverse way, (see Fig. 112) they will when drawn along over each other interlock their scales, serration into serration, and thus become united by the wedged edges of the scales entering into the spaces between the scale and the shaft of the opposing fibre. The tenacity with which they can hold together is regulated by the respective strength of the fibres.

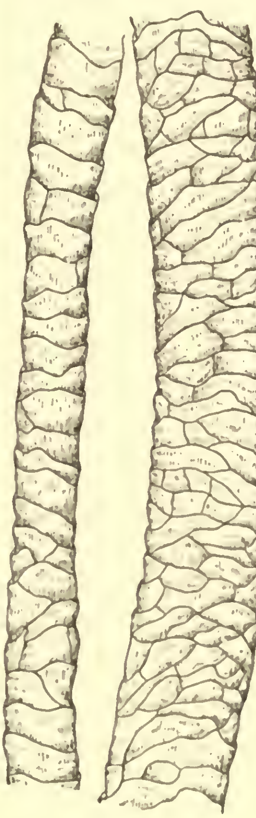


Fig. 110.

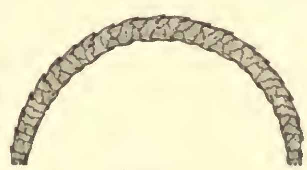


Fig. 111.

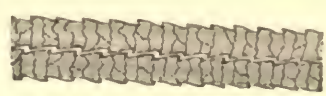


Fig. 112

Felting Properties.—This serrated or toothed surface confers upon wool its felting property, since during the process of carding the wool, the fibres are mixed up and twisted in all possible directions, and the points of the scales projecting as so many small hooks hold the tangled mass closely and firmly together. The felting properties of wool are also greatly increased by the wavy structure of the fibres, which will press the serrations of the one fibre as close as possible into the serrations of other fibres. This will explain that the fulling or felting quality of wool is determined by the amount of serrations per inch in the fibres, since the absence of such serrations would imply a fibre of little or no fulling properties. These scales are very minute and numerous; for example, in a fine Saxony wool there are not less than 2700 scales per inch found in each fibre. In the fibres of the varieties of the common sheep (*Ovis rusticus*) we only find from 1500 to 2000 of those scales in every inch. Upon the whole surface of a fibre of Saxony wool one inch long and $\frac{1}{750}$ of an inch in diameter there are over 23,000 of those minute points of scales to be found. In the finest grade of our domestic merino it is claimed that there are about 6000 of these scales per inch of fibre. In wool, when on the body of the animal, the serrations of the fibres are naturally all pointing in the same direction, hence the chances for felting when on the animal are little if any. The great amount of dirt and grease filling up the serrations of the wool fibre when the latter is on the animal also prevents any possible chance of felting. From explanations given it will thus be readily seen why woolen cloths can be felted, fulled, or milled. The serrations of the fibres, after being previously cleaned or scoured, fitting into each other, will lock fast under the pressure of the fulling process, hence the fabric composed of separated threads will appear after fulling as a solid felt. The process of fulling, as no doubt is generally known, is carried on when the cloth is wet. Warm water, if not injurious to the colors, will assist fulling to a greater extent than cold water. The reason for wetting the cloth in the process of fulling is: the wool fibres are composed of endless numbers of small dried up cells composed of a soft gelatinous membrane, and when put in hot water (for even cold water will heat during the fulling operation) those cells will become soft and expand. In this state, during the fulling process, they are pressed as closely as possible together, and thus actually, one might say, the fibres are glued together uniting in this manner all the different threads of which the cloth is composed in a solid mass. During the fulling operation the individual threads will shrink in their length, which is also a well known fact to the manufacturer. The cells of the wool fibres, after being once softened, do not return to their former state when dry, they shrink into each other, and the threads get heavier in size, a (practical) point that must be well examined and studied when ascertaining the counts of yarns in a finished sample of cloth, given for analysis. The felting properties of the wool fibre make the cloth as produced out of it the most advantageous article for clothing, since after the cloth is fulled the air cannot so easily penetrate, hence the human body is well protected against any influence of the change of climate. The wool fibre is not hollow or tubular but full of cells, and consists of three portions: First, the scales; second, the cortical substance which is the thickest portion of the fibre, and also contains the coloring matter. It is fibrous and striped lengthways. The third or central portion of the fibre is the medullary sub-

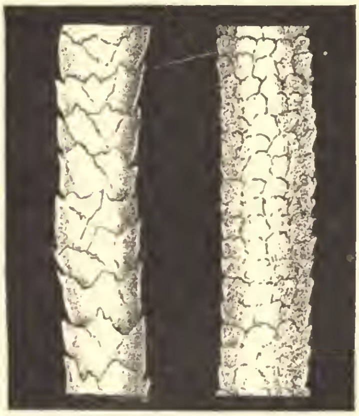


FIG. 113. FIG. 115.

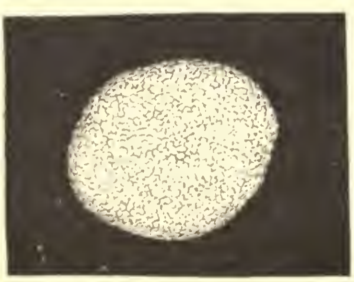


FIG. 114.

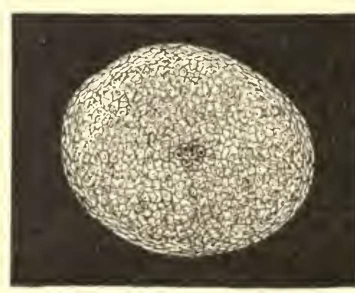


FIG. 116.

stance or marrow which occupies a narrow and irregular cavity. The last mentioned portion is not found in all wool fibres.

Comparing Hair and Wool.—Examining the actual hair (since wool is only a variety of it) under a powerful microscope, we find the same lies straight and even and presents a comparatively smooth surface compared to the serrated surface of wool fibre. To illustrate to the student the difference between hair and wool fibre (as visible by means of the microscope) Figs. 113, 114, 115 and 116 are given. Fig. 113 represents a wool fibre, treated with caustic soda and Fig. 114 shows the transverse section of a wool fibre. Fig. 115 represents a hair (human) also treated with caustic soda so as to show the serrations distinctly. Fig. 116 shows the transverse section of it.

The Natural Color of Wool, and the one in which the same is most generally found is white, in less quantities we find brown, black, gray, red, or a bright yellow. Some of the colors, for instance the yellow, are due to the nature of the sheep, whereas others are due to the soil. Feeding the sheep on rich grass lands generally produces a pure white wool. With regard to its value the color is of less consequence, except if required for white or bright colored yarns or fabrics. Wool is also an excellent absorbent of color; for example, aniline colors can be fixed on wool by simply bringing the wool in contact with the liquid containing the coloring matter.

Length, Crimp and Fineness.—Wools are naturally divided into long and short, coarse and fine, and it is therefore natural that these properties should also be discussed in connection with each other.

Length of Staple.—According to their length, technically, length of staple, wools are graded as previously mentioned, in two principal grades known as *long-stapled* and *short-stapled* wools. Until late years the long-stapled wools were used for the manufacture of worsted yarns, but which is not essential any more, since the machinery for the manufacture of these yarns is at present such, that short-stapled wools can also be made into worsted. Short-stapled wools are generally used for the manufacture of woolen yarns, but as previously mentioned, some can also be spun in worsted yarns.

Crimp and Fineness.—There prevails a popular belief amongst manufacturers and dealers in wool, that the *fineness in the crimp* corresponds in all cases with *fineness in the fibre*, and while there are more or less exceptions to this belief to be found, yet in an average taken, the same is not wholly unjustifiable. Such a relation does exist in very many instances, but it is by no means universal, and therefore cannot be accepted as a rule for determining the fineness of the fibre.

The instrument most frequently used for counting the crimps in a given length of fibre (one inch or parts of an inch) consists of a series of steel plates attached to a brass disk. Each plate is notched on the edge with a number of notches for a given distance, which corresponds with the average number of crimps found in the same distance in the fibre of wools of the different grades. Grasping the instrument by a small knob in the centre by one hand, and with a strong magnifying glass in the other hand, each of the notched plates is successively placed over the sample under examination. The plate in which the notches correspond with the crimps of the fibre, thus readily indicates the number of crimps per inch.

As a rule, the coarser fibres have fewer crimps per inch than the finer ones, yet the crimp of the fibre cannot always be accepted as a guide of the absolute degree of fineness. This can be seen by making a few comparisons; and notwithstanding considerable importance is attached to it among the breeders, and as it is often used by dealers and graders in making their classifications based upon fineness, its true relation has been thoroughly recognized by those who have made a careful scientific examination of the staple. To demonstrate these relations between the diameter of the fibre and the length of the weave in the crimp, we thus quote a table given by W. v. Nathusius-Königsborn, in his "*Das Wollhaar des Schafes in histologisher und technisher Beziehung.*" He has given in this table metric measures, and we refer the reader to the tables at the back of this book for changing the same to measures used in this country.

Number of Sample.	Diameter.	Length of Wave.
	Centimillimeters.	Millimeters.
25	1.53	1 76
16	1.54	1.50
17	1.69	1 61
14	1.79	1.28
13	2.02	1 50
18	2.07	1 55
15	2 21	1 46
21	2.21	2 00
26	2.24	2 60
19	2.76	2.03
20	2 81	1.61
22	3 14	2 76
23	3.40	3.60
24	4.16	2.01

The length of the wave in the crimp of the fibre thus cannot be accepted as a reliable indication of fineness, and other means must be adopted for determining this latter quality, and concerning which (with reference to our American wools at least) there has been a marked demand for information. Distinction in the fineness of the fibre may be determined after practice or experience by sight and touch, but classifications made in this way, have given rise to perplexing disputes because of the naturally wide variations of individual appreciation and judgment. The many systems of measurements devised and applied at different periods among the German and French investigators clearly illustrate the difficulty of arriving at satisfactory results in this work, even by methods other than those just indicated. The principal difficulty consists in the fact that the wool fibres are not exactly cylindrical, as shown previously in Fig. 114, illustrating the cross section of a wool fibre. Generally their sections are of an oval or irregular shape, and the measurements would vary accordingly to positions of fibres, when measurements are taken. The different systems adopted for ascertaining the fineness of the fibre are very numerous, each one has some merit, as all have been more or less extensively employed. These systems are fully described in J. Bohm's "Wollkunde," for which we refer the reader for more detailed information concerning them. Bohm classes the systems and instruments as: first, those requiring the use of the microscope; and second, those not requiring the use of the microscope. Each division he again subdivides in the process of measuring single fibres, or the process of measuring several fibres at the same time. Those involving the use of the microscope are Dollond's, Pilgram's, and Daubenton's; Nathusius's, and Bohm's for measurement of single fibres; Voigtland's and Winkler's for simultaneous measurements of several fibres. Those used for measuring single fibres without the use of the microscope are Lerebour's, Skiadam's, Grawert's, and Thaer-Klinert's; whereas the Köhler instrument is used for the measurement of a bundle of fibres.

It has not been the custom in this country to base the commercial grades of wool upon the fineness of the fibre, as is the practice in Germany. To illustrate this subject of grading as is the custom in that country, the tables given by the leading authorities on the subject (Bohm, Jeppe and Wecherlin) are presented. Bohm gives the number of crimps per inch corresponding with the different grades of fineness in the following table:

Grade.	Number of Crimps Per Inch.	Measurements of Fineness. In Centimillimetres.	In Thousandths of an Inch.	In Fractions of an Inch.
Super electa plus plus	*32	1.25 to 1.50	0.4921 to 0.5905	$\frac{1}{2031}$ to $\frac{1}{1693}$
Super electa plus	30 to 32	1.50 " 1.65	0.5905 " 0.6496	$\frac{1}{1693}$ " $\frac{1}{1587}$
Super electa	28 " 30	1.65 " 1.775	0.6496 " 0.6988	$\frac{1}{1587}$ " $\frac{1}{1430}$
Prima electa	26 " 28	1.775 " 1.90	0.6988 " 0.7480	$\frac{1}{1430}$ " $\frac{1}{1336}$
Secunda electa	24 " 26	1.90 " 2.03	0.7480 " 0.7885	$\frac{1}{1336}$ " $\frac{1}{1267}$
Hohe prima	23 " 24	2.03 " 2.225	0.7885 " 0.8759	$\frac{1}{1267}$ " $\frac{1}{1141}$
Prima	21 " 23	2.225 " 2.40	0.8759 " 0.9448	$\frac{1}{1141}$ " $\frac{1}{1058}$
Geringe prima	20 " 21	2.40 " 2.54	0.9448 " 0.9999	$\frac{1}{1058}$ " $\frac{1}{999}$
Hohe secunda	19 " 20	2.54 " 2.666	0.9999 " 1.0496	$\frac{1}{999}$ " $\frac{1}{952}$
Secunda	17 " 19	2.666 " 2.90	1.0496 " 1.1417	$\frac{1}{952}$ " $\frac{1}{875}$
Geringe secunda	16 " 17	2.90 " 3.175	1.1417 " 1.2499	$\frac{1}{875}$ " $\frac{1}{799}$
Tertia	13 " 16	3.175 " 3.70	1.2499 " 1.4566	$\frac{1}{799}$ " $\frac{1}{686}$
Quarta	0 " 13	3.70	1.4566	$\frac{1}{686}$

* And above.

Jeppe gives the following classification and value:

Grade	Measurements of Fineness.								
	In Centimillimetres.			In Thousandths of an Inch.			In Fractions of an Inch.		
Super Electa	1 65	to	1 90	0.6496	to	0 7480	$\frac{1}{1539}$	to	$\frac{1}{1338}$
Electa	1.90	"	2.09	0.7480	"	0.7909	$\frac{1}{1338}$	"	$\frac{1}{1264}$
(1) Prima	2.09	"	2.15	0 7909	"	0 7983	$\frac{1}{1264}$	"	$\frac{1}{1260}$
(2) Prima	2 15	"	2.58	0 7983	"	0 9960	$\frac{1}{1260}$	"	$\frac{1}{1003}$
Secunda	2.58	"	2.66	0 9960	"	1.0496	$\frac{1}{1003}$	"	$\frac{1}{953}$
Tertia	2 66	"	3 29	1 0496	"	1.2952	$\frac{1}{952}$	"	$\frac{1}{771}$
Quarta	3 29	"	4 05	1.2952	"	1 5767	$\frac{1}{771}$	"	$\frac{1}{634}$

And Welcherlin gives the following:

Grade.	Measures of Fineness								
	In Centimillimetres.			In Thousandths of an Inch.			In Fractions of an Inch.		
(1) Super Electa			1 26			0 4960			$\frac{1}{2016}$
(2) Super Electa			1.52			0 5984			$\frac{1}{1670}$
(1) Electa	1.52	to	1.77	0 5984	to	0 6968	$\frac{1}{1670}$	to	$\frac{1}{1434}$
(2) Electa	1 77	"	2.08	0 6968	"	0 7885	$\frac{1}{1434}$	"	$\frac{1}{1267}$
(1) Prima	2 08	"	2.28	0 7885	"	0 8976	$\frac{1}{1267}$	"	$\frac{1}{1113}$
(2) Prima	2.28	"	2.53	0.8976	"	0.9960	$\frac{1}{1113}$	"	$\frac{1}{1003}$
Secunda	2.53	"	2 785	0.9960	"	1 0964	$\frac{1}{1003}$	"	$\frac{1}{911}$
Tertia	2.785	"	3.04	1 0964	"	1.1826	$\frac{1}{911}$	"	$\frac{1}{845}$
Quarta	3.04	"	3.54	1 1826	"	1 3936	$\frac{1}{845}$	"	$\frac{1}{717}$

Elasticity.—A superior feature of wool compared to other fibres is the great amount of elasticity the former contains. This no doubt is due in a great extent to the wavy character, and also to the nature of its structure. To illustrate this, compress some cleansed, dry wool in your hand; after opening the hand the wool will again slowly expand to its former position. The glossiness, technically *lustre*, of wool is manifold and as a rule, straight, smooth, harsh wools have more lustre compared to soft curly fibres. The flatter the scales of the fibre are the more the lustre of the wool.

The Chemical Composition of Pure Wool is:

49.25	per cent	carbon.
23.66	"	oxygen.
15.86	"	nitrogen.
7.57	"	hydrogen.
3.66	"	sulphur.
100	per cent.	

Trueness.—Under *true* or even fibres, we classify those having a nearly uniform diameter throughout their entire length, whereas fibres wanting this character are termed *untrue* or uneven. The latter is the result of two causes, the one *atrophy* of the fibre at certain parts, the other *hypertrophy*. Untrue fibres are found most frequently in the fleece of poor and neglected sheep, or are the result of sickness of the animal. In some instances we find a sudden contraction of the fibre at certain points, (atrophy) which is frequently sufficient to give the edge of the image a decidedly notched appearance, whereas in other cases we find a more gradual contraction. With reference to hypertrophy none of the sharp or pronounced variations are found; the fibre begins to enlarge at a certain point, and this enlargement may continue through the length of the fibre until attaining a diameter of even twice the dimension as at other parts. Fig. 117 is given, to illustrate such fibres as are termed untrue, and will readily show that where these abnormal forms occur, there are changes in the form and size of the epithelial scales of the outer layer as well as in the diameter of the fibre, consequently the internal structure of the fibre must be equally affected, thus reducing the strength and elasticity of such fibres, and consequently decreasing the value of such lots of wool in which these fibres are more or less frequently found. In the case of atrophy the fibre is necessarily weakened, while on the other hand staples in which the hypertrophied fibres occur in any quantity, the same will interfere with the regular passage of the material through the machine as required for woolen or worsted spinning.

Fig. 117.

Soundness.—This characteristic quality of the wool fibre is closely related to the previously explained trueness, and means the strength of the fibre. It is readily ascertained by drawing a few fibres out of the fleece and grasping each singly by both ends, pulling them until they break. Examining such fractured fibres by a very powerful microscope shows that such fracture occurred at the point of junction of the various scales, which have pulled from amongst each other.

Softness.—The same is a result of the quantity as well as the quality of yolk found upon the fleece and which nature put there both for nourishing the fibres as well as to impart the pliability known as softness.

Examination of Wool Fibres Under the Microscope.—No doubt, no work ever gave as much light on the subject of microscopic examinations of the wool fibre as that of McMurtrie, made by him under the direction of the Commissioner of Agriculture; as the same may be of great interest to the manufacturer we quote from his report. "To discover special forms of structure, the microscope must of course be employed, but the fibre is apparently so uniform throughout, and the lines of structure so weakly defined on account of its transparency, that they may only with considerable difficulty be detected. If, therefore, a specimen of wool be enclosed in any properly refracting and transparent medium, such as water, oil, solution of gum, resin or balsam, and examined in the microscope with transmitted light, its image presents the appearance of a more or less broad transparent band. With a microscope of high magnifying power and with the light passing through the fibre, and the instrument to the eye properly directed, faint lines may be seen crossing the image in a more or less irregular way, while the edges of the image will appear either almost perfectly regular, or it may be slightly serrated, or more properly dentate, the latter quality differing in intensity with the race from which the fibre had been taken. Other than this, and with one further exception, the fibre thus presented appears to be perfectly amorphous and very transparent. This further exception to be noted is found in the pigment that is deposited throughout the centre of the fibre of certain breeds of which it appears to be almost characteristic.

If under ordinary conditions the fibre appears to be amorphous in its internal structure, it is quite different when examined after being subjected to the action of re-agents which may impair its transparency, or effect its partial or complete disintegration. Under such circumstances it appears to be cylindrical in shape, covered with irregular scales or epithelia, and consisting of a bundle of elongated fibres, sometimes surrounding a central cellular cavity or canal filled with granules of pigment. These appear to be three principal parts of the fibre of importance in either a theoretical or practical way, and we shall therefore develop them separately.

If a bundle of fibres of wool be placed upon a glass slide covered with either sulphuric or acetic acid, or with solutions of the fixed alkalies, they quickly begin to swell, and upon examination with the microscope the transverse markings already mentioned become prominent and the irregularities or serrations at the edges of the image more marked, while longitudinal striations become apparent within the body of the fibre. If to the reagents thus employed there be added any substance that may of itself or by subsequent change further impair the transparency of the fibre, many of these characteristics become more completely developed and visible, and may be very readily studied. To this extent this preparation of the fibre presents but little difficulty, but to effect the development of the external markings to such a degree that they may be thoroughly studied without causing too great distortion of the parts, involves the exercise of greater care.

However, for the study of the minute structure without reference to differences depending upon breed or external conditions, the re-agents we have mentioned will fully suffice. Of these we choose for the first gradual disintegration of the fibre, that recommended by Nathusins and Bohm, viz., sulphuric acid. If, as already stated, the fibre be placed upon a glass slide and covered with a glass cover, a small drop of water having been applied to hold the cover in position, one or two drops of very strong sulphuric acid be applied to the slide near to the edge of the cover, it will spread, and upon reaching the latter will be drawn under it by capillary attraction. If then the slide be placed upon the stage of a good microscope of fair magnifying power, the changes which the fibre will undergo may readily be observed. The first that may be noticed is a gradual swelling or expansion of the fibre and almost concomitant with this, the transverse markings, not readily observed without oblique light, make their appearance and very often, unless very strong acid has been employed, no further action seems to take place. If now the slide be removed from the microscope, gently warmed over a lamp, and quickly returned to the field of observation, the transverse markings become more prominent, the serrations at the edges of the image more distinct, and finally very thin scales or *epidermal epithelia*, as they may be called, begin to curl at their edges, which cause the transverse markings to ultimately separate from the main body of the fibre, and float away through the acting medium.

Fig. 118.

As soon as they separate from the fibre, and even before being completely free, they curl upon themselves, and finally roll into compact coils, so that in their free condition their form cannot be determined with any degree of satisfaction. They are very thin, according to Nathusius, having a thickness of only 0.0014 millimetre and very transparent. But if, when the acid has so far acted upon the fibre that it has become thoroughly softened, and before these epidermal scales begin to curl, they be subjected to strong pressure through the medium of the cover-glass and without any lateral motion to cause abrasion, the fibre may be completely flattened; the epidermal covering seems to split in the direction of the length of the fibre, and spread out, affording an excellent opportunity for the study of the form of these scales or epithelia. Their form naturally varies greatly with the variety of fibre to which they belong, and, in the comparison of the external characteristics of the fibres of different breeds. They form nearly annual layers about the shaft of the merino fibre, being very narrow in the direction of the axis of the fibre, and comparatively very wide in the direction of the circumference of the fibre in the finer staples and of very irregular forms in the fibres of the coarse-wool breeds. Some of these forms as separated by the acid mediums are illustrated in Fig. 118, representing specimens separated from a Cotswold fibre, and as seen floating about in the mounting medium. As they separate they appear to be arranged upon the fibre in somewhat the same manner as the scales on a fish, and they should therefore tend to confer upon the fibre the felting property for which wool is celebrated and upon which the value of the staple for manufacturing purposes so largely depends. But the manner of their attachment must still remain an open question, though the action of these scales in the felting operation need be no matter of doubt. As will be seen in the illustration they are usually very irregular in form, especially in the coarser wools. In some cases we may detect markings which seem like *nuclei*, but these are so ill defined, and appear so much like particles of fatty or other extraneous matter, often attached to the fibre in the raw condition, that we can scarcely accept them as nuclei. Many of these scales are entirely free from any such markings, and probably represent the true character with this regard.

After the fibre immersed in the sulphuric acid has been deprived of this outer covering of epidermal epithelia, or scales, it suffers still further disintegration. To hasten it, warming as before may be necessary. Longitudinal striations appear and become more marked, the fibre more swollen, and eventually it breaks down to a mass of elongated fibrous cells which overlap each other throughout the length of the shaft. These cells are more or less spindle-shaped, and as they float through the mounting medium, in consequence of currents produced by pressure applied to the cover glass by means of a mounting needle or other instrument, they are found to be flattened or oval in their cross-section, nearly of uniform thickness throughout their length in the direction of one axis, but tapering toward each end in the direction of the other. Generally they may be completely severed from each other by gentle abrasion caused by slight pressure and movement of the cover-glass, but very often they separate in bundles or clumps. Here their arrangement as regards each other within the fibre may be more easily observed and they are found to be arranged in much the same manner as the ligneous fibre cells in vegetable tissue. In many particulars they are comparable to the latter, and with this difference, that when thus treated they are much more pliable. Thus the cells are arranged as shown in Fig. 119, at *a*. If the portions of the fibre thus under examination have suffered rupture at any point, the fibrous cells are partially separated and give the appearance of great laceration at the ends. When motion of the mounting medium (that is, of the sulphuric acid above referred to) is set up by pressure upon the cover-glass, the disconnected ends may be seen to sway backward and forward with it until they are finally detached. This is illustrated in Fig. 119 in the cells shown at *b*. These cells sway backward and forward for a time, then loosen themselves and float away through the medium. Both before and after detachment in the different positions in which they may be examined, it seems impossible to detect any signs of nuclei, though they are said by some authorities to exist. There are some markings which seem somewhat like elongated nuclei, but there are many reasons for the belief that these may be due to refractions of light passing through them, and caused by longitudinal striations that may often be distinctly seen, as shown in Fig. 120. The cells are more or less flattened, and are sometimes more or less twisted upon themselves, so that these light effects may often become exaggerated; and unless nuclei may be better defined than we have been able to see them, their presence must still remain a matter of doubt. But in the study of the cross-section of the fibre, some kind of central marking is very prominent."

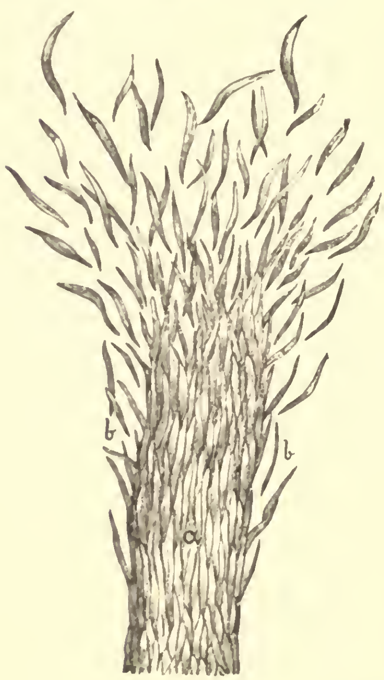


FIG. 119.


FIG. 120.

Nathusius says with reference to these cells: "It is difficult to state what may be their size, for they often vary in the same specimen when differently treated. It is probable that they are separated by the solvent action of sulphuric acid upon the true cell membrane, and the horney kernel alone is apparent, so that we may only guess at the true dimensions. This fibrous tissue is swollen by water, and sulphuric acid must swell it even more." The tissue consisting of these elongated cells, therefore constitutes the principal body of the fibre. In some of the coarser fibres there may be found within this portion a central canal of cellular cavities filled with a characteristic granular pigment. When stronger acid is employed, stronger heat applied, or the action more prolonged, the cells become finally dissolved and disappear.

Fig. 121.

Mouflons or Wild Sheep.—Amongst the different specimens of wild sheep we find, what we might call, the giants of the ovine race. Of these gigantic sheep the *Argali* of Siberia, as shown in illustration, Fig. 121, is the most conspicuous. These animals are agile and strong but rather timid and shy, closely resembling in their habits the domestic sheep. The Argali is nearly the size of an average ox, being four feet high at the shoulders, and proportionately stout in its build. The horns of the full grown male are about four feet in length, if measured from curve to curve, and at their base about nineteen inches in circumference. It has a fur of short hair, covering a coat of soft white wool. The female animal is smaller, having horns more slender and straight, and the absence of the disc on the haunch is noticeable. The Argali is capable of domestication, in which case the quantity of hair on its body decreases and is followed by an increase of wool.

Fig. 122.

Another wild sheep of the same variety as the Argali is the *Big-Horn* or Rocky Mountain sheep of California, as shown in Fig. 122. It closely resembles the Asiatic variety, but is somewhat larger and stronger. Before they became acquainted with the destructive power of mankind they were very fearless, and would curiously survey those who approached them, but now they are shy and suspicious, and at the sight of a person they blow their warning whistle, and immediately take refuge in the recesses of the rocks.

Closely related to the two preceding animals is the *Aoudad* or bearded Argali, as shown in Fig. 123. The same is characterized by a heavy mane, which commences at the throat and falls as far as the knees. The Aoudad is most commonly found in the lofty woods of the Atlas Mountains in Africa. The height of the full grown male is rather more than three feet at the shoulders, it is therefore really a large animal even if not of such gigantic proportions as the Argali.

Europe has also a specimen of the Mouflons or wild sheep, which is known by the name of the variety *Mouflon.* They are found mostly in Corsica and Sardinia, and also in some of the Islands of the Greek Archipelago, and are smaller than the Argali. The male has a formidable pair of horns nearly two feet in length, very thick and differing from the horns of the Argali by turning inward instead of outward at the points; the female is frequently seen without horns. The body of the animal is covered with a hairy brownish fur, beneath which is a short, fine gray-colored wool, which covers all the body. When domesticated the Mouflon has all the habits of the domestic sheep, with which it can be readily bred with favorable results.

FIG. 123.

A sub-variety of the Mouflon family is the *Nemorhedinæ* or goat-like antelopes. Naturalists claim ten species for this variety, of which nine belong to Asia and one, the *Rocky Mountain Goat,* (see Fig. 124 for illustration) to our country. The latter is a true antelope in all essential features, though having something of the aspect of the goat, from which it gets its name. Its under fur is short and woolly, and the outer fur long and pendant. It inhabits the most inaccessible cliffs of the Rocky Mountains.

FIG. 124.

One more sub-family distinguished by being all American (also one species only) is the *Antilo-caprinæ.* The species comprising this family is the *Prong Horn Antelope,* being a familiar animal to the visitors of the great Western Plains. The animal is readily tamed and soon loses its shyness and timid action.

Whether or not the domestic sheep is derived from any of these wild sheep-like creatures, there is no doubt but that the same was first domesticated in Asia, and from there with the advance of civilization introduced into Europe, America, Africa and Australia. No doubt the wild sheep possesses great interest in illustrating the probable origin of our domestic varieties, yet the latter alone are of special interest to us as animals producing wool in quantities for textile purposes.

The Domestic Sheep.—Some naturalists simply divide the sheep into two specimens: *a*, the long-wooled; *b*, the short-wooled, claiming that all others are only varieties produced by crossing, climate and pasturage; whereas other naturalists make more divisions. The most widely adopted classification is the one laid down by Prof. Archer, who bases his classification upon an industrial point of view. He groups those sheep (domesticated or useful to man) into four separated geographically-selected divisions, each one of which is again divided into several sub-divisions, making in all thirty-two (32) varieties, as follows:

A. Europe.—1, Spanish or Merino sheep; 2, Common sheep; 3, Wallachian sheep; 4, Crimean sheep.

B. Asia.—1, Hooniah, or black-faced sheep of Thibet; 2, Cago, or tame sheep of Cabul; 3, Nepal sheep; 4, Curumbar, or Mysore sheep; 5, Garrăr, or Indian sheep; 6, Dukhun, or Deccan sheep; 7, Morvant de la chine, or Chinese sheep; 8, Shaymbliar, or Mysore sheep; 9, Broad-tailed sheep; 10, Many-horned sheep; 11, Pucha, or Hindoostan dumba sheep; 12, Tartary sheep; 13, Javanese sheep; 14, Barwall sheep; and 15, Short-tailed sheep of northern Russia.

C. Africa.—1, Smooth-haired sheep; 2, African sheep; 3, Guinea sheep; 4, Ceylon sheep; 5, Fezzan sheep; 6, Congo sheep; 7, Angola sheep; 8, Yenu, or Goitered sheep; 9, Madagascar sheep; 10, Bearded sheep of West Africa; 11, Morocco sheep.

D. America.—1, West Indian sheep as found in Jamaica; 2, Brazilian sheep.

As numerous as the classification may seem to the student, yet it is not too exhaustive, since many of the sub-varieties of some of these thirty-two given varieties possess characteristics, which if their origin were unknown would entitle them to be considered a separate variety. Thus Prof. Archer in a more detailed classification, grades previously given, thirty-two specimens again in eighty different kinds, demonstrating that there are eighty different kinds of wool to be found in the market, and since his tables have been compiled with the assistance of some of the most eminent wool merchants of England, and also the leading naturalists, the same must be highly accredited. For example—Spanish or Merino sheep (A, 1) he divides in: a, Stationary, 1st, Churrah, 2d, Merino; b, Migratory, 1st, Leonese, 2d, Sorian. (The Leonese he divides again into five kinds, and the Sorian again in 14 special kinds; but these sub-divisions are not included in previously mentioned eighty varieties).

American Breeds of Sheep.—Numerous importations of sheep into America have been constantly made since its discovery. The first of these importations consisted of the common native sheep of Spain, which were introduced by the Spaniards into that part of the American Continent which became subjected to its discoveries, including the West Indies. Similar in character to these sheep is a species of sheep known in our Western States as *Mexican*, and which are found in Mexico, Texas, New Mexico, Arizona, and parts of California and Colorado. They are strong hardy animals, yielding, if not crossed with merino or other breeds, a fleece of about only two pounds of coarse wool, and thus are of little value. If crossed with merinos the weight of the fleece increases to about four pounds. The wool is mostly used for spinning, in the Western States, such yarns as used for the manufacture of home-spun fabrics, and largely in the East for carpet yarns.

About the beginning of the seventeenth century the first English sheep were introduced into Virginia (Jamestown). Repeated importations were made during the next two centuries, and thus was founded a very good specimen known as the *Virginian sheep*, being a long-wool sheep. Lately Leicester, Cotswold and South-down sheep have been imported and crossed with the same.

Another good American breed is known as the *Improved Kentucky sheep*, which breed was begun about fifty years ago by crossing the common native sheep of the locality with Merino, South-down, Leicester, Cotswold and Oxford-down rams.

Another native breed (to which reference is also made under the chapter on merinos) is the *American merino* shown in Fig. 125. The first merinos were imported by a Mr. Foster, of Boston, who presented the same (two ewes and one ram) to a friend who was in the sheep raising business; but somehow this friend transferred these costly sheep into mutton. This same friend of Mr. Foster's paid a short time afterwards $1,000 for one merino ram. Several importations of merinos were made later on by different parties, but the main effort to firmly establish the merino belongs to the late Hon. W. Jarvis, who was our Consul in Lisbon in 1809 and 1810. In 1809 he bought 3850 head, being part of the flocks of Paulars, Negrettis, Aqueirres, and Montarcos of Spain, and which were the choicest kind of Spanish merinos. Of these imported sheep 1500 came to New York, 1000 to Boston and the rest to Philadelphia, Baltimore, Norfolk, Richmond, Portland, Wiscasset and Portsmouth. In 1810 a duplicate shipment of 2500 head arrived from Spain, and these were distributed to different sheep breeders between New York and Boston. In 1851 Silesian merinos were imported, and these animals have also become already acclimated. The ewes from this kind shear from 8 to 11 pounds, and the rams from 12 to 16 pounds of unwashed wool. The staple is from $2\frac{1}{2}$ to 3 inches, and the color of the wool dark on the outside, without gum, but with plenty of oil of a white and free, but not sticky, character. The best grade of our merinos at present produce what is acknowledged as the finest wool in the world. The diameter of these fibres is $\frac{1}{3000}$ part of an inch, with about 6,000 scales per inch.

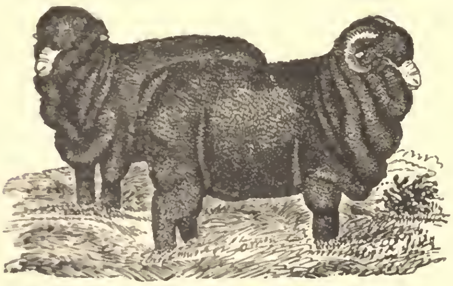


Fig. 125.

Foreign Breeds.—The same may be best classified in two divisions, long-wool sheep and short-wool sheep.

Long-wool Sheep.—Amongst them we find the Lincoln, the Romney Marsh, the Leicester, the Cotswold and the Oxford-downs.

The Lincoln Sheep.—This is an English breed, originating in Lincolnshire from crossing the native breed of that part of the country with Leicester breed. It stands at the head of the long-wooled sheep, both on account of length of staple as well as weight of fleece (8 to 12 lbs.). It is a very large white, coarse, long-wooled, hornless sheep, as shown in illustration Fig. 126. The same has lately been frequently imported into this country. Fig. 127 illustrates a fibre as visible by means of the microscope taken from the shoulders of a well-bred specimen of the Lincoln sheep. Fig. 128 shows a fibre from the same animal, but taken from the britch. Both fibres will thus clearly illustrate the difference in fibres as found on the same animal. To illustrate the difference in taking care or not, of any specimen of sheep, the two succeeding illustrations are given. Fig. 129 represents a fibre of Lincoln wool taken from the shoulders, and Fig. 130 from the britch, both fibres taken from a poorly-bred animal.

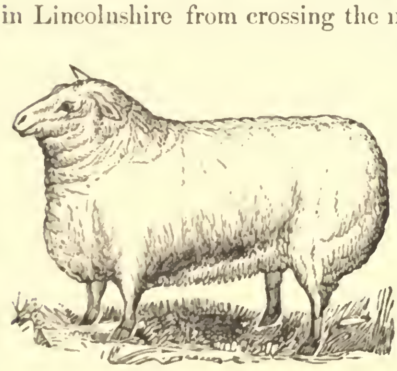


Fig. 126.

Fig. 127. Fig. 128. Fig. 129. Fig. 130

The Romney Marsh Sheep is raised in South-eastern England, in the extensive marshes of the County of Kent, and is the product of the crossing of the original native breed of this district with the (new) Leicester breed. The wool produced is rather finer than that from the Lincoln sheep, the weight of the fleece being from 7 to 10 lbs.

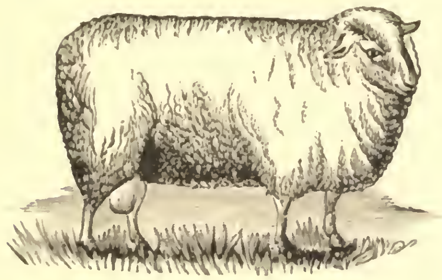


FIG. 131.

The Leicester, or, as now called, the New-Leicester, has been originated by Robert Bakewell, by crossing the old Leicester with several different species, but without much keeping of a record. The fleece is fine, glossy, silky white, and of but moderate length, weighing on an average from 7 to 8 lbs. It was first imported into our country by Washington, and as now found here closely resembles the Cotswold. An illustration of the Leicester sheep is given in Fig. 131, and an illustration of fibres, magnified, in Fig. 132.

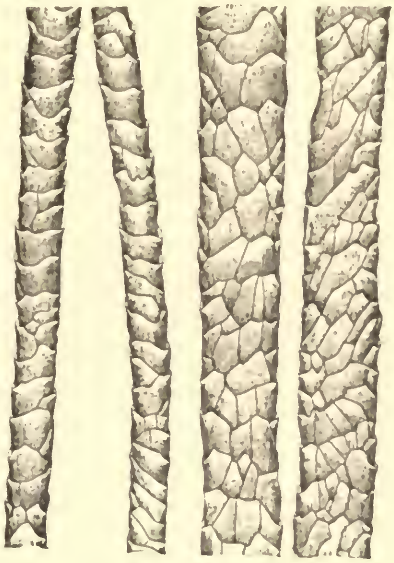


FIG. 132.

The Cotswold.—This breed originated in Gloucestershire, England, and received its name from the hills of the same name as the breed. The Cotswold sheep produces a large, white, coarse, long wool. The breed has become very common in our country, in fact so common since the last sixty years (without any fresh importations of new blood) that it might be well to classify Cotswold also as a native species of the sheep of this country. A specimen of the English breed is given in Fig. 133, and an illustration of our native breed in Fig. 134. The average weight of the fleece is 7 lbs. Fig. 135 illustrates fibres from the Cotswold sheep, magnified.

The Oxford-down.—This is a comparatively new English breed, originated in 1830, by a Mr. Twynham, of Hampshire, England. It is the crossing of a Cotswold ram upon a Hampshire-down ewe, with selection and careful inter-breeding. The wool produced by the Oxford-down is finer and firmer than that of the Cotswold, being from 5 to 7 inches in length, and the average weight of a fleece 9 lbs. (which are in great demand for the manufacture of worsted yarns). This animal has been also introduced successfully in this country. Fig. 136 is an illustration of the animal, and Fig. 137 an illustration of fibres, magnified.

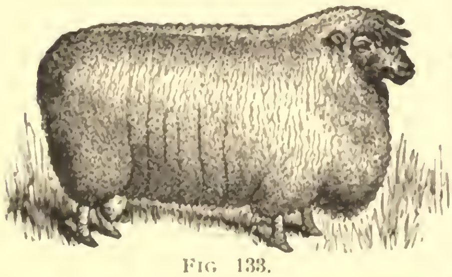


FIG. 133.

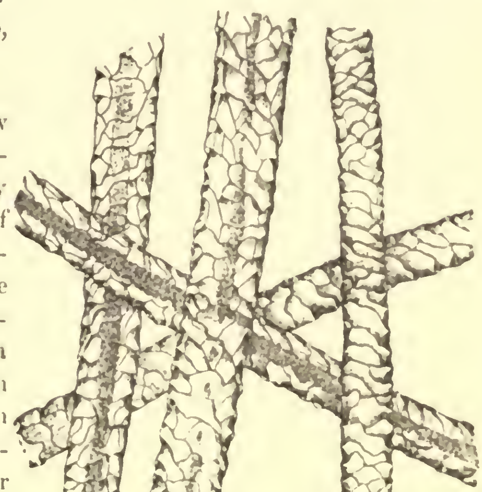


FIG. 135.

Medium and Short-Wool Sheep.—Amongst the same we find—

The South-down.—This sheep is a native of England, and one of the most valuable sheep of that country, being raised there in the counties of Sussex, Kent, Hampshire and Dorsetshire. This sheep has also become naturalized in this country, and its characteristic dark face and compact fleece have left their mark upon a large portion of our native sheep. Fig. 138 shows an illustration of the same, the average weight of its fleece being 6 lbs., and the wool being in demand for producing the yarn for *flannels, kerseys, beavers, tricots,* and other *face-finished fabrics.* An illustration of the fibre as produced by this sheep is given in Figs. 139 and 140. Fig. 139 represents two fibres, magnified, taken from the choicest part of the fleece, whereas the two fibres shown in Fig. 140 are taken from the coarsest part of the fleece.

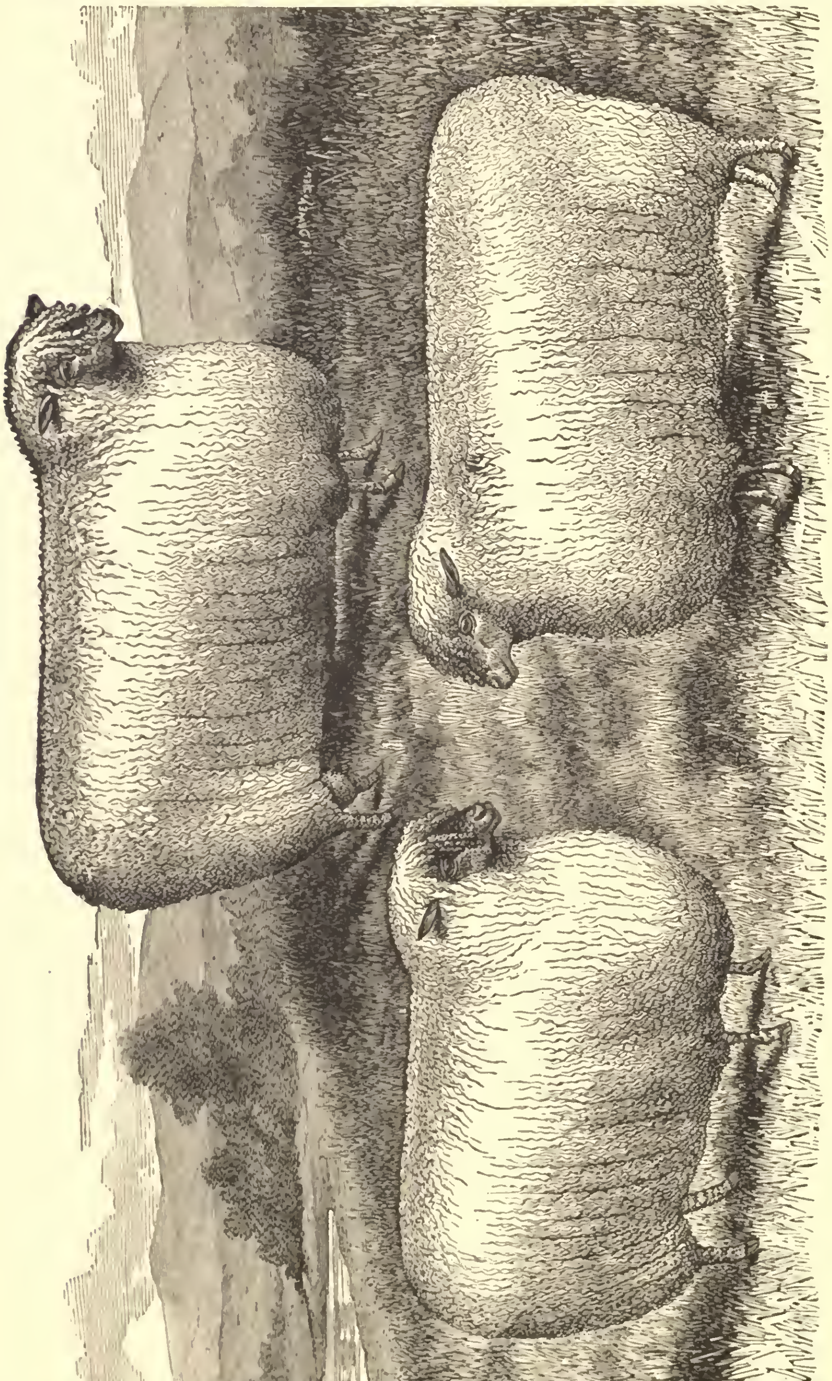


Fig. 134.

The Dorset Sheep.—The same is a native of the southern part of England. The wool is moderately long, bright in appearance and almost free from gray. The weight of the fleece is about 4 lbs. Experiments have been made in our country to introduce this animal in Virginia, but have attracted no notice of any consequence.

The Hampshire-downs.—This is also a native breed of England, and originated some eighty years ago between a white-faced, horned sheep of the Hampshire District and the pure South-down. The weight of the fleece is from 6 to 7 lbs. and the fibre is suitable for combing, being longer and not so fine as that of the South-down. Before the civil war this sheep was frequently imported into our Southern States, under the impression that they surpassed their rivals and founders, the South-downs.

The Cheviot Sheep.—Is found upon the Cheviot Hills which traverse the boundary between England and Scotland. Some writers date their origin back to the attempted invasion of England by the Spanish Armada, claiming that when the fleet was wrecked upon the British coast, some of the Spanish sheep with which the ships were provided swam ashore and escaped to these Cheviot Hills, where they bred and multiplied. An illustration of this species is given in Fig. 141. They have white faces and legs, open countenances, lively eyes, are hornless, and have large ears and eyes. Upon good pasture the fleece becomes fine and brings a good price in return, besides being continually in demand; its weight is from 4 to 5 lbs., and the fibre furnishes the material for the well-known *Scotch tweeds* and *Scotch cheviots.*

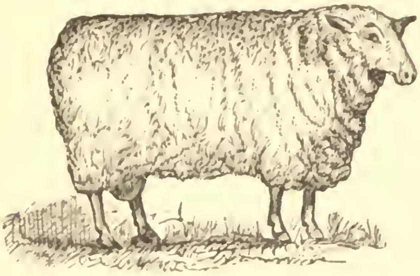


FIG. 136.

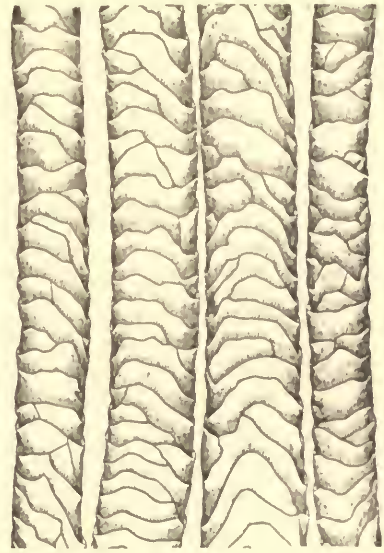


FIG. 137

The Shropshire Sheep.—This sheep is the result of crossing the Cotswold and the *Morfe common* sheep. The average weight of the fleece is 7 lbs. There are also several flocks of the breed kept in different parts of this country.

The Black-faced Scotch Sheep.—This is the oldest breed of sheep in Scotland. It is a hardy and self-dependent animal adapted to exposed mountain localities or unsheltered plains.

FIG. 138.

FIG. 139. FIG. 140.

Amongst other English breeds of any consequence are:

The Highland sheep, found in the extreme north of Scotland, in the Orkney and Shetland Islands and in the Hebrides.

The Welsh Mountain sheep, found in the mountains of Wales.

The Irish sheep, found in Ireland, and of which there are two varieties; *i. e.,* those found in the mountains and those found in the valleys.

The Exmoor sheep, found in Cornwall and Devon.

The Herdiwick sheep, found only in the mountains of Cumberland and Westmoreland.

The Penistone sheep, found in the hills of Yorkshire, Lancashire and Derbyshire.

The Norfolk sheep, found in the higher lands of Norfolk, Cambridgeshire and Suffolk.

The Somerset sheep; the *Portland sheep;* both being a variety of the Dorset sheep.

FIG. 141.

In giving the different species of sheep found in England, we have no doubt given such foreign breeds with which our readers will come mostly in contact; such as are naturalized in this country we have referred to in detail, whereas such as are strictly natives of England we have explained less elaborately.

The European Continent, also Asia and Africa, all contain a great many varieties of native sheep, but to refer to each variety would be too lengthy a matter, besides being of little or no interest to our readers. The merino, the diamond of the sheep has been treated with reference to different countries where naturalized by itself in a following chapter.

Amongst such of the wool as is frequently imported from Europe to this country is the product of the

Fat-rumped Sheep.—These sheep are found in the northern part of Asia and in Russian-Europe. They yield a great supply of coarse wool (carpet wool); but in some districts of Russia care has been and is taken to cultivate this sheep, and as a result a finer quality of wool with only a small amount of hair intermixed has been derived.

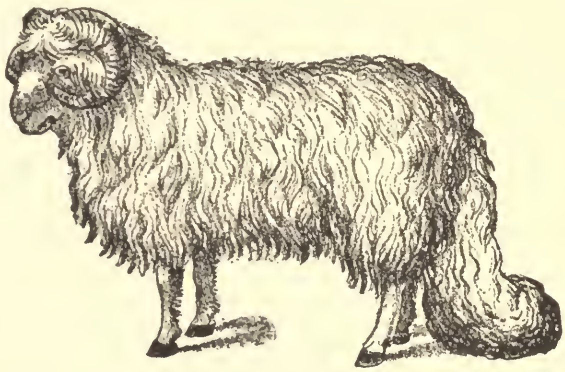


FIG. 142

FIG. 143.

The Fat-tailed Sheep of Palestine, Syria, Persia, India and China (see Fig. 142) is very likely a variety of the previously mentioned sheep. They have an enormous round of fat (like a cushion) weighing on an average from 30 to 40 lbs. in place of a tail. The wool derived from these sheep is coarse and freely intermixed with dark colored hair. Large quantities of this wool are shipped to Europe and this country (carpet wool). An illustration of the fibres of this animal as visible by the microscope is given in Fig. 143, representing fine, coarse, and mixed (part fine and part coarse) fibres.

FIG. 144.

The Wallachian Sheep.—One of the most important of the ovine group is the Cretan or Wallachian Sheep. It is a large noble looking animal, remarkable for the enormous spiral development and magnificent formation of its horns. This splendid animal (Fig. 144) is a native of Western Asia and the adjacent portions of Europe, more especially Roumania and Bulgaria. It is also quite common in Crete, Wallachia and Hungary. The fleece of this animal is composed of a soft woolly undercoat, covered with and protected by long drooping hairs. Its wool is extremely fine in quality and is employed in the manufacture of warm cloaks, largely used by the peasantry, on account of its solidity which defends the wearer against the bitterest cold, the skin being dressed without moving the wool. Lately merinos have been imported into that country for breeding purposes, and tended to improve the native breed in every way.

The Merino Sheep.—The home of this animal is Spain, from there they have been spread during the last two centuries through every quarter of the globe. The Spanish merinos are classified into *stationary* and *migratory*. The former are such as remain always on a certain farm, whereas the latter wander about four hundred miles twice in the year (passing the summer season on the slopes of the Pyrenean Mountains and the winter on the plains toward the South) in search of pasture. The great value of the merino wool consists in the fineness and felting property of their fibres, as well as the weight of the fleece. The average weight of the fleece of the Spanish merino is eight pounds from the ram and five pounds from the ewe. The migration or periodical journeys of the Spanish merino can be traced back to the middle of the fourteenth century, when a tribunal (called the *Mesta*) was established for their regulation. This tribunal consisted of, as it does yet, the largest owners of these migratory flocks, and established a right to graze on all the open and common land laying in the way, besides a path of ninety yards wide through all the enclosed and cultivated country, prohibiting at the same time all persons from using this path during the time the sheep were traveling. These migratory sheep, there being in all about ten millions (10,000,000) in Spain, are divided into several divisions, each of which is placed under the care of a *Mayoral* (chief shepherd), who again has a sufficient number of others under his command. When going through the cultivated country the average distance daily traveled is from eighteen to twenty miles, but when they reach the open country with good pasture they proceed more leisurely. Their average journey of four hundred miles is generally accomplished in about six weeks, thus about one quarter of the year is spent in going and returning. It is claimed that migration does not increase the fineness nor the length of the staple, but otherwise does much damage to the country over which these immense flocks are passing.

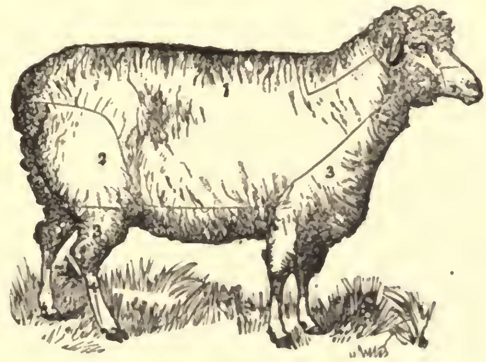


Fig. 145.

The merino fleece of Spain is sorted into four parcels which, with reference to (numbers of reference in) Fig. 145, representing a merino ewe, are as follows:

1. *The refina* or the choicest wool (pick-lock), begins at the withers and extends along the back to the setting on of the tail, reaches only a little way down at the quarters, but dipping down at the flanks, takes in all the superior part of the chest, and the middle of the side of the neck to the angle of the lower jaw.

2. *The fina*, being a valuable wool but not so deeply serrated or possessing so many curves as the first mentioned sort; it occupies the belly, and the hind-quarters and thighs down to the stifle-joint.

3. *The terceira*, being found on the head, the throat, the lower part of the neck and the shoulders terminating at the elbow; also the wool yielded by the legs, and reaching from the stifle to a little below the hock.

4. *The inferior* grade of wool procured from the tuft as growing on the forehead and cheeks from the tail and from the legs below the hock.

A characteristic of the merino is what is called prepotency, that is, the power of imparting its excellence to inferior breeds with which it is crossed. Amongst the different varieties of merinos derived by crossing the Spanish merino with inferior breeds of other countries are the Saxon, the Prussian, the Silesian, the Hungarian, the French, the British, the American, the Australian merino, etc.

Saxon Merino.—Saxony was the second country to introduce the Spanish merino, Sweden having been the first in 1723, amongst its common sheep. In 1765 the Elector of Saxony imported one hundred rams and two hundred ewes from the best Spanish flocks, placing part of them on one of his own farms and which he kept unmixed; the other part he distributed on other farms, and devoted them to the improvement of the native Saxon sheep. This he did to ascertain how far the pure Spanish breed could be naturalized in his country. This in a short time established the fact that the merinos did not degenerate. A second lot of Spanish merinos were soon imported by him, and in a short time they became perfectly naturalized; in several years the Saxon sheep began not only to equal the Spanish but to exceed it in fineness and manufacturing value. Fig. 146 represents the Saxon merino.

Fig. 146.

Prussian Merino.—Into Prussia the Spanish merinos were introduced in 1778 by a Mr. Fink, to whom Germany is greatly indebted in regard to its sheep culture. He took as the guide for all his experiments that which is now received as an axiom among breeders, that the fineness of the fleece is far more attributable to the inherent quality of the animal than to any influence of climate or of soil. Uniformly acting on this fundamental principle, and being most particular in the selection of the animals from which he bred, he improved his own native flocks to a considerable extent, and succeeded to a degree which he had not dared to anticipate, in naturalizing a still more valuable race of animals. His success attracted the attention of the Prussian government which in 1786 imported one hundred rams and two hundred ewes from Spain, followed by an additional purchase of one thousand of the choicest merinos. Agricultural schools were established and Mr. Fink placed in charge of the leading one.

Silesian Merino.—Another grade of wool greatly valued for textile purposes in Europe is the Silesian wool. The native Silesian sheep were small, with long neck and legs, having head, legs and the belly devoid of wool. After crossing the native sheep with imported Spanish merinos, in time the wool yielded, bore comparison with the choicest Spanish merino wool, and a few years later exceeded it in fineness, and value. The Silesian merinos have also already become a successfully acclimated breed in this country.

Hungarian Merino.—Hungary introduced the merinos among its native breed about 1775, and its crossings, similar to the Saxony and Silesian sheep, have finally rivalled, and even beaten in fineness, the Spanish merino.

Into England the first merinos, but of a poor breed, were introduced in 1787, followed by a better selection in 1791, but have never proved a success, as they have done in the previously mentioned countries of the European continent.

French Merino.—France introduced the Spanish merino in the cheapest manner. Being situated on the other side of the Pyrenees, their great Emperor, Napoleon I., simply waited for the migratory flocks to arrive in Spain, on the other side of the mountains, when he sent his troops to drive some of them (about 200,000) over the Pyrenees and into France. No doubt there had been some of the Spanish merinos introduced prior to Napoleon I, but if so, only in small amounts, or such as have gone astray in Spain, climbing the mountains and crossing into France alone.

Russian Merino.—Into Russia (the Crimea) the Spanish merinos were introduced by a Frenchman, M. Rouvier, aided by the loan of $75,000 from the Czar, in 1802, and the wool raised there is of a fine quality, and in great contrast to the great amount of coarse wool raised in the other parts of the Russian Empire.

The Spanish merinos were also introduced in the other parts of Europe, accompanied, with the exception of the one or the other instance, with success in raising the quality of the various native breeds with which they were crossed.

Into Africa (Cape Colony) the Spanish merinos were introduced by England towards the close of the last century.

Australian Merino.—Australia had no native sheep. The first Spanish merinos were taken over from Cape of Good Hope to Sydney in 1794 by Captains Waterhouse and MacArthur. In 1803 the English Government assisted their undertaking by a grant of land as well as other privileges. The official returns of 1794 mention 526 sheep in New South Wales compared to nearly fifty millions (50,000,000) at present. In 1834 the sheep were introduced into Victoria, the first official return, 1836, giving 41,332 compared to nearly eleven millions (11,000,000) at present. From New South Wales and Victoria the sheep were in a short time introduced into the other Australian Colonies. South Australia had 28,000 sheep in 1838 compared to nearly seven millions at present. Queensland having only 4,000 sheep in 1839 raises now over eleven millions (producing amongst it the best quality of merino wool, *botany*, of which an illustration is shown in Figs. 147 and 148; an explanation is given later on) for combing. Western Australia raises over a million and a half of sheep and Tasmania about two millions. New Zealand at present raises about sixteen millions of sheep, the principal breed being the merino. The success of raising sheep in Australia will be better explained by mentioning that the latest official returns for the whole Australian colonies, place the number of sheep raised there close up to one hundred million (100,000,000). Figs. 147 and 148 illustrate Australian wool known as botany, being the product of the sheep derived

FIG. 147. FIG. 148.

FIG. 150. FIG. 151.

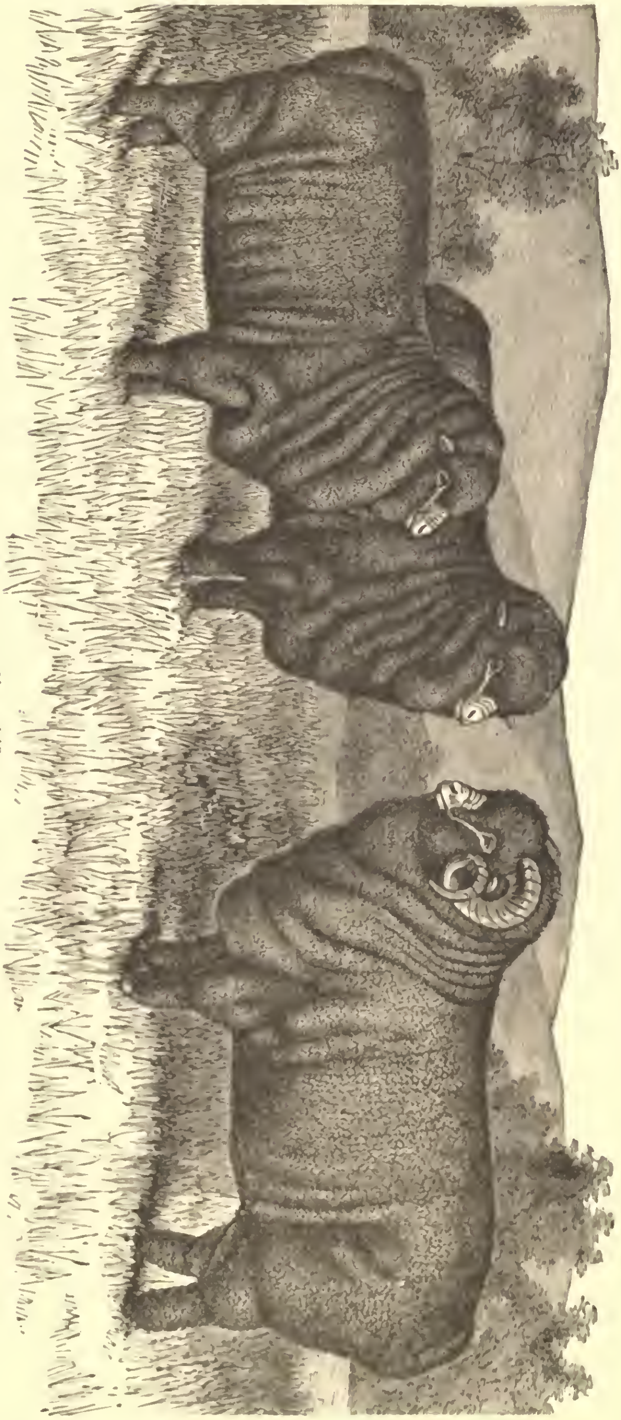


FIG. 149.

from crossing the Leicester with the merino sheep. Fig. 147 shows two fibres taken from the shoulder, and Fig. 148 represents two fibres from the britch.

American Merino.—In our country the merino was introduced about the year 1800. Since that time there have been numerous importations and crossings and the American merino is now established as a distinct native breed. It is a fine white wool sheep of medium size, equally built, the body rather short, round and thick; good quarters; legs stout, short and woolly; ears short; cheeks and forehead to the eyes thickly covered with wool, skin wrinkled or in folds, and of a rosy color; wool of a fine quality and from two to three inches in length. Fig. 149 represents the sheep in question. As already previously mentioned in the chapter on native breeds, the fibre of the American merino rivals and even exceeds in beauty and fineness of fibre any other merino wool. An illustration of fibres of the American merino as visible under the microscope is given in Figs. 150 and 151. Fig. 150 shows two fibres taken from the best part of the fleece, and Fig. 151 two fibres from the britch.

The South American Merino.—Into South America (the Argentine Republic, the greater region of the La Plata Valley) the merino was introduced under the supervision of Germans in 1826, and has since then assumed considerable proportions. The official reports of the Argentine Provinces in 1840, place the number of sheep at 5,000,000, whereas at present about 100,000,000 sheep are raised there.

Amongst mammalian animals producing wool in quantities, besides the sheep, we find the *Cashmere goat*, the *Angora goat*, the *Camel*, the *Paco*, the *Vicugna*, etc., etc.

Cashmere Goat.—This animal (see Fig. 152) is found in the district of that name in India. It is related to the native Thibet goat, only being somewhat smaller. Its horns, which curve backwards, extend frequently half the length of the animal. The fur of the Cashmere goat is of two sorts, viz.: a soft, woolly undercoat of grayish hair, and a covering of long silken hairs that seem to defend the interior coat from the effects of winter. The woolly undercoat is the substance from which the Cashmere shawls are woven (in order to produce a single shawl $1\frac{1}{2}$ yards square, at the least ten goats are robbed of their natural covering, since a single goat only produces from 3 to 4 oz. of it). A strict watch is constantly exercised to keep these cultivated goats from being exported. Attempts have been made to domesticate this valuable animal in Europe, but without real success. It will unite with the Angora goat and produce a mixed breed from which may be procured very soft and fine wool that is even longer and more plentiful than that of the pure Cashmere goat. As a commercial speculation, however, the plan does not seem to have met with success. Fig. 153 shows the fibres of the Cashmere goat as appearing when magnified.

Fig. 152.

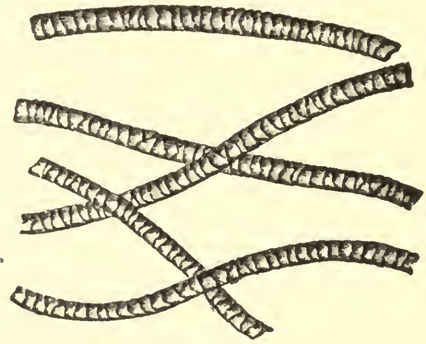


Fig. 153.

Angora Goat.—The same (see Fig. 154) is a native of the mountainous districts of the interior of Asia Minor. The centre of this district is the town Angora, after which the animal is named. The wool of the Angora goat is used for the manufacture of *mohair* yarns. Examining our illustration of the animal, we find that it is rather good looking, with prominent, proud features. Its horns are curved back over the neck, and its fleece furnishes the softest and silkiest hair, which is largely manufactured by the inhabitants of Angora, no less than 13,000,000 pounds of fabrics and yarns being exported by them annually. The average length of the hair is from 6 to 8 inches, but even if called hair it is actually wool possessing a curly structure, with a fine development of the epidermal scales and a bright, metallic lustre. The Angora goat has been introduced by England into Cape Colony and is raised there both in its pure state and crossed with the native African goat. The Angora goat has also been introduced into our own country, and is at present already perfectly acclimated. Fig. 155 shows the hair (actual wool) of the Angora goat as it appears when magnified.

FIG. 154.

Camel's Hair is the product of the camel, as well as those animals belonging to the genus *Llama.*

Camel.—The genus *camelus* embraces two species, which are only known in their domesticated state, viz.: The *Dromedary* or African camel (see Fig. 156), which has only one hunch on the back; the *Bactrian* or Asiatic camel, which has two humps. The long hair of the camel, mixed with wool, or wool and cotton, is spun into the yarn as used frequently for the long hairy backs in cloakings, overcoatings, etc. Of greater value than the hair of the camel for textile purposes is such as is derived from the animals belonging to the genus Llama.

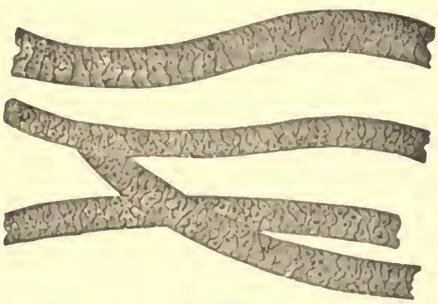


FIG. 155.

Llama.—Four species of Llamas are acknowledged; namely, the *Vicugna,* the *Guanaco,* the *Yamma* and the *Alpaca,* all four being natives of America.

The Vicugna is found in the most elevated localities of Batavia and Northern Chili, and so far has been found to be very wild and untamable. It lives in herds, near the regions of perpetual snow. The short, soft, silky fur of this animal is very valuable causing the death of thousands, which are slain merely for the sake of their coats. The color of the Vicugna is a nearly uniform brown, tinged with yellow on the back and fading into gray on the

FIG. 156

abdomen. Fig. 157 gives a good illustration of the animal, its average height at the shoulder being about 2½ feet. Fig. 158 shows the hair of the Vicugna as visible when examined by means of the microscope.

FIG. 157.

The Guanaco is of no consequence in regard to the value of its hair for textile purposes.

The Yamma or Llama (see Fig. 159) is used by the natives for carrying burdens. It is capable of carrying a weight of one hundred pounds, traveling with it from fourteen to fifteen miles per ten hours. As a beast for carrying burdens it is now more and more supplemented by the ass, while the European sheep is gradually taking its place as wool bearer. The hair of the Llama is of a brown or variegated color, and of very much less value than the hair of the Vicugna. Of the same value as the Vicugna for producing a raw material for textile purposes is the—

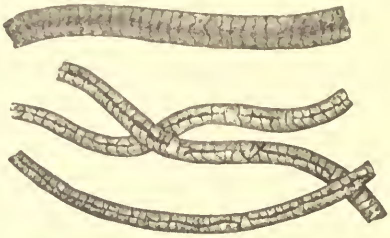


FIG. 158.

FIG. 159

Alpaca or Paco.—Its color is generally black, though frequently variegated with brown and white. The wool of this species is long, soft, silky, and extremely valuable. It is also exclusively South American, and found in the lofty ranges of the Andes. The Alpaca is smaller than the Llama, and in its form resembles the sheep, but has a longer neck and a more elegant carriage of the head compared to the latter, as shown in the illustration of the animal, Fig. 160. The hair of the Alpaca, if the animal is shorn each year, is about eight inches long, but if allowed to grow will attain a length of from twenty to thirty inches. It is rather less curly than sheep's wool, but fine and strong in proportion to its diameter, and is used for producing the yarn for some of the finest dress goods (Alpacas) as well as coatings, the face of overcoatings (Montagnacs), etc. Fig. 161 shows an illustration of the hair of the Paco as visible when magnified.

Grading of the Fleece.—When speaking about the merino (see Fig. 145), we mentioned that a great difference as to quality existed in the fleece as taken from a sheep. It is the duty of the wool sorter to open out the fleeces, which, if they have been carefully sheared, still hang together as when on the animal. After spreading open the fleece he picks it to pieces according to quality and throws each kind into a separate basket. Usually each fleece furnishes eight or ten qualities, more or less. It must also be remembered that the different specimens of sheep require a corresponding different sorting, since not all specimens will have the same quality in the same position of the animal.

FIG 160.

Regarding the different qualities of wool found on a sheep, we generally find that those parts of the fleece covering the shoulders, sides and flanks have the finest, softest and also most regular fibres. They are usually the choicest wools found in the fleece. Both sides of the neck also have a fine, short, soft fibre, but of a less regular growth. If sheep are liable to have gray wool it is sure to be found here. The belly is covered by short dirty fibres which get rather finer towards those parts near the front legs. Such parts of the fleece as cover the rump and back of the animal contain a fibre of a medium, but good quality, characterized by a more or less closeness of the staple. The upper and lower parts of the neck have the wool less deeply grown, and the fibres are of a less fine and soft character and frequently worn by rubbing. Dead fibres, technically known as *kemps*, are found in this part of the fleece, and also in the breech. The chest is covered by a heavier and medium regular hair of greater length. The growth is irregular and points of the fibres are stiff. The upper part of the thigh and hind legs are covered by heavy and medium soft fibres. In these parts we notice most readily any irregularity as to the quality of the fleece in question. The fibres covering the front and rear part of the head are of a coarse and irregular growth, frequently intermixed by stout, rough fibres. The tail is covered by coarse, poor, slack, yet elastic hair. The inside part of the thigh, the lower part of the feet, and the breech contain the coarsest fibres of the fleece.

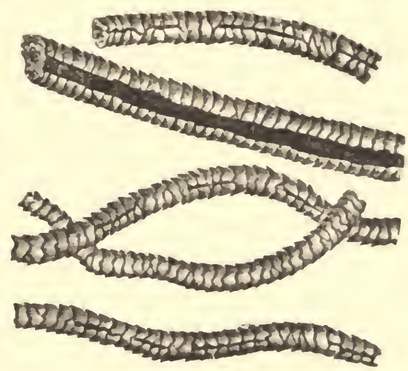


FIG 161.

Fig. 162 is given to illustrate the different qualities of wool as found in an average on a domestic breed of sheep: *a*, the best part; *b*, about the same, but if any difference the wool will be found stronger; *c*, shorter staple, but rather finer in quality compared to *a* and *b*; *d* and *e*, inferior quality; *f*, coarser and shorter; *g*, longer and stronger; *h*, the coarsest part in the fleece; *i*, strong wool, closely resembling *g*; *k*, short and dirty, increasing in a better grade towards the front legs of the animal; *l*, short but fine; *m*, short, and liable to be worn (by rubbing of the animal); *n* and o, rough, coarse, and of little value.

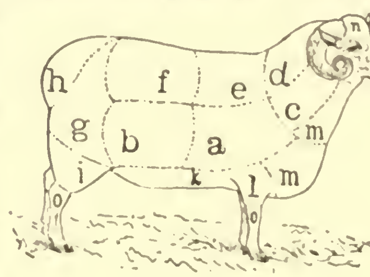


FIG. 162.

The fibres of fine wool are very closely seated upon the skin. The pure merino has from 40,000 to 48,000 fibres to a single square inch; coarse wool breeds contain only from 5,000 to 6,000 fibres to the square inch. The twentieth cross of a pure merino ram upon a coarse wool race had no more than 25,000 fibres to the square inch, which shows plainly how long a period it may take to remove the effects of one cross, for the presence of only $\frac{1}{1024}$ part of impure blood is sufficient to reduce the fineness of the fleece from 48,000 to 25,000 fibres per square inch, or nearly one-half.

Good and Bad Wool.—Since all fine fleeces contain some coarse wool, and all fleeces graded as coarse wool contain some fine wool, we herewith mention rules governing both qualities. A fine or valuable wool to the manufacturer must have the following characteristic points: 1st, fineness, with close ground; 2d, pureness; 3d, straight-haired when broken by drawing; 4th, elasticity; 5th, staple not too long (except if wanted for combing); 6th, color; 7th, defined coarse portions; 8th, tenacity. The points which will make wool poor in the eyes of the manufacturer are: 1st, thin, grounded, toppy, curly-haired, and if in a sorted state a small amount that is very fine; 2d, tender staple; 3d, little or no elasticity; 4th, many dead white hairs; 5th, very yolky.

Yolk.—Before the fleece is sheared from the animal's back it is very dirty, not only with earthy matters, but also with a greasy substance known as *yolk* or *suint*. In some wools this substance is of such an amount that the fleece when properly cleansed from it will retain not more than one-third of its original weight. The average contents of a merino fleece is 40 per cent. of yolk, 27 per cent. of earthy matter adhering to it, and only 33 per cent. of wool. No doubt the amount of yolk and other substances adhering to the fleece varies according to the district in which the sheep have been raised, also in different parts in each individual sheep. It is found in greatest quantity about the breast and shoulders, being the very parts that produce the best and healthiest and most abundant wool; and in proportion as it extends to any considerable degree over other parts, the wool is then improved. It is found the most plentiful on the merinos, and more in any Southern breed of the domestic sheep compared to any Northern breed. In the latter districts, as a substitute for the yolk, farmers smear their sheep with a mixture of tar and oil or butter. Where there is a deficiency of yolk the wool fibres are of a harsh dry character and the fleece gets thin and hairy, but where there is a sufficient quantity of it found on the animal, the wool is soft, greasy, plentiful, and also stronger. This yolk is of great value in softening and protecting the wool fibres during their growth on the animal; it actually oils the fibres and keeps the animal warm, and thus helps to produce a sounder and finer fibre since they are thus not so much exposed to the air. The yolk, or suint consists of a combination of fatty acids with potash, forming a potash soap being soluble in water. Dried, the yolk contains 59 per cent. of fatty compounds with some nitrogen and 41 per cent. of mineral matter; of the latter from 58 to 85 per cent. is potash. Maumené and Rogelet experimented regarding the nature of suint, and communicated their result in detail to the Chemical Society of Paris. They showed that suint is composed of neutral fatty salts containing much potash, but not more than traces of soda, and scarcely even that; further they showed that the soluble portion yields on evaporation and calcination, a mixture consisting of

86.78	per cent.	carbonate of potassium,
6.18	"	chloride of potassium,
2.83	"	sulphate of potassium,
4.21	"	of other substances.
100	per cent.	

Scouring Agents and the Preparation of Scouring Liquors.—Previous to its employment for manufacturing (either for carding or combing) the raw wool must be thoroughly cleansed from the yolk. In nearly all instances the farmers wash or half wash the animal before shearing, but since this will only remove a portion of the yolk it remains for the manufacturer to remove the remainder by means of solutions of soaps, alkaline carbonates, etc. The yolk being a true soap, soluble in water, it is easy to explain why sheep which have the proper proportion of it in their wool, can so readily be washed in a stream. However, there is a small quantity of fatty matter in the wool which not being in combination with the alkali remains adhering to the wool, and keeps the latter, even with the best of washing, a little glutinous; Figs. 163 and 164 are given to illustrate the difference, in its general appearance (if examined by means of a microscope) of wool fibres before and after being scoured. Fig. 163 shows fibres before scouring, and Fig. 164 fibres of scoured wool.

Soap.—To scour wool properly without injuring the fibres is of the greatest importance to the manufacturer, thus he must use an unadulterated soap since the wool fibre can easily get killed or burned if using too strong a soap, especially if using a very hot liquor. If using a soap containing a great amount of resin or alkali the wool gets a yellow singed appearance which might be unwelcome if the wool is required for pure white or very bright colors.

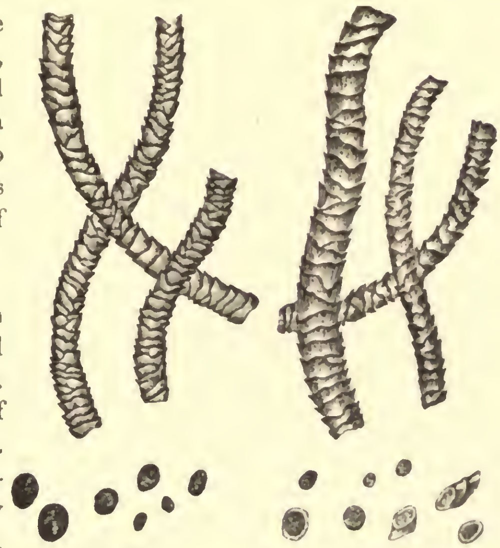


Fig. 163. Fig. 164.

For Testing Soap.—Dissolve one ounce of soap in a given quantity of water, put it in a long test glass and add a quarter of an ounce of diluted sulphuric acid, or less. The acid neutralizes the alkali; the grease and resin if any, float on top, and the earthy matter falls to the bottom. It is a mistake to suppose that soft-soap necessarily contains more water than hard-soap. The reverse may easily be the case. Soda-soaps are hard, potash-soaps are soft, because it is the nature of these materials to make soaps of which they are leading constituents, hard or soft respectively. But as a soda soap will take up four times as much water as a potash soap, and still remain firm, the temptation to adulterate in this way is great. Some soda is often put into professedly potash soaps just because it will hold so much water.

Hard and Soft Water.—Soap no doubt is the best scouring agent, it has a much milder action on the fibre than either the carbonate of soda or potash, but it possesses the disadvantage of being decomposed by hard water forming a sticky insoluble lime-soap being a pasty, greasy substance having no cleansing properties at all. This insoluble soap is deposited on the fibre of the wool submitted for scouring, and makes it difficult (if not impossible) to remove the dirt or grease from the fibre. It is claimed that one pound of lime will destroy from ten to fifteen lbs. of ordinary soap in this manner, thus it will be seen that it is of the greatest importance to have good soft water, for if it is hard, the scouring operation is made much more difficult and also more expensive. The soda or potash with which the soap is made, leaves the oil and tallow (with which it was combined for forming the soap) and unites itself with the carbonic and sulphuric acids contained in the carbonates and sulphates of lime. The lime thus thrown out of combination with the sulphuric and carbonic acids immediately unites with the oil and tallow forming the insoluble soap previously spoken of. In places where the water to be used for scouring is pure and soft, solutions of soap alone have been used with most excellent results; but if we find a hard water to deal with, it should first be softened by the addition of soda-crystals or soda-ash and heating, thus making it fit for scouring purposes. Caustic-soda in a pure and unadulterated state is the best and quickest acting material to use for softening a hard water. It must of course, be put in the water before adding the soap: *i. e.*, soften the water before adding the soap. Four lbs. of caustic soda for one thousand gallons of water is about sufficient for softening the average kind of hard water. It acts with equal results when the water is cold, renders the lime insoluble, and precipitates it along with any iron or magnesia salts that the water may contain.

Heat and Strength for Scouring Liquor.—The water used for scouring should not be too hot, but no doubt dirty wools require more heat than cleaner wools. A practical and old-fashioned method of testing the heat of the water used for scouring is never to make it hotter than the hand can bear. As previously mentioned the wool fibre is protected by a shield or covering of little scales on the outside, while the interior is composed of a great many cells. By the action of hot water these scales are slightly raised, which allows the inner cells to be penetrated and softened. The action is increased if the water contains a little acid, and still more increased if the water is made alkaline. In the latter instance the greatest care must be exercised not to injure the fibre, in a similar manner, as shown in Fig. 119. The rule for good scouring without injuring the fibres is to use a liquid made as dilute as possible, and at the same time have its temperature as low as possible subjected to clean work.

Influence of Scouring Liquor if Either Too Hot or Too Strong, or Both, Upon the Fibre.—As previously mentioned, the water used for scouring should not be too hot, since even pure water if too hot will injure the fibres; and this so much more readily if any carbonate of soda, or a similar scouring agent, should have been added to this hot water. To illustrate the effect of hot water upon the wool fibre, Figs. 165, 166 and 167 are given. Fig. 165 represents a healthy fibre, magnified; Fig. 166 shows the same fibre as visible to the eye, when magnified, after being previously treated in a bath containing five per cent. carbonate of soda to its weight and heated to about 100° F.; whereas Fig. 167 shows the same fibre as visible by being treated in a bath containing only one per cent. carbonate of soda to its weight, but being heated to 212° F. These results will clearly show that alkaline carbonates no doubt will hurt the fibre, but that boiling the scouring liquid will be more hurtful.

Fig. 165.

Fig. 166.

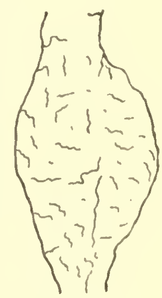


Fig. 167.

Stale Urine has been used for scouring wool since the earliest dates of wool manufacture, and is still extensively used for it in some of the manufacturing districts of Europe. It is an excellent scouring agent, and is generally used in the proportion of one gallon to five gallons of water. Frequently some potash is used in connection with the urine in the make up of the liquor.

Other chemicals used for scouring wool, but of an inferior character as a cleaner compared to soap, are sodium-carbonate, potassium-carbonate, ammonium-carbonate, ammonia, sal-ammoniac, and salt.

Sodium-Carbonate is the scouring agent most frequently used for medium and low-priced wools, either alone, or in combination with soap. When pure it is sold as *pure alkali* of 58° (indicating that there is 58 per cent. of Na_2O present). Impure grades are sold as *soda-ash* of 36° and 40° (referring again to the amount of Na_2O present). An excellent quality of sodium carbonate is known as *sal-soda*, being actually crytallized sodium-carbonate. Soda-ash frequently contains from one to ten per cent. of caustic soda, and the lowest grades even up to fifteen per cent.; thus special care must be used in buying this chemical. In most instances it will be found the most profitable to use pure alkali in place of it.

Potassium-Carbonate is more expensive than soda-salt, but has a rather milder action on the fibre than the latter.

Ammonium-Carbonate has a very mild action on wool; in fact its action is so mild that a higher temperature of the liquor can be employed than if using either of the previously-mentioned chemicals. If it were not for its high cost it would be more frequently used, since wool scoured by it is left in an excellent condition.

Ammonia is also sometimes employed, but only in small quantities, since its cost is also very high.

Sal-Ammoniac is used mostly in combination with carbonate of soda.

Salt is also often used in place of sal-ammoniac, with nearly as good results, besides being a great deal cheaper.

However, it is always more or less difficult to scour wool perfectly clean with any of these chemicals, except that the wool to be scoured contains a sufficient amount of soluble yolk; but if wool is deficient in soluble yolk, it is necessary to use more or less soap to remove all the grease.

Wool-Scouring.—The old style, which is still employed in small establishments, consists in throwing the wool into a kettle filled with scouring liquor, and where the same is worked by hand, with poles, for from ten to fifteen minutes or longer, according to the strength of the liquor as well as the quality and condition of the wool. It is then lifted out with a fork, drained on a wooden screen, and well washed several times in a cistern having a perforated bottom, technically called *rinse-box*.

Modern Wool-Scouring.—An important advantage which the modern wool-scouring machines possess over the old method of kettle and rinse-box, is, that the wool scoured by the former is more open and lofty, whereas if scoured in the old fashioned way, it is always more or less rolled up and partially felted into lumps which are difficult to open and only done so with loss of labor, besides by tearing these lumps or strings open in the process of burring and carding, the staple of the fibre is shortened, reducing proportionately the value of the stock. Another important advantage of machine-scouring compared to hand-scouring is, the squeezing of the wool when it leaves each bowl, whereby the same is relieved of its contained back-liquor and a large portion of the dissolved grease before it goes into the next scouring-liquor, or rinse-water. In the old fashioned style of scouring wool, the same is frequently only incompletely or irregularly scoured, since the kettle containing the liquor is rather small, besides the person attending to the work has to perform the manual labor of working the wool by means of a pole as well as transferring the wool from the kettle to the rinse-box and attending to its washing and taking out of the same; hence he cannot devote his entire time in keeping the liquor in the kettle equally strong and hot. By manufacturers who use the old fashioned method of scouring in the kettle and rinse-box, and who use the finer grades of wool, it has been the custom not to scour (or if compelled to, as little as possible) during the warmest part of the summer, they must therefore scour a supply ahead during the other parts of the year, since it is difficult by this process to cleanse wool properly during hot weather. By the use of the modern wool-scouring machines this difficulty is greatly, if not entirely obviated.

Construction of Scouring Machines.—Generally there are either two or three bowls placed end to end, with heavy squeeze-rolls between, which have for their object (as previously mentioned) the squeezing out of all the liquor possible and returning it to the bath, thus preventing the next bath from becoming dirty sooner than otherwise would be the case. Frequently the wool contains hard lumps of dirt and grease, which are not soft enough to be removed by the liquor in the first bowl, but as they pass through the squeeze-rolls they are broken up and readily removed by the succeeding bath. In using a three bowl machine, the first bowl contains a sufficiently strong alkaline solution to readily start the grease, and when too dirty is run off. Bowl number two, contains a weaker alkaline solution than the preceding, and which when too dirty is transferred to the first bowl and there raised to its required strength. Bowl number three is used for rinsing. If using a two bowl machine only, the latter is simply dispensed with. To work these machines to the best advantage there should be a tank for holding warm water, the bottom thereof being above the top of the bowl. Into this bowl all condensed water from the heating pipes should be carried, so as to have warm water always ready to be run into the bowl when the liquor requires changing. This plan saves much valuable time for both attendants and machine, over the process of heating the water in the bowl by steam; yet a steam pipe entering each scouring bowl is required in all cases to maintain the requisite temperature of the liquor.

Amongst the scouring machines used in this country the *Rake Scouring Machine* and the *Hydraulic Scouring Machine* are those most frequently used.

The Rake Scouring Machine.—An illustration of this machine is given in Fig. 168, representing a large size machine (46 inches wide inside of the bowl side) and which will wash about 1,500 lbs. of wool in the grease per hour. Where large quantities of stock are to be washed, these machines are set up in sets of two or three bowls (as previously mentioned) and the wool fed automatically from one to the other. In building sets of these machines they are placed on a level to readily permit the change of the liquor when desired from one bowl to another by means of an injector. The operation of the machine is as follows: The wool is fed into the first bowl either by hand, by means of an endless apron or by an automatic self-feed (explained and illustrated later). As the wool falls into the liquor it is submerged by the action of the *ducker* attached to the rake, next to the feed-apron, which serves to duck or push down the stock into the liquor and carries the same at once to the bottom of the bowl. In some cases if feeding by hand, trouble is experienced at this point, for if the wool is fed unevenly or too rapidly there is danger of the ducker catching and being stopped. To obviate any of this trouble an automatic self-feed for feeding the wool regularly and equally to the feeding-apron is of great advantage. After the wool is carried by the ducker into the liquor it comes within reach of the first of a series of *sweeping-rakes* which slowly and gently conduct it from one to the other and thus through the bowl to the other end. Besides the overhead movable rakes, there is also a series of stationary *swing-rakes,* suspended in the bowl, which no doubt aid greatly in opening out the wool which always remains behind the first stationary rake till the sweeping-rake as situated in advance reaches it in its backward and downward movement, its tines passing obliquely between those of the stationary rake. At the immediately succeeding forward movement of the sweeping-rakes, the wool is drawn from behind the stationary rake, the latter swinging forward on its pivots to permit the wool to pass underneath it. The machine also has devices for supplying water and steam to the machine, consisting in an arrangement of pipes so placed as to bring the valves all together in one place in the centre of the machine between the turret stands. Steam has access to the water through numerous small holes pierced through a pipe extending lengthwise of the machine, under the false bottom, thus distributing the heat and warming the liquor quickly and economically. The water is supplied through a chamber in the side of the bowl, which opens under the false bottom, thus obviating any splash and spatter in filling the bowl. When the wool by its motion as imparted by the overhead movable rakes arrives at the doffer end of the machine, it is taken up by the double-acting *carrier* or *lifting-device,* which lifts the same up one straight incline from the bottom of the bowl, and delivers it at once to the *press-rolls.* When the stock is to be completely cleansed in once passing through a series of bowls containing scouring liquor, and it is desired to rinse the stock in clear water, the last machine is made of a peculiar construction designed especially for rinsing, the peculiarities of which are the forcing of numerous small streams of water into the stock as it passes along near the bottom of the chute. These streams are projected with great force in the direction of the feed table, so that the rakes have to force the stock along against the streams, which action causes the water to permeate the mass of stock and most thoroughly rinse it. The press-rolls are also placed low down and outside of the bowl, the top of the bottom roller being but one inch above the water level in the bowl. The stock thoroughly saturated with water, is easily pushed over the end of the chute into the bite of the rolls by a short lifter. A shower of clean water being thrown upon the stock at this point, the squeezing and cleansing is most thoroughly effected. The water as it is forced from the stock carries with it every remaining particle of dirt, and as it falls from the rolls is allowed to run into the waste. The rinse water in all instances must be as pure and soft as possible,

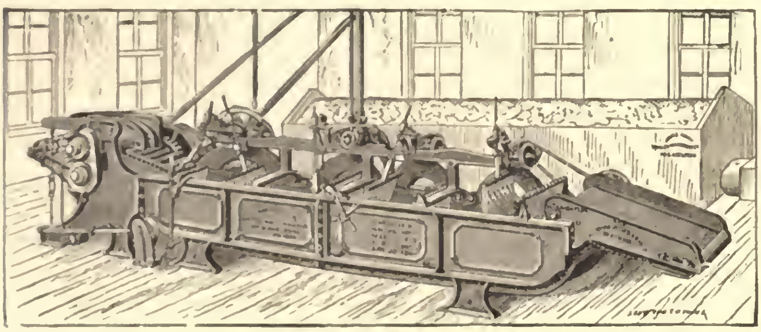


Fig. 168.

since hard water will decompose any soap left in the wool, thus forming insoluble lime soaps which will be of great trouble to the dyer, by means of making it difficult to dye even shades, and also have a tendency to produce a color not fast and liable to being rubbed off by wearing of the cloth so produced. There are also rake scouring machines built having no stationary swing-rakes, hence only sweeping-rakes (generally 12); in these machines the wool has an uninterrupted passage through the bowl.

Hydraulic Scouring Machine.—The construction of this machine, as the name indicates, is such that will take the wool through the bowl without the use of rakes. Fig. 169 is given to illustrate this machine. In the same the wool is carried through the bowl, chiefly by the force of a current of liquor flowing from the feeding end of the machine toward the delivery end, the hydraulic current being aided by a pushing impulse exerted on the continuous unbroken film of wool by teeth projecting from the revolving *ducking-drum,* located in the feed end of the bowl, and by a pulling action exerted by the teeth of the carrier, from the movement of the latter at the doffer end. The construction and operation of the machine is as follows: The bowl is filled with scouring liquor to within six inches of the top. The wool is fed in the usual manner upon the feed apron, from which it drops into the bowl, and is caught as it falls upon upward *raking-teeth* which project from the surface of the slowly revolving ducking-drum. While the wool is descending into the liquor with the drum, a current of warm liquor

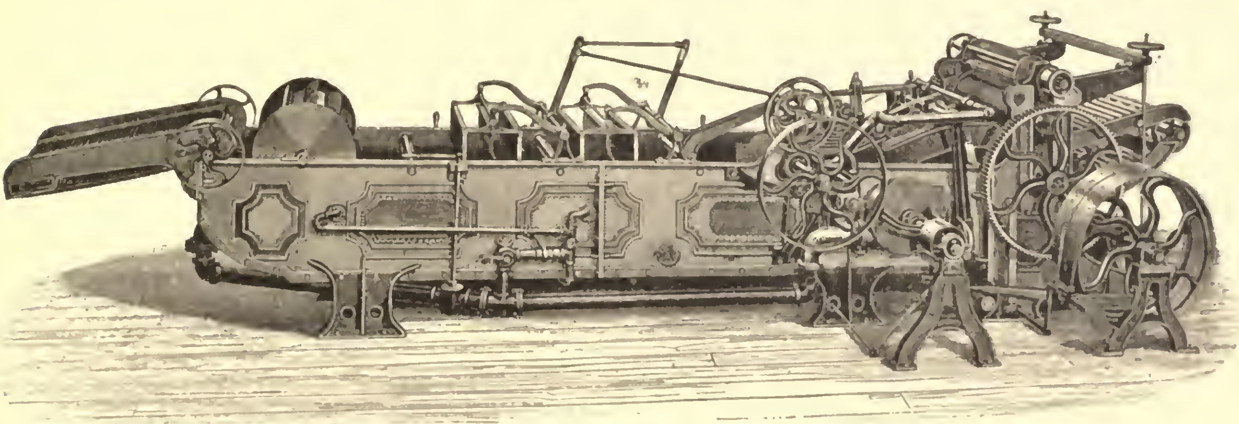


FIG. 169.

pours in upon it from a long inlet extending across the feed end of the bowl next to the said drum. The liquor is supplied to this inlet by a pipe which connects with a rotary pump which pumps liquor from a compartment under the inclined table at the other end of the bowl. The pump is located at the back side of the bowl, which is the side shown in the illustration. As this drum at the feed end slowly revolves, the wool is carried by it downward into the liquor, where it meets the incoming current of warm liquor, which washes off such superficial dirt as can be so removed, which latter falls through the perforations in the false bottom. The current of the inward-pouring liquor, continuing longitudinally through the bowl urges forward with it the submerged wool toward the delivery end. When the wool reaches the *carrier-table* it consists of an unbroken, loosely-contacting film which has been soaking from the time it entered the bowl. The speed of the drum and flow of the liquor can be so regulated that the wool can be subjected to a soakage of from four to eight minutes, according to the requirements of the kind being washed. While the wool is being carried along through the bowl with the current of liquor it is subjected to a continual ducking process by the downward movement of two groups of blades which extend across the inside of the bowl at two points between the ducking-drum and the carrier-table. This downward movement is intermittent and reciprocatory, and is imparted by levers and connecting rod extending to the carrier crank. The action of these duckers is such, that the web of soaking wool is tilted and worked upon while submerged (without otherwise disturbing it), so that the liquor is thoroughly worked into the heavy animal grease, which is thereby effectually dissolved and loosened and the hard pieces of dung effectually softened. The manner of scouring wool by this hydraulic machine is as nearly like the process of intelligently conducted hand-scouring as has ever yet been attained by machinery, while possessing the advantages of greater capacity, perfectly automatic action, and the beneficial effect of the squeeze-rolls in the immediate extracting of the liquor and the impurities dissolved thereby. There are two branches from the discharge pipe of the pump; one of which, the larger, extends to the feed end, producing the current; the other, a smaller one, with swivel-jointed connections going to supply liquor to the device for showering and re-saturating the wool with liquor when it arrives at the top of the inclined table, and just before it enters between the squeeze-rolls. It consists of a long pipe fixed across the top of the carrier, this pipe having perforations through its shell from which jets of liquor pour down through the wool and the perforated carrier-table, as it rests upon the latter, while the carrier makes its travel of fourteen inches over the said table. The latter being perforated allows the liquor to percolate through the wool, thus washing its fibre with a thorough current, or one quite different from that to which it was subjected through the bowl. The principle of thus saturating the wool is that commonly recognized when a person cleanses any porous or fibrous material, such as a sponge. He would naturally fill it with the cleansing liquid, and while so saturated give it a sudden and forcible squeeze, which would effectually expel the liquid, which serves as a vehicle for carrying out the impurities.

After passing through the washing machine the wool can be conveyed by a connecting apron to any required distance, to the dyeing, or the drying departments.

Rules for Scouring Wool, have been laid down by Bowman as follows:

1st. Don't raise the temperature of the scouring liquor above* 100° F. Don't practice turning the steam directly into the vessels containing the wool, because when the steam in the act of condensation, comes into contact with the fibres of wool they may be subjected to a much higher temperature than they can stand without injury, since the mass of wool in the water prevents the free formation of currents and this causes one part of the liquid to be at a much higher temperature than the other. The best plan is to have the water heated in a separate tank or cistern, where the temperature can be kept comparatively even.

2d. Nothing but perfectly neutral soaps should be used, at any rate when the wool is in any degree clean, and potash in preference to soda as the base of the soaps. When the wool is very dirty and the grease hard and stiff, it may sometimes be necessary to use a slightly alkaline soap, and thus remove the adhering grease more rapidly, but the greatest care should be exercised to prevent the surface of the fibre from being injured. The suint which is the natural grease of the wool as we have already seen, is composed in the larger part of the sudorate of potash, which really assists in the washing of the wool without in any way deteriorating it. The higher lustred fibres such as alpaca and mohair are even more sensitive to temperature and free alkali, than wool, and hence in washing all fibres when the lustre is important, the lowest temperature above** 60° F, and the perfect neutrality of the soaps are most important.

3d. The less agitation and mechanical action in the form of squeezing or pressing which can be used the better. When wool fibres are exposed to the action of hot water they are more liable to felt than when in the dry state, and especially when the wool is intended for worsted rather than woolen spinning, the greatest care must be exercised in the manipulation of the wool so as to cause the least felting action.

Another rule (4th) belonging under the succeeding chapter of drying is given by him as—

4th. The greatest care should be exercised in the drying of the wool, after washing, so as to prevent too high a temperature, which should not exceed 100° F. at the most; but the lower the better. This is also a most important matter, because if the wool is too much dried it becomes dessicated, and loses its natural kindness and suppleness, and tends to become brittle. In addition to this, when unduly dry

* In practice it will be found frequently necessary to raise the temperature of the scouring liquor to 120° or even 130° F.

** Up to 100° F.

the wool fibre becomes electrified, and the fibres are then mutually repellant, so that they resist the natural order in which they should be placed by the action of the machinery, and the yarn becomes uneven and rough.

Wool-Drying.—The wool, after being washed, is forwarded either to the dyeing or drying departments. The drying operation is the next to be explained, since such of the wools as are colored, and in succession washed, must be in turn also dried.

The oldest and simplest manner of drying wool (where kettle and rinse-box also are used for scouring) is to extract all the water possible from the washed wool by means of a hydro-extractor (see Fig. 170), and then spread the damp wool, in fair weather and in the open air, upon specially made tables, having wooden sides and wire screen bottoms. No doubt this process produces the most excellent results in drying, not injuring the fibres in the least, but it will not meet the requirements of our present style of manufacturing, and artificial methods of drying are necessary which have given rise to the present styles of wool-dryers in use.

Fig. 170.

Screen or Table Wool-Dryer.—The common form of a wool-dryer is a large flat or sloping table covered with wire netting, and having wooden sides, with suction fan adapted for either hot or cold air currents. Fig. 171 shows in perspective such a dryer. The wool to be dried is laid evenly on the entire surface of the wire netting *A*. The fan *B*, draws the air downward through the wool and forces it outward through the fan opening in the end of the dryer. Another method of using this dyer, with the previously referred to direction of air currents, is to enclose the upper surface in a chamber by casing around and above it, and carrying a circular steam coil around the inside of the enclosure thus formed, drying the wool with a current of air warmed by the steam pipes.

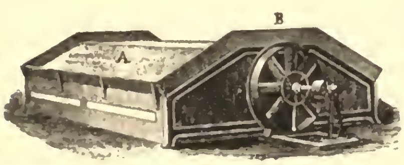


Fig. 171.

Another style of dryer is illustrated in Figs. 172 and 173. Fig. 172 is a side elevation, and Fig. 173 an end elevation of the latter looking on the end of the dryer containing the steam coil-box. Letters of reference indicate as follows: *A*, end view of dryer-frame; *B*, air-box; *C*, coil of steam pipe in the air-box; *D*, door that opens into the air-box, for the purpose of examining the pipes, etc.; *E*, door in the air-box; *H*, opening into the fan, for oiling, etc.

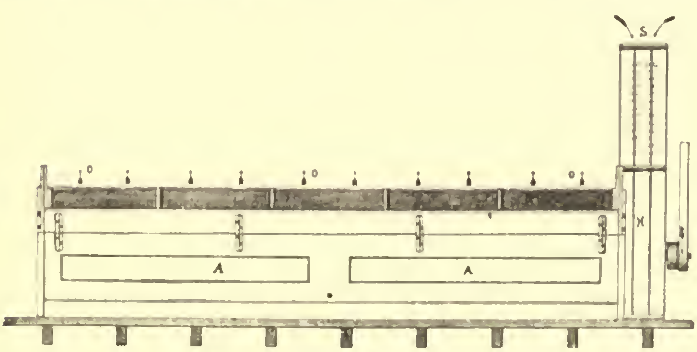


Fig. 172.

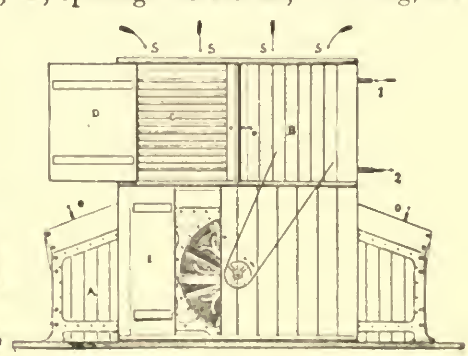


Fig. 173.

The air passes downwards into the steam coil-box through the opening in top (see arrows *S*), thence into the base of the dryer and upward and out through the wool on the screen (see arrows *O*). 1 indicates the steam inlet pipe, and 2 the steam outlet pipe. This style of a dryer can also be used without heating the air by simply shutting off the steam. Arrangements should be made to obtain the air from the source where it is driest, as from the space over the steam boilers.

The principle in building any of these dryers is to pass as much as possible dry air through the wool, since the more air (if dry) that passes through the wool the quicker the latter dries.

Automatic Continuous Wool-Dryer.—The same (Sargent's) is shown in Fig. 174 in its side elevation (four-section machine), and in Fig. 175 in its isometric perspective view (partly in section); it can be made of any desired length and capacity, according to the number of connecting sections. The construction and operation of the machine is as follows: An endless apron made of tinned wire cloth, of one-fourth inch mesh, runs over a drum *A*, at each end, and upon the upper run of this apron the wool is conducted through the dryer from the feed to the delivery end. A horizontal, stationary

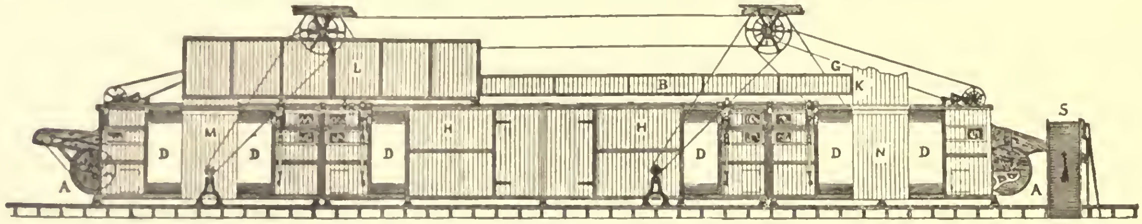


Fig 174.

guard screen, also of wire-cloth, is set about 14 inches above this movable apron and fills the width of the sections from end to end of the machine, and between the two the wool passes, carried by the movable endless apron. The entire length of the dryer is divided at the junction of the sections above the stationary screen and below the upper run of the endless apron, into compartments, each of the length of the sections; viz., 14½ feet. At the side of each section is built a steam coil-closet, and through this the air passes before entering the adjoining chamber, being forced in by a side-action fan located in the wall which separates the chamber from the coil-closet. The movement of the air currents is as follows: The air passes into the dryer via the horizontal air duct *B*, (see Fig. 174) entering one or the other or both the adjustable gates at *G*

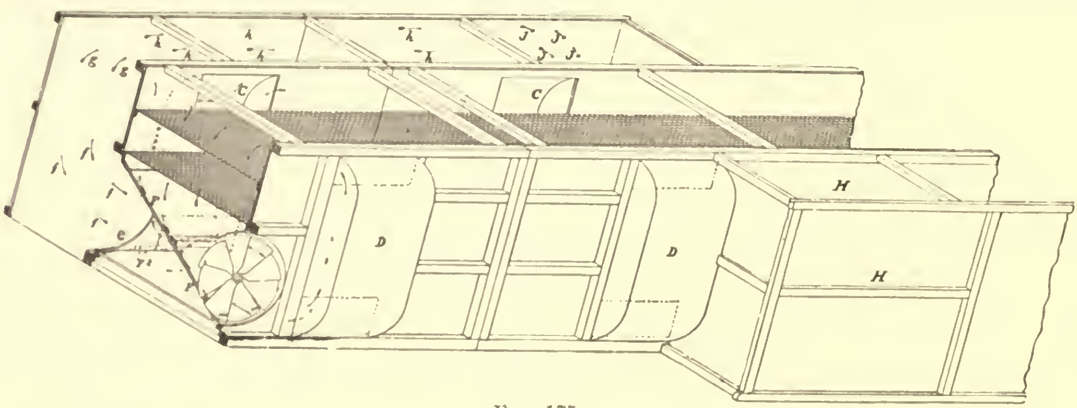


Fig. 175.

and *K*. It passes through the steam-coil into the closet *L*, (Fig. 174) and is then drawn down through shaft *M*, and thence into the section at the delivery end by the fan located in the wall of the section, as shown in the sectional perspective Fig. 175. Continuing the description, mainly by reference to Fig. 175, the air passes through the fan-circle into the section, impinging obliquely on the upper side of the swinging damper *F*, which extends to within three feet, two inches of each end of the section. In the position of this damper, shown by full lines *F*, the air is reflected therefrom upward through the aprons and the wool between them, and distributes itself throughout the upper part of the chamber and seeks four openings in the side walls near the top at the four corners. Two of these openings marked *C*, are shown in Fig. 175. The air then dives down these ducts, as indicated by the full-line arrows shown in one of the ducts *D*, passing into the lower part of the chamber beyond a small partition at the ends of the damper *F*, and passing under said damper to the centre of the opposite side of the section, escapes through a circular opening opposite the fan, at the point *e*, thence in the direction of the arrows *f*, *g*, *h* and *J*, passing through a second steam-coil at *H*, and onward into the next chamber, where a like course of the air obtains, as in the previous section, and so on through the several sections to the feed end of the machine. The air escapes from the dryer upward through shaft *N*, Fig. 174. By means of the second and succeeding coils, one at each section, the air is re-heated and its temperature thereby raised, so that only when it arrives at the chamber at the feed end has it reached its highest temperature, and there it can safely act upon the wool, at the feed end, for there the wool contains the most moisture. Here the hot air rapidly raises the temperature of the wool to the evaporating point and begins the drying process. It will thus be seen that the wool cannot be injured by too rapid drying or over-heating, for, as it passes from the feed to the delivery end of the dryer it goes through chambers of a gradually lower temperature, the air in the delivery section having only once been heated, while that in the first section has been heated as many times as there are sections in the machine. The gates located at *G*, and *K*, (see Fig. 174) are for the following purposes: The one at *G*, gives access of the outer air primarily to the machine through duct *B*, and the one at *K* connects with the duct *B*, at its end inside the large duct *N*. If it should be that the air as it escapes from the dryer still possesses some drying faculty, the gate *G*, can be partly closed and a portion of the escaping air can be arrested at the gate *K*, and re-conducted through the dryer, mingling with the new air in the horizontal duct *B*. The action of the damper *F*, (shown in Fig. 175) is as follows: In its primary position, shown by full lines, indicated by *F*, the air strikes it obliquely and is thrown upward through the wool as before explained, and this current possesses the best drying capacity, as it loosens the wool and makes it lofty, but as the heated air strikes the under side of the wool first, it there dries the soonest. To give the upper part of the wool the same drying advantages as the under side, a current of air downward through the wool is produced in the following manner: By means of cams on a cam-shaft running lengthwise of the machine, the damper *F*, is moved about three times in a minute to the position shown in dotted lines F^2, and in this secondary position the air, coming as before, through the fan circle, strikes the damper on its under side and is stopped from passing up through the wool, but instead it is carried to the ends of the section and at the bottom thereof, and takes a course upward through the four ducts *C*, *C* and *D*, *D* at the four corners of the section, as shown by dotted arrow on duct *D* (an opposite course from that first described), and distributing itself throughout the upper part of the chamber, strikes downward through the wool, and, passing over the upper side of the damper (in the secondary or dotted line position), escapes through the opening *e*, and onward to the next section, as in the first instance. Thus the upper side of the wool is dried equally and evenly as the under side. As the upward current through the wool is the better dryer, on account of its loosening the wool, the movement of the damper is so timed by the shape of the cams that the upward current is about twice as long in duration as the downward current. These automatic wool-dryers have also heavy pressure squeeze-roll devices attached to their feeding end, which is of special advantage if drying dyed wool, saving the procedure of submitting the wool to the *hydro-extractor* previously to drying. The average capacity of drying by this automatic wool-dryer is 1,250 pounds of clean wool in 10 hours per section. The wool dried by this machine is found in an excellent condition (lofty), since as it is carried through the several sections the same lies open and loose upon the endless apron. It is also dried more rapidly for the same reason, and because a free passage of air through thinly-covered or bare places in the apron in one section of the machine merely gives it a free passage to the next section, where its full drying power is utilized; at the same time the ease with which the humidity and heat of the air-current can be controlled and regulated prevents injury to the wool which it might otherwise obtain in rapid drying. The heat and dryness of the air-current can be readily regulated by carrying the escaping air back into the machine, if the wool dries too rapidly, or by shutting off the steam from a steam-coil, if the air within be too hot. The machine can be speeded to suit the character of the stock and the degree of dryness required. This is accomplished by cone driving pulleys to the feed-apron.

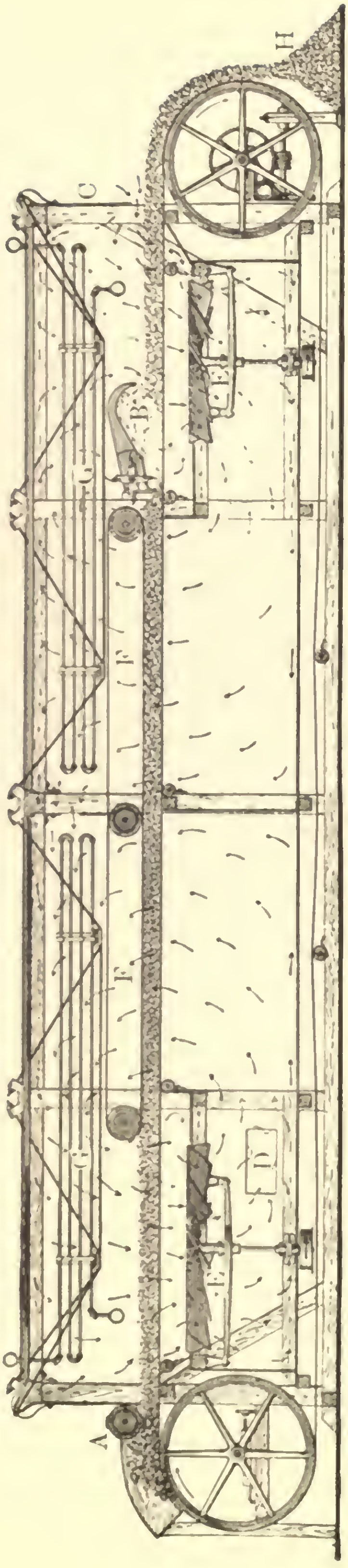


Fig. 176.

Another style of an *Automatic Continuous Dryer*, as built by the Philadelphia Textile Machine Company, is shown in Fig. 176. The same, similar to the previously explained machine is based upon the compartment system; *i. e.*, the material is carried automatically through successive compartments, in each of which is maintained a different temperature, or a different degree of humidity. The special object of this system is to hasten the process of drying itself and to utilize to the utmost the heat employed. Illustration Fig. 176 shows a two compartment machine, being sufficient to explain the *modus operandi;* but the same are also built, with three or more compartments. To illustrate the motion of the air, respective arrows have been inserted in the figure, and to assist our explanations as to the working of the machine, letters of reference in their proper position have been added. The general course of the air through the compartments is in the counter direction of that in which the material is moving; *i. e.*, the air enters at the end *C*, where the dry wool is delivered and exits at the outlet *D*, where the goods enter the dryer. Other letters of reference indicate as follows: *B*, agitator for loosening (opening) the stock during the process of drying. *F*, endless (screen) apron to keep the stock from being lifted from the main or traveling (screen) apron into the steam pipes *G*. *E*, are circulating fans, and *H*, the dried wool. The steam pipes *G*, are sometimes placed in the lower part of the machine (below traveling apron), in such a case the endless apron *F*, is dispensed with. When the air enters the dryer, the same is in the driest and best condition for taking up moisture, and while it is in this favorable condition for absorbing moisture, it is applied to the material, which, in consequence of having passed through previous compartments, has already become partially dried. The heat applied to the air as it enters the dryer, should be, for the purpose of hastening the drying, as great as can be endured without injury to the material or goods being treated. After being circulated through the finishing compartments of the dryer, the air, although it has acquired a certain amount of moisture by absorption from the goods, has still too great a proportion of heat to be wasted, and is still a very good drying medium for wetter material; hence it is passed backward into the previous compartments of the machine, where it acquires a complete load of moisture and is finally discharged at *D*.

Combining, Washing and Drying Machines (Automatic).—The connection between wool washers and automatic continuous wool-dryer situated on the floor above, is made by means of an elevating apron (see *S* in Fig. 174); thus the entire operation of scouring and drying is continuously automatic; *i. e.*, the wool in the grease is fed in the self-feed attached to the first bowl of the train of scouring machines, and the cleansed and dried wool leaves the dryer or the duster as attached on the delivery end of the dryer in a lofty state.

A New Style Wool-Dryer of special advantage for carb nizing purposes, has been lately patented, which has a two-fold object; firstly, the drying of the wool, and secondly, freeing the same during the process from any impurities, as dirt, dust, etc. Fig. 177 illustrates a section of the machine. In the same, letters of reference indicate as follows: The washed and damp wool, after leaving the squeeze-rolls *a*, of the washing machine on the first floor, is deposited upon the endless apron *b*, and from there upon the endless apron *c*; then passed between the two endless lifting aprons *d* and *e*, which raise and deposit the wool into receptacle *f* (on the second floor) by means of the beaters *g* and *h*. A workman standing on platform *i*, takes the wool and places it on the endless feeding apron *m*, which delivers it in the compartments of drum *n* (this drum, as well as those situated below it, is composed of a shaft, a wire gauze cylinder body, sheet-iron plates fitted on the shaft, wire gauze wings, through which the hot air can pass in every part, so as to traverse the layers and locks of wool during its passage from one drum to the other). As drum *n*, rotates it allows the wool to fall in small quantities into the compartments of the drum *o*, which in rotating allows it to fall in small quantities into the compartments of the drum *p* (this drum is taken away to show clearly the structure of the fixed partitions, which have openings, the inner edges of which are covered with strips of felt, to prevent the air and wool from passing between the plates of the drums and the said fixed partition), and which in rotating allows the stock to fall into the compartments of drum *q*, which allows it to fall in small quantities upon the endless band *s*, which in turn carries the wool outside. During the downward course of the damp wool in the case *r*, it falls by its own weight in small quantities, and is dried by a draft of hot air moving upwards, such air being drawn from outside the building, and heated by means of passing suitably situated steam-coils. This hot air enters the drying machine at *t*, and then passes along the passage into the chimney-shaped case *r*, and finally leaves by the orifice *u*, loaded with the humidity, dirt and dust which the wool previously contained.

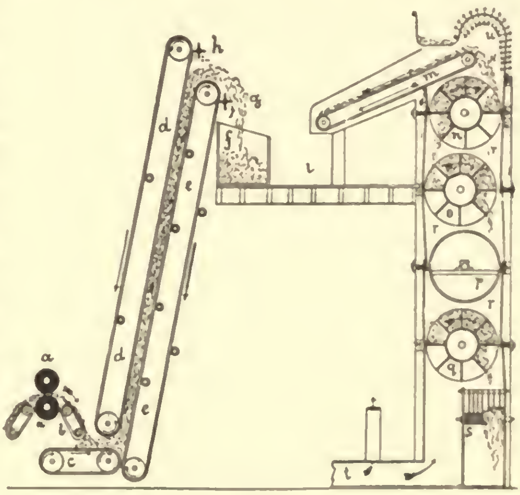


Fig. 177.

Burring.—After the wool has been dried, either in the open air or on the table (hot or cold air) dryer, or on a continuous automatic dryer, it must be freed from burrs and all other vegetable matters adhering to the fibres. Two methods of doing this work are in use, either the wool is *carbonized*, *i. e.*, the burrs, shives, etc., are chemically extracted, or the same is passed through the *burring-machine*. The chemical process is preferred if dealing with small shives, etc., whereas the burr-picker is generally brought into use where there are only burrs to contend with. Some manufacturers object to carbonizing (the fibre getting harsh and brittle) but when the same is done intelligently the fibre will not suffer. Taken on an average in our country, extracting of burrs by means of the burr-picker is the method in most general use, whereas carbonizing is more extensively used in Europe.

Carbonization of Wool.—By this term we understand the process by means of which the wool is freed from burrs or any other impurities of vegetable origin. The removal of these vegetable fibres is accomplished chemically by decomposing them with acid, chloride of aluminum, chloride of magnesium, strong salt solutions or acid vapors; then the wool is thoroughly dried and afterwards brought into a heater or machine capable of being heated to the desired high temperature and which can be maintained evenly for several hours. During this heat the acids and salts held in the wool act powerfully as water absorbents, and as no other water is present, draw away water from the vegetable fibre as found amongst the wool in the heater, thus decomposing the same into its constituents—carbon, hydrogen and oxygen. Hydrogen and oxygen will combine and form water, which will be absorbed by the heat in the machine, therefore leaving carbon behind, thus finishing the process of carbonization. Next the wool thus carbonized is cooled and run through a wool duster (see Figs. 182 and 183) where the carbonized vegetable fibres readily fall out. After thus being freed from all vegetable impurities, the wool is passed through a strong soda bath for removing the acid, and is afterwards well washed. Where salts are used in decomposing the vegetable fibre, it is not necessary to use a strong soda bath, since prolonged washing, or what is preferred, washing with earth, is sufficient to free the wool from all carbon and salts.

Carbonization with Sulphuric Acid.—Great care must be exercised during this procedure, so as not to have the acid bath too strong, since it would act harmfully on the wool fibre. The process of carbonizing is as follows: A diluted sulphuric acid solution, not exceeding 4° B. in strength, is placed in a large wooden box or in a cement-lined cistern. The loose wool is soaked for twelve hours in the acid bath and well stirred several times so that all parts are evenly penetrated. The wool is then extracted by a hydro-extractor having a copper kettle or by squeeze-rolls and thoroughly dried upon wooden poles in a drying chamber at 180° F. When the water from the solution has been driven off, the sulphuric acid exerts its water-absorbing power and draws the hydrogen and oxygen away from the vegetable fibre, taking them up as water, and thus leaving the carbon alone behind. As soon as this process is complete, the wool is removed and subjected to the action of a duster when the carbon falls out as dust or dirt. After this treatment the acid is removed by a soda bath, or in some instances the wool is dyed directly. It is absolutely necessary to raise the temperature in the drying-room to 180° F., since the carbonization will not take place at a lower temperature.

Carbonization with Chloride of Aluminum.—The use of chloride of aluminum for carbonizing has superseded in many mills the older method of carbonizing with sulphuric acid, because the chloride has very little effect upon the woolen fibre even at a high temperature. (It will also act less harmfully upon fast or fugitive colors, if wool to be carbonized has been colored previously). The wool to be thus carbonized must be impregnated (the same as described in the acid method) with a solution of water and aluminum chloride of a strength of from 6° to 7° B. for one hour; then the wool is taken out, extracted and dried (by regular temperature) in a common dryer. After the wool has been dried in this manner the same is placed for one hour in a room heated to about 250° F. which will be sufficient to completely destroy the vegetable fibre. This high temperature can easily be reached by using a suitable apparatus and with machines with superheated steam at a pressure of four to five atmospheres, because the wool, impregnated with chloride of aluminum can be placed directly upon iron without any danger from spots. The drying apparatus for carbonization can therefore be constructed of iron with hollow walls for the passage of the steam, which cannot be done if using the sulphuric acid method as the acid causes the separation of iron rust, and this drops upon the wool and injures it. In this fact lies one of the great advantages of the chloride of aluminum method, as the drying can be done by steam, and can therefore be exactly regulated, besides there is never any danger from fire. After the wool is thus treated, it is taken out of the heating room, cooled and submitted to the action of a duster, afterward washed in clear water, or with some Fuller's earth added, as the residue from the chloride is easily removed.

Carbonization with Chloride of Magnesium.—Similar conditions as explained by the previously given process are necessary for carbonizing wool with this article. The chloride of magnesium will neither attack the wool fibre, nor the color, if dyed wool should be required to be carbonized. Chloride of magnesium is used in solutions of 5° to 6° B. in which the wool is soaked for half an hour. The wool is then taken out and well extracted in a hydro-extractor or by means of squeeze-rolls and dried on a common dryer. When perfectly dry it is placed in a room heated to 250° F. for one hour, then taken out, cooled, dusted, and washed the same as is done with wool carbonized with chloride of aluminum.

Carbonization with a Strong Salt Solution.—The wool to be carbonized is placed in a tinned iron drum and the drum hung in the liquid. The kettle containing the salt solution can then be heated over a free fire and a temperature of 255° to 265° F. easily be maintained for an hour. The wool is then carbonized, and can be treated as in the chloride of aluminum process. It is only necessary to wash the wool well with water, which will perfectly remove the magnesium salts. This method gets rid of the difficulty which usually comes from carbonizing with a free fire and where the injury is due to the too great heating (at the bottom) of the wool, which is likely to lessen materially the elasticity and strength of the fibre. But a carbonizing machine of proper construction, heated by steam, is certainly preferable to any other method, as it is cheaper, more convenient and more regular in its action, and can always be regulated by a valve and pressure gauge.

Carbonization with Acid Vapors.—For this process is used a rotating iron cylinder, which is heated by surrounding it with a coil through which steam at four to five atmospheres pressure is passed, and which heats it to 230° to 260° F. The material is well dried, placed in the cylinder, and the air pumped out with a vacuum pump. The hydrochloric acid vapors are passed into the rotating cylinder, and by the rotation are brought into perfect contact with the wool and perfectly saturate it. As soon as the action of the vapors upon the vegetable fibre is complete, which must be found by previous experiment, the current of gas is shut off and the suction pump again attached. After the acid vapors have been withdrawn, the cylinder having been kept at a temperature of 230° to 260° F., with continual rotation for one or two hours, the carbonization is complete, the cylinder is emptied and refilled. Acid vapors can only be used for white wools or such as are dyed with perfectly fast colors. In the same manner as when using hydrochloric acid vapors, nitric acid vapors can be used for white wools, or only such as are dyed with indigo blue, as all other colors are destroyed by nitric acid.

Burr-Picker.—The object of this machine is to clean the stock from any burrs, shives, etc., without injuring the staple by cutting or rolling. Amongst the burr-pickers most frequently used we find the *Parkhurst Double Cylinder Burring Machine* as shown in its perspective view in Fig. 178. The operation of this machine is as follows: The wool to be burred, is carried by an endless apron to the feed-rolls, the teeth of which are hooked, and the stock is held loosely while the picking cylinder combs it from them and carries the stock up to the two burring cylinders, which are directly over the picking cylinder where the burrs and other foreign substances are knocked out by the guard into the burr-box in front. The stock is then swept by the brush into the beaters at the spout, where shives or other fine particles are knocked out and the cleaned wool delivered into the room or boxed-up receptacle situated behind the picker. Having the burr box in front, the person operating the machine can see at all times what is being thrown out, and can stop the machine immediately if not working properly. The picker-cylinder runs up and the double-burring cylinder being directly over the picker-cylinder gives the same action as a card cylinder, throwing the stock up into the workers making it any easy place for the wool at the point of contact between the picker and burring cylinders. The blower sets on the floor at the back of the machine, and the draught is exactly opposite the feed-rolls under the

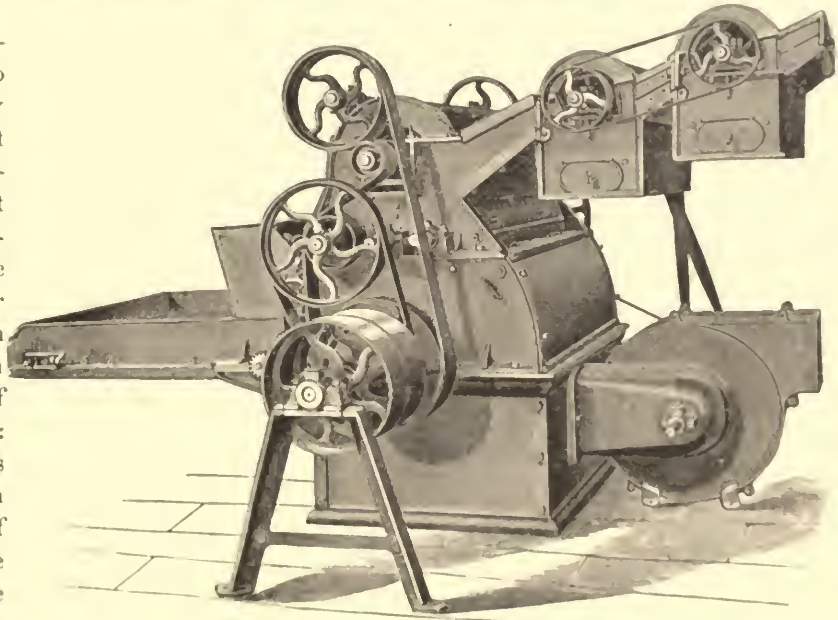


Fig. 178.

stock, so that the dirt and dust are drawn entirely away from the stock; heavy dirt drops through the grates, and fine dirt and dust are carried out of doors. The beaters at the spout are a valuable attachment, particularly for mills manufacturing fine goods, as they knock out large quantities of shives and fine dirt. Being at the spout they are in the best possible position to do this, as they take the stock as it passes out of the machine thoroughly opened. For carpet stock and coarse yarns the beaters are not used.

Another style of burr-picker (Sargent's) is shown in its section in Fig. 179. Its method of operation is as follows: The wool is placed upon the feed-apron *A*, which carries the same between the feed-rolls *B*, (the bottom roll of which is run faster than the top, or vice versa, thus one roll acts as a clearer for the other) from which the same is taken by the picking cylinder *C*, carried forward and combed upon the burring cylinder *D*, on which the burrs are separated from the wool by the guard *E*. The wool thrown off with the burrs by this guard is arrested and carried back into the machine by the currents of air passing through the rack as indicated by arrows. *F*, is the rotary brush which keeps the burr-cylinder constantly clear, removing all cleansed wool therefrom and passing it out from the machine through spout *G*, as indicated by arrows. *H*, indicates the fan which sucks off all light impurities, dust, etc., that are liberated from the wool as cleaned, by the currents of air passing under the feed-rolls *B*, and under the guard *E*, and up through screen *I*, (shown in its side view) into the fan as shown in the illustration by arrows; *K*, the pipe through which the light dust is carried out. *L*, the rack or screen, under the picking cylinder *C*, through which all the heavy dirt, etc., passes after being liberated from the wool by the action of the feed-rolls *B*.

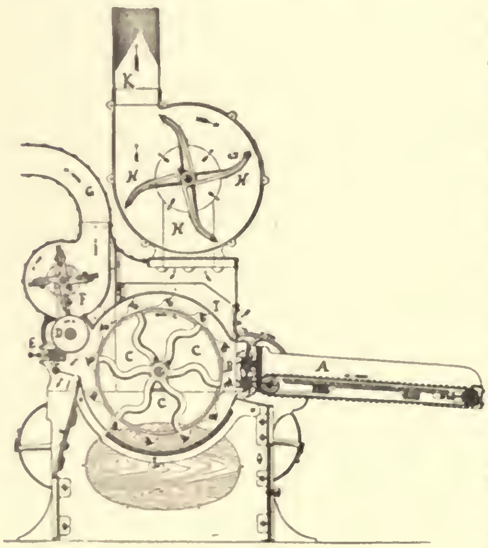


FIG. 179.

The section of the *Curtis and Marble Burr-Picker* is shown in Fig. 180. The operation of this machine is briefly as follows: The wool, being fed by an endless apron, is carried along and taken between the feed-rolls provided with curved or hook-shaped teeth, which securely hold the wool in a position to insure its thorough opening by the combined action of these teeth and those upon the picking cylinder. These teeth are so arranged in the bars as to cover at each revolution of the cylinder every sixteenth of an inch for the entire width of the machine, and by thus opening the wool, the dirt and burrs are fully loosened and the wool well prepared for further operations. Caught upon the teeth of the main cylinder, the fibre is carried around under the screen, through the perforations in which the strong current of air to the exhaust blower carries away with it the fine dust and particles, at the same time drawing out from the line of the teeth of the fibres, wool now opened and rid of much of the foreign matter. In this shape the wool is presented to the first burring cylinder. This is of large size, and takes from off the main picking cylinder such fibres as are in proper shape to be treated, and drawing them into the interstices between the rings, firmly holding them in this position with its teeth, while the burrs and other refuse matter are retained upon its surface and coming in contact with the guard are thrown back. The fibre, however, is carried along under the guards to the point of contact with the second or *cotter-cylinder*, at which place the cots and knots are gently combed apart and thoroughly opened. The brush, acting in contact with both cylinders, removes the fibres, and delivers them through the outlet into the wool-house, passing them, by the way, under the oiler, at which they receive the requisite amount of moisture in the form of fine spray.

The burrs and other refuse matter thrown back by the guards are carried down to the grate-rack by the current of the revolving picker-cylinder. The heavier dirt, kemp and vegetable fibres, pass through the narrow spaces in the grating, while the fibres of wool on the burrs, upheld by the current

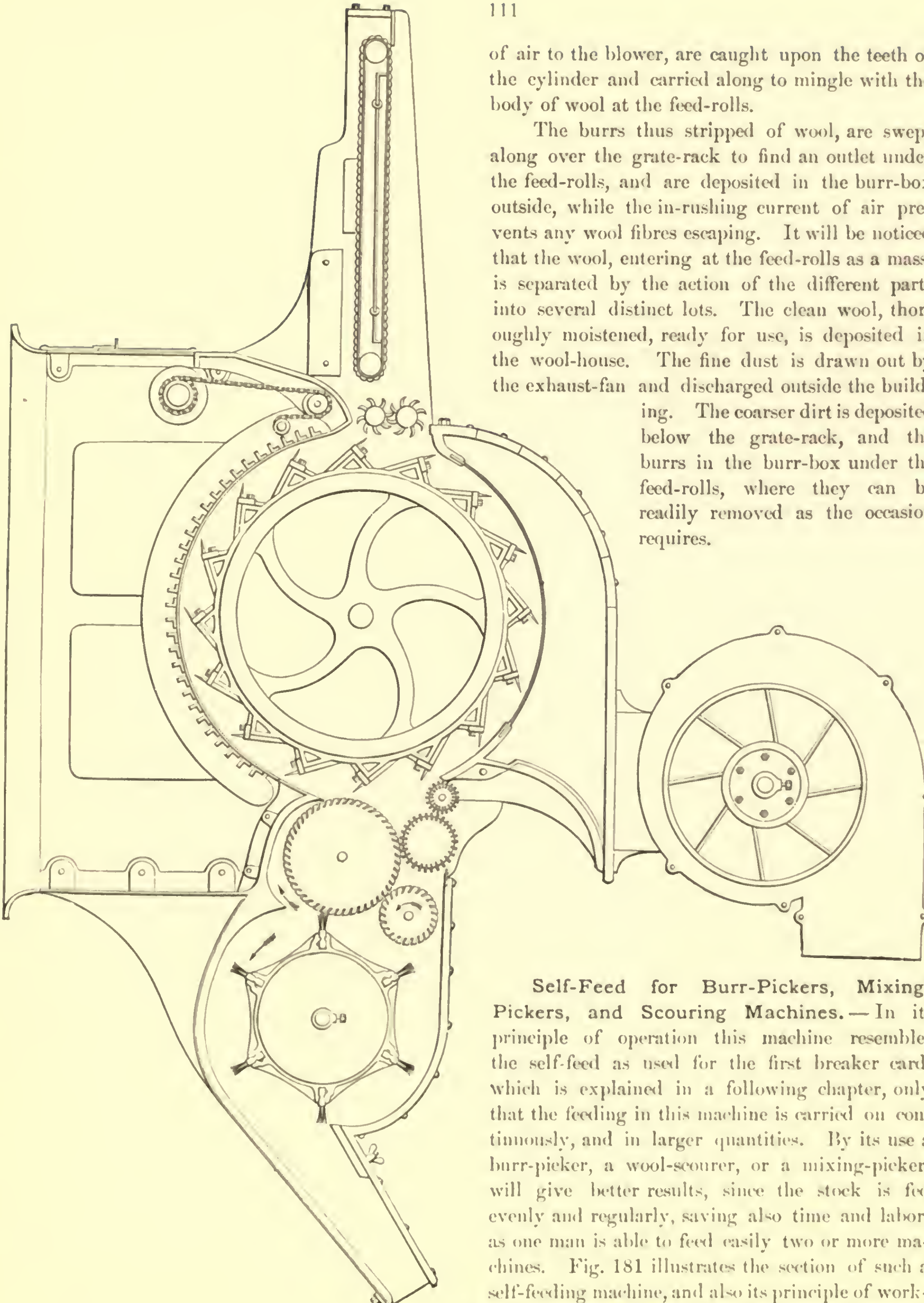


Fig. 180.

of air to the blower, are caught upon the teeth of the cylinder and carried along to mingle with the body of wool at the feed-rolls.

The burrs thus stripped of wool, are swept along over the grate-rack to find an outlet under the feed-rolls, and are deposited in the burr-box outside, while the in-rushing current of air prevents any wool fibres escaping. It will be noticed that the wool, entering at the feed-rolls as a mass, is separated by the action of the different parts into several distinct lots. The clean wool, thoroughly moistened, ready for use, is deposited in the wool-house. The fine dust is drawn out by the exhaust-fan and discharged outside the building. The coarser dirt is deposited below the grate-rack, and the burrs in the burr-box under the feed-rolls, where they can be readily removed as the occasion requires.

Self-Feed for Burr-Pickers, Mixing-Pickers, and Scouring Machines. — In its principle of operation this machine resembles the self-feed as used for the first breaker card, which is explained in a following chapter, only that the feeding in this machine is carried on continuously, and in larger quantities. By its use a burr-picker, a wool-scourer, or a mixing-picker, will give better results, since the stock is fed evenly and regularly, saving also time and labor, as one man is able to feed easily two or more machines. Fig. 181 illustrates the section of such a self-feeding machine, and also its principle of working. The operation of this machine, as illustrated by letters of reference, is as follows: The wool placed in a mass in the feed-box *A*, is acted upon intermittently by a horizontally reciprocating pusher *B*, which impales the wool at the bottom of the feed-box upon the teeth of the elevating apron *C*. The stock as lifted by this elevating apron comes next under the action of the evener *D*, which detaches from it any knots or large particles of wool, and thus prevents the same from being carried over to the rear or delivery side of the elevating apron. Such of the stock as is carried by the elevating apron in the delivery side of the machine is taken from the latter by means of the vibrating clearer or stripper *E*, having two or more rows of needle-pointed teeth, and a stationary toothed holder *F*, having two or more rows of needle-pointed teeth. The extent of movement of the stripper *E*, with relation to the teeth of the elevating apron opposite, to which it travels, and with relation to teeth of holder *F*, is such that the stripper acts to clear the wool not only from the teeth of the apron, but also from the teeth of the holder, the latter acting in turn to detach the wool from the stripper on the return stroke of the latter. The wool is thus evenly deposited upon the feed-apron *H*, and carried by the same to the feed-rolls *I*, and cylinder *K*, of a picker or other machine into which the wool is to be fed. When this machine is applied to a wool-scourer the feed-apron is dispensed with, the wool falling directly into the bowl of the wool-scourer.

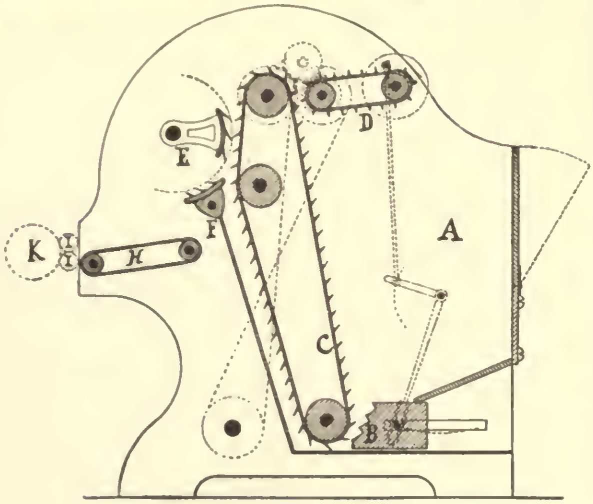


FIG. 181.

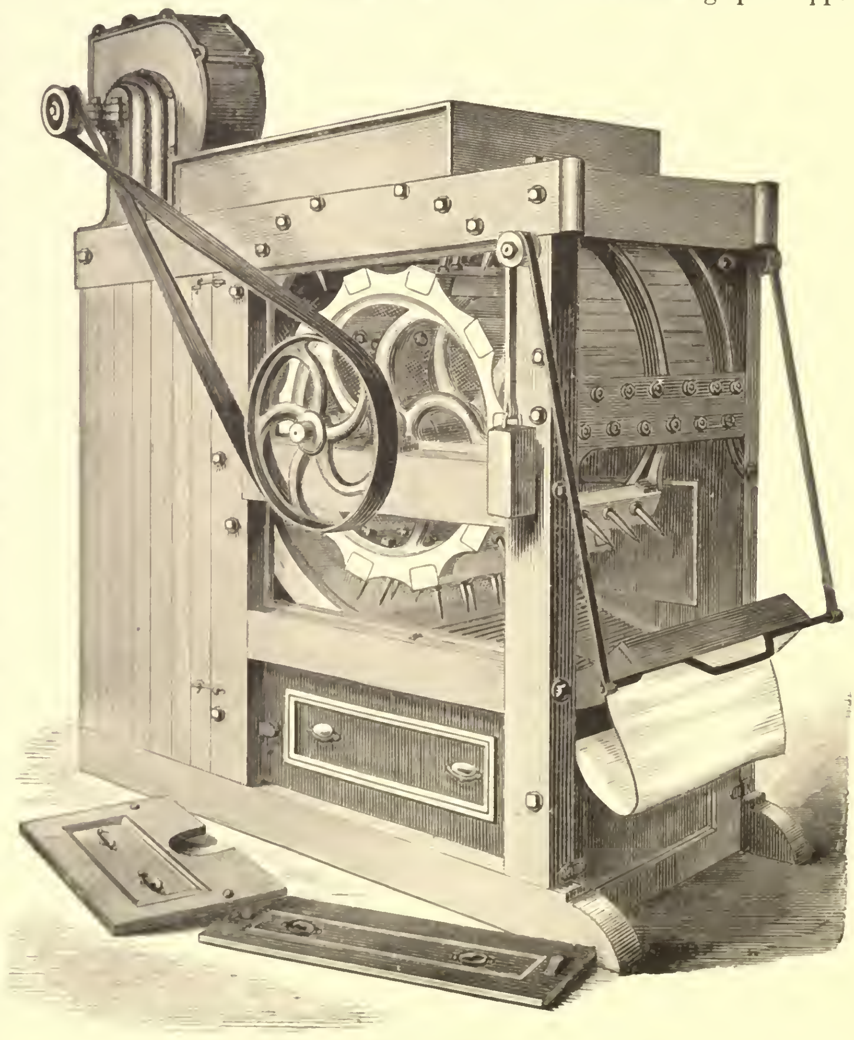


FIG. 182

Wool-Duster.—Another machine, also frequently used in connection with a burr-picker, is a wool-duster. It can also be used independently from the picker, and the stock after being dusted (*i. e.*, any dust or dirt adhering to the fibres removed) transferred either to the self-feed or direct to the feeding apron of the burr-picker. If the wool requires no burr-picking, the same is, after being dusted, transferred to the mixing department. Two different styles of wool-dusters are in most general use, the straight-duster and the cone-duster.

The Straight-Duster (as shown by illustration Fig. 182) is better adapted to medium and long wools, or any kind of wool not very dusty, as the cylinder is short and the wool goes quickly through. Platt Bros. have lately perfected a straight-picker (Willow), containing Indicator and Automatic Discharge. The indicator is set by the operator, according to the quality of material to be cleaned, thus regulating length of time the stock will remain in the machine, producing in turn an even cleaning of the material throughout the entire lot.

The Cone-Duster (as shown by illustration Fig. 183, interior view, front detached) is more suitable for wools which are very dusty, excepting the very long-stapled carpet wools, as the wool remains a longer time in the duster. For these long carpet wools a modification of this duster is built by changing the character of the teeth and feeding device. Care must be taken if using a cone-duster not to get the material in a stringy condition.

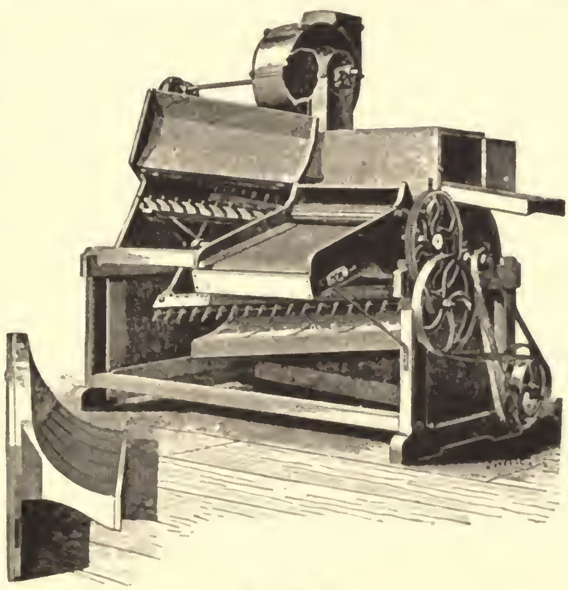


Fig. 183.

After the wool has been freed from all impurities, as burrs, shives, dust, etc., the same is forwarded to the wool-picking department for mixing, oiling and picking; *i. e.*, getting the stock in the proper shape for the carding engine.

Mixing.—This process is of the greatest importance, and requires care on the part of the operator, since imperfect mixing will produce an endless amount of trouble to the manufacturer. Mixing is done not only for combining two or more colors or qualities of stock equally into a mixture, but is also used in lots of one color and one quality of stock, since any imperfections or mistakes in sorting, scouring, dyeing, or burr-picking are by this process equally transferred over the entire lot. The greater the amount of wool to be mixed, the more perfect work (cloth finished) we get. If the lot to be mixed is too large for oiling (getting dry before being used up on the cards), simply divide the same after a thorough mixing in two or more batches, and use them in rotation; *i. e.*, oil and pick the next batch when the first is about running out on the carding engine. For such large lots the automatic (atomizing) wool oiler, as used in connection with the first breaker card, will be found of great advantage. An explanation of the same will be found under its proper heading later on. Rooms for mixing the lots of wool should be always large, to permit the making up of big lots for mixing and picking.

In some mills mixing is greatly undervalued and yet this operation is the backbone of perfect work, for no matter how perfect the carding and spinning, how nice the weave and the color, how beautiful the finish, if that person frequently entrusted with the mixing of a lot of wool composed of two or more materials, qualities, colors, etc., has been careless or ignorant in his work, the finished cloth will be more or less imperfect. Examining a thread produced by such imperfect mixing under the microscope, reveals instead of the perfect amalgamation of each individual fibre, a mass of fibres from the one minor lot in one part, and a mass of fibres from the other in the next part of the thread. Such poorly mixed yarns may be the reason for cockles, streaks, imperfect matching, etc. of the finished fabrics, also poor carding and spinning, in these respective departments, giving in turn the greatest annoyance and trouble to the dresser and weaver.

If mixing two different materials, for example wool and cotton, wool and silk waste, etc., the greatest care must be exercised. To illustrate the proper mixing of cotton and wool the manufacture of *Vigogne yarns* as used extensively in Europe may be given, and which closely resemble our *merino yarns*. Both raw materials for use in the mixture should be of the best of the staple; *i. e.*, the cotton clean Sea-Island and the wool merino fibre. The wool after being scoured, dried (dyed) burr-picked, and oiled is then carded on a common breaker carding engine and the film on leaving the doffer arranged to wind in a lap. The other material, the cotton, must be opened, picked, and run through a common cotton carding engine (breaker) and the film after leaving the doffer wound on a lap the same as is done with the wool. After either material has been thus (roughly) carded, the desired amount of each is picked by itself on a common wool-picker, and then both materials thoroughly mixed and picked twice over again on the wool-picker, ready for the regular process of carding on the woolen card. If there is no arrangement for winding laps on the doffer-end of the breaker-cards (as used for preparing the stock before mixing and final picking) the common style of a sliver on leaving the breaker engine may be used in place of a lap.

If mixing wool with silk-waste the greatest care must be exercised since silk is harder to card than wool. Both wool and silk should also be carded previously to being picked; any way, if not carding the wool, the silk-waste should be carded so as to be thoroughly opened. The silk-waste as used for mixing must also have the color of the ground of the cloth to be manufactured except in dealing with fancy yarns, or yarns manufactured for special purposes. The same method also refers to all-wool mixtures of great diversity in amount of each ingredient. For example, an Oxford mix composed of 97 per cent. black, 3 per cent. white. In such a case the white wool should be run through a card previous to mixing.

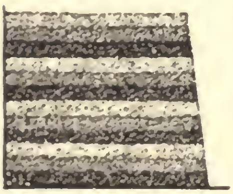


FIG. 184.

Method of Mixing.—Whatever kinds of material required to be mixed, the principle to be observed in mixing is to spread the same evenly and at the same time thinly over as large an area and in as many layers as practicable. For illustration of this subject see Fig. 184, representing the mixing of three different materials, or three different colors of the same material, etc.; in this illustration the dark shaded divisions represent material or color number one, the medium shaded divisions represent material or color number two, and the light shaded divisions, material or color number three. If dealing with mixtures of great diversity in amounts as well as colors and qualities of each ingredient, prepare first a temporary mix of less diversity as to amount of ingredients. This temporary mixture mix finally with the remainder of the large minor lot. For example: 1,000 lbs. gray-mix, composed of 90 per cent. black, 10 per cent. white, mix as follows:

Prepare temporary mix of	100	lbs. white, and
	200	" black,
	300	lbs. amount of temporary lot,
which mix with	700	" black, giving
	1,000	lbs. as the amount of material to use in the second or final mixing.

If oiling the lot simultaneously with picking, each layer when put down on the pile must be oiled and afterwards well beaten down with sticks. If oiling the stock by an automatically working attachment (atomizing wool-oiler on the first breaker card), no oiling in the mixing department is necessary.

When the pile is finished (oiled or not oiled) and the stock to be taken away for feeding into the wool-picker, always break into the pile vertically downward, so as to put at the same time on the feed-apron of the wool-picker, or in its self-feed, part of each layer composing the pile. In some mills the wool is also oiled automatically on a special oiling-picker before being mixed, but as this method requires an extra running through the picker, as well as being inferior in its work, it is not much in use.

Oiling by Hand.—This is the most frequently used method for oiling wool lots and consists in distributing the oil (in a limpid condition so as to permit a free flowing) by means of a can having a spout provided with a cross piece (spout and cross piece in the form of a T) pierced with several rows of small holes. Previous to putting the oil in the can it should be filtered by running through a piece of burlap so as to remove any impurities which might possibly clog the small holes in the cross piece attached to the spout.

Atomizing Wool Oiler for First Breaker Cards.—By oiling the previously mixed stock at the feed of the carding engine by this device, the oil is completely broken into fine particles, like a mist, and is precipitated with force into the evenly spread wool, and as the wool passes the feeding rolls the oil and wool are thoroughly mixed, and if oil-emulsion be used, the chance for evaporation is but slight, as the wool is only exposed to the evaporation while passing through the cards. The arrangement of these oilers is very simple, and the amount of oil put on, can be varied from one quart to ten quarts per hundred pounds of stock to suit the work in process, and is completely under the control of the carder. Figs. 185 and 186 are given to illustrate such an oiler as built by Sargent & Sons. Fig. 185 represents an end elevation of the device; Fig. 186 is a plan of oiler section showing dipper or bucket, for lifting the oil from tank on brush for atomizing. Letters of reference in Fig. 185 indicate as follows: *A*, is one of the side stands that support the end of the machine. There are two of these stands, one at each end, which set outside of the feed sides of the carding engine. *B*, is the oil tank which extends across the feed from side to side, and stands about eight inches above the wool on the feed-table. It holds about four gallons of oil. It also contains the dipper-shaft and buckets, as seen in Fig. 186. *C*, is a lever-arm on the dipper or bucket-shaft, which is adjustable with set screws. *D*, is a connecting link, one end of which is connected by a stud to end of lever-arm *C*; the other is connected to the crank pin on an eccentric which gives the vibrating motion to the bucket. This eccentric is on the end of the driving shaft, and communicates motion to all parts of the machine. An eccentric strap connects by a stud to the lever-arm on the brush-shaft and gives to the brush-shaft a backward and forward motion. *F*, is the driving pulley and has motion in the direction indicated by arrows. On cards using large amounts of wool, such as carpet filling wool, this pulley should run about thirty-two turns per minute and on cards using fine wools, about twenty turns per minute.

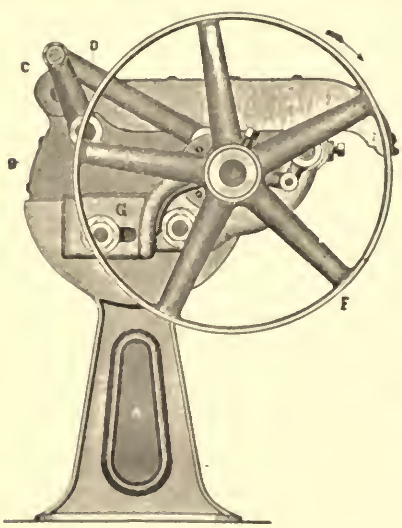


Fig. 185.

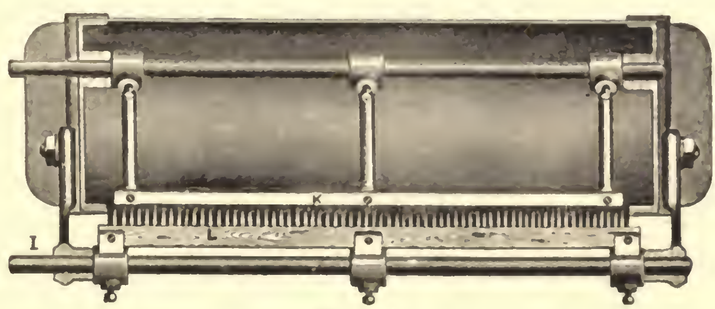


Fig. 186.

When the burring machine is long enough, the oiler is driven from it, but if this cannot be done, then it is arranged to be driven from the first worker shaft outside of the arch. *G*, is the stand to hold driving shaft, etc., and is bolted to the side of the stand *A*. Letters of reference in Fig. 186 indicate as follows: *I*, is the brush shaft. *K*, is the dipper or bucket which brings oil from the tank up to the point of contact with the brush. *L*, is the brush in position to atomize the oil taken out from the bucket.

Kinds of Oil to Use.—The best lubricant to be used is olive oil. It readily softens the fibre and keeps it in this state for a long time. On account of its high price it is only used in connection with the finest grades of wool.

Another and much cheaper lubricant is oleine, which is obtained from the manufacturer of stearine candles, and being free from acid, is well adapted to the oiling of wool. This product is frequently brought into the market for its cheapness, with the acid only imperfectly removed, in which case it will injure the card clothing, and possibly also the hands of the persons handling the oiled stock in the picker and card room.

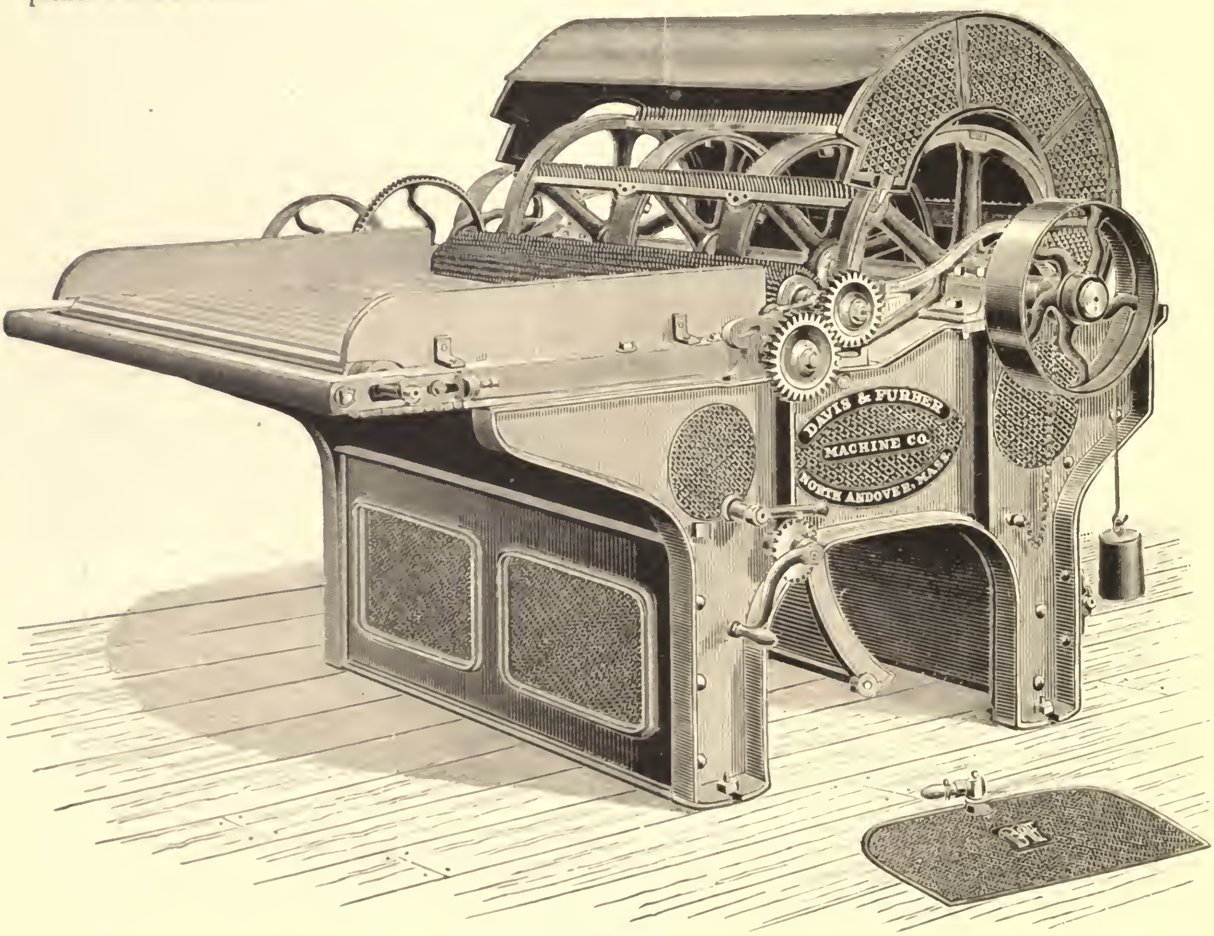


FIG. 187.

Another lubricant used for wool is red-oil, of which there are two kinds in the market, the saponified and the elaine (distilled), the latter being the most suitable for this purpose.

The most frequently used oil for oiling wool is lard oil.

Testing Oils.—The best method for testing oils, as to whether they are unadulterated and a good lubricant, is: Stir up a portion of oil with forty parts of a solution of carbonate of soda of 3° B. If the oil forms a milky emulsion, without any oily drops on the surface, it is a good lubricant for wool fibres.

Quantity of Oil to be Used.—A fair average composition frequently used for wools picked in the uncolored state is 12 to 16 per cent. of oleine and 30 per cent. of boiling water, both taken in proportion to the weight of wool to be oiled. To assist the union of water and oil add a little sal-ammoniac. If dealing with colored wools use only 20 per cent. of water in place of previously mentioned 30 per cent. It would be of little value to lay down a number of receipts for preparing the amount of the lubricant to use, since that depends entirely upon the kind of wool used, the condition of the same, and the quality of the oil.

Construction of the Wool-Picker (also frequently termed mixing-picker).—The operating parts of this picker consist, 1st, of the feed-apron, upon which the stock to be picked and mixed is deposited either by hand or by means of a self-feed (see Fig. 181); 2d, the feed-rolls, which take the stock from the apron and deliver it to the action of, 3d, the main or picking cylinder. The stock is thrown out of the rear of the machine by the current of air produced by the fan-like action of the main cylinder.

Two specimens of this machine are given in Figs. 187 and 188.

Fig. 187 represents the picker built by the Davis & Furber Machine Company, which, with the exception of the feed-apron, is made completely of iron and steel. This method of construction is of

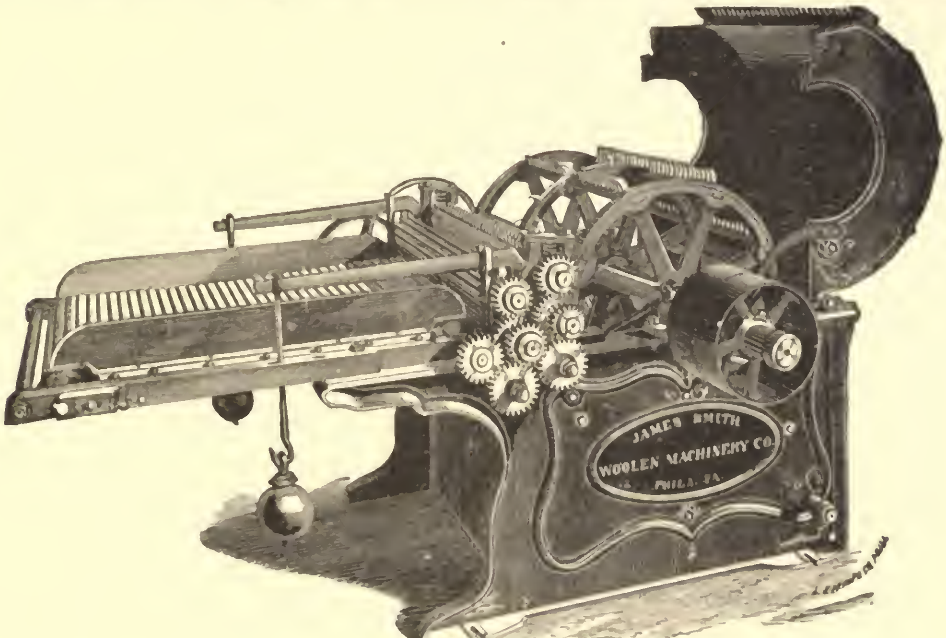


FIG. 188.

decided advantage where the stock is oiled in the picker-room, there being no wood about the machine to be soaked with oil and rendered more inflammable. The teeth for opening the stock are made from cast steel and tempered; they are firmly secured in wrought iron lags, which are mounted on spiders and held in place by heavy wrought iron hoops, shrunk on over their ends. The rack under the toothed cylinder is made to offer the least surface for the accumulation of grease, being hinged at one end, and provision made for swinging up and down by means of a crank, conveniently placed at one side of the machine. The feed-rolls and apron are of usual construction, the rolls of cast iron with pointed teeth, and so mounted as to yield to any unevenness of feeding. The average speed of this machine should be from 900 to 1,000 revolutions per minute.

Fig. 188 illustrates a similar machine built by the James Smith Woolen Machinery Company. This is also what might be termed a fire proof machine, since no combustible material (except the feed-apron) enters into its construction. This machine is provided with a feeding device, consisting of a pair of fluted nipping-rolls combined with a pair of cock-spur toothed rolls. The stock, passing first between the fluted rolls, is held firmly and prevented from being drawn into the machine by the action of the main cylinder. The toothed pair of rolls which follow closely after the fluted pair, are geared to run with an excess of surface-speed over the fluted rolls, so as to cause a pulling action or draft between these two pairs of rolls. The main cylinder picks against the pair of toothed rolls. This feed is particularly adapted to long fibre stock, and is to be strongly recommended for such stock, as the peculiar action of the machine is such that the full length of the staple is preserved.

Carding.—The wool after being picked is ready for the carding engine, which in its principle of operation closely resembles the roller-card, as illustrated and explained in the chapter on cotton carding. The object of carding is to produce a thread in which the fibres composing the same lie roughly and crossed in every direction, and the ends of which are seen to stand out (nap), which is of special advantage in assisting the felting of the cloth, as they will lay hold of each other and unite the different threads of which the fabric is composed into a compact mass. A specimen of a woolen thread (composed of coarse fibres) as visible to the eye when magnified is given in Fig. 189, and will clearly illustrate its construction with reference to previously given explanations.

Fig. 189.

Set of Cards.—Three separate carding engines compose what is known as *one set of cards* and which are individually known as: first breaker, second breaker and, finisher. The wool is fed to the first breaker either by hand, or as is now more frequently the case, by means of a *self-feed.* The connection between the first and second breaker is made either automatically by means of the *Apperly-feed* (or any similar device) or as is preferable; the sliver after leaving the first machine is wound in balls on a *balling-head,* or a *side-drawing-attachment,* and they in turn either set up in a creel (*bank-creel*) in rear of the second breaker and fed in the latter, or wound on a *roving-spooler* into a roll (*lap*) and in this state set in a *back-stand* and thus fed to the card. Both the bank-creel and the back-stand unwind the slivers automatically. The connection between the second breaker and the finisher is always entirely automatic, either by means of an Apperly-feed, or a similar device. This method of feeding the sliver by means of an Apperly-feed greatly assists in keeping the fibres from being drawn out straight, *i. e.,* keeps them in a crossed position, and which will be set in the thread by the next operation or spinning. The stock on entering the finisher-card in the shape of sliver or ribbon, leaves the same on the delivery end in thirty to sixty or more (according to width and build of the machine) thin ribbons (*roving*) which are wound on wooden rollers (*roving-spools*) and taken to the spinning department.

Self-feed Machines.—This attachment to the first breaker is the device with which the stock comes first in contact in modern wool carding. The old-fashioned way (being the style used in smaller mills or on old-fashioned cards), of feeding the stock to the first breaker was to weigh a certain amount of material on a scale fastened to the frame of the feeding table and spread this amount by hand on a certain (marked) space of the feed-apron. This method of feeding the stock is shown in Fig. 190. Generally this work was and is yet (in mills where practiced) in the hands of children, who take little if any interest, hence the feeding is frequently irregular, which is accompanied by a corresponding delivery at the other end of the card, and which imperfections are more or less carried through to the finisher producing in turn uneven roving.

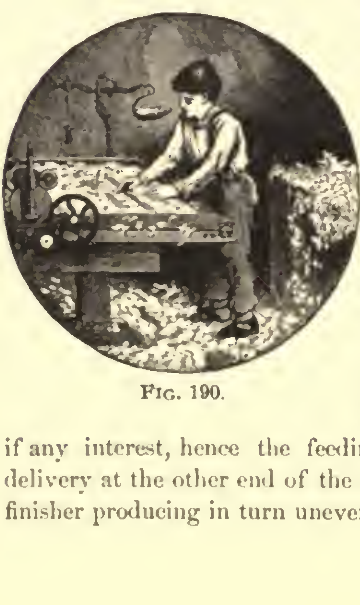


Fig. 190.

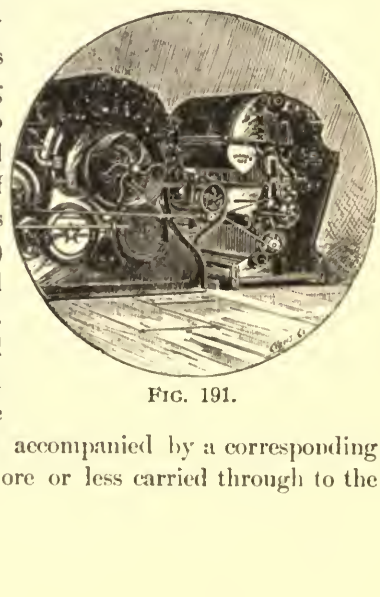


Fig. 191.

Since the last fifteen years or more, an automatic feeding apparatus has been constructed to do away with this hand-feeding, resulting in producing a more perfect thread as to its diameter as well as a saving in labor, since one person can do the work done by two or more persons when using the old style. In contrast to illustration Fig. 190 the new style of feeding the breaker-card automatically by means of a self-feed, is shown in Fig. 191.

The first step for producing a self-feed was made by Mr. Bolette who obtained a patent for it in 1864. It was constructed upon the principle of measuring the material as supplied to the carding engine. Several of these machines were built in this country but never attained great success.

The Bramwell Self-Feed.—This was the first successful machine of this kind put in the market, it being the invention of W. C. Bramwell, and was first brought out in 1876. Fig. 192 illustrates this machine in perspective. In the same the wool is put in a large box having a grating at the bottom, for the exit of the refuse, and an elevating toothed apron at the rear, which raises the material out of the case until near the top, where it is brought under the action of an oscillating comb having a slow but long sweep in front of the apron. The teeth of the comb carry off the surplus wool from the apron, dropping it back among the rest in the box and what is left is evenly distributed over the apron and carried over the top roller and there meets another but shorter apron having a more rapid movement and being provided with flexible strips of leather, which sweep off the wool from the teeth of the large apron and convey it into the scale or trough formed of two covered wings, held together by suitable weights, and the whole suspended on steel knife edges, and balanced with movable weights, which can be fixed to weigh any amount desired. When the scale has received its proper amount, it liberates a small trigger, which causes a projection to catch on one of the teeth of a revolving disc, connected with an automatic clutch, which disengages the driving belt operating the toothed apron, thus instantly stopping further delivery of material to the scale which now remains at rest. When the proper time arrives, the wings are opened apart and the wool is deposited onto the feed apron. The scale is now closed and returned for more wool, the toothed apron is set going at the same time and the delivery repeated. By the time the scale gets filled again such of the stock as has been previously discharged is moved along positively on the feed-apron, to a fixed distance, thus providing a clean space thereon for the next weighing to fall into.

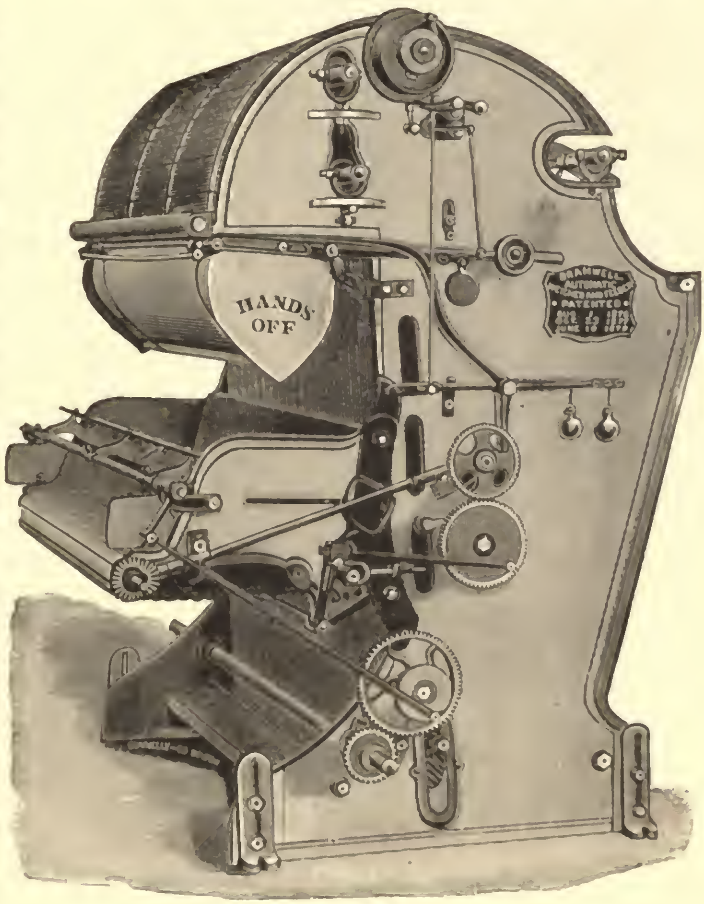


Fig. 192.

Lately an improvement to this self-feed has been patented by G. A. Allison. The object of the invention is to secure a greater degree of uniformity in the feeding or delivery of the stock to the carding engines than heretofore; and it consists, in the combination with the feeding and delivery portions of the mechanism, of an attachment adapted to sound an alarm upon the failure of the requisite supply in the scale from a lack of the proper quantity of material in the box into which it is thrown.

The Peckham Automatic Feeder is another style of self-feed for breaker cards, and in its principle of working resembles the previously explained machine. Figs. 193 and 194 are illustrations of this machine. Fig. 193 represents the receiving end, and Fig. 194 the distributing end. The receptacle for the wool contains two compartments, the outer and the inner, the stock passing down one side and up on the other side, from which it is taken by the apron as it passes upward and over the top. This receptacle is so built that the stock is gradually carried from the outer compartment up into the top of the inner one, and the whole frame presses slowly toward the apron, preventing the stock from falling back from the points of the teeth in the apron. When the stock approaches the top a vibrating evener sweeps backward over it, thus evening the stock off to permit a proper feeding to the delivery side of the apron. The wool is then stripped from the apron by a comb consisting of an oscillating bar with teeth and brush combined. When the motion is moving upward, the brush lifts the stock from the pins of the apron, and in the descent the teeth grasp it and carry it down to the surface of the scale then in position. The scale or weighing arrangement in this feeder acts on the same principle as a platform scale, so that no matter in what part of the scale the stock falls it will weigh accurately. When the stock is weighed every motion of this feeder will stop, preventing any of the wool from getting into the scale after the proper weight is given. A corrugated roller is used for keeping even layers, leading the fibres of the wool straight to feed-rolls of the carding engine, preventing in turn, as much as possible, the breaking of the fibres by the burr cylinder. To prevent the feeder from running out of stock (which makes uneven feeding, producing in turn uneven yarn), the previously-referred-to automatic alarm is attached, which gives warning about ten minutes before time to feed in new stock, the old being carried out, thus leaving no short stock in the bottom of the feeder.

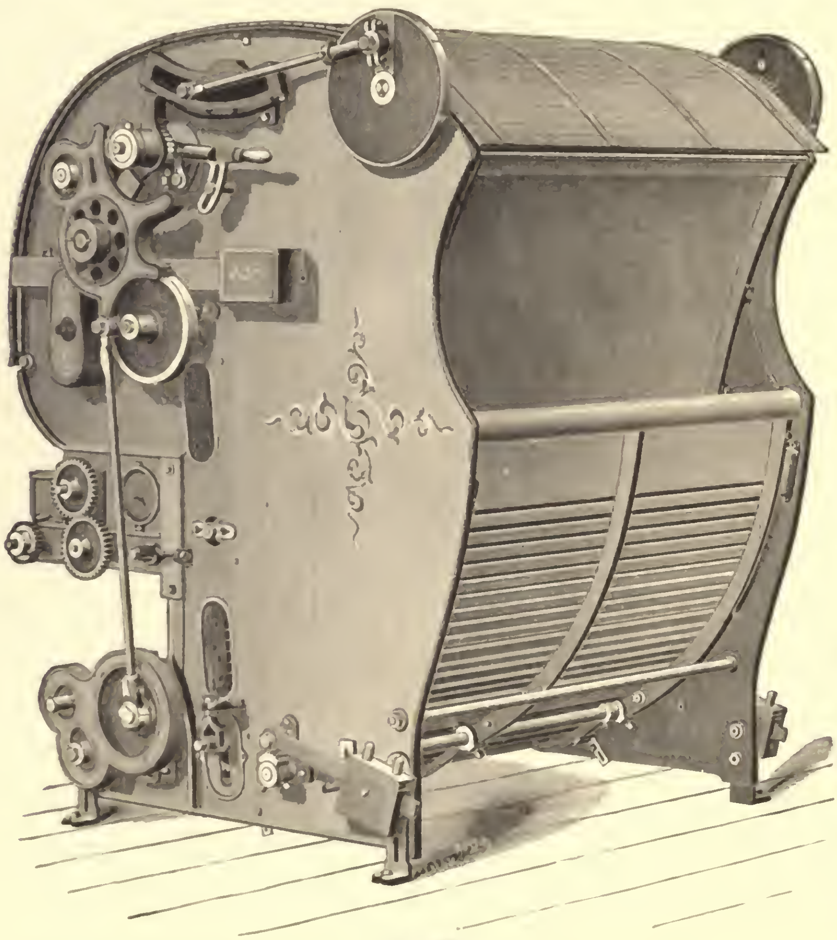


FIG. 193.

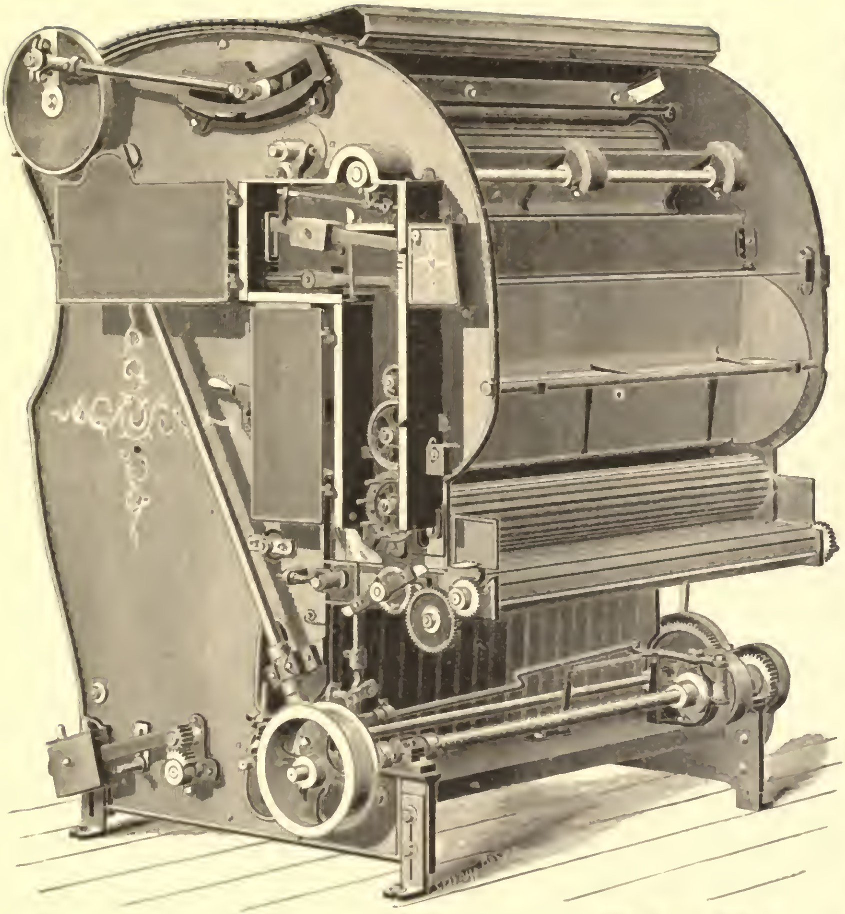


FIG. 194

The Lemaire Feeder.—Another style of self-feed is known as the Lemaire Feeder, of which a perspective view is given in Fig. 195, and a section illustrating the method of operation in Fig. 196. The receptacle for holding the stock forms with the movable back side *A*, a closed box of which the endless apron *B*, forms the bottom. This apron forwards the stock to the hooked roller *C*. The movable back side *A*, constantly exerts a pressure upon the stock towards this roller, consequently the machine will feed until all the stock is used up. Combs *D*, and *E*, have for their object to even off the amount of stock deposited upon roller *C*, as well as to partly straighten the wool fibres as situated upon its surface. The up and down acting comb *F*, liberates the wool from the teeth of roller *C*, delivering the same upon the toothed and slanting plane *G*, from where the stock by means of the up and down moving lever *H*, is forwarded to the endless apron *I*, and from there to the feed-rolls *S*, of the carding engine.

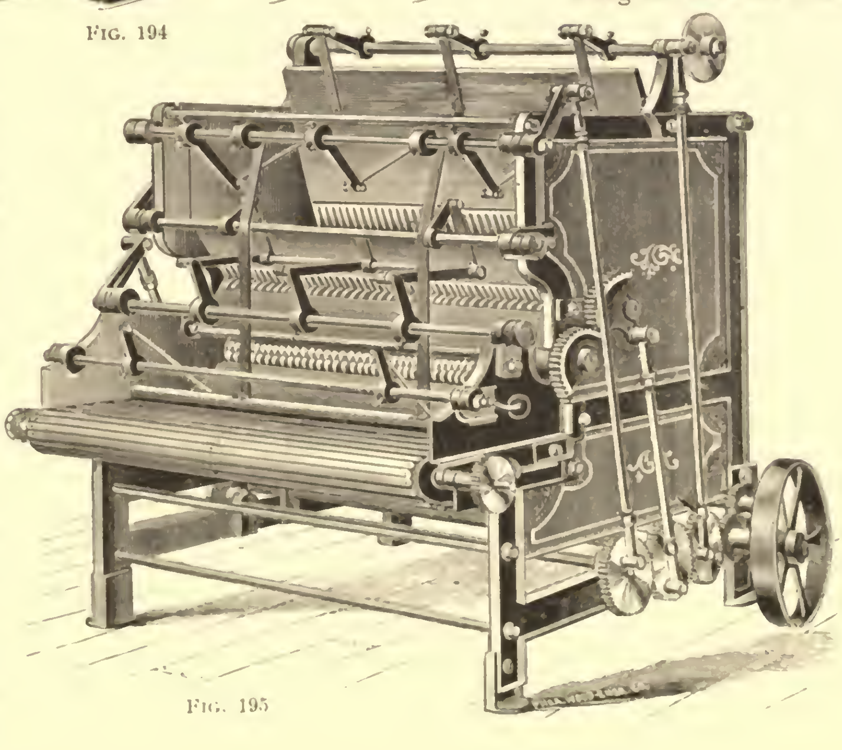


FIG. 195

Construction of the Card Clothing and Relative Action of the Card Wires.—This subject has been described and illustrated in the chapter on cotton carding, and as an explanation of it would only be a repetition of the former, we simply refer our readers to pages 29 and 30.

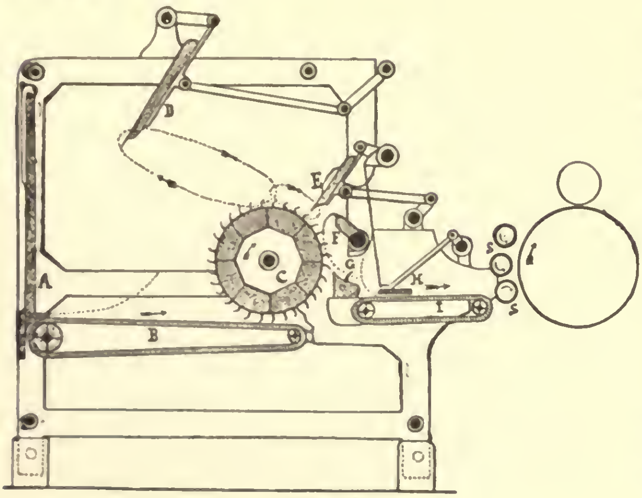


FIG. 196.

Fillet Winding.—The winding of the card clothing on the respective rollers technically known as fillet winding has been also already previously explained and illustrated in its proper place in the chapter on cotton carding, and as the modus operandi for the carding engine for woolen yarns is similar, we refer the reader for information on the subject to pages 41 and 42.

FIG. 197.

Covering with Sheets of Card Clothing.—If using sheets of card clothing for covering the cylinder, the same are first nailed on the upper side in their width to the cylinder, next they are stretched down by means of clamps and nailed on the cylinder at their lower side. Stretching and nailing on being done width for width of the clamp until the sheet is finished, when both sides are simply nailed down. An illustration of such a card clamp is given in Fig. 197. Fig. 198 shows two styles of hammers used for the work by the carder. Lately a card ratchet has been constructed for assisting the carder in his labor as well as providing a uniform stretch. An illustration of this device (as used in connection with a clamp) is shown in Fig. 199, in its perspective view as well as a detailed drawing of the catch.

FIG. 198

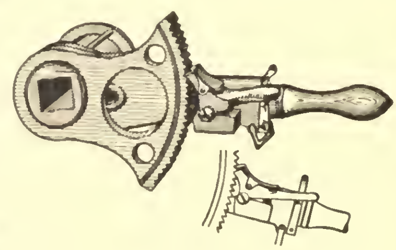


FIG. 199.

One great disadvantage in clothing the cylinder with sheets compared to the use of filleting consists in the reduced working-surface. The clothing for the fancy is either in the shape of sheets or fillets whereas, workers, strippers, and doffers (except rings used in some of the condensers) are clothed with filleting. If covering the swift and the fancy with filleting run the direction of the thread, of the filleting, reverse.

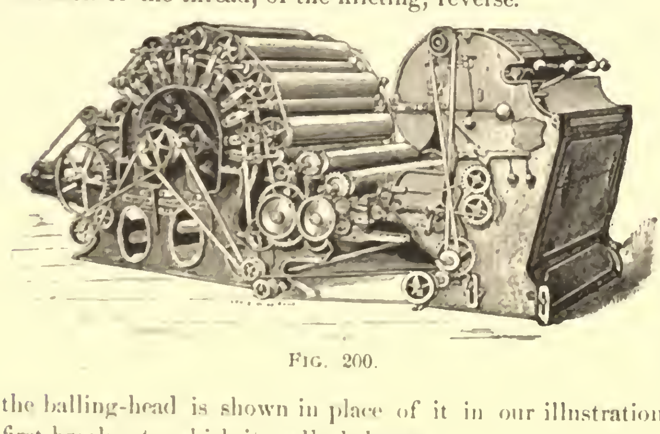


FIG. 200.

Illustration and Explanation of a Complete Set of Cards.—Before going more into detailed explanations of the different carding engines, we give in Figs. 200, 201 and 202 an illustration of a complete set of cards.

Fig. 200 illustrates a *first breaker* with *self-feed* attached.

Fig. 201 represents a *second breaker* with *bank-creel feeding and balling-head* at doffer end. The delivery on this card is generally by means of the *Apperly-feed;* the balling-head is shown in place of it in our illustration, being unable to show this device on the first breaker to which it really belongs.

Fig. 202 illustrates a *finisher-card* with *Apperly-feed* attachment.

First Breaker Card.—This (as the name indicates) is the first carding engine in a set of cards with which the picked wool comes in contact.

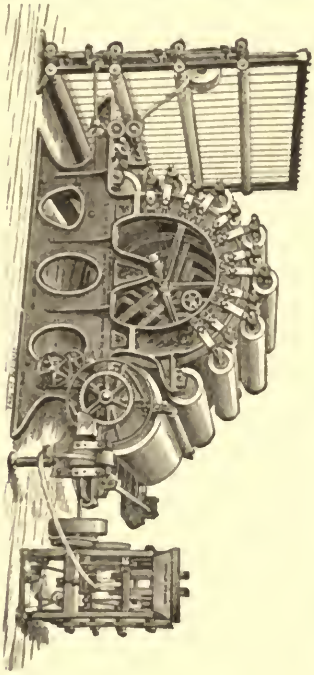


FIG. 201

FIG 202.

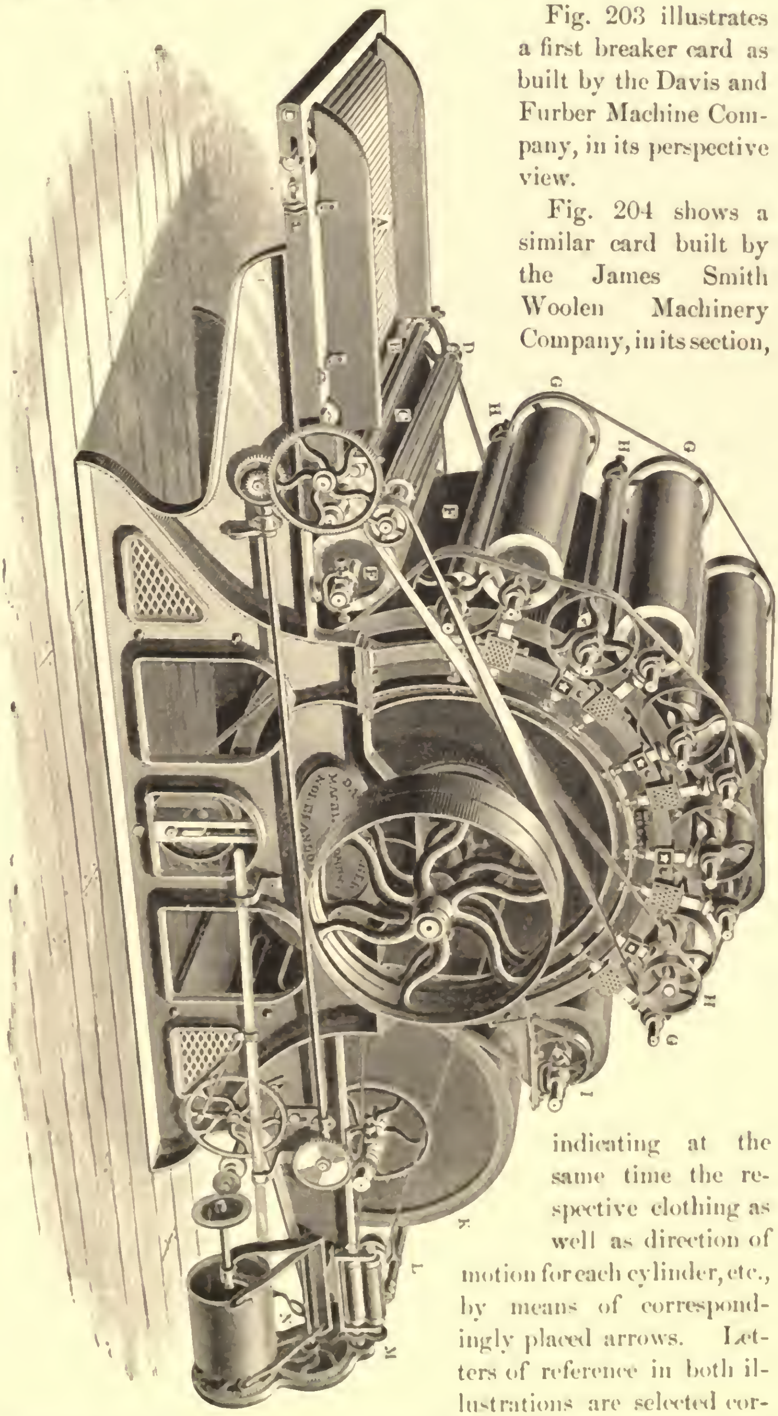


FIG 203.

Fig. 203 illustrates a first breaker card as built by the Davis and Furber Machine Company, in its perspective view.

Fig. 204 shows a similar card built by the James Smith Woolen Machinery Company, in its section, indicating at the same time the respective clothing as well as direction of motion for each cylinder, etc., by means of correspondingly placed arrows. Letters of reference in both illustrations are selected correspondingly. The wool properly weighed and spread evenly either by hand (see Fig. 190) or by means of a self-feeding machine (see Fig. 191), on the endless *feed-apron A*, passes between rollers 1 and 2, of the three roll set of self-stripping metallic-toothed *feed-rolls B*, where it is met by the *burring-cylinder*

C, which wholly stripping number 1 roller, commences the carding process in conjunction with number 2 roller, taking a part of the material from it and leaving some on it, which latter part is taken off and delivered to the *licker-in* by number 3 feed-roller. *D*, is the *beater-guard* which knocks out any impurities, such as burrs, shives, etc., of sufficient size to be reached by it. (This burring machine composed of burring cylinder *C*, and beater-guard *D*, is known as a *single* or *common burring machine* and is explained later on in detail under that heading.) From the burring cylinder the material passes to the *licker-in* *E*, which in turn gives up the same to the *swift* or *main cylinder* *F*, which is running at an average speed of from 80 to 100 revolutions per minute. This quick revolving swift carries forward the material into the slowly retreating teeth of the first *worker* *G*, revolving at an average velocity of from 6 to 7 turns per minute. Between this first worker and the swift the actual carding process commences,

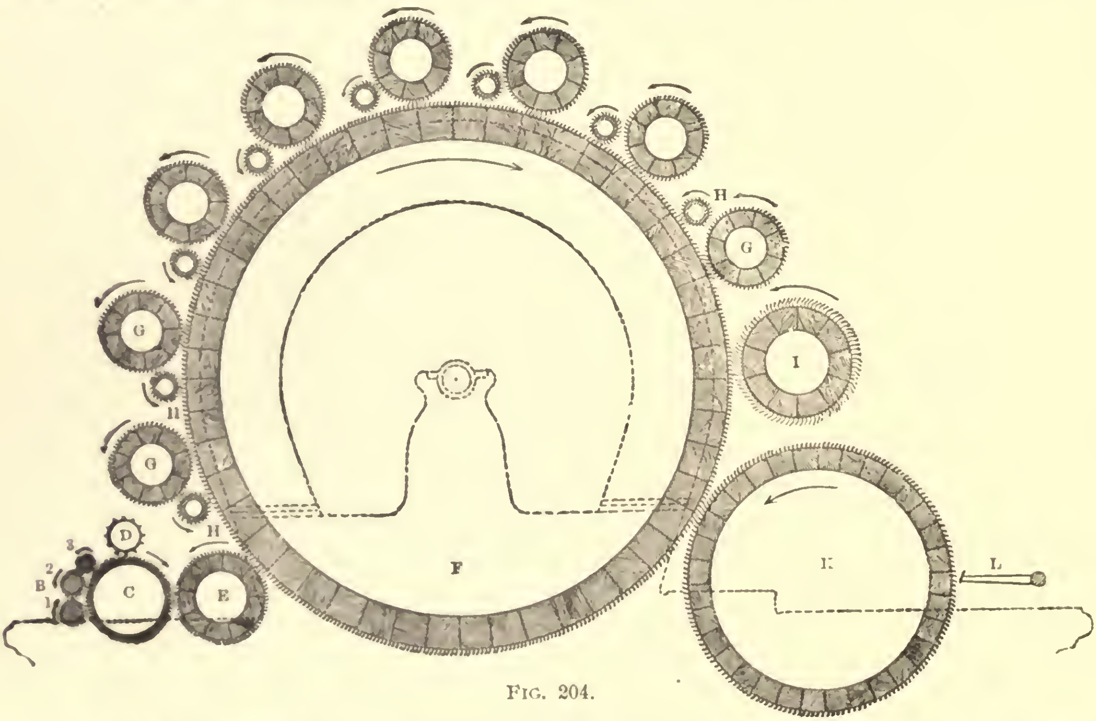


FIG. 204.

the quicker speed of the passing cylinder causes the different teeth of the card-clothing to work point against point. Worker number 1 will get its share of material from the swift, which when brought around, is taken up by its *stripper*, which in turn again delivers the material onto the clothing of the swift. This method of carding the stock is repeated by each successive pair of worker and stripper in the carding engine. A special illustration of the action of a worker and stripper upon the material (carding the fibre) is given in Fig. 205.

FIG. 205

After the material has been carded by the last set of workers and strippers, it is all taken up again by the swift, which carries it a little further until it reaches the next roller, which is known as *fancy I*, whose work is to raise all the material up out of the wires of the main cylinder, into which it has been forced by its velocity in passing the different strippers. To accomplish this task the clothing of the fancy consists of long, fine steel wires, which are set a little way into the clothing of the swift; besides the surface velocity of the fancy is greater than such of the main cylinder, by means of which the same will brush up, raise, the stock sufficiently; *i. e.*, prepare it for the *doffer K*, which revolves slowly and in an opposite direction from the swift, thus the latter will deposit the material upon the surface of the doffer-cylinder, which carries the same about half way around on its clothing, and from whence it is stripped off by the *doffer-comb L*. The film thus combed off is passed between the *compression-roller M*, and is wound on a ball on the *balling-attachment N*, or guided to a special *balling-head,* as shown in illustration Fig. 201. These balls of sliver are afterwards set in the *Bank-creel* of the second breaker carding engine (see Fig. 201), or several of these balls, according to the width of the card, wound in a lap on a *Lap-winder,* also called *Roving-spooler* (see Fig. 206), and two of these laps (for the purpose of doubling, *i. e.,* to balance any imperfections as to dimensions of slivers) put up in the rear of the second breaker card in a *Back-stand* (see Fig. 207) for second carding.

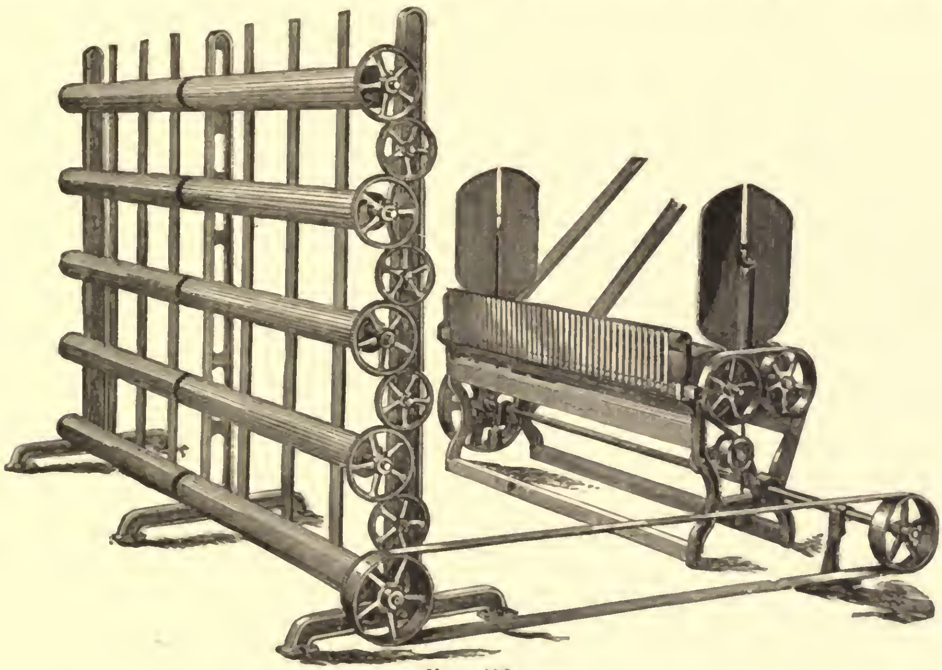


Fig. 206.

Burring Machine as Attached to the First Breaker-Card.—As previously mentioned, this attachment is the first part of the breaker-card with which the stock as deposited on the feed-apron comes in contact. Its object is, to free the material to be carded from any possible impurities not previously removed, and which will also act as a powerful first carder, thus protecting the clothing of the card from any unnecessary wear. This makes this device of such great importance that a special description of the various kinds of burring machines attached to breaker-cards is necessary.

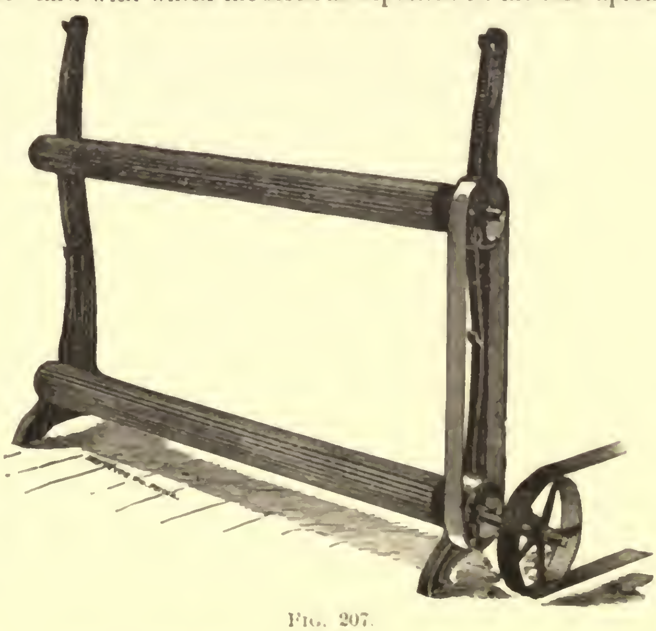


Fig. 207.

Single-Burring Machine—Metallic Feed-Rolls.—To illustrate this device Figs. 208 to 211 are given.

Fig. 208 illustrates a single-burring machine in its perspective view.

Fig. 209 shows the same in section with arrows indicating the motion of each roller.

Fig. 210 illustrates a three-roll set of metallic feed-rolls, used in connection with the burring machine.

Fig. 211 represents the section to Fig. 210, arrows showing the motion of the rolls.

This burring machine is known either as the *single* or the *common burring attachment*, consisting of

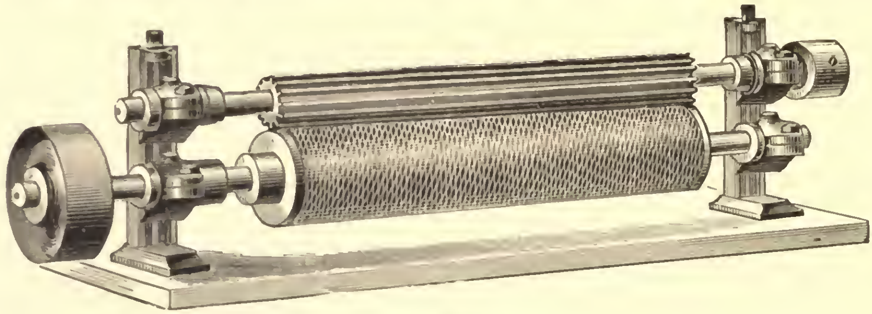


Fig. 208.

burr-cylinder and *beater-guard* (stripper). The clothing of this burr-cylinder is wound upon the cylinder spirally in as many threads per inch as desired, and securely fastened in grooves cut in the metal body of the cylinder. The *feed-rolls* are clothed with steel wire clothing, (made with clean sharp points) since they will exert a safer hold upon the stock compared to the use of the grooved feed-rolls. The speed, for running these feed-rolls is regulated according to the quality of wool to be carded, for the longer the staple of the material, the greater the speed of the feed-rolls, since if running the feed-rolls too slow by working long wool, the burr-cylinder would break the staple. The two lower situated rolls in diagrams, Figs. 210 and 211 (see *A* and *B*, in Fig. 211) are the actual feed-rolls which deliver the wool to the burr-cylinder. It will be seen, when examining illustration Fig. 211 that the burr-cylinder will readily take up the stock from roll *A*, but not as safely from roll *B*; *i. e.* if using only these two feed-rolls, there would be more or less chance for the wool winding around roll *B*. To prevent this trouble, is the work of roll *C*, which will then act as clearer for roll *B*, delivering any stock taken, upon the burr-cylinder. The

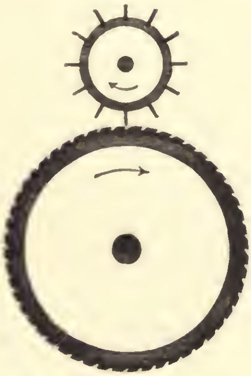


Fig. 209.

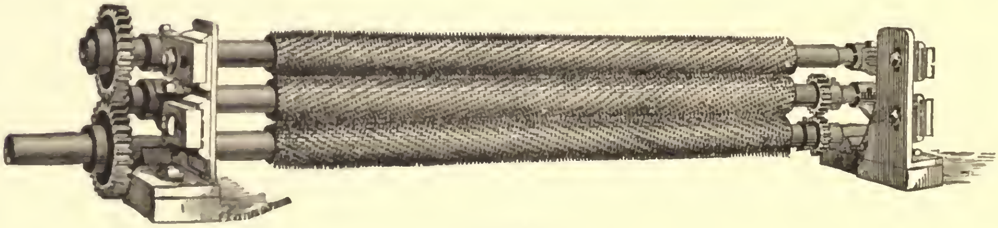


Fig. 210.

object of the burring machine is, to clear the stock of small impurities especially from burrs, which is accomplished by means of the stripper or beater-guard as situated above the burr-cylinder. The direction of motion of the stripper is in opposition to the motion of the burr-cylinder and the knives of the former are set close to the points of the clothing of the burr-cylinder. Impurities of sufficient size will be thus caught by the knives of the stripper or beater and thrown out of the material into a suitably situated dirt box.

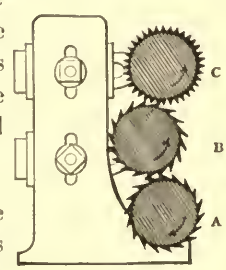


Fig. 211.

Single Burring Machine with Feed-Rollers Attached.—The perspective view of a single burring machine with feed-rollers attached as built by the Atlas Manufacturing Company is shown in Fig. 212 and its section in Fig. 213. In the same the bottom feed-roller is set close to the burr-cylinder which cleans it. The top roller is cleaned by a vibrating comb, worked by an eccentric on burr-cylinder shaft, which combs the wool from the points of the teeth and delivers it to the burr-cylinder. By this application the feed-rollers also never fill up with wool or grease, and as the feed-rollers hold the wool, while it is

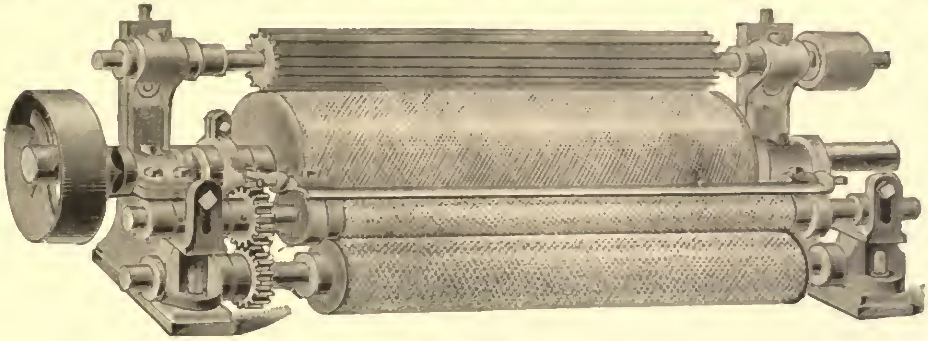


FIG. 212.

being combed off by the burr-cylinder, no lumps of wool pass from the burr-cylinder into the cards thus making an even delivery and even work on the cards.

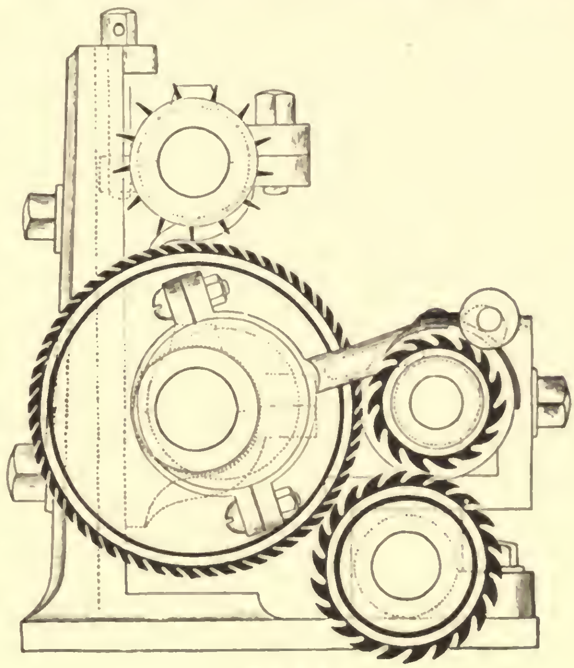


FIG. 213.

Double Burring Machine with Feed-Roller Attached.—This attachment to the breaker card is shown in its perspective view in Fig. 214 and in its section in Fig. 215. The same is also built by the Atlas Manufacturing Company. In its operation, the first two rollers are hook-toothed feed-rollers, revolving in unison; the top roller is cleaned by the first burr-cylinder, the under roller is cleaned by a comb, which combs all wool that may adhere to the points of the teeth, and delivers it to the first burr-cylinder, under which is a steel guard or stripper, which strips from the wool, burrs and all foreign matter. The wool then passes to the second burr-cylinder, which, running up receives on its surface the side of the wool already cleaned, completely turning over the locks of the wool, and presenting to the stripper, burrs etc., on the side not cleaned.

In some machines in place of the stripper-roller or beater-guard, stationary guard knives are used. If so, these are placed below the burring cylinder, in an oblique position towards its motion.

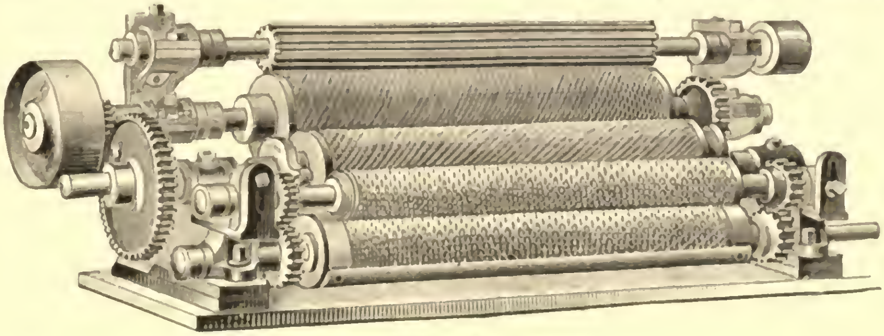


FIG. 214.

They are set sufficiently close to the clothing of the burr-cylinder to throw out the impurities found in the stock.

Retainer-Roll for Feeding Attachments to the First Breaker Card, (also for Garnett machines).—The object of this device, being the invention of J. K. Proctor, is to prevent the feeding into the machine of bunches, snarls, clots, lumps, etc., or the formation of such bunches etc. in the rear of the feeding rolls. Fig. 216 is a longitudinal section of feeding device in a first breaker card, but which also will demonstrate its application to a Garnett machine.

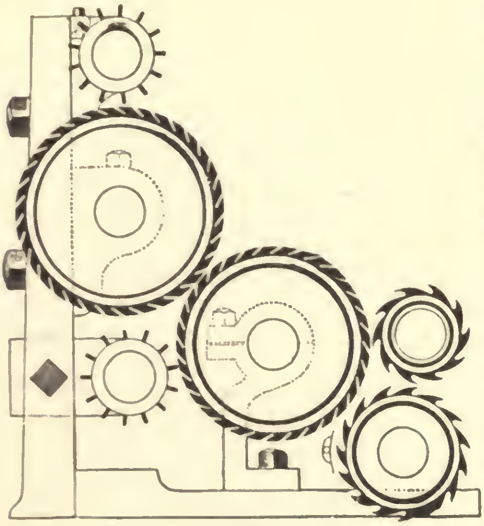


Fig. 215.

The work for the feed-rolls in a carding engine (also in a Garnett machine) is to hold the material, and slowly and evenly deliver it to the licker-in, or to the burring-cylinder of the card. The perfection of the carding operation is largely due to the proper performance of this duty by the feed-rolls. In practice however, it is sometimes found that with one or the other kind of material the feed-rolls do not properly perform the work for which they are intended. For instance when the material contains small and compact masses of fibre, such as are variously called bunches, snarls, clots, lumps, etc., such masses pass through the feed-rolls and are drawn into the machine without being properly combed, while in other classes of material naturally free from such masses, but having long fibres clinging together in disordered condition, such fibres on passing the feed-rolls and being caught by the burr-cylinder, the licker-in or carding engine, are drawn rapidly forward between the feed-rolls with the result that neighboring fibres which had not yet reached the feed-rolls, but which adhere to or touch the rapidly moving fibres, are drawn prematurely up to the feed-rolls, often in quantities sufficient to form clots of considerable size, which pass into the machine, as previously described, and produce the same bad result. In order to overcome these objections the inventor provides what he calls a *retainer-roll* which acts upon the fibres before the latter reach the feed-rolls, this retainer-roll being toothed and so operated, that it serves to comb out or straighten the clots, bunches, snarls, or other masses of fibre, and to prevent the drawing of loose fibres up to the feed-rolls by contact with long strands drawn rapidly between said rolls, as before described. In the illustration: *A*, represents part of a carding engine; *B*, part of the licker-in or first taker of the machine; *D, D*, the usual feed-rolls, and *D*' a clearer-roll (placed below in this case). On the frame *A*, is supported the frame *E*, which has bearings for the rolls *F, F*, of the feed-apron *G*. Immediately behind the feed-rolls and above the feed-apron is placed the *Retainer-roll H*, which is provided with hooked teeth arranged so that they project rearwardly when acting upon the fibre upon the feed-apron, the roll being constructed, and the teeth applied thereto in any desired manner. As shown in the present instance, the roll is made of segments and covered with clothing, which may be similar to that of an ordinary carding engine. This retainer-roll has a surface-speed somewhat less than that of the feed-rolls, so that it serves to catch any compact masses of fibre that may be carried forward on the feed-apron and prevents such masses from passing directly to the feed-rolls, the effect of the toothed retainer-roll being to loosen, comb or straighten these fibres to a certain extent before they reach the feed-rolls, and to catch and retain any loose fibres that may be adhering to long strands drawn rapidly through the feed-rolls by the action of the rapidly moving

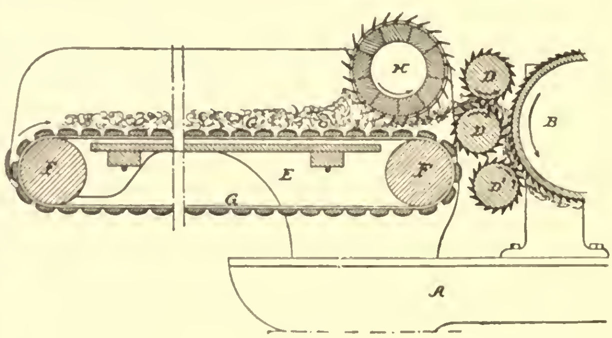


Fig. 216.

licker-in or cylinder of the machine. As previously mentioned, this retainer-roll is also frequently and with the most favorable results used on Garnett machines.

Metallic-Breast.—This is another style of attachment for breaker-cards, and acts as a powerful first-carder for the stock before it reaches the actual carding engine. For the carding of fine wools this is especially of great advantage. The speed of the breast is only about one-fourth of the speed of the swift of the carding engine, hence the former will gently loosen the locks of wool before they come in contact with the quick-revolving swift, thus preventing breakage of the fibre, which is otherwise always more or less inevitable. This loosening by means of the metallic-breast at the beginning of the carding operation prepares the stock for permitting the first cylinder (swift) to do its work to the best of its ability; also permits a closer setting of the workers, producing in turn a sliver well carded. This will be of great advantage in producing a perfect roving on the finisher (also perfect yarn when spun). When the carder sees the first breaker produce a perfect sliver, he always feels confident of being able to produce perfect roving. An illustration of a metallic-breast is given in Fig. 217, in its section. It consists of main cylinder *A*, three workers *B*, three strippers *C*, one licker-in *D*, one breast-roll *E*, one three-roll set of self-stripping metallic-toothed feed-rolls *F*. The other rolls in diagram refer to parts of the actual carding engine, and are as follows: Licker-in *G*, swift *H*, first set of workers and strippers *K* and *I*.

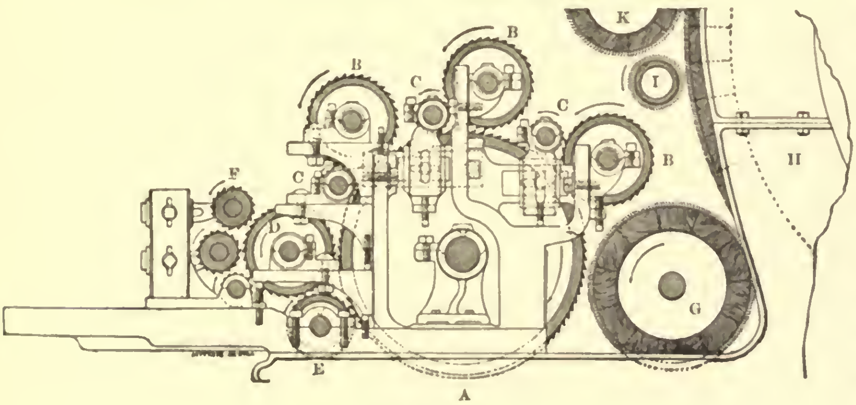


Fig. 217.

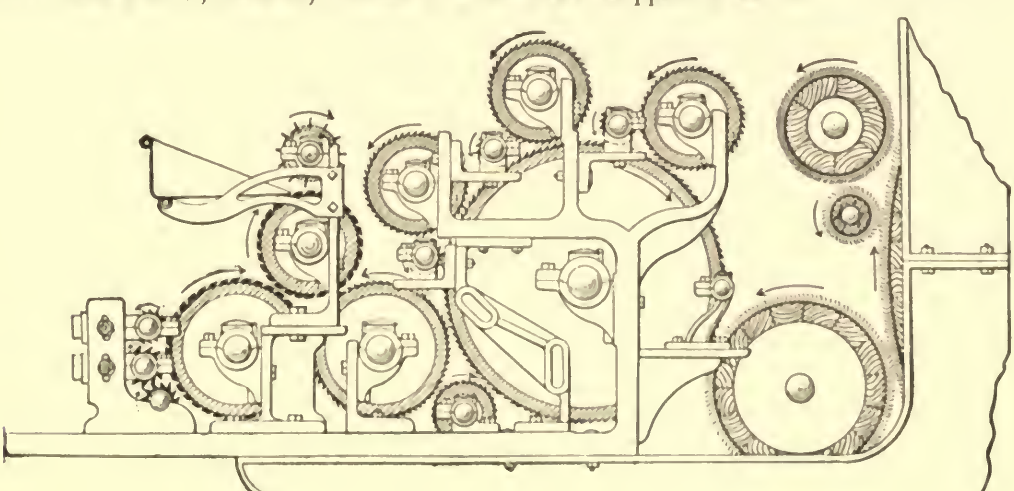


Fig. 218.

Combined Burring Machine and Metallic-Breast.—Frequently a burring machine is attached in front of the metallic-breast for extracting any impurities adhering to the stock. Since the same is nothing else but a combination of a single or double burring machine, explained in the previous chapter on burring machines, with a metallic-breast as previously explained, no special explanations to this attachment as shown in Fig. 218, in its section, are necessary.

Intermediate Feeding Machines.—The object of these attachments to carding engines, as previously mentioned and partly explained, is to make connection between the carding engines composing the set of cards; *i. e.*, between the first and second breaker, and between the second breaker and the finisher.

Three different methods for doing this work are in use: 1st, the *lap-feeding system;* 2d, the *ribbon system;* and 3d, the *side-drawing system.*

Lap-Feeding System.—This is the oldest method of feeding in use, and was formerly employed in this country as the medium between first and second breaker. It is now very extensively used (producing very long laps) in Europe.

Ribbon System.—This attachment is also known as *Scotch-feed.* In the same the film is combed off the doffer-cylinder by means of the doffer-comb, is laid upon an endless apron traveling across the card parallel to the doffer, and drawn off in a flat sliver (being about three inches wide) by means of two rollers. The sliver is afterwards conveyed overhead from the doffer end of one carding engine to the feeding-apron of the next card, upon which it is passed, flat side down, backwards and forwards parallel with the feed-rolls. Each ribbon is laid in such a way that each crossing overlaps the preceding one about 1½ inches, thus producing a continuous lap for the feed-rolls of the receiving carding engine to work on.

Side-Drawing System.—This is the system mostly used in this country. Two methods for it are in use: *a*, by means of *balls* and *creel-feed*, and *b*, the *Apperley-feed.* The first mentioned method is mostly used between the first and second breaker, whereas the latter method is generally employed between the second breaker and finisher.

Balls and Creel-Feed.—There are again two methods of it in use either by means of the common side-drawing spools (as formed in attachment *N*, in Fig. 203) or by means of the balling-head (as shown in connection with a carding engine in Fig. 201). The balling-head is a modification of the common side-drawing spool-system consisting in appliances for winding the sliver in balls under considerable pressure. The advantages of the balling-head compared to the common side-drawing attachment are, first, the balls are all of one size, and second, they permit about twice as much material to be condensed into the same size of spools, thus saving considerable labor in filling up the creel, besides the same are working automatically; *i. e.*, when the ball is sufficiently large, the same is thrown out by an ingenious motion and a fresh bobbin drops in its place. The only objection against the same is, that they take up space in the alley way.

The balls as produced by either method are afterwards set in a bank-creel and fed to the feed-rolls of the receiving carding engine, see Fig. 201, or as is yet the custom in a few mills, wound on laps on a lap winder, also called roving-spooler, see Fig. 206 and used in this manner in a back stand, see Fig. 207, placed in the rear of the receiving carding engine. Either attachment, bank-creel or back-stand, is geared to feed-roll which gives it a positive motion and insures a perfectly even feed, no matter whether spools or laps are full or nearly empty, they always feed the same. The creel has two sets of rolls slightly fluted for each set or bank of spools, and spools are kept apart by a polished iron rod. These rods divide the creel into the number of spaces needed for spools in the creel. With the bank-system from seventy to ninety ends can be fed into a forty-eight inch card, and from ninety to one hundred and twenty ends can be fed into a sixty-inch card without trouble; and as the more ends or strands fed into a second breaker means more doubling and better work, especially when fed by a positive motion, the advantages of this method will be readily understood.

One great disadvantage of this system of feeding compared to a continuous feed is, that it takes on an average one full day to produce one set of these balls for the creel, hence the receiving card will be one day behind the feeding card. This no doubt will be of great inconvenience if carding small lots or wanting roving quickly, besides all the waste made during this day by the receiving card (which cannot be used over again with the original lot) must be stored until a duplicate lot is picked.

Apperley-Feed.—This is the system mostly used in this country for making the connection between second breaker and finisher. The sliver is drawn off by side-drawing and twisted the same as is done by the balling method. It then falls down in coils onto a traveling strap near the ground, which conveys it to the receiving card, where it rises up and is taken by a pair of rollers and placed diagonally across the feed-apron, which in turn conveys the layers to the feed-rollers, etc. The advantages of this method of feeding consists in the fact that small lots can be worked with little waste; again, that roving is at once produced when starting the second breaker and finisher. One disadvantage is, that when either carding engine is stopped for cleaning or any other purpose (except in mills where there are two or more sets of card strippers; *i. e.*, both cards can be cleaned in unison), the companion card remains idle during this time, which no doubt will be a loss in the amount of production. This point is overcome by some carders by cleaning the finisher card first, coiling the sliver produced by the second breaker on the floor, and which in turn is used for feeding to the finisher when cleaning the second breaker.

Second Breaker.—This carding engine in its principle is a duplicate of the first breaker, the only difference being that there are generally one or two more workers and strippers used, and that the card clothing is finer, since the stock is delivered in better shape than is done for the first breaker. An illustration of a second breaker carding engine has been given in Fig. 201.

Finisher Carding Engine.—This is the third or last machine completing the set of cards. Its construction is similar to that of the first and second breaker, the only difference being, that the clothing is (generally) finer, and that the engine contains on its delivery end an attachment technically known as *condenser*, which device we will explain more in detail later on. The feeding to this machine is generally done by means of the Apperley-feed. After the stock is taken hold of by the feed-rolls it is delivered in turn to licker-in, main cylinder, and several workers and strippers, and next to the action of a fancy and doffer. After passing and being worked by all these rollers, the stock arrives at the delivery end of the carding engine, where it is taken hold of by the condenser and delivered in two, three or more decks, each consisting of several minute strands known as *roving*, which after being subjected to the action of *rub-rolls*, are wound automatically, each deck by itself, on large wooden spools of a length corresponding to the width of the card. Fig. 219 gives an illustration of such a spool, technically called either *roving-spool* or *jack-spool*. These spools containing the roving are afterwards forwarded to the spinning department.

Fig. 219.

Condensers—Double-deck Condenser.—About the first condenser for finisher cards invented is the one still frequently used, double-deck condenser shown in the illustration of a finisher carding engine in Fig. 202. The producing of these two sections (double-deck) of roving strands is accomplished by means of two specially clothed small doffers of about fourteen inches diameter, and of which a detailed illustration (part of it) is given in Fig. 220. Each doffer is covered with rings of card clothing leaving always a space between each ring; and both doffers are so placed in the device that the space in one is above or below the ring in the other and vice versa. When this device was first gotten up, the rings and spaces on both doffers were uniform, each about one inch wide; thus they covered in their alternate action exactly the width of the cylinder. One difficulty connected with this arrangement consisted and still consists, where this system of condensing is used, in the uneveness of both decks of slivers if compared to each other, hence the roving (produced from

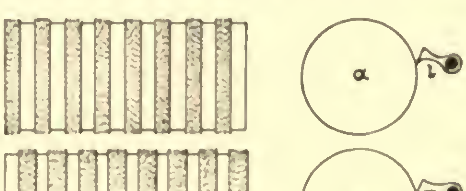


Fig. 220.

the same by passing the fine slivers between and subjecting them to the action of the rub-rolls) was generally kept apart and the yarn as spun out of it also. The reason for this difference in the *top-deck* of roving compared to the *bottom-deck* of roving consists in the fact that the fancy by its action always throws off some loose fibres which fall on the main cylinder and which the *top-doffer* gets. The same will also take hold of such fibres which in their main part belong to the *bottom-doffer*, but of which the ends project more or less into his path of action. To prevent this trouble of producing a heavier set of roving in the top-doffer, compared to the bottom-doffer, some carders speed the former higher, but in an average taken, the result is even then not satisfactory. The proper manner of overcoming this difficulty is to use wider rings on the bottom-doffer compared to the top-doffer, the same as shown in our illustration Fig. 220. After the fine sets of slivers are combed off the rings *a*, by means of the doffer combs *b*, each set is passed between rub-rollers having 7, 9, 11, 13, or 15 rolls in a series.

Single-Doffer Condenser.—The next improvement in the condenser consisted in the establishment of what is known as the English system, or the single-doffer principle, which is used either in connection with one or two series of rub-rolls. In the single-doffer system (as the name indicates) only one doffer is used, which is covered with rings thirteen-sixteenths of an inch wide. Between each ring a leather washer three-sixteenths of an inch wide is placed. The height of these washers corresponds to the height of the rings including their clothing. This doffer, when working against the main cylinder, will clear or take off strips of film about the width of the rings, leaving narrow strips of film (where washers are in doffer-cylinder) on the swift. These are again distributed over the surface by the action of two of the workers, on the card, which, in addition to their regular rotary motion, also have a traverse motion. The narrow strips of film, as taken off by the doffer, are next combed off by doffer-combs and transformed into what is technically known as roving, by the action of rub-rolls. As previously mentioned two methods for condensing these fine ribbons into roving are in use; *i. e., the double* and the *single-rubber condenser.*

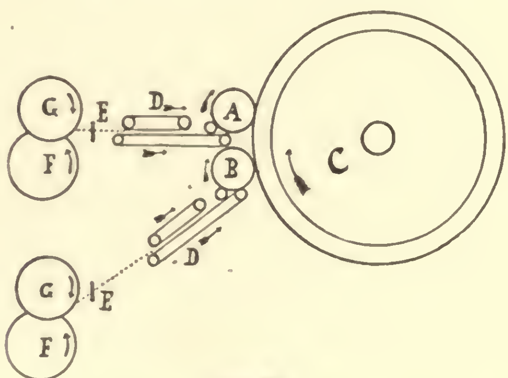


Fig. 221.

Fig. 222.

In the first attachment each alternate ring is cleared by one rubber and the remainder by the other rubber as shown in Fig. 221. *A* and *B*, are the rubbers, (see Fig. 222, their perspective view) *C*, the doffer. The rubbers revolve in the direction indicated by the arrows in the illustration. The fine slivers or ribbons as coming off by them, are passed between the rubbing aprons *D*, which are endless leather aprons traveling as indicated by arrows thus bringing forward the ribbons. At the same time, they have also a side motion (rubbing against each other), which transforms the ribbon into the characteristic roving. After the roving leaves the rubbing aprons, each end is passed through a guide *E*, over roller *F*, onto spool *G*, in which state it is delivered to the spinning room.

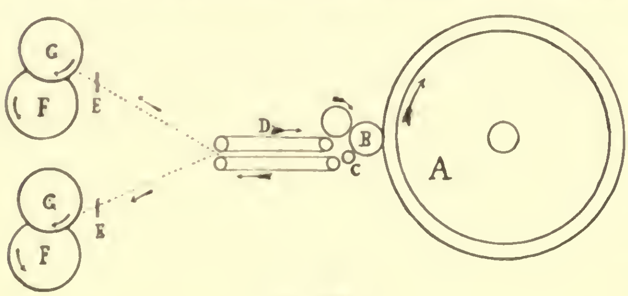


Fig. 223.

If using the single rubber condensing in connection with the single doffer system, the modus operandi with reference to illustration of the principle, Fig. 223 is as follows: *A*, single doffer containing previously explained rings of card clothing; *B*, rubber roller with double the number of bosses on as in the previous system, thus clearing every ring of the doffer at once. The fine ribbons of fibres as coming from the doffer are passed under the grooved roller *C*, (shown in its perspective in Fig. 224) which distinctly separates the different ribbons. Next all the ends are passed through the rubbing-aprons *D*, and condensed during this passage into the roving which in turn is (every alternate end to one of the spools) passed to guides *E*, over roller *F*, and onto spool *G*, when as soon as one spool is filled it is ready for spinning. This system is more specially adopted for fine, short wool, since long, hairy wool is apt to run more or less together and break.

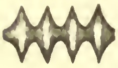


FIG. 224.

Three-Doffer Condenser.—This attachment used in connection with a finisher carding engine is shown in its perspective view in Fig. 225. A section of the same machine is shown in Fig. 226. The difference between the three-doffer condenser and previously explained two-doffer condenser consists, as the name indicates, in having three doffers, *A*, *B*, *C*; three sets of rub rolls, *D*, *E*, *F*; and a spool-rack for winding three spools of roving *G*, *H*, *K*, in place of the two devices of each kind used

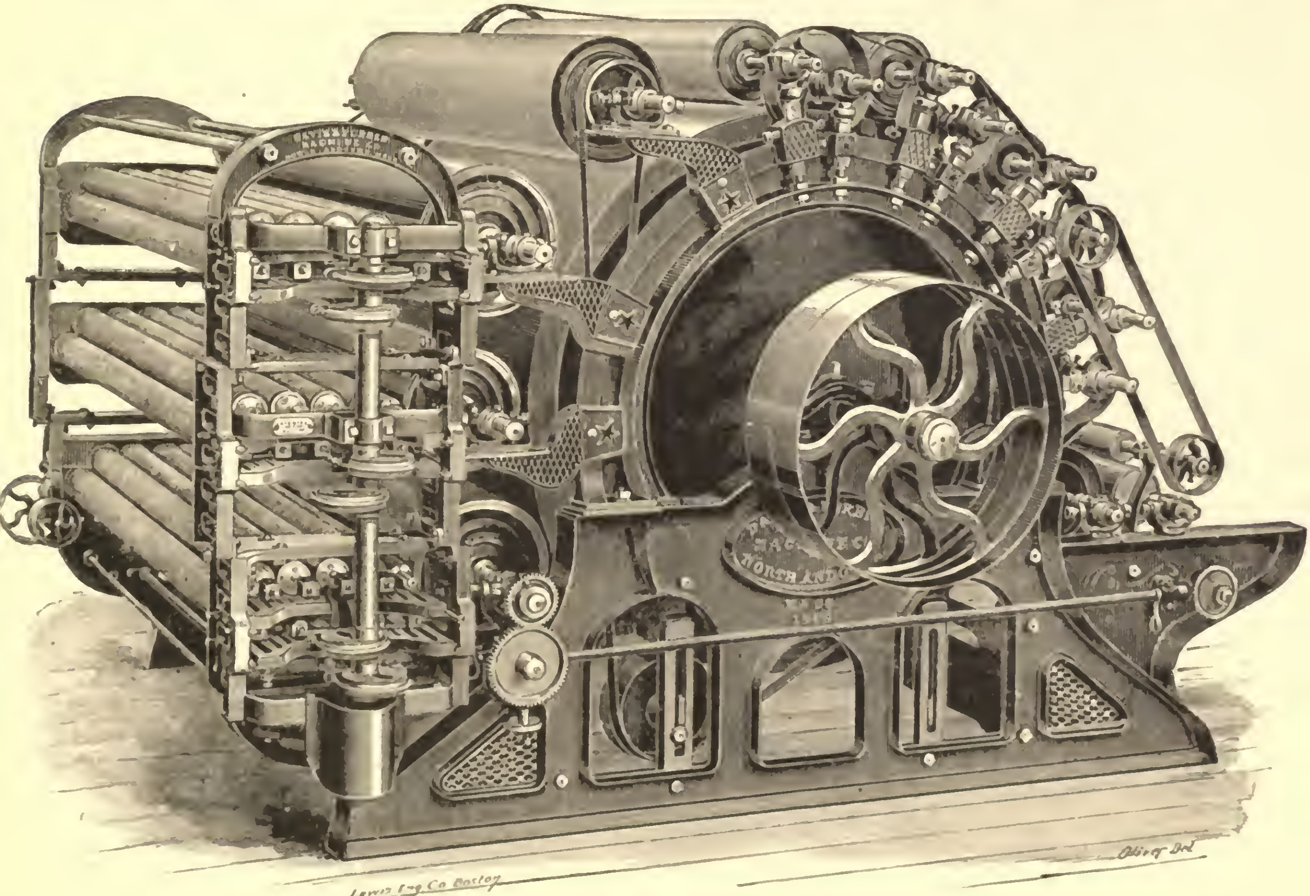


FIG. 225.

in the two-doffer condenser. The advantages of these cards for fine work are obvious, the production being increased without impairing the carding; a large number of ends (ribbons) can be taken off by means of narrow rings without any danger of the roving catching together as it passes through the condenser, the space between the rings being nearly double that in which but two doffers are employed. The arrangement of the rub motion in connection with the doffers is such as to enable the operator to change the speed of either doffer and set of rolls without reference to the other.

Different Styles of Condensing the Ribbons in Roving.—There are three styles: Condensing by means of rolls; Condensing by means of aprons; Condensing by means of aprons and rolls.

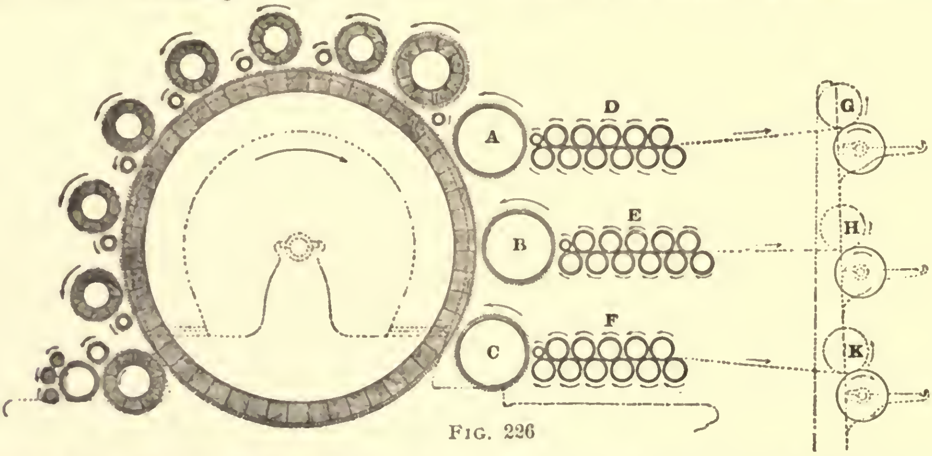


Fig. 226

Condensing by Means of Rolls.—This is what we might call the American plan since it is used exclusively in this country, the European manufacturer mostly using the other two styles. The condensing by means of rub-rolls has been sufficiently explained previously, so that no special reference again will be necessary. It is also clearly illustrated by *D*, *E* and *F* in diagram Fig. 226.

Condensing by Means of Aprons.—This as already previously mentioned is the favorite style for the European manufacturer and is at present coming more and more in use in this country.

Diagram Fig. 227 representing Barker's Patent "Double Apron Rubbing Motion" is given to illustrate this system of condensing. It differs from the first style in having two leather aprons (see *a*, *b* and *c*, *s*) do the condensing. Each of these aprons is stretched over a pair of rolls and neatly

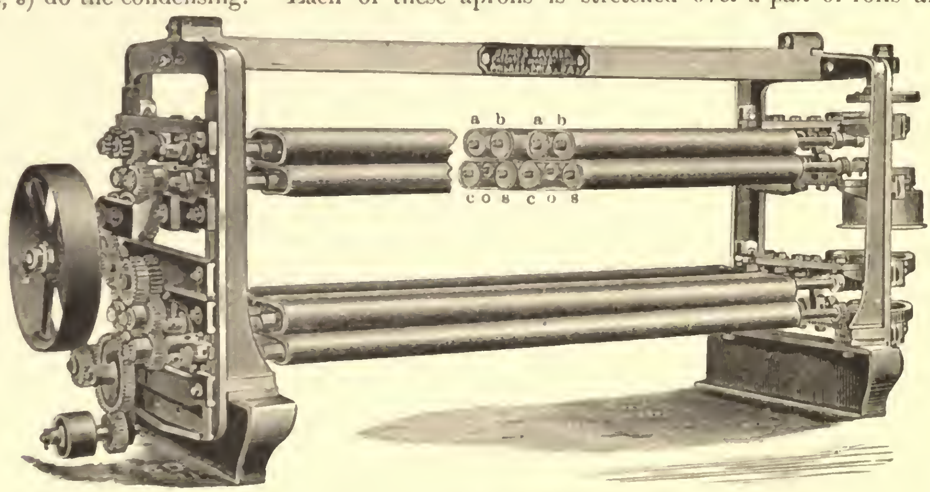


Fig. 227

joined together. The rolls are arranged to permit tightening for the aprons if necessary. These aprons receive their forward motion by means of gears at one end and their reciprocating motion by being fixed to a head stock at their other end. By this method no stretching of the ribbons during condensing in roving can take place. If using a medium stapled fine wool it will not be necessary to have both aprons reciprocate, hence the reciprocating motion is frequently only imparted to one apron. The roll *o*, as shown in the centre of the lower apron in our illustration is put there to prevent the apron from bowing inside.

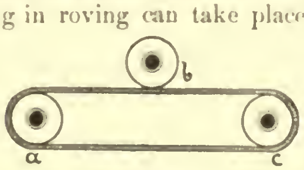


Fig. 228

Condensing by Means of Apron and Rolls.—This method, illustrated in Fig. 228, only finds limited use. In it the rolls (only one of which is shown in our illustration) are placed above the apron, and both receive the reciprocating motion. When spinning long-stapled wool a common custom was and is, to cover the rolls with fine metallic wires, so as to have the same act more powerfully in condensing the ribbons

Bolette Condenser—Method of Operation of the Machine.—This device is intended to substitute the ring-doffers previously explained. In the Bolette condenser only one doffer-cylinder is used. The principle of dividing the film combed from it into the characteristic fine ribbons (later on condensed by means of rubbing in roving) is as follows: On the side of the device standing nearest the doffer are two horizontal rollers of cast iron, one above the other, but at considerable distance (about twelve inches) apart. These rollers are grooved at regular intervals in such a manner that the grooves of one are exactly opposite the spaces on the other roller, and there must be, considering both rolls, as many grooves as fine ribbons are required to be delivered. Closely fitted in these grooves and fastened at one end are bands of steel (blades) of such a width as the proper number of divisions will admit of. The usual number for a 48-inch card is 96 ends or bands, exclusive of the waste ends, and for a 60-inch card, 120 ends or bands, exclusive of the waste ends. Hence on a 48-inch card, with 96 ends or slivers, there would be 48 ribbons or bands, and the necessary waste bands on the top-roller, and a like number on the bottom roller, so spaced that the ribbon or band attached to the top roller, if hanging vertically, would be alongside of and parallel with the ribbon or band standing perpendicularly from the bottom roller. Directly in front of these rollers, to which the steel ribbons or bands are attached, is a top and bottom set of leather aprons arranged radially in such a way that the lines where the upper and the lower aprons come in contact is opposite (slightly below it) an imaginary horizontal line on the doffer, where the web is doffed by the comb. The ribbons or bands of steel are passed between the apron rolls at this point, those from the top roller being deflected downwards between the lower set of apron rubs and those from the bottom roller upward between the upper set of apron rubs. When the web is passed between these apron-rolls at their point of contact it is evident that so much of the web as is under the top set of ribbons or bands will be by them carried downward between the leather aprons forming the bottom set of rubs; and so much of the web as is above the bottom ribbons or bands will be carried upward between the leather aprons composing the top set of rubs. The several strips of webs thus separated or divided by the top set of steel ribbons or bands will form the bottom series of ends, while those separated by the bottom set will form the top ends. These several strips or ribbons of film are next rubbed between the aprons and the condensed strands (roving) passed through vibrating guides and wound on the common jack-spools in the usual style. This mode of dividing the film largely increases the number of ends that can be taken from any given surface. For rovings which are more difficult to condense (made out of coarse wool, mungo, shoddy, etc.) an additional amount of rubbing is derived by adding to a single set of radial aprons, another set of horizontal ones for both the top and bottom series of ends.

Bolette Condenser made with Single Rubbers.—In Fig. 229, a section of the device as patented by the inventor Mr. Bolette of Pepinster near Verviers, Belgium, in 1884 is given. Letters of reference indicate as follows: *A*, doffer; *B*, doffing comb; *C*, film, (nap or web) for dividing; *D*, automatic apparatus for putting the film in the divider; *E* and *F*, oscillating rollers to which are attached the steel blades *K* and *L*; *G* and *H*, dividing aprons; *I*, *I*, rubbing aprons. The method of operating the machine is as follows: the film *C*, as combed by the doffing comb *B*, from the single doffer cylinder *A*, is introduced by means of the automatic appliance *D*, into or between the carrying and rubbing aprons *G* and *H*. There are also seen two rollers *E* and *F*, to which are attached steel blades *K* and *L*. The free or loose ends of the blades attached to the roller *E*, pass between the aprons *G* and *H*, downwards, and are held firmly against the apron *H*, by the small rollers *J*. The blades attached to the roller *F*, pass between the aprons *G* and *H*, upwards, and are, in like manner, held against the apron *G*, by rollers *J*. The blades of rollers *E* and *F*, therefore, cross each other, and the revolving aprons *G* and *H*, draw or carry the sliver in, at points of intersection, thus dividing it into as many points as there are blades, the several divisions being of the same width as the width of the blades. The blades run in grooves, and move with the utmost precision, permitting the sliver to be finely divided and producing in this way very fine roving. The two indicating arrows on rollers *E* and *F*, show the direction of oscillation of these rollers which force the blades in and out between the aprons. The backward and forward movement of these blades prevents the accumulation of dirt or grease at the point where they enter between the aprons. There is an appliance not capable of being shown in the sectional view, which is called the side or lateral motion. Its function is to move the rollers *E* and *F*, slowly to and fro in the direction of their length; the object being to so change the point of contact of the blades with the apron, that the latter undergoes but little wear and tear. The rollers *E* and *F*, can be removed and others substituted, having any number of blades, more or less, thus producing a greater or less number of ends. In this way three or four bobbins can be made at will, each having an equal number of ends. Rolls *E* and *F*, draw by the winding up of the steel bands the same between the rubbing aprons and guide rollers *J*, through, and by means of winding off the roller *J*, guide the ribbons towards the condensing attachments *I*. In this manner a steady motion of the steel bands is accomplished. The actual rubbing or condensing of the ribbons is done between *G* and *I*, respectively, and also between *H* and *I*. Aprons *G* and *H*, have only a forward motion whereas aprons *I*, in addition thereto have also a to and fro sideward acting or rubbing motion imparted by eccentrics. After the ribbons of film have been rubbed or condensed into roving strands they are passed through guides *O*, over rolls *P*, and wound onto jack spools *Q*, which when the proper amount of roving is wound on, are taken out and empty spools put in their places. Another feature greatly in favor of this machine is the saving in card clothing, as the card clothing of the doffer after becoming in time too much worn for the condenser, can be advantageously used for covering the doffer of the first or second breaker.

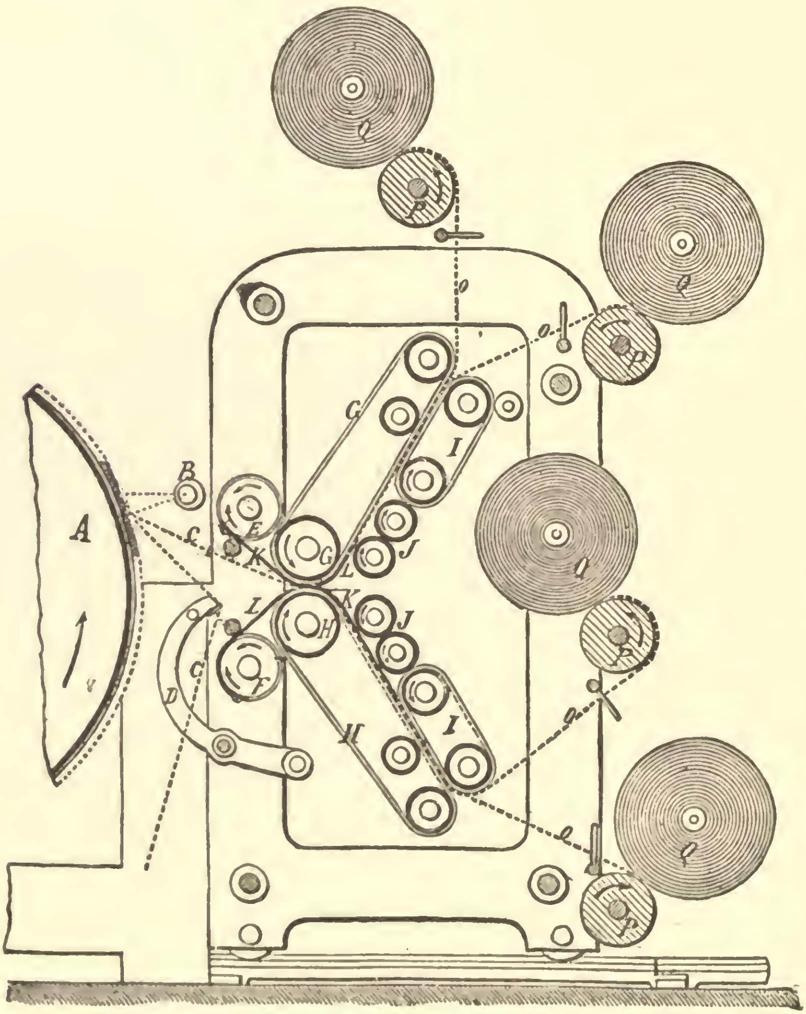


Fig. 229.

This Bolette condenser in a short time after coming into the market worked its way into the leading mills in Europe, and is doing so now in this country. The same is especially of great advantage for mills working short stock, as the method of guiding the ribbons is in favor of protecting the same from breaking, since after the sheet of film on leaving the doffer is cut in its respective ribbons the latter are always supported until condensed in roving.

Bolette Condenser made with Double Rubbers.—For such rovings as require an extra amount of rubbing, or those more difficult to condense, Mr. Bolette invented the double rubbing principle as shown in diagram Fig. 230. This double rubbing action he obtained by cutting in two the large aprons *G* and *H*, as shown in his first machine (Fig. 229) and making one half to vibrate, thus giving four vibrating or rubbing aprons (see *I*,) in place of only two as formerly used, thus increasing in proportion the amount of rubbing, besides making more even work.

Another item of the working of the condenser is indicated in this section by letters *M* and *N*; the same represents the distance traveled by the blade; *i. e.*, while the blades attached to roller *F*, are coiled or wound up, their ends just reaching to *M*, on apron *G*, the blades attached to roller *E*, are uncoiled to their full length, reaching to *M*, on apron *H*. (This working of the blades also refers to the previous illustration, Fig. 229, but in which letters of reference have been omitted.) A perspective view of the original Bolette condenser, (corresponding to section Fig. 229) is given in Fig. 231, which shows the side of the machine as placed toward the carding engine and illustrates the dividing blades and the side of the machine on which the eccentrics are driven.

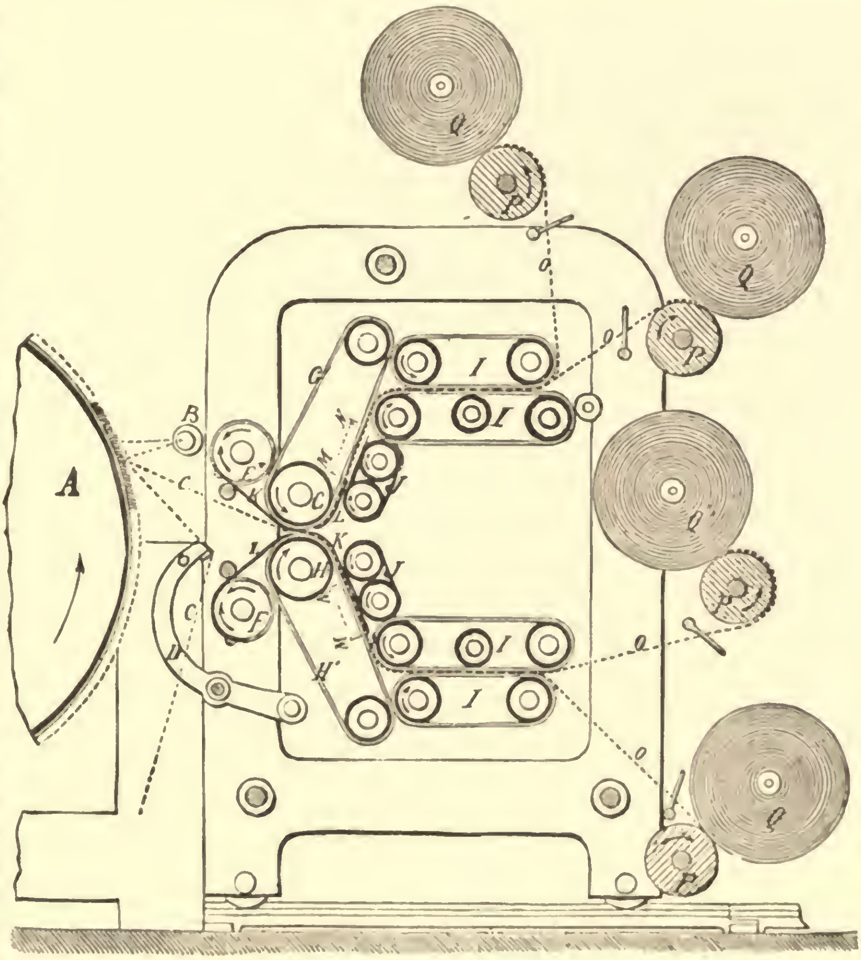


Fig. 230.

Improved Bolette Condenser.—The latest improved form of the Bolette Condenser is given in its perspective view in Fig. 232, and in its section in Fig. 233. Letters of reference in Fig. 233 indicate as follows: *A*, doffer; *B*, doffing comb; *C*, sliver (nap) for dividing; *E* and *F*, oscillating rolls to which are attached the steel blades *K* and *L*; *I* and *I*, dividing aprons; *J* and *J*, rolls for keeping blades against dividing aprons; *G* and *G*, rubbing aprons.

Amongst the improvements we find the new patent device for vibrating the blades; *i. e.*, an appliance for giving the blades a backward and forward movement and side motion at the same time, as follows: The two indicating arrows on rollers *E* and *F*, (Fig. 233) show the direction of oscillation of these rollers, which force the blades in and out between the aprons. The backward and

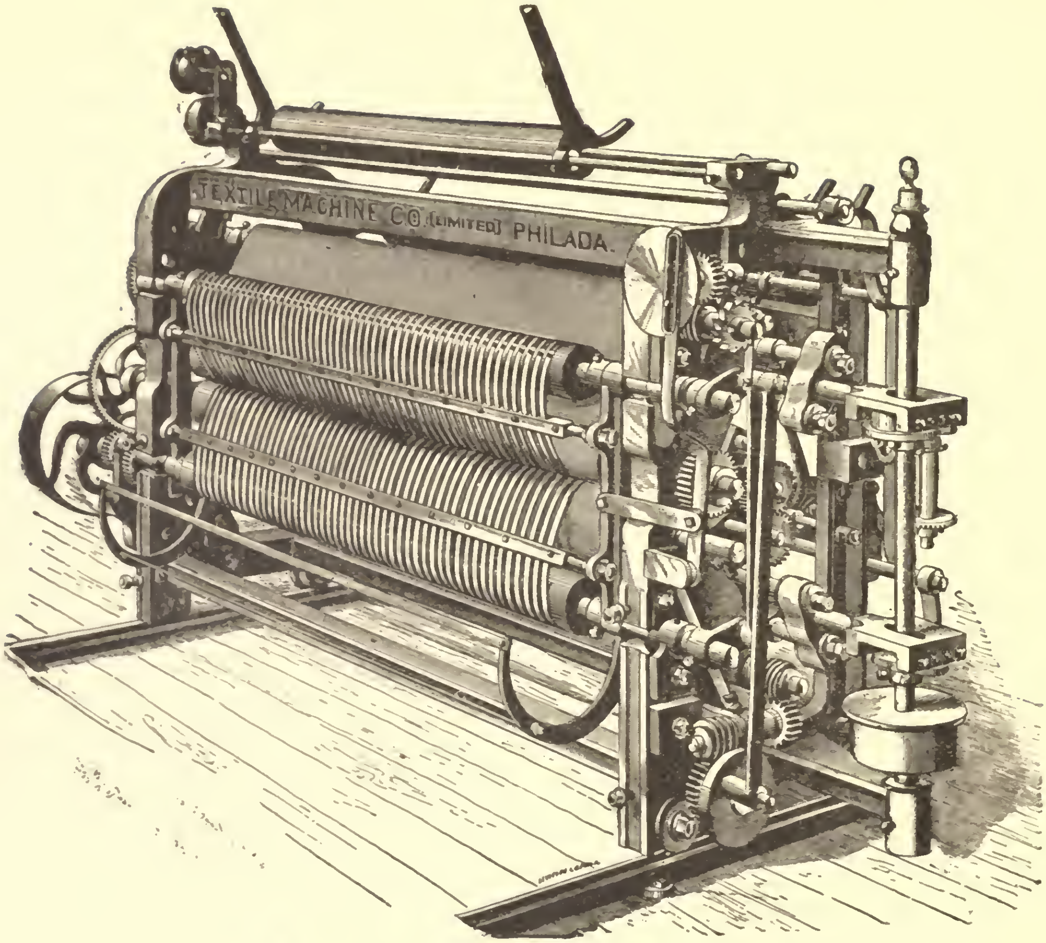


FIG. 231.

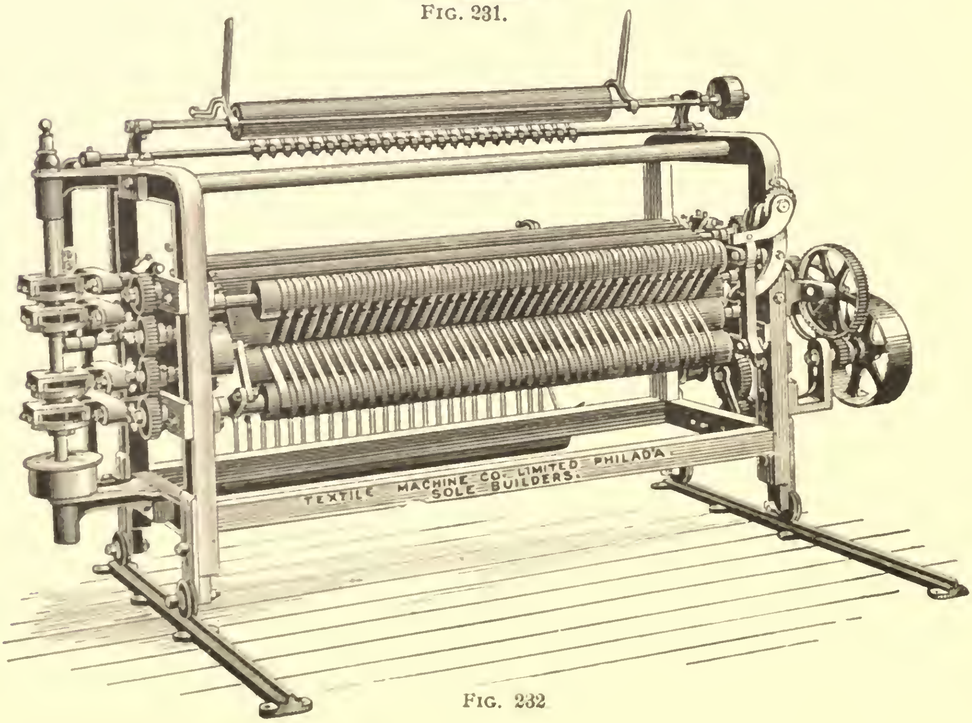


FIG. 232

forward movement of these blades prevents the accumulation of dirt or grease at the point where they enter between the aprons. The distance traveled by the blades is indicated by the letters *M* and *N*.

It will be observed that while the blades attached to roller *F*, are coiled or wound up, their ends just reaching to *M*, the blades attached to roller *E*, are uncoiled to their full length, reaching to *M*, on apron *I*.

There is an appliance, not capable of being shown in the sectional view, which is called the side or lateral motion. Its function is to move the rollers *E* and *F*, slowly to and fro in the direction of their length; the object being to so change the point of contact of the blades with the apron, that the latter undergoes but little wear and tear.

The eccentric in this improved Bolette Condenser is of such a construction to permit greater speed, thus giving all the rubbing required for any grade of stock. Compared as to size and construction the new condenser is much smaller, less complicated and more readily handled.

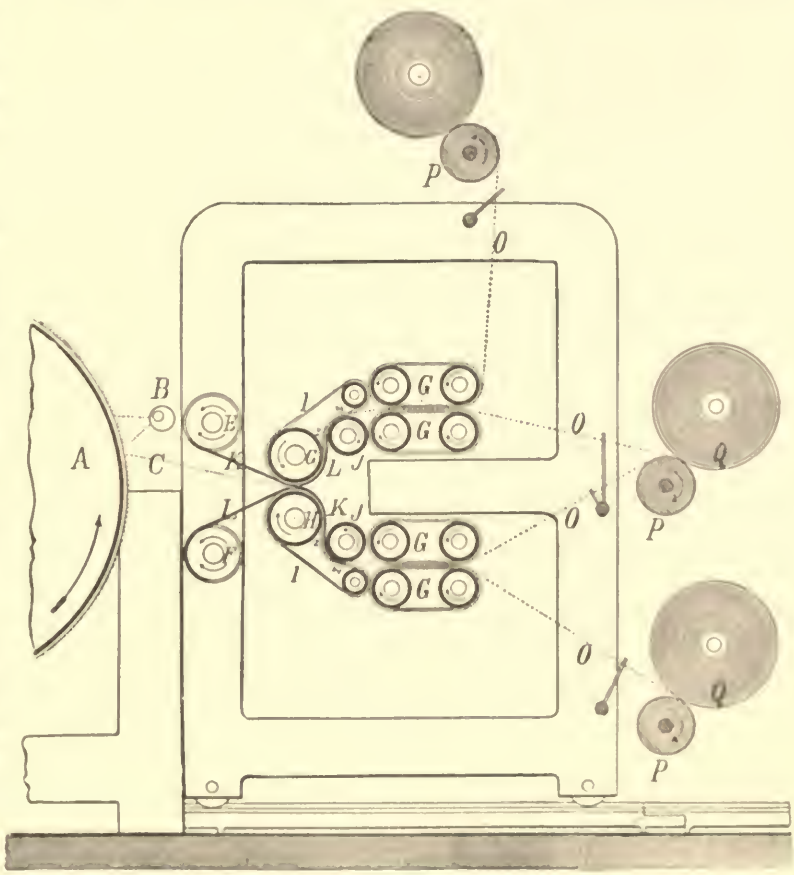


Fig. 233

Grinding.—After covering any roller or cylinder of a carding engine with card-clothing, the latter must be ground so as to take out the inequalities left, even after the most careful covering, as well as to produce the sharp points to the wires as required for good carding.

Two different automatic methods are in use for grinding:

1st. Grinding with a *grinding-roller* about eight to nine inches in diameter, covered with coarse emery and extending across the face of the cylinders or rollers. This grinding-roller also receives a short lateral traverse motion so as to prevent as much as possible the forming of a flat point to the wire which is technically known as chisel-point.

2d. Grinding with a *Traverse Emery Wheel Card-Grinder.* In this device the grinding is done by means of a small drum or pulley covered with emery, which is made to traverse to and fro across the card-clothing surface by means of a double threaded screw placed inside the hollow shaft on which the wheel rotates. For grinding swift and doffer, either kind of grinding device is taken to the carding-engine and the process takes place there, whereas workers and strippers are taken to a card-grinder, as shown in its perspective view in Figs. 234 and 235. The fancy is also taken to the card-grinder, but for the purpose of having the sharp point, formed by itself during carding, taken out. Fig. 234 illustrates the method of using a large grinding-roller (the machine illustrating a card-grinder and turning-lathe combined). Fig. 235 is an illustration of a card-grinder fitted out with a traverse emery wheel.

This machine is arranged for grinding four rollers (workers, strippers, lickers-in etc.) at one time, but it is also built in styles to grind two, and also to grind six rollers at the same time.

After the newly covered clothing has been once ground it will keep itself sharp for a long while, the fancy for example, only needs grinding once, and thereafter keeps itself sharp by the action of the

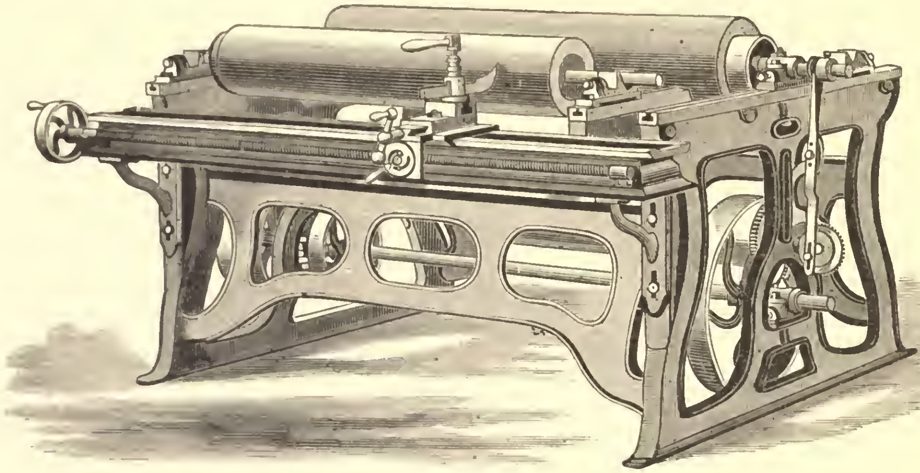


FIG. 234.

swift, in fact the fancy will get too sharp by this action and needs occasionally to be taken to the card-grinder to have this sharp point taken off. The action of the fancy will also assist, to a smaller extent, to keep the swift sharp and thus the latter only occasionally needs very little grinding. The workers

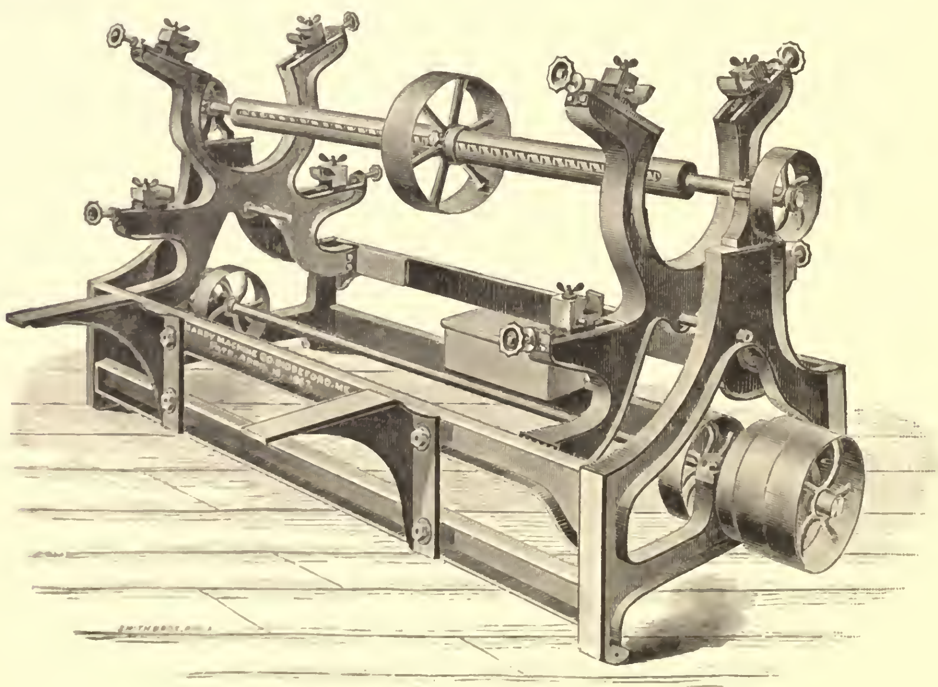


FIG. 235

will keep themselves more or less sharp by the action of the strippers, and the latter vice-versa. The doffer will also be injured by too much grinding, since it will keep sharp by the action of the *tickler* or *dickey* as sometimes called.

The plan observed by carders who object to grinding after the first time, is to simply hold a piece of emery cloth stretched on a wooden frame to the rollers about once a week, or in a fortnight, so as to throw out any dust or dirt from amongst the teeth; this operation will also give some polish to the points of the card clothing. Such carders as insist on carding generally do this work once in every two months, or thereabouts.

Turning and Covering Rollers.—This procedure refers especially to the use of wooden rollers, since those made of iron will be always true. If a wooden roller requires re-covering, the same is turned off so as to make sure of being level. The process of turning a roller is very simple, and is performed on a turning lathe, of which an illustration (card-grinder and turning-lathe combined) is given in Fig. 234, and which will readily explain the modus operandi.

Preparing Waste for Re-working.—The process of re-working the different waste in a woolen mill also comes under the head of carding. All the waste made in a mill can be classified either under *hard waste* or *soft waste.*

Hard Waste.—Under this name we may classify headings as separated from the finished cloth before making the same ready for the market, old samples, woven waste made in the weave room by starting warps, hard twisted or double and twist yarn waste made in the weaving or spinning department, etc.

Soft Waste.—Thus we classify such yarn waste as has received only a little twist, also roving and card-waste, etc.

We do not wish to say by this that all the waste in a woolen mill shall be graded in these two divisions and worked up by two rules, for the practical superintendent will grade his waste with equal care as he does his different wools, and make several divisions of each, since if carefully and knowingly treated, waste will take the place of wool in a minor quality. Speaking about hard waste, for example, headings, he will keep such as have been heavily felted from slightly fulled flannels, or such as came from the weave room. Again, he will keep double and twist yarn waste apart from single yarn waste, also filling yarn waste apart from roving waste, etc., since each waste requires its own method of preparation. Headings, also hard-twisted yarn waste, coming from the mill in balls, bunches, strings, knots, etc., are first roughly cut up by means of a hatchet and then submitted to the action of a Rag or Shoddy Picker. Some kinds may require only one run; others two, before they can be submitted to the action of the Garnett machine. Short, hard waste, and all soft waste, can go directly on the latter machine; whereas card waste, dirty roving waste, is subjected only to the action of a Waste Duster. Clean roving waste may be mixed directly in a duplicate lot.

Rag or Shoddy Picker.—An illustration of this machine is given in Fig 236. The same consists of feed-apron, feed-rollers, cylinder and trunk for conducting the shoddy out of the machine. The cylinder which is the main feature of the machine is strongly built and runs in brass bottom steps. The average length of it is 31 inches from point of teeth, $19\frac{3}{4}$ inches wide, and $16\frac{1}{2}$ inches on face of teeth. They are made with middle casting of solid iron, with double flanges, the lags being bolted on alternately, bringing each bolt through opposite side of flanges; by this means the bolts are not all in the same circle, thus presenting as near as possible a full surface of teeth, besides making the cylinder much stronger. The teeth are made from best English steel, evenly hardened and tempered, and put in the wood in such a manner that it is very rare for one to come out, lag or split. For pulling of ordinary sorted soft woolen rags the cylinder generally contains 10,000 teeth, made from number 10 steel, and for sorted hard woolen rags, 12,000 or 13,000 teeth of number 11 steel. The teeth are $2\frac{1}{4}$ inches long; top lags are $1\frac{1}{4}$ inches thick; teeth stand out 1 inch. The rags to be picked are placed in the feed-apron, which in turn forwards the same to the feed-rolls. On emerging from them they are seized by the teeth of the cylinder, which not only separates thread from thread but actually tears fibre from fibre, reducing the rags to a flossy wool-like state. As the rags are ground up, the material is forced (blown) down and out the trunk, finding exit from the machine to the stock house (a house built at the back to hold the stock and connected with the picker below the feed table by previously-mentioned trunk) Any hard fragments not well picked fall into a cage from which they are taken and replaced on the feed-apron.

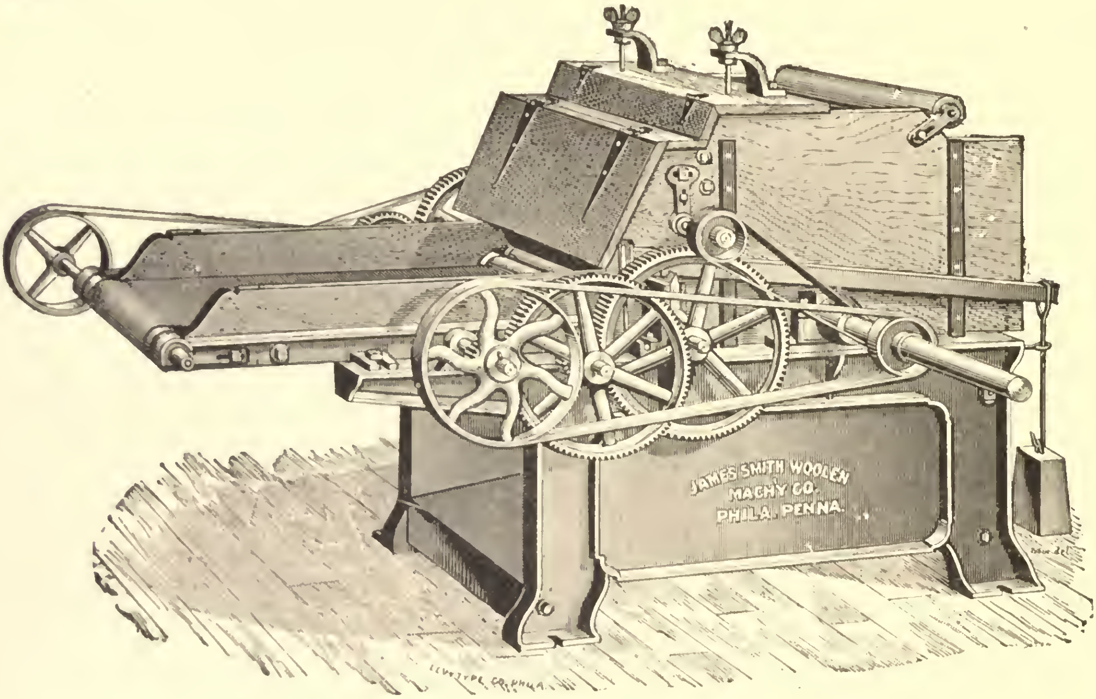


Fig. 236

Garnett Machine.—This is a machine the use of which is of comparatively recent origin. It is only within the past few years that such a machine has been introduced to the notice of manufacturers, and yet so great is its merit that within a short space of time the Garnett machine has become an indispensable adjunct to many mills. It enables manufacturers to comb out all their waste, whether from cards, mules, spinning frames, or from whatever source twisted or tangled fibres are produced in the various processes of manufacture, as well as of the pieces, clippings, or remains of the manufactured product (after being picked on the shoddy picker) and to restore it to the original fibre. This is a great saving, as otherwise such waste would be disposed of at a nominal sum. In many cases a special branch of industry has been originated by parties who make a business of buying wastes of various kinds, and after reducing the same in their Garnett machines re-sell at great profit. These machines in principle are carding engines, constructed in a compact form. The cylinders and workers are clothed with strong, sharp-pointed steel teeth, so adjusted as to work on the twist of the yarn or thread and gradually comb or teasel it out and hold the fibres together. This gradual untwisting preserves the fibres of the wool in nearly their original length of staple. In the profitable working of waste it is advisable not to let it accumulate. That which is made one day should be carded the next, for if it

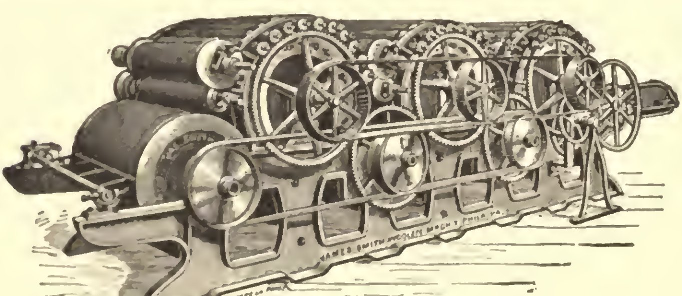
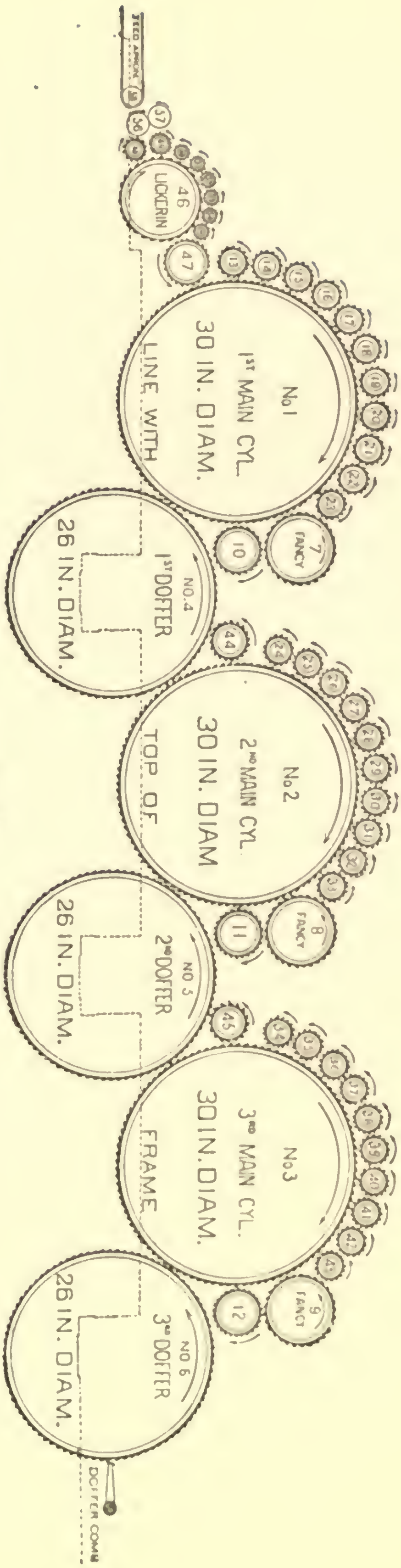


Fig. 237.

be allowed to remain much longer the oil in the same will soon become gummy and will set the twist so firmly that the waste is much harder to comb out, and thus the stock is deteriorated in the carding process. On the contrary, if the waste be worked before the oil sets the twist, the natural spring of the wool, which thus is preserved, assists in opening it out, and the waste or fabric is much more easily reduced to wool again. This point cannot be too carefully noted by parties who work up, or desire to work up, their own waste. Garnett machines are built either as one, two, or three main cylinder machines, either with breast or plain, and from thirty to sixty inches in width. Over each main cylinder are placed the self-stripping workers, and a fancy with stripper. Unlike the fancy of the wool card, on this machine the fancy does as much carding as the workers; it combs the stock across the teeth of the stripper when it raises it from the main cylinder, the stripper revolving slowly lays the stock again on the main cylinder that it may be lashed against the doffer. The three cylinder machine, see Fig. 237, is the most practical and will perfectly reduce to its original fibre the finest twisted and double yarn waste, cop waste, and all kinds of clippings from goods, doing from 300 to 800 pounds per day. A two cylinder machine will work all kinds of soft woolen, common worsted and other yarn wastes, in quantities about like the three cylinder. The one cylinder machine will thoroughly open soft waste in once passing through, and is especially adapted to small mills. All the machines have the same attachments and are alike except in length. As previously mentioned, all machines are either breast or plain. In the plain machine the licker-in runs downward against the feed-rolls and is stripped by the main cylinder. In the breast machine the licker-in runs up against feed-rolls and is stripped by a tumbler, which transfers the stock to the main cylinder. In this machine the licker-in is provided with five toothed rolls called breast workers. The stock being fed in by the feed-rolls is caught up by the licker-in and subject to seven carding points before reaching the main cylinder. The breast machine is best adapted to lumpy, hard-twisted, or tangled stock, as the stock being subject to carding against the workers is much more opened when it reaches the main cylinder than in the plain machine. The plain machine is usually built with an eight-inch worker or lumper-roll between licker-in and main cylinder. This worker is very useful on some kinds of lumpy stock in breaking up the lumps before they reach the main cylinder. The worker is geared to run very slowly, so as to hold the lumps as long as possible while being combed out by the licker-in. In comparing the breast with the plain machine, it should be said in general, that the breast machine is best adapted to every condition where the

FIG. 238.



stock contains firmly twisted threads, lumps or pieces that would injure the more delicate clothing of the main cylinder. But where soft yarn and waste only is to be carded, then the breast is not required. The doffers and workers are driven independently so that their speed can be changed to suit the stock to be worked, as waste that is twisted very hard requires to remain in the machine much longer than soft waste. Fig. 238 illustrates in section the three-cylinder machine with breast. All details necessary for an explanation are indicated in the illustration. Garnett machines and carding engines (Breaker-card) are also frequently combined in one machine. The Retainer-roll, explained on pages 128 and 129, and illustrated in Fig. 216, is also frequently added to Garnett machines.

Waste Duster.—This is another machine used in connection with previously explained machines in the waste-preparing departments of woolen mills. The machine illustrated in Fig. 239 refers more particularly to a duster for soft waste, as card waste, etc., and in its principle of working closely resembles the wool duster, explained in a previous chapter. For the dusting of rags before picking, a larger size of machine (also having a blower and dust trunk on its top) is used. It is very important to have the rags properly dusted before picking the same, since if not cleaned they fill the room with dust when picking, wear out the teeth of the picker faster, injure the appearance of the shoddy, and clog up the card wire in carding. Also in oiling, the rags that have been properly dusted requires less oil.

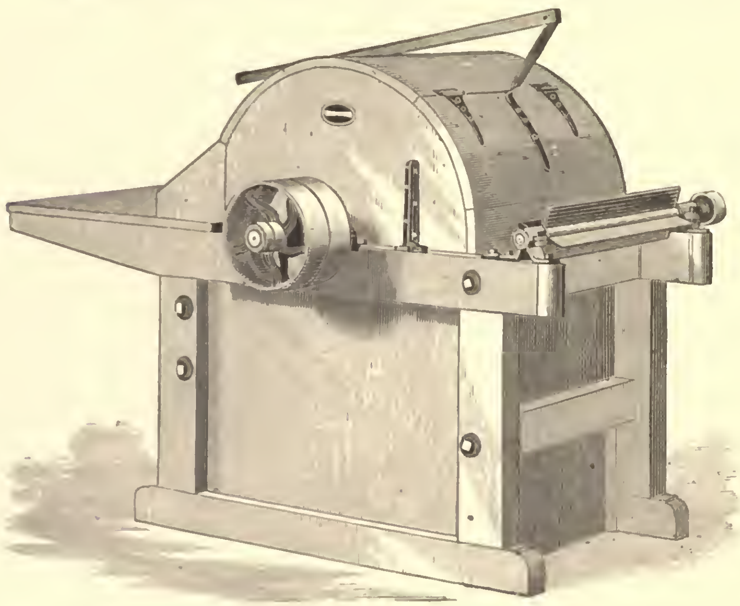


Fig 239.

Spinning.—The object of spinning consists in transforming the roving produced on the finisher-card by means of drawing out and twisting into a thread of required counts and strength.

Some historians claim Leonardo da Vinci as the inventor of the characteristic spindle required for spinning, but if so, his idea or device as (claimed) constructed in 1452 was never universally known. Spinning was carried on in its crudest state until in 1530 a German by the name of Johann Jürgen, of Wolfenbüttel, invented the well-known spin-wheel. The same has been by accident, or fortune we might more properly say, the means for the invention of the *Jenny* by the weaver Hargreaves, of Blackburn, England, in 1767. He was watching his daughter Jenny operate the spinning-wheel when it accidentally fell over and he noticed the continuous turning (for a short time) of the thus vertically-standing spindle. In 1769 the great genius Arkwright received a patent on a device which laid the foundation for our present cotton spinning; *i. e.*, drawing out the sliver by means of three sets of rolls and winding the same upon the bobbin situated on the spindle and between the flyer. The inventions of Hargreaves and Arkwright were successfully combined by Crompton who, about 1775, invented the *Mule-Jenny.*

Modern Spinning Machinery.—Spinning at present is carried on either on the mule or the spinning machine.

Mule.—This is one of the most intricate and complicated machines used in a woolen mill. For illustrating our explanations of the working of this machine, Figs. 240 to 243 are given. Fig. 240

illustrates the front view of the mule as built by the Davis & Furber Machine Company. Fig. 241 shows the rear view of the same machine. Fig. 242 represents the right hand side view of the mule as built by the James Smith Woolen Machinery Company. Fig. 243 illustrates the Bancroft Improved Woolen Mule. Fig. 240 has been marked with letters of reference to which we will refer in our explanations as to construction and operation of this machine. The roving leaves the finisher card wrapped upon long spools (see Fig. 219) which are forwarded to the spinning department and there set on the upright stands *a*, at the back of the mule (shown empty in our illustration). In front of the same are the *delivery rollers* through which the roving ends when unwinding from the spools pass, in front of these rollers is the *carriage d*, containing the *spindles c*, and to which the corresponding roving ends are fastened. Some mills spin directly on the bare spindles, others use paper or tin tubes, whereas others (being the style mostly used) employ wooden bobbins. The modus operandi for imparting the twist into the sliver is thus: A large tin drum runs the entire length of the inside frame work of the carriage which receives motion by wheel and other gearing from the head stock. Round the drum and also around each spindle is wrapped the spindle band, which thus transfers the motion from the drum to the spindle when the former is in motion. Illustrations and more detailed explanations on this subject (as well as the method of running spindle bands) have been given on this subject in the chapter on cotton spinning, to which the reader is referred.

The principle of the working of the mule is as follows: The carriage

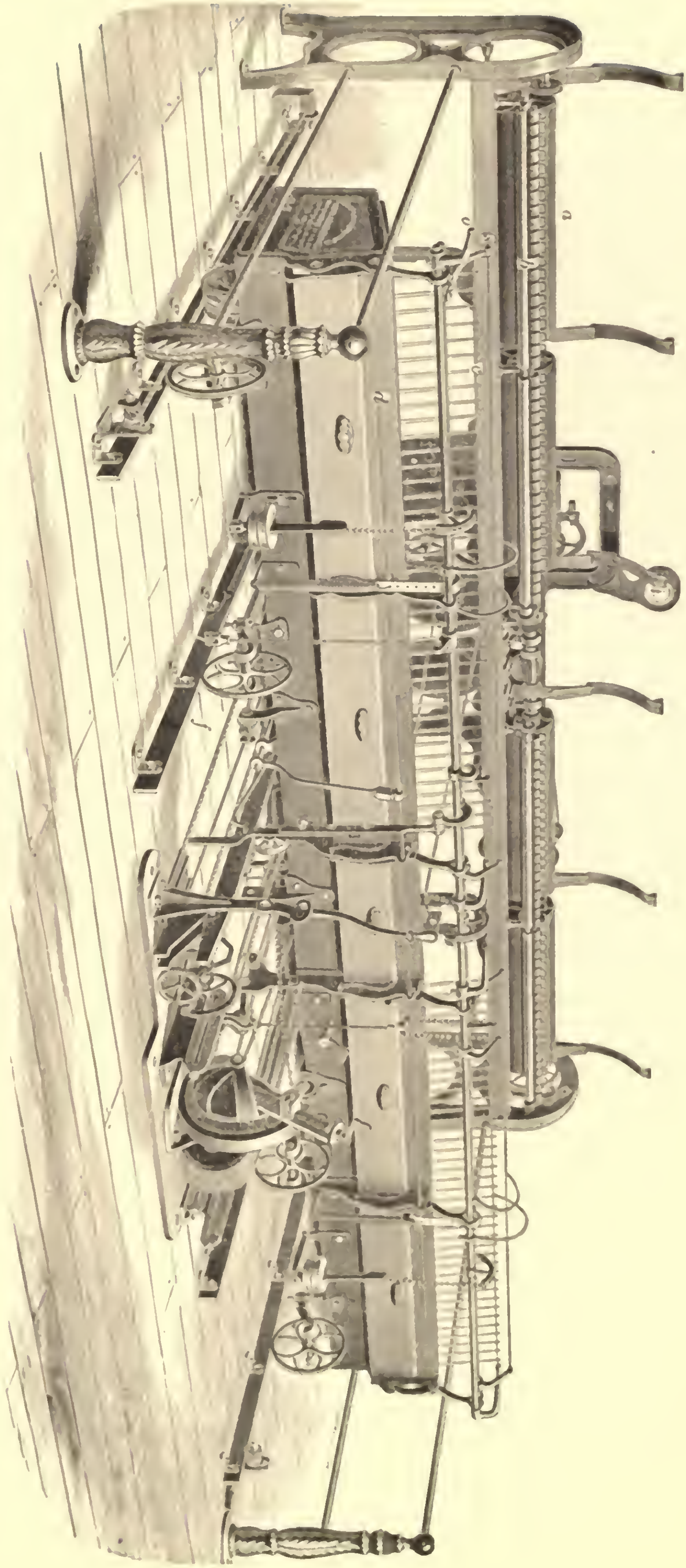


Fig. 240.

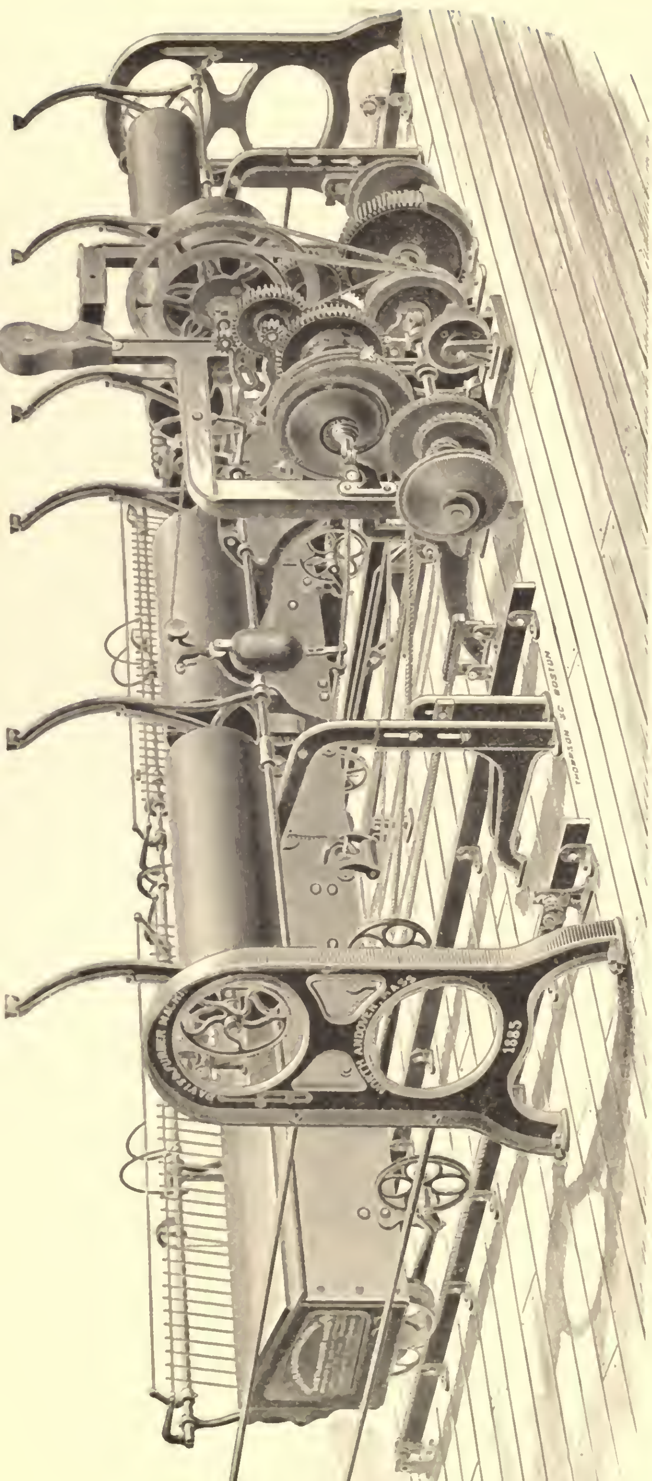


Fig. 241.

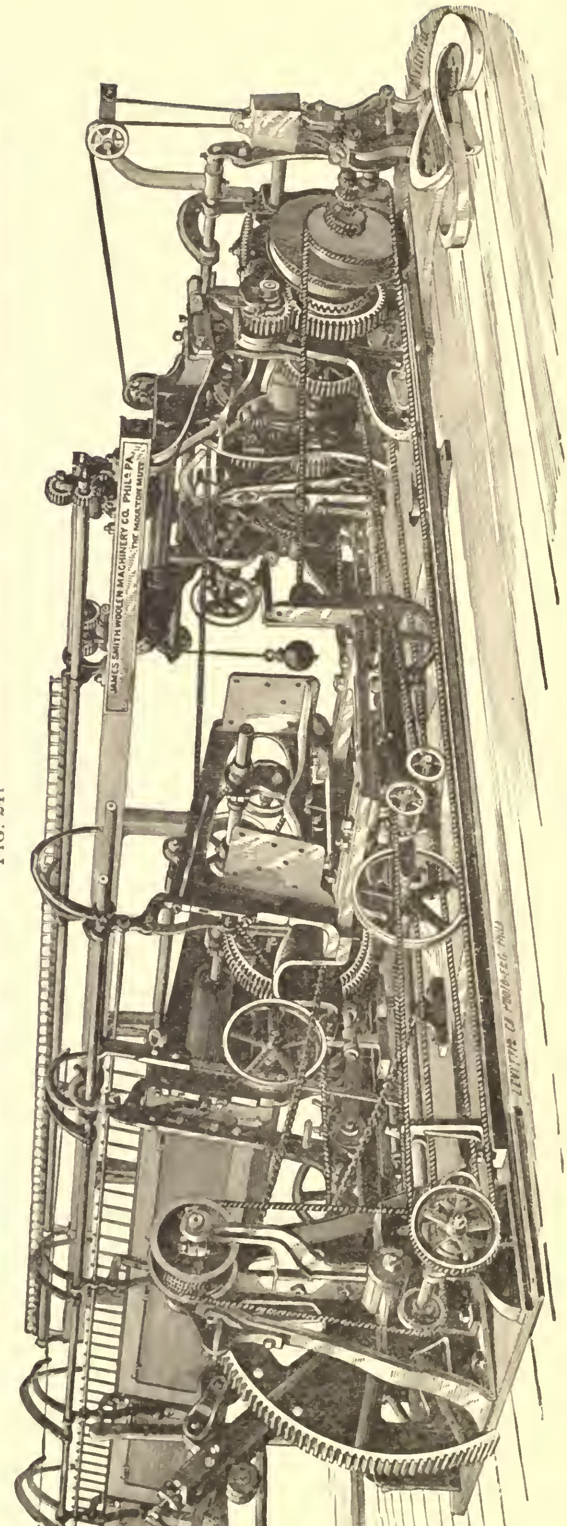


Fig. 242.

d, with the spindles *c*, to which the roving is fastened, is at the beginning, close up to the rollers *b*. As soon as the latter begin to revolve (*i. e.*, deliver roving) the carriage starts simultaneously to *run out* on the rails *f*, and at a corresponding speed to keep the roving nicely taut, but imparting no stretching. The spindles also commence to turn, thus putting some twist in the roving. When the carriage has run out about a yard or so (this is the usual course for medium and fine counts; *i. e.*, to deliver roving during one-half the time of running out of the carriage; but for heavy counts of yarns the rollers are made to deliver during two-thirds, or about that time) the delivery rollers stop, but the carriage continues on its outward run. The spindles also continue to revolve. This will draw out the roving, and the yard or so of roving delivered will get elongated to about two yards, besides twist put in at the same time by the action of the spindles. When the carriage has been completely run out, the spindles are made to revolve at a greatly increased rate of speed, so as to save time. During the twisting, the threads are held slightly above the tops of the spindles by what is called the *faller, s*, to prevent the yarn from being wound up.

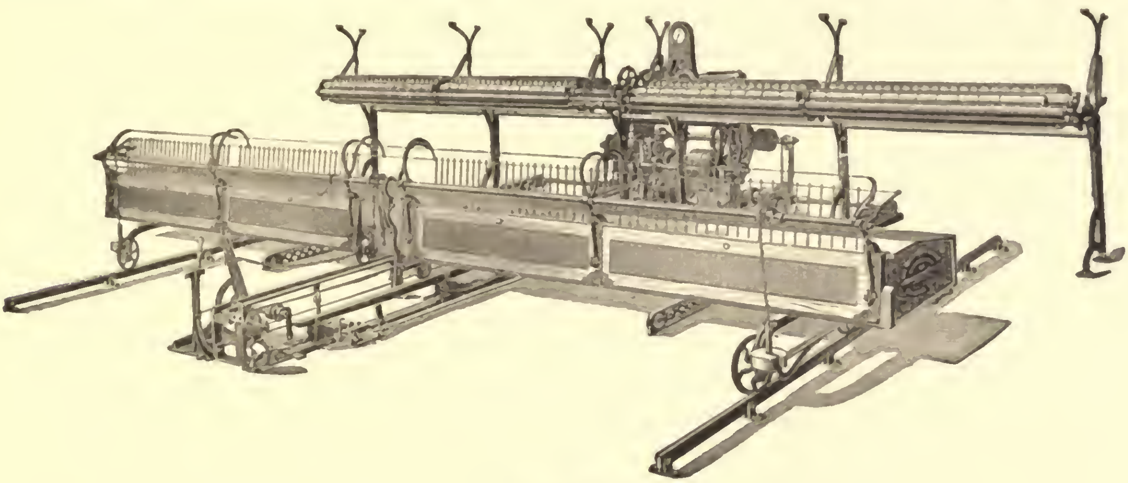


FIG. 243.

When the required amount of twist has been introduced in the yarn, the carriage *d*, returns slowly a few inches, and the spindles also make a few turns backward to undo the extra twist imparted to the yarn nearest the point of the spindle, also to unwind these few inches, as being wrapped too high on the spindle, and which must be re-wound with the stretch of new yarn (2 yards) just spun. After the spindles reversed themselves a few turns, the faller *s*, and *counter-faller o*, exchange positions, being lowered to keep this unwound yarn straight, and then the carriage commences to run in (towards the rollers), and the spindles wind on the yarn in its proper place on the cop or bobbin, as regulated by the counter-faller *o*. A thorough description, with illustration of building, cop or bobbin, has been given in the cotton chapter, to which the reader is referred. All these motions thus far explained are worked automatically from the headstock of the machine. The draft, *i. e.*, the length of roving to be given out by the delivery rollers, is very easily changed by the operator by simply moving the *setting finger* in a groove on the face of the *slubbing wheel* to the figure required, which is indicated on its face, the position of this finger determining the number of inches turned out by the rollers. A similar simple device, by altering a peg on a wheel, regulates the amount of twist put in after the carriage has stopped. Fig 243 illustrates the improved Bancroft Woolen Mule, the main features of which are a steel Race Shaft instead of a Race Belt, and flexible iron chains instead of ropes, which give strength to the machine where required, and ensure perfect work for any counts of yarn. This mule is also provided with what is known as the new Builder, the improved spindle, with a straight foot and an attachment for running the spindles in either direction *i. e.* for making either right hand or left hand twist without the necessity of changing the bands.

Spinning Machine.—This machine is designed to fill the same place in woolen mills that the ring-frame does in cotton mills. An illustration of this spinning machine as built by the Davis & Furber Machine Company is given in Figs. 244 and 245. Both illustrations represent only two

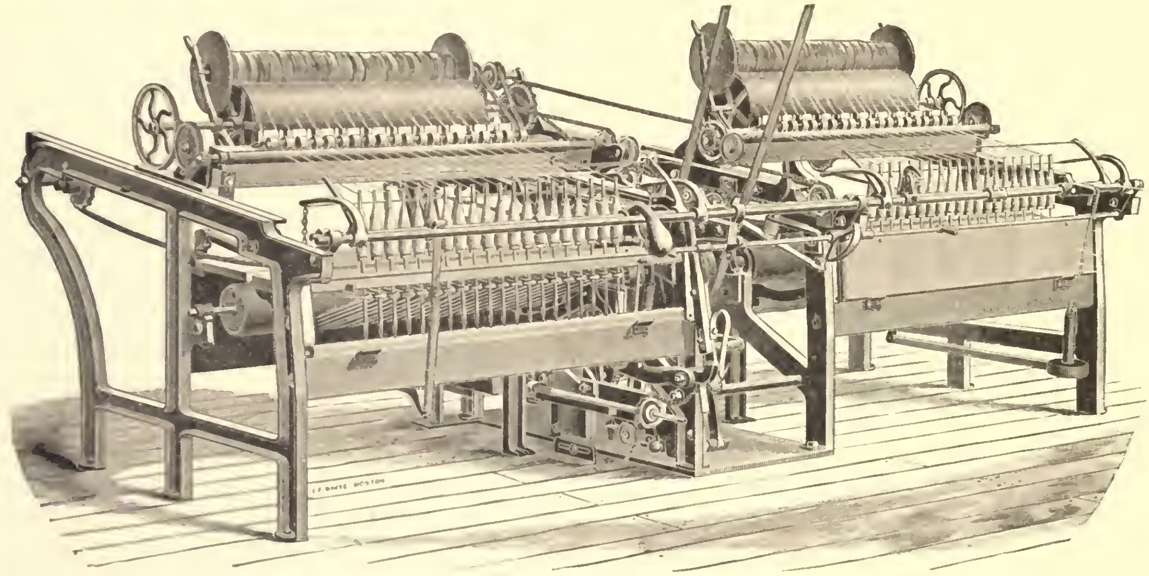


Fig. 244.

sections of the spinning machine which is done in order to bring the cut to a reasonable size for the book. Fig. 244 shows the front view and Fig. 245 the back view of the spinner. The machine is named after the inventor, Mr. Edward Wright, the *Wright Spinner*. The principle and also the object

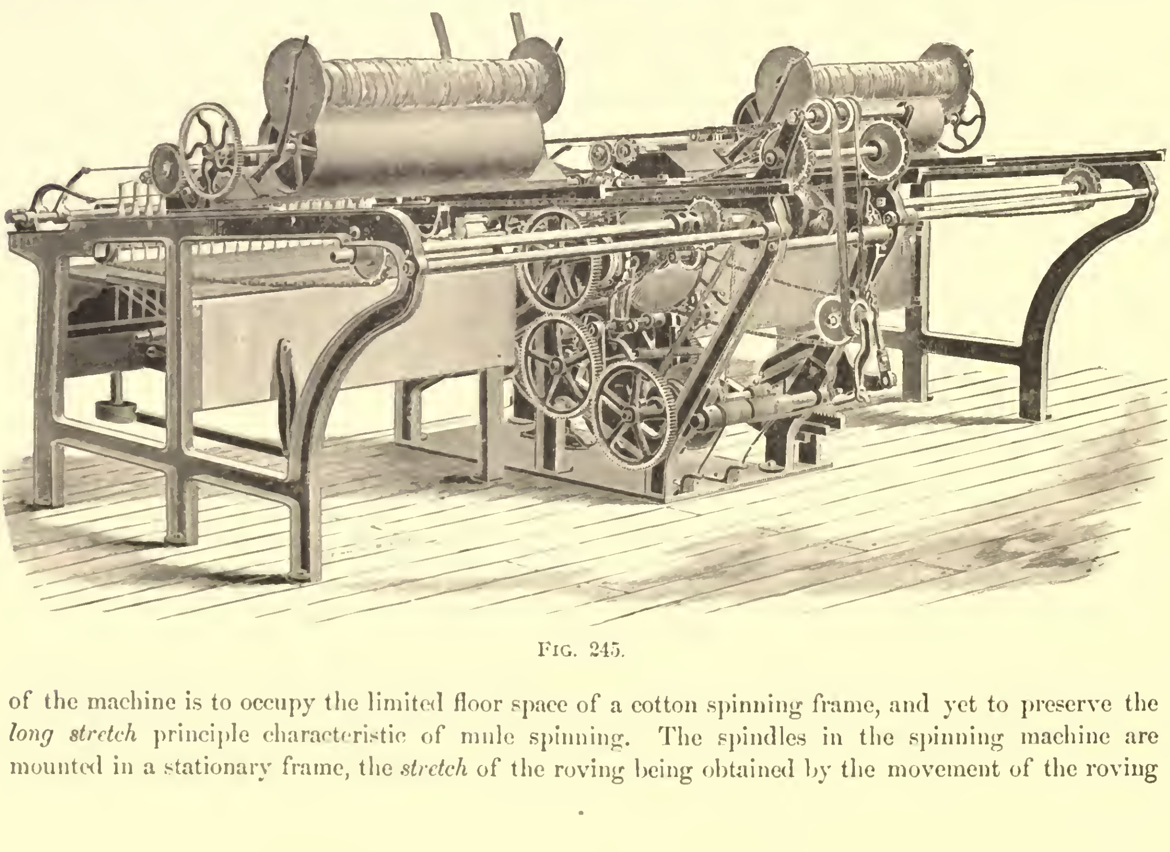


Fig. 245.

of the machine is to occupy the limited floor space of a cotton spinning frame, and yet to preserve the *long stretch* principle characteristic of mule spinning. The spindles in the spinning machine are mounted in a stationary frame, the *stretch* of the roving being obtained by the movement of the roving rolls, to and from the spindles instead of the reverse as with the mule. The plan embraced in the spinning machine makes the tending of the same a simple matter and less exhaustive compared to the tending of a mule, as the operator has only to walk back and forth in front of the spindles, as in the case of a twister. The floor space required by this spinner is but little more than half that necessary per spindle in mule spinning, while the product is substantially the same on all kinds of work. Another feature in favor of the spinning machine compared to the mule is a saving in power, since the spinner saves the propelling of the heavy carriage back and forth as required with the mule. The spinner is also easier on the yarn, both in drawing the roving, and in the actual twisting process; in the drawing, because the light roving rolls can be handled more deftly by the scrolls than the heavy carriage of a mule, while in twisting, as the distance from the spindle to the rolls is but three feet in this spinner, while it is six feet in the mule, there is only one half the weight of yarn bearing on points of spindles, hence, poor stock can be worked with less breakage on the spinner. Another feature in favor of the spinner compared to a mule is that a harder bobbin can be made, because the process of winding occurs twice as often in the spinner or once in every three feet of length of yarn, hence as yarn is wound on closer, and *tied down* more frequently, it follows that more yarn can be put onto a bobbin before doffing, also there will not be so much trouble from ravelling, in the subsequent operations of spooling and weaving. More perfect yarn can be made with the spinning machine because the distance from spindle to rolls being so short, the yarn does not lop down while twisting but extends in almost a straight line, hence the fibres can take a natural position through the entire distance. Again when the ends break on a common mule the operator must hasten to piece up, because the outward movement of the carriage forces him away, therefore a poor splice often results besides some of the ends may have to be left until another *draw*. With the spinner the tender can generally reach to the broken end and *piece* it while the twist is being put in, hence more perfect yarn results.

Ring Spinning.—Experiments have been and are constantly made both here and in Europe, especially the latter place, to adopt the ring spinning machine so extensively used in cotton spinning for the spinning of woolen yarn, but the results thus far derived are not very satisfactory and hardly ever will be, since the roving producing the woolen thread is, on an average, not sufficiently strong to resist the stretch of the ring traveler. No doubt if using only the best of material the question might be more easily solved, but such yarn is only made in very few mills. Most of the manufacturers who insisted upon experimenting in this line, have these ring spinning machines changed into twisters.

Spinning Machine Attached to Finisher Card.—This method of spinning has been lately experimented with in Europe, various patents have been issued in its interest but so far without great results To give an idea of this machine a diagram of such a one as built by O. Shimmel is given in Fig. 246. Letters of reference on the same indicate as follows: *A*, the swift; *B*, the doffer-cylinder; *D*, the doffer-comb; *C*, the condenser-rolls; *K*, the spindle; *G*, the flyer; *E*, whirl for turning the flyer; *L*, the whirl for turning the spindle; *H*, the bobbin; *F*, *F*, rest for holding the flyer; *I*, *I*, movable carriage. The machine is only used for spinning heavy counts of yarn from 2-run to $\frac{3}{4}$-run.

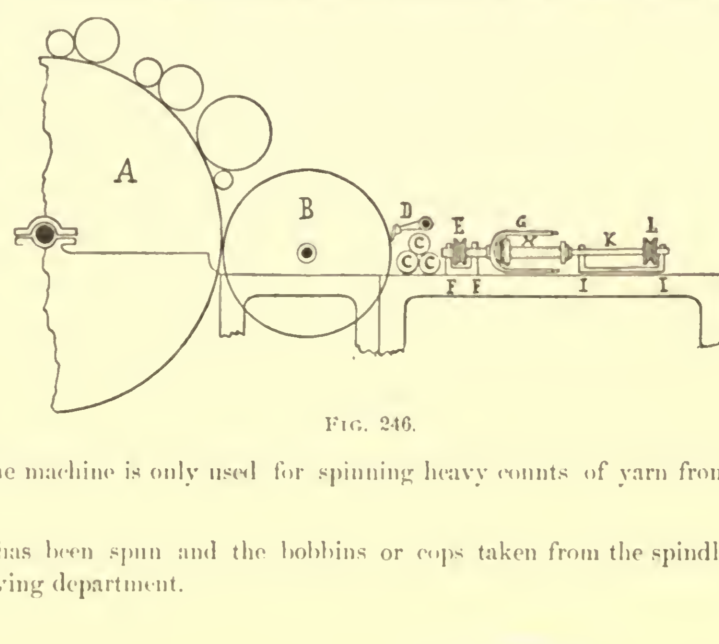


FIG. 246.

Single Yarn.—After the yarn has been spun and the bobbins or cops taken from the spindle (doffed) the same is ready for the weaving department.

Warp Yarn is wound on the *spooler* on large spools (from twenty-five to fifty more or less ends on each). An illustration of the same is given in Fig. 247. *A*, the bobbin stand, for holding the bobbins (or cops); the ends of the latter are passed through guides *B*, as situated vertically above the bobbins from these guides they are passed (running horizontally) to the guides *C*, of the spooling frame, and, from there through the vibrating guides *D* and *E*, onto the large spool (dresser spool) *F*, to which motion is imparted by drum *G*, driven by pulley *H*. A novel feature of this spooler is the arrangement for holding the spool *F*, which does away with the old hanging weights. By means of lever *I*, the spool when filled can be quickly raised from the drum, where held by a dog, the filled spool removed, an empty one substituted and lowered upon the drum, and the process of filling a new spool immediately commenced again. The vibrating arrangement of this machine is such that both guides *D*, and *E*, are simultaneously vibrated in the same direction, which avoids creasing the yarn rollers, and also prevents any undue strain of the threads; this vibrating rigging can be adjusted to give any desired length of traverse. *K*, wheel for indicating amount of yarn wound on spool; the same operates on lever *L*, which strikes on bell *M*, when a certain amount of yarn is wound. The spools as made on this spooler are then forwarded to the dresser.

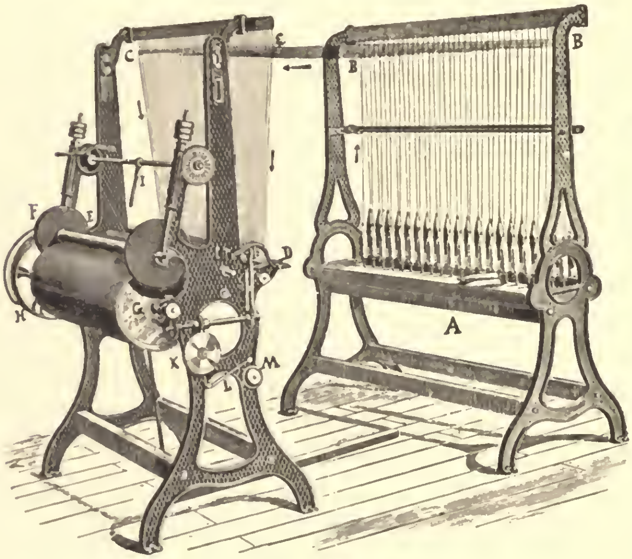


Fig. 247.

Filling Yarn as spun on the spinning machine is ready for the loom when being doffed, *i. e.*, taken from the spindles.

Twisting.—The operation of transforming two, three, or more threads of single yarn into one thread is known as twisting. The same is generally done on the *Ring-twister*, of which a specimen is

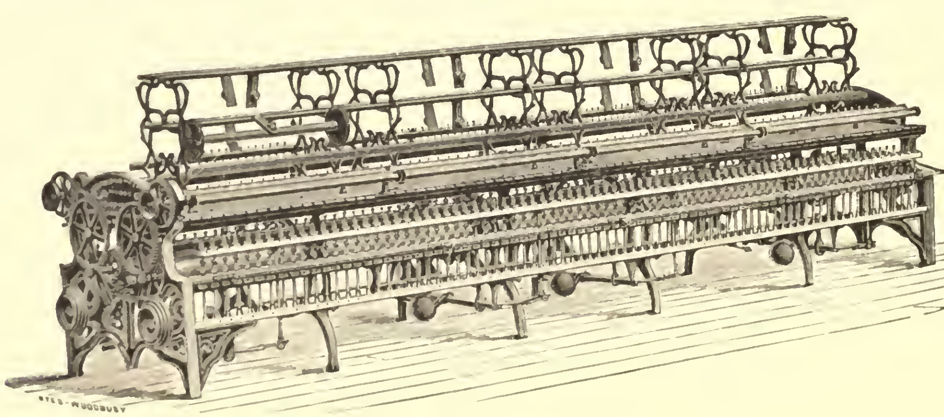


Fig. 248.

shown in Fig. 248; or it can also be done on the mule or spinning machine previously illustrated. In either machine it closely resembles the operation of twisting cotton yarns, as explained in the chapter, on these yarns. Two methods of preparing single yarn for twisting are in use; either the yarns are wound on large spools (on a spooler, as shown in Fig. 247, and previously explained), or the bobbins containing the single yarn are put in a creel on the twister and the yarn twisted direct. The first-mentioned method is more frequently used, whereas the latter is used in dealing with small lots. If winding the yarn on large spools, and using the same in the twister, there is less risk of single ends being allowed to run, hence waste being made in pulling the same off, besides the operator can mind a greater number of spindles. In opposition to this, the method of using bobbins direct from a creel will not ruffle the fibre; besides it is claimed that the twist will lay better if thus twisting the yarn the reverse way from that in which it is wound on the spindle during the winding operation in the spinning process.

The direction of putting in twist on a twister must be always the reverse from the twist the single yarn contains. This twisting will actually take out some of the twist from the minor yarns. Yarns will always lose in length by twisting two or more ends together, and this in proportion to the counts of the minor yarn as well as the amount of twist required to be put in, hence the percentage of loss in twisting will vary with each lot.

Ring-Twister.—An illustration of this machine is given in Fig. 248, and which is built either with single or double cylinders (drums). The *double-cylinder twisters* (being the style shown in our illustration) are arranged with two clock motions, so that each side of the machine runs independently of the other, and when one side is stopped the other side can be kept running.

Two-fold Yarn.—For some fabrics a two (or sometimes a three or more) fold yarn is required; for example, for face filling for chinchillas or single overcoating fabrics. For such yarns the minor threads are wound on a large spool on the spooler, as illustrated in Fig. 247, and from there unwound

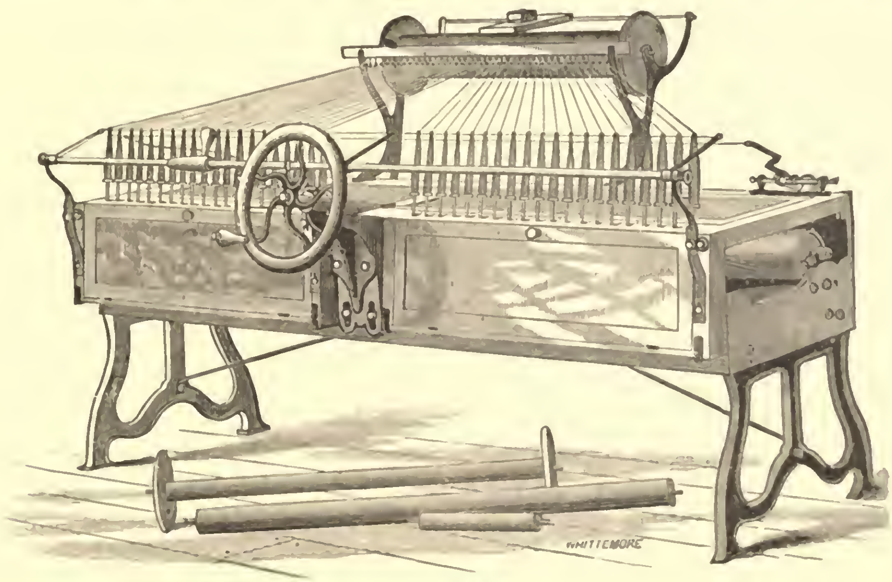


Fig. 249.

on the *bobbin-winder*, of which an illustration is given in Fig. 249. During the unwinding two (or more) ends run together through the same guide and onto the same bobbin.

Worsted.

There was a time when wools were simply divided into two divisions; short and long wools, or as they were then technically known *Clothing* and *Combing* wools. No doubt in those times, such a classification may have been more or less correct, but this is not the case at present, since our modern worsted machinery works a short stapled as well as a long stapled wool, and our modern woolen machinery permits the use of such wools as in former times would have been considered too long.

The principle of manufacturing a worsted thread is to spin a thread from wool with the fibres composing the same placed smoothly in the direction of the thread and parallel to each other (the same as in combed cotton yarn), whereas in woolen yarn we find that the fibres composing the thread are placed in every direction crossing and overlapping each other constantly, so as to produce a fur-like surface caused by the ends extending more or less outside the body of the thread. To illustrate this subject Figs. 250 and 251 are given. Fig. 250 illustrates a worsted thread (magnified) made of long stapled and strong fibres; Fig. 251 shows a worsted thread similarly magnified, made of fine and short stapled wool. In both illustrations the fibres composing the thread are seen to rest more or less parallel, and this will be much more noticeable if comparing them to a similar illustration of a woolen thread given in Fig. 189, page 118 in the previous chapter on the manufacture of woolen yarns.

FIG. 250.

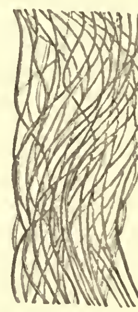


FIG 251.

There is one feature found in wool fibres, which to a great extent classifies them as more or less adapted for wool spinning or for worsted spinning, which is their felting or non-felting properties, since wool with marked felting qualities is better adapted for the manufacture of woolen yarn, whereas wool which is deficient in these qualities is better adapted for the manufacture of worsted yarn.

Different Methods of Manufacturing Worsted Yarns.—All worsted yarns are not manufactured by the same system, but the different methods are closely related by having the same object (*i. e.*, laying the fibres smoothly in the direction of the thread or parallel), and in fact will more or less overlap each other. Some yarns, for example, such as are produced out of long-stapled wool (averaging five inches and more in length), the fibres after being cleansed and dried, are passed through a number of *gill-boxes*, and then combed, drawn and spun, whereas worsted yarns produced from short and medium-stapled wools (from two to five inches in length) are manufactured by carding, combing, drawing and spinning. Again, such worsted yarns as are used in the manufacture of carpets or low counts of knitting yarns (made of fibres of various lengths) are simply carded, passed through a number of gill-boxes, and all the drawing machinery previous to being spun, the combing being omitted. Slivers produced by either system are frequently mixed; for example, a *top* of long, medium quality material produced by one system may be mixed with one of fine, but short staple produced by another system, etc., etc.

Principal Operations Composing the Manufacture of Worsted Yarn.—There are in the manufacture of worsted yarn (technically known as worsted spinning) seven main operations, as follows: 1.—Sorting. 2.—Scouring. 3.—Drying. 4.—Preparing: *a*, carding, backwashing and gilling; *b*, gilling. 5.—Combing: *a*, nip-comb; *b*, square-motion comb; c, Noble comb; *d*, Little and Eastwood's comb. 6.—Drawing: *a*, open; *b*, cone; c, French. 7.—Spinning: *a*, fly-frame; *b*, cap-frame; *c*, ring-frame; *d*, mule.

Sorting, Scouring, Drying.—These three operations are the same as previously explained under corresponding headings in the chapter on the manufacture of woolen yarns, thus no special reference is necessary. In regard to sorting we must mention that the worsted manufacturer only wants the best fibres out of the fleece. The amount of rejection in a good healthy fleece, of fine wool, will reach from ten to twelve per cent., as wool is generally put upon the market by the American farmers. In coarse fleece the amount used is still less.

Preparing wool for Combing.—As previously mentioned two ways, according to length of staple, for preparing wool for combing are used. The long stapled material, (5 or more inches) is submitted to, or passed through the several gill-boxes (generally six) forming the *preparing-set*, whereas short and medium stapled wools are first carded and then passed through one or two gill-boxes corresponding to the fifth and sixth gill-box in the preparing-set.

Preparing by Carding and Gilling.

A. Carding. — This process is about the same as the process of carding for woolen yarns, thus no detailed explanation of the subject will be necessary. The carding engine used for this work is generally that known as a double cylinder card, but in some instances a single cylinder card is employed. An illustration in perspective of the former engine (as built by the Cleveland Machine Works) is given in Fig. 252. These cards sometimes contain as many as four licker-ins, increasing in fineness of their clothing from one roller to the other, and also correspondingly in their speed, hence the first licker-in will have the coarsest clothing and the slowest speed compared to the last licker-in which will have the finest clothing and the greatest speed. These worsted cards also generally contain a metallic breast, or a burring-machine, or both combined, being attachments to cards thoroughly explained and illustrated under corresponding headings in the chapter on woolen carding. The film thoroughly carded is stripped off the last doffer by the doffing-comb and condensed into the characteristic sliver by passing through a kind of funnel. It is then wound in balls. This is done either by means of calender-rolls as shown in Fig. 252,

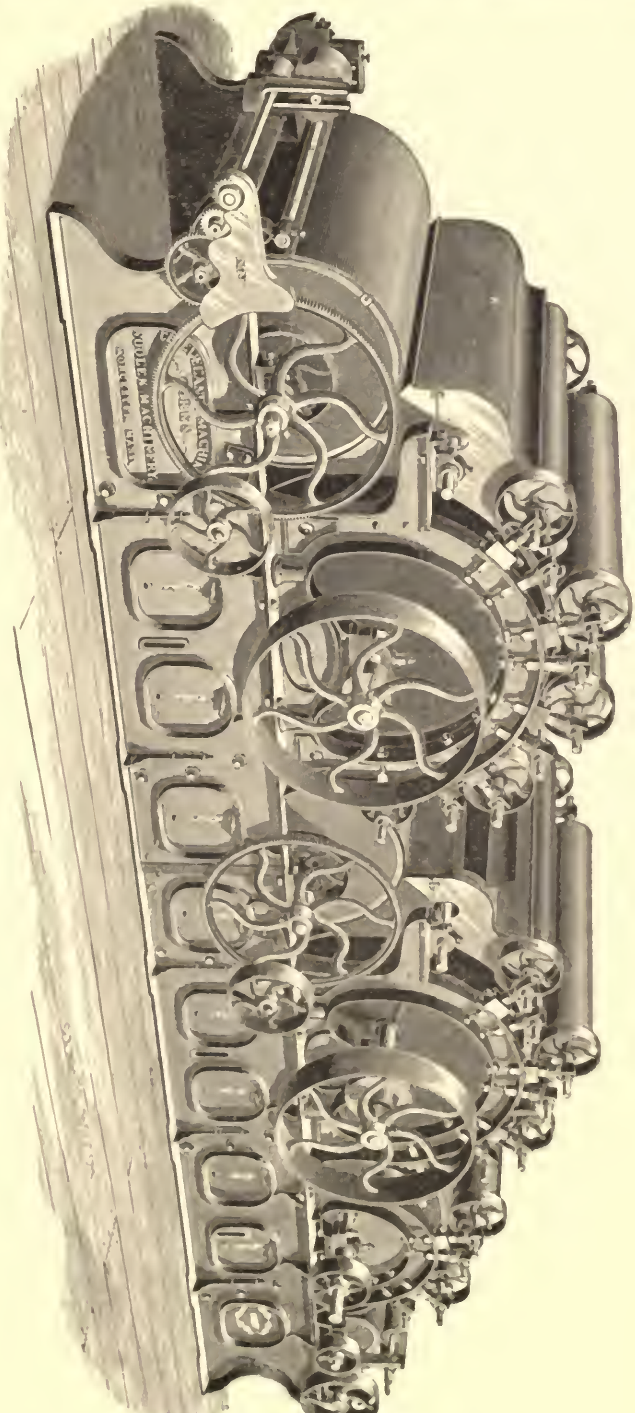


FIG. 252.

or by a balling-head as shown in Fig. 253. The latter illustration represents the section of a double cylinder worsted card with four licker-ins and balling-head. After carding, the material is ready for those processes belonging more especially to the manufacture of worsted yarns, *i. e.*, backwashing, gilling, combing, drawing and spinning.

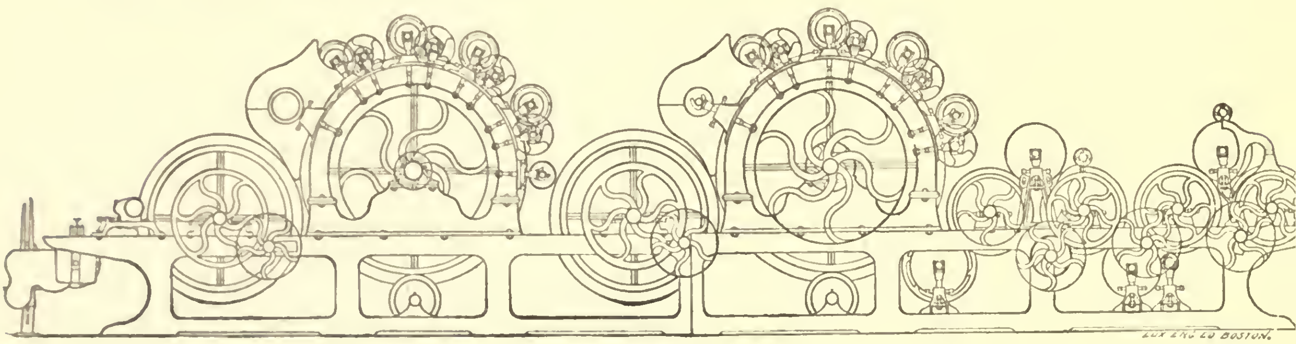


FIG. 253.

B. Backwashing and Gilling.—By means of these two operations as produced on the machine known as *combined backwashing and screw-gill-balling machine*, of which an illustration is given in Fig. 254, the wool is freed from oil (which had been previously added to facilitate carding), and discoloration, and is dampened, drawn, and straightened previous to being combed. A number of balls of slivers are put up in a creel in the rear of the machine; the ends are next passed through two vats, *A* and *B*, containing suds of hot soap and water, each vat possessing a pair each of immersing and squeezing rollers. After leaving the squeezing rollers *C*, of the second bowl *B*, the slivers pass over five copper drums *D*, (heated with steam to dry it) to the rollers of the gill-box *E*, of the machine. The

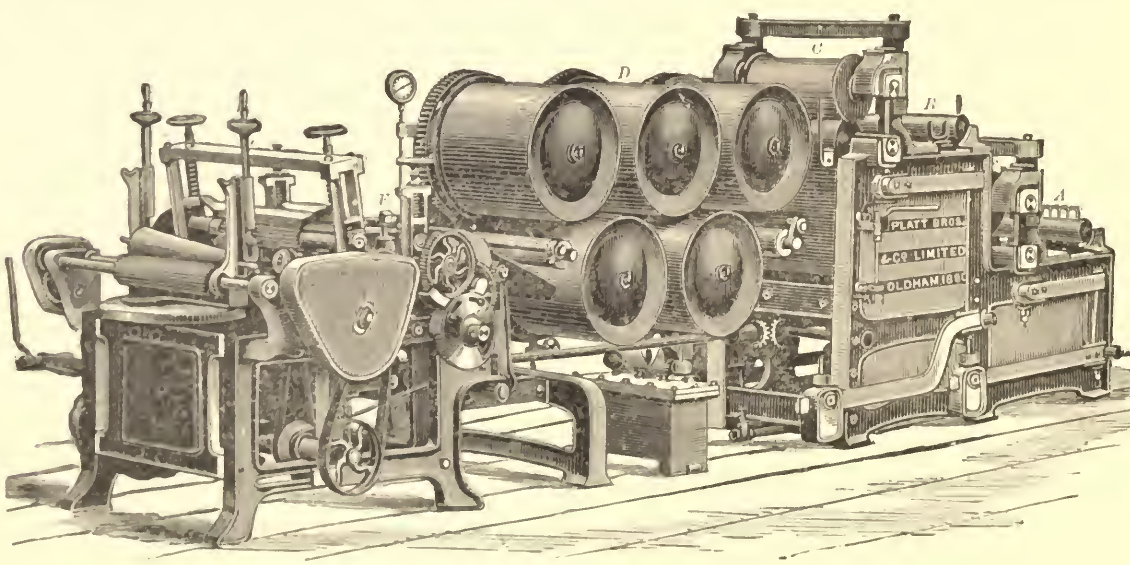


FIG 254.

object of the latter device is to straighten the fibres, that is, prepare the wool for combing. This method of gilling in connection with backwashing is similar to the gilling done by the preparing-set, which is explained in detail in the next chapter. According to the use of either one or two gill-boxes in combination with backwashing they equal the last or the two last gill-boxes of the preparing-set. Having thus far described the process of preparing short or medium long fibres for combing (carding and gilling) we have next to treat the preparing of long staple wools (five or more inches in length) for combing. Medium long stapled wools are at present also mostly carded, and if so the carding engines are built to suit this staple (not break it).

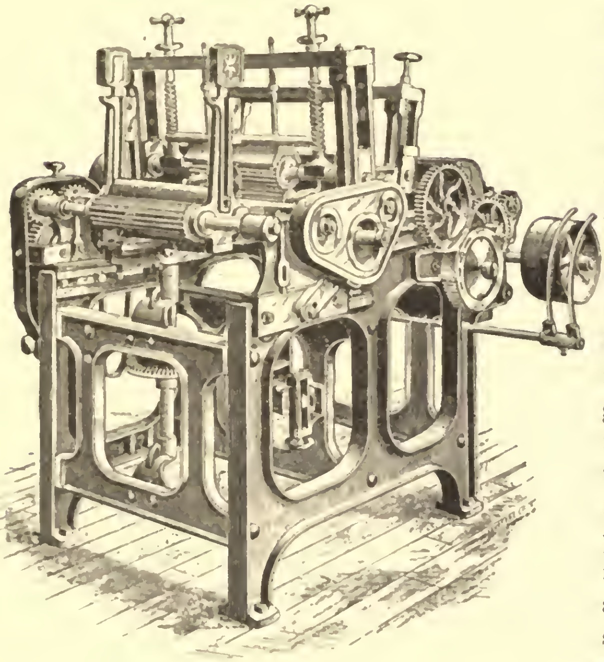


Fig 255.

Preparing by Gilling.—If very long wool was carded a great many of the fibres would get broken by means of the wires of one roller catching one end of a fibre before being liberated from the wires of another roller. This, however, is not the case if dealing with short or medium stapled wools, since on account of their shortness the fibres do not cling to such an extent to the clothing of the rollers. To obviate this trouble for long stapled wools, the preparing for combing by means of screw-gill-boxes has been invented. This modus operandi consists in taking the wool and by a series of successive gillings straighten the long fibres of the wool intended to be combed, in order that the operation of combing may be conducted with greater facility and less damage to the staple. The preparing machinery consists of what are technically known as gill-boxes and of which there are generally five or six used in one preparing-set. The principle for either box is to straighten and separate the fibres of the wool preparatory to combing it. Fig. 255 illustrates such a gill-box as used in a preparing-set. The main parts of it are the back rollers, the fallers and the front rollers. The wool is fed by hand, after being previously transformed, also by hand, into a kind of lap, with the fibres lying as much one way as possible, into the first gill-box and there received by a pair of fluted rollers known as feeding or back rollers. During this passage the material comes in contact with the pins of the fallers, of which a specimen is shown in Fig. 256 (being round or flat steel pins, fixed in rows in steel bars) which travel forward by means of two screws between the threads of which they run. When these fallers arrive at the end of the screws they drop down into a second pair of screws grooved in the opposite direction, which carry the fallers back again and below their starting point, from which they are lifted up to their working position in the upper pair of the screws (*i. e.*, ready for commencing again their forward journey) by an arrangement of cams fixed in the ends

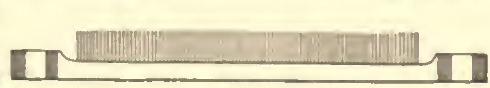


Fig. 256.

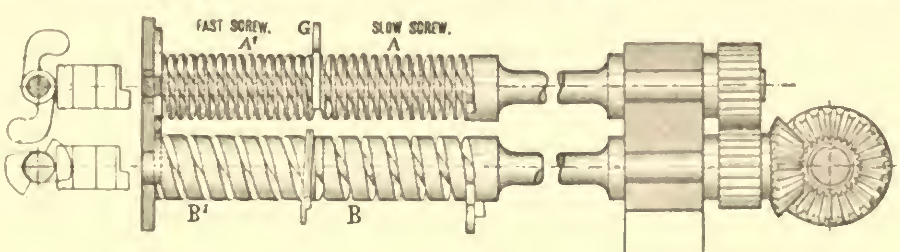


Fig. 257.

of screws. An illustration of the method of operation of these fallers is given in the chapter on Flax in the explanation of the spread-board.

Improved Method of Working Fallers.—An improvement in the modus operandi of these fallers as used for gilling has been made lately. An illustration of this improvement is given in Fig. 257.

Instead of the ordinary screws (the functions of which are to traverse the fallers) being one pitch throughout, or having four separate screws driven from each end by gearing, the inventor of this improved device makes each of the top screws A, and A^1, in one length, and each of the bottom screws B, and B^1, which return the fallers to a working position, also of one length, both sets being driven by bevel and spur wheels in the same way as when the machine is fitted with screws of the same pitch throughout. The portions of the top and bottom screws A, B, next to the feed-rollers are cut with single threads for traversing the fallers, but the second portions A^1, B^1, are cut with double threads which traverse the fallers more quickly. By doing so they straighten the fibres much more perfectly than can be done with the ordinary screws. The sliver, after leaving the feed-rollers, passes to the first set of fallers, which carry it to the ordinary stop at the usual place, but when it is taken to the second set of fallers, actuated by the double-pitched screw A^1 the speed is actuated in proportion, and double the amount of draught is obtained. This, besides more thoroughly straightening the fibres, increases the production and makes it easier to do more work with the same number of machines, or the same work with fewer machines, besides drawing out any curled loop of wool, it at the same time permits the dirt to drop between one set of fallers and the other.

Gill-Box.—The draft in the gill-box is produced by having a greater surface-speed for the front rollers (drawing-rollers) compared to the back rollers (feeding-rollers), which causes the material to be drawn more rapidly through the first mentioned pair than delivered by the others. During its travel, from one pair of rollers to the other, the wool passes through steel pins which are set in steel bars (fallers), which operation separates the fibre, or, technically speaking, opens the wool. Great care must be exercised during the process of gilling or the fibres will be broken by the strain, and unfitted for worsted spinning.

Preparing-Set.—In the first and second gill-box, the material is, after each gilling process, wound in a lap, whereas after leaving number three box it is no more wound in a lap, but transformed into a sliver by being passed through a round hole in a piece of brass or steel, next drawn down by a pair of presser rollers and deposited in a sliver-can (similar to the one explained in the corresponding cotton processes). Generally six, or about that number, of these cans are put at the back of number four gill-box, and the union of the slivers (one from each can) submitted to the action of the machine, and drawn out from six to eight times their original length. This leveling of the slivers by doubling is the backbone for producing even worsted yarn, the same as it has been for cotton, since the more doubling done, the more even the sliver will get (the object is to so intermingle them, that the deficiency in one may be supplied by another, which possibly may be over supplied with material at that point), this process is also duplicated by each of the other boxes (number 5 or numbers 5 and 6 box) used in the preparing-set. The sliver when leaving the last gill-box of the preparing-set is wound automatically on a ball. If any oil is to be added to the wool, this is done on the fourth box by suitable arrangements, since any dust or fine dirt not previously removed from the wool will be shaken out during its passage through the first three boxes if the stock is not oiled.

The sliver thus finally produced (in the last preparer), by repeated doublings is comparatively level and the fibres composing the same, have been, by the continued use of the pins of the fallers, very thoroughly separated and put in parallel positions, but yet contain all the knots and broken fibres the wool originally contained, all of which must be removed by the combing machine. The points on the pins must be kept sharp, and such as get broken repaired as soon as possible.

Combing.—The original method, now extinct, of combing was by hand. The hand-comber in this process made use of two combs (similar to the one shown in Fig. 258). One of these he used as a pad comb, fixed on a post at a convenient height by an iron rod fastened into the post. The cleansed and oiled wool after being made up into handfuls (the staples laid parallel upon a bench) was lashed into each comb placed upon the pad. After each comb had been thus filled with raw wool, they were placed in the *comb-pot* for being heated, during which time the comber prepared again his handfuls of wool for the next lot. He afterwards took the combs out of the comb pot, placed one comb upon the pad, and with the other in hand commenced the lashing or combing operation, each comb becoming alternately a working comb, by the teeth of one being made to pass through the tuft of wool upon the other, until the fibers of each became perfectly smooth, free and clear of short wool or *noils*, which were left imbedded in the comb heads. The combed wool, known as *tops*, were taken off by the comber with his fingers and laid evenly as possible into a sliver a few feet long, by drawing through a bone lined hole, whereas the noil, or short material, was next taken out, collected in a box and sold to woolen yarn spinners.

FIG. 258.

Combing by Machines.—As seen by the previously given explanation of hand combing, there is a two-fold object to be attained in combing by machinery, that is to continue the parallel placing of the fibres, partly accomplished by the previous process of gilling, and second to remove the short curly and neppy fibres (noils) from the long and straight fibres (tops) the former being unfit for use in the manufacture of worsted yarn.

The honor of having made the first practical attempt to solve the problem of wool combing by machinery (toward the close of the eighteenth century) belongs to the great genius Dr. Edmund Cartwright, and this without the advantage of special mechanical training or knowledge of the subject. He created the germ for all subsequent wool combing machines ; no doubt some later inventors of such machinery have proceeded on lines distinctly their own, or even in ignorance of his invention but whichever wool comb we may take in consideration we find a reproduction of the principles of Cartwright's combing machine in it. Cartwright's original combing machine consisted of a cylinder, armed with rows of teeth which revolved in such a manner that its teeth might catch and clear out the wool contained in the teeth of the fixed and upright comb. His second combing machine, patented 1790, superseded the previous imperfect method by the contrivance of a circular horizontal comb-table.

The most frequently used wool combs of modern build are the nip comb, the square-motion comb, the Noble comb, and Little & Eastwood's comb.

The Nip Comb.—On the continent of Europe, (Austria, Germany, France, etc.) Josue Heilmann is generally considered the inventor of the nip system of combing, whereas England claims this honor for S. Cunliffe Lister, and G. E. Donisthorpe. Heilmann was the first to reach the Patent Office with the improvement, hence was in a position, when the two Englishmen brought out their nip machine, to obtain, in their own country, an injunction against them for infringement. Subsequently Heilmann's English patent right was bought by Messrs. Akroyd & Salt for £30,000, and re-sold by these gentlemen for the same sum to Mr. Lister. In this manner the latter obtained absolute control of the manufacture of these machines. Herr Lohren, a German authority on worsted combing says: "Lister's nip comb fulfills all the elementary principles of perfect combing, and yet it has neither a special combing apparatus, nor an intersecting comb, but only a feeding apparatus, in which however, are combined the effects of three of the operations necessary for good combing; *i. e.*, the filling in of the fibre, the combing of the ends, and the adequate preparation for the combing of the middle portion. It could only be accomplished after Heilmann had invented his celebrated nipper, therefore it is a combination of the invention of Cartwright & Heilmann."

Heilmann's machine, as invented by him, has been thoroughly described and illustrated in the previous chapter on combing cotton, hence no special reference to it is now necessary; thus we will give at once an explanation of the nip machine, as gradually improved by Mr. Lister.

Lister's Nip Comb.—An illustration of the latest form of Lister's nip comb is given in Figs. 259, 260 and 261. Fig. 259 gives a general view of the machine; Fig. 260 a sectional view, showing one drawing-off and two feed-heads, and Fig. 261 shows another sectional view of this machine. Letters of reference in all three illustrations are selected to correspond and indicate as follows : *A*, revolving comb-ring ; *B*, *C*, one or two feeding and combing apparatus ; *D*, a stroker ; *E*, a drawing-off apparatus; E, the noil rollers. The comb-ring A, has the usual shape, and is heated by the circular steam chest a, by means of the steam pipes a^1. This combing is driven from the main driving-shaft

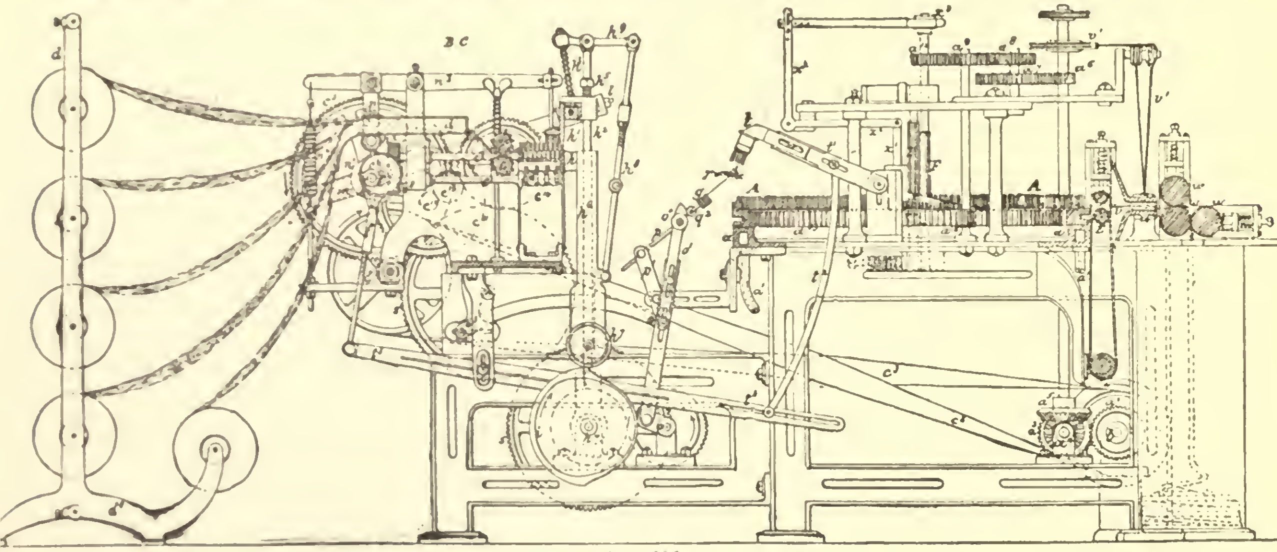


FIG. 259.

b, by means of the wheels a^2 to a^{13}, of which the wheel a^{32}, is geared with the teeth inside the comb-ring. Fig. 260 shows the arrangement of one of Lister's machines, with one drawing-off and two feed heads B, C, the latter being placed at right angles to each other. They are fixed firmly upon the frame of the machine, but are movable upon the slides R, R, and can be set to suit the length of the material which has to be combed. The front part of this feed head is constructed like a gill-box, without drawing-rollers. It consists of a polished guide plate d, the fluted drawing-in or feed-rollers e, e, and the fallers c, c. The balls containing the slivers for feeding the machine are placed into the bobbin stand a^1, and are conducted over a divided plate d^2, to the feed-rollers e, e. The lower screws c^1, receive their regular revolving motion from the main driving shaft b, by means of the belt c^3, the spur wheels c^4, c^5, and the conical wheels c^6 and c^7. The top screws c^2, are connected with the bottom screws by the wheels c^8 and c^9. The feed-rollers e, e, are driven by the wheels c^{10} to c^{14}. The peculiarity of the Lister nip comb, however, consists in the nipper h, h,[1]

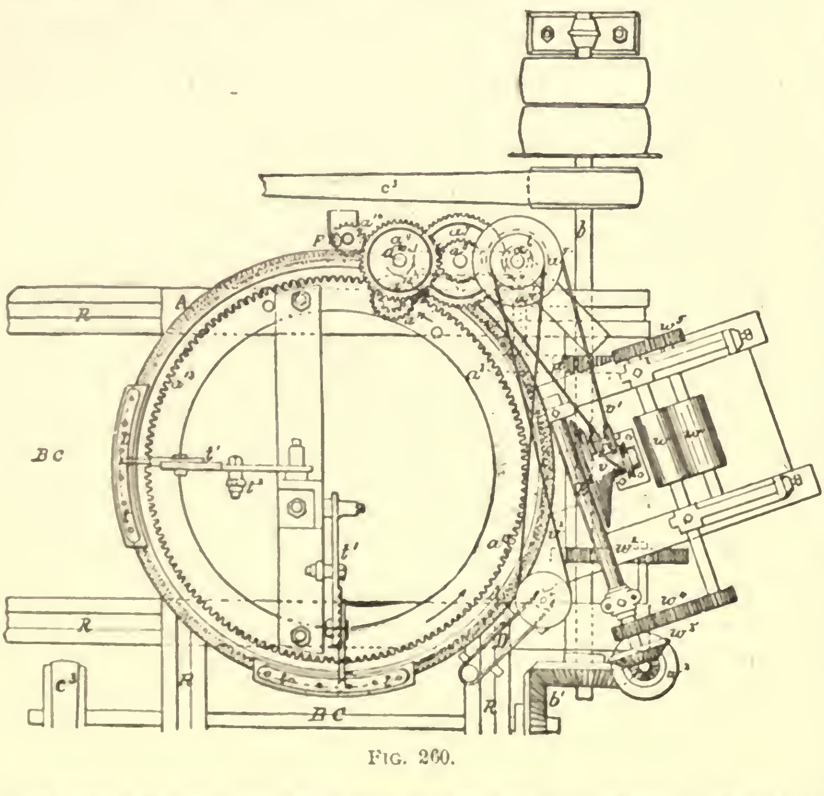


FIG. 260.

which takes hold of the fringe of the fibres projecting from and drawn forward by the fallers, and then deposits the drawn out portion of fibres upon the carrying-comb g. The latter places them in the teeth of the comb-ring A. The nipper consists of two jaws, the lower one h, with a grooved edge, the upper one h^1, with a polished and rounded-off edge. The upper jaw slides upon the lower bar h^2, and is pressed down by spiral spring h^3; the lower bar h^2, swings its lower end round the shaft h^4, and its highest position is fixed by the adjusting screw h^5. The lower jaw is fixed upon the tube or brush h^6, which slides upon the bar h^2, and bears at its lower extremity the truck h^7, and at its side the connecting rod h^8. The latter operates upon one end of the double armed lever h^9, the other end of which presses upon and confines the spiral-spring h^3. The opening and closing of the upper is caused by the cam or lappet i, keyed upon the revolving shaft h^4, and upon the circumference of which runs the truck h^7. The pressure between the two jaws of the nipper is regulated by the nuts upon h^2 and h^8, and the spirals h^3. Besides the opening and closing movement of the jaws of the nipper, by which it takes hold of the fringe of the fibres, a second movement is required to draw out the fibres from between the teeth of the

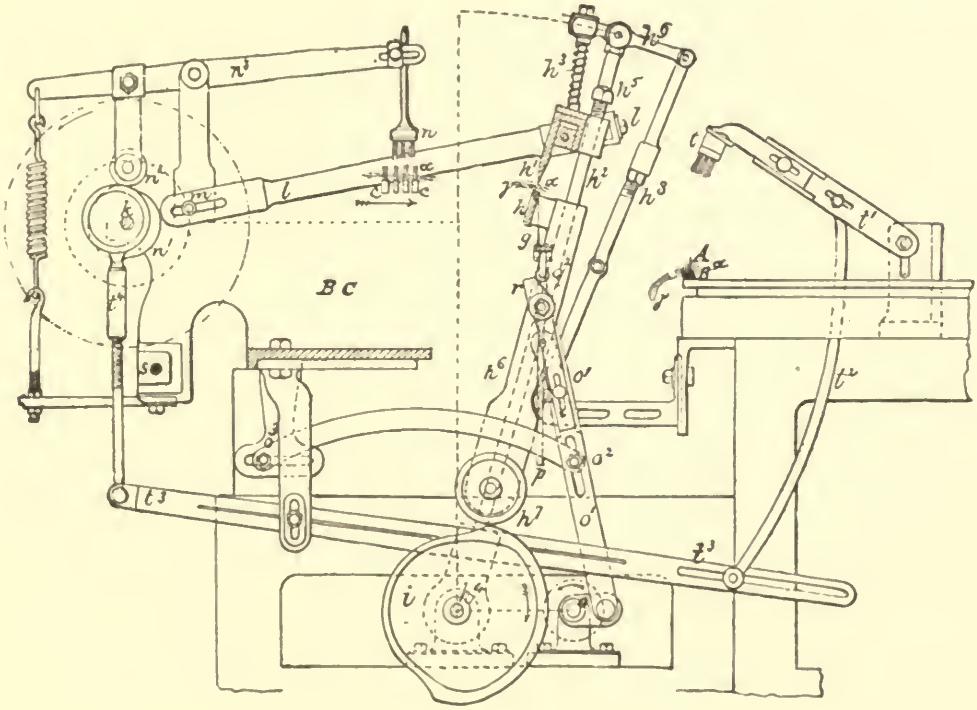


Fig. 261.

fallers and transfer them to the carrying-comb. This motion is produced, in a nearly horizontal direction, from the shaft K, by means of the slotted cranks m, and the connecting rods l, which are connected with the top jaw of the nipper by adjustable bearings. The action of this nipper is as follows: At the moment when one faller c, has fallen from the top into the bottom screw, and the next faller has advanced, the fringe of the fibres thus liberated as far as the screws will permit, the jaws of the nipper close upon this projecting fringe L, as far back as to bring the whole portion of fibre held by the faller just descended, and which portion contains the noils and impurities to the outside of the nipper. As soon as the fringe of fibres is nipped in between the jaws, the detaching movement begins by means of the crank m. To effect thereby the combing of the back end y, of the fibres, the brush n, descends into the pins previous to the fibre being detached, and remains in that position during this operation. The motion is given to this brush from the shaft K, by means of the lapper n^1, the truck n^2 and the lever n^3, tension being given by the spiral spring n^4, at the opposite end. The carrying-comb g, receives the ends l, of the detached tuft of fibres (Fig. 261) and places them so far over the teeth of the comb-ring A, that not only the uncleaned ends L, but also the still impure middle portion B, of the fibres is deposited within them, thus leaving only the combed ends Y, projecting from the comb-ring. From this it will be perceived that the drawing-off apparatus will produce a sliver of fibres combed perfectly clean along their entire length. The work of this carrying-comb is one of the most important features of Lister's machine. The same is shown separately in Figs. 262 and 263, and receives three combined, separate and distinct motions—a vertical one, a horizontal one and a change in the position of the points of its teeth from a straight line (Fig. 262) into a curved one (Fig. 263). The first is produced from the crank o, by means of the bar o^1, and the lever o^2 o^3; the second by the rod p, to the upper end of which the carrying-comb is fixed. This rod turns upon the axis o^4, in the connecting-rod o^1, sliding with its other end in a swivel upon the guide-bar p^1. The third motion which changes the straight line of the points of its teeth into a curved one, and back again to a straight one, is produced by the teeth fixed into a curved spring plate q, (Figs. 262 and 263), which by the pin q, and the truck q, slide upon the slanting projection r, on the connecting-rod o^1. These separate parts have to be arranged by a practical hand in such a manner that, when in the act of receiving the tuft of fibres, the carrying-comb advances in as near as possible a perpendicular position, close to the nipper mouth and takes off the tuft of fibres; then changing its straight form into a curved one, approaches the comb-ring A, upon which it deposits the fibres in nearly a horizontal position, withdrawing from there so as not to disturb the parallel position of the fibres, at the same time placing the fibre ends as far over the comb-ring as to fulfill the above named conditions. To regulate all these requirements and to arrange them for different lengths of fibres, the connecting-rod o^1, and the position of the bar p^1, are adjustable, and the two ends of the lever o^2 and o^3, are moveable in slots. The carrying-comb receives its motion from the crank-shaft o, driven from the nipper-shaft h^4, by two equal spur wheels, the latter being driven from the main shaft s, by the two wheels s^1 and s^2. The brush t, which serves to dab in the tuft of fibres into the teeth of the comb-ring A, receives its oscillating motion from the back screw-shaft K, by means of the lever b^1, the adjustable-bar b^2, the slotted lever b^3, and the eccentric-rod b^4. To avoid entangling and lapping over of the fibres of the tufts laid into the comb-ring, the projecting fringe is kept down by a current of air. The stroker D, is in the shape of an endless band covered with small transverse bars. The form of the drawing-off rollers E, the tunnel v, and the pressure or balling rollers w, w, are already well known and will be understood without further description. They are set in motion by wheels w^1 to w^5, for the lifting out of the noils, the noil knives x, are used, which working between the rows of teeth, raise up the noils and turn toward the noil-rollers F, (Fig. 259). Their lifting motion is produced by the rod x^1, the square lever x^2 and the eccentric x^3, the latter fixed upon the axis of the noil-rollers, which are driven by the wheels a^{14} and a^9. The tunnel v, is put in rotary motion by the band v^1, and the stroker D, by the band v^2.

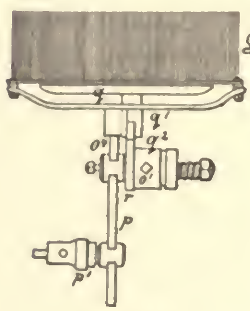


Fig. 262.

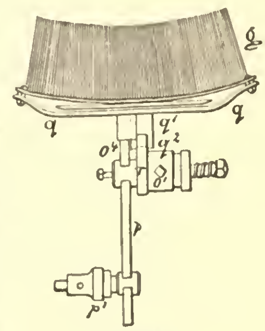


Fig. 263.

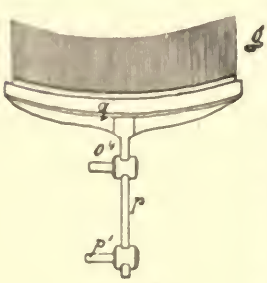


Fig. 264.

Fig. 265.

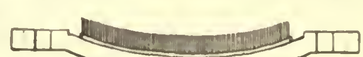
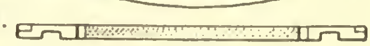


Fig. 266.



This carrying-comb, so far described, (with moveable points) is chiefly used for short and fine wools; for long wools a fixed curved shape, as shown in Fig. 264, is employed, which then necessitates the same curve in the other corresponding parts of the feed apparatus, the jaws of the nipper and the fallers. Figs. 265 and 266 show a faller in that shape.

Square-Motion Comb.—This is the invention of Isaac Holden. The first patent in which the square motion principle was brought forward was taken out in 1848 in S. C. Lister's name but it did not represent the full application of the principle and the successful working of it, the chief merit of the present machine belonging to later improvements. In this machine the material is carried in the form of two thick ribbons by a pair of feeding-rollers, to the main comb constructed on the circular principle. These feeding-rollers have a to and fro motion and almost touch the teeth of the comb, on which they distribute a portion of wool and then recede, drawing or combing the fibres out in the meantime. Such of the material as remains on the inner side of the comb is known as noils. Previously mentioned feeding-rollers continuously supply material to the comb, and a great many of the fibres hang loosely from the pins over its side or edge in which condition they are carried round until coming in contact with the square motion, consisting of a set of fallers constructed in an arc form to work within the convex of the comb. These fallers have a quick motion, and are thus rather frequently introduced into the wool, carrying every time they raise a portion of the fibrous fringe as formed on the edge of the comb. Any noils they may contain are removed by a small comb, which is inserted between the pins on their descending. The combings are then delivered to a series of drawing-off rollers which convey them from the machine.

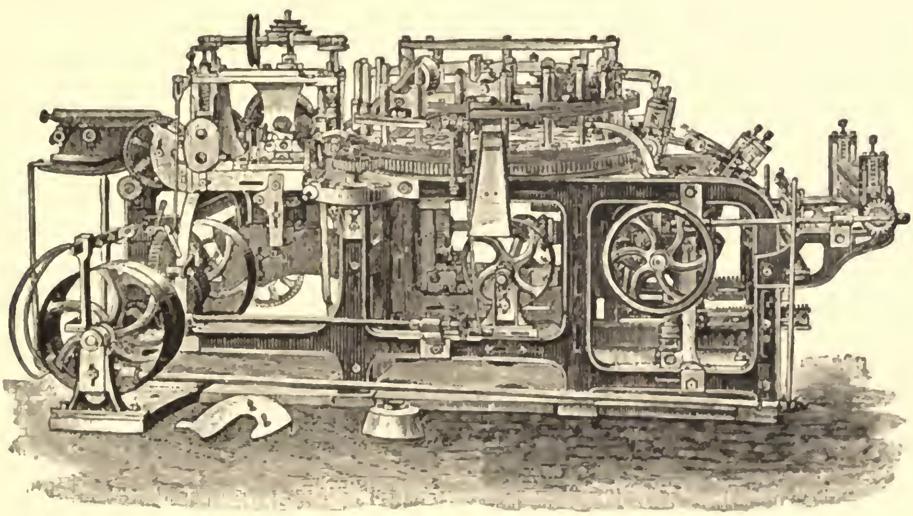


Fig. 267.

An illustration of a square-motion comb thus explained (illustrating an empty machine) is given in Fig. 267. Lohren makes the following remarks on this machine with reference to the feeding action and its effect on the sliver. As regards the feeding device in Holden's machine, it is constructed to the present day according to the manifold undervalued principle of Cartwright's which has often been declared to be the drawback of that system. It is in principle an imitation of filling-in by hand, and the objection against it is, that the comb which has filled in this manner cannot receive the fibre without entangling and knotting the ends, so as to retain them firmly. It cannot, however, be denied that this method of filling in possesses certain advantages appertaining to no other feed apparatus, the first and foremost being that it effects a perfectly regular feeding or filling-in without necessitating a very carefully condensed sliver, the material being capable of being used without so much previous preparing as is required by other kinds of feeding apparatus. All of the better class of combing machines require slivers which not only have to be well carded, but have also to pass through two or more gill-boxes to give them the regularity and parallel position of the fibres which are requisite for a good working effect. Every passage of the fibres through a gill-box, however, not only diminishes the strength of the fibre, but also causes extra waste and expense. Holden, with his great practical clear-sightedness, has so constructed his machine that he can not only use any kind of sliver, but even loose masses of fibre, and still effect a perfectly regular filling-in into the comb. This fact explains why materials can be combed by the square-motion comb which cannot be successfully combed on other makes, and can extract the long fibres from fibrous substances which others cannot work at all. However, there is one fact, this comb is not adapted for working long stapled wool, for if long fibres were to be dragged through the pins of the square-motion fallers, the power required would be very great, besides the fibres get seriously broken.

The Noble Comb.—This machine is the joint invention of G. E. Donisthorpe and James Noble. Noble having conceived the ingenious abstract principle of two circles working one inside the other was unable to design the *modus operandi* for it, hence consulted Donisthorpe, and it was the latter who

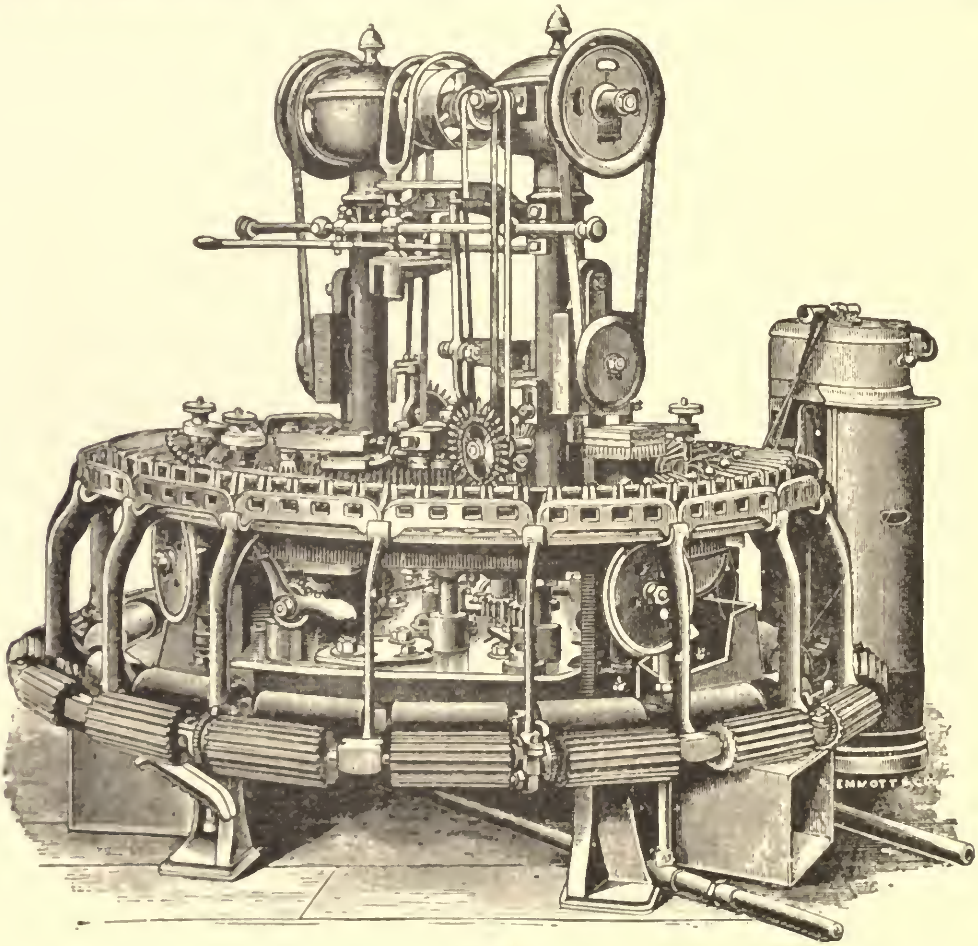


FIG. 268.

solved the problem. The patent was taken out in Noble's name since Donisthorpe was bound in honor to Lister (to whom he had sold his idea of the nip comb) to refrain from inventing different machines for wool combing.

The Noble Comb is the machine most frequently used in this country in worsted spinning mills and this with reference to wools of a short or medium staple; *i. e.*, for wools requiring previous carding, backwashing and gilling. The object of combing is to completely remove all flakes, specks or lumps, not removed by the carding engine, also any fibres too short (noils) for worsted yarn, and to thoroughly straighten the perfect fibres, or to lay them parallel to each other. To obtain this result the wool must be combed in both directions similar to holding some wool in one hand and combing it with the other by an ordinary comb. To comb the wool in question equally throughout, we must, after combing the fibres of the part extending outside the hand, reverse the procedure and take hold of the loose ends, as previously combed, and next comb out the end held in the hand. This object is derived automatically in the Noble comb by dabbing the wool on two circular shaped sets of pins (technically called combs, and which are of different sizes, one from forty-eight to sixty inches,

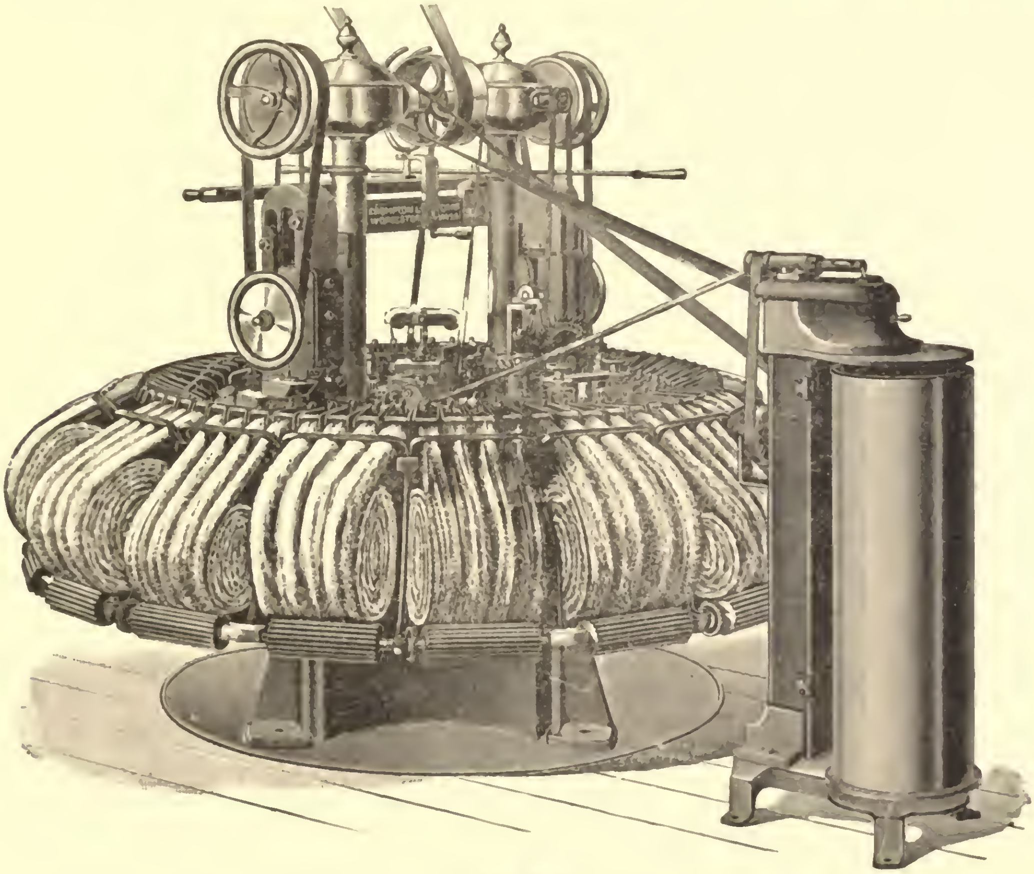


Fig. 269.

and the other from sixteen to twenty inches in diameter; the smaller comb working inside the ring of the larger one) at their place of contact, next parting these two sets of pins (in consequence of their circular shape) which will also separate the wool fibres (part adhering to each set), then drawing the wool out of each set of pins and finally uniting the fibres thus drawn out, producing in this manner what is technically known as the *combed-top*. The sets of pins are then stripped automatically of the short curly nappy fibres imbedded below the working surface (which are known as noils).

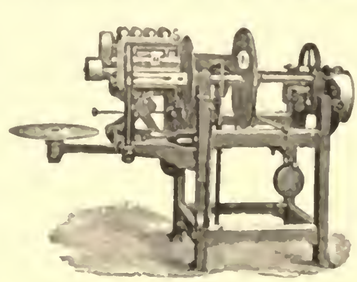


Fig. 270.

Diagrams Figs. 268 and 269 illustrate two perspective views of this comb. Fig. 268 shows the empty machine as built by Taylor, Wordsworth & Co.; Fig. 269 shows the comb as built by the Crompton Loom Works, known in the market as the *Crompton Noble Comb*, filled with slivers of wool, ready for work.

As will be seen by the latter illustration, the slivers are wound onto bobbins, which are placed in the circular rack surrounding the centre of the machine. These balls are made on a special balling machine, of which an illustration is given in Fig. 270, in the following manner: Four full sliver cans are placed behind the machine and the ends, one from each can, passed through the corresponding four guide rings *c*, next through the rollers in front and onto a bobbin which lies horizontally on a spindle at *a*, and is held tight between two plates. The machine is operated by means of friction wheel *b*, producing quite hard balls without imparting any twist, so that when transferred to the creels or racks of the combing machine they permit a ready unwinding. After placing these balls (18 in number) in the creel, their ends are passed through the feed-boxes situated above, made of brass, with a heavy lid, which act as tension to the sliver, preventing at the same time a slipping back of the sliver when closed. These feed-boxes are arranged all around and above the creel in a number (72) to correspond to the number of sliver ends (18 balls $\times$ 4 slivers each = 72) fed in the machine. Nearest to the delivery ends of the feed-boxes is a large circle from 48 to 60 inches diameter, containing around the circumference six or more (according to the grade of wool to be combed) perpendicular rows of sharp needles or pins. This circle and also creel and boxes rotate in unison from right to left. Below the circle is placed a circular stationary steam chest, and inside of the circle revolving in the same direction, and nearly in contact with it are two small circles, from sixteen to twenty inches in diameter, each one containing five or more rows of needles (according to the grade of wool to be combed). These two small circles are on opposite sides of the interior of the large circle (as shown in diagram Fig. 271) and as their action with reference to the large circle is identical only one need be described. As previously mentioned, these three circles of pins of the combing machine all move in the same direction; the small circles almost touch the main circle at one place, but by means of revolving separate from the latter, this being the principle of combing. The carded and gilled, or only gilled material, as the case may be, is by means of, previously referred to, feed-boxes brought to the point of contact of the two circles, being constantly pulled through the boxes so as to extend over and beyond the large circle, thus projecting with its ends over the small circle. When in this position a dabbing brush (of which an explanation in detail is given later) running at a high rate of speed, up to a thousand dabs per minute if required, falls on the fibres pressing the same down into the pins of both of the circles. By means of revolving (as previously mentioned) the little circle will draw from the large circle as many of the fibres (of such as have been pressed in by the dabbing brush) as it is able to retain in its pins. Since only the ends of the slivers as fed in the machine project in the small circle such of the fibres as are retained by the same are the shorter fibres, whereas the long fibres extend outside or project from the main circle. Both beards of the fibres extending outside of their respective circles have by the action thus far explained been thoroughly cleaned as well as straightened; *i. e.*, drawing off the ends of fibres belonging to the large circle through the pins of the small circle into which they have been overlapped and vice versa, the ends of fibres belonging to the small circle through the pins of the large circle. Any noils (very short fibres) as either beard originally contained will have remained in the pins of the circle by which the respective beard has been straightened. The next procedure is to draw the combed fibres out of their respective circles of pins, as well as to clear each circle of the noils, which is accomplished for each circle by a different device. The fibres extending from the small circle (which as previously mentioned are shorter compared to those of the large or main circle, yet sufficiently long to be used in the combed wool) are in turn met by the stroker or licker-in (being a wheel with sharp teeth projecting from it, and screwed on to it, which can be moved together and set at any required angle) which revolves very rapidly from left to right, and strikes the projecting fibres so as to turn the ends, which have been until now standing out, forward. After passing the stroker, the beard is met by a small pair of vertical drawing-off rollers, which catch all that projects, and draw it out, the pins of the circle at the same time combing (straightening and cleaning from noils and any other impurities) those fibres. The noils remaining in the pins are in turn lifted out of the circles by knives set between the rows of pins, and when brought on the surface by means of said lifting knives

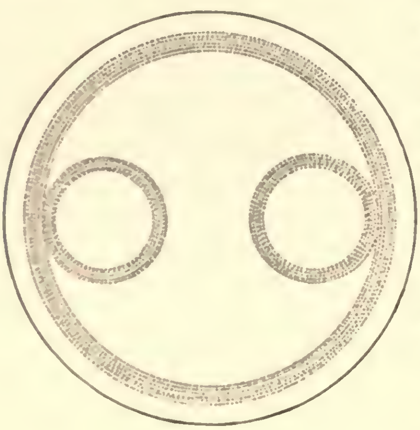


Fig. 271.

tumble over into a can placed below the device for receiving the same. The large circle is cleaned by the following device: Its beard after being cleaned and straightened by the small circle soon comes into contact with a traveling leather apron, which goes quickly, drawing the points of the wool forward, hence acting in a similar capacity as the stroker to the small circle. The drawing-off-rollers are next approached and the leather passes around one of them. These draw off all the wool they can catch, and passes the same along between another part of the first leather and a second leather until meeting and uniting itself with the short wool sliver as drawn off from the small circle. As there are two small circles in the machine, and as the second acts similar to the one explained, there are thus two slivers composed of shorter fibres and two of long fibres, all of which unite, pass up a steel funnel, which puts in them a slight (false) twist. From there they pass through a trumpet and next to a revolving sliver can set outside the machine to receive them. This method is far superior to the old-fashioned style (and yet found in some makes) of passing the slivers through a pair of press-rollers into a long brass funnel and from there to the sliver-can, since by the modern arrangement the so greatly valued parallel position of the fibres (and this with as little as possible twist) in the sliver is preserved, hence less work and waste in the drawing process. If required the large circle slivers and the small circle slivers can be made to deliver into two separate cans. The modern build of Noble comb is also provided with a stop motion, which prevents laps on the drawing-off rollers, thus saving damage to combs, and also stops the machine when an end breaks.

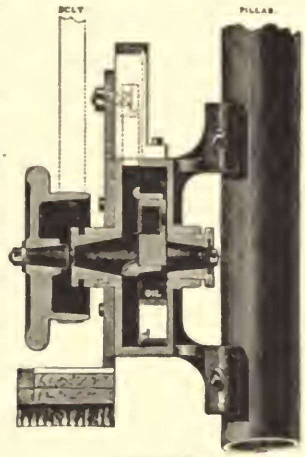


FIG. 272.

Dabbing Brush.—The method of operation of the dabbing brushes in a combing machine has always been a difficulty, for unless the said brushes move very rapidly up and down, some of the wool will not be dabbed down just exactly at the point of contact between the two circles. But if the motion should be too quick, the brush cannot rise sufficiently high and then the wool gets ruffled and rubbed sideways during its passage below the brush.

An illustration of the dabbing brush (as built by Taylor, Wordsworth & Co.) is shown in Fig. 272, and which contains Lister's self-lubricating dabbing motion (shown in section) for its modus operandi. By its application the brushes can run up to a thousand dabs per minute if required, securing also a perfect pressing of the fibres in the pins of the circles. As the name implies, it is self-oiling, and when once charged with half a gallon of oil, will run a week without being touched again, and with a waste of only four drams.

Regarding the dabbing motion of the Crompton Noble Comb, the builders of this machine make the following statement: The Crompton Noble Comb is fitted with the latest-improved, high-speed, single-dabbing motion, and when desired it is supplied with the double-dabbing motion, as shown in illustration Fig. 269. This double-dabbing motion has demonstrated a marked saving in the wear and tear of the brushes as compared with the single-dabbing motion. A successful modification of the Noble Comb thus far explained is the

1888 Comb.—The same is built by the Crompton Loom Works, and is shown in its perspective view in Fig. 273. In its principle of operation the same resembles the comb from which it has been modelled; hence an explanation in detail of the modus operandi is unnecessary. Amongst different features of value to the manufacturer, we find: The new comb has only one dabbing motion, no upright pillars, drawing pulleys, shafts, etc., to obstruct the view of the attendant; in fact, she can stand at any one point and keep her eyes on all the wool boxes, consequently watch the feeding of the comb very readily. Doing away with these upright pillars, drawing pulleys, shafts, etc., greatly decreases the vibration of the machine by having the centre of gravity nearer the floor. Having a steadier running machine to deal with, we consequently can increase speed and in turn production.

The dabbing motion of this comb is of the double or duplex type, capable of high speed, and clearing itself very freely.

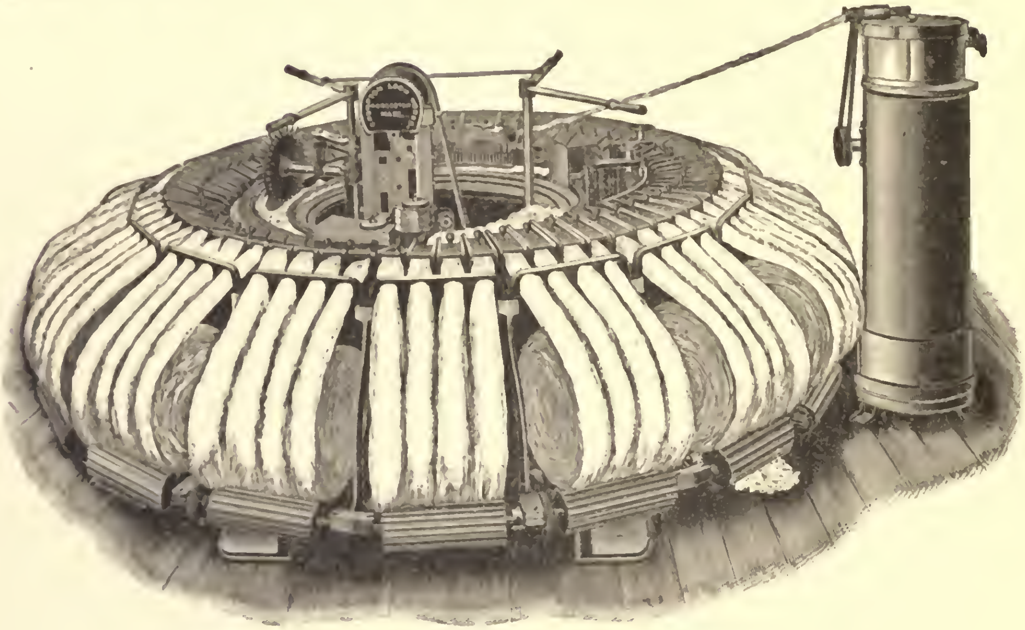


FIG. 273.

Little and Eastwood's Comb.—An illustration of this machine, as built by Platt Bros., is given in Fig. 274. In this comb the prepared or gilled wool, in the shape of 3 laps,

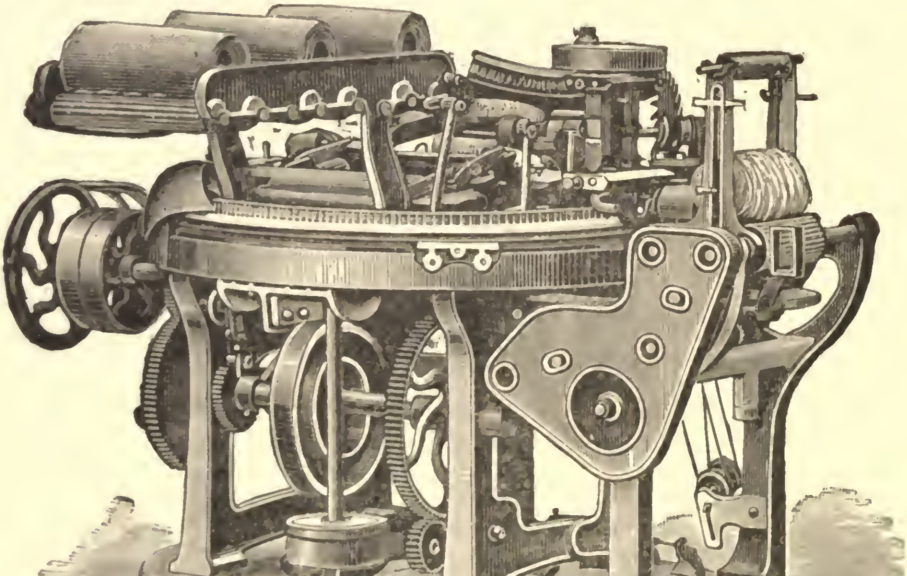


FIG 274.

is fed onto the fallers by a pair of rollers having an intermittent motion. It is drawn by the jaws of the nip cylinder through the pins of the fallers, and deposited by it on the teeth of the circle. The method of the operation of this cylinder is such that it places the wool on the comb with the uncombed ends behind the pins, while the combed wool hangs on the outer edge of the circle. The drawing-off rollers come next into action, and by drawing the fibres through the pins straighten the ends not combed between the nip cylinder and the fallers. The short fibres (noils) remain in the comb and are removed by stripper knives. In this machine the circle receives the wool with one end already combed, as hanging over its outer edge, hence less friction is occasioned in drawing the wool out of the comb than if all the fibres were combed between the pins, consequently less power is required to drive it, and less strain put upon the pins in combing the long fibres through them

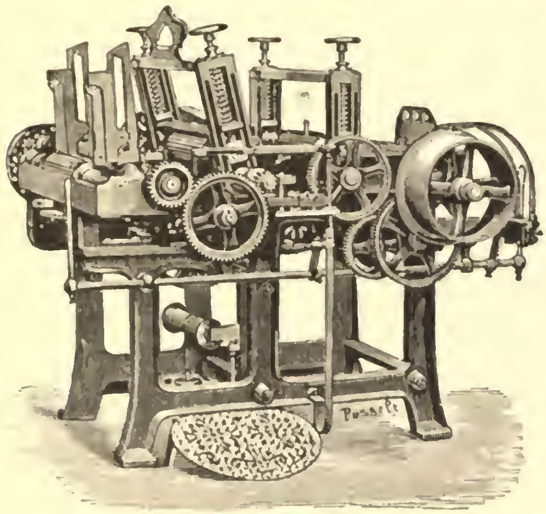


Fig. 275.

Balling or Top Making.—The slivers produced by either system of combing are next put up at the back of a *can-finisher* to further straighten out its fibres. The slivers when leaving the machine collect together again in sliver cans, which are then put up at the back of a *balling-finisher*, as shown in Fig. 275. The same is, as the illustration clearly shows, nothing but a common gill-box, in which the sliver, after its passage through the machine, is wound on a ball (instead of run in a can) by a suitable attachment in front. This ball device has an oscillating movement (constantly passing from side to side), hence the ball is produced by the sliver passing constantly from one side to the other and returning.

In some mills the combed sliver is wound directly onto large bobbins in place of these balls, which process results in keeping them smoother.

Drawing.—The principle of this process is the same as the corresponding procedure for cotton yarns; *i. e.*, combining several slivers, and extenuating them, repeating it several times, until a fine sliver is produced (roving), which when twisted will produce a thread of a certain required count.

There are three different systems of drawing for the manufacture of worsted yarns in use—open drawing, cone drawing and French drawing. Open drawing is used for long and short materials (according to style and build of machines), whereas the cone and French drawing methods refer to short or medium stapled material. The extenuating of the slivers as required for drawing is in all three methods accomplished by means of passing the sliver between two pair of rollers placed some distance apart from each other. The first pair of rollers, feeding-rollers, or back-rollers, revolve slowly, drawing the slivers of loose wool in between each other and feeding the same to the second pair of rollers, drawing rollers or front rollers, which revolve quickly and draw the wool out. This procedure is, as already previously indicated, repeated several times, until roving is produced by the action of the front rollers. The principle of drawing has been thoroughly explained and illustrated in the chapter on Cotton, pages 48 and 49.

Open Drawing.—The balls produced in the balling finisher are next put up in the rear of a *can gill-box* of which we give an illustration in Fig. 276. The same is a double machine, that is, the fallers are divided as shown in special illustration Fig. 277. The sliver-can (not shown in our illustration) is also divided up in the middle and all the rollers etc. are in double sets. Usually from five to six balls (equal number of ends fed in) are put up for each set of the box, which are thus combined and elongated in a single sliver of the dimensions of one of the minor slivers fed in. They are fed in at the back rollers *A*, travel forward in the fallers (one of which is shown in Fig. 277), next are drawn out by the front rollers *B*, and in turn pass through the press-rollers *C*, into the can. The top rollers *D*, are for the purpose of conducting leather aprons around it and round the upper roller of the front roller (*B*) set. The machine with which the sliver next comes in contact is known as the *two-spindle gill-box*, of which an illustration is given in Fig. 278. The same is a duplicate of the previously explained machine, the only difference being that the slivers as drawn through both pair of rollers are wound onto large bobbins, of about fourteen by nine inches inside measurement. The difference between the two latter explained gill-boxes and the

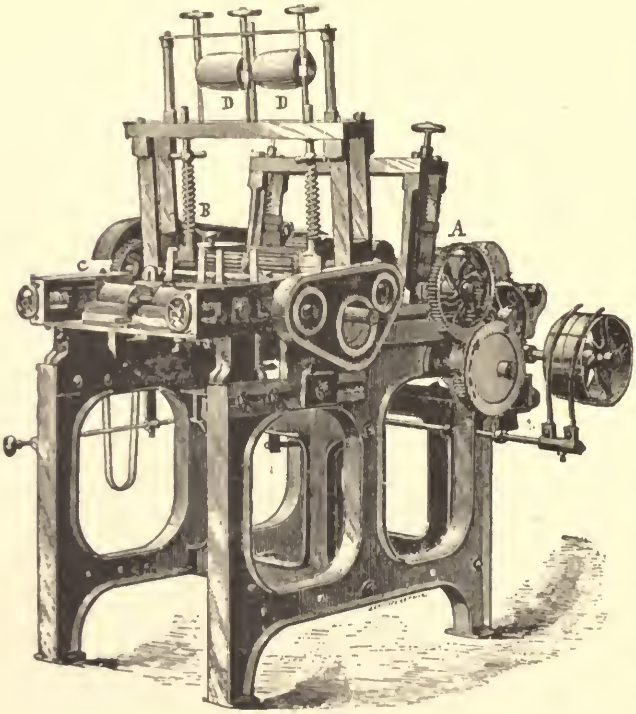


Fig. 276.


Fig. 277

gill-boxes explained when dealing with the preparing set, consists, that in the can gill-box and the two-spindle gill-box, there must be no draft between the fallers and back rollers, for otherwise the ends would not be so even. When the slivers are wound round the bobbins, a small amount of twist (about a fraction of a turn per inch being sufficient) is put in by the flyer, regulated by the speed of the flyer-spindle, relatively to the speed of the front rollers, since the faster these front rollers deliver the end of the sliver, the less twist can the flyer-spindles, at any given speed put into it. The flyer-spindles receive motion by belts round pulleys *A*, from pulleys *B*, as fastened to shaft *C*. A special illustration of a faller used in a two-spindle gill-box, is given in Fig. 279. The *slubbing*, as the sliver is now called, is next delivered to the drawing-frames, also called *open drawing-boxes*, and of


Fig. 279.

which there are generally three machines used in succession. Since their method of operation is very similar we will explain them as briefly as possible. Five bobbins from the two-spindle gill-box are put up in the creel at the back of each spindle, the third box (or the *first drawing-frame*), and the five ends are united and elongated into one end rather thinner than any one of the minor ends. Four of these slivers thus doubled and drawn out, are next put up per spindle at the fourth box (or the *second drawing-frame*), united and elongated into one end still thinner. Four of these are next taken and put

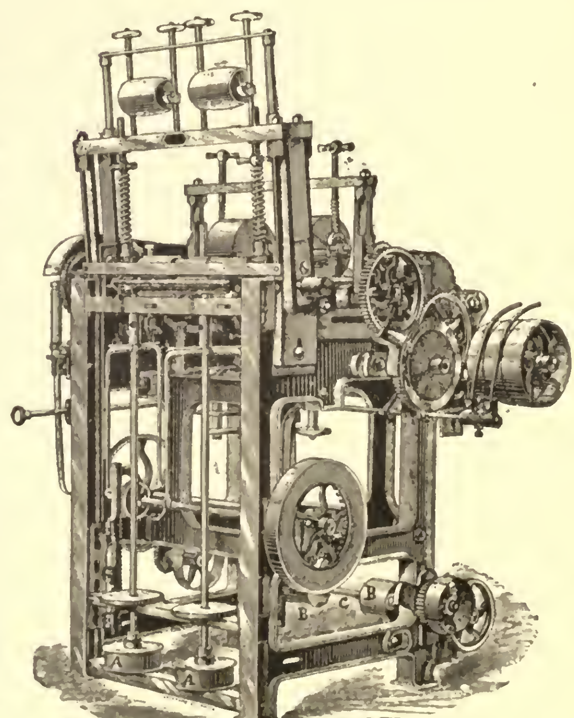


Fig. 278.

up per spindle at the fifth box (or *finisher drawing-frame*), united and elongated into one still thinner end. Of these, two ends are put up per spindle into the *roving-frame* producing in turn the sliver ready for spinning and technically known as *roving*. All these drawing-frames differ from the can gill-box and the two-spindle gill-box in having neither screws nor fallers, but only two pair of rollers (back and front) with two rows of carrier-rollers in between, which steady the material during the procedure; they run somewhat faster than the back rollers but have no relation to the draft. The fourth box (second drawing-frame) is also called the *weigh-box*, since there the weighing of the sliver is done more accurately (automatically) compared to either of the previous machines. An illustration of a *six-spindle drawing-frame* is given in Fig. 280. As already previously mentioned, the bobbins are taken from the finisher drawing-frame to the roving machines and the two ends united and elongated into one, the same as is done in the drawing-frames. An illustration of such a roving machine (also called *rover*) is given in Fig 281. These roving machines are built with up to thirty spindles, according to requirements.

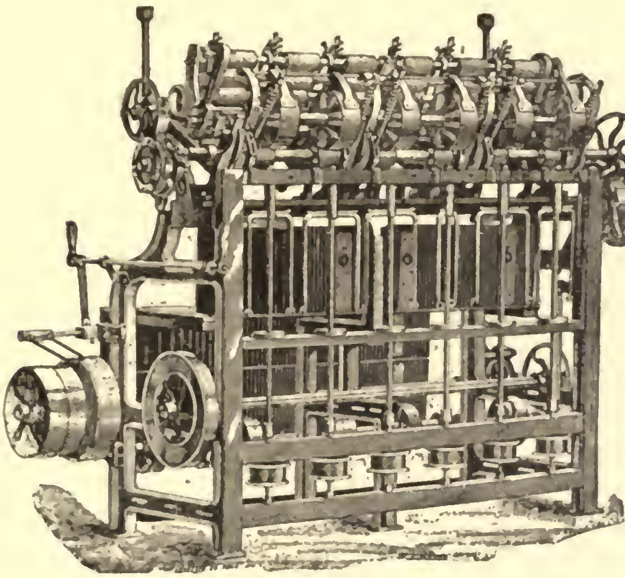


FIG. 280.

The number of drawing-frames to use depends greatly on the stock and the counts of yarns to spin since more operations will be required for fine counts, 60's or more, compared to the previously given arrangement. If spinning such fine counts, drawing without doubling (called reducing), must be added since for such high counts of yarn the roving must be correspondingly fine. Such a set as built by the well-known machine builders Prince, Smith & Son, Keightley, Eng., for such fine yarns consists of: *a*, 2 double-can gill-boxes; *b*, 2 two-spindle gill-boxes; *c*, 1 four-spindle drawing-frame; *d*, 1 six-spindle (weigh-box) drawing-frame; *e*, 1 eight spindle drawing-frame; *f*, 2 eight spindle drawing-frames; *g*, 2 twenty-four spindle (finishers) drawing-frames; *h*, 3 thirty-spindle reducers (elongating but not doubling); *i*, 9 thirty-spindle roving-frames.

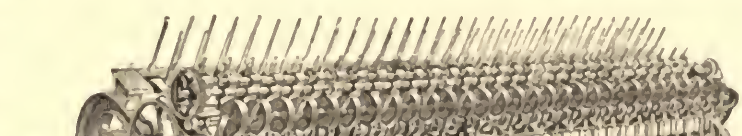


FIG. 281.

For certain kinds of low grade wools as carpet yarns etc., the gill-boxes may be dispensed with and the drawing-frames used direct; however, some spinners use to support the wool, porcupine-rollers in place of the bottom carrier (the same as in French drawing).

Cone Drawing.—The only difference between open and cone drawing consists in the method of changing the speed of the bobbins as they get gradually fuller in dimensions; the bobbin is made to revolve at an increasing rate of speed as it becomes fuller entirely independent of the flyer which never drags it at all. The device by which the speed of the bobbins is regulated is known as the *differential motion*, which has been explained and illustrated in detail in the chapter on Cotton Spinning, hence no special reference will be necessary. In cone drawing there is no drag on the sliver as it comes from the rollers, thus the same can be wound onto the bobbins in the softest state possible, permitting an easier and more perfect drawing of the sliver.

French Drawing.—The principle of French drawing is to put no twist into the slubbing or roving, thus keeping the fibres as straight and parallel to each other as possible. This procedure requires different machinery from that used for the English drawing system (open and cone drawing). The balls or tops made on the comb are mixed in the usual way, in a can gill-box (see Fig. 276). The cans of sliver produced are next put up, two ends together, in the rear of the first drawing-frame, the ends are fed into the back rollers, and in turn passed between the front or drawing rollers which draw them out. Between both rollers is a porcupine-roller (revolving the least bit quicker than the back rollers) over which the sliver passes, *i. e.*, being drawn through its pins. This porcupine-roller acts only as a carrier for supporting the wool between the back and front rollers and prevents the yarn from getting twitty by holding the slivers when the front rollers are drawing. The drawn out sliver when leaving the front or drawing-rollers, is next passed between two rubbing leathers, similar to those used for condensers of the roving in woolen carding, which rub all its fibres together, without putting any twist into it, hence in this system of drawing, a round sliver is produced, compared to the flat or open sliver produced by the English system. The round slivers produced by the condensers of the French drawing-frame are next passed through a guide-wire and wound onto a horizontally placed wooden bobbin traveling at a good speed end-ways, thus causing the end to keep crossing backwards and forwards.

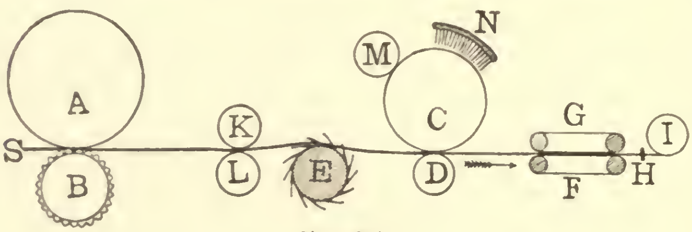


Fig. 282

This principle of doubling and elongating the slivers is repeated successively in three or more machines being nothing but a repetition of the previously explained drawing-frame. Every succeeding operation still further reduces the sliver in thickness. To illustrate this method of drawing, Fig. 282 is given. Letters of reference in illustration indicate as follows: *A*, *B*, back-rollers; *C*, *D*, front or drawing-rollers; *E*, porcupine-roller; *F*, *G*, condenser; *H*, guide-wire; *I*, bobbin; *K*, *L*, carrier-rollers. Examining illustration we find that the upper situated roller in both, the back and front roller set (*A* and *C*) have a larger diameter compared to their companion rollers (*B* and *D*). The work to be performed by rollers *A* and *B*, consists in pressing the sliver *S*, to permit its drawing out by means of the front or drawing-rollers *C*, *D*, respectively, by the porcupine-roller *E*. Roller *A*, will act as a press roller by means of its own weight and in order to insure perfect work (pressing of the sliver) roller *B*, is fluted. Rollers *C*, *D*, are both smooth and covered with parchment paper. The pressure of roller *C*, gets increased by means of weights or springs. The small roller *M*, has for its object to apply the loose paper cover to the roller *C*, and brush *N*, is placed there for the purpose to keep roller *C* constantly clean. To give a clear understanding of the workings of the back, porcupine and front rollers (leveling or straightening fibres) illustration Fig. 283 is given. In the same: *A*, represents the feeding or

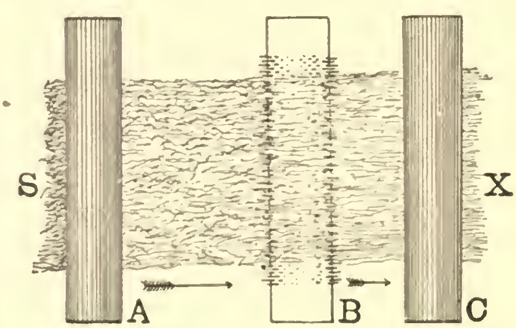


Fig. 283.

back-rollers ; *C*, front or drawing-rollers with *B*, the porcupine-roller ; *S*, the sliver as fed to the back-rollers, and *X*, the sliver as leaving the front-rollers after having been subjected to the action of the porcupine-roller *B*. Fig. 284 illustrates a drawing-frame built by Platt Bros. After leaving the finisher drawing-frame, the now greatly reduced sliver is submitted to the action of the roving frame, which machine continues the work of doubling and elongating the slivers, except that the bobbins are filled more slowly and evenly, and this with a fine sliver now called roving.

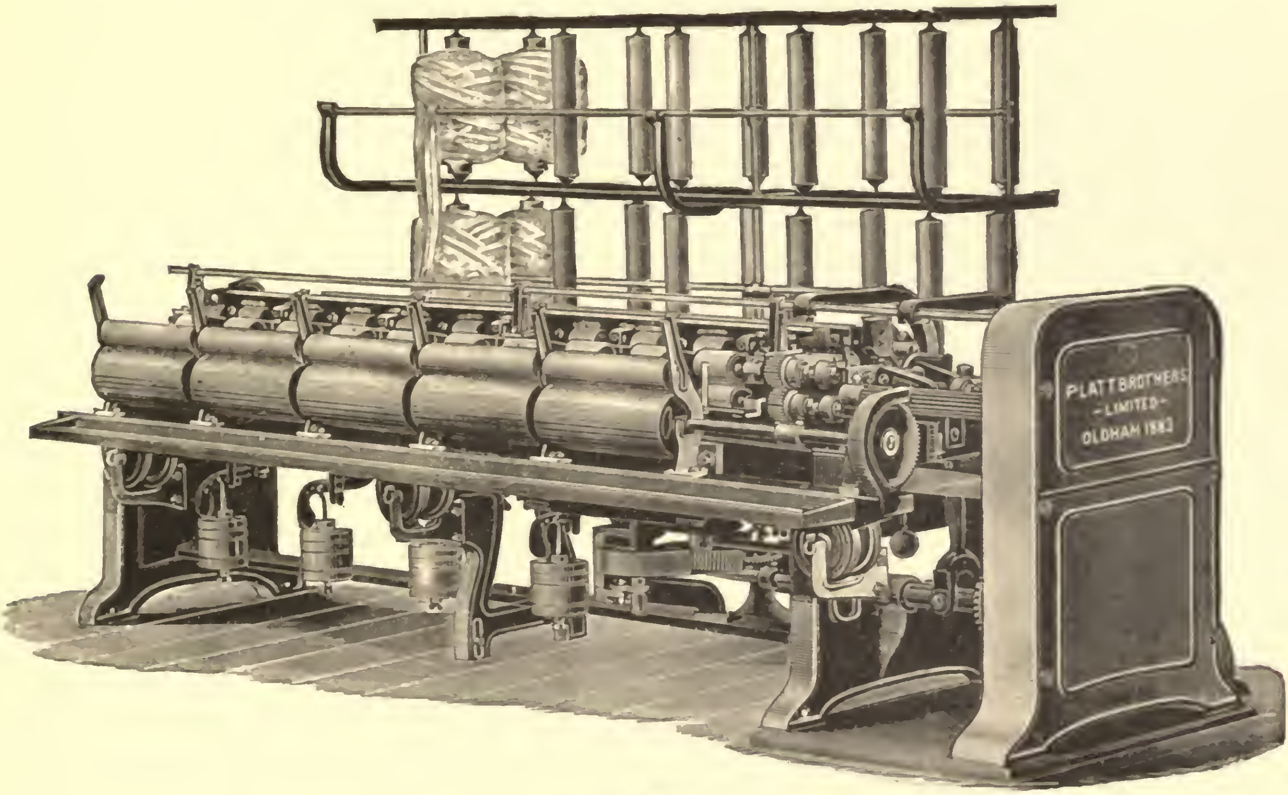


Fig. 284

The Set of French Drawing Machinery, built by Platt Bros., as exhibited at the Royal Jubilee Exhibition in Manchester, is explained by this firm as follows: After the material is combed (Little and Eastwood's comb) it is run through a screw-gill balling machine, consisting of one head of two deliveries to make two balls for the next process.

First Drawing-Frame.—With four boxes, eight porcupines and four bobbins, fourteen-inch traverse doubling two ends into one. The slivers or balls are taken from the last process, and in this machine are doubled two into one with a draft of about four. The two slivers to be doubled pass first through the taking-in rollers, then over a porcupine-roller, and through a pair of front-rollers, which, running faster than the surface velocity of the porcupine-rollers, causes the fibre to be straightened whilst being drawn through the teeth of the latter, and after passing between the rubbers, without putting any twist in it, forms it into a round sliver and carries it forward and delivers it to the bobbin, which is driven by surface contact with a calender or surface-roller.

Second Drawing-Frame.—With four boxes, eight porcupines and four bobbins, fourteen-inch traverse doubling two into one, being a repetition of the first drawing-frame ; the sliver by the operation of this machine is still further reduced in thickness.

The Slubbing-Frame.—Contains four boxes, eight porcupines and eight bobbins, seven inch traverse doubling two or four into one constructed like the drawing-frame, but the sliver is again still further reduced in thickness.

The Roving-Frame.—Contains four boxes, eight porcupines and eight bobbins, seven inch traverse, doubling two to four into one. This machine finishes the drawing process under the French system, the bobbin from this machine being ready for being spun on the mule.

Spinning.—The spinning machinery for worsted, closely resembles the spinning machines used for cotton yarn, of which a detailed description with numerous illustrations is given in that chapter. Four distinct machines for worsted spinning are more or less in use: 1st, the flyer spinning-frame; 2d, the cap spinning-frame; 3d, the ring spinning-frame; 4th, the mule.

Flyer-Spinning.—This system of spinning, as well as the others, may be divided into three parts: *a*, the elongating of the roving; *b*, the putting in of the twist; *c*, the winding. To illustrate these three motions in connection with the fly spinning system, diagram Fig. 285 is given. Each bobbin, containing roving, is placed on a pin *A*, in the creel *B*; next the end of each bobbin is passed between the pairs of rollers *C*, *D*, *E*, *F* and *G*, from where it is guided on to the bobbin *H*, passing previously around one of the legs of the flyer *I*. The elongating of the sliver is done between the feeding or back rollers *C*, and the drawing or front rollers *G*, by means of having the latter pair revolve more quickly than the first, hence drawing out the roving in its length in proportion to the difference in surface-speed between these two pair of rollers. The lower roller of the front roller set *G*, is furrowed and its diameter regulates the amount of draft; the upper roller is simply a presser-roller, being a wooden boss covered with leather and rotating by friction. The three small pairs of rollers *D*, *E*, *F*, as situated between the two large pairs, or working rollers, are simply carriers for conveying the roving from *A* to *G*. When the thus elongated sliver of roving leaves the front-roller set *G*, it is twisted once or twice around one of the legs of the flyer *I*, passed through a twizzle at its lower end, and then wound round the bobbin *H*, as placed on the spindle *K*. The flyer is screwed to the spindle at the centre of the cross-piece. The bobbin travels up and down on a lifter-plate (carriage) *L*, by the action of a heart shaped piece of iron (heart-motion) and a series of chains and pulleys. The shape of the bobbin as required regulates the shape of this heart. The spindles themselves (see whirl *O*, fastened to the spindle) are driven by spindle bands *M*, from a cylinder or drum *N*, the latter extending throughout the length of the machine. The flyer is the medium for keeping the thread at one regular tension, imparting the twist to the yarn and winding the yarn on the bobbin. The yarn spun by this flyer spinning-frame (which is the oldest system of machine spinning, and invented by Richard Arkwright) is very strong and smooth, and most suitable for low counts of yarns (below 30's). The amount of twist put in the yarn depends on the respective speed of the bobbin and the flyer.

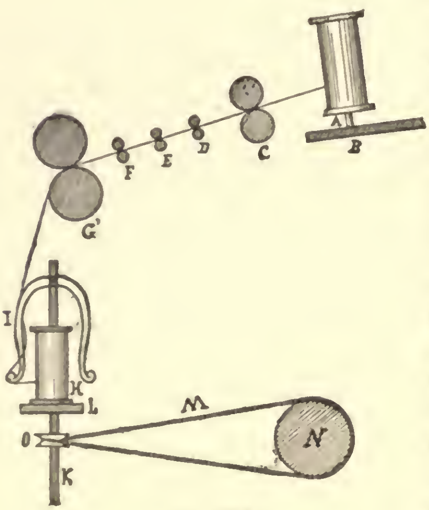


Fig. 285.

Cap-Spinning.—The principle of cap-spinning is quite different from the previously explained system, and is used for spinning finer counts (of from 30's to 40's, or thereabouts) of yarns. An illustration of the *cap-frame* is given in Fig. 286. As already mentioned when explaining the fly-frame, the elongating or drawing out of the roving is identical for fly and cap-spinning, and hence consists of the feeding and the drawing-rollers as well as the carriers. This will leave us only the explanation of the *modus operandi* for imparting the twist and the winding of the thread on the bobbin. To illustrate these two points, Fig. 287 is given. The spindle *A*, and the cap *B*, have no rotary motion. The spindles do not reach to the bottom rail, as is the case in the fly frame, the cap as placed upon them is a steel cup, shaped like a bobbin, but rather larger, to permit the bobbin to enter even when filled

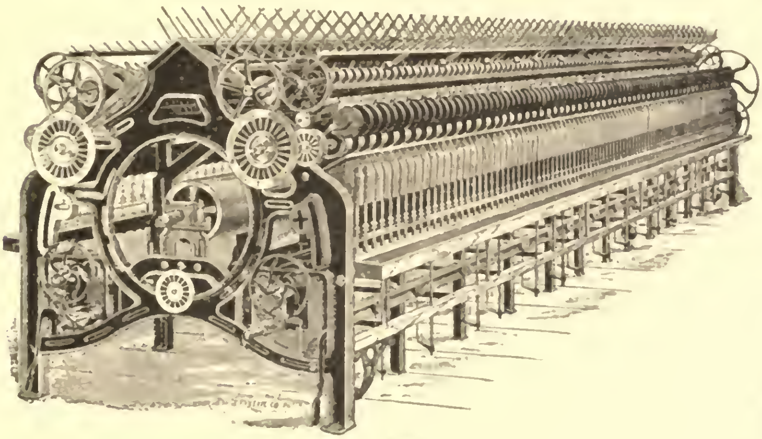


Fig. 286.

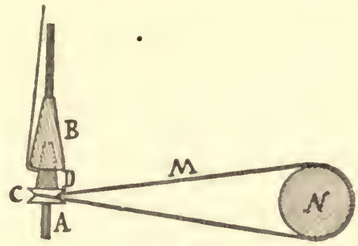


Fig. 287.

with yarn. Its lower rim is perfectly smooth (polished) so as to reduce the friction of the thread whirling against it to the lowest possible minimum. These caps remain on the frame when spinning, but must be taken off when doffing. On the spindle *A*, is placed the rotary part, consisting of a small tube or shell *D*, to which is attached the whirl *C*. The shell *D*, receives motion from the drum or cylinder *N*, (as extending from end to end throughout the machine) by means of driving bands *M*, in a corresponding manner to the spindle in a fly-frame. The shell in turn imparts its motion to the bobbin, to which an up and down motion is given (so as to distribute the yarn regularly on its circumference) by means of the whirl resting on the carriage or lifter rail of the machine. The difference between fly and cap spinning is simply this: In the former the flyer revolves around the bobbin, thus imparting twist, whereas in the latter system, we find the bobbin revolving around the spindle and inside the cap, hence imparting the twist itself. The number of times the bobbin revolves during the time the front-rollers deliver one inch of roving regulates the amount of twist (turns) per inch. To prevent the ends from flying into each other when ballooning, separators (tin shields) are placed between the bobbins.

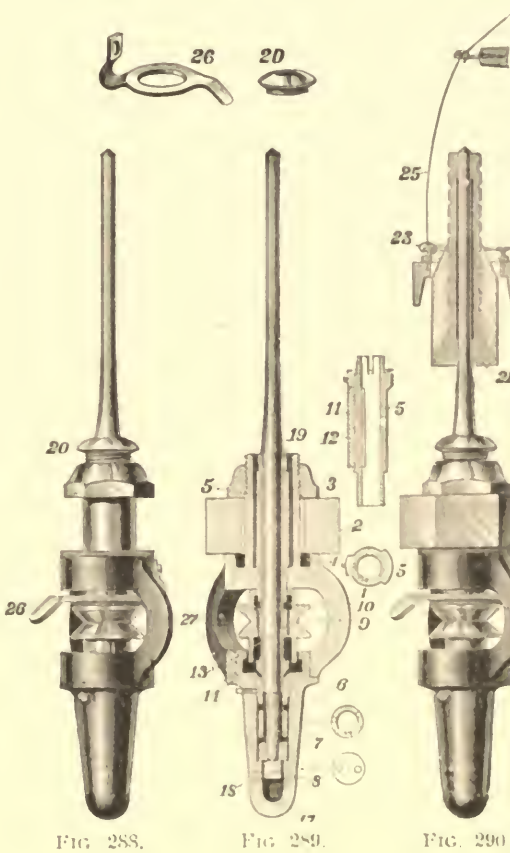


Fig. 288. Fig. 289. Fig. 290.

Ring Spinning.—The principle of this method of spinning has been thoroughly explained and illustrated in the cotton chapter, hence a special reference to it is unnecessary. It is used with success both for spinning and twisting worsted. Mention has been also made on pages 61, 62 and 63 of some of the most prominent spindles as used in connection with ring spinning. Lately a new spindle, known as the *Bates' Spindle*, has come in the market, of which an illustration is given in Figs. 288, 289 and 290.

Fig. 288 is an elevation, showing all the parts in working order. Fig. 289 shows all except the steel spindle itself in section. Fig. 290 shows the spindle and all parts belonging to it in elevation, and the bobbin, ring and ring traveler in sectional view, also showing guide and thread, thus illustrating the entire procedure of ring spinning.

The spindle is supported in a holder attached by a retaining nut to the bolster rail of the spinning frame. The whirl driving the spindle is below the bolster rail. The spindle has two bearings, one above and one below the driving whirl. The band driving the spindle has, therefore, the resistance equally divided between the upper and lower bearings. The holder is separable at the lower extremity of the yoke, and thus enables the spindle to be removed and replaced at pleasure, without disturbing the adjustment of the bolster bearing.

The spindle proper has an egg-shaped or parabolic foot which rests and revolves upon a flat, hardened disc. The foot is not confined, so that there can be no binding or friction by reason of want of alignment with the upper bearings. In the upper part of the yoke there is an annular chamber for holding oil. A wick feeds this oil by capillary attraction to the upper part of the bearing. The lower part of the support has ample space for a store of oil. Below the disc, upon which the spindle revolves, there is a chamber into which the sediment from the oil can collect, and from which it may be removed occasionally.

A description of the construction of the spindle, with reference to letters of reference in illustration is as follows :

The spindle support consists of an upper section (1), which fits from below through an opening in the single rail (2) of the machine frame, resting with a shoulder against the under side of the rail, being drawn up and held in position by a nut (3) upon the upper part. An oil receptacle (4) is formed around the central portion of the upper part of the bearing, within the shoulder, which receives an absorbent packing, and is in fluid communication with an oil-space in the central cavity, containing the upper bush or bearing (5). A lower section (6) is screwed into the bottom of the upper section, containing the lower bush or bearing (7) and the bottom or end-bearing (8) and an oil receptacle. In the upper section (1), which is bored out concentrically with the screw and shoulder already referred to, is inserted the upper bushing or sleeve (5), extending downwardly into a chamber (10) formed in the upper side of the whirl (9). A steel plate (11) is inserted in the bushing (5) on the side receiving the draft of the driving-band, with a wooden strip (12) laid under it. The whirl (9) has apertures (13) made through it, reaching from the upper cavity (10) into the lower cavity, through which oil can descend but cannot be whirled off by reason of the lower rim (14) of the whirl extending into a chamber formed in the lower part of the support. A bushing (7) removably fitted into the lower part of the support serves to centre the lower end and a hardened steel plate (8), beneath the spindle, supports the weight. The bushings (5) and (7), which form the bearings, are not made with continuous outer surfaces to fit in the casing portions of the support, but are fluted or grooved so as to provide oil channels (15) and (16) and chambers between the bushing and the casings.

Below the hardened steel bearing (8) there is a cavity (17), into which any foreign substances in the oil can subside without injury to the bearing. A cap (20), fitted loosely around the spindle (19) at the top of the bearing (1) serves to exclude dust, and is easily raised by the spout of the oiler. An oil-chamber (4) is formed around the bearing, which being filled with an absorbent, saturated with oil, insures continuous lubrication for a long time.

The portion of the bearing surrounding the whirl is formed with curved pillars and intervening open spaces so as to permit easy access to the whirl for the driving-band, and to afford opportunity for inspection.

An elastic plate of metal (26), secured by a screw to the upper part of the bearing at the rear, and extending across the upper surface of the whirl, with a projecting ear at the front, acts as a break when pressed against the whirl, so that the motion of any spindle can be arrested without affecting that of any other.

Mule.—The mule is the modus operandi for imparting twist into roving produced by French drawing. The worsted mule differs in its action from the woolen mule, where only a single pair of rollers (delivery-rollers) for delivering the roving from the roving-spools are used, but closely resembles the cotton mule. The elongating of the roving is produced in the same way as explained for the fly-frame, viz., feeding-rollers, carriers and front-rollers, but being placed horizontally in the mule compared to the oblique position in the fly-frame. The twist (by means of the spindles) is put in the yarn during the time the rollers deliver the elongated roving. The carriage containing the revolving spindles runs out steadily, from the rollers, so as to keep the yarn taut. When arriving at the end of its journey the delivery of the roving ceases as well as the quick revolution of the spindles, and the running in of the carriage commences. During the running in of the carriage, the length of yarn spun is wound on the bobbin, guided by the faller wires, which are thus actually the builders of the bobbin. The winding of the yarn on the bobbin is done by the spindles, which after stopping for a moment, commence to wind on the yarn as soon as the carriage commences to run in. (The building up of the bobbin or cop, *i. e.* the working of the fallers etc., has been explained in detail in the chapter on the mule in Cotton Spinning). As soon as the carriage has arrived again in front of the rollers it stops for a moment, the rollers commence to revolve, the elongated roving is delivered, the spindles begin their quick revolution, and the carriage simultaneously commences again its outward journey.

Diagram Fig. 291 is given to illustrate the principle of drawing as done in mule spinning. Letters of reference referring to the method of operation indicate as follows: The roving *S*, enters between the feed-rolls *A*, *B*, and from there between the drawing rolls *C*, *D*, *E*, *F*, *G*, *H*. Upon the axle *G*, and support *K*, rest the lever *I*, which is connected by cord *L*, to lever *M*. The pressure for lever *I*, and drawing-rollers *G*, *H*, is regulated by weight *N*.

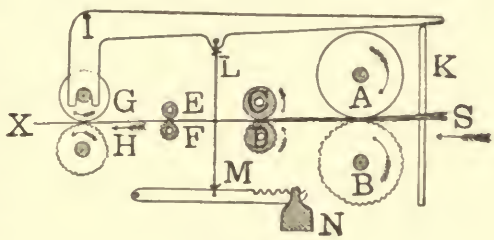


Fig. 291.

Difference between the English and French System of Drawing and Spinning.—Worsted yarn spun by the French system will appear more bulky and spongy compared to yarn of the same material and counts spun by the English system. The reason is found in the method of operation of each system. In the English system a constant stretching and flattening of the yarn is done, thus taking out nearly all the elasticity the material contains; whereas in the French process this is avoided. In the drawing process no twist is put in the slubbing, and the roving, after leaving the front-rollers, touches absolutely nothing until twisted in the thread. In reference to the English system of spinning, one feature in its favor is a greater production and less space per spindle, whereas in favor of the mule is the spinning of higher counts, as well, as previously mentioned, the more natural position of the material in the thread.

Twisting.—Worsted yarn is very frequently made in two, three or more ply yarns. This process is the same, and is also done on the same machine, explained for woolen yarn (see pages 150, 151).

Genapping.—Genapping, or Gassing, is the process to which some of the worsted yarns may be subjected, and has for its object the removal of all the loose fibres (nap) extending outside the thread. It is the same process as gasing for cotton yarns, explained on page 72. The yarn is rapidly wound off the bobbin onto a reel, and in its transit passes through a gas-jet, which slightly singes it. Great care must be exercised not to hurt the thread. Light or medium-colored yarns are generally genapped before dyeing, whereas dark colors can be genapped after dying.

Silk.

Silk consists of the pale yellow, buff colored, or white fibre, which the silkworm spins around about itself when entering the pupa or chrysalis state. Silkworms are divided into two classes, the *Bombyx mori*, or mulberry-feeding worm, from the cocoons of which is reeled the ordinary raw silk, and the wild silkworms which feed upon certain kinds of oak, ailanthus, castor-oil plant, etc. The product of the latter specimens (amongst which the *Tussah-worm* is found, producing the *Tussah-silk*) was little heard of in this country and Europe until recently, and but for the outbreak of the silkworm disease in Europe the Tussah-worm which now gets more and more introduced there, would probably have remained in India and China, although it had been utilized in both these countries for many centuries. The date when the use of silk for textile purposes, was first discovered is not exactly known. Some of the Chinese historians claim that it was about 2,700 years B. C., whereas others only go as far back as about 1703 B. C. or the reign of *Hoang-ti*, the third of the Chinese emperors. He, the legend tells us, was desirous that his legitimate wife *Si-ling-chi* should contribute to the happiness of his people, thus charged her to examine the silk-worms and test the practicability of using the thread. In accordance with this wish, she collected insects and feeding them in a specially prepared place commenced her studies and examinations, discovering not only the means of raising them, but also the manner of reeling the silk and its use for textile purposes. It is claimed that even to the present day the empresses of China on a certain day go through the ceremony of feeding the silkworms, and rendering homage to *Si-ling-chi* as *Goddess of Silk Worms.*

Fig. 292

The Mulberry Silk Worm.—(see Fig. 292). The principal countries for carrying on the silk worm culture are Southern Europe, China, Japan, and India. In our country silk culture is only in its infancy, yet it is rapidly assuming considerable proportions. The silkworm exists in four stages—*egg*, *larva*, *chrysalis*, and *adult*.

Egg.—The eggs, called by silk raisers the seeds, are about the size and shape of turnip seeds. One ounce will balance about 38,000 to 40,000, which have when first deposited a yellowish color which is retained if unimpregnated, but if impregnated, the same soon gets a gray, slate, lilac, violet, or dark green hue, according to the breed. If diseased it assumes a still darker tint. The eggs of some specimens are fastened by a gummy secretion of the moth to the substance upon which they are deposited, whereas other specimens (amongst which are the *Adrianople whites*, and the *yellows from Nouka*) do not have this natural gum. The eggs become lighter in color when approaching the hatching which is due to the fluid becoming concentrated in the centre forming the worm, leaving an intervening space between it and the shell which is semi-transparent. After the worm has left its shell the latter becomes quite white. The average production of each female is about 400 eggs. The color of the albuminous fluid of the egg is the same as that of the cocoon formed later, hence when the fluid is yellow the cocoon will be yellow, and again if white, the cocoon will be white.

Larva.—The silkworm remains in its larva state about six weeks, changing its skin four times during that period and abstaining from food (like other caterpillars) for some time before each change. When full grown the worm ceases to feed, shrinks somewhat in size, and *mounts*, *i. e.*, climbs up from the feeding tray to the bush, *echellette*, or whatever may have been prepared for it, and commences to form itself in a loose envelopment of silken fibres gradually enwrapping itself in a much closer covering forming an oval ball (*cocoon*,) (Fig. 293) about the size of a pigeon's egg. The worm generally requires from four to five days in constructing the cocoon and then passes three days more in the chrysalis state (Fig. 294.).

Fig. 293.

Fig. 294.

Cocoon.—The cocoon (Fig. 295) consists of two parts:—First, of an outer lining of loose silk, used for waste silk, and which has been spun by the worm in first getting its bearings, and second the inner cocoon, which being a strong and compact mass composed of a firm and continuous thread, which is not wound in concentric circles as might be expected, but in a short figure 8, resembling loops (Fig. 296) first in one place and then in another, hence in reeling, several yards of silk may be taken off without the cocoon turning around.

FIG. 295.

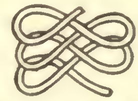


FIG. 296.

Color.—Chinese cocoons are usually white or yellow, varying from pure white to a pure lemon color, those of Japan are of a pale green color, and those of France, Italy and Spain are of a white or yellow color, or occasionally tinged with a pale green, whereas those of Broussa and Adrianople, being the best silk districts of Turkey, are of a pure white color.

Moth.—(See Fig. 297) As soon as the change of the worm into the chrysalis state is completed, which will be in about eight days from the time the spinning commenced, the cocoons are collected and such as are intended for breeding are put in a room heated to 66-70° *F.* After lying thus about fifteen days the silk moth has been formed in the interior of the cocoon, and which emits a peculiar kind of *saliva*, with which it softens one end of the cocoon and thus pushes its way out. The discharging of this saliva greatly injures the silk. A few days after the females have laid their eggs they die, not being provided with any organ of nutrition. The eggs are gradually dried and stored in glass bottles in a dry dark place till next spring.

FIG. 297

Introduction of the Silk Worm into Europe dates back to A. D. 555, when two Nestorian Monks, who had been for some years missionaries in China, at the peril of their lives came across the Asiatic continent bringing concealed in the hollow of their pilgrim's staves a quantity of the choicest silk worm eggs, and which they delivered to the Roman Emperor Justinian I., revealing to him at the same time the entire process of silk culture, which they had carefully studied when in China. Emperor Justinian took a great interest in establishing silk culture in his Empire, putting the Nestorian Monks in full charge of his undertaking. Soon afterwards all over what is at present European Turkey, Greece and Asia Minor, silk culture became a favorite employment. At the downfall of the Eastern Empire (Twelfth Century) the knowledge of silk culture was carried by the Arabs and Saracen Princes to Northern Africa, Spain, Portugal and Sicily, and from there found its way to France, Venice and Genoa and gradually to Switzerland, Austria, Germany, etc.

Cocoons in Their Natural State Contain

68.2 per cent. Moisture,
14.3 per cent. Silk,
0.7 per cent. Floss (bourre)
16.8 per cent. Chrysalis.

100.–

Polyvoltines.—The best breeds of silkworms go through their changes but once a year, yielding in return large cocoons, and being of little trouble to the silk grower, whereas other breeds (apparently of the same species, but of the same genus) go through these changes two, three, four or more times a year, yielding in turn an equal number of crops of cocoons. These silkworms are classified as *polyvoltines*, such as yielding two crops are known as *bivoltines*; three crops as *trivoltines*, etc., etc. The silkworm yielding the greatest number of crops (8) is known as *dacey* and is found in Bengal.

Stifling.—As previously mentioned, after the cocoons are collected they are sorted; such as are intended for breeding are treated as previously explained, wheras those intended for commerce are subjected to the next process, that of *stifling*, or destroying the vitality of the chrysalis by steam. It consists in submitting the cocoons to a steam bath at a uniform temperature of 212° F., the steam rising practically uncondensed, under an iron receiver, which covers the cocoons. The chrysalides are suffocated by the diffused heat which penetrates thoroughly, while the web of the cocoon retains its natural condition. This method of destroying the vitality of the chrysalis was invented by Professor Castrogivanni, of Turin. The apparatus required for this consists of a basin connected by a pipe with a steam boiler, two circular plates running on rails on which the trays holding the cocoons are placed, a bell receiver, supported by two iron uprights, arranged by means of a pulley and counterpoise to permit an easy raising and lowering. The bell is provided with a thermometer and a stop-cock for letting off the air and steam when required. The method of procedure is as follows: Fill the basin partly with water (about 4 inches high), admit the steam to it and lower the bell, having the stop-cock open. Raise the temperature until the thermometer registers 210 to 212° F.; the cock must then be closed, not to be opened again during the operation. The bell is next raised to allow the plate on which the trays of cocoons are placed to be run over the basin, and then lowered again into the water until the edges are covered but not touching the bottom of the basin. In about fifteen minutes the bell is lifted, the cocoons which have been steamed are run off, and a second lot, which have been previously made ready, are placed on the plate and proceeded with as before. For perfect work care must be taken to maintain the internal temperature of the bell receiver at the same degree, hence the water must always be boiling, and a fresh supply regularly admitted to take the place of that evaporated in the steam. Although the killing of the chrysalis by steam does not damage the silk at all, as might be the case if using the older process; *i. e.*, killing the *pupæ* of the cocoon by means of heating the cocoons for about three hours in an oven heated to 145 to 155° F., yet the steam process has one serious defect—some of the pupæ may burst and soil the silk, and the fibres may soften somewhat, being apt to stick together and render subsequent reeling more difficult. In the warm Southern States the dry-heat choking can be accomplished by simple exposure to the sun. There the cocoons need only to be fully exposed to the rays of the sun from 9 o'clock in the morning until 4 o'clock in the afternoon. Two or three days of such exposure are sufficient, but, as sometimes strong wind can annihilate the effect of the sun's warmth, it is good to have for that purpose long boxes, 4 feet wide, sides 6 inches high, to be covered with glass frames. This will increase the heat and, by absorbing the air of the box, stifle the chrysalis most surely. Some silk raisers say that in the glass cover of the box a crack should be left open to allow the evaporation of the moisture, which otherwise would collect in large drops upon the glass and, falling back upon the cocoons, would keep them moist for a longer time. However, don't allow ants to creep in at the crack, as they will penetrate the cocoon to feed upon the chrysalis.

In the colder climates it has been suggested that the chrysalis could be well choked, with no injury to the cocoons, by placing them in a vacuum-box and exhausting the air. Chloroform has been used to a certain extent, and experiments are being made in France with sulphydric acid gas, also with bisulphide of carbon.

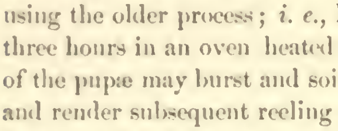


Fig. 298

Sorting.—After destroying the vitality of the chrysalis, the cocoons are sorted into different grades, according to quality. In the best cocoons the silk thread as formed by the worm will measure from 1,000 to 1,300 feet, and though it appears to the naked eye single, it is in reality composed of two threads (see Fig. 298) which are glued together and covered as they issue from the spinneret of the moth with a glossy gum which enables the worm to fasten the silk where it wants it, and which is soluble in warm water.

Reeling.—The silk as formed by the worm is so very fine that if each ball or cocoon were reeled separately, it would be totally unfit for the purpose of the manufacturer; in reeling, therefore, the ends of several cocoons are joined and reeled together out of warm water, which softening their natural gum makes them stick together so as to form one strong thread. This process of reeling silk from the cocoons is very simple. The common reeling machine in use consists of a reel of sixty to ninety inches in circumference, the frame work containing the guides, the basins and means for heating the water therein. The cocoons are next stripped of their surrounding floss, being placed conveniently beside the reeler, who taking a handful puts them in the basin containing hot water, and by watching them soon ascertains whether the water is sufficiently hot or not, for if during reeling the cocoons lift from the basin, the water is not hot enough to dissolve the natural gum of the cocoon with sufficient rapidity; if on the other hand the silk comes from the cocoon in flakes, the water is too hot. After putting the cocoons in the basin filled with hot water, they are prior to reeling beaten with a small birchen broom (having the tips split so that the loose threads readily fasten to them) until the *floss* is gotten rid of and the true thread drawn from the cocoon. The reeler next seizes as many single filaments as he intends to convert into one thread, according to the quality of the silk wanted, and quickly passes them through the first guide. The same operation is simply duplicated by drawing the filaments from another equal number of cocoons through another guide. There are now two threads drawn from equal numbers of cocoons above the first guides, these are then brought together, twisted several times so as to form for a short space the strand as if it were a two-ply thread. The two minor threads again diverge, and being passed through the second fixed guides, and next through the distributing guides are attached to the *tambour,* which is kept revolving in a steady, rapid manner, and to which is also given a certain back-and-forth side motion. In some instances the twisting of the minor threads, as previously explained, is duplicated before passing the threads to the distributing guides. The object of thus twisting the minor threads is to deliver the same on the reel in a rounded form, well joined, properly free from moisture, and crossed on the reel so that they will not stick or glaze; if otherwise, these minor threads, being as before explained in a soft condition, would in passing the guides not only assume a flat shape but also obtain an undesirable roughness. The silk reeler must be very careful throughout his entire work, for he must keep the silk thread of a uniform size. For example, let him start his work with five cocoons or minor fibres to one thread; the filament of each of these five cocoons gradually becomes more and more attenuated, the nearer it approaches the chrysalis, and to be able to balance the required count of the thread by adding the filaments of other cocoons is a very particular work. These five cocoons, with which the reeler started, may sometimes have to be increased to six, seven, eight or more cocoons and this without altering the counts of the silk thread when on the reel. Another point, which makes reeling rather a difficult procedure is, that no two of the same breed of worms will spin just the same amount, and between cocoons of different breeds or those spun under different circumstances, the length varies from 300 to 1,300 yards. The person doing the work must be careful not to reel too close to the chrysalis, as such silk is inferior in quality as well as color. Double cocoons, soft cocoons, imperfect cocoons, and diseased cocoons, can never be reeled completely and frequently not at all. Double cocoons can only be reeled by means of boiling water, which would hurt good cocoons.

Good reeling is of the greatest importance to the manufacturer, which is clearly demonstrated by the fact that Italian raw silk, even at an advanced price, is more economical for him to use compared to a similar quality of Chinese silk, but which is generally of a poorer reeling.

Silk Reel.—To illustrate the process of silk reeling, Figs. 299, 300 and 301 are given. Fig. 299

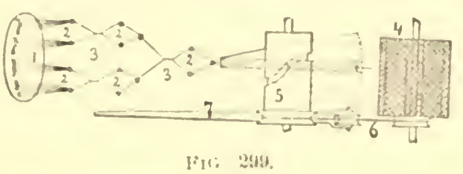


Fig. 299.

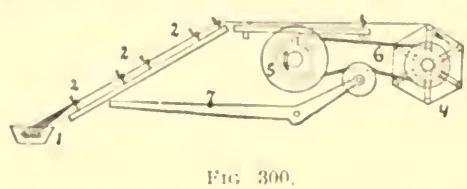


Fig. 300.

illustrates the plane and Fig. 300 the corresponding section of what is known as an old *French reel,* but which embodies the principle of any reel used nowadays in an improved reeling establishment. Numbers of references in both drawings are selected accordingly. 1, Water basin, which may be heated by steam or a charcoal furnace. 2, Guides for the threads. 3, Position in which the threads are twisted to clean their surfaces and to give them roundness. 4, Reel or tambour. 5, Cylinder (on shaft) having a spiral groove in its surface, in which a pin fits from the transversing bar, hence giving the lateral movement to the thread, which goes through a guider on the front end of the bar, moving through the arc of a circle. 6. Connection of reel to the cylinder for transmitting motion to the former. 7. Friction lever, for tightening or slackening the endless cord or belt which transmits the power from the cylinder to the reel. Diagram Fig. 301 shows an improved Lombardy hand reel (constructed on about the same principle as the French reel), set up and ready for work. 1, Water basin, to be heated by a charcoal fire. The basin fits tightly over—2, the square tin tray which holds the cocoons, etc. 3, Short stick inserted in a holder 3′, on which the ends of the cocoons are wound, so as to be ready for use. 4, Cock, for drawing the water from the basin every night after use. 4′, Door to furnace, lined with fire brick, wherein the charcoal fire is lighted to heat the water in the basin. 4″, Flue pipe for carrying the charcoal fumes either into a chimney or into the open air. 5, Guides for the threads from the cocoons, through these guides the threads pass to and over the pulleys or rollers 5′, revolving on bent wire stands. The guides must be placed in such a position that the threads pass upward in a straight line from the water in the basin to the pulleys, and from there to the top of the wheel (except when diverted laterally by the long guider at 5″), friction being in consequence reduced to a minimum, and the elasticity of the thread preserved. 6, The grooved arrangement, by means of which the long guider working to and fro distributes the thread to the reel on the required *cross* or *lease*. 7, The reel or *tambour*, which has one of its arms supplied with a screw-hinge, by means of which the length of the arm can be diminished to take off the silk. 8, Stool, on which the adult reeler sits, being in front of the cocoons, whereas the child, or whoever turns the crank for operating the machine, takes his place on the other stool 8′. (For illustrating parts 5, 5′ and 6, drawings in detail are given.) In larger reeling establishments there are usually several of these reels in one room and driven by power, but each is arranged so that it can be stopped when necessary without disturbing the others. If the motive power in the establishment is steam, suitable arrangements can easily be made by means of pipes and stop-cocks to heat the water in every basin instantly or gradually by steam.

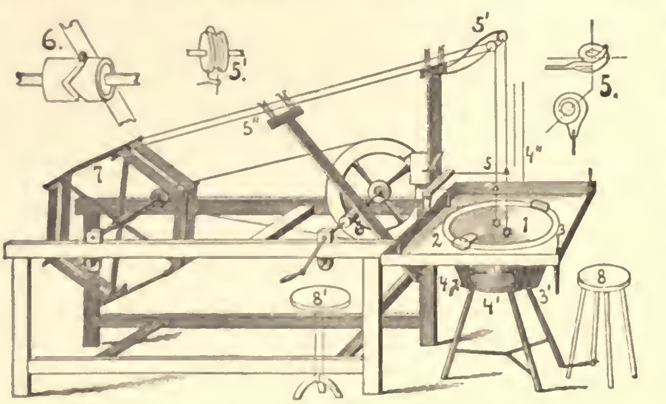


FIG. 301.

Improved Silk Reel.—A most ingenious method of reeling silk has been lately patented by a Mr. Serrell in this country, France, Austria, Germany, Italy, Spain, Sweden, and Portugal. As mentioned previously in this chapter on silk reeling, the filament from a cocoon is coarsest at the outer end, and becomes finer toward the inner end, hence the operator must add a fresh filament from time to time to the thread, so as to keep the latter uniform. This operation requires very close attention, as well as experience, on the part of the operator. The object of Mr. Serrell's invention is to gauge the thread during the process of reeling, and to supply to it automatically additional filaments, as it becomes weaker in consequence of a cocoon becoming exhausted, or of the diminution in size of the filaments, thus maintaining for the thread the greatest possible uniformity in size and strength for the thread as reeled. Fig. 302 is a side view, partly in section, of the silk-reeling machine, with the floor upon which the machine rests, also in section. Fig. 303 is a plan view of a portion of the table, the water basin, a pair of cocoon holders, feeding drums, and filament attaching devices, with pulleys and belts for rotating the drums and filament-attaching devices. Fig. 304 is a sectional elevation of the parts shown in Fig. 303. Fig. 305 is a diagram illustration of the electric devices and connections of the apparatus. Fig. 306 is a sectional plan, showing the ratchet-wheel upon the shaft

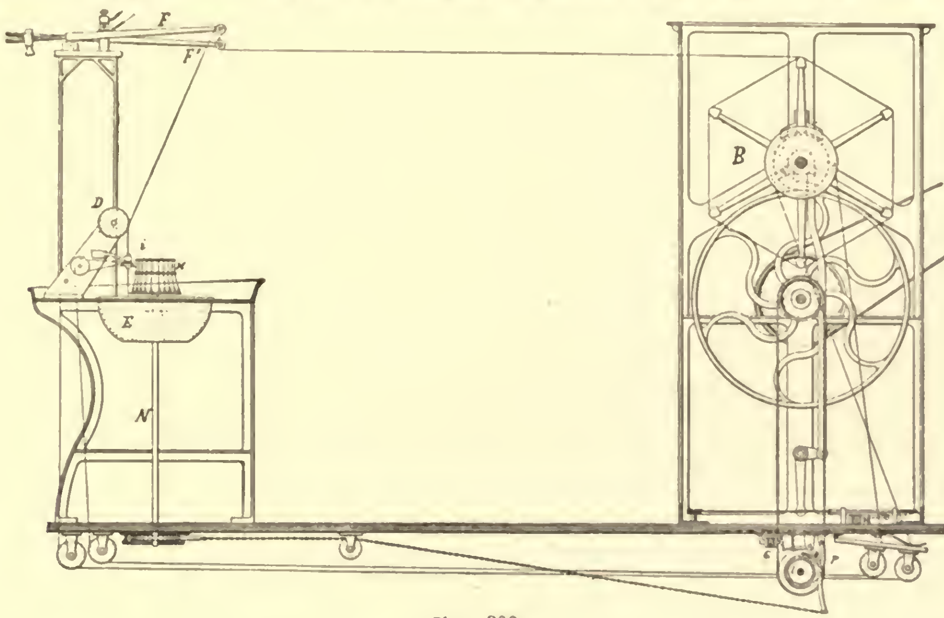


Fig. 302.

of the cocoon-holder, and the devices at one end of the chain for turning said wheel and shaft. In practice two threads are wound upon the same reel, hence two cocoon-holders and two sets of apparatus, in conjunction with each basin and with one reel, are used; but as these are similar only one is described. In most of the reeling establishments there are several basins, side by side, each being provided with two sets of devices, as previously alluded to, and the reels for each set of devices are situated in a frame common to all, with but one driving shaft to rotate all the reels. Letters of references in all four illustrations are selected to correspond.

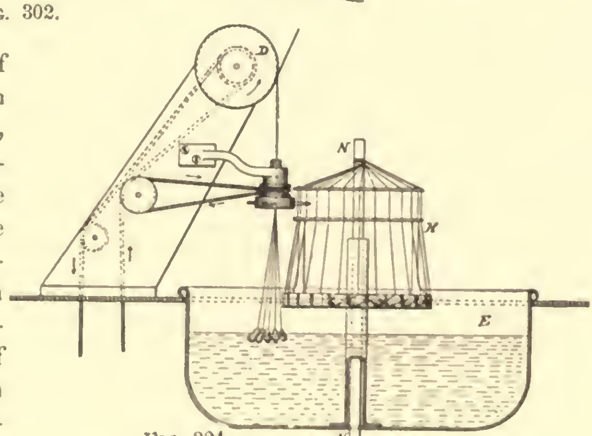


Fig. 304.

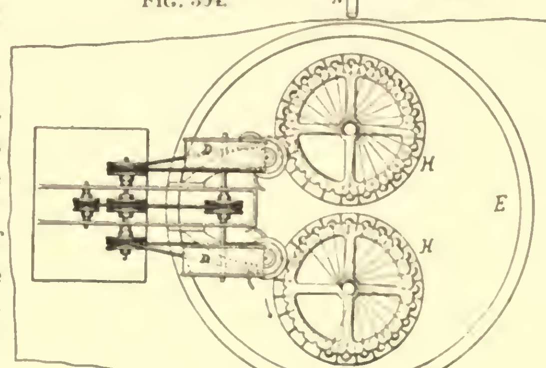


Fig. 303

The operation of the machine is as follows: The operator places a cocoon in each compartment of the cocoon-holder or magazine *H*, and leads the filaments of each of the cocoons up over the upper plate, attaching them in any convenient manner, as shown in Fig. 304. The filaments of several other cocoons are then passed through the attaching devices, or cylinder, *i*, to form the beginning of a thread. The thread thus formed is passed one or more times around the feeding drum *D*, so as to secure sufficient adhesion to prevent slipping, and the thread, after making the *croisure* (crossings), is carried over the small pulley at the end of the lever *F*, and under the pulley at the end of the lever *F'*, and thence to the reel or tambour *B*. The counter-weight of the lever F, is adjusted by trial to the position required for the size of silk which it is desired to reel, and the reel is allowed to revolve. The thread is delivered from the drum D, at a speed about five per cent. less than that at which it is wound in by the reel B, which will result that in the process of winding, the thread is uniformly stretched this per centage or a fixed proportion in relation to its length, being the proportional difference in winding speed between the drum D, and the reel B. The passing thread thus stretched acts upon the lever F, with a force which varies according to the strength of the thread to resist the elongation. Now the force which is required to stretch a silk thread a given proportion in relation to its length is practically in direct proportion to its diameter, and from this it follows that the forces tending to depress the lever F, being in proportion to the resistance to elongation are proportional to the size of the thread which is passing at any given moment. The lever F, having been adjusted for the desired size of silk, is held down at the end nearest the reel as long as the passing thread is sufficiently strong, and therefore of the required size; but as soon as the thread becomes too weak, the resistance diminishes and the lever F, rises and touches the contact point c^1. An electric circuit is thus closed, and the magnet G, attracts its armature, releasing the latch-lever S. The spring now causes the pawl p, to engage with a tooth of the ratchet-wheel l, and the cam-case o, begins to make a revolution. This allows the spring T, to contract, causing the ratchet-wheel X, to advance one tooth through the action of the pawl t^2. The shaft N, revolves with the ratchet-wheel X, sufficiently to advance the magazine H, by one compartment, because the magazine contains the same number of compartments as there are teeth in the ratchet-wheel X. In thus partly revolving the cocoon holder H, brings a cocoon filament within reach of one of the hooks upon the rapidly revolving cylinder i. The filament so brought within reach is seized by the hook, and the revolution of the latter causes the newly-caught filament to be wrapped around those which are already paying out at a point between the lower end of the cylinder i, and the water in the basin E. The filament so wound around the running thread adheres because of the glutinous matter with which heated and wet cocoon filaments are naturally coated, and becomes attached to and a part of the thread being reeled. The thread being thus strengthened, is usually of sufficient size, and, in consequence strong enough to draw down the end of the lever F, and break the electric circuit before the cam-case o, has completed its revolution with the shaft J. When this is the case, the lever F, no longer touches the contact-point c^1, and the magnet G, not being excited the hook of the armature retains the latch-lever S, and the pawl p, being withdrawn from the teeth of the ratchet-wheel l, the filament-supplying mechanism comes to rest until the thread becoming again weakened, the operation is repeated and another cocoon filament added. Should however, the first cocoon not be sufficient, or should the cylinder i, fail in seizing and attaching it, then the lever F, is not drawn down, the contact remains closed at the point c^1, and the cam-case o, continues to revolve, thus progressively advancing the magazine and causing to be added as many cocoon filaments as may be

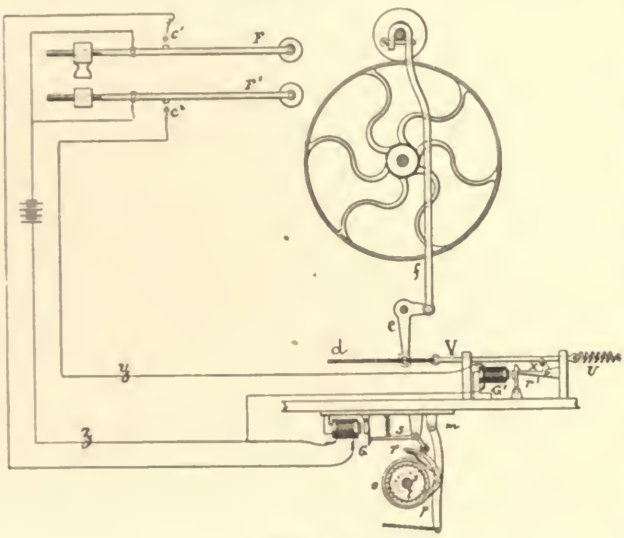


FIG. 305.

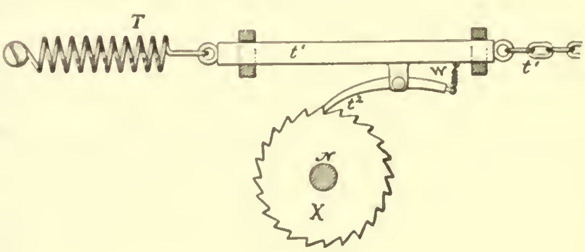


FIG. 306.

necessary to bring the thread up to the desired strength and size. The lever F^1, is used in combination with the magnet G^1, the armature r^1, the lever x, the spring U, the slide-rod V, to stop the reel when the thread breaks, and the operation of the device is as follows: As long as the thread is unbroken the lever F^1, is held up and does not touch the contact-point c^2; but as soon as the thread breaks, the lever F^1, falls and makes contact at the point c^2. The electric circuit is completed through the magnet G^1, and the wires y, z. The magnet G^1 is thus excited, and the armature r^1, is attracted, thus releasing the lever x, allowing the spring U, to lift the friction-wheel of the reel off from the main friction-wheel by means of the rod V, lever e, and rod f. This causes the reel B, to stop. To put the reel in motion, the cord d, is drawn upon by means of a pedal, or otherwise, which again latches the armature r^1, and moves the lever e, and this extends the spring U, and allows the friction-wheel of the reel to bear upon the main friction-wheel which is constantly in motion.

This silk as it leaves the reel is known in commerce as *raw silk*, and it is determined to a great extent by its fineness and regularity of thread, its clearness or freedom from knibs, or particles of skin and badly attached filaments. Its counts are not judged entirely by the eye, but by weighing a certain length of thread. The adopted custom of specifying the size of silk yarns is in giving the weight of the 1000 yards hank in drams avoirdupois, except in fuller sizes where 1000 yard skeins would be rather bulky and apt to cause waste. Such counts are made into skeins of 500 and 250 yards length, and their weight taken in proportion to the 1000 yards. In Milan (Italy) a most complicated slow process of silk reeling is practised, allowing the thread to dry, and passing it direct from the distributing guides to the throwing machinery which at once puts the first twist into the threads and also delivers them to a bobbin in the form of ***singles***.

Raw Silk.—(*i. e.*, Reeled Silk)—Constitutes the raw material for the American silk manufacturer. When imported the same generally comes in picul bales of one hundred and thirty-three and a third pounds. Such as come from China are made up in bundles weighing from eight to twenty-five pounds each and are protected at the corners by floss or waste. The Italian silk comes in bales made up of skeins. Before it reaches the loom this raw silk must pass several manipulations and processes. First the same is taken to the sorting-room, and the various sizes of thread or, in other words, the different degrees of fineness, are assorted each by itself. The next process is the transferring of the silk from the skeins (which are of irregular length) to the bobbins. A parcel of skeins enclosed in a light cotton bag is soaked in water having a temperature of 110°F. for a few hours so as to soften the gum. After taking these bags out of the water they are submitted for from 5 to 10 minutes to the action of a hydro-extractor to liberate the superfluous water and the silk with its gum, thus sufficiently softened is ready for winding. The skein is stretched upon the ***swift*** or light revolving frame for holding it, the thread passes through the traversing guide onto the bobbin which rotates on a horizontal axis and receives its motion by means of a small roller fastened on the bobbin spindle. This spindle is placed in two grooves, and also is parallel to a light shaft bearing at one end a metal wheel, the friction of which conveyed by the little roller gives motion to the bobbins. A face cam gives motion to the traversing guides calculated according to the length of the bobbin. The next manipulation the silk thread undergoes is cleaning.

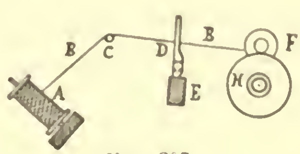


Fig. 307.

Cleaning.—In this process the silk thread is simply transferred from one bobbin to another and passes during the transfer through the cleaner, which consists of two sufficiently close parallel plates to catch any irregularity upon the silk, and at the same time arrest the motion of the spindle until the operator removes the cause. Fig. 307 illustrates the principle of the cleaning process. The bobbin A, containing the silk is unwound and the thread B, passed over the rod C, and the *cleaner D*, which is fixed in guide-rail E. The thread B, is wound upon the bobbin F, which is turned by friction roller H. Chinese silk always requires cleaning, whereas Italian silk does not usually require this cleaning.

Doubling.—The third process is doubling, which is done by means of the doubling machine, and consists in bringing two or more single threads from two or more bobbins side by side onto one bobbin but without any twist.

Twisting or Spinning.—The fourth manipulation of the silk thread is accomplished on the spinning machine. The latter puts a twist into the two threads which the doubling machine brought already together. In finer counts the third process is omitted, hence the twisting machine is also used to put twist in a single thread.

Take-up Attachments for Doubling, Twisting or Spinning.—Lately a most ingenious device for machines used either for doubling, twisting, or spinning, has been patented by a Mr. Conant providing said machine with take-up attachments combining the functions of taking up the slack produced by stopping the machine, placing the silk under perfect control as to its tension. Fig. 308 is a transverse section view of the invention. The silk is led from the feeding bobbin *A*, over the supporting and guide-wire *K*, then through the hook *S*, of the arm *B*, of the take-up, then through the hook *S*, of the arm *R*, of the take-up, then over the distributing roller *I*, revolving in frame *H*, and thence to the receiving bobbin *F*, which is turned by means of friction with pulley *G*. When the machinery is in motion the bobbins rotate at a very high rate of speed imposing sufficient tension on the silk passing from the feeding to the receiving bobbin to support the take-up in a normally elevated position, in which, however, it exerts a constant tendency to drop down and draw the silk down on opposite sides of the combined lift-detent and silk-supporting wire and below the silk supporting and guiding wire in the form of two long independent loops, so that any fluctuations in the amount of silk thrown from the feeding-bobbin or wound upon the receiving bobbin will be automatically met and compensated for by the dropping of the take-up, whereby the virtual distance between the two bobbins will be increased exactly in proportion to the amount of slack to be taken up. This action of the take-up not only preserves the silk at a uniform tension, but also prevents it from snarling. When the frame is stopped, the feeding-bobbin, by reason of the inertia acquired when it is running, does not stop the moment the power is cut off, but makes a few turns and throws off a few coils of silk before its inertia is overcome. The slack so produced is at once taken up or absorbed by the take-up, which drops virtually into the position indicated by the broken lines in the illustration where it is shown as resting upon the drop-detent wire *L*, which prevents it from swinging so far under the carrying-wire as not to be readily lifted again by the strand. It will be noted that when the take-up is in this position the virtual distance between the two bobbins is very largely increased. When the machine is started again, the tension imposed upon the strand by the receiving bobbin at once operates to lift the take-up to its normal position, the lift-detent wire *M*, preventing it from being lifted too far or to a point from which it will not readily fall back. By taking up, as described, the slack produced by stopping the machine, the product of the operation will be free from knits and kinks.

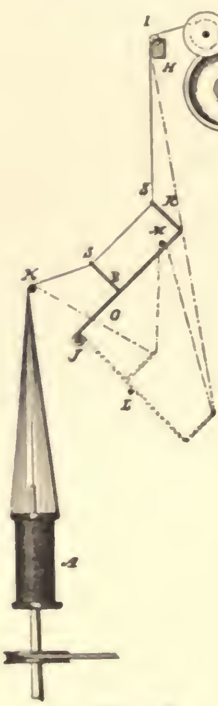


Fig. 308.

In case the silk breaks, the take-up at once drops onto the drop-detent wire *L*, and so indicates to the operator the breakage, which is difficult to detect without some such visual signal, especially if the light is not good, or by artificial light, on account of the extreme fineness of the silk in this stage of working.

The spinning machine also resolves the silk into the specific terms *tram* and *organzine*.

Tram Silk is made by twisting two or more single untwisted threads, which are then doubled and slightly twisted. The object of tram silk is to form simply a heavier count, and the product is chiefly used for filling.

Organzine Silk is produced by the union of two or more single threads twisted separately in the same direction, which are doubled and then re-twisted in the opposite direction. Organzine silk is chiefly used for warp.

Silk Throwing (from the Saxon, *thrawan*, to twist) is the technical term used for winding, twisting, doubling and re-twisting raw silk, as the case may require, either for tram or organzine. The person doing this work is called a throwster.

Single Silks.—In some fabrics, for example, *pongees*, the silk yarn is used without doubling or twisting, or is used in its single state; *i. e.*, after leaving the second process of cleaning, which has been already explained. Such silks are known as *singles*, and produce a cloth which possesses (after being bleached and dyed) a softness and brilliancy unattainable with silk which has been twisted; *i. e.*, tram or organzine. This point will readily demonstrate the advantage of not imparting to silk any more twist than is absolutely necessary on account of the scouring, dyeing and weaving processes.

Scouring.—The next process which silk undergoes before dyeing is scouring. As previously mentioned, silk contains a large amount of gum or saliva, which the silk-worm spins into the single thread; also other impurities, which have been necessarily added in throwing it, and which all have to be removed, although in some silks this is less fully done. According to the quantity of saliva removed, the different processes of scouring are called, *boiled*, *souple*, and *ecru*.

Boiled-off Silk.—This scouring or ungumming of silk is performed by means of soap solutions, heated to about 195° to 205° F. Boiling silk repeatedly in these soap baths deprives the silk of its gum or saliva, and the same acquires the softness and lustre so highly prized in silk fabrics. In the process the silk will lose from 24 to 30 per cent., according to the class of raw silk used; China silk losing the most and European and Japanese silks the least. These soap baths as used for boiling-off silk are utilized as much as possible, and afterwards worked up for the recovery of the fatty acids by treatment with sulphuric acid. These soap-suds are also very useful as an addition to dye-baths when dyeing silks with aniline colors.

Souple Silk, is silk which only lost from 5 to 8 per cent. of its weight, and consequently is in scouring only partly deprived of its gum or saliva.

Ecru Silk, is the fibre deprived of its gum to the extent of from 2 to 5 per cent. by washing in weak soap-suds and afterwards sulphuring.

After the silk has been thus scoured, it is ready for dyeing. For white, and also very delicate bright shades, the silk is bleached before dyeing in an air tight room in which sulphur is burnt.

Shaking, Glossing and Lustreing.—One of the most important physical properties of silk is its lustre, and in order to develop this feature to its maximum, silk is submitted, after scouring, bleaching or dyeing, to either one or the other, or to all of the various processes known as shaking, glossing or lustreing. The *shaking process* is to open out the hanks and remove all chance for curling of the threads. It is generally done before the yarn (after being dyed or scoured) gets perfectly dry, since dampness will greatly facilitate the process. It may be performed by machine or hand. In the latter instance after extracting all superfluous water by means of an hydro-extracter, (see Fig. 309) a strong and perfectly smooth wooden peg is fixed to the wall, and a hank of silk yarn hung on it. A wooden stick is next inserted in the loop of the hank of yarn and the latter is quickly and forcibly pulled, the operator taking care to frequently change the position of the hank. After one hank is finished, it is taken from the peg, a fresh one substituted, and the operation repeated. *In glossing*

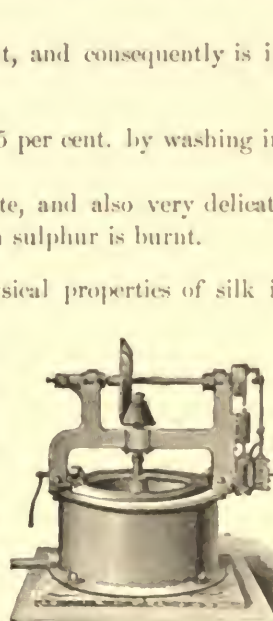


Fig. 309.

also called *stringing*, the silk is operated upon when dry. This process is of great importance especially with souple silks with which it forms the last operation before winding and weaving. The main feature is to twist the hanks of silk when dry, and can either be done by hand or by means of stringing machines. The hand process closely resembles the previous process of shaking, the only difference being that instead of pulling the hank of yarn, it is twisted as tightly as possible, and left in this condition for several hours, the operation being frequently repeated for several days. A *silk stringing machine* is shown in Fig. 310 and consists of a series of pegs placed horizontally (see 1) on each of which a hank of yarn is hung which is fastened below to the corresponding peg of another series of horizontal rollers (see 2). Pegs indicated by 1 revolve by means of a lever, ratchet and cog-wheel arrangement; whereas the lower rollers are capable of two movements, first revolving on the axis and then at right angles to this. Each spindle is also arranged to permit its sliding up and down. The movements for the hanks of silk yarn are thus automatic, and several repetitions of twisting, re-twisting and corresponding changes in position for the hanks completes an operation whose sole object is to increase the lustre of the silk. That operation by which the maximum of lustre upon silk is effected is termed *silk lustreing*, and is done by means of the *silk lustreing machine* as shown in Fig. 311. During the operation the silk is subjected to an easy tension between two polished steel rollers which revolve in the same direction and are enclosed in a cast-iron box. The necessary amount of stretching the yarn is effected by drawing the right hand rollers away from its corresponding stationary one by means of a hook worked by cog-wheels. While the steel rollers revolve in the same direction, steam at a moderate pressure is introduced.

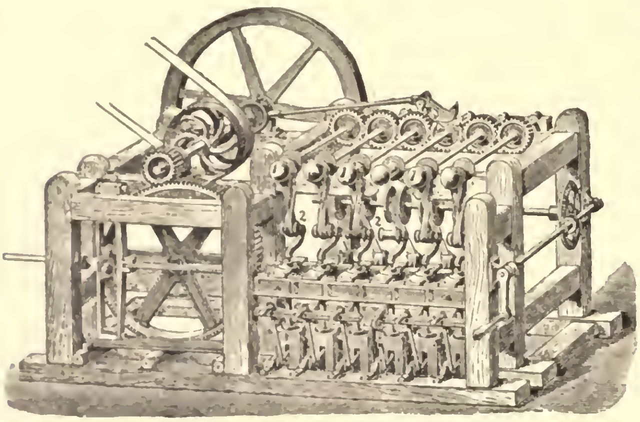


FIG. 310.

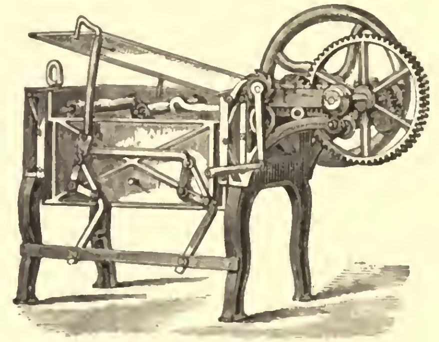


FIG. 311.

Weighting of Silk.—This manipulation of silk has recently acquired quite a strong hold in the silk industry. In silks for ribbons, and broad silks, double weight is frequently given to the fabric, while in silks used in the manufacture of fringes up to four times the original weight is thus obtained. The silk threads acquire during this manipulation a heaviness in their counts which they really have not, hence it is easy to deceive the buyer who judges the article by its general appearance and handling. Prof. Sansone gives the following very interesting matter regarding this subject of weighting silk. "The charging of silk, which by some has been recognized as an art, has been the cause of injuring the prosperity of the industry very considerably, and this beautiful fibre which in olden times was the symbol of strength and durability, is now-a-days simply the emblem of the hollow and presumptuous show in which this age heartily delights. I do not think that modern chemists need after all to be so proud of their achievement in this direction. It must be owned however, that in recent times attempts have been made to atone in a certain sense, by introducing methods of weighting silk which should not be injurious to the fibre. The methods mostly employed for this process rely on the selection of ingredients according as the silk is white, light, or heavy colored. Sugar and glucose were at one time the favorite products for sophistication, but the weighting cannot be made very high, and accordingly the ingredients though harmless are not now in favor. For white and light colors, stannic chloride solution is employed, which is made up to 35—45° Tw., the silks being immersed, lifted out, wrung, and finally washed in a boiling soap and soda bath; each treatment increases the weight about 8 per cent. and is repeated according to the amount of weighting required. Silks so charged are easily deteriorated by long exposure to the sun-light. For dark shades, and especially for blacks, the ferric hydrate or peroxide is the weighting mostly employed, in the shape of the old and well-known iron mordant, for silk the nitrate or persulphate of iron, which is prepared from copperas by the addition of sulphuric and nitric acids. The application relies on the employment of this liquor made up to 45° Tw. or 25° Tw., according as it is a boiled or a souple silk. After remaining in this liquor long enough to thoroughly impregnate it, the silk is lifted out, wrung, then washed, and finally passed through a tepid soda bath, and soaped at the boiling point; every time the operation is repeated the weight is increased about 10 per cent. Silks so charged are generally employed for blacks; the iron charge does not deteriorate the fibre so readily as the stannic chloride, but the silks have a tendency to ignite spontaneously, and this has been the cause of fires on board of ships carrying these heavily charged silk goods. Tannins are also largely used for weighting silks, and they do not act so injuriously on the strength of the fibre as the metallic charges do, but they can only be employed for dark colors. Special tannin products artificially purified or bleached, have however, been introduced of late which allow tannins to be employed even with some lighter colors."

Silk-Conditioning.—Silk kept in a humid atmosphere is capable of absorbing 30 per cent. of its weight of moisture without being noticeable in its general appearance. The high price of raw silk will make it of the greatest importance for the manufacturer to have the means of detecting the exact amount of moisture in any lot of raw silk offered for sale. For this reason so-called *silk-conditioning establishments* are to be found in the centres of silk industry all over the world, whose business it is to ascertain the amount of moisture in lots of silk given for testing. The apparatus used for the purpose is called the *dessicator*. The average loss of weight; *i. e.*, moisture found, is, as already mentioned, 30 per cent., but absolutely dry silk is not calculated as the basis or standard article; this is raw silk, containing 90 per cent. dry silk and 10 per cent. moisture.

Chemical Compositions.—The chemical compositions of silk, according to Prof. Mulder, are:

	Yellow Italian Silk.	*White Levant* Silk.
Silk fibre	53.35	54.05
Matters soluble in water	28.86	28.10
" " " acetic acid	16.30	16.50
" " " alcohol	1.48	1.30
" " " ether	0.01	0.05
	100.00	100.00

Examining in detail the substances which each solvent had extracted, he obtained the following results:

	Yellow Italian Silk.	*White Levant* Silk.
Silk fibre	53.37	54.04
Gelatin	20.66	19.08
Albumen	24.43	25.47
Wax	1.39	1.11
Coloring Matter	0.05	0.00
Resinous and fatty matter	0.10	0.30
	100.00	100.00

Waste Silk, is all silk obtained from cocoons in any way soiled or unable to produce a continuous thread; also the extreme outer and inner portions of every cocoon. This waste silk is washed, boiled with soap and dried, and is afterwards carded and spun like cotton, producing a silk yarn technically known as *spun silk.* The grading of these yarns according to the size is not the same as the raw silk, but is the same system as is used for cotton, with the exception of two or more ply yarns. Another kind of silk made from waste silk is *shappe silk,* which is manipulated the same as spun silk, except that the silk is not previously boiled.

Wild Silks.—The most important of them is Tussah, being the product of the larva of the moth *Antherœa mylitta,* and is principally found in India. This silk has until lately been greatly neglected, but at present commences to attract great notice. The cocoons are larger than those of the Bombyx mori, have the shape of an egg, and are of a silver-drab color. The outside silk of the cocoon is slightly reddish, and consists of separate fibres of different lengths, while the remainder of the cocoon is generally unbroken to its centre. Its fibres are somewhat glued together by a peculiar secretion of the worm, which permeates the whole wall of the cocoon, imparting to it its drab color. Fig. 312 shows the microscopic appearance of the tussah silk fibre. Tussah silk is bleached before dyeing delicate and bright colors. The process invented by M. Tessiè du Montay is the most frequently used. The agent used in this process is barium binoxide, from which free baryta hydrate is first removed by washing the binoxide in cold water. A bath is next prepared containing binoxide in proportions from 50 to 100 per cent. of the weight of silk to be bleached. The silk is afterwards washed in this bath, which is heated to 175° F. for about one hour, and in succession passed into dilute chlorhydric acid and washed again. If the silk does not become a clear white the operation must be repeated, or we may also complete the bleaching by scouring the silk in a solution of potassium permanganate and magnesium sulphate, and afterwards in a solution of sodium bisulphite, to which hydrochloric acid has been added. Great care must be used during this operation not to leave the silk longer than necessary in contact with the barium binoxide, as otherwise it becomes dull, harsh and tender. Another agent for bleaching silk is hydrogen dioxide. The silk is steeped for several hours in a dilute and slightly alkaline solution of commercial hydrogen dioxide, and afterwards is well washed; first with water acidulated with sulphuric acid, and afterwards with water only. Another kind of wild silk is the one derived from the *Antherœa yamamai* of Japan. The cocoon of this silk-worm can be reeled with great facility; hence it is of great importance, for though some of the Indian wild silks are reeled by the natives, the process is tedious and very slow, and thus it is hopeless to expect any large quantity of reeled silk from there. In India the report compiled by that government give particulars of no less than thirty-six varieties of wild silk-worms feeding upon different forest trees and shrubs. Chief among these are mentioned the *Antherœa paphia,* found in the jungles all over India, Burmah, and Assam. *Antherœa Perui,* an oak feeder. *Antherœa Assami,* or moonga, described as a very excellent silk-producer, which feeds upon the mango as well as the mulberry, and whose larva produces a large, fine and easily-reeled cocoon, of a medium light color being one of the best, if not *the* best, of the wild varieties. *Attacus Atlas,* the largest of the silk-producers. *Attacus Cynthia,* or the *Ailanthus* worm, feeds on the *Palma Christi,* or castor-oil plant, and is found in Nepaul, Mussooree, Java, and is now also reared in this country, Europe, and Australia; its silk is of a fair quality, but hard to reel, and generally used as waste silk (for carding and spinning purposes). The thread produced from it is rather coarse, but very durable. *Attacus Ricini,* the castor-oil plant feeder of Assam, which is claimed to be easily reared and to produce a good, light-colored silk.

Fig. 312.

Wild Silk Compared to Silk Produced by the Bombyx Mori.—Wild silk is distinguished from the silk of the bombyx mori by the longitudinal striations seen in each of the double fibres when under the microscope, and by the apparent contraction of the fibre at certain points. The former are due to the fact that the wild silk fibre is composed of a large number of fibrils, while the latter appearance is seen because more or less flattened fibres are twisted at the contracted points.

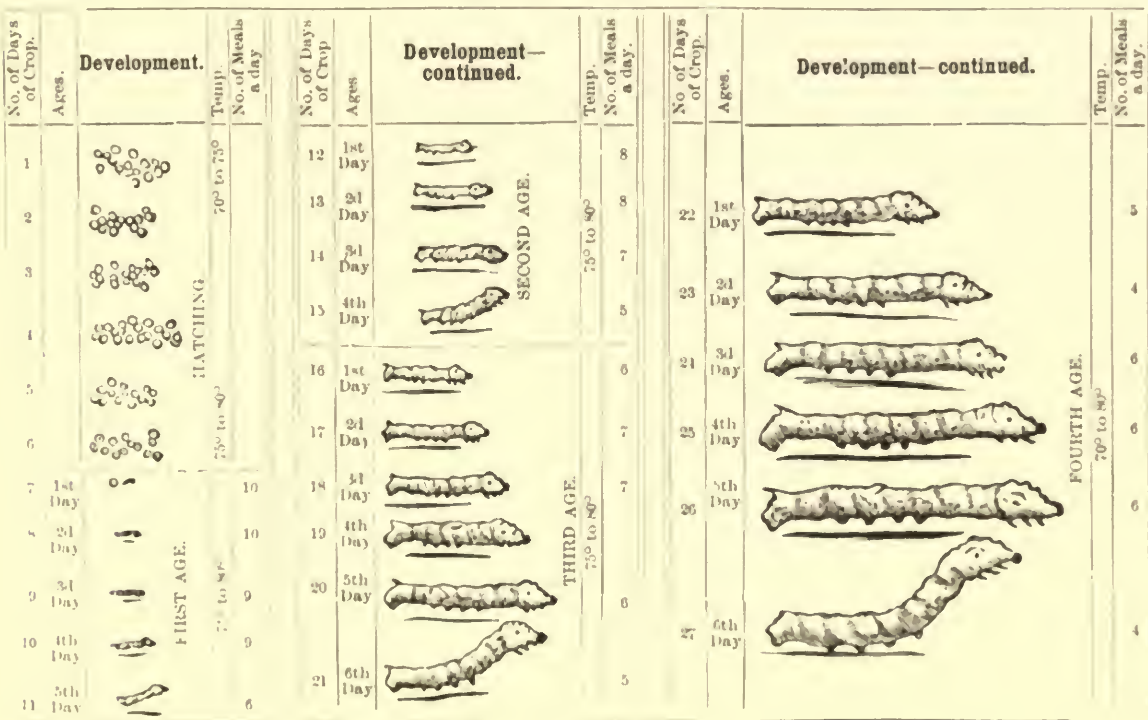
Carding, Combing and Spinning.—As already mentioned, wild silk is at present extensively used in this country and in Europe, and thus has given a stimulus for the invention of machinery for dressing, carding, combing and spinning these cocoons with waste and floss-silks of a higher class. The cocoons are first treated in strong alkaline solutions which dissolve the saliva and release the fibres from the lime-like secretions of the insect, after which the silk is boiled with soap until in a condition to be carded, combed and spun. The machines used for this process closely resemble the procedure of carding, combing and spinning cotton, worsted and flax, for when silk ceases to be a filament it becomes a fibrous material like cotton, wool or flax and thus may be treated as such, subjected to the consideration that length of the silk fibre outmeasures the previously mentioned fibres.

Tests for Distinguishing Silk from the other Fibres.—The tests for silk are by burning and treatment with chemicals. Silk if burnt curls up in the flame and emits the characteristic odor of nitrogenous animal matter in calcination. The best solvent for silk is an alkaline solution of copper and glycerine, made up as follows:—Dissolve 16 grams copper sulphate in 140–160 c.c. distilled water, and add 8 to 10 grams pure glycerine (sp. gr. 1.24); a solution of caustic soda has to be dropped gradually into the mixture till the precipitate just formed re-dissolves; excess of Na. O. H. must be avoided. This solution does not dissolve either wool or the vegetable fibres and thus serves as a distinguishing test.

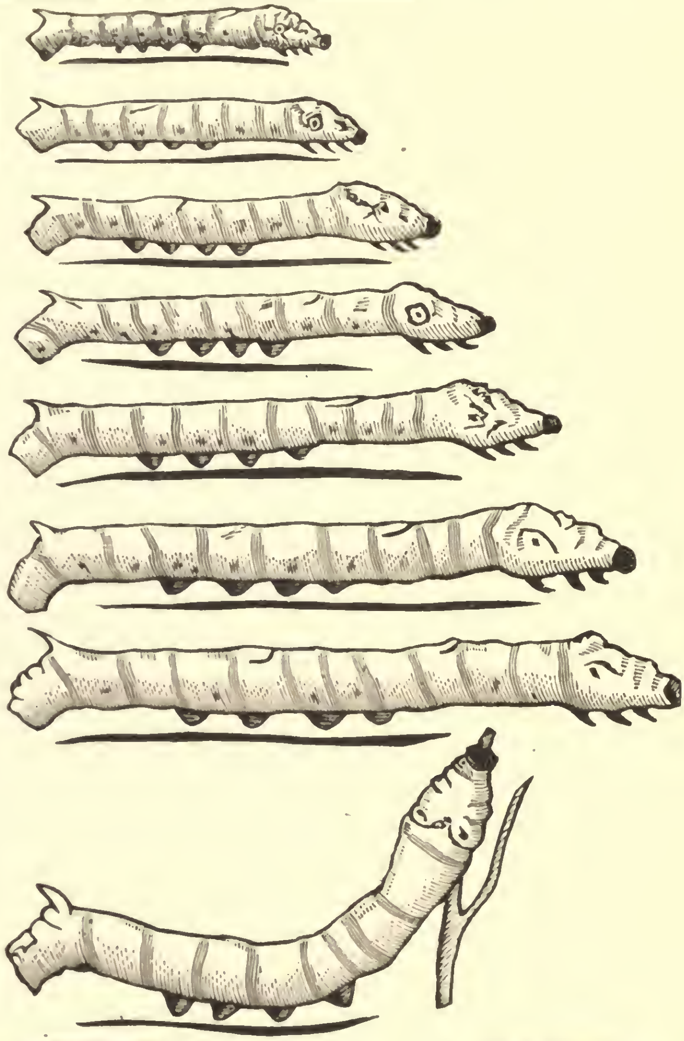
Still another method is as follows:—Concentrated zinc chloride, 138° Tw. (sp. gr. 1.69) made neutral or basic by boiling with exceess of zinc oxide, dissolves silk, slowly if cold, but very rapidly if heated, to a thick gummy liquid. This re-agent may serve to separate or distinguish silk from wool and the vegetable fibres, since these are not affected by it. If water be added to the zinc chloride solution of silk, the latter is thrown down in a flocculent precipitate. Dried at 230° to 235° F. the precipitate acquires a vitreous aspect, and is no longer soluble in ammonia.

According to Liebermann, silk can be distinguished from cotton by alkalinizing a solution of fuchsine, by adding drop by drop a liquor of potash or caustic soda. The moment the liquor gets discolored, the threads are immersed and lifted after half an hour and carefully washed. Under this treatment silk threads or fibres become red, but the cotton threads or fibres remain colorless.

Thirty-eight Illustrations Showing the Gradual Development of Eggs into Larva (or Worm), Chrysalis (or Cocoon), and Adult (or Moth).

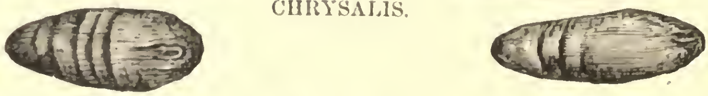


No. of Days of Crop.	Ages.	Development.	Temp.	No. of Meals a day.
1		HATCHING	70° to 75°	
2		HATCHING		
3		HATCHING		
4		HATCHING		
5		HATCHING	75° to 80°	
6		HATCHING		
7	1st Day	FIRST AGE.		10
8	2d Day	FIRST AGE.	75° to 80°	10
9	3d Day	FIRST AGE.		9
10	4th Day	FIRST AGE.		9
11	5th Day	FIRST AGE.		6
12	1st Day	SECOND AGE.		8
13	2d Day	SECOND AGE.	75° to 80°	8
14	3d Day	SECOND AGE.		7
15	4th Day	SECOND AGE.		5
16	1st Day	THIRD AGE.		6
17	2d Day	THIRD AGE.		7
18	3d Day	THIRD AGE.		7
19	4th Day	THIRD AGE.	75° to 80°	
20	5th Day	THIRD AGE.		6
21	6th Day	THIRD AGE.		5
22	1st Day	FOURTH AGE.		5
23	2d Day	FOURTH AGE.		4
24	3d Day	FOURTH AGE.		6
25	4th Day	FOURTH AGE.	70° to 80°	6
26	5th Day	FOURTH AGE.		6
27	6th Day	FOURTH AGE.		4

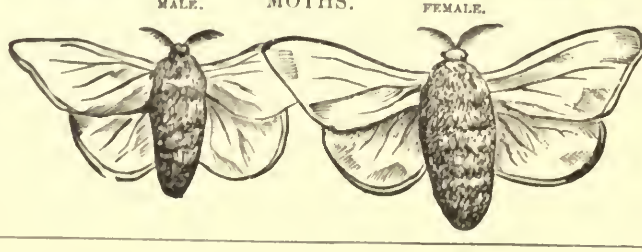
No. of Days of Crop.	Ages.	DEVELOPMENT.—Continued.	Temperature.	No of Meals a Day.
28	1st Day	FIFTH AGE. 		5
29	2d "			6
30	3d "			7
31	4th "			7
32	5th "			7
33	6th "		70° to 80°	8
34	7th "			8
35	8th "			4

COCOONS.

CHRYSALIS.



MOTHS.



Flax.

The flax plant is divided by botanists into four distinct species, of which the common (annual) flax *Linum usitatissimum* has been cultivated from the earliest times. It is yet growing wild in some parts of Asia and in Egypt. In Europe it is extensively cultivated; the time of sowing is between February and April, and the harvest season varies between June and September, whereas in Egypt it ripens under cultivation in the winter. The flax plant grows to a height of from three to four feet, and its stem branches more or less according to the thickness it is planted, *i. e.*, to the degree to which it is crowded by the other plants. The stem of the plant consists internally of the woody shore or boon which must be decomposed and removed ; externally of a layer of bast fibres encased in a fine outer skin or membrane, being the fibre from which *linen* is made.

FIG. 313.

FIG. 314

When the flax attains its full growth and approaches maturity, its tall and elegant stems of a soft green hue are surmounted by a corona of delicate branches, each branch supporting a bright blue flower. Fig. 313 illustrates flax as planted for fibre, *i. e.*, thick seeding. Fig. 314 shows the flower, Fig. 315 the seed-boll of flax (*a*, un-cut, *b*, cut through). Fig. 316 shows the flower cut lengthwise through the centre. There are five outer leaflets of the flower, all ovate and with a slightly hairy covering, and almost as long as the capsule. The stamens are alternate with the petals, and have their filaments united near their base in a circular form. The ovary is divided into five vesicles surmounted by corresponding stigmata, the capsules being egg-shaped and having a slightly pointed apex. Each of the five cells is sub-divided into two (and within these the seeds are secreted) making ten in all. These seeds vary slightly in shape, according to different conditions of growth ; but those which are slightly oval, smooth and brown in color, approach nearest to a perfect form. An internal examination of the seed shows them to be white, with the kernel oleaginous and farinaceous, while the external surface has a viscous covering soluble in water. As previously mentioned, the flax plant also grows wild, closely, but on a reduced scale, resembling the cultivated specimen. The wild flax plant never exceeds a height of about eight inches, hence is of no use for textile purposes.

a. *b.*

FIG. 315.

FIG. 316

Fig. 317 illustrates flax magnified.

FIG. 317

Chemical Composition of Flax.—The flax plant is chemically composed of:

41.97 per cent. Organic matter,
56.64 per cent. Water,
1.39 per cent. Ash.

Pulling of Flax.—The farmer who aims at the production of a good fibre, must pull the plant before it has attained its full maturity ; namely, when the lower portion of the stalk, to the extent of two-thirds of its height, has become yellow, and while the bolls or seed capsules are just changing from green to brown. At this stage the plants are pulled in handfuls, and these are laid across each other diagonally until a *sheaf* is complete, when the whole is carefully bound. If the plants are left in the ground until fully ripe (*i. e.*, the whole stem yellow) the fibre afterwards obtained will be stiffer and coarser. In finding stems of a different length, each should be pulled separately and kept in separate sheafs. as should also stems prostrated by the wind or saturated with rain.

Rippling.—The next process to which the freshly pulled flax is submitted is *rippling,* which has for its object the separation of the bolls from the stems. Flax should be rippled as soon as pulled, and the process be carried on in the same field. The *ripple* is a kind of large comb composed of iron teeth about eighteen inches long, made of half-inch square iron teeth placed $\frac{3}{16}$ of an inch apart at the bottom and tapering slightly toward the apex, screwed down to the centre of a nine-foot plank, resting on two stools. This comparatively great length and smallness of the iron teeth allows them to spring lightly, and so yield to pull of the stalk, instead of presenting a rigid surface, which would act too roughly upon them. The operation of rippling is performed by hand, drawing successive bundles of flax through the upright prongs of the ripple. The bulbs being greater in diameter than the distance apart of the rods, they are therefore stripped off and fall upon a sheet spread upon the ground under the plank for this purpose. Flax should not be rippled severely, since it is better to leave some of the seeds on than to run the risk of bruising or splitting the delicate fibres about the top of the plant. As each handful is rippled, it is deposited on the ground on the left-hand side of the operator, one being placed diagonally over the other until a sheaf is completed, when it is bound up and removed for—

Retting.—The next process and one of the most important is *retting, steeping* or *watering,* which requires from 10 to 14 days. The object of retting is to dissolve by means of decomposition the gummy or resinous matter which exists between and binds together the outer membrane and inner stalk, by submersion in water for the previously mentioned time. Pure soft water is claimed to be the best for this purpose. Hard water, or water containing lime must be avoided, and water containing iron will give the flax a rusty, or what spinners call a foxy color. The size of steeping pools or retting dams may vary from 8 to 20 feet in breadth, 30 to 50 feet in length and from 3½ to 4 feet in depth, according to the requirements of the district. These pools must be thoroughly watertight, and after the flax is put in, no water admitted or run off until the flax is taken out. The color of the flax is also affected by the nature of the soil in which the dam is located. In Ireland, which is the country most famous for its flax industry, a rich blue, or what is called clay color, is liked best. The *beets* or sheaves are placed loosely and in regular rows with the root ends downwards. They are next covered with rag-weeds and sods, and weighted with stones to keep the flax firmly under water. If the weather is warm fermentation commences in two or three days, and generally in 13 to 14 days this fermentation has proceeded far enough to permit the removal of the flax from the pool. To ascertain if the flax is ready for removal, take out four or five reeds; if you find them covered with a greenish substance, and if the woody shore separates freely from the fibre on breaking the stem about six or seven inches apart, the operation is complete. The coverings must then be taken off, and the flax removed from the pool carefully by hand, and allowed to drain and dry for a few hours preparatory to being spread evenly and thinly on a meadow.

Grassing.—The object of spreading the stalks, called *Grassing,* is, that by the action of the air and sun the drying process is completed as well as the fibres bleached. This process of grassing also renders the wood part, *Shore,* short and brittle, and easily crushed and broken. The most suitable place for spreading is grazing land of short and thick grass. In spreading the flax the same must be laid down thinly and evenly over the field and in a few days turned so as to finish the process more rapidly and perfectly. About 5 to 6 days is the average length of time required for grassing, but this, of course, depends greatly on the atmosphere. Under no circumstances should flax be spread in wet or damp weather. As heretofore mentioned, by means of the grassing operation the woody part of the flax gets brittle and breaks, easily separating from the fibre. The general method for testing if flax has been spread long enough is, to crush and rub a few stalks between the fingers and ascertain if the wood breaks easily or not. If found so, the flax is ready for *lifting*, tying in bunches and storing for the *scutch-mill*. Another method in use for retting flax is what is called *Dew-retting*.

In Dew-Retting, the flax is grassed (spread on meadow land) without steeping, simply exposing it to the action of the weather for six or eight weeks. Damp weather is the most suitable for this system of retting, since all fermentation ceases if the flax becomes dry. Some of the best flax produced, either by dew or pool retting, is such as raised in the country of Waes and Brabant, Belgium, and which is known as *blue flax*, from its very dark color.

A third method of retting is what is termed—

Cold-Water Retting.—The best flax gotten in this manner is *the creamy Flemish flax*, as found in the neighborhood of Curtrai, in Belgium. It is steeped in the soft, slowly-running, almost sluggish waters of the river, *The Golden Lys*, which, although not stagnant, has the property of causing fermentation, and gives it a fine cream color. The finest grades of this flax, after being steeped and dried, are stacked until the following year, and then steeped a second time. (In addition to the well-adapted quality of the water of the Lys for retting purposes, there are other important factors which aid in the result of producing this excellent fibre. They are: a soil preparation, with systematic rotation of crops and extent of fertilizing that few, if any, of our flax farmers have ever practiced; the use of only the best of seed, and, lastly, the most careful handling and skilful manipulation from the time the crop is ready to pull until the straw goes to the scutch-mill.)

The highest price for this flax is about $800 per ton, but it is known that $1,300 per ton has been paid, when bought for special purposes. The value of the low Russian flax (compared to the former) is only about $120 to $130 per ton.

A new method of retting flax, which has for its object the hastening of the process by a series of connected steps or treatments, has lately been patented in this country, and is as follows: After the flax has been pulled and the bolls removed (*i. e.*, rippled) the same is placed in a tight receiver or vessel, where it may be agitated, if desired, but where it will be subjected to the action of hot water under a pressure of from 20 to 60 pounds to the inch, and so remain for a period of about an hour, for the purpose of making soluble the gummy and starchy elements of the material and for expanding the stalk and woody parts of the material. After being thus treated, as stated, the water and pressure are removed and the material in the receiver is treated with cold air for about an hour, or time enough to cool it, this cooling having the effect of separating the fibrous cuticle from the woody stalk part. After being thus cooled, the material is treated in the receiver with a steam pressure of from 30 to 60 pounds to the inch for about an hour, to expand the cellulose of the bark or cuticle, which by the preceding steps has been caused to cleave from the woody stalk parts of the material. After being thus treated under steam pressure for the time before stated, the material is then treated with cold water to remove the gummy, starchy and earthy elements made soluble by the process before named. After being thus treated the fibrous cuticle is free from the woody stalk centre of the flax, and also free from gummy and starchy elements, and in good condition for scutching, roughing, hackling, etc. The second treatment used in sequence to the former serves to still further divide up the cellulose and removes the soluble material adhering to the fibre after the condensation following the first treatment. This method of quick retting of flax is claimed to be also available for jute, hemp, and other forms of vegetable cellulose, using less time for treatment and less pressure than that before-named, where the size of the stalks is small, but increasing the time and pressure from that before-named, where the size of the stalks is larger.

Scutching.—The next process to which the flax-plant is subjected is *scutching*, which can be done by power or hand work.

In *hand-scutching* the flax is broken by threshing it with a wooden mallet. Fig. 318 illustrates a *hand-brake* as used in connection with this operation, and consists of three slats of hard wood fastened at one end to a solid stand and having the other end mortised into a frame. Fig. 319 illustrates a *gavel-holder* which is a great convenience in holding of flax during the process of breaking. The

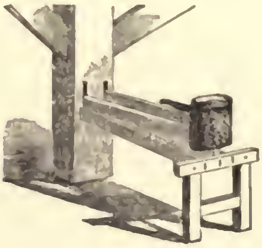


FIG. 318.


FIG. 319.

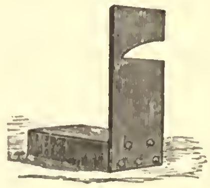


FIG 320.


FIG. 321.

scutcher must always commence threshing at the root end. After breaking the stems of the flax, a convenient amount is hung through a niche in an (upright) *scutching-board*, see Fig. 320, and struck several times with the blade of a *scutching-knife* (of which three different specimens are shown; see Figs. 321, 322 and 323) until the fibre is completely cleaned, *i. e.*, the operator by means of the scutch-


FIG. 322.


FIG. 323.

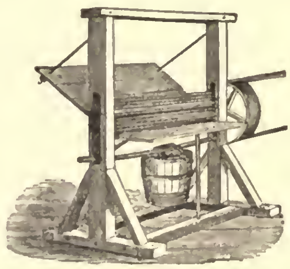


FIG. 324.

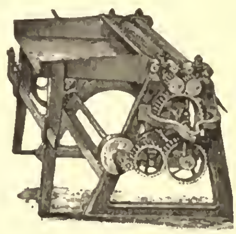


FIG. 325.

ing, breaks up the outside membrane into fibres, and removes the internal woody part, which of course falls to the ground.

In scutching the flax by machinery, *power-scutching*, the same is submitted to a *power-brake*, of which we give illustrations of three different makes in Figs. 324, 325 and 326. In Fig. 324 which is the most simple in its construction, the flax has to go through two fluted iron rollers for the purpose of breaking the woody part into small bits, leaving the stalks pliable and so manageable for the *power-scutcher*. In Fig. 325 a better built and more effective style of a flax-brake is shown, consisting of two pairs of fluted iron rollers between which the flax as spread on the feeding-table must pass. Fig. 326 illustrates another flax-brake. In this machine two sections of several iron rods arranged in the shape of a grate are moved against and with their edges slightly past each other and back again, thus breaking the flax held between during the operation. After the flax has been broken on either one of these flax-brakes, the same is submitted to the power-scutcher, of which we give illustrations of two styles of machines as used, in Figs. 327 and 328. Fig. 327 illustrates the most simple specimen as to construction, consisting of a wooden shaft, having five scutching-knives set in it similar to the spokes of a wheel. These scutching-knives must be set perfectly true so that each strikes exactly the same spot as the previous one. They


FIG. 326.

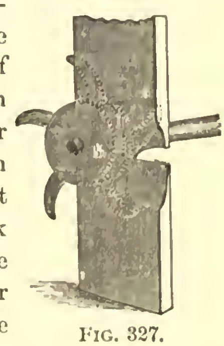


FIG. 327.

are thick at the back and tapering on one side to a pretty sharp edge, the plain side being placed next the stock. The scutching-knives revolve close to a wooden or metal upright stock or scutching-board at the back of which the man stands, putting the flax over the top and allowing the blades to strike it and so clear off the wood. Fig. 328 illustrates a more practically constructed machine, yet in its principle it is similar to the previously explained scutcher. Five scutching-knives are used, see *B*, each one fastened to one of the arms *C*. In using this machine the flax is generally submitted to two operations, the *rough-scutching* and the *finishing-scutching*. For rough-scutching the knives are set some short distance apart from the scutching-board (see *A*,) whereas, for the finishing operation, the knives are set to work closely toward the scutching-board. The upper part of the scutching-board has a rectangular-shaped piece (see *a*,) cut out, and the same fastened or held in its original position by the two steel braces *b*. This is done to permit a slight outside motion of the piece *a*, hence to save the fibres in case the knives are set too close, or a few extra heavy stems mixed in with the material. The average speed of a power-scutcher is 200 revolutions per minute, hence 200 × 5 (five knives used in the machine) = 1,000 strokes of knives upon the flax per minute.

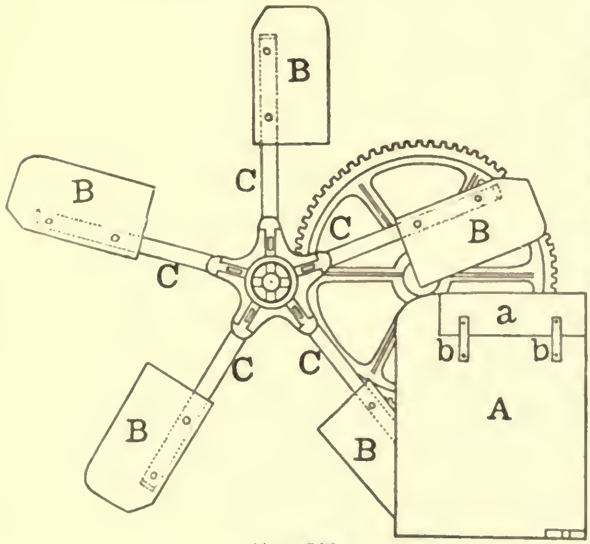


Fig. 328.

Improved Power Scutcher.—An ingenious machine for scutching flax has lately been invented by McGrath and Manisty. The invention relates to an apparatus for scutching or similarly treating flax (and other fibrous materials as jute, hemp, &c.) in a continuous manner and embraces means of

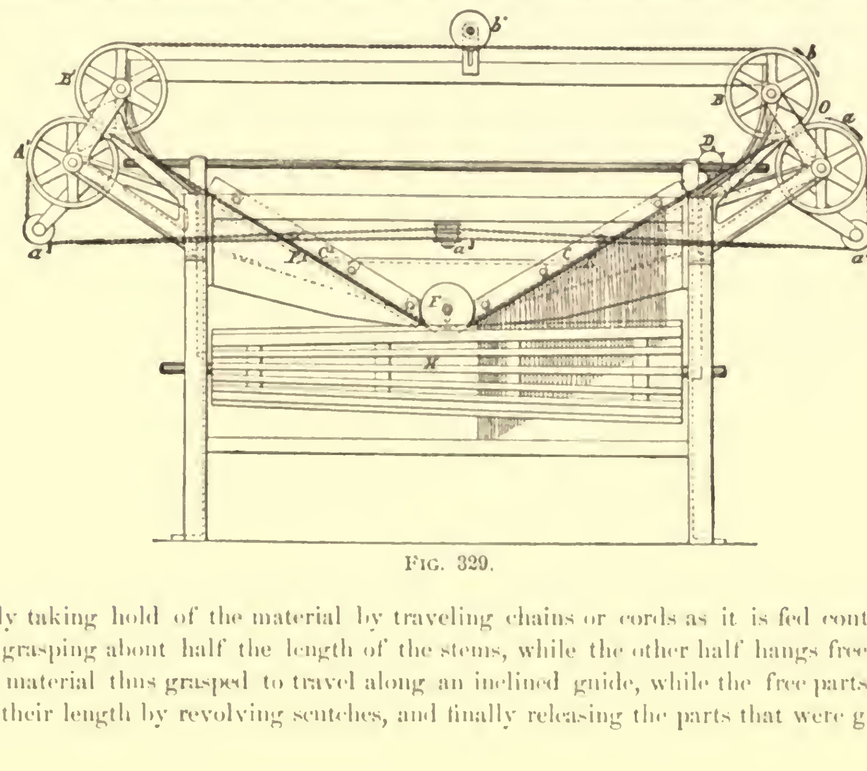


Fig. 329.

automatically taking hold of the material by traveling chains or cords as it is fed continuously, and thus firmly grasping about half the length of the stems, while the other half hangs freely downward, causing the material thus grasped to travel along an inclined guide, while the free parts are acted on throughout their length by revolving scutches, and finally releasing the parts that were grasped so that they in their turn can be scutched, while the parts already scutched are similarly grasped and moved. Diagrams, Figs. 329 to 337 are given to convey a clear idea of the apparatus and procedure. Fig. 329 is a side view; Fig. 330 is an end view, and Fig. 331 is a plan of the machine. The other figures drawn to an enlarged scale are: Fig. 332, a part side view, and Fig. 333 a part plan, showing the arrangement of the chains at the entering end of the inclined guide. Figs. 334, 335, 336 and 337 are part transverse sections on the lines z, z_1, z^2 and z^3 respectively of Fig. 333. Letters of reference in all nine illustrations are taken correspondingly. In bearings in a suitable framing are journaled the shafts of two scutching-drums *H*, which are driven at considerable speed in opposite directions, as indicated by the arrows *h*. These drums may be cylindrical or of equal diameter throughout, but it will be advantageous to make them taper as shown in our illustrations, so that at the entering or right hand end where the scutches act first on the fibrous material, breaking the woody substance of the stems, they have greater speed than they have at the leaving end, where they act chiefly for brushing or clearing off the woody fragments. In the upper part of the framing are mounted two pairs of chain-wheels, one pair *A*, below and a little to the one side of the other pair *B*. These are driven in

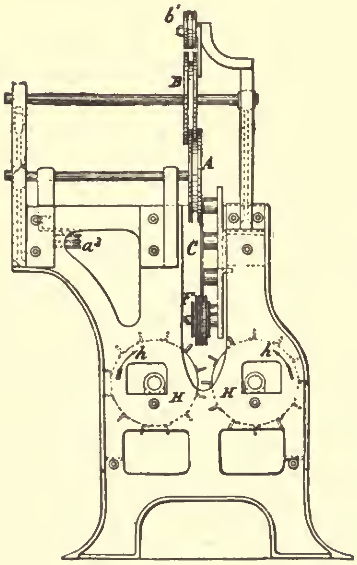


Fig. 330.

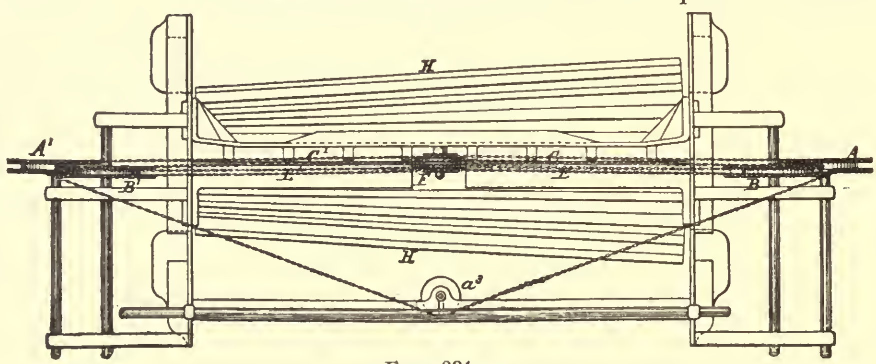


Fig. 331.

opposite directions, as indicated by the arrows *a*, *b*, at a relatively slow speed, for example, the scutch-drums *H*, should revolve from thirty to forty times faster than the chain-wheels *A*, *B*, for the average quality of flax; but this proportion may be varied according to the quality and the nature of the material operated upon. By the chain-wheels *A*, *B*, four endless chains 1, 2, 3 and 4 are caused to travel down an inclined carrier rail *E*, under a guide-pulley *F*, up an inclined rail E^1, around chain-wheels A^1, B^1. At the left hand end of the machine the chains from the wheels *A*, A^1 are led by guide pulleys a^1, a^2 and a tension pulley a^3, obliquely away and back in a horizontal plane, and the other two chains from *B*, B^1, are led under a tension pulley b^1, at the top of the machine. A star-wheel *D*, is so arranged (as shown more clearly in Figs. 332 and 333) that its teeth or

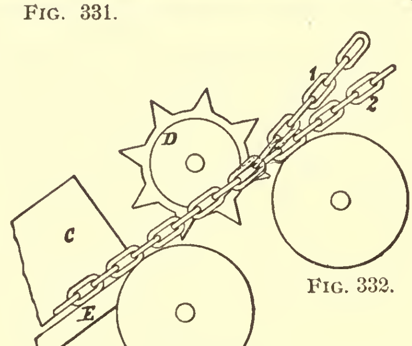


Fig. 332.

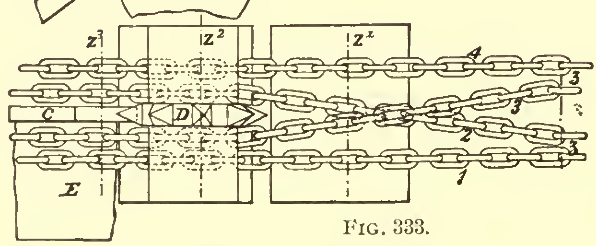


Fig. 333.

rays penetrate between two of the chains, 2 and 3, just beyond a point where these chains cross each other, one above the other (as shown in Fig. 333), and before the four chains reach the beginning of the inclined rail *E*. This star-wheel is free to revolve, being driven by the friction of the chains that bear against its sides. A little above the front edge of the carrier-rail *E*, and parallel to it (as shown in Fig. 337) is fixed a skid-rail *C*, leaving between its lower edge and the upper face of the rail *E*, a narrow space not wide enough to allow any of the chains to pass through it. The material is fed in between the chains passing around pulley *B*, and those passing around pulley *A*, and will assume the position shown in Fig. 334 by reason of the chains from said pulleys being carried past each other by the alternating overlapping peripheries of said pulleys on which the chains are carried. After passing between the pulleys, the chains 2 and 3 are crossed and carried upon opposite sides of the star-wheel *D*; and in effecting this the flax is brought into the position shown in Fig. 335, in which it will be noticed the relative positions of the chains 1 and 4, are the same as in Fig. 334, while the chains 2 and 3 have simply assumed the opposite relative positions ensuing from their crossing, caused by the intervention of the star-wheel. By now bringing all four chains into substantially the same horizontal plane, which is the position they naturally tend to assume after passing the star-wheel *D*, owing to the guidance of pulley *F*, the overlapped loops of fibre are formed, as shown in Fig. 336, forming the triple strand between chains 1 and 3 and chains 2 and 4. The triple strand thus formed is then drawn under the edge of the skid-rail *C*, as shown in Fig. 337. While nearly half the length of the fibrous material is thus grasped, there hangs from between the chains 2 and 4 somewhat more than half the length of fibrous material free, which, as the chains move along the incline *E*, downward, is caught between the scutch-drums *H*, and acted on by their scutches or beaters, first at the lower end, and then at parts gradually higher and higher, until the lowest part of the incline is reached. The whole length of free fibres being thus scutched, it is again acted on as the chains ascend the slope E^1. At the left hand end of the machine the chains are made to alter their relative positions in an inverted order by simply crossing chains 2 and 3 after they leave the skid-rail *C*, and carrying them to the pulleys A^1, B^1, respectively, so as to release the fibres from their entanglement; and the fibres, having one part, about one-half of their length, scutched, are delivered from between the chain-wheels A^1, B^1. By feeding the fibrous stems in an inverted position into the machine again at its right hand end, or into another similar machine, so that the scutched part of their length is grasped by the chains, while the part hitherto unscutched hangs free, the scutching of the whole length can be accomplished. The scutches or beaters on the drums *H*, may have plain edges, or edges waved, serrated, or indented, according to the character of the material on which they have to operate. Throughout half the length of the drums the beaters may be of one pattern for breaking, and throughout the other half they may be of a different pattern, suited for brushing off the woody fragments from the fibres. The guide pulley *F*, has the outside grooves of less diameter than the two intermediate grooves, to permit the same to be set down deeper between the drums *H*, than if all the grooves were of the same diameter. The scutching-drums *H*, and the chain-wheels *A*, *B*, may be arranged either to be driven independently from any convenient motor, or they may be connected by any suitable gear to give them relative speeds required.

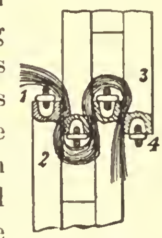


FIG. 334.

FIG. 335.

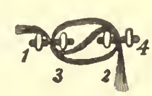


FIG. 336.

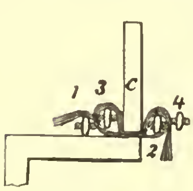


FIG. 337.

A competent scutcher aims to thoroughly separate the fibre from the woody part with as little waste as possible. No doubt there will always be more or less short fibre removed along with the unworkable matter, the percentage of loss being greater when the retting process has been slighted. These short fibres called *tow*, when removed from the woody droppings, are afterwards manufactured (by means of carding in place of hackling and spreading as used for linen yarns) into an inferior grade of yarns known as *tow-yarns*. When scutched, a good flax fibre is of a bright silver-gray color, and glossy (resembling silk) in its appearance. When dark in color or of a greenish tint, the fibres are either of an inferior quality, or have been imperfectly treated during the previously explained manipulations. After scutching, the flax is ready for the market, *i. e.*, the spinning mill.

Flax Spinning.—Under this name we technically classify all the different processes the fibre is subjected to for producing either flax or tow yarns; *i. e.*, roughing, hackling, spreading, carding, drawing, roving and spinning.

Roughing is the first process the flax is subjected to in a spinning mill, and the object of the operation is, to divide the flax into *pieces* of a certain size, this being regulated according to the description of the flax. The work is done by the *rougher* by means or help of a hackle. He places the root end of the flax in the hackle and holding the piece by the crop end, then pulls it out. Consequently fibres that were loose or straggling are left in the hackle, which are then taken out and placed evenly on the piece with the others. Some roughers place both ends of the flax (successively crop and root end) in the hackle for pulling out the loose or straggling fibres. The pieces of flax after thus being separated according to length are next drawn across the hackle, thus being opened up and freed from any lumps, knots and coarse tow. The loose fibres left in the hackle are afterwards broken off by means of a *touch-pin.* When each handful of the material has thus been fully operated upon, the rougher gives it a slight twist so as to keep each piece separate. When roughing is found too expensive a process, *stacking* is substituted, which consists in piecing the flax in double pieces, straightening out their length some, next opening on the hackle and breaking the root ends. Stacking is done by boys, whereas roughing is men's work. In some instances both processes are done away with, which is a great error, for spinners will lose a great deal more in waste during spinning operations.

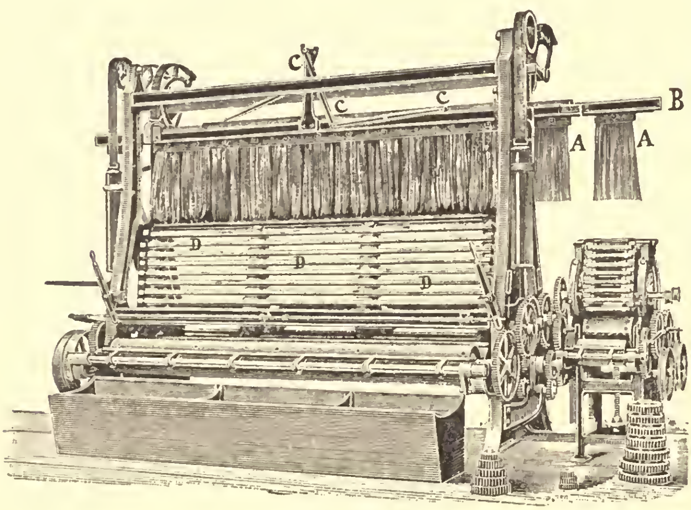


Fig. 338.

Hackling is the next process through which the flax passes in a spinning mill and consists in the splitting of the fibres to the finest condition they are capable of assuming without detriment. The work is done on the *hackling machine,* of which we give an illustration in Fig. 338. The flax arranged in bundles by the rougher at the finishing of the roughing process, is now taken in charge by a boy or girl called a *filler*, who lifts two pieces of flax off the rougher's bench before him, arranges the same between two small iron plates called *holder*, and which are then screwed securely together by a bolt and nut through their centres. To secure a positive grip of the holder, the inside faces are covered with corrugated india rubber or cloth. After the filler has filled the holder, he places the same (see *A*) on their edges in a horizontal groove or channel (see *B*) running along the machine above the hackle needles, which revolve on two parallel rollers working into each other. From the channel overhead the flax is hanging between the cylinder needles, which when revolving pierce it, splitting or reducing the fibres to the finest condition they are capable of assuming, as well as combing off all impurities from the fibres, leaving them straight and parallel. Inside the head (or channel) of the machine is a rack working upon a slide. This rack, by means of detents, catches the holder as soon as it passes into the channel and moves it along the channel towards the other end of the machine. By means of cams and connecting rods (see *C*), the channel alternately rises and lowers towards the hackle, thus permitting the flax from the edge of the holder downwards to be fully operated upon. Each time the head rises to its full height each holder in the machine is moved its own length forward, the flax always passing, as before, between the two vertical sets of hackles, but in a finer set. These two sets of hackles (see *D*) are technically called *tools* and the number of tools to each sheet varies according to circumstances, the coarsest coming into contact with the material first, and the finest when the end of the traverse has been reached. These tools penetrating the flax would easily get clogged but for their being automatically cleaned by means of rotating brushes fixed upon wooden cylinders. These tools are not arranged in single rows, but in pairs, one higher compared to the other. When the holders containing the flax have passed over the width of the machine, they are then automatically deposited upon a kind of rail from whence they are removed by the boy or girl in attendance on the machine, who, laying it flat on a table and in a bed arranged to receive it, permitting the hackled portion of the flax to fall evenly over another holder lying open in its bed to receive it. After fastening the new holder the former is opened and removed, whereas the flax in its new holder is again passed into operation by being placed in another machine and the other end combed similar to the first explained. Frequently a *double-acting hackling machine* is used. Such a machine (for illustration see Fig. 339) is really a combination of two machines in one; hence, after each holder has passed on one side, and the flax changed to a new holder, the latter is inserted and run through number two division (or the other side). When this operation is completed the flax is taken from the holders and placed in a box, the pieces being laid crosswise upon each to keep them separate for future processes. Underneath the hackles, boxes or baskets are placed to receive the combings, called tow, which are used for the manufacture of inferior yarns known as tow-yarns. Each parcel of hackled flax is called a *tipple*, and after the box is filled with them, it is removed to another department to undergo the operation of

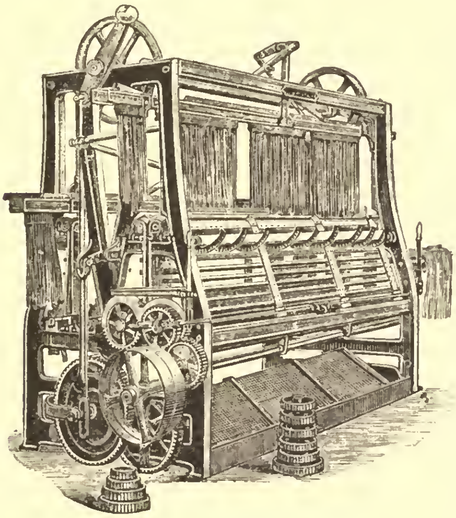


FIG 339.

Sorting.—In the sorting room each box of hackled flax is separated into various qualities. At the same time the fibre is pulled by the sorter through a coarse hackle called a *ten*, broken, and afterwards cleaned out over a finer hackle called a *switch*. This work in addition to sorting requires men who are good hacklers as well as experienced sorters. To supply roughed flax for a hackling-machine requires the work of four roughers, whereas seven sorters (on an average) are required to dress and sort the hackled flax obtained from one machine.

Spreading.—This is the next process to which the dressed and sorted flax is subjected, and is produced on the *spread-board*, of which an illustration is given (feeding end) in Fig. 340. The object of spreading is to produce a sliver out of the bunches of dressed and sorted flax, as is done in worsted spinning by means of the preparer. The spread-board is about ten feet long and four feet high and wide. Examining our illustration we find the feeding table indicated by *A*. Upon this table the

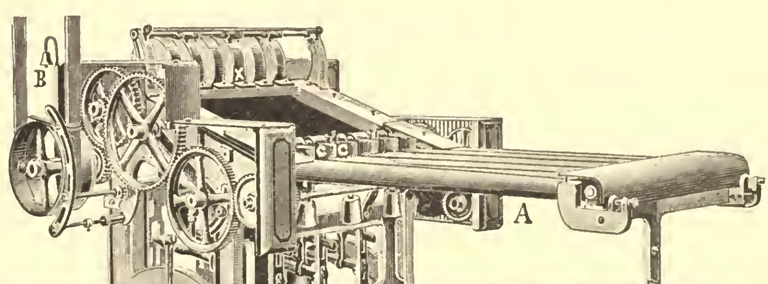


FIG. 340.

flax fibres are spread in even layers, having the length parallel to the direction of the motion of the line, and so arranged that the pointed ends of the one flax bunch overlays into the next, thus producing a continuous bunch of about the same thickness. It must be remembered that the root end of the bunch will be always heavier than the crop end, hence care must be taken to spread all the bunches in the same direction, *i. e.*, have the root end of the one bunch overlap with the crop end of the succeeding bunch. At the end of the table and connecting with the machine we find the vertical partitions indicated by *C* in diagram. Between those the spread flax passes in its course to a pair of rollers (feed-rollers) which after once taking hold of a bunch will pull the others gradually along. On the upper part of the machine we readily notice in the illustration a second system of rollers which are indicated by *X*. These rollers in turn take the bunches of flax from the first set of rollers, and having a greater surface-speed compared with the first set of rollers, consequently pull or draw on the bunches of flax after they leave the first set of rollers. If we were only to submit the flax to the action of these two pairs of rollers, no doubt the bunches of flax as overlapped on the table before feeding in the machine, would again easily separate after leaving the second pair of rollers. To prevent this a peculiar and ingenious arrangement of combs called *fallers* is added to the machine. This system of combs catches in the fibre from underneath, between the feeding and drawing-rollers (first and second pair of rollers previously mentioned) consequently hold the fibres, draw, and at the same time prevent a separation of the material. The fallers as previously mentioned are situated below both pairs of rollers, and thus are not visible in the illustration of the machine. In order to illustrate the subject in detail to the student, the following four special illustrations, Figs. 341, 342, 343 and 344, are given (letters of reference in all four diagrams are selected correspondingly). Fig. 341 shows their top view. The pins or gills are fastened upon little narrow strips of steel of a rectangular section, (fallers) each of which rests on both ends in the thread of an endless screw *a*. Turning the screws consequently moves those individual fallers along parallel with each other. After each faller in succession has traveled the distance from *b* to *c*, as shown in the illustration, it is lowered by means of an ingenious arrangement (shown in Fig. 342) below the working combs and returned in the threads of the screws at *b*. Examining illustration Fig. 342 we find below the screw *a*, another endless screw indicated *d*. As soon as each gill has finished the thread of the screws *a*, they fall down and are taken up by the lower screws *d*, which in turn guide each faller back. Arriving at the end of screws *d*, the same is taken hold of and lifted by means of an arrangement of levers (as clearly visible at *e*, in Fig. 343) in the threads of the screws *a*, to commence work over again. Fig. 344 shows an individual faller as well as the sections of the screws *a*, also clearly indicates the manner in which the ends of the fallers rest on the threads of the screws. The thread of the lower situated screws is such as to produce a quicker movement of the fallers compared to the motion of the fallers produced by the upper or working screws. This permits the use of a less number of fallers than if both sets of screws were to have the same thread.

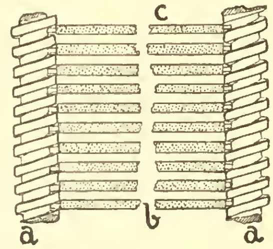


Fig. 341.

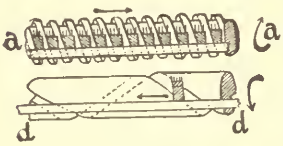


Fig 342.

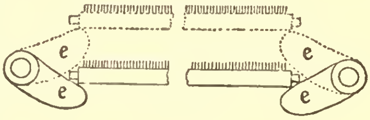


Fig. 343.

As previously mentioned, the bunches of flax spread on the feeding table of the spread-board are stretched or drawn out by means of the two pairs of rollers called feed-rollers and delivery-rollers, and are mixed in a solid continuous sliver by means of the gills of the fallers. Out of each one of the six bunches of hackled flax fed into the spread-board we find only a single (and proportionately thin) sliver leaving. This sliver is caught by two conductor rollers situated in front of the machine, which deliver it into cylindrical cans (sliver cans) placed in front to receive it. Each yard of sliver so delivered is measured previously to its delivery in the sliver can, and registered by a simple arrangement. *B*, in illustration Fig. 340, shows the bell which rings when

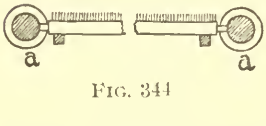


Fig. 344

a certain fixed length of the sliver has been delivered into the can, and which, after being filled, must be replaced by an empty one, to be filled in its turn. The intervals at which the bell rings can be altered, by change of wheel, to suit any required length of sliver (from 300 to 2,000 yards) to be delivered in the can. The measuring of the sliver as it leaves the spread-board is necessary, since it is essential for future operations to be able to produce the sliver of a given weight for a certain number of yards in length.

A certain number of the measured cans are weighed, the net total being given as the weight of the *set.* Since all cans in a set must be doubled into one sliver, there are actually only so many yards to this weight of set as there are yards in the bell, hence it is only a question of calculation to ascertain the yards per pound or ounce. The length of the sliver will be increased during future operations; *i. e.*, drafting and doubling. Rule.—The shorter the drafts and the greater the doublings, the lighter will be the set required to produce a given number of yards; and the longer the drafts and the less the doubling, the heavier must it be to produce the same number of yards. For fine and special preparation light sets must be produced.

The spread-board is capable of spreading, drawing, stretching or extending the bunches of flax to from 25 to 40 times their original length, as when fed in the machine. As previously mentioned, every division of flax bunches is fed to its own set of feed-rollers, as well as corresponding drawing-rollers; hence in most machines six sets of these rollers (corresponding to the divisions on the spreading table) are used, though some machines are built to contain only four departments each in place of six. The feed-rollers are made of iron and extend across the machine, whereas there is a special drawing-roller for each sliver. The latter are made of hard wood and are firmly pressed to the bottom roller (by means of hand-screws) from the contact of which they derive their motion. This prevents any possibility of the material slipping while passing between the same, and keeps the *draft* perfectly uniform at every point. Before continuing the explanation of the further processes, the sliver on leaving the spread-board is subjected to, we must mention another process by means of which a sliver is also produced, *i. e.*

Carding.—This process is required for producing the characteristic sliver from the short fibres and impurities that come from flax during scutching, hackling and dressing. These fibres are technically known as *tow,* and are put through a different process than is done with the line flax so far. To produce a sliver from tow the carding engine is brought into requisition. The process of carding tow consists in arranging the mixed up fibres parallel to each other, to form a continuous lap, and then convert the same into the sliver ready for the succeeding operations. Thus in its principle the carding of the tow is the same as the carding of the cotton, the only difference being found in the construction of the different parts of the carding engine. Tow as compared to cotton is of a coarser nature, also a correspondingly longer fibre, consequently the working parts of the carding engine as used for tow, must be of a heavier build, and the card clothing made of pins set rather open. There are two kinds of cards in use;—*breaker card* and *finisher card.* The tow is first put through the breaker card or coarse card and there sometimes mixed with coarse grades of hackled flax (which are termed *milled tows*) and afterwards carded on the finisher card and successively prepared for spinning into tow yarns.

Breaker Card.—This consists of a large cast-iron cylinder, of about three to five feet diameter, and four to eight feet face or width. This cylinder, called a *swift,* rests upon strong cast-iron stands, and in operating, the machine is made to revolve at a great speed. The stands are also arranged to carry the axles of several rollers of similar face covering as the swift, but of a much smaller diameter. These rollers revolve in different directions, but parallel and facing close up to the large cylinder or swift. The clothing for swift and the rollers are pins of a size and texture (number per square inch) to suit the grade of the raw material to be worked upon the carding engine. To illustrate the process of carding Fig. 345, representing such a carding engine, is given. The tow is placed upon the feed-lattice or apron *A*, which is divided into three subdivisions (see 1, 2 and 3). This feed-apron passes the tow spread upon it between two rollers parallel to one another and to the face of the swift. These rollers, called feed-rollers, are about three inches in diameter, revolve in opposite directions and inwards towards the swift. They are, as the name indicates, the medium of feeding the tow to the swift or main cylinder, which revolving downwards, strikes and carries away the tow from the feed-rollers. The average clothing of the swift consists of pins about $\frac{7}{8}$ inch in length, set at a slightly downward inclination through strips of wood from $\frac{3}{8}$ inch to $\frac{5}{8}$ inch thick, 3 inches broad, and 24 inches long, and which are screwed to the cylinder. This will give us an actual length of the pins over its wooden clothing of from $\frac{1}{4}$ to $\frac{1}{2}$ inch ($\frac{7}{8}-\frac{5}{8}=\frac{2}{8}$ and $\frac{7}{8}-\frac{3}{8}=\frac{4}{8}$). As previously mentioned, the points of these pins face close up to the pins in the feed-rollers, and as the latter deliver the tow, the pins of the cylinder strip it slowly away. The roller on which most of the material rests is the one uppermost, and which, by being merely a hooker-in, allows the fibres to hook against the pins of the cylinder. Hence the latter does not take too much away at once; besides such of the fibres as it does take are pretty well broken by means of the splitting between the points of the pins. To prevent tow from clogging the lower feed-roller there is a *feed-stripper* connected to its under side, and at the same time to the cylinder. This feed-stripper revolves at a high rate of speed in the direction of the cylinder, and has its pin hooked in toward those of the cylinder and of the lower feed-roller. The feed-stripper consequently strips the tow out of the lower feed-roller, and in turn gets stripped itself by the cylinder. The cylinder or swift carries the tow from the feeding-roller (towards the lower half of the carding engine) until caught up by the first *worker*, which has the same diameter as the feed-stripper, and which revolves slowly in an opposite direction from the swift, having its pins hooked against the pins of the swift, so that they lift away those fibres that are on the swift, at the same time splitting them still more between the points of the pins. This first worker is stripped by the roller as situated between it and the feed-stripper, called the first *stripper*, and which revolves at a high rate of speed in the same direction as the worker, stripping the fibre of the worker and returning it to the swift. The setting of the pins in the stripper and the swift is such as to work in towards one another; consequently there is only a delivery of the fibres from the former to the latter; all the cutting of the fibres being done between the pins of the swift and those of the workers, the pins of the latter being hooked against those of the former, and revolve slowly in an opposite direction. The continuous retaining, stripping and delivering of the fibres to and fro from the swift in return, cleans, equalizes and splits the fibres; the process is carried on around the swift over as many pairs of workers and strippers as there are in the card. The number of these workers and strippers employed is regulated by the fineness of the card. When the *baird* arrives at the last worker on the card it is consequently stripped by its mate stripper, and from there carried to the swift until intercepted by the next roller, which is of a large size, called *doffer*, and works on the same principle as a worker, only without a stripper-roller to clean it. From this doffer the tow is taken off by a quickly oscillating comb, called *doffer-comb*, which beats down the tow from the pins. The tow is then separated into three divisions, and drawn through calender-rollers *C*, in the form of a coarse sliver. In the same manner the fibres are stripped off one or two other doffer cylinders situated beneath this first doffer. The three slivers as coming from the calender-rollers are either run off individually into cans arranged near the machine to receive them, by means of conductor-rollers *B*, or, as is mostly the case, they are united in one sliver before leaving the card. After filling the cans with slivers, they are taken to a machine and lapped onto large bobbins or reels, and when the latter is filled, taken and set in a creel or rack before the feed-rollers of the finisher card, taking the place of the feeding table in the

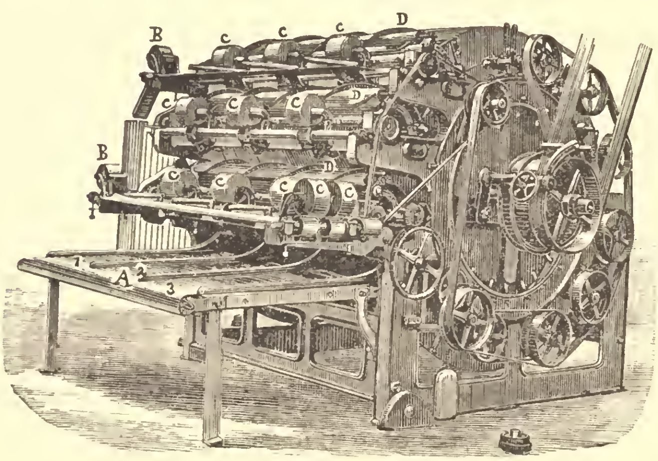


Fig. 345.

breaker card. Below each doffer we find a revolving brush *D*, whose object it is to clean the clothing of the respective doffer from any possible impurities adhering to the fibres.

Finisher Card.—This machine is constructed on the same principle as the previously explained breaker card, the only difference being that the clothing is finer and thicker set, shorter pins in the clothing being used, and also more pairs of rollers of a smaller diameter so as to give more working to the fibres.

Combination Cards.—These machines are intended for carding the better grade of tow, for which one operation is sufficient. This carding engine is also called *breaker and finisher* from the fact of its being a combination of both as well as being a machine which does with one manipulation for the better grade of tow, which for a coarse grade requires the two separate manipulations as previously explained. In this combination card of which we give an illustration in Fig. 346 the tow is, similarly as done in the breaker card, spread evenly upon the feeding table *A*, and delivered in an even body to the machine to be separated into as many slivers as there are front conductors *C*. These slivers are next passed on the sliver plate *E*, which is a polished cast iron plate as long as the face of the carding engine and sufficiently deep to permit the various slivers, into which the deliveries have been doubled, to be carried round large pins (horns) then along the sliver plate into the back conductors of a small card-drawing head which is called a *rotary*, and from which the separately entering slivers emerge in one sliver which is delivered in the sliver can ready for the next operation.

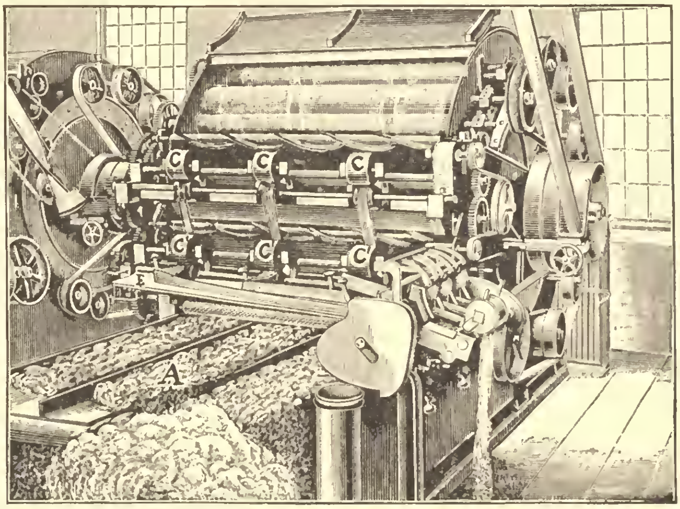


Fig. 346.

In mills where only a single carding engine is used, the material is first passed through a *teaser* for the purpose of shaking the tow loose and knocking out the impurities to allow the card to act more effectively on the fibres.

Combing.—The method of combing the slivers in the form in which they are delivered at the card has since the last few years been introduced in several mills. The work is done on the combing machine; the slivers as delivered at the carding engine are taken and placed up at the back, six ends generally being passed into one machine. After passing the slivers through the feed-rollers they are pierced by a series of steel pins, *combs*, which divide the fibres, lay them in parallel directions, and comb out the short fibre and various impurities. The six (or less) slivers in the machine are united and contracted into the form of a single sliver by being passed through a trumpet mouth and pair of rollers, from which they are carried to a second pair and finally delivered into a can. Connected with the delivery rollers of a combing machine by means of proper gearing, is a bell, which rings when a certain length of material has passed into the can. This is done to keep the length as delivered into each can approximately equal, hence easier for calculation in future process of drawing out the sliver to a requisite length. A better yarn, stronger and more equal, can be produced from combed material than where only carding machines are employed.

Drawing.—So far we have explained the production of the first sliver or foundation of the future yarn either for the *line* by means of the spread-board or for *tow* by means of the carding engine. The next machine which either sliver is subjected to for the purpose of still further increasing the fineness and uniformity of the sliver is the *drawing-frame*. Both fibres (line and tow) are from now treated by similar processes. The tow being a shorter staple compared to the line will necessitate a few slight changes in the construction of the machinery and to which we will refer in following chapters. The drawing-frame of which we give an illustration in Fig. 347, is in its principle identical with the spread-board previously explained, as well as with the drawing-frames used in cotton spinning. The main feature of it is to pass the sliver between two sets of rollers of which the second or drawing-roller set has a greater surface speed compared to the first (or feeding-roller set), consequently a drawing out of the sliver takes place. One feature in which the drawing-frame for flax differs from the one used for cotton is the arrangement of fallers, situated between the feeding and drawing-rollers in the drawing-frame for the flax fibre. This ingenious mechanism (in its construction similar to the arrangement of the fallers in the spread-board) is of a twofold advantage; first it continues always more or less the hackling process and secondly it assists in elongating the sliver by means of having a greater speed than the feeding-rollers. The hackled flax (or line) is generally drawn three times, and with about the following dimensions as to distance of rollers. In the first drawing the distance is 28 inches, which is reduced in the second drawing to 26 inches, and in the third drawing to 24 inches. Each machine is capable of reducing the size of the sliver from 10 to 20 times, but the general plan in use is to draw out the sliver the most on the first machine, less on the second, and less yet on the third frame. During the process of drawing we also double, *i. e.*, several slivers on leaving the drawing-frame are combined together, and drawn out again to any desired consistency by regulating the speed between the rollers. The number of drawn out slivers to be doubled is regulated by the amount of drawing out the fibre, have been subjected to. In drawing tow, the sliver generally only passes through two drawing-frames, and for reason of the shorter staple of the fibre (compared to the line) the distance between the feeding and delivery-rollers must be less than drawing line. The average distances are 14 inches on the first drawing-frame and 12 inches on the second. Both machines allow a drawing out of from 6 to 14 times, consequently the amount of doubling done in tow is less than for line. Examining the illustration of the drawing-frame we find the following letters of reference used. The pair of drawing-rollers consists of an iron roller having a larger wooden roller *A*, on top. This wooden roller is pressed by means of levers and weights (see *B* and B^1) against the bottom roller (which is not visible in our illustration) and receives motion by means of the friction with the latter roller. The upper roller is generally made of alder wood and sufficiently large to permit its being turned off several times if getting worn or imperfect on its working surface. Frequently three separate rollers are used for the feeding arrangement. If so, the two original rollers are placed a short distance apart and each touched by the third roller. The advantage of this arrangement is readily explained. The object of the feed-rollers is to hold the sliver sufficiently tight to allow the gills of the fallers as well as the front or drawing-rollers to do their work, *i. e.* draw the sliver out by means of a greater surface velocity. Using three rolls for the feeding arrangement will actually press the sliver feed in the machine between two pairs of rollers, hence a sliding of the sliver is impossible. The sliver on leaving the drawing-rollers is taken care of by the front conductors *C* and C^1, and guided in a sliver can ready for the next machine.

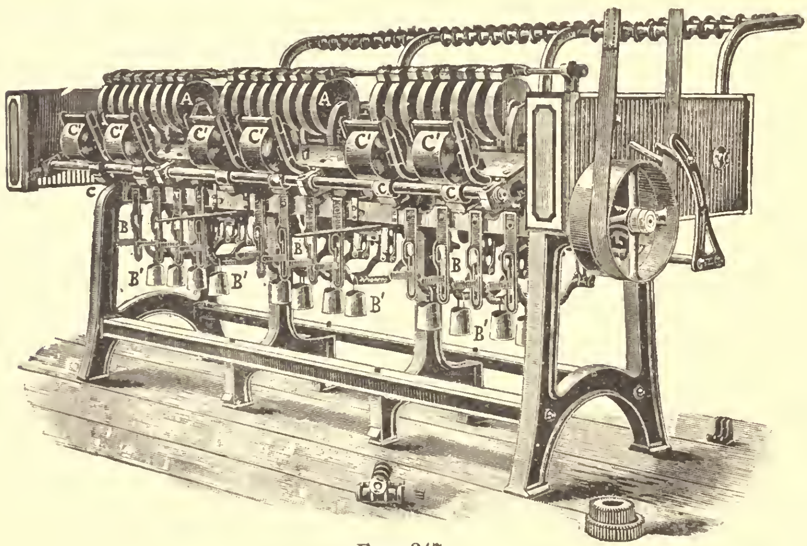


Fig. 347.

Roving-Frame.—This is the next and last machine over which the material passes in the preparing department, and is illustrated in Fig. 348. In appearance it is a long, rectangular frame, containing from four to eight *heads* (divisions), and each with any number of rows of gills, as 8, 10, or 12 per head, according to material to be worked. Over these gills only single slivers pass; thus there is only drafting, and no doubling, done on the roving-frame. The cans filled at the third drawing, if working line, or second drawing if working tow, are placed at the back of the roving-frame, and the sliver passed over guide-rollers to the gills in the same manner as at the previous machines. From the gills the sliver goes to the drawing-rollers, which revolve at a speed necessary to reduce the sliver to the required size, regulated by the counts of the yarn to be spun. To illustrate the operation of slightly twisting the roving and winding it on a bobbin, Fig. 349 is given. After the sliver, by means of drafting is reduced to its required size, it, on being delivered from the front roller or drawing-roll set *a*, passes through the neck of the *flyer* *b*, which is an iron tube of about the shape of an inverted *U*, and which is fixed upon the top of an upright revolving spindle; from there the roving is passed through a slit in the leg of the flyer and through the flyer-eye, onto the barrel of a bobbin *c*, revolving around the spindle *d*, and under the flyer *b*. The object of this arrangement is to put some twist into the attenuated sliver (and which is now called *roving*), so as to give it sufficient strength for winding on the bobbin. This winding of the roving upon the bobbin is done by means of having spindle and bobbin revolve at different velocities in the same direction, the difference in speed being the means by which the flyer can lap the strands around the barrel. The bobbin at the same time is made to travel slowly up and down the spindle blade, so as to receive the roving in an even layer. This traversing motion is caused by the bobbins resting upon a movable tray surrounding the spindles which contain the gearing to drive the bobbins at the necessary speed, rising and falling regularly thereby, and thus causing the building of the roving onto the bobbin. The technical name for this motion is *builder*, and its speed per minute, and the revolutions of the bobbin, are made to vary as each layer passes on the bobbin; so that there may be no difference on the tension of the roving by the alteration in the circumference of the barrel as each row is added. The mechanism producing this motion is known as the *differential motion*, which has been thoroughly described in the chapter on cotton spinning.

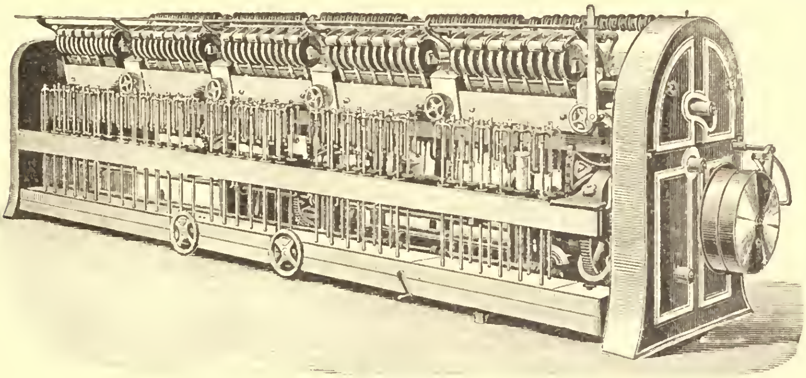


Fig. 348.

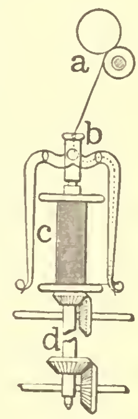


Fig. 349.

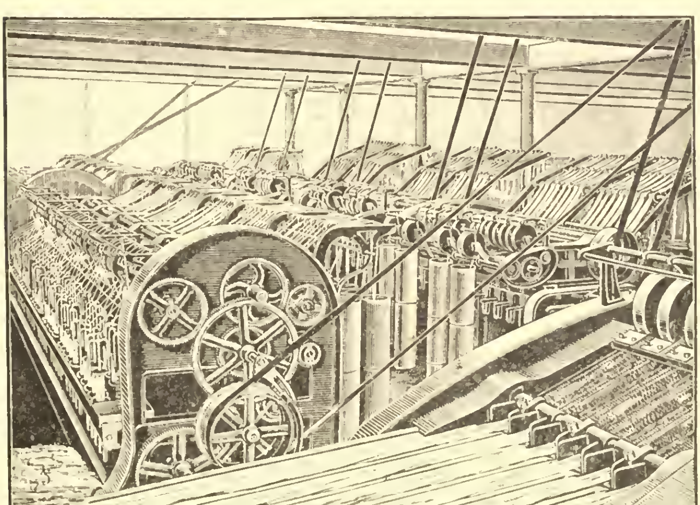


Fig. 350.

A Line System.—By this we classify a certain number of machines as used in the preparing department, arranged and specially adapted to each other for the preparation of a particular grade or quality of flax. The same may consist of one or two spread-boards, two or three drawing-frames, and one roving-frame. Each individual machine in a line system supplies the succeeding machine. The most frequently found arrangement is—one spread-board, one first drawing-frame, one second drawing-frame, one third drawing-frame, and one roving-frame; but, as mentioned, changes, with the exception of using one roving-frame, may arise, either by means of the materlal to use or the floor space in the mill. Fig. 350 is given to illustrate the working of a line system.

Spinning.—The spinning-frame, as used for converting the roving of flax or tow into a thread, is also nearly related in its principle of construction to the fly-throstle as used for spinning cotton yarns. The *throstle* principle is the one most generally used, yet in some places mule spinning is introduced. Two different systems of throstle spinning are in use—the wet spinning and the dry spinning processes.

Wet Spinning.—Like the spinning of all the other materials before the invention of spinning machinery, flax was spun by hand, being a home industry, and was generally performed by the housewife or her daughters. In doing the work the *spinsters* used to moisten the fibres with their saliva to make them adhere to each other, also to make them more pliable and easy to twist. In imitation of this old-fashioned practice, the flax fibres were wet in cold water previous to their spinning; but at present warm water, of about 120° F. is used. This softening of the flax fibres is based on the fact that flax fibres are, comparatively speaking, perfectly inelastic, for when dry they cannot be stretched beyond the $\frac{4}{100}$ or $\frac{5}{100}$ part of their original length without being ruptured; but when softened in hot water (the fibres increase in diameter, and consequently in length) their elasticity is raised to about $\frac{1}{10}$, in addition to which they are rendered more adhesive to one another, and will lie closer in the process of twisting. Fig 351 illustrates a *wet spinning-frame* for line and tow. It is oblong in shape, being built on a structure of supports (see *A*, *A*), two or three feet apart, and used in a number regulated by the length of the machine. Situated transversely to the supports are the sides of the frame, composed of two horizontal rows of rails (see 1 and 2), situated parallel, one above the other. These sides, with the help of the beam of the frame (set slightly backwards, but horizontal to the rails) bind or hold the supports of the frame together, and complete the framework of the machine. The rails form the supports for the vertical spindles, which revolve at great speed (4,000 to 6,000 turns per minute) to enable the yarn passing through the eye of a flyer, as screwed to the top of each spindle, to be properly twisted before being wound on the bobbin which revolves on the spindle, and under the flyer (see 4). The lower end of the spindle, called the *spindle foot*, works in a brass bush inserted in the lower rail (see 1), called the *spindle step*. The *spindle neck* works in a brass bush set in the upper rail (see 2), and is commonly called the *neck*. Running parallel to the two sets of rails, and between them, in the inside and extending throughout the full length of the frame, is situated a tin roller *D*, having a diameter of about 10 to 11 inches. This tin roller revolves on an iron axle, bearing on seats cast in the centre of the two outside supports of the frame. The *spindle bands* pass around the tin roller, and thence to the *whirl* (a small iron grooved boss, see below Fig. 2) of the spindle;

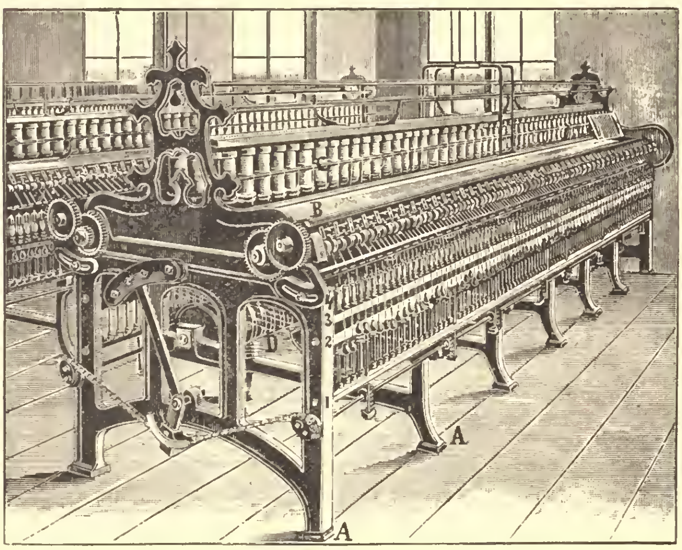


FIG. 351.

consequently the great surface speed of the cylinder is communicated to the spindles. One end of the cylinder axle is extended outside of the one end-support to allow a small wheel, *cylinder pinion*, to be fastened on, and which gives motion to the rest of the gearing. Outside the cylinder pinion a pulley is fastened to the elongated axle of the cylinder, and which is, in the common manner, by means of a belt, connected with the respective driving wheel as situated on the driving shaft of the room. As long as the driving shaft is revolving and the belt is left on the keyed pulley of the spinning-frame, so long the latter remains in motion; hence a loose pulley is placed close to the keyed one (and on the same shaft), to permit the shifting or guiding of the belt, by means of the belt fork, from either pulley to the other, producing respectively a starting or stopping of the machine. The entire length of the spindles varies from 14 to 24 inches, according to the kind of material to be spun; thus the upper and lower rails of the frame are also the guides for the spindles, and must be set a proportionate distance apart. That part of the spindle which extends clear of the upper rail of the frame is called the *spindle-blade* (see 4) and over it is let down the *builder* (see 3). The bobbins containing the roving are arranged in two parallel creels extending along on the top of the machine (see *C*). One creel supplies each side of the spindles, and since no doubling process takes place, one bobbin is required for each spindle. From the bobbins on the creel the roving ends are passed through a shallow wooden trough situated over the entire length of the machine (see *B*) from which they are drawn by and between a pair of rollers called *top-rollers* or *feeding-rollers*, the bottom one of which is made of iron covered with brass, fluted horizontally and has a positive drive, whereas the top one is made of box-wood and with flutes similar to those of the iron rollers. These wooden rollers are pressed by means of leverage to the former, hence revolve by means of frictional contact. In a certain distance apart from the top-rollers, as regulated by the material to be used (line or tow, or finer or poorer qualities of either) a similar pair of rollers called *bottom-rollers* or *delivery-rollers* are arranged, but which revolve at a much greater speed. The difference between the speed of the top and bottom rollers is regulated by the difference as to counts between the roving and the spun yarn required. The distance between the top and bottom rollers is called the *reach*. The flutes in the top and bottom rollers are to hold the roving firm during the drawing operation, *i. e.*, insure perfect work. From the bottom or delivery-rollers the drawn out roving passes to a flyer and spindle, which in many points, only in a reduced size, resemble the same parts in a roving-frame. Leaving the bottom of the *flyer-leg*, the thread passes to the bobbin, which fits loosely on the spindle, and round which it is wound by the rotation of the spindle. In diagram, Fig. 352 we show the difference in setting a frame for spinning either warp yarn or filling yarn (or hard or soft twist yarn). In this diagram the solid lines represent the frame set for spinning warp, whereas those dotted show the set of the same frame for spinning filling yarn. Examining the illustration closer we find that the amount of projection of the *line* depends also on the width of the flyer, hence if dealing with poor yarns we must use narrow flyers and correspondingly narrower bobbins so as not to bring too much strain on the yarn, which may be caused either by greater projection of the line above the thread plate eye, or the increased diameter of circle inscribed by using a large flyer. Both points must be taken care of if changing the spinning from warp to filling since the simple changing of the flyer would go only a small way to fit that frame for the required change in work. As before mentioned the average temperature of the water in the troughs is 120° F., but it must be understood that not all yarns spin best with this temperature. Poor filling yarns frequently spin best with the water at a temperature of 90° F., but in no instance should we raise this temperature above 160° F., since if heating the water above the mark it will boil out of the material too much of its saliva or nature, and the cloth produced out of such yarn will get a rough, cheap, coarse, cotton-like appearance.

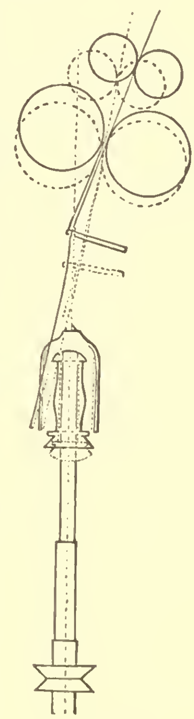


Fig. 352.

Dry Spinning-Frame.—As previously mentioned, wet spinning of flax and tow allows us to produce a very fine thread in counts but we have to remember that this is done to some extent at the expense of the general appearance of the cloth, whereas in the dry spinning-frame the so greatly valued silk-like appearance of the flax fibre is retained for the cloth produced out of such yarn. Fig. 353 illustrates such a dry spinning-frame which in its principle of construction differs only in not having the characteristic water troughs, hence the creel containing the roving bobbins is situated handier, *i. e.*, more in front or closer to the delivery-rollers. The draft in this machine is less compared to the wet spinning-frame for reasons previously given.

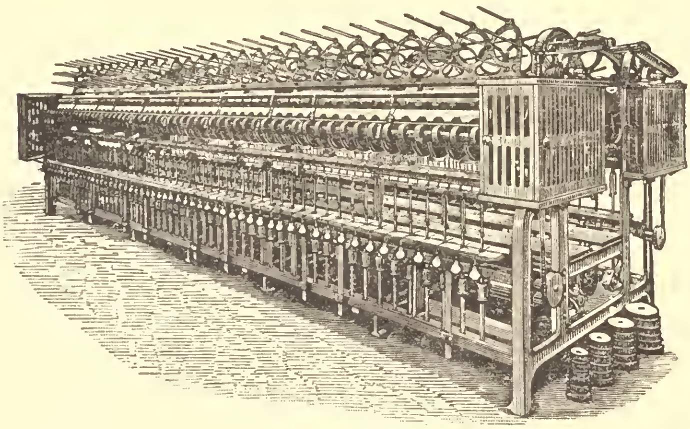


Fig. 353.

Drawing of Line and Tow During the Spinning.—There is very little difference in constructing spinning-frames, either for line or tow. The average amount of drawing for the first kind of yarn is from 7 to 8 times its roving length, whereas for tow it is from 6 to 7 times its roving length. In spinning tow the flyers are arranged to revolve about 1,000 revolutions per minute less than if spinning line. Explanations given previously (regarding projections of line, as well as size of flyers to use) regarding spinning poor yarns, will be also worthy of consideration if changing the spinning on the same machine from line to tow, or *vice versa.*

Reeling.—The yarn, after leaving the wet spinning-frame, must be dried as quickly as possible, so as to prevent any possible blue-molding and decaying. When the bobbins on the spinning-frame are full of yarn the operator takes them off, placing them in boxes, to be carried to the reeling department (see Fig. 354), where a number of those bobbins are put at once on a creel situated on top of the machine, and are re-wound in hanks and then dried, either in the air or by means of a drying machine. If using the latter process (drying by machine) the yarn must be placed, after being perfectly dried, in a *cooling shed.* This cooling brings back the over-dried portions of the yarn to the normal temperature, restoring strength and the silky appearance to the fibres. The yarn leaving the dry spinning-frame is also reeled, so as to have the bobbins empty, but requires, as is readily seen, no drying. The yarn from either kind of frame, after being reeled, is ready for bundling or bunching, and is put in bunches of any size, according to the size of the yarn presses or the special wishes of the manufacturer.

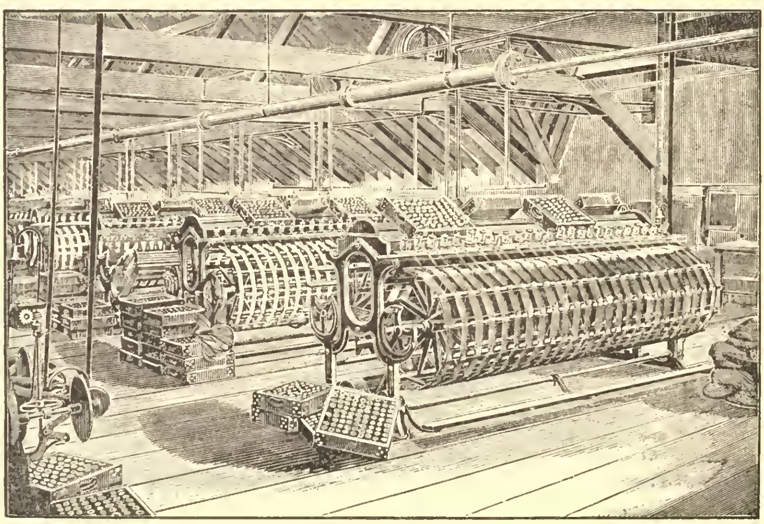


Fig. 354.

Jute.

Jute is the name for the bast fibres of *corchorus olitorius* and *corchorus capsularis*, belonging to the family of the *Tiliaceæ,* which are largely cultivated in India and China. The material is used in the manufacture of carpets, rugs, upholstery fabrics, trimmings, etc.; for the manufacture of the gunny-bags so extensively used for packing cotton, rice, and other articles. The fibre is separated from the plant by processes similar to those employed in obtaining the flax fibre; *i. e.*, retting, beating, washing, drying, etc. Under cultivation, the jute plant grows to a height of six, eight, or ten feet, attaining in rich soil a height of from twelve to fifteen feet. Its stem is straight and smooth, with an average circumference of one inch. This stem throws out lateral branches, depending in number (similar to the flax plant) upon the degree to which they are crowded by neighboring plants. Most of the jute is obtained from the species known as *Corchorus capsularis,* and of which we give an illustration in Fig. 355.

FIG 355.

Fibres Magnified.—Examining jute under the microscope (see Fig. 356) shows it to consist of bundles of stiff, lustrous, cylindrical fibrils, having irregularly thickened walls, and a comparatively large central opening.

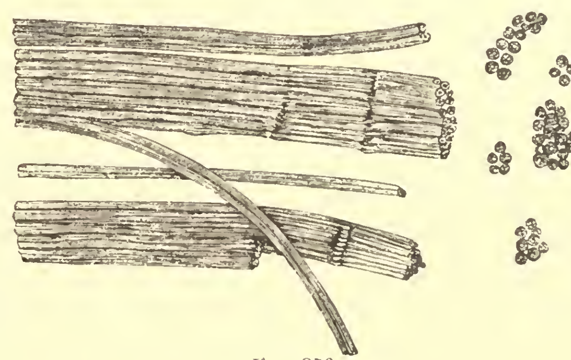


FIG. 356.

Color.—The color of the fibre varies from brown to silver gray, and is distinguished from flax by being colored yellow, under the influence of sulphuric acid and iodine solution.

Place of Growth.—The jute plant can be raised in any country having sufficient warmth and moisture, but, as previously mentioned, it is cultivated mostly in India (Bengal), and somewhat in China. Its best place for growth is in the alluvium in the deltas of rivers, and less on the higher situated parts of the country, a rich loam being the most suitable ground for cultivating the jute plant, which is produced by the overflowing of rivers. The time for sowing the seed is March or April. The fields are weeded after the plants attain a height of about one foot. If planted for the u-e of the fibre, they are cut down during August and September, tied up in bunches and ready for the steeping, beating, washing and drying processes. After drying they are cleaned and tied up into bundles for the market. In this state they are bought by dealers, forwarded to Calcutta, where they are made up, by means of hydraulic presses, into bales of an average weight of 375 pounds each and shipped to Europe or this country.

Jute Spinning.—Pressing the jute into bales by means of powerful presses causes streaks which are very hard, and render it rather difficult to be opened and reduced to a workable dimension. In some mills the bales are placed under a steam hammer, and subjected for a short time to a beating process. Other mills use in place of it what is termed a *crushing machine,* which is illustrated in Fig. 357 in its top view, and in Fig. 358 in its section. Letters of reference in both illustrations are corresponding, and are as follows: *A*, the crushing-rollers, having on one-half its length blunt teeth, and on the other half a fluted surface. The lower situated set of rollers are arranged reversed to the upper set; *i. e.,* where we find teeth in the upper set, we have grooves in the lower, and where we find grooves in the upper, we have teeth in the lower. The purpose of these rollers is to

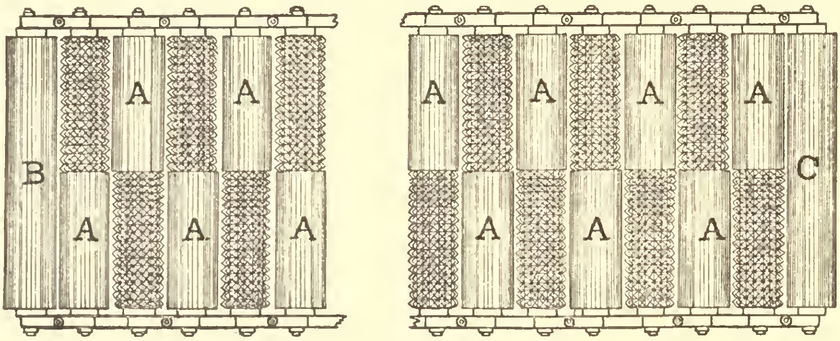


FIG. 357.

press, by means of the teeth of the rollers, the strands of the fibres into the correspondingly situated grooves, and thus split the same. Since a great many of these pairs of rollers are used in a machine, it will be readily seen that each strand is separated in its lowest constituent of fibres when leaving the machine. *B*, are the feeding-rollers, being simply a pair of rollers grooved over their entire surface. Their work consists in feeding, in proper amounts, the raw material to the previously alluded to sets of working-rollers. *C*, are what is called delivery-rollers (constructed similar to the feeding-rollers) which

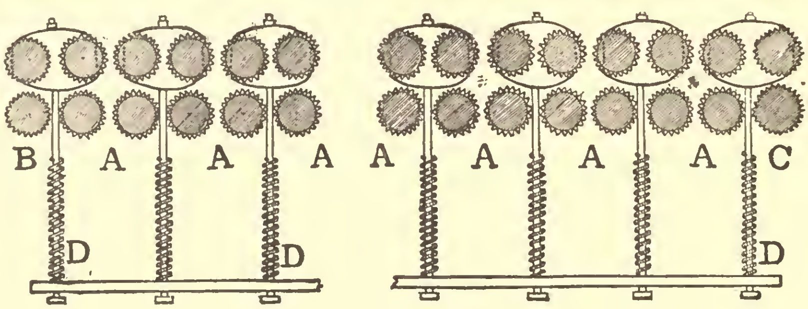


FIG. 358.

have for their object to take off from the workers the prepared fibres ready for future processes. Springs *D*, are the means for compressing the correspondingly situated rollers, also allowing the expansion of some of them if some of the strands fed into the machine are too thick.

Softening.—The nature of the jute fibre requires it, prior to being crushed, to be subjected to softening, *i. e.,* spread over with oil and water or some other suitable substance for making it more pliable. The amount of water to be used varies according to the nature and quality of the material, the counts of yarn into which it is to be spun, temperature and state of the atmosphere, and the time and mode of application, whereas the oil as used does not vary as much in quantity as quality, *i. e.,* using for the lower grades of the material a cheaper oil and for the finer grades a better oil. Whale and seal oil mixed with mineral oils for cheaper grades of yarns are mostly used; both water and oil being heated to about 100° F. There is quite a difference in the fibre between the root end and the crop end of the jute plant, hence it is rather difficult, if not impossible to soften both ends alike with the same operation, since if softening the root end sufficiently, the crop end (being softer in its nature of growth) would be materially damaged. Again if suiting the softening to the crop end, the root end will not get sufficiently pliable to permit good work during future operations. This will explain the reasons for the great diversity of opinions as to the proper amount of softening the different grades of jute require. Great care must be exercised to distribute the oil and water equally over and throughout the entire lot of jute. To gain this purpose batches of from 10 to 12 by $3\frac{1}{2}$ to 4 feet are formed. The streaks forming the bale must be divided, using great care when laying them in rows to have the heads, *i. e.*, where the piece is doubled, placed evenly. After laying each row, first a portion of the oil and then a part of the water is always distributed over it by means of a can. When the batch is completed it should be covered with a cloth to prevent the heat from passing quickly off. Some of the crushing machines are arranged to permit a softening automatically (adding of oil and water) during the operation. The crushing machine generally contains from 26 to 36 pairs of rollers, the water being generally applied about the second or third pair of rollers and the oil about the fifth or sixth pair. Some of the machines are arranged to distribute the oil and the water in the centre of the machine, permitting the first rollers to clean off any loose root. The oil and water as used for softening are heated either by steam pipes passing through the liquids, while in others the oil cistern is heated by being placed inside the one containing the hot water. By means of suitable arrangements the amount of oil and water can be easily regulated.

The Preparations Most Frequently Used for Softening are:

For Fine Yarns, per bale of 350 lbs. Mix $\frac{3}{8}$ gallon whale oil, $\frac{3}{8}$ gallon seal oil, $\frac{1}{4}$ gallon mineral oil, and 6 to 7 gallons water. Another mixture is as follows: Mix $\frac{1}{3}$ gallon whale oil, $\frac{1}{3}$ gallon seal oil, $\frac{1}{3}$ gallon mineral oil, and 6 to 7 gallons water.

For Coarse Yarns, mix 1 gallon mineral oil with 5 to 6 gallons water, or $\frac{7}{8}$ gallon mineral oil with from 5 to 6 gallons water.

If making up batches say 7500 lbs., use as follows: for fine yarns; Mix 8 gallons whale oil, 3 gallons seal oil, 3 gallons mineral oil and 100 gallons water, or use 5 gallons whale oil, 5 gallons seal oil, $4\frac{1}{2}$ gallons mineral oil, 8 lbs. soap and 100 gallons water. If using the latter preparation mix the oils previously to the adding the heated water containing the soap mixed. The appearance of this preparation if properly mixed will be rich and creamy. Another preparation which is cheaper but apt to dirty the card clothing (if working jute tow) is as follows: Mix 6 gallons whale or seal oil or both mixed, with 10 gallons of mineral oil, 8 lbs. soap and 100 gallons water.

Jute Line.—The average length of the jute strand is from ten to thirteen feet. The reducing of these strands into its lowest constituent of fibres for the finest qualities is done on a similar built (hackling) machine, as is used for flax; and the product thus derived (by means of future operations) is known as jute line.

The Hackling Machine as used for jute is built somewhat stronger than the similar machine used for flax, since the jute plant in its nature of growth is correspondingly coarser and stronger than the flax. To facilitate the operation the jute strands are cut up in pieces in their length.

The succeeding operations are:

Spreading, Drawing, Roving and Spinning, the processes of which are the same as those explained for flax.

Jute Tow.—The medium and lower grades of jute as well as the coarse unsplit ends, which are found even in the finer sorts, are manufactured by means of carding, drawing, roving and spinning, into what is called jute tow.

Carding.—The object of this is to transfer the previously softened and opened jute strands into tow (similar to the tow made from the flax fibre). This work is done on the carding engines of which two machines, *i. e.*, breaker card and finisher card successively following each other in their operation are employed.

Breaker Card.—This is the machine to which the fibre is first submitted. The breaker card consists of the characteristic main cylinder or swift, several workers and strippers, doffer-cylinder and comb. As easily understood the clothing used for this card must be very strong, by reason of the coarseness of the fibre to be worked upon. The average surface speed of the swift is thirty-two feet, for the worker five inches, and for the stripper three feet per second. By means of cylinder, workers and strippers, the jute strands as fed in the machine get reduced to their lowest constituents of fibres as well as reduced to proper size in their length. When leaving the last worker, the properly split jute fibre is found evenly spread over the surface of the cylinder from whence it is taken off by the comb in the shape of a continuous film, which is guided by means of delivery-rollers upon an oblique table the shape of the letter *V* (see Fig. 359); *a*, in diagram indicates position of previously referred to delivery-rollers; *b*, and *c*, guides for table *d*. When the fibre arrives at the place indicated by letter *e*, in diagram, the same is taken off by means of a pair of conductor-rollers *f*, (and which constantly draw the baird off the table) delivering it in a single sliver for the finisher card. In spreading jute upon the feeding-table of the breaker card, the root end is spread first, and the distance the next piece has to overlap depends upon the weight of fibre in the crop end of the strand. Some difference between a jute card and a flax (tow) card is found in the feeding arrangement. The former machines contain a shell feeding-roller, whereas the latter cards have the regular or two feeding-rollers.

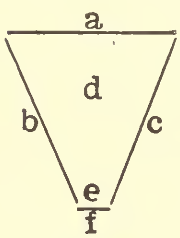


Fig. 359.

Finisher Card.—The sliver, as formed by the breaker card, is next supplied to the finisher card either in cans or made into laps or balls. The construction of the finisher card for jute is so nearly the same as the one used for flax (tow) that a special explanation of the same is unnecessary. Similar to the flax tow card the jute tow finisher card has for its main object the parallel arrangement of the fibres, so as to permit the succeeding operation of drawing out the sliver. The finisher cards for jute are *full circular* for the higher counts of yarn, and *half circular* for the lower counts. The first mentioned build of cards deliver on the side where the feeding-roller is situated; whereas the latter mentioned kind deliver on the opposite side from the feeding-rollers. Half circular cards contain only two to three pairs of rollers (worker and stripper), whereas full circular cards have from four to five pairs.

Drawing, Roving, Spinning.—There is very little difference, if any, in these different processes as required for the spinning of jute tow as compared to the corresponding process for spinning flax tow (and which we thoroughly explained and illustrated in a previous chapter); consequently a special reference to either subject is unnecessary; in fact, the different machinery used for tow spinning being suitable for either. The counts to which jute yarns are spun are generally coarser than tow yarns made from the flax fibre; hence the machinery used in jute spinning is simply built heavier and coarser in its details.

Ramie.

Ramie or *Boehmeria utilis* of which we give an illustration in Fig. 360 is a specimen of the nettle family *Uticaceæ.* It is a native of East India, China and Japan, but at present experiments are being made rather extensively in our country's Gulf States (especially in the vicinity of New Orleans) to cultivate this fibre. The actual introduction of it in this country dates back to the year 1855. The plant when fully grown attains a height of from 4 to 8 feet, and is surrounded with large ovate acuminate leaves which are green above and whitish or silvery beneath, the fibre being formed in the bark surrounding the stalk which has a pithy centre. Similar to the China-grass, it is of a rapid growth producing from two to five crops a year (according to the climate and soil) without re-planting.

The method for obtaining the fibre as practiced by the natives in East India, China and Japan, is splitting and scraping the plant stems and then steeping them. As this method is very tedious, a machine and process is wanted to accomplish this labor quickly and automatically. The ordinary retting process, as used for flax, is not sufficiently effective, since the succulent nature of the stem and the great amount and acridity of the gummy matter rapidly coagulate, becoming insoluble on exposure to the air.

Fig. 360.

The use of the Fibre.—In East India, China and Japan where, as previously mentioned, the fibre is extracted by the natives by hand labor it is manufactured not only into cordage, nets and similar coarse fabrics, but also used for the construction of some of their most beautiful textile fabrics. On the European Continent and in England this fibre also has been woven into a great variety of fabrics, since it can be dyed in any color and rivals silk in brilliancy. Another feature greatly in favor of this fibre is its remarkable strength and durability, being also the textile fibre least affected by moisture. With reference to spinning, ramie can be used either alone or in conjunction with cotton, wool, silk or flax for the manufacture of such textiles where elasticity is not essential.

Ramie has three times the strength of Russian hemp, while its filaments can be separated almost to the fineness of silk. The average value of ramie, either imported (including transportation and duty) or American grown material, is 9 cents per pound.

Its Cultivation.—As previously alluded to, Ramie is in this country mostly grown in the vicinity of New Orleans; the Southern States, and especially such as border on the Gulf of Mexico, are the most favorable for its cultivation, yet the plant has also been grown as far north as Pennsylvania and New Jersey, and as far west as California. As to the cultivation of Ramie, the Department of Agriculture, in a report just published, has given the following directions: "The plant is propagated by seeds, by cuttings or by layers, and by division of the roots. When produced from seed the greatest care must be taken with the planting, as the seed is very small. For this reason open air planting can hardly be relied upon, plants started in the hot bed giving the best results. After planting, the seeds are covered thinly with sifted earth and kept shaded from the sun until the young plants are 2 or 3 inches high, when sunlight must be gradually admitted to them. In five or six weeks they will be strong enough to transplant to the field.

In the East Indian method of propagating by cuttings of the stems, the spring grown stems are used and when fully ripe. Only the well ripened portion where the epidermis has turned brown is employed, the stem being divided into lengths that will include three buds, care being taken to cut a quarter of an inch above and the same distance below the top and bottom buds. These are planted with the central bud on a level with the soil. The cuttings are shaded for ten days or more unless the weather be cloudy or rainy. In India the cuttings are planted a foot apart, although given more room as the plants mature. By far the most practical method and the one which will give the best results in this country is a propagation by the division of the roots of old or fully matured plants. The old plants are better than young ones for the purpose, as the root mass is larger, the tuberous portions showing a greater number of eyes and therefore giving stronger plants after division. The practice varies as to distance apart that these are planted. In India four feet apart each way is considered the proper distances though in France some favor two feet apart each way as giving better results."

In a former report on the culture of ramie issued by the Department of Agriculture these directions are given: "Furrows five or six inches deep, and five feet apart are opened with the plow. The roots are laid lengthwise in the middle, close in succession if a thick standing crop is desired, but placed at intervals if nursery propagation is the object in view. The first mode will absorb 3,000 roots per acre, but will save the labor of often filling the stand by propagation.

"The plants are given cultivation at first, being hilled like corn or potatoes, all weeds being kept down, though after getting a good start from the rankness of their growth and the density of the foliage, weeds will have little chance to grow.

"A rich loam suits the plants best, but they will grow in any kind of soil, provided a full supply of moisture be available, combined with thorough drainage.

"If sufficient moisture cannot be assured it should be supplied by irrigation, a positive necessity in many localities where ramie is grown. However, it must be remembered, that ramie will not thrive in a wet soil. The ground must be well prepared by plowing to the depth of ten inches, and well pulverized, and if the land is poor, fertilizers must be applied to bring it up to a good state of fertility. All weeds must be removed from the soil or they will sorely plague the cultivator in the first year or so until the plants have grown large. When the climate will permit of producing three crops a year the cuttings are made at intervals of about ten or twelve weeks, the first cuttings to be made about the middle of May, dependent on the season."

Status of the Ramie Industry.—No doubt it has been clearly demonstrated both in this country and in Europe that ramie is and can be manufactured in an endless variety of textile fabrics, yet the disadvantage (as previously referred to) of not having a real practical chemical process or machine for decorticating the raw fibre (producing the cleaned fibre as required for spinning from the stalks as harvested) is a serious drawback so far. No doubt hundreds of processes and machines for doing this work have, in the last 30 years, been patented in the different countries more interested in this fibre, yet the proper process is as yet wanting. This feature will readily explain why ramie is not grown very extensively in this country. It is an important industry in China, Japan and East India, also in a very limited amount, in parts of Southern Europe, the French Colonies in Africa, in some of our South American Republics, and in the British Colonies. The fact of not having the proper means for decorticating the stalks, has thus far been a serious impediment to its commercial demand which at present is yet very limited, the present supply of cleaned fibres being so changeable and uncertain that manufacturers do not feel inclined to invest their capital in factories and machinery, but had this fibre a good decorticator this hinderance to success would readily disappear, and ramie take an equal value and place of importance among cotton, wool, silk and flax, as a fibre for textile fabrics.

The first machine for decorticating ramie in our country was patented by a Dr. Benito Roezel, September 17th, 1867, and it is said that hundreds of them were made at a foundry in New Orleans the succeeding year and offered for sale at $225.00, but very few found buyers.

The editor of the "Bulletin of the Royal Kew Gardens" lately expressed

England's Opinion on Ramie as follows:—"In order to understand the present position of the ramie industry it would be useful to adopt some kind of classification of the details connected with it. In the first place we have the mere business of cultivating the ramie plant, and of producing stems with the fibre in the best possible condition. This is purely the work of the planter. Secondly, we have the process or processes necessary to separate the fibre from the stem in the form of ribbons and filasse. It is necessary for many reasons that this should be done either by the planter on the spot or by a central factory close at hand. Thirdly, we have the purely technical and manufacturing process in which ramie filasse is taken up by the spinners and utilized in the same manner as cotton, flax and silk are utilized for the purpose of being made into fabrics.

"For our present purpose we may take it for granted that the cultivation of the ramie plant presents no insuperable difficulty. Also, that if a suitable selection of soil is made, and the locality possesses the necessary climatic conditions as regards heat and moisture, there is no reason to doubt that ramie could be grown, to greater or less extent, in most of our tropical possessions. As regards the second stage, in which is involved the decortication of the ramie stems, the problem is by no means completely solved.

"On this really hangs the whole subject. The third stage is disappointing and unsatisfactory, because the second stage is still uncertain; and being thus uncertain, the fibre is necessarily produced in small and irregular quantities, and only comes into the market by fits and starts. It would appear that ramie fibre differs so essentially from cotton and flax that it can only be manipulated and worked into fabrics by means of machinery specially constructed to deal with it. Owing to the comparatively limited supply of ramie fibre hitherto in the market, no large firms of manufacturers have thought it worth while to alter the present or put up new machinery to work up ramie fibre. If appliances or processes for decorticating ramie in the colonies were already devised, and the fibre came into the market regularly and in large quantities,—say hundreds of tons at a time—there is no doubt manufacturers would be fully prepared to deal with it. At present the industry is practically blocked by the absence of any really successful means of separating the fibre from the stems and preparing it cheaply and effectively. This, after all, is the identical problem which has baffled solution for the last fifty years."

Before closing the subject on ramie (the future fibre for textile fabrics), it will no doubt be of great interest to the student to have a short description of the latest styles of machines and processes in use in this country and Europe for decorticating the stalks.

Machines and Processes for Decorticating Ramie, as Exhibited at the Late Paris Exposition.—The ramie, and its method of decorticating, attracted great attention at the late Paris Exposition. Several countries which took part in the Exposition sent specimens of fibre to show the result of experiments or progress of its own culture, or sent representatives to ascertain the latest facts on this fibre. Our country made also a small display of the fibre, illustrating the fact that the plant can be grown successfully here. Amongst the machines and chemical processes entered for decorticating the plant were the *Favier Machine*, in two forms (one for green and one for dry stalks); two forms of the *Landthsheer Machine* (one large and one small), the *Armand Barbier Machine*), and the *Felician Michotte Machine*, and the chemical process of *Ch. Crozat de Fleury et A. Moriceau*, for the treatment of stems in green condition.

The Favier Machine consists of two compartments which may be used separately or in unison. The first slits the stem or stalk either entirely or nearly through, flattening it into two bands. The stem being fed by hand to two vertical feed-rollers, which pass it through a tube, provided with a slitting knife, which is shaped that the slit is opened out. Flattening rollers next receive the stems, crushing them, the wood and bark however, maintaining their layer-like position. Next the stems pass into the second compartment where rollers with wide grooves, take hold of these ribbons, (or layers of wood and bark) breaking the wood into short pieces of about $\frac{1}{4}$ of an inch in length which drop away leaving the bark intact, which is then subjected to a series of rubbing and beating rollers, manipulating the ribbon on both sides, removing the pellicle and thus disintegrating the fibre which is produced thoroughly clean and straight within two seconds from the time the stem leaves the attendant's hands.

The working capacity of this machine is as follows: 100 kilograms of green stalks have been passed through the machine in twelve minutes, corresponding to 500 kilograms an hour, or 5,000 for ten hours; and this with but two workmen employed. It is claimed that four workmen can decorticate 7,500 kilograms in ten hours.

The Landtsheer Machine is composed of three cylinders tangent to another central cylinder. The feeding cylinder is arranged with spiral grooves to regulate the feeding of the ramie stalks. The crushing cylinders are alternately smooth and grooved longitudinally in such a manner that when working together the grooved part of one bearing upon the smooth part of the other crushes the stalks. These cylinders are held in place by springs. After leaving the crushing cylinders the broken stalk passes between a pair of beaters, each supplied with sixteen winglets geared in such a manner that they lightly interlock, this action brushing off or removing the woody matter and the bark.

This machine is built in two sizes, known respectively as large and small machines. Trials of decorticating ramie upon either machine resulted as follows: 36 kilograms of stripped green stems were decorticated on a large-size machine in 2 minutes and 35 seconds, yielding 10 kilograms of wet ribbons. This was in two lots of 10 kilograms without leaves, and 26 kilograms with the leaves. In a second trial on the same machine, 46 kilograms of green stalks with leaves (200 stems) were cleaned in $11\frac{1}{2}$ minutes, yielding 15 kilograms of wet ribbons, filled with fragments of woody matter, chips, and even short sections of stems, which were next passed through a small machine in $6\frac{1}{2}$ minutes, giving in return $10\frac{1}{2}$ kilograms of clean, wet ribbons. A third trial, using a small machine, resulted in decorticating $24\frac{4}{10}$ kilograms of green stalks with leaves in ten minutes, yielding $6\frac{1}{2}$ kilograms of ribbons. Experiments with dry stalks on a large machine resulted in decorticating 30 kilograms in 21 minutes, yielding 10 kilograms of flat ribbons, the outer pellicle not being removed.

The Armand Barbier Machine.—This machine is quite simple and very similar to the Landsheer Machine previously explained. The dry ribbons produced are broad and flat and none of the outer pellicle is removed. The refuse with the material comes away in large pieces and a considerable percentage of the fibre itself is whipped or torn off and falls with the refuse of decortication.

Trials with this machine resulted in decorticating 10 kilograms of stripped green stalks in 6 minutes, yielding $1\frac{3}{10}$ kilograms of wet ribbons. In a second trial, 24 kilograms of green stems, including leaves, were operated on in 10 minutes and 30 seconds, yielding $1\frac{1}{5}$ kilograms of wet ribbons. Experiments with dry stalks resulted in decorticating 12 kilograms in 30 minutes, producing $2\frac{1}{5}$ kilograms of ribbons.

The Michotte.—This machine is composed of four crushing rollers (having a special form of fluting) of large size, which are followed by a steel breaker with elastic beaters working in connection with another breaker of similar form. The first mentioned large rollers after crushing the stems next pass the same to the beaters for freeing them of the wooden part of the fibre.

In a trial, $17\frac{2}{5}$ kilograms of green stems with leaves were decorticated in $2\frac{1}{2}$ minutes, yielding 6 kilograms of ribbons.

The Fleury et A. Moriceau process consists in simply immersing a quantity of ramie stalks (either dry or green) in a rectangular galvanized iron tank of boiling water set upon masonry to admit of fire beneath, to continue the boiling for a certain time, varying from five to fifteen minutes. The stripping of the ribbons is performed by hand by two men with occasional outside assistance. This process is of little advantage as it is too laborious and the production too small for the amount of time consumed.

An American Machine for Decortication.—A decorticator for ramie, which is the latest American invention of such a machine, is shown in Figs. 361 and 362. The invention consists in the combination of pressing and decorticating cylinders, brushes for cleaning the cylinders and the fibre, and an automatic feeding arrangement by means of which the raw material is continuously supplied to the decorticating apparatus. Fig. 361 is a plan view and Fig. 362 is a side elevation of the same. Similar letters of reference indicate corresponding parts in both illustrations. The method of operation of the machine is as follows: The stalks to be treated are laid upon the apron *N*, and carried forward to the fluted crushing-rollers *L*, which crush them and deliver them to the steel points *b*. The crushed fibres are drawn between the points by the action of the teeth *T*, and the beaters *U*, carried by the cylinder *D*. The fibre passes under the cylinder *D*, is carried forward by the teeth and beaters on the cylinders,

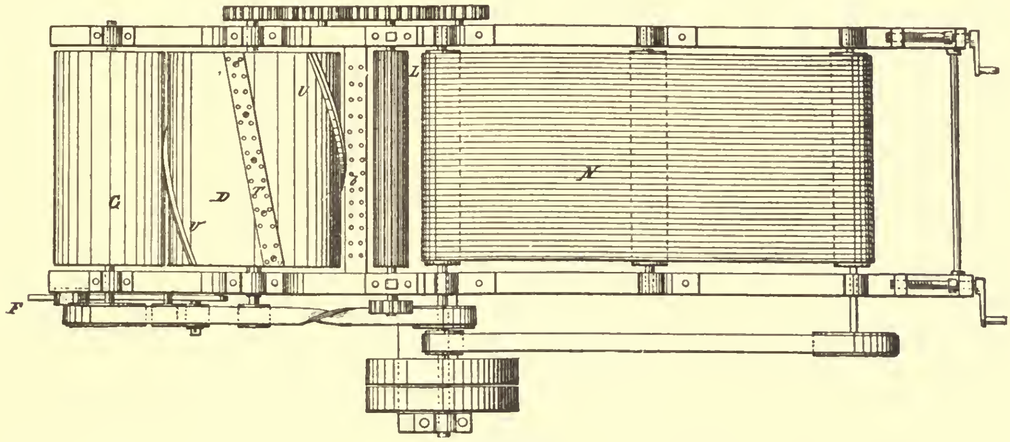


FIG. 361.

and is brushed by the rotary brush *E*, which revolves with a greater peripheral speed than cylinder *D*, and removes the greater portion of the dust adhering to the fibre. It is further treated in a similar manner by the brush *F*, and the dust removed by the brushes *E*, *F*, delivered to the table *R*. The cleaned fibre is carried upward by the cylinder *D*, until it reaches the brush *G*, when the fibre is removed by the action of the brush *G*, assisted by the natural tendency of the fibre to spring toward it, and delivered to the table *S*, in a thoroughly cleaned condition. The brushes *E*, *F*, not only clean

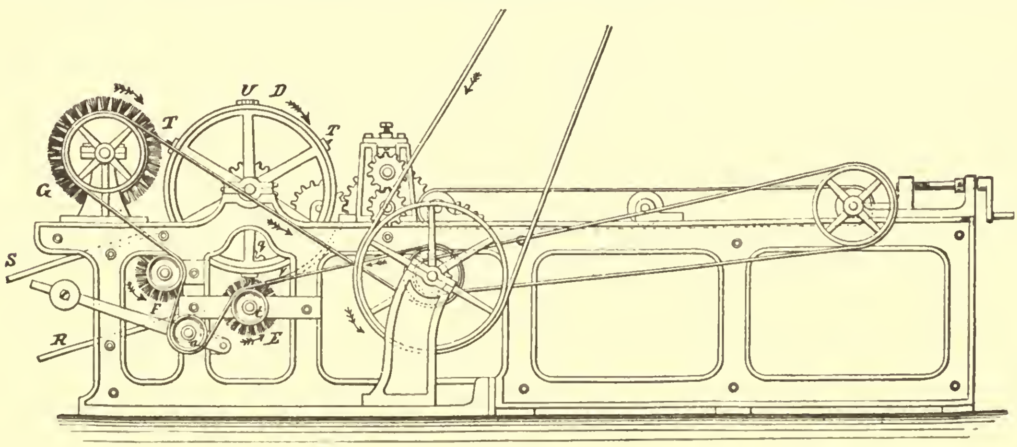


FIG. 362.

the fibre, but assist in retaining it on the cylinder until it is removed therefrom by the brush *G*. The fibre is held against the cylinder *D*, by the teeth *b*, and the concave *V*, leading from the teeth to the first cleaning brush *E*. The stalks thus treated are seven feet in length or longer, and the machine is so constructed that the front ends of the stalks will reach the brush *G*, before the rear ends are disconnected from the points *b*. The points *b*, do not hold the stalk so firmly as to prevent the cylinder from drawing them therethrough, but serve to retard the passage of the stalks, so that they will be thoroughly treated throughout their entire lengths, as described. The front ends of the bent fibre, after being carried above the table S, will naturally project toward the brush G, and this tendency is assisted by the centrifugal action of the cylinder D, and the brush G, will therefore effectually prevent the cylinder D, from carrying the fibre around with it and delivers the same to the table S, as before stated. This decorticating machine can also be used for china-grass, jute or hemp.

Spreading, Drawing, Carding, Spinning.—In Europe, ramie has been worked almost entirely upon machinery as used for the manufacture of linen yarns. Lately experiments have been made there, as well as in our New England States, to use the regular woolen and cotton machinery for shorter fibres as well as the waste caused by drawing. If using the latter system of manufacture of yarns the degumming is only carried to the point where a filasse is produced which, when separated and broken in its length on a Fearnought, is sufficiently soft and pliable to be worked well on the woolen

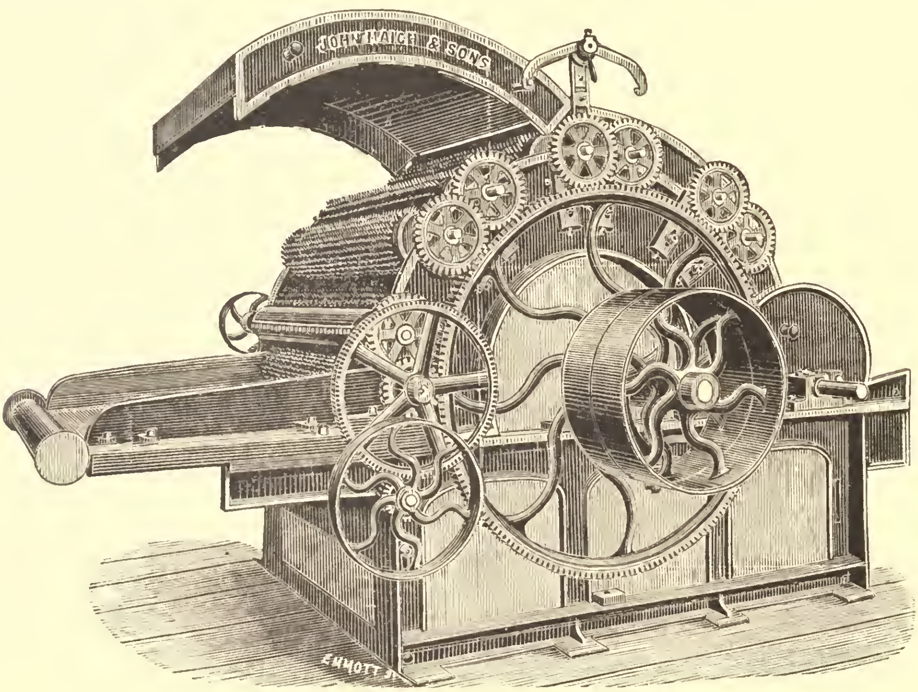


FIG. 363.

or cotton card. An illustration of a *Fearnought*, as built by John Haigh & Sons, is given in Fig. 363, being their regular machine used for opening, mixing and blending wool, and consists of two feed-rolls, one cylinder, with seven rollers over same, which are all steel-toothed, except the first, which is a brush roller. Grates are under cylinder and fan.

The average value of these ramie yarns in the gray is from 75 cents to $1.00 per pound, and $1.50 to $2.00 per pound when colored.

China-Grass.

China-grass (see Fig. 364) belongs to the same family of plants as ramie, and grows extensively in China, Japan and East India. It consists of the bast cells of *Boehmeria nivea,* belonging to the nettle family *Uticaceœ.* The separated and bleached fibre in appearance resembles silk (similar as the ramie) and is pure white. In Fig. 365 we give the fibre as visible under the microscope. China-grass, as previously mentioned, and as is also indicated by its name, is most extensively cultivated in China, where the yearly production amounts to (100,000,000) one hundred million kilograms (equal to 220,462,000 lbs.). There it is grown on plantations, which remain fertile from seven to eight years. The green stalks are cut as soon as about four feet high. Four to five crops are raised each year, the remarkable fact being that the frequent cutting of the stalks improve their fineness. The fibre as produced by means of splitting and scraping and successive steeping of the stalks, is performed by the natives by hand, and is of great strength, but owing to the slow and tedious process, only a limited amount of the thus prepared fibre is obtained.

FIG. 364.

FIG. 365.

The process of *decorticating,* or *retting,* by machinery is similar to ramie, and which has been thoroughly described in the previous chapter.

After opening the bale in which the raw material has been shipped from China, its contents are sorted according to length, color and quantity, then the respectively wanted lot is subjected to the breaking process; *i. e.,* broken by means of grooved iron rollers moving forward and backward. Next the material is soaked for some time in an alkaline bath, from which it is delivered to large air-tight kettles, being boiled under the pressure of several atmospheres. From there it is again removed, receiving several baths containing various chemical compositions, according to kind, at different temperatures, and is next submitted to a treatment with chlorine-ether and sulphur vapors. All these chemical processes have for their object the solution of the resinous and gummy matters, thus softening and dividing the material into its lowest constituents of fibres. After finishing these chemical processes, the long fibres are subjected to spreading, drawing, roving and spinning (similar as the process of preparing linen yarns) whereas the short fibres are treated similar as tow yarns.

Hemp.

The hemp plant (*Cannabis sativa*) is supposed to be a native of India, but has long been naturalized in Europe and this country. Fig. 366 gives an illustration of the plant, and Fig. 367 illustrates stalks, magnified. The average height of the plant is from six to eighteen feet, according to the soil and place of growth. Climate has much to do with the successful cultivation of this plant, as it makes the best length of stalks, and, therefore, gives a greater yield of fibre in countries where the climate is mild and the atmosphere humid. Limestone soils, or the alluvial soils, as found in the river bottoms, are most congenial to its growth.

Fig. 366.

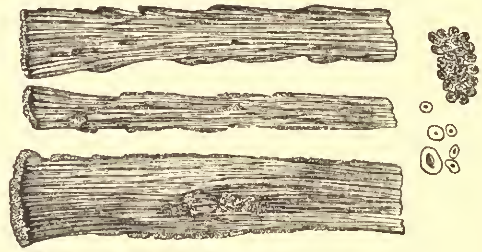


Fig. 367.

Place of Growth.—The best hemp comes from Piedmont, Italy, although only very little of it comes into this market.

The only hemp which comes into direct competition with the best of American is the Russian, but the former possesses greater flexibility, and can be dressed finer, although the Russian is more equal in length.

Best Method of Cultivation.—In the cultivation of hemp, high fertilizing is necessary, as hemp absorbs the equivalent of 1,500 pounds of fertilizer for every hundred pounds of fibre obtained. If the soil is not sufficiently rich in phosphates, or the salts of potassium, these must be supplied by the use of lime, marl, ground bone, animal charcoal, or ashes mixed with prepared animal compost. Leaves of the plant and *shives* may be returned with benefit to the land. There are two modes of gathering according to the use to which the fibre will be put. If for cordage, the stalks are cut with a sharp instrument (similar to a short scythe) and laid upon the ground in sheaves where they are left to dry from one to three days. Next the leaves are stripped, and the stalks removed to the sheds for sorting, placed in piles horizontally, the lower ends of the stalks being pressed firmly against a wall, so that the inequalities of their length may plainly appear. To prevent deranging the stems while drawing them out in assorting, a weight is placed upon each pile close to the wall. The drawing out of the stems from the pile is done by handfuls, commencing with the longest stems, taking the medium next, and finally the shortest ones. After sorting the stems according to length they are bound into sheaves, the tops of which are then cut off, and only the portion preserved that will make good fibre. Several sheaves are next put together, thus forming bundles.

If planting hemp for the manufacture of yarns, the stalks are not cut but are pulled like flax. The leaves are next removed by the farm hand so as to return the latter to the soil where grown. According to the ease with which they can be drawn out of the ground, from six to fifteen stalks are pulled at one operation. These handfuls are made into bundles about six inches in diameter; next the roots and tops are chopped off by means of an axe. The thus clipped stalks are made up in bundles of a foot or more in diameter, and ready for retting immediately, as it is claimed that the hemp is not so white if it is dried before retting.

When the seed is saved the procedure is as follows: The male stalks ripen six weeks earlier than the female stalks; the latter are given plenty of time to mature, not being gathered until their leaves and stems begin to turn yellow and the seeds to grow dark. They are tied in bunches, and of these there are made large bundles which are placed upright that the seed may complete its opening, which are extracted afterward by beating the stalks. This operation produces less fibre, and these female plants yield fibre of inferior quality from those collected at the time of maturing of the male plants, but the harvest of the seed compensates for the difference.

The next processes, as retting, scutching, hackling, as well as the different spinning processes, are similar to those used for flax.

Retting.—There are two kinds of processes in use for retting, *dew-retting* and *water-retting*. The first mentioned system is carried on in the open field, where the stalks are allowed to lie about a month. This is the process mostly practiced by the American farmers although manufacturers prefer water-retted material. The latter process is accomplished both in pools and in running streams. The retting in running streams accomplishes the best results, although requiring more time than pool-retting. The time of immersion varies from five to eight days, but if the weather is rather cool, it will retard the operation from one to three days, which also accounts, too, for the shorter time required for pool-retting. The pools as used, if pool-retting is the system employed, are dug to a depth of a yard or more, walled up or the sides made solid, and usually lined and floored with cement so as to keep the water clean, and the hemp retain its color. Care must be taken by the farmer against over retting, which will weaken the fibre. For this purpose, the stalks are watched very closely after the fourth day of immersion, the farmer, at intervals, pulling out a few and breaking them with his hands. After being sufficiently retted by either system, the bundles of hemp are agitated to remove all waste matter that may adhere to the stalks, which are next removed from the water, drained, the bundles opened at the bottom and set up in conical sheaves to dry, which is generally accomplished in two or three days. Henry Clay introduced into our country the water-retting process; but few farmers of the present day will undergo the trouble connected with the operation, although the practice would give better results by producing a better quality of material and return a better price; and as the total imports of raw fibre amount to some ($44,000,000) forty-four million dollars per year, it is safe to state that ($26,000,000) twenty-six million dollars could be saved to this country, or the farmers, by adopting water-retting. The best results as to the quality of fibre are obtained by gathering the plants when the male stalks have shed their flowers and the stems begin to get yellow.

Power Breaker in use in this Country.—The most frequently used of these machines is the one invented by Hartshorn. This machine consists of several pairs of fluted rollers, interspersed at intervals with peculiarly constructed scutchers, or cleaning rollers, which pierce the hemp with steel pins, and also beat, shake and scrape it vigorously, while it is held on either side by the breaking rollers. By reason of a more rapid motion given to the scutching than to the breaking rollers, the breaking, piercing, beating, shaking and scraping are all accomplished while the hemp is passing rapidly through the machine. The flutes are graduated from very coarse to fine, and the rollers are driven in such a manner that the stalks are not crushed, but broken by the most favorable leverage.

The coarser kinds of hemp are used for the manufacture of cordage, whereas the finer grades are used for textile purposes.

Hemp Compared to Flax.—Hemp though inferior in delicacy and fineness to linen, is incomparably stronger, equally susceptible of bleaching, and possesses more of the property of improving in color by wear. The finer grades of the fibre are spun in yarn and used extensively in the manufacture of carpets of all descriptions (hemp carpets, also stoffer warp for brussels, tapestry carpets, etc.)

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CALCULATIONS.

Grading of the Various Yarns Used in the Manufacture of Textile Fabrics According to Size or Counts.

The size of the yarns, technically known as their *"Counts"* or numbers, are based for the different raw materials (with the exception of raw silks) upon the number of yards necessary to balance one (1) lb. avoirdupois. The number of yards thus required (to balance 1 lb.) are known as the *"Standard"* and vary accordingly for each material. The higher the count or number, the finer the yarn according to its diameter.

COTTON YARNS.

Cotton yarns have for their standard 840 yards (equal to 1 hank) and are graded by the number of hanks 1 lb. contains. Consequently if 2 hanks, or 2 × 840 yards = 1680 yards are necessary to balance 1 lb. we classify the same as number 2 cotton yarn If 3 hanks or 3 × 840 or 2520 yards are necessary to balance 1 lb., the thread is known as number 3 cotton yarn. Continuing in this manner, always adding 840 for each successive number gives the yards the various counts or numbers of cotton yarn contain for 1 lb.

Table of Lengths for Cotton Yarns.

(From number 1 to 240's.)

No.	Yds. to 1 lb.	No.	Yds to 1 lb	No.	Yds. to 1 lb	No	Yds. to 1 lb.	No	Yds. to 1 lb.
1	840	17	14,280	33	27,720	50	42,000	85	71,400
2	1,680	18	15,120	34	28,560	52	43,680	90	75,600
3	2,520	19	15,960	35	29,400	54	45,360	95	79,800
4	3,360	20	16,800	36	30,240	56	47,040	100	84,000
5	4,200	21	17,640	37	31,080	58	48,720	110	92,400
6	5,040	22	18,480	38	31,920	60	50,400	120	100,800
7	5,880	23	19,320	39	32,760	62	52,080	130	109.200
8	6,720	24	20,160	40	33,600	64	53,760	140	117,600
9	7,560	25	21,000	41	34,440	66	55,440	150	126,000
10	8,400	26	21,840	42	35,280	68	57,120	160	134,400
11	9,240	27	22,680	43	36.120	70	58,800	170	142,800
12	10,080	28	23,520	44	36,960	72	60,480	180	151,200
13	10,920	29	24,360	45	37,800	74	62,160	190	159,600
14	11,760	30	25,200	46	38,640	76	63,840	200	168,000
15	12,600	31	26,040	47	39,480	78	65,520	220	184,800
16	13,440	32	26,880	48	40,320	80	67,200	240	201,600

Grading of 2-ply, 3-ply, etc., Cotton Yarns.

Cotton Yarns are frequently manufactured into 2-ply. In such cases the number of yards required for 1 lb. is one-half the amount called for in the single thread.

For Example.—20's cotton yarn (single) equals 16,800 yards per pound, while a 2-ply thread of 20's cotton, technically indicated as 2/20's cotton, requires only 8400 yards, or equal to the amount called for in single 10's cotton (technically represented as 10's cotton). Single 7's cotton yarn has 5,880 yards to 1 lb., and thus equals 2-ply 14's cotton yarn ; or 2/14's cotton yarn equals one-half the count (14÷2=7), or number 7 in single yarn.

If the yarn be more than 2-ply, divide the number of the single yarn in the required counts by the number of ply, and the result will be the equivalent counts in a single thread.

Example.—Three-ply 60's, or 3/60's cotton yarn, equals in size

{Number of single yarn in required counts.}		{Number of ply.}		{Equivalent counts in a single thread}
(60	÷	3	=	20)

single 20's cotton yarn, or 16,800 yards of single 20's cotton yarn weigh 1 lb., and 16,800 yards of 3/60's cotton yarn weigh also 1 lb. Again, 4-ply 60's or 4/60's cotton yarn equals in size

{Number of single yarn in required counts.}		{Number of ply.}		{Equivalent counts in a single thread.}
(60	÷	4	=	15)

single 15's cotton yarn; or single 15's cotton yarn has 12.600 yards, weighing 1 lb., which is also the number of yards required for 4/60's cotton yarn.

Rule for finding the Weight in Ounces of a given Number of Yards of Cotton Yarn of a known Count.

Multiply the given yards by 16, and divide the result by the number of yards of the known count required to balance 1 lb.

Example (single yarn).—Find weight of 12,600 yards of 30's cotton yarn. 12,600×16=201,600; 1 lb. 30's cotton yarn=25,200 yards. Thus, 201,600÷25,200=8.

Answer.—12,600 yards of 30's cotton yarn weigh 8 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/30's cotton yarn. 12,600×16=201,600; 1 lb. 2/30's cotton yarn=12,600 yards. Thus, 201,600÷12,600=16.

Answer.—12,600 yards of 2/30's cotton yarn weigh 16 oz.

Example—(3-ply yarn).—Find the weight of 12,600 yards of 3/30's cotton yarn. 12,600×16=201,600; 1 lb. 3/30's cotton yarn=8,400 yards. Thus, 201,600÷8,400=24 oz.

Answer.—12,600 yards of 3/30's cotton yarn weigh 24 oz.

Another rule for ascertaining the weight in ounces for a given number of yards of cotton yarn of a known count is as follows: Divide the given yards by the number of yards of the known count required to balance one ounce (being yards per lb.÷16).

Example (single yarn).—Find the weight of 12,600 yards of 30's cotton yarn. 25,200÷16=1,575 yards 30's cotton yarn=1 oz.; 12,600÷1,575=8.

Answer.—12,600 yards of 30's cotton yarn weigh 8 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/30's cotton yarn. 12,600÷16=787½ yards 2/30's cotton yarn=1 oz.; 12,600÷787½=16.

Answer.—12,600 yards of 2/30's cotton yarn weigh 16 oz.

Example (3-ply yarn).—Find the weight for 12,600 yards of 3/30's cotton yarn. 8,400÷16=525 yards 3/30's cotton yarn=1 oz.; 12,600÷525=24.

Answer.—12,600 yards of 3/30's cotton yarn weigh 24 oz.

Rule for finding the Weight in Pounds of a given Number of Yards of Cotton Yarn of a known Count.

Divide the given yards by the number of yards of the known count required to balance 1 lb.

Example (single yarn).—Find the weight of 1,260,000 yards of 30's cotton yarn. 30's cotton yarn=25,200 yards to 1 lb. Thus, 1,260,000÷25,200=50.

Answer.—1,260,000 yards of 30's cotton yarn weigh 50 lbs.

Example (2-ply yarn).—Find the weight of 1,260,000 yards of 2/30's cotton yarn. 2/30's cotton yarn=12,600 yards to 1 lb. Thus, 1,260,000÷12,600=100.

Answer.—1,260,000 yards of 2/30's cotton yarn weigh 100 lbs.

Example (3-ply yarn).—Find the weight of 1,260,000 yards of 3/30's cotton yarn. 3/30's cotton yarn=8,400 yards to 1 lb. Thus, 1,260,000÷8,400=150.

Answer.—1,260,000 yards of 3/30's cotton yarn weigh 150 lbs.

To find the Equivalent Size in Single Yarn for Two, Three, or More, Ply Yarn Composed of Minor Threads of Unequal Counts.

In the manufacture of fancy yarns the compound thread is often composed of two or more minor threads of unequal counts. If so, the rules for finding the equivalent in single yarn is as follows:

Rule.—If the compound thread is composed of two minor threads of unequal counts, divide the product of the counts of the minor threads by their sum.

Example.—Find the equal in single yarn to a two-fold thread composed of single 40's and 60's. $40\times60=2400\div100\ (40+60)=24$.

Answer.—A two-fold cotton thread composed of single 40's and 60's equals a single 24's.

Rule.—If the compound thread is composed of three minor threads of unequal counts, compound any two of the minor threads into one, and apply the previous rule to this compound thread and the third minor thread not previously used.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 20's, 30's and 50's. $20\times30=600\div50\ (20+30)=12$; $12\times50=600\div62\ (12+50)=9\frac{21}{31}$.

Answer.—A 3-ply cotton yarn composed of 20's, 30's and 50's equals in size a single $9\frac{21}{31}$'s thread.

A second rule for finding the equivalent counts for a yarn when three or more minor threads are twisted together is as follows: Divide one of the counts by itself, and by the others in succession, and afterwards by the sum of the quotients. To prove the accuracy of this rule we give again the previously given example.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 20's, 30's and 50's.

$$
\begin{aligned}
50\div50&=1 \\
50\div30&=1\tfrac{4}{6} \qquad\qquad 50\div5\tfrac{1}{6}=9\tfrac{21}{31} \\
50\div20&=2\tfrac{3}{6} \\
\hline
&\ \ 5\tfrac{1}{6}
\end{aligned}
$$

Answer.—A 3-ply cotton thread composed of 20's, 30's and 50's equals in size a single $9\frac{21}{31}$'s thread.

Example.—Find equal counts in a single yarn for the following 3-ply yarn composed of 40's, 30's, and 20's cotton threads.

$$
\begin{aligned}
40\div40&=1 \\
40\div30&=1\tfrac{1}{3} \qquad\qquad 40\div4\tfrac{1}{3}=9\tfrac{3}{13} \\
40\div20&=2 \\
\hline
&\ \ 4\tfrac{1}{3}
\end{aligned}
$$

Answer.—The 3-ply yarn given in the example equals a single $9\frac{3}{13}$ cotton thread.

Memo.—In the manufacture of twisted yarns (composed either out of two, three, or more minor threads) a certain amount of shrinkage will take place by means of the twisting of the threads around each other. No doubt if both minor threads are of equal counts this shrinkage will be equal for both, but if the sizes of the yarns, or the raw materials of which they are composed, are different, such "*take-up*" will be different for each minor thread. For example: a strong and heavy minor thread twisted with a fine soft thread; in this case the finer thread will wind itself (more or less) around the thick or heavy thread, not having sufficient strength to bend the latter, thus the finer thread will take up more in proportion than the heavy thread. Twisting a woolen thread with a cotton thread, both supposed to be of the same counts, will stretch the former more than the latter; *i. e.* it will lose less in length during twisting compared to the latter. Again two or more minor threads twisted with different turns per inch will accordingly take up differently. In giving rules for any of the yarn calculations in 2, 3, or more ply yarn, no notice of shrinkage or take-up by means of twisting the minor threads is taken in account, since otherwise an endless number of rules of the most complicated character would be required with reference to raw materials, the different counts of threads, turns of twist per inch and tension for each individual minor thread during the twisting operation. Such rules would thus be of little value to the manufacturer since his practical experience regarding this subject will readily assist him to calculate quickly and exactly by rules given, with a proportional allowance for a take up of minor threads as the case may require.

WOOLEN YARNS.

A. "Run" System.

Woolen yarns are with the exception of the mills in Philadelphia and vicinity, graded by "*runs*" which have for their standard 1600 yards. Consequently 1 run yarn requires 1600 yards to 1 lb., 2 run yarn—3200 yards to 1 lb., 3 run yarn—4800 yards to 1 lb., etc., always adding 1600 yards for each successive run. In addition to using whole numbers only as in the case of cotton and worsted yarn, the run is divided into halves, quarters, and occasionally into eighths, hence—

200	yards equal	$\frac{1}{8}$	run	1000	yards equal	$\frac{5}{8}$	run	
400	" "	$\frac{1}{4}$	"	1200	" "	$\frac{3}{4}$	"	
600	" "	$\frac{3}{8}$	"	1400	" "	$\frac{7}{8}$	"	
800	" "	$\frac{1}{2}$	"	1600	" "	1	"	&c.

Table of Lengths for Woolen Yarns (*Run System*).

(From one-fourth Run to fifteen Run)

Run.	Yds. to 1 lb.	Run.	Yds. to 1 lb.	Run.	Yds to 1 lb	Run.	Yds to 1 lb
¼	400	3	4,800	5¾	9,200	8½	13,600
½	800	3¼	5,200	6	9,600	8¾	14,000
¾	1,200	3½	5,600	6¼	10,000	9	14,400
1	1,600	3¾	6,000	6½	10,400	9½	15,200
1¼	2,000	4	6,400	6¾	10,800	10	16,000
1½	2,400	4¼	6,800	7	11,200	10½	16,800
1¾	2,800	4½	7,200	7¼	11,600	11	17,600
2	3,200	4¾	7,600	7½	12,000	12	19,200
2¼	3,600	5	8,000	7¾	12 400	13	20,800
2½	4,000	5¼	8,400	8	12,800	14	22,400
2¾	4,400	5½	8,800	8¼	13,200	15	24,000

Rule for Finding the Weight in Ounces of a Given Number of Yards of Woolen Yarn of a Known Count Graded After the Run System.

The run basis is very convenient for textile calculations by reason of the standard number equaling 100 times the number of ounces that 1 lb. contains; thus by simply multiplying the size of the yarn given in run counts by 100, and dividing the result into the number of yards given (for which we have to find the weight), gives us as the result the weight expressed in ounces

Example.—Find the weight of 7200 yards of 4 run yarn—$4\times100=400$. $7200\div400=18$.
Answer.—7200 yards 4 run yarn weigh 18 ounces.

Example.—Find the weight of 3750 yards of $3\frac{3}{4}$ run woolen yarn—$3750\div375=10$.
Answer.—3750 yards of $3\frac{3}{4}$ run woolen yarn weigh 10 ounces.

Rule for Finding the Weight in Pounds of a Given Number of Yards of Woolen Yarn of a Known Count Graded After the Run System.

If the weight of a given number of yards and of a given size of woolen yarn, run system, is required to be calculated in pounds, transfer the result obtained in ounces into pounds or fractions thereof.

Example.—Find the weight of 100,000 yards of 6¼ run yarn—100,000÷625=160 oz.÷16=10.

Answer.—100,000 yards of 6¼ run yarn weigh 10 lbs.

B. "Cut" System.

As heretofore mentioned, woolen yarn is also graded by the "cut" system. 300 yards is the basis or standard, consequently if 300 yards of a given woolen yarn weigh 1 lb., we classify it as 1 cut yarn; if 600 yards weigh 1 lb. we classify it as 2 cut yarn; if 900 yards weigh 1 lb. we classify it as 3 cut yarn, and so on; hence the count of the woolen yarn expressed in the cut multiplied by 300 gives as the result the number of yards of respective yarn that 1 lb. contains.

Table of Lengths for Woolen Yarns (*Cut System*).

(From 1 cut to 50 cut Yarn.)

Cut.	Yards to lb.	Cut.	Yards to lb.	Cut.	Yards to lb.	Cut.	Yards to lb.	Cut.	Yards to lb.
1	300	12	3,600	23	6,900	34	10,200	45	13,500
2	600	13	3,900	24	7,200	35	10,500	46	13,800
3	900	14	4,200	25	7,500	36	10,800	48	14,400
4	1,200	15	4,500	26	7,800	37	11,100	50	15,000
5	1,500	16	4,800	27	8,100	38	11,400	54	16,200
6	1,800	17	5,100	28	8,400	39	11,700	58	17,400
7	2,100	18	5,400	29	8,700	40	12,000	60	18,000
8	2,400	19	5,700	30	9,000	41	12,300	65	19,500
9	2,700	20	6,000	31	9,300	42	12,600	70	21,000
10	3,000	21	6,300	32	9,600	43	12,900	75	22,500
11	3,300	22	6,600	33	9,900	44	13,200	80	24,000

Rule for Finding the Weight in Ounces for a Given Number of Yards of Woolen Yarn of a Known Count Figured by the "Cut" Basis.

This rule is similar to the one given for cotton yarn. "Multiply the given yards by 16 and divide the result by the original number of yards for the given count of cotton yarn that 1 lb. contains."

Example.—Find the weight of 12,600 yards of 40-cut woolen yarn. 12,600×16=201,600; 1 lb. of 40-cut woolen yarn=12,000 yards. Thus, 201,600÷12,000=16.8.

Answer.—12,600 yards of 40-cut woolen yarn weigh 16.8 oz.

The other rule for ascertaining the weight in ounces for a number of yards of cotton yarn of a known count is as follows: Divide the given yards by the number of yards of the known count required to balance one ounce.

Example.—Find the weight for 12,600 yards of 40-cut woolen yarn. 12,000÷16=750 12,600÷750=16.8.

Answer.—12,600 yards of 40-cut woolen yarn weigh 16.8 oz.

Rule for Finding the Weight in Pounds of a Given Number of Yards of Woolen Yarn of a Known Count, Graded by the Cut Basis.

This rule is also similar to the one previously given for cotton yarn. Divide the given yards by the original number of yards for the given count of woolen yarn (cut basis) in 1 lb. The result expresses the weight in pounds, or fractions thereof.

Example.—Find the weight of 1,260,000 yards of 40-cut woolen yarn. 40-cut woolen yarn=12,000 yards to 1 lb. Thus, 1,260,000÷12,000=105.

Answer.—1,260,000 yards of 40-cut woolen yarn weigh 105 lbs.

Grading of Double and Twist or more Ply Woolen Yarn.

Woolen yarns are sometimes manufactured in double and twist (*d&tw.*), seldom in a more ply.

If produced in *d&tw*, and if both single threads are of the same counts, the established custom is to consider the compound thread one-half the count of the minor. Thus, a *d&tw.* 6-run woolen yarn will equal a single 3-run; or either yarn figures 4,800 yards to a lb. A *d&tw.* $7\frac{1}{2}$-run woolen yarn will equal a single $3\frac{3}{4}$-run woolen yarn; or either yarn requires 6,000 yards per lb. A *d&tw.* 30-cut woolen yarn equals a single 15-cut, or both kinds of yarn required 4,500 yards per lb.

If the compound thread is composed of three or more single threads, divide the number of the single yarn by the number of ply, and the result will be the required counts in a single thread.

Examples.—Three-ply 10-run woolen yarn equals a (10÷3) $3\frac{1}{3}$-run single thread, or requires $5{,}333\frac{1}{3}$ yards per lb. A 3-ply 45-cut woolen yarn equals a (45÷3) 15-cut single yarn, or requires 4,500 yards per lb.

Double and twisted woolen yarns, used in the manufacture of "fancy cassimeres," are frequently composed of two minor threads of unequal counts. If so, the rule for finding the equal in a single thread as compared with the compound thread is as follows: Divide the product of the counts of the minor threads by their sum.

Example.—Find the equal counts in single woolen yarn (run basis) for a double and twist thread composed of single 3-run and 6-run woolen yarn. $3\times6=18\div9(3+6)=2$.

Answer.—A 3-run and 6-run woolen thread being twisted equal a single 2-run woolen thread.

Example.—Find the equal counts in single woolen yarn (cut basis) for a double and twist thread composed of single 20-cut and 30-cut yarn. $20\times30=600\div50\ (20+30)=12$.

Answer.—A 20-cut and 30-cut woolen yarn twisted equal single 12-cut woolen yarn.

As previously mentioned, we may in a few instances be called on to calculate for a 3-ply yarn. If such a compound thread is composed of three minor threads of unequal counts, compound any of the minor threads into one, and apply the previously-given rule for *d&tw.*

Example.—A 3-run, 6-run and 8-run thread being twisted together, what are the equal counts in one thread for the compound thread?

$3\times6=18\div9(3+6)=2$. (A 3-run and a 6-run thread compounded equal a 2-run single thread) Thus, $2\times8=16\div10(2+8)=1\frac{6}{10}=1\frac{3}{5}$.

Answer.—Compound thread given in example equals $1\frac{3}{5}$ run.

Example.—A 20-cut, 30-cut and a 36-cut thread, being twisted together, what is its equal size in a single yarn? $20\times30=600\div50(20+30)=12$, and $12\times36=432\div48(12+36)=9$.

Answer.—Compound thread given in example equals a single 9-cut thread.

As already mentioned, under the head of cotton yarns, a second rule for finding the equivalent counts for a yarn where three or more minor threads are twisted together is as follows: Divide one of the counts by itself, and by the others in succession, and afterwards by the sum of the quotients.

To prove this rule, we will use examples heretofore given.

Example.—Find equal counts in one thread for the following compound thread, composed of a 3-run, 6-run and 8-run thread.

$$8\div8=1$$
$$8\div6=1\tfrac{1}{3}$$
$$8\div3=2\tfrac{2}{3}$$
$$\overline{5}$$

$$8\div5=1\tfrac{3}{5}$$

Answer.—Compound thread given in example equals 1$\frac{3}{5}$ run.

Example.—A 20-cut. 30-cut and 36-cut thread, being twisted together, what is its equal size in a single yarn ?

$$36 \div 36 = 1$$
$$36 \div 30 = 1\tfrac{1}{5} \qquad\qquad 36 \div 4 = 9$$
$$36 \div 20 = 1\tfrac{4}{5}$$
$$\overline{\quad 4}$$

Answer.—Compound thread given in example equals a single 9-cut thread.

WORSTED YARNS.

Worsted yarns have for their standard measure 560 yards to the hank. The number of hanks that balance one pound indicate the number or the count by which it is graded. Hence if 40 hanks each 560 yards long, weigh 1 lb. such a yarn is known as 40's worsted. If 48 hanks are required to balance 1 lb. it is known as 48's worsted. In this manner the number of yards for any size or count of worsted yarns is found by simply multiplying the number or count by 560.

Table of Lengths for Worsted Yarn.

(From No. 1 to 200's).

No.	Yds. to 1 lb.	No.	Yds. to 1 lb.	No.	Yds. to 1 lb.	No.	Yds to 1 lb.	No.	Yds. to 1 lb.
1	560	15	8,400	29	16,240	46	25,760	74	41,440
2	1,120	16	8,960	30	16,800	48	26,880	76	42,560
3	1,680	17	9,520	31	17,360	50	28,000	80	44,800
4	2,240	18	10,080	32	17,920	52	29,120	85	47,600
5	2,800	19	10,640	33	18,480	54	30,240	90	50,400
6	3,360	20	11,200	34	19,040	56	31,360	95	53,200
7	3,920	21	11,760	35	19,600	58	32,480	100	56,000
8	4,480	22	12,320	36	20,160	60	33,600	110	61,600
9	5,040	23	12,880	37	20,720	62	34,720	120	67,200
10	5,600	24	13,440	38	21,280	64	35,840	130	72,800
11	6,160	25	14,000	39	21,840	66	36,960	140	78,400
12	6,720	26	14,560	40	22,400	68	38,080	160	89,600
13	7,280	27	15,120	42	23,520	70	39,200	180	100,800
14	7,840	28	15,680	44	24,640	72	40,320	200	112,000

Grading of 2-ply, 3-ply, etc. Worsted Yarns.

Worsted yarn is like cotton yarn, very frequently produced in 2-ply. If such is the case, only one-half the number of yards as required per pound for the single yarn are required to balance the pound of 2-ply yarn. Hence 40's worsted (technically for single 40's worsted) requires 22,400 yards per lb. and 2/80's worsted (technically for 2-ply 80's worsted) requires also 22,400 yards per pound. 2/60's worsted has 16,800 yards per pound corresponding to single 30's worsted.

If the yarn be more than 2-ply, divide the number of yards of single yarn by the number of ply.

Examples.—3-ply 90's (3/90's) worsted yarn equals in size (90÷3) a single 30's thread; or both kinds of yarn require 16,800 yards to balance 1 lb.—4/80's worsted yarn equals a (80÷4) single 20's.

Rule for Finding Weight in Ounces for a Given Number of Yards of Worsted Yarn of a Known Count.

Multiply the given yards by 16, and divide the result by the number of yards the given count of worsted yarn contains balancing 1 lb.

Example (single yarn).—Find the weight for 12,600 yards of 40's worsted. 12,600×16=201,-600. 1 lb. of 40's worsted=22,400 yards, thus:—201,600÷22,400=9.

Answer.—12,600 of 40's worsted weigh 9 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/40's worsted. 12,600×16=201,600. 1 lb. of 2/40's=11,200 yards. Hence 201,600÷11,200=18

Answer.—12,600 yards of 2/40's worsted weigh 18 oz.

Example (3-ply yarn).—Find the weight of 12,600 yards of 3/40's worsted. 12,600×16=201,-600. 1 lb of 3/40's=$7,466\frac{2}{3}$ yards, thus 201,600÷$7,466\frac{2}{3}$=27.

Answer.—12,600 yards of 3/40's worsted weigh 27 oz.

Another rule for ascertaining the weight in ounces for a given number of yards of worsted yarn of a known count is as follows: Divide the given yards by the number of yards of the known count required to balance 1 oz.

Example (single yarn).—Find the weight for 12,600 yards of 40's worsted. 22,400÷16=1,400. 12,600÷1,400=9.

Answer.—12,600 yards of 40's worsted weigh 9 oz.

Example (2-ply yarn).—Find the weight of 12,600 yards of 2/40's worsted. 11,200÷16=700 12,600÷700=18.

Answer.—12,600 yards of 2/40's worsted weigh 18 oz.

Example (3-ply yarn).—Find the weight of 12,600 yards of 3/40's worsted. $7466\frac{2}{3}\div16=466\frac{2}{3}$ and $12,600\div466\frac{2}{3}=12600\div\frac{1400}{3}=\frac{12600\times3}{1400}=27$.

Answer.—12,600 yards of 3/40's worsted weigh 27 ounces.

Rule for Finding the Weight in Pounds of a Given Number of Yards of Worsted Yarn of a Known Count.

Divide the given yards by the number of yards of the known count required to balance 1 lb.

Example (single yarn).—Find the weight of 1,260,000 yards of 40's worsted yarn, 40's worsted=22,400 yds. to 1 lb. Thus, 1,260,000÷22,400=$56\frac{1}{4}$.

Answer.—1,260,000 yds. of 40's worsted weigh $56\frac{1}{4}$ lbs.

Example (2-ply yarn).—Find the weight of 1,260,000 yards of 2/40's yarn. 2/40's worsted=11,200 yards to 1 lb. Thus, 1,260,000÷11,200=$112\frac{1}{2}$.

Answer.—1,260,000 yards of 2/40's worsted yarn weigh $112\frac{1}{2}$ lbs.

Example (3-ply yarn).—Find the weight of 1,260,000 yards of 3/40's worsted yarn. 3/40's worsted=7,467 yards to 1 lb. Hence, 1,260,000÷7,467=$168\frac{3}{4}$.

Answer.—1,260,000 yards of 3/40's worsted yarn weigh $168\frac{3}{4}$ lbs.

To Find the Equivalent Size in Single Yarn of Two, Three or More Ply Yarn Composed of Minor Threads of Unequal Counts.

Worsted yarn is also occasionally manufactured in 2, 3, or more ply yarn in which the minor threads are of unequal counts; if so the rules for finding the equivalent in a single yarn are similar to those given for cotton and woolen yarns.

If the compound thread is composed of two minor threads of unequal counts, divide the product of the counts of the minor threads by their sum.

Example.—Find the equal in single yarn to a 2-fold thread composed of single 20's and 60's. $20 \times 60 = 1200 \div 80\ (20+60) = 15$.

Answer.—A 2-fold worsted yarn composed of 20's and 60's equals a single 15's.

If the compound thread is composed of 3 minor threads of unequal counts, compound any two of the minor threads into one, and apply the rule given previously to this thread and the third minor thread not previously used.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 20's, 40's, and 60's. $20 \times 40 = 800 \div 60\ (20+40) = 13\frac{1}{3}$. $13\frac{1}{3} \times 60 = 800 \div 73\frac{1}{3}\ (13\frac{1}{3}+60) = 10\frac{10}{11}$.

Answer.—A 3-ply 20's, 40's, and 60's worsted thread equals in size a single $10\frac{10}{11}$'s.

These examples can be proved by the second rule, viz.: Divide one of the counts by itself and by the others in succession, and after this by the sum of the quotients.

Example.—Find equal counts in a single thread to a 3-ply yarn composed of 60's, 40's and 20's worsted.

$$60 \div 60 = 1$$
$$60 \div 40 = 1\tfrac{1}{2} \qquad\qquad 60 \div 5\tfrac{1}{2} = 10\tfrac{10}{11}.$$
$$60 \div 20 = 3$$
$$\overline{5\tfrac{1}{2}}$$

Answer.—A 3-ply 20's, 40's and 60's worsted thread equals in size a single $10\frac{10}{11}$'s.

SILK YARNS.

A. Spun Silks.

Spun silks are calculated as to the size of the thread, on the same basis as cotton (840 yards to 1 hank), the number of hanks one pound requires indicating the counts. In the calculation of cotton, woolen or worsted, double and twist yarn, the custom is to consider it as twice as heavy as single; thus double and twisted 40's (technically 2/40's) cotton, equals single 20's cotton for calculations. In the calculation of spun silk the single yarn equals the two-fold; thus single 40's and two-fold 40's require the same number of hanks (40 hanks equal 33,600 yards). The technical indication of two-fold in spun silk is also correspondingly reversed if compared to cotton, wool and worsted yarn. In cotton, wool and worsted yarn the 2 indicating the two-fold is put in front of the counts indicating the size of the thread (2/40's), while in indicating spun silk this point is reversed (40/2's), or in present example single 80's doubled to 40's.

B. Raw Silks.

The adopted custom of specifying the size of raw silk yarns is in giving the weight of the 1000 yards hank in drams avoirdupois; thus if one hank weighs 5 drams it is technically known as "5 dram silk," and if it should weigh $8\frac{1}{2}$ drams it is technically known as "$8\frac{1}{2}$ dram silk." As already mentioned the length of the skeins is 1000 yards, except in fuller sizes where 1000 yard skeins would be rather bulky, and apt to cause waste in winding. Such are made into skeins of 500 and 250 yards in length and their weight taken in proportion to the 1000 yards; thus if the skein made up into 500 yards weighs $8\frac{1}{2}$ drams, the silk would be 17-dram silk; if a skein made up into 250 yards weighs 4 drams the silk would be 16-dram silk. The size of yarn is always given for their "gum" weight; that is their condition "before boiling off," in which latter process yarns lose from 24 to 30 per cent. according to the class of raw silk used; China silks losing the most and European and Japan silks the least. The following table shows the number of yards to the pound and ounce from 1 dram silk to 30 dram silk. The number of yards given per pound in the table is based on a pound of gum silk.

Length of Gum Silk Yarn per Pound and per Ounce.

(From 1 dram to 30 drams.)

Drams per 1000 yards.	Yards per lb.	Yards per oz.	Drams per 1000 yards	Yards per lb.	Yards per oz.	Drams per 1000 yards.	Yards per lb.	Yards per oz.
1	256,000	16,000	5	51,200	3,200	16	16,000	1,000
1¼	204,800	12,800	5½	46,545	2,909	17	15,058	941
1½	170,666	10,667	6	42,667	2,667	18	14,222	889
1¾	146,286	9 143	6½	39,385	2.462	19	13,474	842
2	128,000	8,000	7	36,571	2,286	20	12,800	800
2¼	113,777	7,111	7½	34,133	2,133	21	12,190	762
2½	102,400	6,400	8	32,000	2,000	22	11,636	727
2¾	93,091	5,818	8½	30,118	1,882	23	11,130	696
3	85,333	5,333	9	28,444	1,778	24	10,667	666
3¼	78,769	4,923	9½	26,947	1,684	25	10,240	640
3½	73,143	4,571	10	25,600	1.600	26	9,846	615
3¾	68,267	4,267	11	23,273	1,455	27	9,481	592
4	64,000	4,000	12	21,333	1,333	28	9 143	571
4¼	60,235	3,765	13	19,692	1,231	29	8,827	551
4½	56,889	3,556	14	18,286	1,143	30	8,533	533
4¾	53,368	3,368	15	17,067	1,067			

LINEN YARNS.

Linen yarns are graded, or have for their standard 300 yards to the hank or "lea," which is the same basis for calculations with reference to size, count, or diameter of thread, as the one given for the woolen yarn, viz., (cut system); hence, rules given for woolen yarn (cut system), will also apply to linen yarns by simply changing the denomination.

Jute Yarns, Chinagrass and Ramie

Are also graded similar to the woolen yarn (cut system), with 300 yards to the hank, the number of hanks required to balance 1 lb. indicating the size or count of the yarn.

For Reproducing Fabrics in a Required Material From a Given Fabric Made Out of Another Material it is Often Necessary to Find the Equivalent Counts, Thus we Give

Rules for Finding the Equivalent Counts of a Given Thread in Another System.

A. COTTON, WOOLEN AND WORSTED YARN.

Rule.—The counts of a given thread are the counts of an equal thread (in size) of a different material, or a thread of the same material but figured after the different "standard" in the same proportion as the "standard number" of the one to be found is to the "standard number" of the one given.

Example.—**Cotton-Worsted.** Find equal size in worsted yarn to 20's cotton yarn.

(Cotton standard.) : (Worsted standard).

840 : 560 = 3 : 2

Thus 20:x::2:3 and $3 \times 20 = 60 \div 2 = 30$.

Answer.—A thread of 20's cotton yarn equals (in size) a thread of 30's worsted yarn.

Example.—**Cotton-Wool** (run system). Find equal size in woolen yarn (runs) to 10's cotton yarn.

(Cotton standard.)	:	(Run standard.)	
840	:	1,600	=21 : 40

Thus 10:x::40:21 and 21×10=210÷40=5¼.

Answer.—A thread of 10's cotton equals (in size) a thread of 6¼-run (wool).

Example.—**Cotton-Wool** (cut system). Find equal size in woolen yarn (cut basis) to 10's cotton yarn.

(Cotton standard.)	:	(Cut standard.)	
840	:	300	= 14 : 5

Thus 10:x :: 5:14 and 14×10=140÷5=28.

Answer.—A thread of 10's cotton yarn equals (in size) a thread of 28-cut woolen yarn.

Example.—**Worsted-Wool** (run system). Find equal size in woolen yarn (run basis) to 20's worsted yarn.

(Worsted standard.)	:	(Run standard.)	
560	:	1,600	=7:20

Thus 20:x :: 20:7 and 7×20=140÷20=7.

Answer.—A thread of 20's worsted equals (in size) a thread of 7-run woolen yarn.

Example.—**Worsted-Wool** (cut system). Find equal size in woolen yarn (cut basis) to 15's worsted yarn.

(Worsted standard.)	:	(Cut standard.)	
560	:	300	=28:15

Thus 15:x :: 15:28 and 15×28=428÷15=28.

Answer.—A thread of 15's worsted equals (in size) a thread of 28-cut woolen yarn.

Example.—**Worsted-Cotton.** Find equal size in cotton yarn to 30's worsted.

30:x :: 3:2and 30×2=60÷3=20.

Answer.—A thread of 30's worsted equals (in size) a thread of 20's cotton yarn.

Example.—**Wool** (run system) **-Cotton.** Find equal size in cotton yarn to a 5¼-run woolen yarn

5.25:x :: 21:40 and 5.25×40=210÷21=10.

Answer.—A 5¼-run woolen yarn equals (in size) a 10's cotton yarn.

Example.—**Wool** (run system) **-Worsted.** Find equal size in worsted yard to a 7-run woolen yarn.

7:x :: 7:20 and 7×2=140÷7=20.

Answer.—A 7-run woolen yarn equals in size a 20's worsted yarn.

Example.—**Wool** (run system) **-Wool** (cut system). Find equal size in the cut basis for a 6-run woolen thread.

6:x :: 3:16 and 6×16=96÷3=32.

Answer.—A 6-run woolen thread equals (in size) a 32-cut thread of the same material.

Example.—**Wool** (cut system) **-Cotton.** Find equal size of cotton yarn to a 28-cut woolen yarn.

28:x :: 14:5 and 5×28=140÷14=10.

Answer.—A 28-cut woolen yarn equals (in size) a 10's cotton yarn.

Example.—**Wool** (cut system) -**Worsted.** Find equal size worsted yarn to a 28-cut woolen yarn.

$$28 : x :: 28 : 15 \text{ and } 28 \times 15 = 420 \div 28 = 15.$$

Answer.—A 28-cut woolen yarn equals (in size) a 15's worsted yarn.

Example.—**Wool** (cut system) -**Wool** (run system). Find equal size of the run basis for a 32-cut woolen yarn.

$$32 : x :: 16 : 3 \text{ and } 3 \times 32 = 96 \div 16 = 6.$$

Answer.—A 32-cut woolen yarn equals (in size) a 6-run woolen yarn.

B. SPUN SILK YARNS COMPARED TO COTTON, WOOLEN OR WORSTED YARNS.

As already stated in a previous chapter the basis of spun silk is the same as that of cotton; therefore the rules and examples given under the heading of "Cotton" refer at the same time to spun silk.

C. LINEN YARNS, JUTE AND RAMIE.

These yarns have the same standard of grading as woolen yarn (cut system); thus examples given under the latter basis will also apply to the present kind of yarns.

D. RAW SILK YARNS COMPARED TO SPUN SILK, COTTON, WOOLEN OR WORSTED YARNS.

Rule.—Find the number of yards per pound (in table previously given) in raw silk and divide the same by the standard size of the yarn basis to be compared with.

Example.—**Raw Silk-Cotton** (or spun silk). Find equal size in cotton yarn to 9-dram raw silk. 9-dram raw silk=28,444 yds. per lb. Thus 28,444÷840 (cotton standard)=$33\frac{6}{7}$.

Answer.—2-dram raw silk equals (nearly) 34's cotton.

Or if calculating without a table proceed as follows: 1 lb.=16 oz. 1 oz.=16 drams. Thus $16 \times 16 = 256$ drams per lb.

(Counts given.)	:	(Yards in 1 hank.)		(Drams per lb.)		(Yards per lb.)
9	:	1000	::	256	:	x

$256 \times 1000 = 256{,}000 \div 9 = 28{,}444\frac{4}{9}$ yds. per lb. of 9 drams raw silk.

(Yards per lb.)	::	(Basis of yarn to compare with.)	
28,444	÷	840	$=33\frac{6}{7}$

being with the same result as before.

Example.—**Spun Silk or Cotton to Raw Silk.** Find equal size in raw silk to 38's cotton. 38's cotton=(38×840) 31,920 yds. per lb. Refer to previously given table for raw silk, where you will find 8 drams to equal 32,000 yards per lb.

Answer.—A 38's cotton thread equals (nearly) an 8-dram raw silk thread.

Or if calculating without table find result by:

Rule.—Divide the standard measure (number of yards per lb.) of the given yarn by 1000 (yards in one hank) and the quotient thus obtained into 256. (drams in 1 lb.)

Example.—Find the answer by this rule for previously given question. 38's cotton=31,920 yards. Thus 31,920÷1000=31.92 and 256÷31.92=8.02.

Answer.—A 38's cotton thread equals (nearly) an 8-dram raw silk thread.

Ascertaining the Counts of Twisted Threads Composed of Different Materials.

The above question may often arise when manufacturing fancy yarns and of which it is requisite to know the compound size for future calculations.

RULE A.---**If the compound thread is composed of two minor threads of different materials,** one must be reduced to the relative basis of the other thread and the resulting count found in this system.

Example.—Find equal counts in a single worsted thread to a 2-ply thread composed of 30's worsted and 40's cotton yarn.

40's cotton=60's worsted. Thus, $30\times60=1800\div90\ (30+60)=20$.

Answer.—Compound thread given in example equals a single 20's worsted thread.

Example.—Find the equal counts in single cotton yarn to a 2-ply thread composed of single 30's worsted and 40's cotton yarn.

30's worsted=20's cotton. Thus, $40\times20=800\div60\ (40+20)=13\frac{1}{3}$.

Answer.—Compound thread given in example equals a single cotton thread of number $13\frac{1}{3}$.

Example.—Find the equal counts in single woolen yarn (run basis) to a 2-ply thread composed of single 20's cotton yarn and 6-run woolen yarn.

20's cotton=$10\frac{1}{2}$-run woolen yarn. Thus, $10\frac{1}{2}\times6=63\div16\frac{1}{2}\ (10\frac{1}{2}+6)=3\frac{9}{11}$.

Answer.—Compound thread given in example equals a single woolen thread of $3\frac{9}{11}$-run.

Example.—Find the equal counts in single woolen yarn (cut basis) to a 2-ply thread composed of single 40's cotton and 28-cut woolen yarn.

40's cotton=112-cut. Thus, $28\times112=3136\div140\ (28+112)=22\frac{4}{10}$.

Answer.—Compound thread given in example equals a single woolen yarn of $22\frac{2}{5}$-cut.

Example.—Find the equal counts in single worsted yarn to a 2-ply thread composed of single 20's worsted and 60's spun silk. 60's silk=90's worsted. Thus, $20\times90=1800\div110\ (20+90)\ 16\frac{4}{11}$.

Answer.—Compound thread given in example equals a single $16\frac{4}{11}$'s worsted.

RULE B.---**If the compound thread is composed of three minor threads of two or three different materials,** they must by means of their relative length be transferred in one basis and the resulting count found in this system.

Example.—Find equal counts in single woolen yarn, run basis, for the following compound thread composed of a 3-run, a 6-run woolen thread, and a single 20's cotton twisted together.

$$3\times6=18\div9\ (3+6)=2.$$

(3-run and-6 run threads compounded, equal a single 2-run thread.)

20's cotton equals $10\frac{1}{2}$-run, thus $2\times10\frac{1}{2}=21\div12\frac{1}{2}\ (2+10\frac{1}{2})=1\frac{17}{25}$.

Answer.—The three-fold thread given in example equals in count a single woolen yarn of $1\frac{17}{25}$ (nearly $1\frac{3}{4}$) run.

The previously given example may also be solved as follows:—20's cotton=$10\frac{1}{2}$-run woolen yarn, thus,

$$\begin{aligned} 10\tfrac{1}{2}\div10\tfrac{1}{2}&=1\\ 10\tfrac{1}{2}\div\ 6\ &=1\tfrac{3}{4}\\ 10\tfrac{1}{2}\div\ 3\ &=3\tfrac{1}{2}\\ &\overline{\ 6\tfrac{1}{4}\ } \end{aligned} \qquad 10\tfrac{1}{2}\div6\tfrac{1}{4}=1\tfrac{17}{25}.$$

Answer.—A 3-run, a 6-run woolen thread, and a single 20's cotton twisted together equal in size a $1\frac{17}{25}$-run woolen thread.

Ascertaining the Counts for a Minor Thread to Produce, with Other Given Minor Threads, Two, Three, or More Ply Yarn of a Given Count.

A. ONE SYSTEM OF YARN.

In some instances it may be required that the compound thread produced out of two, three, or more, minor threads must be of a certain count. We may be requested to twist with a minor thread of a given count a minor thread of unknown count (to be ascertained); both threads to produce a compound thread of known count. If such is the case proceed after the following *Rule*: Multiply the counts of the given single thread by the counts of the compound thread, and divide the product by the remainder obtained by subtracting the counts of the compound threads from the counts of the given single thread.

Example.—Find size of single yarn required (run basis) to produce with a 4-run woolen yarn a compound thread of 3-run. 4×3=12÷1(4—3)=12.

Answer.—The minor thread required in the present example is a 12-run thread, or a 4-run and a 12-run woolen thread compounded into a 2-fold yarn, are equal in counts to a 3-run single woolen thread.

Proof.—4×12=48÷16=3-run, or compound thread, as required.

Example.—Find size of single yarn required (worsted numbers) to produce with a 48's worsted thread a compound thread the equal of 16's worsted yarn. 48×16=768÷32(48—16)= 24.

Answer.—The minor thread required in the present example is a 24's worsted thread, or a 48's worsted thread and a 24's worsted thread compounded into a two-fold yarn, are equal in counts to a single 16's worsted thread.

Proof.—48×24=1152÷72=16's worsted or compounded size required.

Example.—Find size of single yarn required (cotton numbers) to produce with an 80's cotton thread a 2-fold yarn of a compound size of equal 30's cotton yarn. 80×30=2400÷50(80—30)=48.

Answer.—The minor thread required in the present example is a 48's cotton thread compounded into a 2-fold yarn equal in this compound size to a single 30's cotton thread.

Proof.—80×48=3840÷128=30's cotton, or compound size required.

If one of the minor threads is to be found for a 3-ply thread of which two minor threads are known, use the following *Rule:* Compound the two minor threads given into their equal in a single thread, and solve the question by the previously given rule.

Example.—Find minor thread required to produce with single 30's and single 60's worsted a 3-ply yarn to equal single 12's worsted. 60's and 30's worsted compound =(60×30=1800÷90–(60+30)=20) single 20's worsted.

Thus	20	×	12	=240÷8	(20	—	12)	=30
	{Compound two minor threads of which size is known.}	×	{Known size of ply yarn.}		{Compound two minor threads of which size is known.}	—	{Known size of 3-ply yarn.}	

Answer.—The size of the third minor required to be ascertained in the given example is single 30's worsted yarn, or a 3-ply thread composed of single 30's, 60's, and 30's worsted yarn equals single 12's worsted counts as shown by the

Proof.—

60 ÷ 60 = 1
60 ÷ 30 = 2   60÷5=12's worsted.
60 ÷ 30 = 2
—
5

B. TWO SYSTEMS OF YARNS.

In the manufacture of fancy yarns we may be called on to select the proper minor thread required in another material. This, however, will not change previously given rules, for after finding the counts in the given system we only have to transfer the same to the required system.

Example (2-ply yarn).—Find the size of single worsted yarn required to produce with an 8-run woolen yarn a compound thread of 6-run yarn.

$8 \times 6 = 48 \div 2\ (8-6) = 24$-run woolen yarn required.

24-run woolen yarn=38,400 yards per lb. and $38,400 \div 560 = 68\frac{4}{7}$.

Answer.—The single worsted thread required in given example is $68\frac{4}{7}$'s.

Example (3-ply yarn).—Find the size of the spun silk required to produce with a 40's and 60's worsted a 3-ply yarn of equal count to single 12's worsted. $40 \times 60 = 2,400 \div 100\ (40+60) = 24$ = compound size of 40's and 60's. $24 \times 12 = 288 \div 12\ (24-12) = 24$'s worsted size required to be transferred in spun silk.

$$24 \times 560 = 13,440 \div 840 = 16$$

Answer.—16's spun silk is required in present example.

Ascertaining the Amount of Material Required for Each Minor Thread in Laying Out Lots for Two, Three, or More Ply Yarn.

A. DOUBLE AND TWIST YARN.

Composed of Minor Threads of the Same Material.

For producing a certain amount of fancy double and twist yarn it is necessary to ascertain the amount of stock required for each minor thread. This question will readily be solved by—

Rule.—The sum of both counts is to the one of the counts, in the same proportion as the amount of double and twist yarn required is to the amount of the yarn required for producing the other minor thread.

Example.—Find amount of material required for each minor thread for producing 1000 lbs. of double and twist yarn made out of 6 and 7-run minor threads.

$$(6+7) = 13 : 6 :: 1,000 : x$$
$$(6+7) = 13 : 7 :: 1,000 : x$$
$$6 \times 1,000 = 6,000 \div 13 = 461\tfrac{7}{13}$$
$$7 \times 1,000 = 7,000 \div 13 = 538\tfrac{6}{13}$$
$$\overline{\quad 1,000 \quad}$$

Answer.—In previously given example the following amount of yarn (of minor threads) is required :—$461\frac{7}{13}$ lbs. of 7-run yarn.

$536\frac{6}{13}$ " " 6-run yarn.

Proof.— $461\frac{7}{13}$ lbs. of 7-run yarn=$(461\frac{7}{13} \times 11,200) = 5,169,230\frac{10}{13}$ yds.

$538\frac{6}{13}$ lbs. of 6-run yarn=$(538\frac{6}{13} \times 9,600) = 5,169,230\frac{10}{13}$ yds.

Example.—Find amount of material required for each minor thread for producing 250 lbs. of double and twist yarn made out of 32's and 40's worsted for the minor threads.

$$(32+40) = 72 : 32 :: 250 : x$$
$$(32+40) = 72 : 40 :: 250 : x$$
$$32 \times 250 = 8,000 \div 72 = 111\tfrac{1}{9}$$
$$40 \times 250 = 10,000 \div 72 = 138\tfrac{8}{9}$$
$$\overline{\quad 250 \quad}$$

Answer.—For producing 250 lbs. of double and twist worsted yarn composed of 32's and 40's for minor threads,

$111\frac{1}{9}$ lbs. of 40's and $138\frac{8}{9}$ lbs. of 32's are required.

Proof.— $111\frac{1}{9}$ lbs. of 40's worsted equal $(111\frac{1}{9} \times 22{,}400) = 2{,}488{,}888\frac{8}{9}$ yds.
$138\frac{8}{9}$ lbs. of 32's worsted equal $(138\frac{8}{9} \times 17{,}920) = 2{,}488{,}888\frac{8}{9}$ yds.

Example.—Find amount of material required for each minor thread for producing 1,000 lbs. of double and twist cotton yarn made with 60's and 80's for minor threads.

$$(60 + 80) = 140 : 60 :: 1{,}000 : x$$
$$(60 + 80) = 140 : 80 :: 1{,}000 : x$$
$$60 \times 1{,}000 = 60{,}000 \div 140 = 428\tfrac{4}{7}$$
$$80 \times 1{,}000 = 80{,}000 \div 140 = 571\tfrac{3}{7}$$
$$\overline{1{,}000}$$

Answer.—For producing 1,000 lbs. of double and twist cotton yarn made out of single 60's and 80's the following amount of each are required:

$428\frac{4}{7}$ lbs. of 80's
$571\frac{3}{7}$ lbs. of 60's

Proof.— $428\frac{4}{7}$ lbs. of 80's cotton equal $(428\frac{4}{7} \times 67{,}200) = 28{,}800{,}000$ yards.
$571\frac{3}{7}$ lbs. of 60's cotton equal $(571\frac{3}{7} \times 50{,}400) = 28{,}800{,}000$ yards.

Composed of Minor Threads of Different Materials.

If the minor threads are of different materials transfer either one to the relative length of the other, and solve example by previously given rule.

Example.—Find amount of material required for each minor thread to produce 100 lbs. double and twist yarn made out of 40-cut woolen yarn and 60's spun silk.

60's spun silk equals 168-cut. Thus,

$$(40 + 168) = 208 : 40 :: 100 : x$$
$$(40 + 168) = 208 : 168 :: 100 : x$$
$$40 \times 100 = 4{,}000 \div 208 = 19\tfrac{3}{13}$$
$$168 \times 100 = 16{,}800 \div 208 = 80\tfrac{10}{13}$$
$$\overline{100}$$

Answer.—To produce 100 lbs. of double and twist yarn as mentioned in example, $19\frac{3}{13}$ lbs. of 60's spun silk and $80\frac{10}{13}$ lbs. of 40- cut woolen yarn are required.

Proof.— $19\frac{3}{13}$ lbs. of 60's spun silk equal to $(19\frac{3}{13} \times 50{,}400) = 969{,}230\frac{10}{13}$ yards.
$80\frac{10}{13}$ lbs. of 40-cut woolen yarn equal $(80\frac{10}{13} \times 12{,}000) = 969{,}230\frac{10}{13}$ yards.

As already mentioned in a previous chapter, if twisting silk yarn with a woolen yarn the former thread will twist proportionately more around the latter, thus we must add an allowance for it to the silk yarn, which in turn we must deduct from the woolen yarn. But as this difference (or allowance) is regulated by the turns of twist per inch, also the tension of the yarn when twisting it will vary (as little as it will be) in each different *d & tw.* yarn; but will be readily ascertained by the manufacturer in his practical work.

B. THREE-PLY YARN.

Composed of Minor Threads of the Same Material.

Sometimes it may be required to find the amount of material for each minor thread for a given weight of a 3-ply yarn. If so the example must be solved by

Rule.—Transfer the given three counts to their equivalent in a single thread and find number of yards required to balance given weight. Afterwards divide each standard (number of yards necessary to balance 1 lb.) of the three given minor threads in the number of yards required, the result being pounds necessary for each count.

Example.—Find amount of material required for each minor thread for 100 lbs. of 3-ply yarn, produced out of 5, 6 and 7-run woolen yarn for the minor threads.

5, 6, and 7-run.

$7 \div 7 = 1$

$7 \div 6 = 1\frac{5}{30}$

$7 \div 5 = 1\frac{12}{30}$

$3\frac{17}{30}$ $\quad 7 \div 3\frac{17}{30} = 1\frac{103}{107}$ equivalent count in a single thread for 5, 6 and 7-run.

$1\frac{103}{107} \times 1{,}600 = 3{,}140\frac{20}{107}$ yards per lb., $\times 100$ lbs. (total amount of yarn wanted) $= 314{,}018\frac{74}{107}$ total number of yards of 3-ply yarn required.

$314{,}018 \div 8{,}000$ (Standard for 5-run) $= 39.25$

$314{,}018 \div 9{,}600$ (Standard for 6-run) $= 32.71$

$314{,}018 \div 11{,}200$ (Standard for 7-run) $= 28.04$

100.00

Answer.—The amount of yarn for each minor thread in given example is as follows:

39.25 lbs. of 5-run woolen yarn.
32.71 lbs. of 6-run woolen yarn.
28.04 lbs. of 7-run woolen yarn.

100 lbs. Total amount of yarn wanted.

Composed of Minor Threads of Different Materials.

If in a 3-ply yarn one of the minor threads is of a different material (compared to the other two), transfer this thread to its equivalent count of the other basis, and solve example by previously given rule.

Example.—Find amount of material required to produce 1,000 lbs. of 3-ply yarn made out of 30's worsted, 45's worsted and 60's spun silk.

60's spun silk equals 90's worsted yarn, thus:

30—45—90 $\quad 90 \div 90 = 1$

$90 \div 45 = 2$ $\qquad 90 \div 6 = 15$'s equivalent count in single thread.

$90 \div 30 = 3$

6

$15 \times 560 = 8{,}400$ yards per lb. $\times 1{,}000$ lbs. (total amount of yarn wanted) $= 8{,}400{,}000$ total number of yards of 3-ply yarn required.

$8{,}400{,}000 \div 16{,}800$ (Standard for 30's worsted) $= 500.00$

$8{,}400{,}000 \div 25{,}200$ (Standard for 45's worsted) $= 333.33 + (\frac{1}{3})$

$8{,}400{,}000 \div 50{,}400$ (Standard for 90's worsted) $= 166.66 + (\frac{2}{3})$

1000.00

Answer.—The amount for each minor thread in given example is as follows:

500 lbs. of 30's worsted.
$333\frac{1}{3}$ lbs. of 45's worsted.
$166\frac{2}{3}$ lbs. of 60's spun silk.

1,000 lbs. Total amount of yarn wanted.

Ascertaining the Cost of Two, Three, or More Ply Yarn.

COMPOSED EITHER OF DIFFERENT QUALITIES (AS TO PRICE) OF YARN ONLY, OR OF THE LATTER ITEM IN ADDITION TO DIFFERENT COUNTS OF THE MINOR THREADS.

If a 2-ply yarn is composed of minor threads of equal counts, but different qualities, (as to cost) the average between the two prices will be the cost of the 2-ply thread.

Example.—Find the price for 2/40's worsted composed of minor threads worth respectively $1.00 and $1.36.

$$\$1.00+\$1.36=\$2.36\div2=\$1.18.$$

Answer.—The price of the yarn in question is $1.18 per pound.

By means of the average we will also find the price for a three or more ply yarn provided the counts of each minor thread are the same.

Example.—Find the price for a 3-ply yarn composed of minor threads of equal counts, but costing respectively 60 cts., 80 cts. and $1.00 per pound.

$$\$0.60+\$0.80+\$1.00=\$2.40\div3=\$0.80.$$

Answer.—The price for the yarn in question is 80 cents.

If a 2-ply yarn is composed of minor threads of unequal counts as well as of different price we must find the cost per pound of the compound thread by—

Rule.—Multiply each count by the price of the other yarn, next divide the sum of the products by the sum of the counts.

Example.—Find cost per pound for 2-ply yarn composed of 32's and 40's worsted. The price of the 32's to be $1.04 and that of the 40's $1.60.

$$\begin{array}{ll} 40\times\$1.04=\$41.60 & \\ 32\times\ 1.60=\ 51.20 & \qquad \$92.80\div72=\$1.28\tfrac{8}{9} \\ \overline{72}\qquad\quad \overline{\$92.80} & \end{array}$$

Answer.—The price for the yarn in question is $1.28\tfrac{8}{9}$ or nearly $1.29.

Proof.—40's and 32's.

$40\times32=1{,}280\div72(40+32)=17\tfrac{7}{9}$ compound size of thread.

$17\tfrac{7}{9}\times560=9{,}957$ standard number of yards in compound thread, or number of yards of each minor thread required.

40's worsted = 22,400 yards per lb.

32's worsted = 17,920 yards per lb., thus:

$$22{,}400:1.60::9{,}957:x \text{ or } \frac{9{,}957\times1.60}{22{,}400}=\$0.7112\text{—} = 71.12 \text{ cents.}$$

$$17{,}920:1.04::9{,}957:x \text{ or } \frac{9{,}957\times1.04}{17{,}920}=\$0.5777\text{—} = 57.77 \text{ “}$$

Answer.— $128\tfrac{89}{100}$ cents = $1.29.

If one of the minor threads is of a different material than the other, reduce the one thread to its equivalent counts in the basis of the other and find the cost per pound of compound yarn by previously given rule.

Example.—Find cost per pound for 2-ply fancy cassimere yarn, composed of 5-run woolen yarn and 40's cotton yarn for minor threads. Value of the single woolen yarn 86 cents per pound, and value of the cotton yarn 36 cents.

40's cotton equals 21-run woolen yarn thus:

5-run at 86 cents, and 21-run at 36 cents.

$$\begin{array}{rl} 5\times36= & 180 \\ 21\times86= & 1{,}806 \\ \hline 26 & 1{,}986 \end{array} \qquad 1{,}986\div26=76.38$$

Answer.—The price of given 2-ply fancy cassimere yarn is $76\frac{38}{100}$ cents (or about $76\frac{1}{3}$ cents.)

Proof.—5 and 21-run.

$5\times21=105\div26(5+21)=4\frac{1}{26}$ compound size.

$4\frac{1}{26}\times1{,}600=$ 6,461.5 yards length of each minor thread.

5 run = 8,000 yards per lb.

21 " =33,600 " " " thus:

$$8{,}000:86::6{,}461.5:x \text{ or } \frac{86\times6{,}461.5}{8{,}000} = 69.46 \text{ cents.}$$

$$33{,}600:36::6{,}461.5:x \text{ or } \frac{36\times6{,}461.5}{33{,}600} = 6.92 \text{ cents.}$$

Answer.— $76\frac{38}{100}$ cents.

If a 3-ply yarn is composed of minor threads of unequal counts as well as of a different price, we must find the cost of the compound yarn by

Rule.—Find average price and compound counts between any two minor threads given, and afterwards proceed in the same manner between the respective results and the third minor thread.

Example.—Find cost per pound of 3-ply fancy yarn composed of the following minor threads: 60's worsted costing \$2.00 per pound; 40's worsted costing \$1.50 per pound; and 30's worsted costing \$1.00 per pound.

60's at \$2.00. 40's at \$1.50

$$\begin{array}{rl} 60\times1.50= & 90 \\ 40\times2.00= & 80 \\ \hline 100 & 170.00 \end{array} \qquad 170.00\div100=1.70.$$

\$1.70 average price between 60's worsted at \$2.00, and 40's at \$1.50.

$60\times40=2{,}400\div100\,(60+40)=24$. 24's worsted compound counts for 60's and 40's worsted; thus:

24's worsted at \$1.70. 30's worsted at \$1.00.

$$\begin{array}{rl} 24\times1.00= & 24.00 \\ 30\times1.70= & 51.00 \\ \hline 54 & 75.00 \end{array} \qquad 75.00\div54=1.3888.$$

Answer.—The price for the 3-ply yarn given in the example is \$1.3888 or nearly \$1.39.

Proof.—60's, 40's and 30's worsted.

$$\begin{array}{l} 60\div60=1 \\ 60\div40=1\frac{1}{2} \\ 60\div30=2 \\ \hline \quad 4\frac{1}{2} \end{array}$$

$60\div4\frac{1}{2}=13\frac{1}{3}$'s worsted compound counts for 60's, 40's and 30's.

$13\frac{1}{3}$ worsted $=13\frac{1}{3}\times560=7{,}466\frac{2}{3}$ yards per pound.

60's worsted=33,600 yards per lb. at \$2.00

40's worsted=22,400 yards per lb. at \$1.50

30's worsted=16,800 yards per lb. at \$1.00

$$33{,}600 : 2.00 :: 7{,}466\tfrac{2}{3} : x \quad \frac{2.00 \times 7{,}466\tfrac{2}{3}}{33{,}600} = \$0.4444$$

$$22{,}400 : 1.50 :: 7{,}466\tfrac{2}{3} : x \quad \frac{1.50 \times 7{,}466\tfrac{2}{3}}{22{,}400} = \$0.5000$$

$$16{,}800 : 1.00 :: 7{,}466\tfrac{2}{3} : x \quad \frac{1.00 \times 7{,}466\tfrac{2}{3}}{16{,}800} = \$0.4444$$

Answer :—$1.3888

Answer.—The price as found before ($1.38) is correct.

If a 3-ply yarn is composed of minor threads of different materials as well as different prices, and we must find the cost per pound for the compound yarn, reduce the different counts to their equivalent counts in one basis and find the result by previously given rule.

To Find the Mean or Average Value of Yarns of Mixed Stocks.

In the manufacture of mixed yarns wools of different price are frequently mixed together. To ascertain the medium price of a mixture when the price and quantity of each ingredient are given, use—

Rule.—Divide the cost of all the ingredients by the sum of the quantities mixed, the quotient will be the average value.

Example.—Find the mean or average value of the following wool mixture:

160 lbs. costing 75¢ per lb.
160 " " 86¢ " "
40 " " $1.10 " "
40 " " 1.16 " "

400 lbs. total amount of wool used in this lot.

75¢ × 160 lbs. = $120.00
85¢ × 160 lbs. = 136.00
$1.10 × 40 lbs. = 44.00
$1.16 × 40 lbs. = 46.40

400 lbs. $346.40

(Cost of all the Ingredients.) (Sum of the Quantities.)
$346.40 ÷ 400 lbs. = $0.866

Answer.—The value of the wool mixture is $86\tfrac{6}{10}$¢ per lb.

Example.—Find the value per lb. for the following mixture of wool.

680 lbs. costing 65¢ per lb.
300 " " 68¢ " "
20 " " 98¢ " "

1,000 lbs. in lot.

65¢ × 680 = $442.00
68¢ × 300 = 204.00 $665.60 ÷ 1,000 = $0.6656
98¢ × 20 = 19.60

$665.60

Answer.—Wool mixture in question is worth $66\tfrac{56}{100}$¢ per lb.

Another question frequently appearing in the mixing of lots for the manufacture of "Mixed Yarns" is—

To Find the Quantity of Each Kind of Wool to Use in a Mixture of a Given Value.

In such a mixture the total loss on the kinds of wool used of the several prices or qualities must equal the total gain.

Rule.—Arrange the prices of the different kinds of wool, we have at our disposal, in a vertical column with the mean price at the left. Next find the gain or loss on one unit of each ; take such an additional portion of any as will make the losses balance the gains or *vice versa.*

Example.—Two kinds of wool at respective values of 56¢ and 63¢ per pound are required to be mixed to produce a mixture worth 60¢. Find quantities of each kind wanted.

$$60 \left| \begin{array}{ll} 56+4\times 1 \ =4 & \text{gain.} \\ 63-3\times 1\frac{1}{3}=4 & \text{loss.} \end{array} \right.$$

Answer.—1 part of the wool costing 56¢ and

$1\frac{1}{3}$ " " " " 63¢ are required for

$2\frac{1}{3}$ parts to produce a mixture of the required value of 60¢.

Proof.—		
	1 lb. @ 56¢	=56¢
	$1\frac{1}{3}$ " @ 63¢	=84¢
	$2\frac{1}{3}$	140¢

$140 \div 2\frac{1}{3} = 140 \div \frac{7}{3} = \frac{140 \times 3}{7} = 420 \div 7 = 60$¢ average price of mixture per lb.

Example—Three different qualities of wool at respective values of 60¢, 68¢ and 70¢ per lb. are required to be mixed to produce a mixture worth 64¢ per lb. Find quantities of each kind required.

$$64 \left| \begin{array}{ll} 70-6\times 1 \ =6 & \\ 68-4\times 1 \ =4 & 10¢ \text{ loss.} \\ 60+4\times 2\frac{1}{2}= & 10¢ \text{ gain.} \end{array} \right.$$

Answer.—To produce mixture of a value of 64¢ per lb., use—

1 part from the wool costing 70¢
1 part from the wool costing 68¢
$2\frac{1}{2}$ parts from the wool costing 60¢ in

$4\frac{1}{2}$ parts.

Proof.—		
	1 lb. @ 70¢	= 70¢
	1 " @ 68¢	= 68¢
	$2\frac{1}{2}$ " @ 60¢	=150¢
	$4\frac{1}{2}$ lbs.	288¢

$288 \div 4.5 = 64$¢ average price of mixture per lb.

Example.—Four different qualities of wool at respective values of 80¢, 85¢, 96¢ and 98¢ per lb. are required to be mixed to produce a mixture worth 92¢. Find quantities of each kind required.

$$92 \left| \begin{array}{ll} 80+12\times 1 \ =12 & \\ 85+\ 7\times 1 \ = 7 & 19¢ \text{ gain.} \\ 96-\ 4\times 1 \ - 4 & \\ 98-\ 6\times 2\frac{1}{2}-15 & 19¢ \text{ loss.} \end{array} \right.$$

Answer.—To produce mixture of wool of a value of 92¢ use—

1	part of the wool costing 80¢
1	part of the wool costing 85
1	part of the wool costing 92
2½	parts of the wool costing 98 in
5½	parts.

Proof.—

1	lb.	@ 80¢	= 80¢
1	lb.	@ 85	= 85
1	lb.	@ 96	= 96
2½	lbs.	@ 98	=245
5½	lbs.		506¢

506¢÷5.5=92¢ being the average price of mixture per lb.

Another question frequently arising in laying out "wool-lots" is—

To Find the Quantity of Each Kind to Use When the Quantity of One Kind, the Different Prices of Each Kind and the Prices of the Mixture, are Given.

Example.—What quantity of each kind of wool costing 60¢, 80¢ and 90¢ must be mixed with 20 lbs. at 71¢ so as to bring the mixture to a value of 75¢ per lb.

	¢ ¢ lbs.	
75,	60+15× 1=15¢	
	71+ 4×20=80	
	—	95¢ gain.
	80— 5× 1— 5¢	
	90—15× 6—90	
	—	95¢ loss.
	28	

Answer.—Use

1	part or lb.	of the wool costing 60¢
20	parts or lbs.	" " " 71
1	part or lb.	" " " 80
6	parts or lbs.	" " " 90
28	parts or lbs.	Mixture so as to bring the price of the latter to 75¢ per lb.

Proof.—

1	lb.	@ 60¢=	60¢
20	lbs.	@ 71 =	1,420
1	lb.	@ 80 =	8
6	lbs.	@ 90 =	540 or
28	lbs. at	.	2,100¢.

Hence 2,100¢÷28=75¢ average price of mixture per lb.

Example.—Having four different lots of wool at respective values of 70¢, 74¢, 82¢ and 84¢ on hand, how many lbs. of each kind must we use to make up a lot of 500 lbs. costing us 78¢ per lb.

78	70+ 8×1 =8	
	74+ 4×1 =4	
	—	12¢ gain.
	82— 4×1½=6	
	84— 6×1 =6	
	— —	12¢ loss.
	4½	

$500 \div 4\frac{1}{2} = 111\frac{1}{9}$.

$1 \times 111\frac{1}{9} = 111\frac{1}{9}$ lbs. @ 70
$1 \times 111\frac{1}{9} = 111\frac{1}{9}$ " @ 74
$1 \times 111\frac{1}{9} = 166\frac{6}{9}$ " @ 82
$1 \times 111\frac{1}{9} = 111\frac{1}{9}$ " @ 84

500 lbs.

Answer.—We must use $111\frac{1}{9}$ lbs. of the lot valued at 70¢ per lb.
$111\frac{1}{9}$ " " " " 74 "
$166\frac{6}{9}$ " " " " 82 "
$111\frac{1}{9}$ " " " " 84 "

to make up a lot of 500 lbs. at a value of 78¢ per lb.

Proof.— $111\frac{1}{9} \times 70¢ = \$77.77\frac{7}{9}$
$111\frac{1}{9} \times 74 = 82.22\frac{2}{9}$
$166\frac{6}{9} \times 82 = 136.66\frac{6}{9}$
$111\frac{1}{9} \times 84 = 92.33\frac{3}{9}$

$390.00—and 500 lbs. at 78¢ = also $390.00.

Reed Calculations.

The reed is named by numbers, the number in each case indicating how many splits are in each inch, Thus a number 8-reed means a reed with 8 splits in every inch over the required width. If we call for number $16\frac{1}{2}$-reed, we want a reed having $16\frac{1}{2}$ splits in one inch, equal to 33 dents in every 2 inches over the entire width of the fabric. Whole numbers or half numbers alone are used for grading of reeds.

Example.—Suppose we have a number 9-reed, four threads in one split or dent, how many ends are in one inch? How many are in full warp if 70 inches wide in reed?

Answer.— $9 \times 4 = 36$ ends of warp in one inch.
$\times 70$ width of warp in reed.

2,520 ends in warp.

Rule for ascertaining the number of ends in the warp if the reed number, the threads per dent and the width of the warp in the reed are known: Multiply the reed number by the threads per dent and multiply the result by the width of the warp in reed.

Example.—How many ends are in the warp if using $13\frac{1}{2}$-reed, 6 threads per dent, 80 inches wide in reed?

$$13\frac{1}{2} \times 6 = 81 \times 80 = 6{,}480.$$

Answer.—6,480 ends are in warp.

Rule for ascertaining the reed number, if the number of ends in the warp and the width in the reed are known, the threads per dent, either given or to be selected, according to the fabric: Divide the number of ends in the warp by the width in the reed, which gives the number of threads per inch; divide this result again by the number of threads in one dent according to the weave or pattern required, the answer being the reed (number) required.

Example.—6,480 ends in warp, 80 inches wide in reed. How many ends per inch and what reed is required if 6 ends per dent are to be used?

$$6{,}480 \div 80 = 81 \div 6 = 13\tfrac{1}{2}.$$

Answer.—81 ends per inch and $13\frac{1}{2}$ is the reed number required.

Rule for ascertaining the width of the warp in the reed if the reed number, the threads per dent, and the number of threads in the warp are known: Divide the number of ends in the warp by the number of ends per inch, giving as the result the number of inches the warp will be in the reed.

Example.—Find width in reed for fabric made with 3,600 ends in warp, reeded 3 threads per dent in a number 12-reed.

$$12 \times 3 = 36 \quad 3{,}600 \div 36 = 100.$$

Answer.—The width of the fabric in reed is 100 inches.

Example.—Find width in reed for fabric made with 4,752 ends in warp, reeded 4 threads per dent in a number $16\frac{1}{2}$-reed.

$$16\tfrac{1}{2} \times 4 = 66 \qquad 4{,}752 \div 66 = 72$$

Answer.—The width of the fabric in reed is 72 inches.

The number of ends to put in one dent has to be regulated according to the fabric and the weave. Experience is the only guide for this. The coarser the reed, to a certain extent, the easier the picks go into the fabric. The finer the reed, the smoother the goods, and with perfect reeds, the less reed marks.

The same number of ends are not always used in each dent, but in such a case the preceding rules may be used with the average number of threads per dent.

Example.—What are the threads per inch? Reed number 20, using one dent, 4 ends—one dent 5 ends.

		(Average threads per dent.)		(Number of reed.)		
$4+5=9\div2$	=	$4\frac{1}{2}$	×	20	=	90

Answer.—90 threads per inch.

Example.—What are the threads per inch? Reed number 18, using 1 dent, 3 ends—1 dent, 4 ends—1 dent, 3 ends—1 dent, 6 ends.

		(Threads in four dents.)		(Average thread per dent.)		(Number of reed.)		
$3+4+3+6$	=	16	÷	4	×	18	=	72

Answer.—72 threads per inch.

Sometimes it happens that the average number of threads includes an inconvenient fraction. To avoid a calculation with this fraction, multiply the sum of the contents of the dents by the dents per inch, and then divide by the dents per set.

Example.—What are the threads per inch, warp reeded as follows in number 12-reed: 1 dent, 5 threads—1 dent, 3 threads—1 dent, 3 threads.

$$3+3+5=11\times12=132\div3=44.$$

Answer.—44 threads per inch.

Example.—What are the threads per inch, warp reeded as follows in a number 15-reed:—1 dent, 4 threads—1 dent, 4 threads—1 dent 5 threads.

$$4+4+5=13\times15=195\div3=65$$

Answer.—65 threads per inch.

Warp Calculations.

TO FIND WEIGHT OF WARP IF NUMBER OF ENDS, COUNTS AND LENGTH ARE GIVEN.

Multiply number of ends in the width of the cloth by yards in length (dressed), and divide product by the number of yards of the given count per pound.

Example.—Cotton Yarn. Find weight of warp, 50 yards long, 2,800 ends, single 40's cotton in warp.

2,800×50=140,000 yards. 40×840=33,600 yards per lb. in 40's cotton.

140,000÷33,600=$4\frac{1}{6}$.

Answer.—The weight of the warp in the present example is $4\frac{1}{6}$ lbs.

Example.—Woolen Yarn (run system). Find weight of warp, 40 yards long, 3,600 ends, $4\frac{1}{2}$-run woolen yarn.

3,600×40=144,000 yards. $4\frac{1}{2}$-run=7,200 yards. 144,000÷7,200=20.

Answer.—The weight of the warp in present example is 20 lbs.

Example—Woolen Yarn (cut system). Find weight of warp, 45 yards long, 4,800 ends, 32-cut woolen yarn.

4,800×45=216,000 yards. 32-cut=9,600 yards. 216,000÷9,600=$22\frac{1}{2}$.

Answer.—The weight of the warp in the present example is $22\frac{1}{2}$ lbs.

Example.—Worsted Yarn. Find weight of warp, 60 yards long, 6,000 ends, 2/60's worsted yarn.

2/60's worsted=16,800 yards. 6,000×60=360,000 yards. 360,000÷16,800=$21\frac{3}{7}$.

Answer.—The weight of the warp in present example is $21\frac{3}{7}$ lbs.

If two or more different kinds of yarn are used, ascertain number of threads in warp for each kind by proportion, and solve answer (for each kind) by previously given rule.

Example.—Find weight of warp, 50 yards long, 6,000 ends.

Dressed.—2 ends 2/60's worsted.
1 end 2/50's cotton.

3 ends in repeat.

6,000÷3=2,000

2,000×2=4,000 ends 2/60's worsted in warp.
2,000×1=2,000 ends 2/50's cotton in warp.

6,000, complete number of ends in warp.

4,000×50=200,000 yards. 2/60's worsted=16,800 yards. 200,000÷16,800=$11\frac{19}{21}$.
2,000×50=100,000 2/50's cotton=21,000 yards. 100,000÷21,000=$4\frac{16}{21}$

Answer.—The weights of the warp in present example are:

$11\frac{19}{21}$ lbs. of 2/60's worsted.
$4\frac{16}{21}$ " " 2/50's cotton.

$16\frac{14}{21}$ lbs.=$16\frac{2}{3}$ lbs. total weight of both kinds of yarn.

Example.—Find weight of warp for each kind of yarn separately in the following example:

Lengths of warp 50 yards. Number of ends 4,800.

Dressing.—4 ends	4-run woolen yarn	blue
4 "	4 " " "	black
4 "	4 " " "	brown
4 "	4 " " "	black
16 "	4 " " "	olive mix
2 "	4 " " "	blue
2 "	4 " " "	black
2 "	4 " " "	brown
2 "	4 " " "	black
8 "	4 " " "	olive mix

48 threads in repeat of pattern.

(Number of ends in warp.)		(Threads in one repeat of pattern.)		(Number of repeats of patterns in warp.)
4,800	÷	48	=	100

{Ends of each kind of yarn in one pattern.}	×	{Number of repeats of patterns in warp.}	=	{Threads of each kind of yarn in full warp.}
6 ends blue	×	100	=	600
6 " brown	×	100	=	600
12 " black	×	100	=	1,200
24 " olive mix	×	100	=	2,400
48 threads in one repeat of pattern.				4,800 threads in warp.

4-run woolen yarn=6,400 yards per lb.

$600 \times 50 = 30{,}000 \div 6{,}400 = 4\frac{11}{16}$

$600 \times 50 = 30{,}000 \div 6{,}400 = 4\frac{11}{16}$

$1{,}200 \times 50 = 60{,}000 \div 6{,}400 = 9\frac{6}{16}$ (or $9\frac{3}{8}$)

$2{,}400 \times 50 = 120{,}000 \div 6{,}400 = 18\frac{12}{16}$ (or $18\frac{3}{4}$)

Proof.— $4{,}800 \times 50 = 240{,}000 \div 6{,}400 = 37\frac{8}{16}$ (or $37\frac{1}{2}$)

Answer.—The different amounts of yarn required for given example are:

$4\frac{11}{16}$ lbs. of 4-run blue woolen yarn.
$4\frac{11}{16}$ " 4 " brown " "
$9\frac{3}{8}$ " 4 " black " "
$18\frac{3}{4}$ " 4 " olive mix " "

This method of finding the weight for different warp yarns is no doubt the easiest to understand by any student, and will solve the most complicated arrangements of dressings and variety of yarns used.

The latter example can also be solved by—

Rule.—Find total weight of warp yarn required and divide in proportion to each kind of yarn used.

$4{,}800 \times 50 = 240{,}000 \div 6{,}400 = 37\frac{8}{16}$ lbs. total weight.

6 blue =1
6 brown =1
12 black =2
24 olive =4
—
8

$37\frac{8}{16} \div 8 = 4\frac{11}{16}$ for each part.

Answer.—	$1 \times 4\frac{11}{16} = 4\frac{11}{16}$	lbs. of	4-run	blue	woolen	yarn.
	$1 \times 4\frac{11}{16} = 4\frac{11}{16}$	" "	4 "	brown	"	"
	$2 \times 4\frac{11}{16} = 9\frac{3}{8}$	" "	4 "	black	"	"
	$4 \times 4\frac{11}{16} = 18\frac{3}{4}$	" "	4 "	olive mix	"	"

$37\frac{8}{16}$ (or $37\frac{1}{2}$) lbs. total weight.

If weight of warp is required to be found for one yard only, the answer may be required expressed in ounces; if so, change fraction of pounds in ounces, or use rules given previously under "Grading of the Various Yarns," after finding the number yards of yarn required.

When required to ascertain the weight of a warp dressed with yarns of various counts, and answer required is for the total weight of warp only, we may solve question by finding the average counts of the threads in question, and deal with this average count and the entire number of ends dressed, the same as if all the yarns used are of one count.

The average counts of two or more threads we find by—

Rule A.—Multiply the compound size of the given counts of yarn by number of threads compounded, or we may use

Rule B.—Divide any one of the given counts by itself and by the others given in rotation, multiply each quotient by the numbers of threads of the kind used in one repeat of pattern; next multiply previously used common dividend with the numbers of threads in one repeat of pattern, and divide the product by the sum of the quotients obtained. Either of these two rules will find the average counts. Rule A answers when using short repeats of patterns, and Rule B is adopted for large repeats.

Example.—Find average counts for the following dressing of a warp:

2 ends 30-cut woolen yarn.
1 end 20-cut " "

3 ends in repeat of pattern.

Using Rule A, we get

$30 \div 30 = 1$
$30 \div 30 = 1$
$30 \div 20 = 1\frac{1}{2}$

$3\frac{1}{2}$

$30 \div 3\frac{1}{2} = 8\frac{4}{7}$ compound size.

$8\frac{4}{7} \times 3 = 25\frac{5}{7}$ average counts.

Answer.—The average counts are $25\frac{5}{7}$-cut.

Using Rule B, we get

		Quotient.		Threads of each kind in pattern.		
$30 \div 30$	=	1	×	2	=	2
$30 \div 20$	=	$1\frac{1}{2}$	×	1	=	$1\frac{1}{2}$
						$3\frac{1}{2}$

$30 \times 3 = 90 \div 3\frac{1}{2} = 25\frac{5}{7}$

Answer.—The average counts by Rule B are also $25\frac{5}{7}$-cut.

Example.—Find weight per yard for a warp of 3,600 ends,

Dressed.—2 ends face 30-cut woolen yarn.
1 end back 20-cut woolen yarn.

3 ends in pattern.

2/30-cut and 1/20-cut $= 25\frac{5}{7}$-cut average size.

$25\frac{5}{7} \times 300 = 7{,}714\frac{2}{7}$ yards per lb.

$3{,}600 \times 16 = 57{,}600 \div 7{,}714\frac{2}{7} = 7.46$

Answer.—Weight of warp per yard is 7.46 oz.

Proof.—

3,600 ends, dressed: { 2 ends 30-cut. 1 end 20-cut. } $3{,}600 \div 3 = 1{,}200$

$1{,}200 \times 2 = 2{,}400$ yards of 30-cut (9,000 yards per lb.) $2{,}400 \times 16 = 38{,}400 \div 9{,}000 = 4.26$ oz.
$1{,}200 \times 1 = 1{,}200$ yards of 20-cut (6,000 yards per lb.) $1{,}200 \times 16 = 19{,}200 \div 6{,}000 = 3.20$ oz.

7.46 oz.

Example.—Find weight, per yard, for a warp of 4,800 threads, dressed as follows:

2 ends face 6-run. $6 \div 6 = 1 \times 2 = 2$
1 end back 4-run. $6 \div 4 = 1\frac{1}{2} \times 1 = 1\frac{1}{2}$

3 ends in pattern. $3\frac{1}{2}$

$6 \times 3 = 18 \div 3\frac{1}{2} = 5\frac{1}{7}$-run $\times 1{,}600 = 8{,}228.57$ yards.
$4{,}800 \times 16 = 76{,}800 \div 8{,}228.57 = 9.33$.

Answer.—Weight of warp, per yard is 9.33 oz.

Proof.—

4,800 ends, dressed: { 2 ends 6-run. 1 end 4-run. } $4{,}800 \div 3 = 1{,}600$

$1{,}600 \times 2 = 3{,}200$ yards of 6-run (9,600 yards per lb.).
$1{,}600 \times 1 = 1{,}600$ yards of 4 run (6,400 yards per lb.).
$3{,}200 \times 16 = 51{,}200 \div 9{,}600 = 5.33$ oz.
$1{,}600 \times 16 = 25{,}600 \div 6{,}400 = 4.00$ oz.

9.33 oz.

Example.—Find the average counts for the following dressing of a warp:

2 ends 60's $60 \div 60 = 1 \times 2 = 2$
1 end 20's $60 \div 20 = 3 \times 1 = 3$
1 end 10's $60 \div 10 = 6 \times 1 = 6$

4 ends in repeat of pattern. 11

$$60 \times 4 = 240 \div 11 = 21\tfrac{9}{11}$$

Answer.—The average counts are $21\frac{9}{11}$'s.

Proof.—(Using the same rule, but a different count, for dividend.)

$$10 \div 60 = \tfrac{1}{6} \times 2 = \tfrac{2}{6}$$
$$10 \div 20 = \tfrac{1}{2} \times 1 = \tfrac{3}{6}$$
$$10 \div 10 = 1 \times 1 = 1$$
$$1\tfrac{5}{6}$$

$$10 \times 4 = 40 \div 1\tfrac{5}{6} = \tfrac{40}{1} \div \tfrac{11}{6} = \tfrac{40}{1} \times \tfrac{6}{11} = 240 \div 11 = 21\tfrac{9}{11}\text{'s.}$$

Proof.—(Using Rule A.)

$60 \div 60 = 1$
$60 \div 60 = 1$
$60 \div 20 = 3$
$60 \div 10 = 6$

11

$60 \div 11 = 5\frac{5}{11} \times 4 = 21\frac{9}{11}$'s.

Example.—Find weight per yard for a warp of 2,850 ends, dressed as follows

20 ends 40's cotton
1 end 50's "
16 ends 30's "
1 end 50's "
—
38 ends in repeat of pattern.

$40 \div 40 = 1 \times 20 = 20 = 20$
$40 \div 30 = 1\frac{1}{3} \times 16 = 21\frac{1}{3} = 21\frac{5}{15}$
$40 \div 50 = \frac{4}{5} \times 2 = 1\frac{3}{5} = 1\frac{9}{15}$
$38 \qquad 42\frac{14}{15}$

$40 \times 38 = 1{,}520 \div 42\frac{14}{15} = 35\frac{90}{161}$'s average counts.
$35\frac{90}{161} \times 840 = 29{,}869.56$ yards per lb.
$2{,}850 \times 16 = 45{,}600 \div 29{,}869.56 = 1.52$ oz.

Answer.—The weight of given warp in example is 1.52 oz.

Proof.— $2{,}850 \div 38 = 75$ repeats of pattern in warp.

$20 \times 75 = 1{,}500$ ends of 40's cotton. (33,600 yards per lb.)
$16 \times 75 = 1{,}200$ ends of 30's cotton. (25,200 yards per lb.)
$2 \times 75 = 150$ ends of 50's cotton. (42,000 yards per lb.)

$1{,}500 \times 16 = 24{,}000 \div 33{,}600 = 0.71$
$1{,}200 \times 16 = 19{,}200 \div 25{,}200 = 0.76$
$150 \times 16 = 2{,}400 \div 42{,}000 = 0.05$

1.52 oz. (being the same answer.)

Rules given refer to finding the weight of a warp in its original length, technically known as "dressed." During weaving and the process of finishing, in most cases, the warp will shrink or "take up," thus if figuring for weight of warp in a cloth from loom, or also when finished, we must calculate back to the original number of yards required dressed, to produce a certain number of yards of cloth either woven or finished; or in other words, take the percentage for either or both "take ups," as the case may require, into consideration. Rules governing the "take ups" in a fabric cannot be given. They are guided by the cloth required, nature of material, twist, amount of intersections in weave, process of finishing, etc., in fact, practical experience is necessary to designate accurately these points.

A table of relative lengths of inches dressed, and one yard woven, with reference to a "take up" during weaving, from 1 per cent. to 50 per cent., (which also can be used for "take up" of warps during finishing) is found in my "*Technology of Textile Design*," on page 266, in the chapter on "*Ascertaining the weight of cloth per yard from the loom.*

TO FIND THE COUNTS FOR WARP YARN IF NUMBER OF ENDS IN WARP, AND AMOUNT OF MATERIAL, LENGTH AND WEIGHT TO BE USED, ARE GIVEN.

Multiply the ends in warp by the length, multiply the basis of the yarn in question by the weight, next divide the latter product in the one previously obtained.

Example.—Cotton Yarn. Find counts of yarn required—2,800 ends in warp, 50 yards long, weight $4\frac{1}{6}$ lbs.

$2{,}800 \times 50 = 140{,}000 \div 3{,}500 \; (4\frac{1}{6} \times 840) = 40$

Answer.—40's cotton yarn is required.

Example.—Woolen Yarn (run system). Find counts of yarns required—3,600 ends in warp, 40 yards long, weight 20 lbs.

$3{,}600 \times 40 = 144{,}000 \div 32{,}000 \; (1{,}600 \times 20) = 4\frac{1}{2}$

Answer.—The yarn required to be used in example given, is $4\frac{1}{2}$-run.

Example.—Woolen Yarn (cut system). Find counts of yarn required—4,800 ends in warp, 45 yards long, weight $22\frac{1}{2}$ lbs.

$$4{,}800 \times 45 = 216{,}000 \div 6{,}750\ (300 \times 22\tfrac{1}{2}) = 32$$

Answer.—32-cut yarn is required.

Example.—Worsted Yarn. Find counts of yarn required—6,000 ends in warp, 60 yards long, weight of warp $21\frac{3}{7}$ lbs.

$$6{,}000 \times 60 = 360{,}000 \div 12{,}000\ (21\tfrac{3}{7} \times 560) = 30$$

Answer.—Single 30's (or 2/60's) worsted yarn are required.

TO FIND NUMBER OF THREADS IN WARP TO USE, IF COUNTS OF YARN, LENGTHS AND WEIGHT OF WARP, ARE GIVEN.

Multiply counts by basis of yarn and weight of warp, and divide product by length of warp.

Example.—Cotton Yarn. Find number of ends for warp, 40's cotton, 50 yards long to dress, weight of yarn on hand $4\frac{1}{6}$ lbs.

$$40 \times 840 \times 4\tfrac{1}{6} = 140{,}000 \div 50 = 2{,}800$$

Answer.—Use 2,800 ends in warp.

Example.—Woolen Yarn (run system). Find number of ends for warp $4\frac{1}{2}$-run woolen yarn, 40 yards long to dress, weight of yarn to use 20 lbs.

$$4\tfrac{1}{2} \times 1{,}600 \times 20 = 144{,}000 \div 40 = 3{,}600$$

Answer.—Use 3,600 threads in warp.

Example.—Woolen Yarn (cut system). Find number of ends for warp, 32-cut yarn, 45 yards long to dress, $22\frac{1}{2}$ lbs. weight of yarn on hand.

$$32 \times 300 \times 22\tfrac{1}{2} = 216{,}000 \div 45 = 4{,}800$$

Answer.—Use 4,800 threads in warp.

Example.—Worsted Yarn. Find number of ends for warp, 2/60's worsted, 60 yards length of warp required, $21\frac{3}{7}$ lbs. amount of yarn on hand.

2/60's worsted=1/30's; thus: $30 \times 560 \times 21\frac{3}{7} = 360{,}000 \div 60 = 6{,}000$.

Answer.—Use 6,000 threads in warp.

TO FIND THE LENGTH FOR A WARP, IF NUMBER OF ENDS IN WARP, COUNTS AND WEIGHT OF YARN, ARE GIVEN.

Multiply counts by basis of yarn and weight of warp, and divide product by number of ends in warp.

Example.—Cotton Yarn. Find length of warp, 2,800 threads in width, 40's cotton yarn, weight of yarn on hand $4\frac{1}{6}$ lbs.

$$40 \times 840 \times 4\tfrac{1}{6} = 140{,}000 \div 2{,}800 = 50.$$

Answer.—The length for the warp is 50 yards.

Example.—Woolen Yarn (run system). Find length of warp, 3,600 threads in width, $4\frac{1}{2}$-run woolen yarn, weight of yarn on hand 20 lbs.

$$4\tfrac{1}{2} \times 1{,}600 \times 20 = 144{,}000 \div 3{,}600 = 40.$$

Answer.—The length for the warp is 40 yards.

Example.—**Woolen Yarn** (cut system). Find length of warp, 4,800 threads in width, 32-cut yarn, $22\frac{1}{2}$ lbs. weight of yarn on hand.

$$32 \times 300 \times 22\tfrac{1}{2} = 216{,}000 \div 4{,}800 = 45.$$

Answer.—The length for the warp is 45 yards.

Example.—**Worsted Yarn.** Find length of warp, 6,000 threads in width, 2/60's worsted, $21\frac{3}{7}$ lbs. weight of yarn on hand.

2/60's worsted=1/30's worsted; thus: $30 \times 560 \times 21\frac{3}{7} = 360{,}000 \div 6{,}000 = 60.$

Answer.—The length for the warp is 60 yards.

Example.—**Cotton Yarn** (2-ply). Find length of warp (for extra super ingrain carpet) 1,072 ends, 2/14's cotton yarn, weight of yarn on hand 50 lbs.

2/14's cotton=1/7's cotton. Thus: $7 \times 840 \times 50 = 294{,}000 \div 1{,}072 = 274\frac{17}{67}$

Answer.—The length for the warp is $274\frac{1}{4}$ (actual $274\frac{17}{67}$) yards.

Proof.—$\dfrac{274\frac{17}{67} \times 1{,}072}{5{,}880\ (7 \times 840)} = 274\frac{17}{67} \times 1{,}072 = 294{,}000 \div 5{,}880 = 50$, being the amount of lbs. of yarn on hand.

Example.—**Worsted Yarn** (3-ply). Find length of warp 4,800 ends in width of fabric, 3/60's worsted yarn, weight of yarn on hand 80 lbs.

3/60's worsted=1/20's worsted. Thus: $20 \times 560 \times 80 = 896{,}000 \div 4{,}800 = 186\frac{2}{3}.$

Answer.—The length for the warp is $186\frac{2}{3}$ yards.

Proof.— $\dfrac{186\frac{2}{3} \times 4{,}800}{11{,}200\ (20 \times 560)} = 186\frac{2}{3} \times 4{,}800 = 2{,}688{,}000 \div 11{,}200 = 80$, being the amount of pounds of yarn on hand.

When two or more different materials are used in the construction of a cloth, previously given rules for warp must be solved by combining one repeat, or the average of one repeat, of pattern in a compound thread; and if required by question, after finding answer in such a compound thread, we must transfer the same to the respective minor threads.

To give a clear understanding to the student, we give, correspondingly to previously given rules, one example in three different changes.

Example.—Find counts of yarn required, 4,800 ends in warp.

Dressed.—2 ends face. }
1 end back. } Woolen yarn, run basis.

3 ends in repeat.

Back-warp threads to be twice as heavy as to size as face warp threads. Length of warp, 50 yards. Weight of same to be 40 lbs.

4,800÷3=1,600 repeats of pattern, or 1,600 compound threads.

$1{,}600 \times 50 = 80{,}000 \div 64{,}000\ (1{,}600 \times 40) = 1\frac{1}{4}$-run compound size.

$1\frac{1}{4} \times 4 = 5$ $\quad\quad 1\frac{1}{4} \times 2 = 2\frac{1}{2}$

Answer.—The dressing in example given will be
2 ends face @ 5-run.
1 end back @ $2\frac{1}{2}$-run.

3 ends in repeat.

Proof.— $5—5—2\frac{1}{2}$

$5 \div 5 = 1$
$5 \div 5 = 1$ $\quad\quad 5 \div 4 = 1\frac{1}{4}$ compound size.
$5 \div 2\frac{1}{2} = 2$

4

4,800 ends in warp÷3 ends in repeat of dressing=1,600 compound threads of $1\frac{1}{4}$-run.

1,600×50 yards long.
80,000

$1\frac{1}{4}$×1,600=2,000.

2,000 : 1 :: 80,000 : x =80,000÷2,000=40 lbs.=the weight given in the example.

Example.—Find number of ends for the following warp:

Dressing.—2 ends face warp, 5-run.
1 end backing warp, $2\frac{1}{2}$-run.
3 ends in repeat.

Length of warp 50 yards. Weight of same, 40 lbs.

5÷5 =1
5÷5 =1
5÷$2\frac{1}{2}$=2
4

5÷4=$1\frac{1}{4}$ compound size of the 3 threads in repeat of pattern.

$1\frac{1}{4}$-run=2,000 yards per lb., hence

40×2,000=80,000 yards of the compound thread in the amount of weight required.

8,000÷50 (Length of warp.) =1,600

1,600×3 (Number of threads in compound count.) =4,800

Answer.—4,800 threads are required for warp given in example.

Proof.— 4,800 threads, dressed: 2 face 5-run.
1 backing $2\frac{1}{2}$-run.
3 threads in repeat.

4,800÷3=1,600
1,600×2=3,200 threads 5-run (8,000 yards per lb.)
1,600×1=1,600 threads $2\frac{1}{2}$-run (4,000 yards per lb.)

3,200×50 (length of warp) 160,000÷8,000=20 lbs.
1,600×50 (length of warp) 80,000÷4,000=20 lbs.
40 lbs. weight given in example.

Example.—Find length of warp required—4,800 threads in width of cloth.

Dressing.—2 ends face 5-run woolen yarn
1 end back $2\frac{1}{2}$-run woolen yarn
3 ends in repeat.

Weight of complete warp 40 lbs.

5÷5 =1
5÷5 =1
5÷$2\frac{1}{2}$=2
4

5 ÷4=$1\frac{1}{4}$ compound size.
$1\frac{1}{4}$-run=2,000 yards per lb.
2,000×40=80,000 yards of the compound thread in the amount of weight required.

80,000÷1,600 (Number of compound threads in width.) =50.

Answer.—50 yards, length of warp required in given example.

Proof.—

4,800 threads { 2 face, 5-run
1 back, $2\frac{1}{2}$-run } =1,600 threads $1\frac{1}{4}$-run.
3 threads repeat.

1,600×50 {Length of warp required by answer in example.} =80,000÷2,000 {Number of yards in $1\frac{1}{4}$-run or compound count.} =40 lbs. weight of complete warp, as given in example.

Filling Calculations.

TO FIND LENGTH OF FILLING YARN REQUIRED FOR PRODUCING ONE OR A GIVEN NUMBER OF YARDS OF CLOTH, IF PICKS PER INCH AND WIDTH OF CLOTH IN REED, (INCLUDING SELVAGE) ARE KNOWN.

Rule.—Multiply picks per inch by width of fabric in reed, the product will be number of inches of filling yarn required for one inch cloth, or, at the same time, number of yards of filling yarn required for one yard of cloth. By simply multiplying yards of filling required for one yard of cloth, with the yards of cloth given in example, we get in product number of yards of filling yarn required for given yards of cloth.

Example.—Find yards of filling required for *a*, one yard *b*, 8 yards of cloth woven 72 inches wide in reed, with 52 picks per inch.

$52 \times 72 = 3{,}744$ | $3{,}744 \times 8 = 29{,}952$

Answer.—One yard cloth requires 3,744 yards filling. Eight yards cloth require 29,952 yards filling.

TO FIND WEIGHT OF FILLING YARN REQUIRED, EXPRESSED IN OUNCES, PRODUCING ONE YARD OF CLOTH, IF PICKS PER INCH, WIDTH OF CLOTH IN REED, AND THE COUNTS OF YARN ARE KNOWN.

Rule.—Multiply picks by width of warp in reed, and divide product by number of yards of the known count required to balance 1 oz.

Example.—Cotton Yarn. Find weight of filling required for one yard cloth of the following description: 64 picks per inch, 68 inches reed space occupied, single 20's cotton yarn.

$64 \times 68 = 4{,}352$ yards. 1/20's cotton=16,800 yards per lb. or 1,050 yards per oz.
$4{,}352 \div 1{,}050 = 4.14$.

Answer.—The weight of filling required is 4.14 oz. per yard.

Example.—Woolen Yarn. Find weight of filling required for one yard cloth having 52 picks per inch, 72 inches reed space, 4-run yarn.

4-run$=(4 \times 100)=400$ yards per oz. $52 \times 72 = 3{,}744 \div 400 = 9.36$

Answer.—9.36 oz. is the weight of the filling required per yard.

Example.—Worsted Yarn. Find weight of filling necessary for one yard cloth having 68 picks per inch, 61 inches reed space, 2/36's worsted yarn.

$68 \times 61 = 4{,}148$. 2/36's worsted=10,080 yards per lb. or 630 yards per oz. $4{,}148 \div 630 = 6.59$ oz.

Answer.—The weight of filling required is 6.59 oz.

TO FIND WEIGHT OF FILLING YARN REQUIRED (expressed in pounds or fraction thereof,) FOR ANY NUMBER OF GIVEN YARDS, IF PICKS PER INCH, WIDTH OF CLOTH IN REED, AND THE COUNTS OF YARN, ARE KNOWN.

Rule.—Multiply picks by width in reed and the number of given yards, next divide product thus derived by the number of yards of the known count per pound.

Example.—**Cotton Yarn.** Find weight of filling required for 40 yards of cloth woven with 68 picks per inch, 70 inches reed space and 30's cotton yarn.

$68 \times 70 = 4{,}760 \times 40 = 190{,}400$ $30 \times 840 = 25{,}200$ $190{,}400 \div 25{,}200 = 7\frac{5}{9}$.

Answer.—Weight of filling required in given example is $7\frac{5}{9}$ lbs.

Example.—**Woolen Yarn.** Find weight of filling required for 120 yards of cloth woven with 44 picks per inch, 71 inches reed space and 22-cut woolen yarn.

$44 \times 71 = 3{,}124 \times 120 = 374{,}880$ $22 \times 300 = 6{,}600$ $374{,}880 \div 6{,}600 = 56.8$.

Answer.—Weight of filling required in given example is 56.8 pounds.

Example.—**Worsted Yarn.** Find weight of filling required for 600 yards of cloth, woven with 64 picks per inch, 62 inches reed space, 2/32's worsted.

$64 \times 62 = 3{,}968 \times 600 = 2{,}380{,}800$. $16 \times 560 = 8{,}960$ $2{,}380{,}800 \div 8{,}960 = 265\frac{5}{7}$.

Answer.—Weight of filling required in given example is $265\frac{5}{7}$lbs.

If two or more different kinds of filling yarn are used, and it is required to ascertain weight of material for each kind, the solving of the example depends entirely on the arrangement of colors used and their respective counts.

If the counts are equal, and lots differ only in color or twist, ascertain the weight for the entire filling required by previously given rules, and find answer for each kind by proportion of picks as used of each kind.

Example.—Find weight (in ounces) for filling required per yard in the following fabric:

Arrangement of filling.— 4 picks brown 6-run woolen yarn.
6 " black 6-run " "
4 " blue 6-run " "
6 " black 6-run " "
—
20 picks in repeat of pattern.

72 inches reed space of fabric. 84 picks per inch.

$84 \times 72 = 6{,}048$ yards of filling per yard cloth.

$6{,}048 \div 600$ {Yards of yarn per oz. in 6-run yarn.} $= 10.08$ oz. complete weight of filling required per yard cloth.

In one repeat we find: Brown 4 picks=1
Blue 4 picks=1
Black 12 picks=3
— —
20 picks. 5

thus: $10.08 \div 5 = 2.016$

Answer.—2.016×1 or 2.016 oz. brown filling
2.016×1 or 2.016 oz. blue "
2.016×3 or 6.048 oz. black "
} required per yard of cloth woven.

Proof.— (+) 10.080 total weight of filling required for one yard cloth woven.

Example.—Find weight in pounds of filling required for weaving 2,000 yards of cloth of the following dimensions: Reed space 64 inches—picks per inch 66.

Arrangement.—	2 picks	2/32's	worsted	black.
	2 "	2/32's	"	brown.
	2 "	2/32's	"	black.
	2 "	2/32's	"	olive.
	8 picks in repeat of pattern.			

$66 \times 64 = 4{,}224 \times 2{,}000 = 8{,}448{,}000$ yards of filling required for 2,000 yards of cloth.

2/32's worsted=8,960 yards and $8{,}448{,}000 \div 8{,}960 = 942\frac{6}{7}$ lbs. total weight of filling required for the 2,000 yards cloth.

Black	4	picks in one repeat of color arrangement	=2
Brown	2	" " " " "	=1
Olive	2	" " " " "	=1
	8 picks.		4 Thus:

$942\frac{6}{7} \div 4 = 235\frac{5}{7}$

Answer.—

$235\frac{5}{7} \times 1 = 235\frac{5}{7}$ lbs. 2/32's olive worsted
$235\frac{5}{7} \times 1 = 235\frac{5}{7}$ " 2/32's brown "
$235\frac{5}{7} \times 2 = 471\frac{3}{7}$ " 2/32's black "
} Amount of filling required for weaving 2,000 yards cloth.

Proof.— (+) $942\frac{6}{7}$ lbs. total weight of all 3 kinds filling for 2,000 yards cloth.

If filling yarns of different counts or materials are used, find number of yards of yarn of each kind required for given number of yards, and transfer the same to their respective weight (in oz. or lbs. as required) by means of rules given previously under the heading of "Grading Yarns."

Example.—Find weight in ounces for filling required per yard in the following fabric:

Arrangement.—10 picks black 4-run woolen yarn.
2 " blue 6 " " "

12 picks in repeat of pattern.

70 inches reed space of fabric. 64 picks per inch.

$64 \times 70 = 4{,}480$ yards of filling required per yard of cloth.

10 picks black	=5
2 picks blue	=1
12 picks in repeat	6

Thus: $4{,}480 \div 6 = 746\frac{2}{3}$

$746\frac{2}{3} \times 1 = 746\frac{2}{3}$ yards blue 6-run
$746\frac{2}{3} \times 5 = 3{,}733\frac{1}{3}$ " black 4-run
} filling required for one yard of cloth.

$746\frac{2}{3}$ yards 6-run$=(746\frac{2}{3} \div 600) = 1.24$ oz.
$3{,}733\frac{1}{3}$ " 4-run$=(3{,}733\frac{1}{3} \div 400) = 9.33$ oz.

Answer.—1.24 oz. 6-run blue filling and
9.33 " 4-run black filling, or

10.57 oz. complete weight of filling required for weaving one yard cloth.

Example.—Find weight in pounds of filling required for weaving 3,500 yards of cloth of the following details: Reed space 72 inches, 84 picks per inch.

Arrangement.—2 picks 32-cut woolen yarn, brown.
1 pick 14 " " " black.
2 picks 32 " " " blue.
1 pick 14 " " " black.
—
6 picks in repeat.

84×72=6,048×3,500=21,168,000 complete yards of filling required.

2 picks 32-cut brown=1
2 " 32 " blue =1
2 " 14 " black =1
— —
6 picks in repeat. 3 Thus:

21,168,000÷3=7,056,000 yards of filling required of each kind.

7,056,000÷9,600 (standard of 32-cut)=735 lbs.
7,056,000=4,200 (standard of 14-cut)=1,680 lbs.

Answer.—In given example the following amounts of filling are required:

735 lbs. 32-cut brown woolen yarn.
735 " 32-cut blue " "
1,680 " 14-cut black " " or
——
3,150 lbs. complete weight of filling required for weaving the 3,500 yards of cloth.

TO FIND THE COUNTS FOR A FILLING YARN REQUIRED TO PRODUCE A CERTAIN GIVEN WEIGHT PER YARD CLOTH (in which also the picks per inch and width in reed are known).

If such example refers to weight given in ounces for one yard, use—

Rule.—Multiply picks by width of fabric in reed, and divide product by number of oz. given, and the quotient by the sixteenth part of the number of yards in the basis of the yarn in question.

Example.—Worsted Yarn. Find counts for filling yarn required of following cloth. 90 picks per inch, 58⅓ inches width of fabric in reed. 5 oz. weight for filling to be used.

90×58⅓=5,250÷5=1,050÷35(560÷16=35)=30.

Answer.—The counts for filling yarn required are either single 30's or 2/60's worsted yarn.

Proof.—90×58⅓=5,250(yards wanted)÷1,050(yards per oz.)=5 oz. weight of filling per yard.

Example.—Woolen Yarn (cut basis). Find counts for filling yarn required of following cloth: 45 picks per inch, 75 inches width of fabric in reed, 9 oz. weight for filling to be used.

45×75=3,375÷9=375÷18¾=20.

Answer.—The counts for filling yarn required are 20-cut woolen yarn.

If example refers to a given number of yards and weight is expressed in pounds, use—

Rule.—Multiply width of fabric (in loom or in reed) with the number of picks per inch, and the result with the given yards of cloth to be woven; the result thus obtained divide by the given weight, and the quotient by the basis of the yarn.

Example.—Woolen Yarn (run basis). Find counts for filling yarn required of following cloth: Reed space occupied $66\frac{2}{3}$ inches, 72 picks per inch, 40 yards length of cloth to be woven, 30 lbs. amount of filling to be used.

$$66\tfrac{2}{3} \times 72 = 4{,}800 \times 40 = 192{,}000 \div 30 = 6{,}400 \div 1{,}600 = 4.$$

Answer.—Counts for yarn required are 4-run woolen yarn.

Example.—Cotton Yarn. Find counts for filling yarn required for following cloth. Reed space occupied 30 inches, 80 picks per inch, 70 yards length of cloth to be woven, 10 lbs. amount of filling to be used.

$$30 \times 80 = 2{,}400 \times 70 = 168{,}000 \div 10 = 16{,}800 \div 840 = 20$$

Answer.—Counts for yarn required are 20's cotton yarn.

TO FIND THE PICKS PER INCH FOR A CERTAIN PIECE OF GOODS OF WHICH THE COUNTS OF THE YARN, LENGTH OF CLOTH TO BE WOVEN, ITS WIDTH IN REED, AND THE AMOUNT OF MATERIAL TO BE USED, ARE GIVEN.

In such a case use—

Rule.—Multiply counts by basis of yarn and amount of material to be used, the product thus obtained divide by the yards given and the quotient by width of fabric in reed.

Example.—Woolen Yarn (run basis). Find number of picks necessary to produce the following fabric: 6-run woolen yarn, 80 inches width of cloth in reed, 40 yards length of cloth woven, 20 lbs. weight of filling to be used.

$$6 \times 1{,}600 = 9{,}600 \times 20 = 192{,}000 \div 40 = 4{,}800 \div 80 = 60$$

Answer.—60 picks are required.

Proof.—$60 \times 80 = 4{,}800 \times 40 = 192{,}000$ yards required.

$6 \times 1{,}600 = 9{,}600$. Thus: $192{,}000 \div 9{,}600 = 20$ lbs., weight of filling to be used.

Example.—Worsted Yarn. Find number of picks required to produce the following fabric: Single 15's worsted filling, 60 inches width of cloth in reed, 40 yards length of cloth woven, 22 lbs. weight of filling to be used.

$$15 \times 560 = 8{,}400 \times 22 = 184{,}800 \div 40 = 4.620 \div 60 = 77$$

Answer.—77 picks are required.

In some instances there may be two or more different counts of filling used. For example in fabrics made with one system of warp and two or more fillings, or fabrics made on the regular double cloth system, etc. If the arrangement as to counts of a filling is of a simple form, compound the counts of the respective number of threads in one thread, and solve answer in compound size by previously given rule. Next multiply compound number thus derived by number of picks compounded, and the result will be the answer for picks wanted in fabric.

Example.—Woolen Yarn (cut basis). Find number of picks necessary to produce the following fabric.

Arrangement of filling.—2 picks 32-cut woolen yarn (face).
1 pick 18 " " " (back).
—
3 picks in repeat.

36 yards length of cloth woven, $26\frac{5}{24}$ lbs. weight of filling to be used, 74 inches reed space to be occupied.

$32 \div 32 = 1$	$32 \div 3\frac{7}{9} = 8\frac{8}{17}$-cut compound size.
$32 \div 32 = 1$	$8\frac{8}{17} \times 300 = 2{,}541\frac{3}{17} \times 26\frac{5}{24} = 66{,}600$
$32 \div 18 = 1\frac{7}{9}$	$66{,}600 \div 36 = 1{,}850 \div 74 = 25$, compound number of picks required.
—	25×3 (number of minor picks compounded)$=75$
$3\frac{7}{9}$	

Answer.—75 picks are required.

Proof.—2 picks 32-cut. | 75 picks per inch.
1 pick 18-cut. | 36 yards length of cloth.
—
3 picks in repeat. 74 inches reed space occupied. Find weight ($26\frac{5}{24}$).

$75 \times 74 = 5{,}550 \div 3 = 1{,}850.$ 1,850—18-cut—($18 \times 300 = 5{,}400$ yards per lb.)
3,700—32-cut—($32 \times 300 = 9{,}600$ yards per lb.)

$1{,}850 \times 36 = 66{,}600 \div 5{,}400 = 12\frac{1}{3} = 12\frac{8}{24}$ lbs.
$3{,}700 \times 36 = 133{,}200 \div 9{,}600 = 13\frac{7}{8} = 13\frac{21}{24}$ lbs.
—
$26\frac{5}{24}$ lbs., being the same weight as given in example.

If the arrangement of filling has a large number of picks in repeat proceed as follows: Ascertain weight of filling for one repeat of number of yards required woven and find answer by proportion, for picks in one repeat are to their weight in the same proportion, as picks required (or x) to given weight.

Example.—Cotton Yarn. Find number of picks required for the following cloth:

Width of fabric in reed 30 inches.
Length of cloth woven 60 yards.
Weight of filling to be used 12 lbs.

Arrangement of filling.—20 picks single 20's cotton.
24 " " 12's "
—
44 picks in repeat.

$20 \times 30 = 600 \times 60 = 36{,}000$
$24 \times 30 = 720 \times 60 = 43{,}200$ } for one repeat of
—
44 picks.

20's cotton=16,800 yards per lb. and 36,000 yards are required.
12's " =10,080 " " " 43,200 " " "

$36{,}000 \div 16{,}800 = 2\frac{1}{7}$ lbs.
$43{,}200 \div 10{,}080 = 4\frac{2}{7}$ lbs.
+—
$6\frac{3}{7}$ lbs., weight required for one repeat (=44 picks) of given counts of cotton yarn.

$44 : 6\frac{3}{7} :: x : 12$ $\qquad 44 \times 12 = 528 \div 6\frac{3}{7} = 82\frac{2}{15}$

Answer.—82 picks (actually $82\frac{2}{15}$ picks) are required.

Proof.—$82\frac{2}{15} \times 30 = 2{,}464 \times 60 = 147{,}840 \div 44 = 3{,}360.$

$3{,}360 \times 20 = 67{,}200 \div 16{,}800 = 4$ lbs.
$3{,}360 \times 24 = 80{,}640 \div 10{,}080 = 8$ lbs.
—
12 lbs., weight of filling to be used in given example.

To ascertain the number of yards of cloth woven, a certain amount of yarn on hand will give. Such examples will frequently arise in working up old lots on hand; again every time at weaving the last pieces cloth of large orders, where the superintendent wants a final review before the last or last few looms may have to wait for filling, or cut warps short. In such instances, width of fabric in reed, counts of yarn, and picks per inch are known. Thus : find number of yards for which material on hand by—

Rule.—Ascertain weight of filling required per yard, and divide the latter into the total weight of yarn on hand.

Example.—Woolen Yarn (run system). Find number of yards of cloth we can weave with 92 lbs. 4-run woolen yarn filling in a fabric, which is set 70 inches wide in reed and for which we use 60 picks per inch.

Picks per inch		Width of fabric in reed.		Yds of filling wanted for 1 yard cloth.		6,400÷16 or yards per oz	
60	×	70	=	4,200	÷	400	$=10\frac{1}{2}$ oz., weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz.		Oz of filling in 1 yard of cloth.	
92	×	16	=	1,472	÷	10.5	=140.19 yards.

Answer.—Filling in hand will weave 140 yards (140.19) of cloth.

Example.—Woolen Yarn (cut system). Find number of yards of cloth we can weave with 42 lbs. 32-cut woolen yarn filling in a fabric, which is set 72 inches in reed and for which we use 84 picks per inch.

Picks per inch.		Width of fabric in reed.		Yds. of filling wanted for 1 yard cloth.		9,600÷16 or yards per oz.	
84	×	72	=	6,048	÷	600	=10.08 oz., weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz.		Oz. of filling in 1 yard of cloth	
42	×	16	=	672	÷	10.08	$=66\frac{2}{3}$ yards.

Answer.—Filling on hand will weave 66 yards ($66\frac{2}{3}$) of cloth.

Example.—Worsted Yarn. Find number of yards of cloth we can weave with 52 lbs. of 2/36's worsted filling in a fabric, which is set 62 inches wide in reed and for which we use 70 picks per inch.

Picks per inch.		Width of fabric in reed.		Yds. of filling wanted for 1 yd. of cloth.		10,080÷16 or yards per oz.	
70	×	62	=	4,340	÷	630	=6.888 oz., weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz. in 1 lb.		Total amount of oz		Oz. of filling in 1 yard of cloth	
52	×	16	=	832	÷	6.888	=120.79 yards.

Answer.—Filling on hand will weave 120 yards ($120\frac{4}{5}$) of cloth.

Example.—Cotton Yarn. Find number of yards of cloth we can weave with 18 lbs. of single 40's cotton filling in a fabric, which is set 30 inches in reed and for which we use 60 picks per inch.

Picks per inch.		Width of fabric in reed		Yds. of filling wanted for 1 yard of cloth		33,600÷16 or yards per oz.	
60	×	30	=	1,800	÷	2,100	$=\frac{6}{7}$ oz., weight of filling wanted per yard cloth woven.

Lbs. of filling on hand.		Oz in 1 lb.		Total amount of oz.		Oz. of filling in 1 yard of cloth	
18	×	16	=	288	÷	$\frac{6}{7}$	=336 yards.

Answer.—Filling on hand will weave 336 yards of cloth.

(Answers are given in these examples without reference to any waste of material during the weaving process.)

Ascertaining the Amount and Cost of the Materials used in the Construction of Fabrics.

A. FIND THE TOTAL COST OF MATERIALS USED, and

B. FIND THE COST OF THE SAME PER YARD, FINISHED CLOTH.

Fancy Cassimere.

Warp.—3,600 ends 4-run brown mix. Price of yarn, 85 cents per lb. Length dressed, 50 yards. Reed, $12\frac{1}{2}\times 4$.

Selvage.—40 ends, 2-ply 4-run. Reeded, 4 ends per dent. Price of yarn, 50 cents.

Filling.—52 picks, $3\frac{3}{4}$-run gray mix. Price of yarn, 65 cents per lb.

Length of fabric from loom, 43 yards. Length of fabric finished, 40 yards.

	Ends. × Yards.		Total yards.		Yards per lb.		Total lbs.		Price per lb.		
Warp.—	$\frac{3,600\times 50}{6,400}$	=	(180,000	÷	6,400)	=	$28\frac{1}{8}$	×	85¢	=	$23.905, price of warp.

		Total yards.		Yards per lb.			Price per lb.		
Selvage.—	40×2=80 ends×50 yds.=	4,000	÷	3,200=	$1\frac{1}{4}$ lbs.	×	50¢	=	$62\frac{1}{2}$¢, price of selvage.

Filling.—3,600÷50=72 inches, width of warp in reed.
+ $1\frac{3}{5}$ " width of selvage ($80\div 4=20\div 12\frac{1}{2}=1\frac{3}{5}$).

$73\frac{3}{5}$ inches, width of warp and selvage.

Width.		Picks		Yards filling per yard cloth.		Yards Woven.		Total yards filling.		Yards per lb.		Weight of filling.
$73\frac{3}{5}$	×	52	=	$3,827\frac{1}{2}$	×	43	=	$164,582\frac{1}{2}$	÷	6,000	=	27.43 lbs.
												×65¢, price per lb.
												$17.8295, price of filling.

$23.90½, price of warp.
62½, price of selvage.
17.83, price of filling.
$42.36, total cost of all.

$42.36÷40=$1.059 or $1.06, price of material per yard finished.

Answer.—A. $42.36, total cost of all materials.

Answer.—B. $1.06, cost of materials per yard of finished cloth.

Worsted Suiting.

Warp.—3,968 ends, 2/32's worsted. Price of yarn, $1.05 per lb. Length dressed, 45 yards. Reed, 16×4.

Selvage.—30 double ends, 2/30's worsted, 3 double ends per dent. Price of yarn, 75 cents per lb.

Filling.—66 picks, 2/32's worsted. Price of yarn, 95 cents.

Length of fabric from loom, 40 yards. Length of fabric finished, $39\frac{1}{4}$ yards.

Warp.—3,968×45=178,560 yards of warp wanted.

2/32's worsted=1/16's=8,960 yards per lb. 178,560÷8,960=$19\frac{13}{14}$ lbs., weight of warp.

$$19\tfrac{13}{14}\times 1.05=\frac{279}{14}\times 1.05=\frac{279\times 1.05}{14}=292.95\div 14=\$20.92\tfrac{1}{2}\text{, cost of warp.}$$

Selvage.—$60 \times 2 = 120 \times 45 = 5{,}400$ yards of selvage are wanted.

2/30's=1/15's=8,400 yards per lb.

(Price per lb.)

$$5{,}400 \div 8{,}400 = \frac{54}{84} \text{ or } \frac{9}{14} \times 75¢ = 675 \div 14 = 48\tfrac{3}{14}¢, \text{ cost of selvage.}$$

Filling.—$3{,}968 \div 64 = 62$ inches width of warp.

10 dents each side for selvage=20 (both sides) $\div 16 = 1\frac{1}{4}$ inches, width of selvage.

62 inches, width of warp.
$1\frac{1}{4}$ " " selvage.

$63\frac{1}{4}$, total width of fabric in reed, and $63\frac{1}{4} \times 66 = 4{,}174.5$ {Yards filling wanted per yard.}
$\times 40$ length of cloth from loom.

166,980 yards of filling wanted.

$166{,}980 \div 8{,}960 = 18\frac{285}{448}$ lbs. of filling wanted.

{Price per lb.}

$$18\tfrac{285}{448} \times 95¢ = 17.70\tfrac{195}{448} \div 100 = \$17.70\tfrac{1}{2}, \text{ cost of filling.}$$

Warp, $\$20.92\frac{1}{2}$
Selvage, $0.48\frac{3}{14}$
Filling, $17.70\frac{1}{2}$

$\$39.11\frac{3}{14}$, total cost of materials.

$\$39.1175 \div 39.25 = \$0.996$ or $99\frac{3}{5}¢$, cost of material per yard.

Answer A.—$\$39.11\frac{3}{4}$, (practically \$39.12) total cost of all materials.

Answer B.—\$ $0.99\frac{3}{5}$, (practically \$1.00) cost of materials per yard of finished cloth.

Cotton Dress Goods.

Warp.—1,392 ends, single 18's cotton. Price of yarn, 22 cents per lb. Length dressed, 60 yards. Reed, 24×2.

Selvage.—12 ends, 2/20's cotton, 3 ends per dent. Price, 20 cents per lb.

Filling.—54 picks, single 26's cotton. Price, 24 cents per lb.

Length of cloth from loom, 56 yards. Length of cloth finished, $56\frac{1}{2}$ yards.

Warp.—$1{,}392 \times 60 = 83{,}520 \div 15{,}120 (840 \times 18) = 5\frac{94}{189}$ lbs. $\times 22¢ = \$1.20\frac{178}{189}$, price of warp.

Selvage.—$24 \times 60 = 1{,}440 \div 8{,}400 = \frac{144}{840}$ or $\frac{6}{35}$ lbs.

$\frac{6}{35} \times 20 = (120 \div 35) = 3\frac{3}{7}¢$, price of selvage.

Filling.—$1{,}392 \div 48 = 29$ inches, width of fabric in reed.
$\frac{1}{3}$ inch " " both selvages.

$29\frac{1}{3}$ inches, total width of fabric and selvages.

$29\frac{1}{3} \times 54 = 1{,}584$ yards of filling wanted per yard.
$\times 56$ " length of cloth from loom.

88,704, total number of yards wanted.

{Yards per lb. in 26's cotton.} (lbs.)

$$88{,}704 \div 21{,}840 = 4.061 \times 24¢ = .97\tfrac{46}{100}¢, \text{ price of filling.}$$

\$1.21, price of warp .03½, " " selvage .97½, " " filling \$2.22, total price of material used in the fabric.	\$2.22÷56½=3$\frac{105}{113}$ or nearly 3⅞¢, price of material per yard finished.

Answer A.—\$2.22, total cost of material used.

Answer B.—\$ .03⅞, (practically 4 cents) cost of materials per yard finished cloth.

Woolen Tricot Suiting.

Warp.—4,608 ends, 32-cut woolen yarn. Price of yarn, \$1.15 per lb. Length dressed, 40 yards. Reed, 16×4.

Selvage.—40 ends, single 10-cut, 2 ends per dent. Price, 54 cents per lb.

Filling.—76 picks, 36-cut woolen yarn. Price, \$1.08 per lb.

Length of cloth from loom, 36 yards. Length of cloth finished, 32 yards.

Warp.—4,608×40=184,320÷9,600(300×32)=19.2 lbs×\$1.15=\$22.08, price of warp.

Selvage.—40×2=80×40=3,200÷3,000(300×10)=1$\frac{1}{15}$ lbs.×\$0.54=\$0.576, price of selvage.

Filling.—4,608÷64=72 inches, width of warp.
2½ " " " selvage. (40×2=80÷2=40÷16=2½)

74½ inches, total width of fabric.
74½×76=5,662 yards filling per yard.
×36 yards of cloth woven.

203,832, total yards filling wanted.
203,832÷10,800=18,873 lbs., weight of filling.
18,873 lbs.×\$1.08=\$20.383, cost of filling.

Warp, \$22.08 Selvage, .576 Filling, 20.383 \$43.039, total cost.	\$43.039÷32=\$1.345, or \$1.34½, cost of materials per yard finished.

Answer A.—\$43.039, (practically \$43.04) is the total cost of the materials used; and,

Answer B.—\$1.34½, is the cost of the same per yard finished.

Worsted Suiting.

Warp.—3,960 ends. Length dressed, 45 yards. Reed, 16×4. Take up of warp during weaving, 12 per cent.

Dressed.—4 ends black 2/32's } 4 times over=24 ends.
2 " slate 2/36's }
4 " black 2/32's = 4 "
1 " 30/2's lavender spun silk = 1 "
1 " 30/2's red " " = 1 "

30 ends in pattern.

Price of black worsted, \$1.05. Price of slate worsted, \$1.12. Price of silk, \$6.50.

Selvage.—30 double ends, 2/30's worsted each side, 3 double ends per dent. Price of yarn, 75¢ per lb.

Filling.—66 picks per inch, 2/32's worsted.

Arrangement of colors.—28 picks black worsted 2/32's (price 95¢ per lb.)
1 pick lavender spun silk 30/2's (price \$6.50 per lb.)
1 pick red " " 30/2's (price 6.50 per lb.)

30 picks in repeat. Loss in length during finishing, $1\frac{1}{2}$ per cent.

20	ends black	2/32's	worsted	=10
8	" slate	2/36's	"	= 4
2	" spun silk	30/2's	"	= 1
30	ends in pattern			=15

3,960÷15=264 repeats (of half patterns.)

264×10= 2,640 ends of 2/32's black worsted×45=118,800 yards.
264× 4= 1,056 " " 2/36's slate " ×45= 47,520 "
264× 1= { 132 " " 30/2's lavender silk ×45= 5,940 "
{ 132 " " 30/'2s red silk ×45= 5,940 "

3,960 ends of warp ×45=178,200 yards.

2/32's=1/16's=16×560=8,960 yards per lb.

$118,800 \div 8,960 = 13\frac{29}{112}$ lbs. $\times \$1.05 = \frac{1,485}{112} \times 1.05 = (1,485 \times 1.05 = 155,925 \div 112 =)$ \$13.921.

Price of 118,800 yards 2/32's black worsted is \$13.92.

2/36's=1/18's=18×560=10,080 yards.

$47,520 \div 10,080 = 4\frac{5}{7}$ lbs. × \$1.12=\$5.28, price of 47,520 yards 2/36's slate worsted.

30/2's silk=25,200 yards per lb. 5,940÷25,200=0.235 lbs.×\$6.50=\$1.52750.

Price of 5,940 yards 30/2's lavender silk=\$1.527. Price of 5,940 yards 30/2's red silk=\$1.527.

Black worsted,	\$13.92
Slate, "	5.28
Lavender silk,	1.527
Red silk,	1.527
	\$22.254, total cost of warp.

Selvage.—2/30's=1/5's=15×560=8,400 yards per lb.

120×45=5,400 yards. $5,400 \div 8,400 = \frac{54}{84} = \frac{9}{14}$ lbs.×75¢=48.2¢, price of selvage

Filling.—$3,960 \div 64 = 61\frac{14}{16}$ inches, width of cloth in reed.

$60 \div 3 = 20$ dents $\div 16 = 1\frac{4}{16} = 1\frac{1}{4}$ inch, width of selvage.

$61\frac{14}{16}$, width of cloth.

$1\frac{4}{16}$, width of selvage.

$62\frac{18}{16}$ inches $= 63\frac{1}{8}$ inches, width of cloth and selvage.

$63\frac{1}{8} \times 66 = \frac{505}{8} \times 66 = (505 \times 66 = 33,330 \div 8 =) 4,166\frac{1}{4}$ yards filling wanted for 1 yard cloth from loom.

45 yards length dressed.
— 5.4 " 12 per cent. take up.

39.6 yards, length of cloth woven.

4,166.25×39.6=164,983.5 yards, total amount of filling wanted.

$164,983.5 \div 15 = 10,998.9$	$10,998.9 \times 14 = 153,984.6$ yards of 2/32's worsted wanted.
	$10,998.9 \times 1 = 10.998.9$ " " 30/2's silk wanted.
	164,983.5

$153,984.6 \div 8,960 = 17.185$ lbs. $\times 95¢ = \$16.326$, price of the black worsted filling.

30/2's silk = 25,200 yards per lb. $10,998.9 \div 25,200 = 0.436$ lbs. $\times \$6.50 = \$2.834$, total price of silk.

$\$2.834 \div 2 = \$1.417$, price for each kind silk.

$16.326	black worsted filling.	Cost of warp,	$22.254
1.417	lavender silk "	" " selvage,	.482
1.417	red " "	" " filling,	19.160
$19.160,	total cost of filling.		$41.896, total cost of materials.

39.6 yards, length of cloth woven.	$41.896 \div 39.006 = 1.074$, cost of materials per finished yard.
.594 " 1½ per cent. loss in finishing.	
39.006 yards, finished length.	

Answer.—A. Total cost of material, $41.90.

Answer.—B. Cost of materials per yard finished cloth, $1.07½.

Fancy Cassimere.

Warp.—4,032 ends. Reed, 14×4. Length of warp dressed, 50 yards. Take-up of warp during weaving, 10 per cent.

Dressed.—4 ends 5-run black / 4 " 5 " brown	4 times over	=32 ends.
4 ends 5-run black		= 4 ends.
3 " 5 " brown		= 3 ends.
1 end twist	5-run black wool and 30's blue spun silk twisted together; take up of silk, 12 per cent. / " " " wool, 3 per cent. during twisting.	=1 end.
2 ends 5-run black / 2 " 5 " brown	9 times over	=36 ends.
2 ends 5-run black		= 2 ends.
1 end 5 " brown		= 1 end.
1 " twist (the same as above)		= 1 end.
		In pattern 80 ends.

Price of the 5-run warp yarn, 96 cents per lb. Price of the 5-run woolen yarn (soft-twist) as used in twist, 96 cents per lb. Price of the spun-silk as used in twist, $5.60 per lb.

Selvage.—40 ends of 2-ply 4-run listing yarn for each side, 4 ends per dent. Price of yarn, 50 cents.

Filling.—The same arrangement as the warp, only using 5½-run yarn in place of the 5-run. For twist use the same material for both minor threads as in warp. 60 picks per inch. Price of the 5½-run filling yarn, 85 cents. Loss in length of fabric at finishing (fulling), 6 per cent.

Warp.—4,032 ends. 78 ends 5-run / 2 " twist / 80 ends in repeat.	$4,032 \div 80 = 50$ repeats plus 32 ends.

$50 \times 78 = 3,900 + 32 = 3,932$ ends of 5-run $50 \times 2 = 100$ ends twist.

(Ends in warp.) (Yards long.) (Yards wanted.) (5×1,600)
3,932 × 50 = 196,600 ÷ 8,000 =24,575 lbs.@96¢=$23.592, price of 5-run warp.

100 ends of twist×50 yards (dressed)=5,000 yards, total length of twist yarn wanted.

Take-up of silk (during twisting) 12 per cent. Thus: (100:88 :: x:5,000)=5,681.81 yards of 30's spun silk are wanted.

Take-up of wool (during twisting) 3 per cent. Thus: (100:97 :: x:5,000)=5,154.64 yards of 5-run woolen yarn are wanted.

(30×840) (Weight wanted.) (Price per lb.)
5,681.81 ÷ 25,200 = 0.2254 lbs. × $5.60 = $1.262, price of silk yarn used in twist for warp.

(5×1,600) (Weight wanted.) (Price per lb.)
5,154.64 ÷ 8,000 = 0.6443 lbs. × 96¢ =$0.618, price of the 5-run minor yarn for twist.

$23.592 cost of 5-run warp yarn.
1.262 " " 30's spun silk } for twist.
0.618 " " 5-run soft twist }

$25.472, total cost of warp.

Selvage.—80 ends×50 yards dressed=4,000 yards of yarn÷3,200 (2×1,600) =$1\frac{1}{4}$ lbs.

$1\frac{1}{4}$ lbs @ 50¢ = $62\frac{1}{2}$¢, price of selvage yarn used.

(Ends in warp.) (14×4)
Filling.—4,032 ÷ 56 = 72 inches, width of cloth in reed.

80 (ends selvage) ÷4 (ends per dent) =20 dents÷14=$1\frac{3}{7}$ inches, width of selvage.

72 inches, width of cloth,
$1\frac{3}{7}$ " " " selvage,

$73\frac{3}{7}$ inches, total width.

{Width of cloth.} {Picks per inch.}
$73\frac{3}{7} \times 60 = \frac{514}{7} \times 60 = \frac{30,840}{7} \times 45$ {50 − 5=10 per cent. take up; 45} $=198,257\frac{1}{7}$, total number of yards of filling wanted.

$198,257\frac{1}{7}$÷40=4,956.43× 1= 4,956.43 yards of twist. } filling yarn are wanted.
and 4,956.43×39=193,300.77 " " $5\frac{1}{2}$-run. }

$5\frac{1}{2}$-run=8,800 yards per lb. Thus:

193,300÷8,800=$21\frac{85}{88}$ lbs. @ 85¢=$18.671, price of the $5\frac{1}{2}$-run filling.

Twist yarn. { Silk take-up 12 per cent., thus: (100:88 :: x:4,956.43)=$5,632\frac{27}{88}$ yards are wanted.
Wool " 3 " " " (100:97 :: x:4,956.43)=$5,109\frac{70}{97}$ " " "

30's spun silk=25,200 yards per lb. Hence:

5,632÷25,200=0.2235 lbs., weight of silk wanted @ $5.60=$1.251, price of silk.

5-run woolen yarn=8,000 yards per lb. Hence:

5,109÷8,000=0.6386 lbs., weight of woolen yarn @ 96¢=61.3¢, price of the woolen yarn.

$18.671 cost of $5\frac{1}{2}$-run filling.
1.251 " " 30's spun silk. } for twist.
0.613 " " 5-run soft twist. }

$20.535, total cost of filling.

$25.472, cost of warp.
0.625, " " selvage.
20.535, " " filling.
$46.632, total cost.

45 yards, woven length of cloth.
— 2.7 " (6 per cent. shrinkage in fulling).
42.3 yards, length of cloth when finished.

46.632÷42.3=1.124

Answer.—A. The total cost of materials used are $46.632 ($46.64) and

Answer.—B. The cost of the same per finished yard is $1.124 ($1.13.)

Fancy Cotton Dress Goods.

(27 inches finished width.)

2,204 ends in warp. Reed, 38×2. Length of cloth from loom, 80 yards.

Dressing:

1 end dark blue (ground) 1 end white "	} ×4	= 8 ends	1/20's
1 end light blue "		= 1 end	2/30's
2 ends " " (pile)		= 2 ends	2/24's
1 end " " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end flesh "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
1 end white "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
1 end dark blue " 1 end white "	} ×4	= 8 ends	1/20's
1 end maroon "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end white "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
24 ends tan "		=24 ends	1/20's

Dressing:—continued.

1 end dark blue (ground) 1 end white "	} ×4	= 8 ends	1/20's
1 end maroon "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end white "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
1 end light blue "		= 1 end	2/30's
2 ends " " (pile)		= 2 ends	2/24's
1 end " " (ground)		= 1 end	2/30's
1 end dark blue " 1 end white "	} ×4	= 8 ends	1/20's
1 end " "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
8 ends tan "		= 8 ends	1/20's
1 end flesh "		= 1 end	2/30's
2 ends " (pile)		= 2 ends	2/24's
1 end " (ground)		= 1 end	2/30's
24 ends tan "		=24 ends	1/20's

Repeat of pattern, 152 ends.

Take-up of ground-warps during weaving, 8 per cent.
Take-up of pile-warp during weaving, 70 per cent.

Price of warp yarns (including coloring or bleaching) as to their respective counts, are:

1/20's ground, 30 cents.
2/30's ground, 38 cents.
2/24's pile, 36 cents.

Selvage.—10 two-ply ends of 2/20's white cotton for each side. 2 double ends per dent. 8 per cent. take-up during weaving. Price of yarn, 22 cents.

Filling.—78 picks per inch.

Arrangement of colors.—
4 picks white
8 " tan
4 " maroon
8 " tan
6 " white
8 " tan
4 " light blue
28 " tan

70 picks in repeat.

Counts for all the filling 1/20's cotton.
Price of all the filling yarn, inclusive of coloring and bleaching, 28 cents.
Length of cloth from loom to equal length finished.

Warp.—1/20's ground	= 112	ends in one pattern		
2/30's "	= 20	" " " "		
2/24's pile	= 20	" " " "		
	152	ends in one repeat of pattern.		

2,204 (ends in warp) ÷ 152 (repeat of pattern) $=14\frac{1}{2}$ repeats of pattern in width of fabric.

Pattern, with reference as to counts, repeats twice in one repeat of pattern. Thus:

	Take-up during weaving.	Yards of yarn wanted per yard cloth woven.		Length of cloth woven.		Yards of yarn wanted for the entire piece.
$112\times14\frac{1}{2}=1{,}624$ ends of 1/20's cotton—	8 per cent. —	1,765.2174	×	80	=	141,217.392 yds.
$20\times14\frac{1}{2}=$ 290 " " 2/30's " —	8 " " —	315.2174	×	80	=	25,217.392 "
$20\times14\frac{1}{2}=$ 290 " " 2/24's " —	70 " " —	966.6666	×	80	=	77,333.328 "

Yards of yarn wanted for the entire piece.		Yards per lb.		Lbs. of yarn wanted for the entire piece.		Price of the yarn per lb.		Value of yarn
141,217.392 yards..	÷	16,800	=	8.4058	×	30¢	=	$2.52
25,217.392 "	÷	12,600	=	2.0013	×	38	=	0.76
77,333.328 "	÷	10,080	=	7.6719	×	36	=	2.76
								$6.04, price of warp yarn.

Filling.—29 inches, width of fabric in reed.
$\frac{5}{19}$ " " " selvage in reed.

$29\frac{5}{19}$ inches, total width of cloth in reed.

$29\frac{5}{19}\times78=\left(\frac{556}{19}\times78\right)=2{,}282.5263$ yards of filling per yard cloth woven.

	Length of cloth woven.		Total yards of filling wanted.		20 × 840		Lbs. of yarn wanted.		Price of yarn per lb.		Value of total filling yarn.
2,282.5263 ×	80	=	182,602.1040 yds.	÷	16,800	=	10.8691	×	28¢	=	$3.04

Selvage.—40 ends. 8 per cent. take-up (100:92 :: x:40) required 43.478 yards yarn per yard cloth woven.

		Length of cloth woven.		Yards of selvage wanted for the entire piece.		10 × 140		Total weight of selvage.		Price per lb.	
43.478 yards	×	80	=	3,478.24 yards	÷	8,400	=	0.414 lbs.	×	22¢	= 9¢, total price of selvage.

$6.04 cost of warp,		
3.04 " " filling,		
0.91 " " selvage,		9.99÷80=12.487.
$9.99, total cost.		

Answer.—A. The total cost of materials used in fabric is $9.99, and

Answer.—B. The value of this stock, per finished yard, is 12.487 cents, practically $12\frac{1}{2}$ cents.

Worsted Suiting.

3,968 ends 2/32's worsted. Length of warp dressed, 45 yards. Reed, 16×4.

Arrangement of dressing.—4 ends black,
4 ends brown,
4 ends black,
4 ends indigo blue.

16 ends in repeat.

Price of yarn in the white, (scoured) $1.05 per lb.

Allowance for waste during spooling, dressing and weaving, 5 per cent.

Selvage.—30 double ends of 2/30's white worsted for each side, 4 double ends per dent. Price, per lb., 75 cents.

Filling.—66 picks, 2/32's worsted. Same arrangement of colors as in warp. Price of yarn in the white, (scoured) 95 cents.

Allowance for waste during spooling and weaving, 6 per cent.

Length of fabric from loom, 40 yards. Length of fabric finished, $39\frac{1}{4}$ yards.

Cost of coloring yarn, black, 6 cents per lb.; brown, 6 cents per lb.; indigo blue, 15 cents per lb. (Weight of yarn before coloring to equal its weight when colored.)

Cost of weaving, 16 cents per yard, from loom. Cost of finishing, 12 cents per yard, finished.

General mill expenses, 10 cents per yard, finished cloth.

Warp.—

(Ends)		Yards dressed.		Total yards.		(16×560)		(Lbs.)		Price per lb.		(Cost.)
3,968	×	45	=	178,560	÷	8,960	=	19.928	×	$1.05	=	$20.9244

19.928 ÷ 4 = 4.982 × 1 = 4.982 lbs. @ 15¢ (indigo blue) = .7473

4.982 × 3 = 14.946 " " 6¢ (black and brown) = .8967

$22.5684

5 per cent. allowance for waste, 1.1284

Total cost of warp yarn, $23.6968

Selvage.—60 double ends 2/30's worsted = 20 single ends 2/30's.

$120 \times 45 = 5{,}400 \div 8{,}400 = \frac{54}{84} = \frac{9}{14}$ lb. @ 75¢=48.214¢

5 per cent. allowance for waste, 2.410

Cost of selvage, $0.562

Filling.—Reed, 16×4=64 warp threads per inch.

(Ends in full warp.)÷(Ends per inch.)

3,968 ÷ 64 =62 inches, width of cloth in reed.

$\frac{15}{16}$ " width of selvage (60÷4=15 dents, reed 16=$\frac{15}{16}$ inch).

$62\frac{15}{16}$ inches, total width of fabric (including selvage) in reed.

Width in reed.		Picks per inch.		Yards of filling wanted per yard of cloth woven.		Yards from loom.	
$62\frac{15}{16}$	×	66	=	$4,153\frac{7}{8}$	×	40	=166,155 yards of filling wanted in cloth.
							+ 9,969 yards, 6 per cent. allowance for [waste.
							176,124 yards, total amount of filling wanted.

(Total length.) (15 × 560) (Total weight.)

176,124 ÷ 8,960 = 19.6567 lbs. @ 95¢ = $18.6739, cost of filling yarn.

19.6567 ÷ 4 = 4.9141 × 1 = 4.9141 lbs. @ 15 = 0.7371, " " indigo blue color.

4.9141 × 3 = 14.7426 lbs. @ 6 = 0.8845, " " black and brown colors.

$20.2955, total cost of filling yarn.

40 × 16¢ = $6.40, cost of weaving.

$39\frac{1}{4}$ × 12 = $4.71, " " finishing.

$39\frac{1}{4}$ × 10 = $3.93, general mill expenses (office insurance, watchmen, mechanics, per cent. on capital, etc.)

$23.70 cost of warp.
0.51 " " selvage.
20.30 " " filling.
6.40 " " weaving.
4.71 " " finishing.
3.93 general mill expenses.

$59.55

$59.55 ÷ $39\frac{1}{4}$ = $1.517.

Answer.—A. $59.55, total cost of the fabric.

Answer.—B. $1.52, cost of fabric per finished yard.

Beaver Overcoating. (*Piece-dyed.*)

4,800 ends in warp. Reed, 10 × 6. 42 yards long, dressed.

Arrangement of dressing.—2 ends face, $5\frac{1}{2}$-run. Price of yarn per lb., $1.25.
1 end back, 5-run " " " " " .84.

3 ends in repeat.

Filling.—2 picks face, $5\frac{1}{2}$-run. Price of yarn per lb., $1.18.
1 pick back, $1\frac{3}{4}$-run. " " " " " .40.

3 picks in repeat.

80 picks per inch.

16 cents for weaving.
4 " general weave room expenses.

20 cents per yard from loom for weaving.

Selvage.—40 ends of 2-run listing yarn (each side). Price, 50 cents per lb. 3 ends per dent (outside dent 4).

Take-up of warp during weaving, 11 per cent. Take-up of cloth during finishing (fulling), 10 per cent. Flocks used during fulling process, 20 lbs. at 8 cents per lb. Cost of finishing and dyeing, 25 cents per yard, finished. General mill expenses, 10 cents per yard, finished.

Warp.—4,800 ÷ 3 = 1,600.

(Yards wanted.)

1,600 × 2 = 3,200 ends $5\frac{1}{2}$-run × 42 = 134,400 ÷ 8,800 = $15\frac{3}{11}$ lbs. @ $1.25 = $19.09.

1,600 × 1 = 1,600 ends 5-run × 42 = 67,200 ÷ 8,000 = $8\frac{2}{5}$ lbs. @ .84 = 7.06.

Cost of warp, $26.15.

(Yards wanted.)

Selvage.—80 ends 2-run × 42= 3,360 ÷ 3,200 = 1.05 lbs. @ 50¢ = $52\frac{1}{2}$¢ (53¢), cost of selvage.

Filling.—Reed, 10 × 6 = 60 ends per inch and
4,800 ÷ 60 = 80 inches, width of cloth in reed.
2.6 " " " selvage (80 ÷ 3 = 26 dents = 2.6 inches).

82.6 inches, total width.

82.6 × 80 = 6,608 yards (total amount of filling per yard woven).
6,608 ÷ 3 = 2,202$\frac{2}{3}$ and 2,202$\frac{2}{3}$ × 2 = 4,405$\frac{1}{3}$ yards face filling.
2,202$\frac{2}{3}$ × 1 = 2,202$\frac{2}{3}$ " backing.

11 per cent. take-up of warp during weaving.
100 : 89 :: 42 : x = 89 × 42 = 3,738 ÷ 100 = 37.38 yards, woven length.

Hence: 4,405$\frac{1}{3}$ × 37.38 = 164,671.35 yards 5$\frac{1}{2}$-run = 18.712 lbs. @ $1.18 = $22.10
2,202$\frac{2}{3}$ × 37.38 = 82,335.67 " 1$\frac{3}{4}$ " = 29.456 " @ .40 = 11.78

Cost of filling, $33.88

37.38 × 20¢ = $7.47, cost of weaving.
10 per cent. shrinkage of cloth during finishing. Hence:
100 : 90 :: 37.38 : x = (90 × 37.38 =) 3,360.20 ÷ 100 = 33.64 yards, finished length.

$26.15 cost of warp.	33.64 × 25¢ = $8.41 cost of finishing.
.53 " " selvage.	33.64 × 10 = 3.37 general mill expenses.
33.88 " " filling.	20 × 8 = 1.60 cost of flocks.
7.47 " " weaving.	
8.41 " " finishing.	
3.37 " " general expenses.	81.41 ÷ 33.64 = 2.42.
1.60 " " flocks.	
$81.41	

Answer.—A. $81.41, total cost of the fabric.

Answer.—B. $ 2.42, cost of fabric per yard, finished.

Ingrain Carpet. (*Extra fine;* Cotton Chain, Worsted Filling)

832 ends in warp, 2/14's cotton, 5 per cent. take-up by weaving and shrinkage in finishing, etc. Finished length of fabric, 60 yards.

Cost of yarn,	17 ¢ per lb.
Cost of color,	5 " " (average price).
Winding and beaming,	2$\frac{1}{2}$ " "
	24$\frac{1}{2}$¢, price of warp yarn per lb. on beam.

Selvage.—Four ends of 4/10's cotton on each side. Price, 20 cents per lb. (same amount of take-up as warp).

Filling.—10 pair, (in finished fabric) 36 inches, width of fabric in loom.

Yarn used: One-half the amount 5/8's single, light colors (50 yards per oz. in the grease). Price, 16$\frac{1}{2}$ cents per lb. in the grease, or 26$\frac{1}{2}$ cents per lb. scoured and colored. One-half the amount 5/8's single, dark colors (48 yards per oz. in the grease). Price, 12 cents per lb. in the grease, or 20 cents per lb. scoured and colored.

Loss (average) of weight for filling in scouring and dyeing, 15 per cent. Waste of filling (average) in winding and weaving, 15 per cent.

Length of the yarn to remain uniform from the grease to colored. Weaving and weave-room expenses, 10 cents per yard finished fabric. General mill expenses, 5 cents per yard finished fabric.

Warp.—832 ends 2/14's cotton, 5 per cent. take-up, 60 yards finished length, $24\frac{1}{2}$ cents per lb.

$100:95::x:832=83,200\div95=875\frac{15}{19}\times60=52,547.37$ yards, total amount of yarn wanted.

2/14's=5,880 yards per lb. Hence: $52,547.37\div5,880=8.9536$ lbs., total weight of yarn wanted.

8.9536 lbs. @ $24\frac{1}{2}$¢=\$2.1936 (=\$2.20) cost of warp-yarn.

Selvage.—$4\times2=8\times60=480$.

$100:95:x::480=48,000\div95=505.26$ yards, total length of selvage yarn wanted.

4/10's=2,100 yards per lb. Hence: $505.26\div2,100=0.24$ lbs., total weight.

0.24 lbs. @ 20¢=$4.\frac{8}{10}$¢ (=5¢) cost of selvage.

Filling.—20 picks per inch in finished fabric. 36 inches, width of fabric.

$36\times60=2,160\times20=43,200$ yards, total amount wanted in fabric.

= { 21,600 yards light colored yarn, at 50 yards per oz. in the grease.
21,600 yards dark colored yarn, at 48 yards per oz. in the grease. }

$50\times16=800$ yards per lb. for light colors. $48\times16=768$ yards per lb. for dark colors.

$21,600\div800=27$ lbs., weight in the grease.

$$100:85::27:x=\frac{85\times27}{100}=22.95 \text{ lbs., weight of yarn scoured and colored.}$$

22.95 lbs.@$26\frac{1}{2}$¢=\$6.082, cost of light colored filling used in fabric.

$21,600\div768=28.12$ lbs., weight in the grease.

$$100:85::28.12:x=\frac{85\times28.12}{100}=23.90 \text{ lbs., weight of yarn scoured and colored.}$$

23.9 lbs. @ 20¢=\$4.78, cost of dark colored filling used in fabric.

\$ 6.082 light colored.
4.780 dark "

\$10.862, total value of filling used in fabric, subjected to 15 per cent. waste of material in winding and weaving. Hence:

$$100:85::x:10.86=\frac{10.86\times100}{85}=12.776, \text{cost of filling, including of waste made in winding and weaving.}$$

Cost of warp,	\$ 2.194		
Cost of selvage,	0.048		
Cost of filling,	12.776		$24.01\div60=0.40$
Weaving and weaveroom expenses,	6.000	(60 yards × 10 cents)	
General mill expenses,	3.000	(60 yards × 5 cents)	
	\$24.018		

Answer.—A. \$24.02, total cost of the fabric.

Answer.—B. 40 cents, cost of fabric per yard finished.

Ingrain Carpet. (*Extra Super;* Worsted Chain.)

1,072 ends in warp, 2/14's worsted, 5 per cent. take up by weaving and shrinkage in finishing, etc. Price of yarn, including coloring (average) and winding and beaming, $52\frac{1}{2}$ cents per lb.

Selvage.—Four ends of 4/10's cotton on each side.

Price, 20 cents per lb. (same amount of take up as warp).

Filling.—13 pair (in finished fabric) 36 inches, width of fabric in loom.

Arrangement.—1 pick double reel yarn (60 yards per oz. in the grease.) Price, 22 cents per lb. in the grease, or 33 cents per lb. scoured and dyed.
1 pick, 5/8's single, light color (50 yards per oz. in the grease). Price $16\frac{1}{2}$ cents per lb. in the grease, or $26\frac{1}{2}$ cents per lb. scoured and dyed.
1 pick, double reel (as before).
1 pick 5/8's, single dark color (48 yards per oz. in the grease). Price, 12 cents per lb. in the grease, or 20 cents per lb. scoured and dyed.

Loss of weight (average) for filling in scouring and dyeing, $12\frac{1}{2}$ per cent. Waste (average) of filling in, winding and weaving, $12\frac{1}{2}$ per cent. No shrinkage for yarn during scouring and coloring. Weaving and weaveroom expenses, 12 cents per finished yard. General mill expenses, 6 cents per finished yard.

Warp.—1,072 ends, 2/14's worsted, 5 per cent. shrinkage. Price, $52\frac{1}{2}$ cents per lb.
$100:95::x:1{,}072=107{,}200\div 95=1{,}128.421\times 60=67{,}705.26$ yards, total amount of warp yarn wanted.
2/14's=3,920 yards per lb. Hence: $67{,}705.26\div 3{,}920=17.27$ lbs., total weight.
17.27 lbs.@$52\frac{1}{2}$¢=$9.066, value of warp yarn.

Selvage.—(The same as in previously given Example) 5 cents.

Filling.—26 picks, 36 inches, 60 yards. Hence:
$26\times 36\times 60=56{,}160$ yards, total amount of filling wanted in fabric.
$56{,}160\div 4=14{,}040$. Hence:
$14{,}040\times 2=28{,}080$ yards of double reel yarn@33¢ per lb.
$14{,}040\times 1=14{,}040$ " " 5/8's single light color@$26\frac{1}{2}$¢ per lb.
$14{,}040\times 1=14{,}040$ " " 5/8's single dark color@20 per lb.
$60\times 16=960$ yards per lb. and $28{,}080\div 960=29\frac{1}{4}$ lbs. @ 33 ¢=$9.652, value of double reel.
$50\times 16=800$ yards per lb. and $14.040\div 800=17.55$ lbs. @ $26\frac{1}{2}$ =$4.65, value of 5/8's light color.
$48\times 16=768$ yards per lb. and $14{,}040\div 768=18.28$ lbs. @ 20 =$3.656, value of 5/8's dark color.

$9.652 value of double reel.
4.650 " 5/8's light color.
3.656 " 5/8's dark color.

$17.958, total value of filling used in carpet (subject to $12\frac{1}{2}$ per cent. waste in winding and weaving).
$100:87.5::x:17.958=1{,}795.8\div 87.5=\$20.523$, cost of all the filling in fabric and waste.

Memo.—The same answer as to the cost of filling, may be obtained by calculating the $12\frac{1}{2}$ per cent. loss of material during winding and weaving to the amount of filling wanted in the fabric, as follows:
56,160 yards total amount of filling wanted. Thus:
$100:87.5::x:56{,}160=5{,}616{,}000\div 87.5=64{,}182.856\div 4=16{,}045.714$.
$16{,}045.714\times 2=32{,}091.428\div 960=33.428\times 33=\$11.031$
$16{,}045.714\div 800=20.057\times 26.5=5.315$
$16{,}045.714\div 768=20.891\times 20=4.178$

$20.523, being the same answer as before.

Cost of warp,	$ 9.066	
Cost of selvage,	0.048	
Cost of filling,	20.523	
Weaving and weave-room expenses,	7.200	(60 yards @ 12¢.)
General mill expenses,	3.600	(60 yards @ 6¢.)
	$40.437	

$40.437\div 60=0.67$.

Answer.—A. $40.44, total cost of fabric.

Answer.—B. 67¢, cost of fabric per yard, finished.

STRUCTURE OF TEXTILE FABRICS.

To produce a perfect fabric the following points must be taken into consideration: The purpose of wear that the fabric will be subject to, the nature of the raw material to be used in its construction, the size or counts of the yarns and their amount of twist, the texture (number of ends of warp and filling per inch) to be used, the weave and "take up" of the cloth during weaving, the process of finishing and the shrinkage of the cloth during this operation.

THE PURPOSE OF WEAR THAT THE FABRIC WILL BE SUBJECT TO.

This point must be taken into consideration when calculating for the construction of a fabric for the following reasons: The more wear a fabric is subject to, the closer in construction the same must be; also the stronger the fibres of the raw material as well as the amount of twist of the yarn. For this reason upholstery fabrics, such as lounge covers, must be made with a closer texture and of a stronger yarn than curtains. Woolen fabrics, for men's wear, are in an average more subject to wear than dress goods made out of the same material; hence the former require a stronger structure. Again, let us consider woolen cloth for men's wear by itself, such as trouserings or chinchilla overcoatings. No doubt the student will readily understand that such of the cloth as is made for trouserings must be made of a stronger construction, to resist the greater amount of wear, compared to such cloth as made for the use of overcoatings which actually are subject to little wear, and for which only care must be taken to produce a cloth permitting air to enter and remain in its pores, assisting in this manner in producing a cloth with the greatest chances for retaining the heat to the human body.

THE NATURE OF RAW MATERIALS.

The selection of the proper quality of the material to use in the construction of a fabric is a point which can only be mastered by practical experience. No doubt a thorough study of the nature of raw materials, as well as the different processes they undergo before the thread as used by the weaver, (either for warp or filling) is produced, will greatly assist the novice to master this subject. For this reason the different raw materials, as used in the construction of textile fabrics and the different processes necessary for converting the same into yarn, have been previously explained.

As known to the student every woven fabric is constructed by raising or lowering one system of threads (technically known as warp) over threads from another system (technically known as filling). This will readily illustrate that the warp threads of any woven cloth are subjected to more or less chafing against each other during the process of weaving.

There will be more chafing the higher the warp texture, and the rougher the surface of the yarn. In some instances the manufacturer tries to reduce this roughness by means of sizing or starching the yarn during the process preceding weaving and known as "dressing;" but sizing will correspondingly stiffen the warp yarns, and reduce their chances for bending easily around the filling, and the warp will take up the filling harder than if the yarn was not sized. If, by means of sizing, the chafing is not dispensed with, we must reduce the warp texture to the proper point where perfect weaving is possible. No doubt the using of proper warp texture is so greatly neglected, that many a poor weaver's family is suffering by its cause.

To illustrate the roughness of the different yarns as used in the manufacture of textile fabrics the five illustrations, Figs. 1 to 5 are given: Fig. 1 represents a woolen thread; Fig. 2 represents worsted yarn; Fig. 3 represents mohair; Fig. 4 represents cotton yarn; Fig. 5 represents silk yarn.

An examination of these five illustrations shows the silk yarn to be the smoothest, followed in rotation, getting gradually rougher by cotton, mohair and worsted, until reaching the woolen thread which represents the roughest surface. These illustrations will also show that (in an average) a woolen fabric requires a lower texture than a worsted cloth, or a cotton cloth, and a silk fabric a higher texture

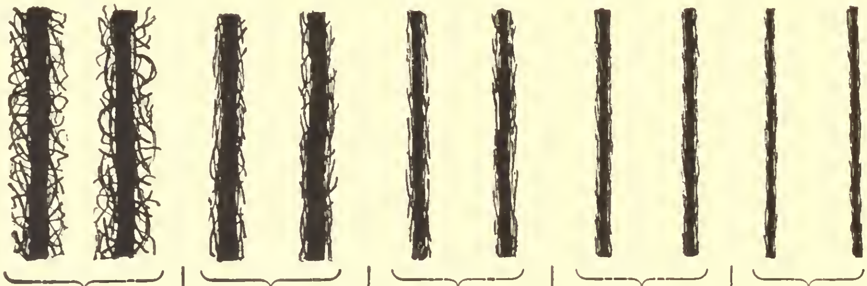

Fig. 1 | Fig. 2 | Fig. 3 | Fig. 4 | Fig. 5

compared to fabrics made out of other materials. In addition to the roughness of the surface of a thread, we must also take into consideration the pliability of the fibres, for the softer the pile of the yarn the less the chafing will influence the strength of the yarn, whereas a coarse and stiff fibre will produce the reverse result.

COUNTS OF YARN REQUIRED TO PRODUCE A PERFECT STRUCTURE OF CLOTH.

In speaking of the size or counts of a thread we mean the weight of solidity, or the bulkiness of a thread, or in other words the diameter of the same. These diameters in threads do not vary in the direct ratio to the respective counts, but do vary as to the square roots of their counts. Thus, if we find the diameter of a thread it will be easy for us to ascertain how many of those threads can rest side by side in one inch.

Rule for finding the number of ends which in Cotton, Woolen, Worsted, Linen and Silk Yarns can lie side by side in one inch.

Find number of yards per pound for the yarn in question and extract the square root of this number. From this square root deduct four per cent. for raw-silk yarns, seven per cent. for cotton, spun silk and linen yarns, ten per cent. for worsted yarns, and sixteen per cent. for woolen yarns. The answer in each case indicates the number of threads that will lie side by side in one inch (without being interlaced at right angles by another system).

Example.—Find number of threads of 1's cotton yarn which will lie side by side in one inch.

840 yards per lb. Thus: $\sqrt{840}=28.9$

$$\begin{array}{rl} 28.9 & \\ -\ 2.0 & \text{(7 per cent.)} \\ \hline 26.9 & \end{array}$$

Answer.—26$\frac{9}{10}$ threads (practically 27) of single 1's cotton yarn will rest side by side in one inch.

Example.—Find number of threads of 2's cotton yarn which will lie side by side in one inch.

$840\times2=1680$ yards per lb. Thus: $\sqrt{1,680}=40.9$

$$\begin{array}{rl} 40.9 & \\ -\ 2.8 & \text{(7 per cent.)} \\ \hline 38.1 & \end{array}$$

Answer.—38$\frac{1}{10}$ threads (practically 38) of single 2's cotton yarn will rest side by side in one inch.

Example.—Find number of ends of 2/50's cotton yarn which will lie side by side in one inch.

2/50's cotton $=$ 1/25's $= 840 \times 25 = 21{,}000$ yards per lb. Thus: $\sqrt{21{,}000} = 144.9$

$$\begin{array}{rl} 144.9 & \\ -\ 10.1 & \text{(7 per cent.)} \\ \hline 134.8 & \end{array}$$

Answer.—$134\frac{4}{5}$ threads (practically 135) of 2/50's cotton yarn will rest side by side in one inch.

Example.—Find nnmber of threads of 6-run woolen yarn which will lie side by side in one inch.

6-run $=$ 9,600 yards per lb. Thus: $\sqrt{9{,}600} = 97.97$

$$\begin{array}{rl} 97.97 & \\ -\ 15.67 & \text{(16 per cent.)} \\ \hline 82.30 & \end{array}$$

Answer.—$82\frac{3}{10}$ threads (practically 82) of 6-run woolen yarn will rest side by side in one inch.

Example.—Find number of threads of 22-cut woolen yarn which will lie side by side in one inch.

22-cut $=$ 6,600 yards per lb. Thus: $\sqrt{6{,}600} = 81.24$

$$\begin{array}{rl} 81.24 & \\ -\ 12.99 & \text{(16 per cent.)} \\ \hline 68.25 & \end{array}$$

Answer.—$68\frac{1}{4}$ threads (practically 68) of 22-cut woolen yarn will lie side by side in one inch.

Example.—Find number of ends of 2/32's worsted that will lie side by side in one inch.

2/32's $=$ single 16's $= 560 \times 16 = 8{,}960$ yards per lb. Thus: $\sqrt{8{,}960} = 94.6$

$$\begin{array}{rl} 94.6 & \\ -\ 9.4 & \text{(10 per cent.)} \\ \hline 85.2 & \end{array}$$

Answer.—$85\frac{2}{10}$ threads (practically 85) will lie side by side in one inch.

Example.—Find number of threads of 40/3-ply spun silk which will lie side by side in one inch.

40/3-ply $=$ 33,600 yards per lb. Thus: $\sqrt{33{,}600} = 183.3$

$$\begin{array}{rl} 183.3 & \\ -\ 12.8 & \text{(7 per cent.)} \\ \hline 170.5 & \end{array}$$

Answer.—$170\frac{1}{2}$ threads (practically 170) of 40/3-ply spun silk will rest side by side in one inch.

Example.—Find number of threads of 4-dram raw silk which lie side by side in one inch.

4-dram raw silk $=$ 64,000 yards per lb. Thus: $\sqrt{64{,}000} = 252.9$

$$\begin{array}{rl} 252.9 & \\ -\ 10.1 & \text{(4 per cent.)} \\ \hline 242.8 & \end{array}$$

Answer.—$242\frac{4}{5}$ threads (practically 243) of 4-dram silk will rest side by side in one inch.

To illustrate clearly to the student that the diameter of a thread (*i. e.*, respectively the number of threads which will lie side by side in one inch) does not vary in the direct ratio to its counts, but in the ratio of the square root of its counts, we give three examples, using for the first example a single yarn; for the next the same number in 2-ply; and for the third the same number in 3-ply.

Examples.—Find number of threads that will lie side by side for the following yarns: Single 30's cotton, 2/30's cotton, and 3/30's cotton yarn.

30's cotton $=$ 25,200 yards per lb.

Thus: $\sqrt{25{,}200} = 158.7$

$$\begin{array}{rl} 158.7 & \\ -\ 11.1 & \text{(7 per cent.)} \\ \hline \end{array}$$

147.6 threads (practically 148) of 30's cotton yarn will lie side by side in one inch.

2/30's cotton=12,600 yards per lb.

Thus: $\sqrt{12,600}=112.2$ 112.2
— 7.9 (7 per cent.)

104.3 threads (practically 104) of 2/30's cotton yarn will lie side by side in one inch.

3/30's cotton=8,400 yards per lb.

Thus: $\sqrt{8,400}=91.6$ 1.6
— 6.4 (7 per cent.)

85.2 threads (practically 85) of 3/30's cotton yarn will lie side by side in one inch.

Answer.—Single 30's cotton=148 threads per inch.
2/30's " =104 " " "
3/30's " = 85 " " "

Table Showing the Number of Ends of Cotton Yarn from Single 5's to 2/160's that Will Lie Side by Side in One Inch.

Counts. Single.	Counts. Double.	Yards per Pound.	Square Root.	7 Per Cent.	Diameter, or Ends per inch.	Counts. Single.	Counts. Double.	Yards per Pound.	Square Root.	Per Cent.	Diameter, or Ends per inch.
5	2/10	4,200	64.8	4.5	60.3	22	2/44	18,480	135.9	9.5	126.4
6	2/12	5,040	70.9	5.0	65.9	24	2/48	20,160	141.8	9.9	131.9
7	2/14	5,880	76.6	5.4	71.2	26	2/52	21,840	147.7	10.3	137.4
8	2/16	6,720	81.9	5.7	76.2	28	2/56	23,520	153 3	10.7	142.6
10	2/20	8,400	91.6	6.4	85.2	30	2/60	25,200	158.7	11.1	147.6
11	2/22	9,240	96.1	6.7	89.4	32	2/64	26,880	163.8	11.5	152.3
12	2/24	10,080	100.3	7 0	93.3	34	2/68	28,560	168.9	11.8	157.1
13	2/26	10,920	104.4	7.3	97.1	36	2/72	30,240	173.8	12.2	161.6
14	2/28	11,760	108.4	7 6	100.8	38	2/76	31,920	178.6	12.5	166.1
15	2/30	12,600	112.2	7.9	104.3	40	2/80	33,600	183.3	12.8	170.5
16	2/32	13,440	115.9	8.1	107.8	45	2/90	37,800	194.4	13.6	180.8
17	2/34	14,280	119.4	8.3	111.1	50	2/100	42,000	204.9	14.3	190.6
18	2/36	15,120	122.9	8.6	114.3	60	2/120	50,400	224.4	15.7	208.7
19	2/38	15,960	126.3	8.8	117.5	70	2/140	58,800	242.4	17.0	225.4
20	2/40	16,800	129.6	9.0	120.6	80	2/160	67,200	259.2	18.1	241.1

For Spun Silks use also above table, but only refer to single count column for reference for any number of ply of spun silk.

Table Showing the Number of Ends of Woolen Yarn "Run Basis," from 1-run to 10-run, that Will Lie Side by Side in One Inch.

Run.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.	Run.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.
1	1,600	40.0	6.4	33.6	4¾	7,600	87.2	14.0	73.3
1¼	2,000	44.7	7.2	37.5	5	8,000	89.4	14 3	75.1
1½	2,400	49.7	8.0	41.7	5¼	8,400	91.6	14.7	76.9
1¾	2,800	52.8	8.4	44.4	5½	8,800	93.8	15.0	78.8
2	3,200	56.5	9.0	47.5	5¾	9,200	95.8	15.3	80.5
2¼	3,600	60.0	9.6	50.4	6	9,600	97.9	15.6	82.3
2½	4,000	63.2	10.1	53.1	6¼	10,000	100.0	16.0	84.0
2¾	4,400	66.3	10.6	55.7	6½	10,400	101.9	16.3	85.6
3	4,800	69.2	11.0	58.2	6¾	10,800	103.9	16.6	87 3
3¼	5,200	72.1	11.5	60.6	7	11,200	105 8	16.9	88 9
3½	5,600	74.8	11.9	62.9	7½	12,000	109.5	17.5	92.0
3¾	6,000	77.4	12.3	65.1	8	12,800	113.1	18.1	95.0
4	6,400	80.0	12.8	67.2	8½	13,600	116.6	18.6	98.0
4¼	6,800	82.4	13.1	69.3	9.0	14,400	120.0	19.2	100.8
4½	7,200	84.8	13.5	71.3	10	16,000	126.4	20.2	106.2

Table Showing the Number of Ends of Woolen Yarn "Cut Basis," from 6-cut to 50-cut that Will Lie Side by Side in One Inch.

Cut.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.	Cut.	Yards per Pound.	Square Root.	16 Per Cent.	Diameter, or Ends Per Inch.
6	1,800	42.4	6.8	35.6	22	6,600	81.2	13.0	68.2
8	2,400	49.7	8.0	41.7	23	6,900	83.0	13.3	69.7
9	2,700	51.9	8.3	43.6	24	7,200	84.8	13.5	71.3
10	3,000	54.7	8.8	45.9	25	7,500	86.6	13.8	72.8
11	3,300	57.4	9.2	48.2	26	7,800	88.3	14.1	74.2
12	3,600	60.0	9.6	50.4	27	8,100	90.0	14.4	75.6
13	3,900	62.4	10.0	52.4	28	8,400	91.6	14.7	77.0
14	4,200	64.8	10.4	54.4	29	8,700	93.2	14.9	78.3
15	4,500	67.0	10.7	56.3	30	9,000	94.8	15.2	79.6
16	4,800	69.2	11.0	58.2	32	9,600	97.9	15.7	82.2
17	5,100	71.4	11.4	60.0	34	10,200	100.9	16.1	84.8
18	5,400	73.5	11.8	61.7	36	10,800	103.4	16.5	86.9
19	5,700	75.4	12.0	63.4	40	12,000	109.5	17.5	92.0
20	6,000	77.4	12.3	65.1	45	13,500	116.1	18.6	97.5
21	6,300	79.3	12.7	66.6	50	15,000	122.4	19.6	102.8

Table Showing the Number of Ends of "Worsted Yarn," from Single 5's to 2/160 that Will Lie Side by Side in One Inch.

Counts.		Yards per Pound.	Square Root.	10 Per Cent.	Diameter, or Ends per Inch.	Counts.		Yards per Pound.	Square Root.	10 Per Cent.	Diameter, or Ends per inch
Single.	Double.					Single.	Double.				
5	2/10	2,800	52.9	5.3	47.6	22	2/44	12,320	110.9	11.1	99.8
6	2/12	3,360	57.9	5.8	52.1	24	2/48	13,440	115.9	11.6	104 3
7	2/14	3,920	62.6	6.3	56.3	26	2/52	14,560	120.6	12.1	108.5
8	2/16	4,480	66.8	6.7	60 1	28	2/56	15,680	125.2	12.5	112.7
10	2/20	5,600	74 8	7.5	67.3	30	2/60	16,800	129.6	13.0	116.6
11	2/22	6,160	78.4	7 8	70.6	32	2/64	17,920	133.8	13.4	120.4
12	2/24	6,720	81.9	8.2	73.7	34	2/68	19,040	137.9	13.8	124.1
13	2/26	7,280	85.3	8.5	76.8	36	2/72	20,160	141.8	14.2	127.6
14	2/28	7,840	88.5	8.8	79.7	38	2/76	21,280	145 8	14.6	131.2
15	2/30	8,400	91.6	9.2	82.4	40	2/80	22,400	149.6	15.0	134.6
16	2/32	8,960	94.6	9.4	85 2	45	2/90	25,200	158.6	15.9	142.7
17	2/34	9,520	97.5	9.7	87 8	50	2/100	28,000	167.3	16.7	150.6
18	2/36	10,080	100.3	10.0	90.3	60	2/120	33,600	183.3	18.3	165.0
19	2/38	10,640	103.1	10.3	92.8	70	2/140	39,200	197.9	19.8	178.1
20	2/40	11,200	105.8	10.6	95.2	80	2/160	44,800	211.6	21.2	190.4

Table Showing the Number of Ends of Raw Silk Yarn, from 20 Drams to 1 Dram, that will Lie Side by Side in One Inch.

Dram.	Yards per Pound	Square Root.	4 per Cent.	Diameter, or Ends per inch.	Dram.	Yards per Pound	Square Root.	11 Per Cent	Diameter, or Ends per inch.
20	12,800	113.1	4.5	108.6	5	51,200	226 2	9.0	217.2
18	14,222	119.2	4 8	114.4	4¾	53,368	231.0	9.2	221.8
16	16,000	126 4	5.0	121.4	4½	56,889	238.5	9 5	229.0
14	18,286	135.2	5.4	129.8	4¼	60,235	245.4	9.8	235.6
12	21,333	146.0	5.8	140.2	4	64,000	252.9	10.1	242.8
10	25,600	160.0	6.4	153.6	3¾	68,267	261.2	10.4	250.8
9½	26,947	164.1	6 6	157.5	3½	73,143	270.4	10.8	259 6
9	28,444	168.6	6.7	161 9	3¼	78,769	280.6	11.2	269 4
8½	30,118	173.5	6.9	166.6	3	85,333	292.1	11.7	280.4
8	32,000	178.8	7.1	171.7	2¾	93,091	305.1	12.2	292 9
7½	34,133	184.7	7.4	177.3	2½	102,400	320.0	12.8	307.2
7	36,571	191.2	7.6	183.6	2¼	113,777	337.2	13.5	323.7
6½	39,385	198.4	7.9	190.5	2	128,000	357.7	14.3	343.4
6	42,667	206.5	8.2	198.3	1½	170,666	413.1	16.5	396.6
5½	46,545	215.7	8.6	207.1	1	256,600	505.9	20.2	485.7

Table Showing the Number of Ends of Linen Yarns from 10's to 100's that Will Lie Side by Side in One Inch.

Counts.	Yards per Pound.	Square Root.	7 Per Cent.	Diameter, or Ends Per Inch.	Counts.	Yards per Pound.	Square Root.	7 Per Cent.	Diameter, or Ends Per Inch.
10	3,000	54.7	3.8	50.9	40	12,000	109.5	7 6	101.9
12	3,600	60.0	4.0	56.0	42	12,600	112.2	7.8	104 4
14	4,200	64.8	4 5	60.3	44	13,200	114.8	8.0	106.8
16	4,800	69.2	4.8	64.4	46	13,800	117.4	8.2	109.2
18	5,400	73.5	5.1	68.4	48	14,400	120.0	8 4	111.6
20	6,000	77.4	5.4	72.0	50	15,000	122.4	8.6	113.8
22	6,600	81.2	5.7	75.5	55	16,500	128.4	9.0	119 4
24	7,200	84.8	5.9	78 9	60	18,000	134.1	9.3	124 8
26	7,800	88.3	6.1	82.2	65	19,500	139 6	9.8	129.8
28	8,400	91.6	6 4	85.2	70	21,000	144.9	10.0	134.9
30	9,000	94.8	6.6	88.2	75	22,500	150.0	10 5	139 5
32	9,600	97.9	6 8	91.1	80	24,000	154.9	10.8	144 1
34	10,200	100.9	7.0	93.9	85	25,500	159.6	11.2	148.4
36	10,800	103.9	7 2	96.7	90	27,000	164.3	11.5	152 8
38	11,400	106.7	7 4	99.3	100	30,000	173.2	12.1	161.1

TO FIND THE DIAMETER OF A THREAD BY MEANS OF A GIVEN DIAMETER OF ANOTHER COUNT OF YARN.

If the number of threads of a given count which will lie side by side (*i. e.*, its diameter) in one inch (without riding) are known, the required number of threads (which will also lie side by side) for another count of the same system can be found by—

Rule.—The given counts of which we know the diameter are to the counts for which we have to find the diameter in the same ratio as the given diameter squared is to the required diameter squared.

Example.—As shown in a previous example, 148 threads of single 30's cotton yarn will lie side by side in one inch (or the diameter of a thread of 30's cotton yarn is the $\frac{1}{148}$ part of one inch); required to find by rule given the number of threads that will lie side by side in one inch for 2/30's cotton yarn.

2/30's=single 15's.

{ Given counts. } : { Required counts. } :: { Diameter squared of the given counts. } : { Diameter squared of the required counts. }

$$30 : 15 :: 148^2 : x$$

$$\frac{\sqrt{15 \times 148 \times 148}}{30}$$ Thus: $15 \times 148 \times 148 = 328,560 \div 30 = 10,952$, and $\sqrt{10,952} = 104$

Answer.—104 threads of 2/30's, or 1/15's cotton yarn, will lie side by side in one inch.

Proof.—2/30 cotton yarn=12,600 yards per lb.

Thus: $\sqrt{12,600} = 112.2$ 112.2

— 7.9 (7 per cent.)

104.3 (practically 104) being the same answer as previously received.

Example.—85 threads of 2/32's worsted yarn will lie side by side in one inch, required to find the number of threads which will lie side by side in one inch with 2/40's worsted yarn.

2/30's=1/16's 2/40's=1/20's.

$16 : 20 :: 85^2 : x$, or $\frac{\sqrt{20 \times 85 \times 85}}{16}$ and $85 \times 85 \times 20 = 144,500 \div 16 = 9,031$ $\sqrt{9,031} = 95$

Answer.—95 threads of 2/40's worsted yarn will lie side by side in one inch.

Proof.—2/40's worsted=560×20=11,200 yards per lb.

Thus: $\sqrt{11,200}=105$ 105
— 10 (10 per cent.)

95, being the same answer as received by the previous process.

Example.—84 threads of $6\frac{1}{4}$-run woolen yarn lie side by side in one inch, required to find the number of threads which will lie side by side in 4-run woolen yarn.

$6\frac{1}{4}:4::84^2:x$ or $\sqrt{\frac{4\times84\times84}{6.25}}$ and $84\times84=7,056\times4=28,224\div6\frac{1}{4}=4,515$ and $\sqrt{4,515}=67.2$

Answer.—67 threads (actually 67.2) of 4-run woolen yarn will lie side by side in one inch.

Proof.—4-run=4×1,600=6,400 yards per lb.

Thus: $\sqrt{6,400}=80.0$ 80.0
—12.8

67.2, being the same answer as previously received.

Example.—$68\frac{1}{4}$ threads per inch is the average number of threads which will lie side by side for 22-cut woolen yarn, required to find the number of threads for 30-cut woolen yarn.

$$22:30::68\tfrac{1}{4}^2:x \text{ or } \frac{68\frac{1}{4}\times68\frac{1}{4}\times30}{22} \text{ and}$$

$$68.25\times68.25\times30=139,741.875\div22=6,351.\ \sqrt{6,351}=79$$

Answer.—79 threads of 30-cut woolen yarn will lie side by side in one inch.

Proof.—30-cut woolen yarn=9,000 yards per lb.

Thus: $\sqrt{9,000}=94$ 94
—15 (16 per cent.)

79, being the same answer as received by previously given process.

TO FIND THE COUNTS OF YARN REQUIRED FOR A GIVEN WARP TEXTURE BY MEANS OF A KNOWN WARP TEXTURE WITH THE RESPECTIVE COUNTS OF THE YARN GIVEN.

A. Dealing with One Material.

If we know the number of ends of a given count of yarn that will lie side by side in one inch (technically their diameter), and we want to ascertain the counts of yarn required for a certain number of threads to lie side by side (diameter), we must use—

Rule.—As the given diameter squared is to the required diameter squared, so is the given count to the required count.

Example.—85 threads of 2/32's worsted lie side by side in one inch, required to find the counts of yarn for 95 threads per inch.

$$85^2 : 95^2 :: 16 : x$$
$$(85\times85):(95\times95)::16:x$$
$$7,225 : 9,025 :: 16 : x$$
$$9,025\times16=144,400\div7,225=20$$

Answer.—1/20's or 2/40's worsted yarn is the number of yarn wanted.

Proof.—2/40's or 1/20's worsted yarn=11,200 yards per lb.

Thus: $\sqrt{11,200}=105$ 105
— 10 (10 per cent.)

95 threads of 1/20's worsted will lie side by side; being the same answer as texture given in example.

Example.—84 threads of $6\frac{1}{4}$-run woolen yarn, lie side by side in one inch, required to find the counts of yarn for 68 threads per inch.

$$84^2 : 68^2 :: 6\tfrac{1}{4} : x$$
$$(84\times84):(68\times68) :: 6\tfrac{1}{4} : x$$
$$7,056 : 4,624 :: 6.25 : x$$
$$4,624\times6.25=28,900\div7,056=4.09$$

Answer.—4-run (actual counts 4.1-run) yarn must be used.

Proof.—4.1-run=6,560 yards per lb.

Thus: $\sqrt{6,560}=81$ 81
—13

68 threads of 4-run (4.1) woolen yarn will lie side by side in one inch, being the same number as given in example.

B. Dealing with Two or More Materials.

Frequently it happens that we have to reproduce a cloth from a given sample or texture, etc., in another material. For example, a worsted cloth may be required to be duplicated in woolen yarn. If such is the case, transfer counts of yarn given, or as ascertained from sample given, into its equivalent counts of the required grading, and take care of the difference of 6 per cent. between the diameters of threads that will lie side by side in one inch of a woolen yarn compared to worsted yarn. In a similar manner proceed if dealing with other yarns.

P. S.—The allowance for worsted yarn in all the samples given is based (as also previously mentioned) on 10 per cent.; for cotton yarn and spun silk on 7 per cent.; for raw silk on 4 per cent, and for woolen yarn on 16 per cent. These allowances refer to a perfect and smooth A[1] yarn; but if such should not be the case, we are required to make, according to the yarn, a proportional allowance of one, two, or three per cent. more.

INFLUENCE OF THE (AMOUNT AND DIRECTION) TWIST OF YARNS UPON THE TEXTURE OF A CLOTH.

The influence of the twist of a yarn upon the number of warp threads to use per inch depends upon the amount of the twist, as well as the direction of the latter. It will easily be understood by the student that the more twist we put in a yarn the less space the same will occupy; *i. e.*, the smaller its diameter, and the less chances for a chafing; hence, we can use a "heavier" texture (more ends per inch) with a hard-twisted yarn compared to a soft-twisted yarn. But it must be remembered that the amount of twist to use is again regulated by the character of the fabric the yarn is used for, since the yarn will lose on softness the harder we twist it, and that a hard-twisted yarn will reduce the fulling properties of the cloth during the process of finishing. Again, hard-twisted yarn will not bend as easily around the filling during weaving as a soft yarn, which no doubt might injure the general appearance of the face of the cloth. This will also illustrate another point; *i. e.*, the width of the cloth to use in loom. As previously mentioned, the harder we twist a yarn the less chances there are for fulling; hence, fabrics made with hard-twisted yarn must be set narrower in loom than fabrics made with a softer twisted yarn. Thus we will set a fancy worsted suiting (in an average) only from 60 to 62 inches wide in loom, and a fancy cassimere or fancy woolen suiting (in an average) from 70 to 72 inches wide, and yet the finished width for both will be 54 inches.

To explain the influence of the direction of the twist of the yarn upon the texture of a cloth, Figs. 6 and 7 are given. Fig. 6 illustrates the interlacing with yarns spun with its twist in the same direction; *i. e.*, from left to right (technically known as right hand twist.) Fig. 7 illustrates the interlacing of a similar cloth with right hand twist yarn for the warp, but left hand twist yarn (the direction of the twist being from the right to the left) for the filling. It will readily be seen by the student that if, using in both examples the same counts of yarn for warp and filling, the combination, as shown in Fig. 7, will allow a readier compressing of the filling for forming the cloth, compared to the

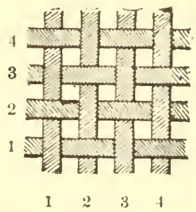

FIG 6

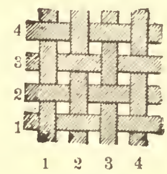

FIG 7

using of warp and filling, as illustrated in diagram, Fig. 6; *i. e.*, if using the same direction of twist for warp and filling yarn, larger perforations will appear in the cloth than if using opposite twist for both systems, since in the first instance, the twist of both yarns will cross each other, thus resisting compression; whereas, if using opposite twist in the spinning of the two systems of yarns, the twist of both yarns will be in the same direction when interlacing, and thus a falling of the twist in each other be produced.

Rule.—We may use a heavier texture for warp and filling, if using opposite twist in the spinning of the yarns, than if using the same direction of twist for both systems.

The finer in quality and the longer in its staple the material is, as used in the manufacture of a yarn, the less twist is necessary to impart to the thread for giving it the requisite strength; whereas, the shorter and coarser the material the more twist we must use. The actual amount of twist to use depends entirely upon the material and counts of yarn, as well as weave and process of finishing required. For a fabric requiring a smooth, clear face, we must use more twist in the yarn than for such as used in the manufacture of cloth requiring a nap; *i. e.*, much giging, or "velvet finish."

TO FIND THE AMOUNT OF TWIST REQUIRED FOR A YARN, IF THE COUNTS AND TWIST OF A YARN OF THE SAME SYSTEM, (AND FOR THE SAME KIND OF FABRIC) BUT OF DIFFERENT COUNTS ARE KNOWN.

The points as to amount of twist to use for the different counts of yarn manufactured are based between each other upon the fact that the diameters of threads vary in the same ratio as the square roots of their counts.

Example.—Find twist required for a 40's yarn, if a 32's yarn of the same material requires 17 turns per inch (twist wanted in proportion the same).

$$32 : 40 :: 17^2 : x, \text{ or } \sqrt{\frac{40 \times 17 \times 17}{32}}, \text{ or } \sqrt{361.25} = 19.$$

Answer.—19 turns per inch are required.

$$\text{or, } \sqrt{32} : \sqrt{40} :: 17 : x \qquad \sqrt{32} = 5.65 \qquad \sqrt{40} = 6.32.$$

$$\text{Hence: } 5.65 : 6.32 :: 17 : x \qquad 6.32 \times 17 = 107.44 \div 5.65 = 19.$$

Answer.—19 turns per inch are required (being the same answer as previously received.

INFLUENCE OF THE WEAVE UPON THE TEXTURE OF A FABRIC.

In the previous chapter we have given a clear understanding as to the number of threads of any counts of yarn, and of any kind of material, that will properly lie side by side in one inch. We now take this same item into consideration, but in addition, with reference to the different weaves as used in the manufacture of textile fabrics; *i. e.*, give rules for constructing with a given weave and given count of yarn, a cloth which has a proper texture.

Rule.—The less floats of warp and filling (*i. e.*, the greater the number of interlacings between both systems) in a given number of threads of each system, the lower the texture of the cloth (the less number ends and picks per inch) must be; and consequently the less interlacings of warp and filling in a given number of threads of each system, the higher a texture in the cloth we can use. For example, examining the 8-harness twill shown in Fig. 8, we find each thread to interlace twice in one repeat of the weave, thus actually $8+2=10$ threads will lie side by side for each repeat (since by means of the interlacing of the filling with the warp the former takes, at the places of interlacing, the place, with regard to its diameter, of one thread of the latter system). Suppose we used 64 warp threads to one inch, we find the threads that will lie side by side in one inch as follows:

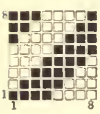

Fig. 8.

Warp threads in one repeat of the weave.	:	Warp and filling threads in one repeat of the weave.	::	Warp threads per inch.	:	Threads lying side by side in one inch.
8	:	10	::	64	:	x

and $\frac{10 \times 64}{8} = 80$

Answer.—8-harness $\frac{4}{4}$ twill, 64 warp threads per inch, equals 80 diameters of threads per inch.

Example.—Find the number of diameter of threads per inch, using the same number of warp threads as before (64) per inch, and for weave the plain weave shown in Fig. 9.

The repeat of the latter weave is 2 threads, = 2 interlacings in repeat; thus, with reference to the 64 warp threads per inch used, we find 64 interlacings of the filling.

Fig. 9.

Hence: 2:4 :: 64: x and $\frac{4 \times 64}{2} = 128$

Answer.—Plain weave, 64 warp threads per inch, equals 128 diameters of threads per inch.

No doubt these two examples will readily demonstrate to the designer the value of examining the number of interlacings of any new weave. If, in given examples, the first mentioned "make up" $\frac{4}{4}$ 8-harness twill, 64 warp threads per inch, using the required material and counts of yarn is producing a perfect fabric, and we want to change to plain weaving, using the same yarn, we must deduct $\frac{3}{8}$ of the number of warp threads (and correspondingly also of the filling) to produce the same number of diameters of threads side by side as in previously given example; *i. e.*, we must only use 40 warp threads per inch, since those 40 diameters of the warp yarn, plus 40 diameters of the filling, by means of the principle of the interlacing of the plain weave, produce the (equal number as before) 80 diameters of threads side by side in one inch. Hence we may put down for—

Rule.—The weave of a cloth has an equal influence on the number of ends per inch to use as the counts of the yarn we are using. We mentioned previously that by the diameters of threads per one inch we mean the number of ends that could lie side by side per inch, providing there were no interlacings of both systems of threads; but since such interlacing or intertwining of the warp and filling must take place in order to produce cloth, we must deduct the number, or average number, of interlacings per inch from the originally obtained diameters of threads that will lie side by side per inch, to obtain the correct number of warp ends and picks we can use per inch. Thus far given explanations will readily assist the student to ascertain the number of threads of any material that will lie side by side (without riding) in one inch of the fabric (single cloth). Hence:

TO FIND THE TEXTURE OF A CLOTH USE—

Rule.—Multiply the number of threads of a given count of yarn that will lie side by side in one inch by the threads in one repeat of the pattern, and divide the product by the number of threads in repeat, plus the corresponding number of interlacings of both systems of threads found in one repeat of the weave.

By the number of interlacings of a weave we understand the number of changes from riser to sinkers, and *vice versa*, for each individual thread in each system.

Examples.—Fig. 10 represents one pick of the common twill known as $\frac{2}{2}\frac{1}{2}\frac{1}{2}$ and shown in one full repeat in Fig. 11. Diagram Fig. 12 illustrates the corresponding section to pick 1 shown in Fig. 10. The full black spots represent one repeat, whereas the commencement of the second repeat is shown in dotted lines. A careful examination of both diagrams, Figs. 10 and 12, will readily illustrate to the student the number of interlacings in one repeat (6), as indicated by corresponding numbers below diagram Fig. 12. Thus, in order to find the number of warp threads of a given count per inch for a cloth made with this weave, we must multiply the number of diameters of threads that will lie side by side with 10 (being one complete repeat of the weave) and divide the product thus derived by 16 (10 plus 6, or repeat plus number of interlacings). The result will be the required number of warp threads per inch. If given illustrations would refer to a 32-cut woolen yarn, we find answer as follows:

FIG. 10.

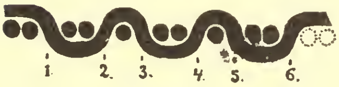

FIG. 12.

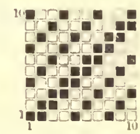

FIG. 11.

32-cut yarn=9,600 yards per lb.

32-cut yarn=82.2 threads will lie side by side.

Thus: $82.2 \times 10 = 822 \div 16 = 51\frac{1}{2}$, or

51 warp threads per inch (or actually $51\frac{1}{2}$ per inch, or 103 threads for every two inches) of 32-cut woolen yarn will be the proper number to use. In diagram Fig. 13 we illustrate a pick of another 10-harness twill weave. Fig. 14 represents the corresponding section, and Fig. 15 one complete repeat of the weave.

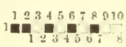

FIG. 13

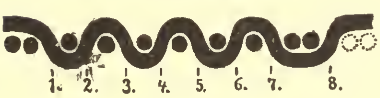

FIG. 14.

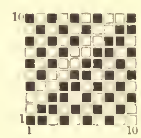

FIG. 15.

All three diagrams show 8 points of interlacings for each thread in one repeat; hence, if applying counts of yarn from previously given example for this case we find:

32-cut yarn=82.2 threads will lie side by side. Thus: $82.2 \times 10 = 822 \div 18 = 45\frac{2}{3}$, or 46 warp threads per inch (actually $45\frac{2}{3}$) of 32-cut woolen yarn are the proper number of threads if using the $\frac{2}{1}\frac{1}{1}\frac{1}{1}\frac{1}{1}\frac{1}{2}$ 10-harness twill.

Answers.—For both given examples are as follows:

Warp yarn used 32-cut woolen yarn.

$\frac{2}{2}\frac{1}{2}\frac{1}{2}$ 10-harness twill=6 interlacings=$51\frac{1}{2}$ warp threads per inch.

$\frac{2}{1}\frac{1}{1}\frac{1}{1}\frac{1}{1}\frac{1}{2}$ 10- " " =8 " =$45\frac{2}{3}$ " " "

A careful examination and recalculation of these two examples will readily illustrate to any student the entire modus operandi.

Example.—Find number of threads for warp for a fancy worsted suiting, to be interlaced with the 6-harness $\frac{3}{3}$ twill (see Fig. 16) and made of 2/32's worsted yarn. (Fig. 17 illustrates number 1 pick separated and Fig. 18 its corresponding section.)

FIG. 16.

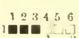

FIG. 17.

2/32=1/16=16×560=8,960 yards per lb.

$\sqrt{8,960}$ less 10 per cent.=85 threads of 2/32's worsted yarn will lie side by side in one inch. And

$$\left\{\begin{matrix}\text{Diameters}\\ \text{per inch.}\end{matrix}\right\} \times \left\{\begin{matrix}\text{Repeat of}\\ \text{weave.}\end{matrix}\right\} \quad \left\{\begin{matrix}\text{Repeat of}\\ \text{weave}\end{matrix}\right\} + \left\{\begin{matrix}\text{Interlacings}\\ \text{in repeat.}\end{matrix}\right\}$$

$$85 \times 6 = 510 \div 8 \quad (6 + 2) = 64.$$

FIG. 18.

Answer.—64 ends per inch is the proper warp texture for fabric given in example.

Example.—Find proper number of threads to use for a woolen dress good, to be interlaced with the 9-harness $\frac{2}{1}\frac{1}{1}\frac{1}{1}\frac{1}{1}$ twill (see Fig. 19), and for which we have to use $6\frac{1}{4}$-run woolen yarn.

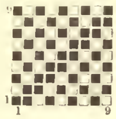

FIG. 19.

FIG. 20.

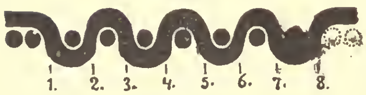

FIG. 21.

(Fig. 20 represents pick 1 separated, and Fig. 21 its corresponding section.)

6-run=10,000 yards per lb.

$\sqrt{10,000}$, less 16 per cent.=84 threads of $6\frac{1}{4}$-run woolen yarn, will lie side by side in one inch.

$$84\times 9=756\div 17(9+8)=44\tfrac{8}{17}$$

Answer.—44 threads per inch (actually $44\frac{8}{17}$) is the proper warp texture for cloth given in example.

Example.=Find the proper number of warp threads to use for a cotton dress good, using the plain weave (see Fig. 22), with single 40's cotton yarn for warp.

FIG. 22.

40's cotton=40×840=33,600 yards per lb.

$\sqrt{33,600}$=183—13 (7 per cent.)=170 threads of 40's cotton yarn will lie side by side in one inch.

$$\frac{170\times 2}{2+2}=170\div 2=85$$

Answer.—85 threads of 40's cotton yarn, and interlaced with the plain, will produce a perfect texture.

It will be proper to mention here another point which must also be more or less taken into consideration. During the process of weaving both systems of threads press more or less against each other, thus each thread is pushed to a certain degree out of position, consequently we may add to each system a slight advance, according to counts, texture and quality of material in question, without influencing the process of weaving or the handling of the fabric; but in all cases such an advance in threads (and picks) will be very small and is readily ascertained after finding, by rules given, number of ends and picks per inch, that could be used if no pressure from one system upon the other was exercised.

If using a soft-twisted yarn for filling, the latter will have less influence for pressing the warp threads (harder-twisted yarn) out of position; *i. e.*, the filling will stretch and thus in proportion reduce the counts of the yarn, consequently a higher texture for such filling may be used. We may thus also mention this fact in the shape of a—

Rule.—The softer the filling yarn is twisted, the more readily the same will interweave and the higher a warp texture we can use. Warp yarns are in most all cases harder twisted than the filling yarn as used in the same fabric, for the simple reason that the warp threads are subject to more strain and wear during the process of weaving compared to the filling. The softer a yarn is twisted, the softer the finished cloth will handle; and, if we refer, regarding this soft twist specially to the filling, the easier the same can be introduced in the warp during the process of weaving. This will explain the general method of using a few more picks per inch compared to the warp threads as used per inch in reed. But as everything has a limit we also must be careful not to use too many of these additional picks, for if "piling-in" even a soft filling too hard in a cloth during weaving, it will ultimately result in an imperfect fabric when finished. Frequently we would thus produce fabrics which require too much fulling, or which with all the fulling possible, could not be brought to its required finished width. The same trouble will also refer to the setting of a fabric too wide in reed, for the sake of producing heavier weight of cloth. Again, if setting a cloth too loose, either in warp or filling, or both systems, it will produce a finished fabric handling too soft, flimsy or spongy; consequently great care must be exercised in the "setting of cloth" in order to produce good results, and rules given for foundation weaves (with reference to an average fair and most often used counts of yarn, producing what might be termed staple textures and correspondingly staple fabrics) will form a solid basis to build upon for other fabrics as may be required to be made. Special fabrics, such as Union Cassimeres, Chinchillas, Whitneys, Montagnacs and other pile fabrics, are left out of question.

Example.—Fancy Cassimere: Weave ^{2}——$_{2}$ twill (see Fig. 23). Yarn to use, 22-cut.

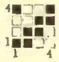

FIG. 23.

Question.—Find the proper number of threads for one inch to use.

22-cut=22×300=6,600 yards per lb. And

$\sqrt{6,600}$, less 16 per cent.=$68\frac{1}{4}$ threads of 22-cut woolen yarn will lie side by side in one inch.

$$\frac{68\frac{1}{4}\times4}{4+2}=68\tfrac{1}{4}\times4=273\div6=45\tfrac{1}{2}.$$

Answer.—45 threads per inch (actually 91 threads for two inches) are the proper number of threads to use for the cloth given in example. In this weave (^{2}——$_{2}$ twill) warp and filling interlace after every two threads. In previously given example (the plain weave) warp and filling interlaced alternately; hence, if comparing the plain weave and the 4-harness even-sided twill we find:
Plain weave=4 points of interlacings in 4 threads.
^{2}——$_{2}$ twill=2 points of interlacings in 4 threads.

Previously we also mentioned that the space between the warp threads where the intersection takes place must be (or must be nearly as large) equal to the diameter of the filling yarn (also *vice versa*); thus, if comparing both weaves, using the same yarn for warp and filling in each example, we find in the plain weave:

4 points of interlacings of the filling in
4 warp threads, giving us
—
8 diameters of threads in four threads, or two repeats of the plain weave, and in the 4-harness even-sided twill we only find:
2 points of interlacings of the filling in
4 warp threads, giving us
—
6 diameters of threads in four threads, or one repeat of the ^{2}——$_{2}$ twill weave.

Again in the plain weave we find:
4 intersections of each warp thread in
4 picks, giving
—
8 diameters of threads in four threads, or two repeats of the plain weave, and in the 4-harness even-sided twill we find:
2 intersections of each warp thread in
4 picks, giving
—
6 diameters of threads in four threads, or one repeat of the ^{2}——$_{2}$ twill weave.

Hence, the proportion of the texture between a cloth woven with the plain weave and the 4-harness twill will be as 6:8 or 3:4.

Consequently if 60 ends per inch (in each system), woven with the plain weave, produce a well-balanced cloth, and we want to use the same yarn for producing a similar perfect cloth, woven with the ^{2}——$_{2}$ twill, we find the number of threads required readily by the following proportion:

Ratio of the plain weave compared to the 4-harness twill.		::	Texture used with the plain weave.	:	Texture to be used with the 4-harness twill.
3 :	4	::	60	:	x

$\frac{4\times60}{3}$=4×20=80 threads must be used in proportion with the 4-harness even-sided twill to produce a well-balanced cloth structure.

This example will also explain that the le s points of intersections we find in a given number of threads interlaced with one weave, compared to the same number of threads interlaced with another weave, the higher a texture we must employ, producing at the same time a proportional heavier cloth.

TO CHANGE THE TEXTURE FOR GIVEN COUNTS OF YARN FROM ONE WEAVE TO ANOTHER.

Rule.—The repeat of the given weave multiplied by repeat plus points of intersections of the required weave is to repeat of the required weave, multiplied by the repeat, plus points of intersections of the given weave, the same as the ends per inch of the given cloth are to the ends per inch for the required cloth. Thus we will find answer to previously given example by this rule, as follows·

$$(2\times(4+2)):(4\times(2+2)) :: 60: x \text{ and}$$
$$(2\times12) \; : \; (4\times4) \; :: 60: x \text{ and}$$
$$12 \; : \; 16 \; :: 60: x\text{; hence,}$$

$\frac{16\times60}{12}=16\times5=80$ threads must be used, being the same answer as previously received.

Example.—Fancy Worsted Suiting. Weave $\frac{3}{\quad}\frac{\quad}{3}$ 6-harness twill (see Fig. 24). Warp and filling 2/32's worsted. Texture, 64×64. Question: Find texture required for producing a well balanced cloth using the same counts of yarn with the $\frac{3}{\quad}\frac{\quad}{2}\frac{1}{\quad}\frac{\quad}{3}$ 9-harness twill (see Fig. 25) for weave.

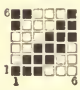

FIG. 24.

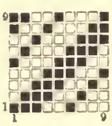

FIG. 25.

$$(6\times(9+4)):(9\times(6+2)) :: 64: x$$
$$(6\times13) \; : \; (9\times8) \; :: 64: x\cdot$$
$$78 \; : \; 72 \; :: 64: x$$

$$\frac{72\times64}{78}=\frac{12\times64}{13} \qquad 12\times64=768\div13=59\tfrac{1}{13}$$

Answer.—The number of ends to be used with 2/32's worsted, and the $\frac{3}{\quad}\frac{\quad}{2}\frac{2}{\quad}\frac{\quad}{1}$ twill are 59 ends per inch.

TO CHANGE THE WEIGHT OF A FABRIC WITHOUT INFLUENCING ITS GENERAL APPEARANCE.

Previously we mentioned "the less points of interlacings we find in a given number of threads the higher a texture (more threads per inch) we can use in the construction of a cloth." This will also apply to the use of a heavier count of yarn, or both items (higher texture and heavier yarn) at the same time. In the construction of a new fabric we are frequently required to produce a fabric of a given weight per yard; hence, after we find by rules given that the yarn we intend to use will, with its corresponding texture and weave, produce a cloth either too heavy or too light, we must carefully consider how to remedy this. In some instances the difference could be balanced by either laying the cloth wider or narrower in the reed, or shorter or longer at the dressing, and regulate the weight during the finishing process; *i. e.*, full the flannel to the required weight. By some fabrics (of an inferior grade) we might also regulate the weight to some extent during the fulling process (by adding more or less flocks, the latter of which will felt during the fulling to the back, and partly between both systems of threads the fabric is composed of. But in most fabrics a too heavy or too little fulling or additional flocking (according to the class of cloth) would reduce or destroy the beauty of its face, and thus decrease its value; hence we must regulate texture, weave, and counts of yarn to be used, to a certain extent, to suit the weight per yard of the finished fabric required. Most always the heavier a weight is wanted, the heavier a yarn we must use, and in turn suit texture to the latter. Again, the lighter in weight a cloth is required, the finer counts of yarn we must use, also with a proportional regulation of the texture. If the weight per yard in a given fabric is required to be changed (either increased or reduced) without altering the weave, or the width in reed, or length dressed (*i. e.*, want the new cloth to be fulled about the same amount as the given), we must alter the counts of the yarn in the process of spinning, producing a heavier yarn if a heavier cloth is wanted, and a lighter yarn if a lighter cloth is wanted.

Rule.—The ratio between the required weight per yard squared and the given weight per yard squared, is in the same ratio as the counts of yarn in the given cloth are to the counts of yarn required for use in the new cloth.

Example.—Suppose we are making the following cloth :


FIG. 26. Weave $\frac{2}{2}$ twill.

Fancy Cassimere : 3,240 ends in warp. 10 per cent. take-up during weaving. Weave given in Fig. 26. 72 inches width in loom. Warp and filling, 22-cut woolen yarn. Weight of flannel from loom, 17.2 oz.

Question.—Find the proper counts of yarn to use if given weight, 17.2 oz., is to be changed to 19.1 oz.; *i. e.*, a flannel of 19.1 oz. is required (from loom).

Memo.—In this, as well as the following example, no reference to any selvage is taken.

Required weight squared.	:	Given weight squared.	::	Counts of yarn in given cloth.	:	Required counts for the new cloth.
19.1^2	:	17.2^2	::	22	:	x
(19.1×19.1)	:	(17.2×17.2)	::	22	:	x
364.81	:	295.84	::	22	:	x

$$\frac{295.84 \times 22}{364.81} = 17.9$$

Answer.—18-cut yarn is required.

Example.—Prove previously given example for each texture; *a*, as to weight, and *b*, as to the proper construction according to rules given.

I. Given Cloth.

a. Ascertain given weight (17.2 *oz.*).

Fancy Cassimere: 3,240 ends in warp. 10 per cent. take-up during weaving. Weave, $\frac{2}{2}$ 4-harness twill. 72 inches width in loom. 48 picks per inch. Warp and filling, 22-cut woolen yarn. 3,240 ends in warp. 10 per cent. take-up. How many yards dressed ?

100 : 90=x : 3,240 and 324,000÷90=3,600 yards of warp required dressed per yard of cloth woven.

22-cut=300×22=6,600 yards per lb.÷16=412½ yards per oz.; hence—

3,600÷412.5=8.8 oz. weight of warp.
72×48=3,456 yards of filling required per yard.
3,456÷412.5=8.4 oz., weight of filling.

Warp, 8.8 oz.
Filling, 8.4 oz.

Answer.— 17.2 oz., total weight per yard from loom.

b. Proof of Proper Structure of Given Cloth.

22-cut =6,600 yards per lb. and $\sqrt{6,600}$, less 16 per cent. =68¼ threads of 22-cut yarn will lie side by side in one inch.

$\frac{2}{2}$ twill =2 points of interlacings in one repeat of the weave.

Thus: $\frac{68\frac{1}{4} \times 4}{4+2} = 68\frac{1}{4} \times 4 = 273 \div 6 = 45\frac{1}{2}$, or practically—

Answer.—45 warp threads per inch should be used, and this is the number of ends used, since.—

(Threads in full warp.)	÷	(Width of cloth.)	=	(Ends per inch.)
3,240	÷	72	=	45

2. Required Cloth.

b. Find Proper Texture for Warp.

18-cut woolen yarn to be used $=18\times300=5{,}400$ yards per lb., $\sqrt{5{,}400}=73.49$, less 16 per cent. $(11.74)=61\frac{3}{4}$ threads of 18-cut woolen yarn will lie side by side in one inch.

4-harness twill contains 2 points of intersections in one repeat.

$$\frac{61\frac{3}{4}\times4}{4+2}=247\div6=41\tfrac{1}{6}, \text{ or practically—}$$

Answer.—41 threads per inch must be used.

a. Ascertain Weight for Required Cloth.

Using the same width in reed as in the given cloth (72 inches).

$41\times72=2{,}952$ ends must be used (10 per cent. take-up).

$100:90::x:2{,}952$ and $295{,}200\div90=3{,}280$ yards warp required for one yard cloth from loom.

18-cut yarn $=5{,}400$ yards per lb. $\div16=337\frac{1}{2}$ yards, per oz.

$3{,}280\div337.5=9.7$ oz. warp yarn required.

$44\times72=3{,}168$ yards filling required, and $3{,}168\div337.5=9.4$ oz., filling required.

Warp, 9.7 oz.
Filling, 9.4 oz.

Answer.—19.1 oz., total weight per yard from loom, being exactly the weight wanted.

Memo.—In calculating weight for both fabrics we used three additional picks compared to the warp threads, which is done to illustrate practically the softer twist of the filling compared to the warp yarn (and which item has already previously been referred to). In the calculations we only used approximately the decimal fraction of tenth, since example refers only to illustrate the procedure. In examples we exclude any reference to selvage.

Example.—The following cloth we are making: Worsted Suiting. 3,840 ends in warp, 8 per cent. take-up, 60 inches width in loom, warp and filling 2/32's worsted, weight of flannel from loom, 14.6 oz. For weave, see Fig. 27. (No reference taken of selvage.)


Fig. 27. Weave $\frac{3}{3}$ 6-harness twill.

Question.—Find the proper yarn to use if given weight, 14.6 oz., must be changed to 16.3 oz. (from loom); *i. e.*, a flannel of 16.3 oz. is wanted (exclusive of selvage).

$$16.3^2 : 14.6^2 :: 16 : x$$
$$(16.3\times16.3):(14.6\times14.6)::16:x$$
$$265.69 : 213.16 :: 16 : x$$
$$213.16\times16=3{,}410.56\div265.69=12.9$$

Answer.—1/13's or 2/26's worsted yarn is required.

Example.—Prove previously given example for each structure; *a*, as to weight; *b*, as to the proper construction according to rules given.

1. Given Cloth.

a. Ascertain Given Weight (14.6 oz.).

Warp.—3,840 ends, 2/32's worsted, 8 per cent. take-up, weave $\frac{3}{3}$ 6-harness twill. 60 inches width of cloth on reed.

Filling.—66 picks per inch, 2/32's worsted.

3,840 ends in warp, 8 per cent. take-up, how many yards dressed?

100 : 92 :: x : 3,840 384,000÷92=4,173$\frac{84}{92}$ yards (practically 4,174) of warp required dressed per yard of cloth woven.

2/32's worsted=16×560=8,960 yards per lb.÷16=560 yards per oz.

Hence: 4,174÷560=7.5 oz., weight of warp.

66×60=3,960 yards of filling required per yard. 3,960÷560=7.1 oz., weight of filling.

Warp, 7.5 oz.
Filling, 7.1 "

Answer.—14.6 oz., total weight per yard from loom.

b. Proof for Proper Structure of Given Cloth.

2/32's worsted =8,960 yards per lb., and $\sqrt{8,960}$—10 per cent. =85 threads of 2/32's worsted will lie side by side in one inch.

$\frac{3}{}\frac{}{3}$ twill=2 points of interlacings in one repeat of the weave. Thus: $\frac{85\times6}{6+2}=510\div8=64.$

Answer.—64 threads per inch must be used, and since 3,840÷60=64, this is the number of ends used per inch in given cloth, the structure of the given cloth is perfectly balanced.

2. Required Cloth.

b. Find the Proper Texture for Warp.

2/26's worsted =13×560=7,280 yards per lb.

$\sqrt{7,280}$=85.3 less 10 per cent. (8.5)=76.8 diameters of threads of 2/26's worsted will lie side by side in one inch.

$\frac{3}{}\frac{}{3}$ twill=2 points of interlacings in one repeat. Thus: $\frac{76.8\times6}{6+2}$=460.8÷8=57.6, or practically—

Answer.—58 threads per inch must be used.

a. Ascertain Weight for Required Cloth.

Using the same width in reed as in the given cloth (60 inches).

58×60=3,480 ends must be used (8 per cent. take-up).

100 : 92 :: x : 3,480. 348,000÷92=3,782 yards required for one yard cloth from loom.

2/26's worsted=7,280 yards per lb.÷16=455 yards per oz.; thus: 3,782÷455=8.3 oz. warp yarn required.

Using 61 picks we find—

61×60=3,660 yards filling (2/32's worsted) wanted. 3,660÷455=8 oz., weight of filling yarn wanted.

Warp, 8.3 oz.
Filling, 8.0 oz.

Answer.—16.3 oz., total weight of cloth (exclusive of selvage) from loom, being exactly the weight wanted.

To Find the Number of Ends per Inch in the Required Cloth.

The two examples previously given will also assist us to illustrate the next rule; *i. e.*, "Finding number of ends per inch in the required cloth."

Rule.—The weight per yard of the required cloth is to the weight per yard of the given cloth in the corresponding ratio of the warp ends per inch in the given cloth to the warp ends per inch in the required cloth.

Example.—Prove rule by previously given example of a fancy cassimere.

Given Cloth.—Weight per yard=17.2 oz. Ends per inch=45$\frac{1}{3}$ (for 45).

Required Cloth.—Weight wanted, 19.1 oz. Find ends per inch required, or x.

$19.1 : 17.2 :: 45.5 : x. \qquad \frac{17.2 \times 45.5}{19.1} = 17.2 \times 45.5 = 782. \qquad 60 \div 19.1 = 40\frac{181}{191}$, or practically—

Answer.—41 warp threads must be used, and this is exactly the answer previously derived in the same example (see page 72).

Example.—Prove rule by previously given example of a worsted suiting.
Given structure.—Weight per yard, 14.6 oz. Ends per inch, 64.
Required structure.—Weight wanted, 16.3 oz. Find ends per inch required, or x.

$16.3 : 14.6 :: 64 : x \qquad \frac{14.6 \times 64}{16.3} = 14.6 \times 64 = 9{,}344 \div 16.3 = 57\frac{53}{163}$ (See answer on page 73, being 57.6.)

Answer.—58 warp threads (practically) per inch must be used; this being the same number as derived previously in the same example. (See page 73.)

WEAVES WHICH WILL WORK WITH THE SAME TEXTURE AS THE $\frac{2}{\quad 2}$ 4-HARNESS TWILL.

The following few weaves (given for examples) have the same number of interlacings as the 4-harness even-sided twill:

Memo.—Weaves indicated by *u.* are uneven-sided twills. Weaves indicated by *e.* are even-sided twills.

$\frac{3}{\quad 1}$ u. 4-harness twills.

8-harness twills:

$\frac{5 \quad 1}{\quad 1 \quad 1}$ u.
$\frac{4 \quad 1}{\quad 1 \quad 2}$ u.
$\frac{3 \quad 1}{\quad 1 \quad 3}$ e.
$\frac{4 \quad 2}{\quad 1 \quad 1}$ u.
$\frac{3 \quad 1}{\quad 2 \quad 2}$ u.
$\frac{3 \quad 2}{\quad 2 \quad 1}$ u.

12-harness twills:

$\frac{7 \quad 1 \quad 1}{\quad 1 \quad 1 \quad 1}$ u.
$\frac{6 \quad 1 \quad 1}{\quad 1 \quad 1 \quad 2}$ u.
$\frac{5 \quad 1 \quad 1}{\quad 1 \quad 1 \quad 3}$ u.
$\frac{4 \quad 1 \quad 1}{\quad 1 \quad 1 \quad 4}$ e.
$\frac{6 \quad 2 \quad 1}{\quad 1 \quad 1 \quad 1}$ u.
$\frac{5 \quad 3 \quad 1}{\quad 1 \quad 1 \quad 1}$ u.
$\frac{4 \quad 4 \quad 1}{\quad 1 \quad 1 \quad 1}$ u.
$\frac{5 \quad 2 \quad 1}{\quad 2 \quad 1 \quad 1}$ u.
$\frac{4 \quad 2 \quad 1}{\quad 2 \quad 1 \quad 2}$ u.
$\frac{4 \quad 3 \quad 1}{\quad 2 \quad 1 \quad 1}$ u.
$\frac{3 \quad 3 \quad 1}{\quad 3 \quad 1 \quad 1}$ u.
$\frac{4 \quad 2 \quad 1}{\quad 3 \quad 1 \quad 1}$ u.
$\frac{3 \quad 2 \quad 1}{\quad 2 \quad 2 \quad 2}$ u.
$\frac{3 \quad 3 \quad 2}{\quad 1 \quad 1 \quad 2}$ u.
$\frac{2 \quad 2 \quad 5}{\quad 1 \quad 1 \quad 1}$ u.
$\frac{2 \quad 2 \quad 4}{\quad 1 \quad 1 \quad 2}$ u.
$\frac{2 \quad 2 \quad 3}{\quad 1 \quad 1 \quad 3}$ u.
$\frac{2 \quad 2 \quad 3}{\quad 2 \quad 2 \quad 1}$ u.
$\frac{2 \quad 2 \quad 1}{\quad 3 \quad 3 \quad 1}$ u.
$\frac{2 \quad 2 \quad 1}{\quad 5 \quad 1 \quad 1}$ u.

Proceeding in this manner, the student can readily find the different (common) twills which will work on the same basis of texture as the 4-harness even-sided twill.

Amongst "derivative weaves," working on the same basis of texture as the $\frac{2}{\quad 2}$ twill, we find—

$\frac{3}{\quad 1}$ 4-harness broken twill and the following weaves given in my "*Technology of Textile Design*," Figs. 398, 409, 411, 412, 416, 417, 420, 421, 445, 448, 449, 470 (476 ◘=◘), 479, 482, 492, 497, 499, etc., etc.

WEAVES WHICH WILL WORK WITH THE SAME TEXTURE AS THE $\frac{3}{\quad 3}$ TWILL, $\frac{4}{\quad 4}$ TWILL, Etc.

In the same manner as we previously found some of the different weaves to work on an equal basis with the $\frac{2}{\quad 2}$ twill, it will be advisable for the student to use different other "standard foundation weaves" on the same basis. For example: the $\frac{3}{\quad 3}$ twill, the $\frac{4}{\quad 4}$ twill, etc.

SELECTION OF THE PROPER TEXTURE FOR FABRICS INTERLACED WITH SATIN WEAVES.

As mentioned in my "*Technology of Textile Design*," fabrics made with satin weaves or "Satins" are characterized by a smooth face. The principles for the construction of satins are to arrange as much as possible distributed stitching, for the more scattered we arrange the interlacing of warp and filling the less these points of intersection will be visible in the fabric. Thus, the method of construction of this third class of foundation weaves is quite different from the other two classes (the plain and twill weaves); hence, the setting of the warp for fabrics interlaced with satins requires a careful studying and possibly a slight modification towards one, two, or three threads more per inch; but such an increase is regulated by the material. If we have an extra good and very smooth yarn we may do this, but if dealing with a rough or poorly carded yarn we must use ends per inch as found by rule.

As previously mentioned, in cloth interlaced with satin weaves we want a smooth face; hence, the warp yarn must cover the filling. Thus, as always one or the other of the threads in the repeat of the weave is withdrawn on every pick the remaining warp threads must cover this spot where the one warp thread works on the back of the cloth and the filling tries to take its place on its face; and, as according to rules given, the interlacing of the filling is dealt with similar to warp threads, the remaining warp threads in this instance would have to be spread so as to cover the filling, which, no doubt, is more readily accomplished by using a heavier texture of the warp; *i. e.*, putting two or three more threads per inch than actually will lie properly side by side, less the customary deduction on account of the nap of the yarn. If we resort to this plan, it will be readily understood by the student that this will produce a closer working of the threads than they properly should; hence, chafing or riding of threads (to a slight extent) will be the result. If, as previously mentioned, we are dealing with an extra good and smooth yarn and the warp yarn is properly sized and dressed, we may make use of those few ends, but otherwise in most every common fabric, threads as found by rule to lie side by side in one inch will do, since the nature of the weave (hence, cloth with it produced) will by itself hide the filling to a great extent by means of the warp being nearly all on the face, the filling forming the back and the one end warp as coming in the lower shed, having little power to pull the filling up, which for the main part forms the back of the structure.

Example.—Find threads of warp to use for weaving a "Kersey," with the 7-leaf satin (see Fig. 28), using 6-run woolen yarn. Width of cloth in reed (setting) to be 84 inches (exclusive selvage). 6-run woolen yarn =84 ends per inch, side by side. $84 \times 7 = 588 \div 9 = 65\frac{1}{3}$, or say 66 threads per inch. $66 \times 84 = 5{,}544$.

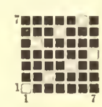

Fig. 28.

Answer.—5,544 threads texture for warp to use, but which may be increased to 5,700 ends if dealing with a good smooth yarn. 5,700 ends in warp equals nearly 68 threads per inch. ($68 \times 84 = 5{,}712$) which is about 2 threads per inch in excess of proper number ascertained by the regular procedure.

SELECTION OF THE PROPER TEXTURE FOR FABRICS INTERLACED WITH RIB WEAVES.

As mentioned in my "*Technology of Textile Design*," fabrics interlaced with rib weaves require, for either one system of threads (warp or filling), a high texture.

Rib weaves classified as "warp effects," must have a high texture for warp, and

Rib weaves classified as "filling effects," must have a high texture for filling.

Warp Effects.

In the manufacture of fabrics interlaced with warp effect rib weaves, the warp forms the face and back of the fabric, whereas the filling rests imbedded, not visible on either side. This being the case there is no necessity for calculating (in the setting of the warp) for a space for the filling to interlace; thus, the texture is ascertained by the number of threads that will lie side by side per inch.

Example.—Find the warp texture for a fabric interlaced with the rib weave (warp effect) as shown in Fig. 29, using for warp 6-run woolen yarn.

6-run=9,600 yards per lb., and $\sqrt{9,600}$, less 16 per cent.=82.3.

Answer.—82 warp threads per inch must be used.

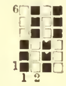

Fig. 29.

Example.—Find texture for a fabric interlaced with the rib weave, shown in Fig. 30, using for warp 2/40's worsted yarn.

2/40's worsted=11,200 yards per lb., and $\sqrt{11,200}$, less 10 per cent.=95.

Answer.—95 warp threads per inch must be used.

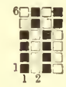

Fig. 30.

Filling Effects.

As previously mentioned, for filling effects we require a high number of picks, since the latter system has to form face and back of the cloth, and the warp the interior. In most instances the filling yarn as used for these fabrics is softer spun than the warp, for allowing a freer introducing of the former; thus, we may use even a few more picks per inch compared to the texture previously found for rib weaves warp effects.

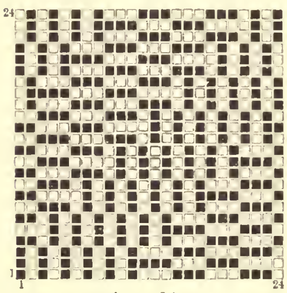

Fig. 31.

Figured Rib Weaves.

If dealing with figured rib weaves, their texture for warp and filling is found by ascertaining the number of threads for both systems that will lie side by side in one inch.

Example.—Find texture for a cloth to be interlaced with the figured rib weave, shown in Fig. 31, using for warp and filling 2/36's worsted yarn.

2/36's=10,080 yards per lb., and $\sqrt{10,080}$, less 10 per cent.=90.

Answer.—90 warp threads and 90 picks per inch must be used.

SELECTION OF THE PROPER TEXTURE FOR FABRICS INTERLACED WITH CORKSCREW-WEAVES.

On page 68 of my "*Technology of Textile Design*" I mentioned, amongst other points, referring to the method of construction of corkscrew weaves, "this sub-division of the regular 45° twills is derived from the latter weaves by means of double draws, which will reduce the texture of the warp for the face in the fabric; hence, a greater number of those threads per inch (compared to fabrics interlaced with the foundation weaves) are required."

A careful examination of the different corkscrew weaves (see Figs. 345 to 383 in "*Technology of Textile Design*,") with regard to their setting in loom, will readily illustrate their near relation to the warp effect rib weaves as explained in the previous chapter. In both systems of weaves (speaking in a general way) the warp forms the face and back of the cloth and the filling rests imbedded between the former; the only difference between both being that the break-line, as formed by the exchanging of the warp threads from face to back, is in the rib-cloth in a horizontal direction compared to the running of the warp threads, whereas in the corkscrews this break-line is produced in a oblique direction. But as this is of no consequence regarding structure (in fact only in preference of the forming of a better shed with the corkscrew weave, since not all the threads break—exchange positions—at the same time) we may readily use the setting of the number of warp threads per inch in corkscrews the same as done in rib weaves warp effects; *i. e.*, use the number of warp threads that will lie side by side in one inch for the texture of warp and again increase this texture one, two, three, or four ends, if dealing with an extra good yarn.

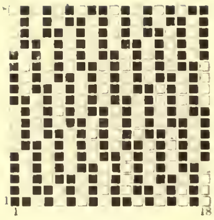

Fig. 32.

Example.—Find warp texture required for a fabric made with weave Fig. 32. Yarn to be used is 2/40's worsted. 2/40's worsted =11,200 yards per lb., and $\sqrt{11,200}$, less 10 per cent. =95.

Answer.—95 warp threads per inch must be used, and in case of extra good yarn we may increase this warp texture to 98 ends per inch.

Example.—Find number of threads in warp if fabric in previously given example is made 61 inches wide in loom. $95 \times 61 = 5,795$.

Answer.—5,800 threads in warp must be used to produce a perfect cloth; *i. e.*, perfect fabric, and 5,950 to 5,980 ends can be used with an extra good yarn ($98 \times 61 = 5,978$).

Example.—Find *a*, texture of warp per inch; *b*, threads in warp to use if 61 inches wide in loom, for fabric interlaced with fancy corkscrew weave Fig. 33, using 2/60's worsted for warp.

2/60's worsted=16,800 yards per lb., and $\sqrt{16,800}$, less 10 per cent.=117.

Answer.—*a*, 117 warp threads per inch must be used; and $117 \times 61 = 7,137$; thus *b*, 7,140 threads must be used in full warp.

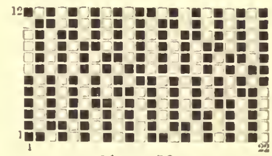

Fig 33

Memo.—In such fine yarn, and correspondingly high texture, it will be hardly necessary to use those two to four additional threads as made use of if dealing with a lower count of yarn.

SELECTION OF THE PROPER TEXTURE FOR FABRICS BACKED WITH FILLING; i. e., CONSTRUCTED WITH TWO SYSTEMS OF FILLING AND ONE SYSTEM OF WARP.

A thorough explanation of the construction of weaves for these fabrics has been given in my "*Technology of Textile Design*," on pages 105, 106, 107 and 108. Thus, we will now consider these points with reference to the setting of cloth in the loom, since, no doubt, the additional back filling will have more or less influence upon the setting of the face cloth. Weave Fig. 34 (corresponding to weave Fig. 558 and section Fig. 557 in Technology) illustrates the common 4-harness twill $\frac{2}{2}$ for the face structure, backed with the 8-leaf satin.

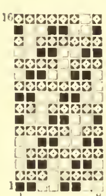

Fig. 34.

In this weave, as well as any similar combinations, the texture of the face warp can remain nearly the same as if dealing with single cloth, a deduction of 5 per cent. from the number ends per inch found for the single cloth is all that is required to be deducted for the same cloth made with a backing.

If we exchange the 8-leaf satin, as used for backing, with a twill, $\frac{3}{1}$ as shown in weave Fig. 35, we must deduct 10 per cent. from the warp texture, as found for the face of the cloth, to produce the proper chances for weaving. If we back the 4-harness $\frac{2}{2}$ twill with the arrangement of 2 picks face to alternate with 1 pick back, and use for the interlacing of the latter filling (and warp) the $\frac{3}{1}$ 4-harness twill, (using every alternate warp thread only for interlacing) see weave Fig. 36, no deduction of the warp texture compared to single cloth is required; or, in other words, if using a weave 2 picks face to alternate with 1 pick back, and in which the backing is floating from $\frac{7}{1}$ to $\frac{15}{1}$ (or a similar average), no reference must be taken of the back filling in calculating the setting of the warp; or, in other words, the fabric is simply to be treated as pure single cloth. The most frequently used proportions of backing to face are: 1 pick face to alternate with 1 pick back, and 2 picks face to alternate with 1 pick back. Seldom we find other arrangements, as 3 picks face to alternate with 1 pick back; or irregular combinations, as 2 picks face 1 pick back, 1 pick face 1 pick back,—5 picks

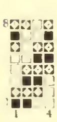

Fig. 35.

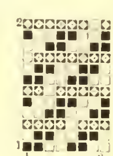

Fig. 36.

in repeat, etc. If using the arrangement "1 pick face to alternate with 1 pick back," be careful to use a backing yarn not heavier in its counts than the face filling; for a backing heavier in its counts than the face filling will influence the closeness of the latter, and in turn produce an "open face" appearance in the fabric.

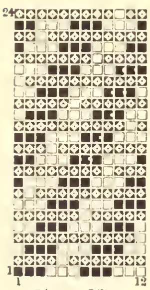

FIG. 37.

Weave Fig. 37 shows the ^{3}——$_{3}$ 6-harness twill for the face structure, backed with the 12-leaf satin. Arrangement: 1 pick face to alternate with 1 pick back. It will readily be seen by the student that this combination of weaves (also any similar ones) will be very easy on the warp threads; thus, the setting of the latter per inch in the reed is (about) designated by the counts of yarn used with reference to the single cloth weave (^{3}——$_{3}$ twill), being the same as if dealing with no backing, for the most allowance we would have to make for fabrics interlaced with this weave would be a deduction of 2 to $2\frac{1}{2}$ per cent. from the single cloth warp texture.

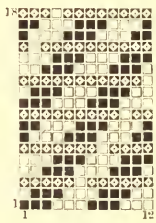

FIG. 38.

Weave Fig. 38 shows the same face weave (^{3}——$_{3}$ twill), arranged with 2 picks face to alternate with 1 pick back. There will be no difference experienced in the number of threads (warp) to use per inch between this weave and the single face weave (*i. e.*, the face weave if treated as single cloth); hence, the setting of the warp for both will be the same.

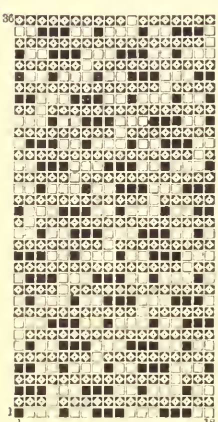

FIG. 39.

Example.—Find the proper number of warp threads to use for a worsted suiting, to be interlaced with the granite weave shown in Fig. 39. For warp yarn use 2/50's worsted.

2/50's worsted=14,000 yards per lb. and $\sqrt{14,000}$ less 10 per cent.=106.5

Points of interlacing in face weave=8

Warp threads in repeat of weave=18

106.5×18=19,170÷26 (8+18)=73.7

— 3.7 (5 per cent.)

70.0

Answer.—70 warp threads per inch of 2/50's worsted are required.

Example.—Ascertain for the previously given fabric the proper filling texture, if using the same counts of yarn as used for warp, and find weight of cloth per yard from loom (exclusive of selvage).

Required { Face filling, 74 picks per inch (2/50's worsted).
Backing, 74 " " " (single 24's worsted).

Width in loom, 60 inches (exclusive of selvage). Take-up of warp during weaving, 12 per cent.

70×60=4,200 warp threads in cloth. 100:88 :: x :4,200.

4,200×100=420,000÷88=4,772 yards of warp are wanted dressed for 1 yard cloth from loom.

14,000 yards per lb. in 2/50's worsted=875 yards per oz.

4,772÷875=5.45 oz., weight of warp,
74 × 60=4,440 yards face filling wanted,
4,440÷875=5.07 oz., face filling,
24's worsted=13,440 yards per lb.=840 yards per oz.
4,440÷840=5.28 oz., weight of backing.

Warp,	5.45 oz.
Face filling,	5.07 "
Backing,	5.28 "
	15.80 oz.

Answer.—Weight of cloth per yard from loom (exclusive of selvage) is 15.8 oz.

Example.—Find the proper texture for warp and filling, and also ascertain the weight of flannel per yard from loom (exclusive of selvage). Cloaking: Warp 5-run, filling 5-run, backing $2\frac{1}{2}$-run. Weave, see Fig. 40 (8 warp threads and 12 picks in repeat). Take-up of warp, 10 per cent. Width of cloth in reed, 72 inches (exclusive of selvage).

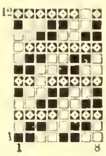

Fig. 40.

5-run=8,000 yards per lb.

$\sqrt{8,000}$, less 16 per cent.=75 ends of 5-run yarn will lie side by side in one inch.

75× 4= 300÷6=50 ends of warp must be used per inch, and

50×72=3,600 ends must be used in full warp.

100 : 90 :: x : 3,600

3,600×100=360,000÷90=4,000 yards of warp yarn are required per yard cloth woven.

5-run yarn=500 yards per oz. 4,000÷500=8 oz. of warp yarn are wanted.

52 picks (50+2 extra) of face filling, } are wanted per inch
26 picks (corresponding to face picks) of back filling, }

52×72=3,744 yards of face filling are wanted.

3,744÷500=7.5 oz., weight of face filling.

26×72=1,872 yards of backing are required.

1,872÷250 (yards of $2\frac{1}{2}$-run filling per oz.)=7.5 oz., weight of backing.

Warp,	8.00 oz.
Face filling,	7.50 "
Backing,	7.50 "
	23.00 oz.

Answer.—Total weight of cloth per yard from loom (exclusive of selvage), 23 oz.

SELECTION OF THE PROPER TEXTURE FOR FABRICS BACKED WITH WARP; i. e., CONSTRUCTED WITH TWO SYSTEMS OF WARP AND ONE SYSTEM OF FILLING.

To ascertain the texture of the warp in these fabrics we must first consider the counts of the yarn as used for the face structure, and secondly the weave.

After ascertaining this texture (for the single cloth) we must consider the weave for the back warp; *i. e.*, the stitching of the same to the face cloth. If dealing with a weave of short repeat for the back warp (for example a $^{1}{——}_{3}$ twill) we must allow a correspondingly heavy deduction from the threads as ascertained for the face cloth (about 20 per cent. for the $^{1}{——}_{3}$ twill); whereas, if dealing with a far-floating weave for the back (for example the 8-leaf satin) we will have to deduct less (about 10 per cent. for the 8-leaf satin) from the previously ascertained texture of the face cloth. Since the 8-leaf satin is about the most far-floating weave, as used for the backing, thus, 10 per cent. will be about the lowest deduction, and as the $^{1}{——}_{3}$ twill is the most frequently interlacing weave, in use in the manufacture of these fabrics, thus, 20 per cent. deduction from the respectively found texture of the face cloth is the maximum deduction. To illustrate the subject more clearly to the student we will give both weaves as previously referred to with a practical example.

Example.—Find warp texture for the following fabric: Fancy worsted trousering.

Fig. 41.

Weave, see Fig. 41. Face warp, 2/36's worsted. Back warp, single 20's worsted.

2/36's worsted =90 threads (side by side per inch).

Face weave $^{2}{——}_{2}$ twill =4 threads in repeat and 2 points of interlacing.

90×4=360÷6=60 threads, proper warp texture for the single structure.

60
—12 (20 per cent. deduction caused by the back warp ($^{1}{——}_{3}$) stitching in the face structure).
—
48

Face warp per inch, 48 threads 2/36's worsted.
Back warp " 48 " single 20's worsted.

96

Answer.—96 warp threads must be used per inch.

Picks per inch must be 52 (4 extra over the texture of the face warp). Use 2/36's filling and find weight of cloth per yard from loom (exclusive of selvage), allowing 10 per cent. take-up for face warp, and 12 per cent. for back warp, using 62 inches as the width of cloth in loom.

48×62=2,976 ends of face warp, and
2,976 " " back warp.

5,952, total number of ends in the entire warp.

100:90 :: x:2,976 297,600÷90=3,306⅔ yards or face warp are wanted per yard of cloth woven.
2/36's worsted=10,080 yards per lb.÷16=630 yards per oz. 3,306.66÷630=5.25 oz., weight of face warp.
100:88 :: x:2,976 297,600÷88=3,381$\frac{9}{11}$ yards of back warp yarn are wanted per yard of cloth woven.
1/20's worsted=11,200 yards. 11,200 yards per lb.÷16=700 yards per oz.
3,381.81÷700=4.83 oz., weight of the back warp.
52 picks per inch×62=3,224 yards of filling wanted.
3,224÷630=5.12 oz., weight of filling per yard of cloth woven.

Warp,	Face,	5.25 oz.
	Back,	4.83 "
Filling,		5.12 "
		15.20 oz.

Answer.—15.2 oz. is the weight of the cloth per yard (from loom exclusive of selvage).

To illustrate the difference regarding the weave as selected for interlacing the back warp, we will next calculate the previously given example with the same counts of yarn but with the weave as given in Fig. 42.

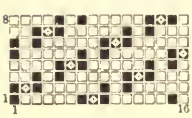
FIG. 42.

This weave contains the same face weave (^{2}——$_{2}$ twill) as previously used, the only difference being the interlacing of the back warp, for which we use the 8-leaf satin in place of the ^{1}——$_{3}$ twill as used in the former example.

Face warp and filling, 2/36's worsted. Back warp, single 20's worsted.

2/36's worsted=90 threads will lie side by side per inch.

Face weave ^{2}——$_{2}$ twill. 90×4=360÷6=60 threads is the proper texture for face structure, and
60
— 6 (10 per cent. deduction by means of the back warp stitching with the 8-leaf satin in the face structure).

54 Warp threads per inch 54 threads 2/36's worsted, for face.
54 " 1/20's " " back.

108 Thus: 108 warp threads per inch must be used.

Picks per inch, 58 (the same 4 extra pick as in previous given example).

Filling, 2/36's worsted. Take-up of face warp 10 per cent. Take-up of back warp 8 per cent. 62½ inches for width of cloth in loom, since the 8-leaf satin will permit a readier milling (during the process of scouring) than the ^{1}——$_{3}$ twill.

Question:—Find weight of cloth per yard and compare it with previously given example.

54×62.5=3,375 threads each of face and back warp are wanted.

100:90 :: x :3,375. 337,500÷90=3,750 yards of face warp are wanted per yard of cloth woven.
2/36's worsted=630 yards per oz. 3,750÷630=5.95 oz., weight of face warp.
100:92 :: x :3,375. 337,500÷92=3,668½ yards of back warp are wanted per yard of cloth woven.
1/20's worsted=700 yards per oz.
3,668.5÷700=5.24 oz., weight of back warp per yard of cloth woven.

58 picks per inch×62.5 inches width of cloth in reed=3,625 yards of filling wanted, and 3,625÷630=5.75 oz., weight of filling per yard of cloth woven.

Face warp,	5.95 oz.
Back warp,	5.24 "
Filling,	5.75 "
	16.94 oz.

Thus: 16.94 oz. (or practically 17 oz.) is the weight of cloth per yard from loom.

A comparison between both cloths results as follows:

	(Using weave Fig. 41.)	(Using weave Fig. 42.)	(Difference.)
Face warp,	5.25 oz.	5.95 oz.	0.70 oz.
Back warp,	4.83 "	5.24 "	0.41 "
Filling,	5.12 "	5.75 "	0.63 "
Weight per yard,	15.20 oz.	16.94 oz.	1.74 oz.

Or, the difference between using the 8-leaf satin or ^{1}——$_{3}$ twill for the weave for the back warp is 1.74 oz.

Given two examples will readily illustrate to the student that he must select the weave for the backing with the same care as the face weave, for, as shown in examples given, we produced a difference of $1\frac{3}{4}$ oz. simply by changing the weave for the back warp, using the same counts of yarn for warp and filling, leaving the face weave undisturbed.

The most often used proportion of the arrangement between face and back warp is the one previously explained; *i. e.*, 1 end face to alternate with 1 end back, but sometimes we also use—

2 ends face warp		1 end face warp.
1 end back warp	or	1 end back warp.
—		2 ends face warp.
3 ends in repeat.		1 end back warp.
		—
		5 ends in repeat, or any similar arrangement.

If using the arrangement "1 end face warp to alternate with 1 end back warp," never use a heavier size of warp yarn for the back warp than for the face warp. (See previously given example and you find face yarn 2/36's worsted, (= single 18's) and for back warp, single 20's worsted yarn used.)

If using "2 ends face warp to alternate with 1 end back warp" a proportional heavier yarn can be used for the back warp. (See the previous example where 2 ends face warp, 2/36's worsted, alternate with one end back warp, $3\frac{1}{2}$-run woolen yarn).

Great care must be exercised in selecting the stock for the face warp and back warp for such fabrics as require any fulling during the finishing process. The material in the back warp, which can be of a cheaper grade, must have about, or as near as possible, the same tendency for fulling as the "stock" which is used in the face warp. The student will also readily see that there will be a smaller deduction (after finding the face texture) necessary if using the arrangement of 2 ends face to alternate with 1 end back than if using the simple alternate exchanging of face and back warp explained at the beginning of the chapter.

For example, take weave Fig. 43, illustrating an 8-harness Granite weave, backed 2 ends face warp, 1 end back warp. The back warp interlaces 1 pick up and 7 picks down = 8 picks in the repeat. Examining rules as given for the arrangement 1 and 1, we find a call for a deduction for the face texture of 10 per cent. (see weave Fig. 42), but which, if using the present arrangement, must be reduced to 5 per cent.; this being one-half less reduction to make for 2 face 1 back compared to 1 face 1 back.

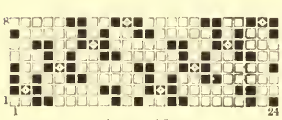

Fig. 43.

Weave Fig. 44 illustrates the ^{2}——$_{2}$ twill, backed 2 ends face warp and 1 end back warp. The back warp interlaces 1 pick up, 3 picks down = 4 picks in the repeat. Examining rules as given for the arrangement of 1 and 1, we find a call for a deduction from the face texture of 20 per cent. (see weave Fig 41), but which, if using arrangement to suit weave Fig. 44, must be reduced one-half; *i. e.*, deduct only 10 per cent.

Fig. 44.

Example.—Find warp threads per inch for the following cloth: Worsted suiting, Face warp, 2/36's worsted yarn. Back warp, $3\frac{1}{2}$-run woolen yarn. Use *a*, weave shown in Fig. 43; *b*, weave given in Fig. 44.

2/36's worsted $=\frac{1}{90}$ inch diameter. Face weave, { 8 threads in repeat, 4 points of interlacing.

$\frac{90\times8}{12}=60$ threads, proper warp texture for face.

60
— 3 (5 per cent.)
57

Answer.—If using weave Fig. 43, use 57 warp threads per inch for face.

Thus: 58 ends 2/36's worsted for face, and
+29 " $3\frac{1}{2}$-run woolen yarn for back, giving us
87 ends of warp to be used per inch.

2/36's worsted $=\frac{1}{90}$ inch diameter. Face weave, { 4 threads in repeat, 2 points of interlacing.

$\frac{90\times4}{6}=60$ threads, proper warp texture for face.

60
— 6 (10 per cent.)
54

Answer.—If using weave Fig. 44, use 54 warp threads per inch for face.

Thus: 54 ends 2/36's worsted for face,
+27 " $3\frac{1}{2}$-run woolen yarn for back, gives us
81 ends of warp as total number of ends to be used per inch.

SELECTION OF PROPER TEXTURE FOR FABRICS CONSTRUCTED ON THE DOUBLE CLOTH SYSTEMS; i. e., CONSTRUCTED WITH TWO SYSTEMS OF WARP AND TWO SYSTEMS OF FILLING.

Under double cloth we comprehend the combining of two single cloths into one fabric. Each one of these single cloths is constructed with its own system of warp and filling, while the combination of both fabrics is effected by interlacing some of the warp threads of the one cloth at certain intervals into the other cloth; hence, in ascertaining the warp texture of these fabrics we have to deal with a back warp and back filling, both exercising their influence upon the texture of the fabric at the same time.

As mentioned and explained in my "*Technology of Textile Design*," double cloth may be constructed with:

1 end face to alternate with 1 end back, in warp and filling.
2 ends face to alternate with 1 end back, in warp and filling.
2 ends face to alternate with 2 ends back, in warp and filling.
3 ends face to alternate with 1 end back, in warp and filling, etc.

The two first mentioned arrangements are those most often used; hence, we will use the same for illustrating the selection of the proper warp texture for the present system of fabrics.

1 End Face to Alternate with 1 End Back in Warp and Filling.

For face warp use 4-run woolen yarn. For back warp use $4\frac{1}{4}$-run woolen yarn.

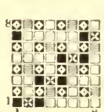

Fig. 45.

Question.—Find texture for warp yarn: *a*, if using weave Fig. 45; *b*, if using weave Fig. 46.

First we have to ascertain the warp texture for the face cloth, dealing with the same as with pure single cloth.

Face weave for both weaves is the $^{2}—_{2}$ 4-harness twill, and the yarn to use is 4-run woolen yarn.

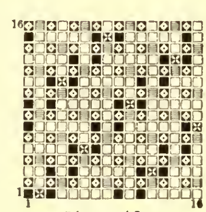

Fig. 46.

4-run=6,400 yards per lb.
$\sqrt{6,400}=80$
—12.8 (16 per cent.)
———
67.2

$\frac{2}{2}$ twill = { repeat of weave, 4 threads, points of interlacing in one repeat, 2.

$\frac{67.2 \times 4}{6}=268.8 \div 6=44.8$ threads (or practically 45) required to be used if dealing with a single cloth.

The next to be taken into consideration is the stitching of both cloths. In both weaves the back warp interlaces into the face cloth. In weave Fig. 45, we find the $\frac{1}{3}$ twill used for stitching, the proper allowance for the same is a deduction of 24 per cent. from the face structure; hence, in example:

45 threads, proper warp texture for face cloth, treated as single cloth.
—11 " (24 per cent. deducted for $\frac{1}{3}$ stitching).
—
34 threads per inch must be used for each system if using weave given in Fig. 45.

In weave Fig. 46, we find the 8-leaf satin used for stitching the same face cloth as previously used, the proper allowance for the same is a deduction of 16 per cent. from the face structure; In example given, we find—

45 threads, proper warp texture for face cloth, treated as single cloth.
— 7 threads (16 per cent. deducted for the $\frac{1}{7}$ stitching).
—
38 warp threads per inch must be used for each system if using weave given in Fig. 46.

Answer.—Double cloth fabrics given in question require the following warp texture:

a. If using weave Fig. 45, we must use—
34 warp threads 4 -run woolen yarn for face,
+34 warp threads $4\frac{1}{4}$-run woolen yarn for back.
—
or 68 warp threads per inch.

b. If using weave Fig. 46, we must use—
38 warp threads 4 -run woolen yarn for face,
+38 warp threads $4\frac{1}{4}$-run woolen yarn for back;
—
or 76 warp threads per inch.

2 Ends Face to Alternate with 1 End Back in Warp and Filling.

For face warp use 4-run woolen yarn (same counts as used in previously given example).
For back warp use $2\frac{1}{4}$-run woolen yarn.

Question.—Find texture for warp yarn: *a*, if using weave Fig. 47; *b*, if using weave Fig. 48.

The face weave in both weaves is the same as given in previous weaves, Figs. 45 and 46, or the $\frac{2}{2}$ twill, the counts of yarn being also the same; thus, we can use texture for face cloth required from previous example, being 45 threads per inch in loom.


FIG. 47.

In weave Fig. 47, we used the plain weave for stitching, the proper allowance for the same is a deduction of 8 per cent. from the face structure; hence,

45 threads, proper warp texture for face cloth (single cloth),
— 3 " 8 per cent. (3.6 actual) deducted for the stitching $\frac{1}{1}$.
—
42 threads per inch to be used for the face system if using weave given in Fig. 47.

In weave Fig. 48, we find the 8-leaf satin used for stitching the same face cloth as previously used. The manner in which the stitching is done in this example will be of very little, if any, consequence to the face cloth; hence, the full number of ends (or as near as posible) as ascertained for the face cloth, treated as if single cloth, must be used. In the present example this would be 44 or 45 threads per inch to be used for face system if using weave shown in Fig. 48.

Answer.—Double cloth fabrics given in question require the following warp texture: *a.* If using weave Fig. 47, we must use—

42 warp threads 4-run woolen yarn for face.
+21 warp threads $2\frac{1}{4}$-run woolen yarn for back; or
—
63 warp threads per inch.

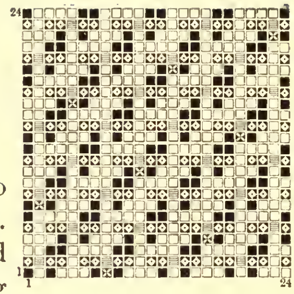

FIG. 48.

b. If using weave Fig. 48, we must use—

44 warp threads 4-run woolen yarn for face.
+22 warp threads $2\frac{1}{4}$-run woolen yarn for back; or
—
66 warp threads per inch must be used.

Example.—Ascertain texture of warp required for a worsted suiting, to be made with 2/40's worsted for face warp, and 2/28's cotton for back warp. Arrangement of warp and filling to be 2 ends face to alternate with 1 end back. Weave to be used, Fig. 48. Next, ascertain the proper counts of filling and the number of picks per inch, take-up of warp, width of cloth in reed, and ascertain total amount of each kind of material required per yard from loom (exclusive of selvage).

2/40's worsted=11,200 yards per lb. $\sqrt{11,200}$, less 10 per cent.=95 threads will lie side by side in one inch.

Face weave (in Fig. 48) is the $\frac{2}{2}$ twill=4 threads in one repeat, with 2 points of interlacings; hence, $\frac{95\times4}{6}=380\div6=63\frac{1}{3}$, warp texture to be used for the face cloth, the same being treated as if single cloth.

In weave Fig. 48, the arrangement between face and back is 2:1; the weave used for the back is the 8-leaf satin, and, as we mentioned when laying down rules and examples, for setting double cloth fabrics in the loom, that the $\frac{1}{7}$ requires no deduction on account of the stitching of the back warp in the face cloth, texture to use in this example must be

64 face warp threads (2/40's worsted), and
+32 back warp threads (2/28's cotton); hence,
—
96 warp threads per inch must be used.

Take-up of warp during weaving 12 per cent. for face and 10 per cent for back. The width of cloth to use in reed will be 62 inches.

For face filling use the same counts as for face warp, and for back filling use 3-run woolen yarn.

Picks, 66 face.
+33 back.
—
99, total picks to be used per inch.

64×62=3,968 threads in face warp—12 per cent. take-up. Thus:
3,968×100=396,800÷88=4,509 yards of face warp yarn are necessary for 1 yard cloth woven
2/40's worsted=11,200 yards per lb.÷16=700 yards per oz.
4,509÷700=6.44 oz., weight of face warp.
32×62=1,984 threads in back warp—10 per cent. take-up. Thus:
198,400÷90=2,204 yards of back warp yarn necessary for 1 yard cloth woven.
2/28's cotton=11,760 yards per lb.÷16=735 yards per oz.
2,204÷735=3 oz., weight of back warp.
66×62=4,092 yards of face filling are wanted.
4,092÷700=5.85 oz., weight of face filling. 33×62=2,046 yards of back filling are wanted.
3-run woolen yarn=300 yards per oz. 2,046÷300=6.82 oz., weight of back filling.

Hence: 6.44 oz., weight of face warp (2/40's worsted).
3.00 " " " back " (2/28's cotton).
5.85 " " " face filling (2/40's worsted).
6.82 " " " back " (3-run wool).
—
22.11 oz.

Answer.—Fabric given in example will weigh 22.11 oz. per yard from loom.

ARITHMETIC.

(Specially Adapted for Textile Purposes).

ADDITION.

Addition has for its object the finding of a number (called sum) equal to two, three, or more numbers.

The symbol + (read plus) is used to indicate the operation of addition. The symbol = (read is equal to, or are) is the sign of equality.

Example.— 3 + 4 + 7 yards=14 yards.

If adding higher numbers than units place figures that represent units in each number in the same vertical line, those representing tens in the same vertical line and continue in this manner with the numbers representing hundreds, thousands, ten-thousands, hundred-thousands and millions. Next draw a horizontal line under the last number, and under this line place (in the same arrangement as to value of positions) the sum of the given numbers ; *i. e.*, commencing to add the right-hand column, writing the units of the sum beneath, and adding the tens, if any, to the next column, and continue in this manner with all the columns until writing the entire sum of the last column.

Examples.—

206 lbs.
320 "
+54760 "
———
55286 lbs.

46 yards.
230 "
4377 "
+57698 "
———
62351 yards.

Question.—Find number of threads in pattern dressed :

10 threads black.
2 " blue.
4 " brown.
24 " black.
+ 2 " blue.
—
Answer.— 42 threads in pattern.

Question.—Find total weight for the following lot of wool :

960 lbs. Domestic.
40 " Australian.
——
Answer.— 1000 lbs., total weight.

SUBTRACTION.

Subtraction is the process of taking away a number (called subtrahend) from a larger number (called minuend). The result of a subtraction is termed difference.

The symbol — (read minus, or less) denotes the operation of subtracting. To prove a subtraction, remember that the difference and subtrahend, added, must equal the minuend.

Example.— 8 — 3 lbs. = 5 lbs. *Proof.*— 5 + 3 = 8.

If subtracting higher numbers than units, write the subtrahend under minuend, placing units of the same order in the same column. Next draw a horizontal line under the subtrahend and begin to subtract with the units of the lowest order, and proceed to the highest, writing the result beneath.

If any order of the minuend has less units than the same order of the subtrahend, increase its units by ten and subtract; consider the units of the next minuend order one less, and proceed as before.

Examples.—

4322 lbs. (minuend)	4284 yards
—2111 " (subtrahend)	—3395 "
2211 lbs. (difference).	889 yards.

Question.—Weight of cloth required, 21 oz.; weight from loom, 19 oz. Find difference.

21 oz.
—19 "
2 oz.

Answer.—The cloth in question is 2 oz. too light.

Question.—The weight of a lot of wool in grease is 100 lbs.; its weight after being scoured and dried is 67 lbs. Find loss during scouring process.

100 lbs.
— 67 "
33 lbs.

Answer.—The lot of wool in question lost during scouring 33 lbs.

Question.—Basis of cotton yarn, 840 yards per lb.; basis of worsted yarn, 560 yards per lb. Find difference.

840 yards.
—560 "
280 yards.

Answer.—The worsted yarn basis is 280 yards less than the one for cotton yarns.

MULTIPLICATION.

Multiplication is the process of taking one number (called multiplicand) as often as another number (called multiplier) contains ones. The sum thus derived, or the result of a multiplication, is called the product or result.

The symbol $\times$ (read multiplied, or times) denotes the operation for multiplying.

Example.—

Multiplicand.		Multiplier.		Product.
4	$\times$	3	=	12

Proof.—

4
4
+ 4
12

If multiplying higher numbers than units, begin the process with the ones, and write the ones of the product reserving the tens if any. Next multiply the tens of the multiplicand, adding number of tens reserved from the previous process, write tens in place for tens in product and reserve (if any) the hundreds; continue in this manner, always multiplying the next highest number of the multiplicand, adding number of same value (if any) from the previous part of the operation, until all the numbers of the multiplicand are taken up, writing in full the last operation.

Example.—If weaving 212 yards of cloth in one day, how many yards will be woven, under the same circumstances, in 3 days? $212 \times 3 = 636$.

Answer.—636 yards.

The product for multiplying a number by 10, is obtained by simply annexing 0 to the multiplicand.

Example.— 336 yards×10=3,360 yards.

By annexing 00 to the multiplicand, we multiply the latter by 100; by annexing 000, with 1000, etc.

If required to multiply with a number having tens and zeros (0) for ones, we first multiply with the tens and annex 0 to the result.

Examples.— 36×30=1,080; 36×300=10,800; 36×3,000=108,000, etc.

Remember that the multipler and multiplicand can change places, without altering the product; thus, if zeroes are found in the multiplicand reverse factors so as to apply previously given rules.

Example.—How many picks per hour does a loom make if running 85 picks per minute? 1 hour=60 minutes; thus, 60×85=5,100.

Answer.—The speed per hour is 5,100 picks.

If the multiplier contains two parts, for example 5 and 60 (or 65), multiply the multiplicand first with the units (5 in example) and afterwards with the tens, using zero for ones (60 in example). In setting down this second result omit the zero, as it has no effect on the addition to be performed.

Example.—If one loom produces 235 yards of cloth in one week, how many yards will 23 looms produce in the same time and on the same work?

235×23 Thus:
235× 3= 705
235×20= 4700
———
5405

or,
235×23
———
705 = (235× 3)
470 = (235×20)
———
5405

Answer.—23 looms will produce 5,405 yards per week.

If the multiplier is made up of three parts, multiply with the units and tens as before, next the hundreds, using zeros for tens and units, but omitting both zeros in setting down the third result. For similar reasons any future value of figures in the multipler requires corresponding increase of zeros not set down in the respective result.

Example.— 783×233
———
2349 =(783× 3= 2349).
2349 =(783× 30= 23490).
1566 =(783×200=156600).
———
Answer.— 182439

In some instances we are requested to find the continued product of three, four, or more numbers. In such instances multiply the first two numbers, and multiply product derived with the third, etc.

Example.—Find number of yards of filling wanted to weave 32 yards cloth, 72 inches wide in loom, 45 picks per inch. Thus: 32×72×45.

32×72=2,304×45=103,680

Answer.—103,680 yards of filling are wanted.

Some examples call for a number to be multiplied by itself once, twice, three times, or oftener. If so, the resulting products are called the second, third, fourth, etc., powers of the number. The process is termed involution, and the power to which the number is raised is expressed by the number of times the number has been employed as a factor in the operation. The raising of a number to the second power is called square; the raising to the third power being termed cube. Thus:

16 is the square of 4, because 4×4=16
64 " " cube " 4, " 4×4×4=64

DIVISION.

Division is the process by which we find how many times one number (called divisor) is contained into another (called dividend) The quotient is the result of a division, and the part of the dividend not containing the divisor an exact number of times, is called the remainder.

The symbol of division is ÷ (read divided by), and is written between the dividend and divisor; for example, 8÷4; but is also frequently substituted, either by writing the divisor at the left of the dividend with a curve, for example, 4) 8, or by writing the divisor under the dividend, both numbers to be separated by a horizontal line.

For example, $\frac{8}{4}$.

Dividend.		Divisor.		Quotient.
8	÷	4	=	2

Example.—If dividing higher numbers than units, find how many times the divisor is contained in the fewest left-hand figures of the dividend that will contain it; write answer as the first number of the quotient. Next multiply this number by the divisor; subtract the product from the partial dividend used, and to the remainder annex the next dividend figure for a second partial dividend. Divide and proceed as before, until all the numbers of the dividend are called for, writing the last remainder (if there is one left), with the divisor under it (as common fraction), as a part of the quotient.

Example.—Find number of repeats of pattern in the following warp:

3,904 threads in warp. 32 threads in pattern.

```
3904÷32=122
32
--
 70
 64
 --
  64
  64
```

Answer.—In the warp given in the example there are 122 repeats of pattern.

Remember that the dividend is the product of the divisor and the quotient; hence, use this as proof for the division in question.

```
Divisor.   Quotient.
  32    ×    122     =   3,904 (Dividend.)
 ----------------
   64
  64
 32
 ----
 3904
```

If we have to divide a number by ten, simply insert a decimal point between the last two figures (toward the right) in the dividend, thus expressing at once the quotient.

Example.—4,220 end in warp, dressed with 10 sections. Find number of ends used in each section.

4,220÷10=422.0, or

Answer.—422 ends are used in each section.

If the divisor is hundred, thousand, or more, always move the decimal point correspondingly one more point toward the left in the dividend, so as to get the quotient.

Example.—125 lbs. of filling must weave 100 yards of cloth, how many pounds must be used per yard, to weave up all this filling?

125÷100=1.25

Answer.—1¼ lbs. yarn must be used per yard.

Dividing or multiplying the dividend and the divisor by one number does not alter the quotient; thus, if the divisor contains zeros for either units, units and tens, units, tens and hundreds, etc., we can shorten the process by throwing out such zeros and reducing the dividend correspondingly, by simply placing a decimal point in its proper place.

Example.—4,905 threads in warp, 30 threads in pattern. Find number of repeats of pattern in warp.

$$4905 \div 30 = 490.5 \div 3\not{0} = 163.5$$

```
 3
---
 19
 18
---
  10
   9
---
  15
  15
---
```

Answer.—There are 163½ repeats of patterns in warp.

Previous example also explains the multiplying of both the dividend and the divisor (without altering the proper quotient) towards the close of the division, when 1.5 is to be divided by 3.

$$\frac{1.5 \times 10 = 15}{3 \times 10 = 30} \text{ or } \frac{1}{2} \text{ or } 0.5.$$

PARENTHESIS OR BRACKETS.

A parenthesis (expressed by symbol ( )), is used in calculations for enclosing such numbers as must be considered together. Hence, the whole expression which is enclosed is affected by the symbol preceding or following the parenthesis.

Hence, $(18 \times 4) \div (4 \times 2) = 72 \div 8 = 9$; whereas without parenthesis example would read as follows:

$$18 \times 4 \div 4 \times 2 = (18 \times 4 = 72 \div 4 = 18 \times 2 =)\ 36$$

If the main operation, as in the present example, is a division, we may use in the place of the parenthesis, the vinculum (expressed by symbol ——), writing the dividend above the line, and the divisor below; thus, previously given example would read $\frac{18 \times 4}{4 \times 2} = 9$

$240 \div (7 + 4 \times 2)$ means that twice the sum of $7 + 4$ equal 22 is to be divided into 240. It might also have been written $\frac{240}{7 + 4 \times 2}$

$(3 \times 4 - 2) \times (6 \times 9 + 4) + 43$ means: Subtract 2 from the product of 3 multiplied by 4, and multiply the remainder (10) by the sum of 6 multiplied by 9, plus 4 (58), and add to the product ($10 \times 58 = 580$) thus obtained 43, which gives 623 as the result or answer.

Frequently brackets are made to inclose one another, if so, remove the brackets one by one, commencing by the innermost.

Example.—

$$(2 + 5 \times (4 + 82) + 8) \times (3 + 10).$$
$$(2 + 5 \times 86 + 8) \times (3 + 10).$$
$$(7 \times 86 + 8) \times (3 + 10).$$
$$(602 + 8) \times (3 + 10).$$
$$610 \times 13$$

Answer.—$(2 + 5 \times (4 + 82) + 8) \times (3 + 10) = 7{,}930.$

Example.— $(3\times(6+9\div2\times(4\times8)+8))\times2.$

$(3\times(6+9\div2\times\ 32\ +8))\times2.$

$(3\times(\ 248\ ))\times2.$

$744\ \times2.$

Answer.—$(3\times(6+9\div2\times(4\times8)+8))\times2=1{,}488.$

PRINCIPLE OF CANCELLATION.

Example given in previous chapter on brackets $\frac{18\times4}{4\times2}$ we will also use to explain the subject of cancelling or shortening calculations. The rule for this process is: Strike out all the numbers common to both dividend and divisor, and afterward proceed as required by example.

$$\frac{18\times4}{4\times2}=\frac{18\times\not4}{\not4\times2}=\frac{18}{2}=18\div2=9.$$

Another point for cancellation is to ascertain if a number in the dividend and in the divisor have the same common factor.

Example.— $$\frac{36\times9}{18\times5}=\frac{\overset{2}{\not{36}}\times9}{\underset{1}{\not{18}}\times5}=\frac{2\times9}{1\times5}=18\div5=3\tfrac{3}{5}.$$

Proof.— $$\frac{36\times9}{18\times5}=\frac{324}{90}=324\div90=3\tfrac{3}{5}.$$

$$\begin{array}{r}270\\ \hline \frac{54}{90}\ \Big|\ \frac{6}{10}\ \Big|\ \frac{3}{5}\end{array}$$

For reducing fractions to their lowest denomination as in previous example $\frac{54\div9=6\div2=3}{90\div9=10\div2=5}$ as well as for assisting the student quickly to find the same common factor for two numbers, we give herewith rules by which he can quickly ascertain if a number is exactly divisible by 2, 3, 4, 5, 6, 7, 8, 9, 10 or 11.

If the last figure of the number is either zero or an even digit, such a number is exactly divisible by 2.

Examples.— $420\div2=210,\qquad 336\div2=168.$

If the sum of the figures is divisible by 3, such a number is exactly divisible by 3.

Example.— $38{,}751\div3=12{,}917.$

If the last two figures of a given number are divisible by 4, such a number is exactly divisible by 4.

Example.— $396{,}564\div4=99{,}141.$

If the last digit in a number is either 0 or 5, such a number can be exactly divided by 5.

Examples.— $320\div5=64,\qquad 38{,}745\div5=7{,}540.$

When the last three figures of a number are divisible by 8, such number can be divided by 8

Example.— $376{,}256\div8=47{,}032.$

A number is exactly divisible by 9, when the sum of its digits is divisible by 9.

Example.— $887{,}670\div9=98{,}630.$

A number is exactly divisible by 11, when the difference between the sum of the digits in the uneven places (commencing with the units) and the sum of the digits in the even places, is either zero or divisible by 11.

Example.— $514{,}182{,}746\div11=46{,}743{,}886.$

COMMON FRACTIONS.

A common fraction is a fraction in which we write the numerator above, and the denominator below, the dividing (— or /) line.

Example.— $\frac{1}{2}$ $\equiv$ numerator of the fraction / $\equiv$ denominator of the fraction } Both being the terms of the fraction.

The horizontal dividing line is the one most frequently used, but the oblique (½) answers the same purpose.

The *denominator* of a fraction indicates in how many equal parts the unit is divided; and the *numerator* shows how many of those parts are taken.

There are two kinds of fractions:

(*a*) **Proper Fractions,** which have for their terms a numerator which is less than the denominator. For example, $\frac{3}{4}$, $\frac{5}{8}$, $\frac{6}{7}$, etc.

(*b*) **Improper Fractions,** which have for their terms a numerator, which is greater than the denominator. For example, $\frac{4}{3}$, $\frac{8}{5}$, $\frac{7}{6}$, etc.

An *improper fraction* can be changed to a *mixed number* by dividing the numerator by the denominator, setting down the quotient as the integral part, and making the remainder the numerator of the fractional part of the mixed number, whose denominator is the denominator of the original fraction.

An integer (= whole number) can be expressed as an improper fraction, without reducing its value, for example, $6=\frac{6}{1}$, $8=\frac{8}{1}$, etc. The combination of an integer and a fraction is termed a mixed number. For example, $7\frac{3}{4}$ (7 Integer. 3 Numerator. / 4 Denominator.)

A *mixed number* can be changed to an *improper fraction* by multiplying the integer by the denominator of the fraction, adding to the product the numerator of the fraction. This sum is the numerator of the improper fraction of which the denominator is the denominator of the given fraction.

Example.— $2\frac{4}{7} = \frac{2\times7+4}{7} = \frac{18}{7}$ improper fraction.

A fraction is expressed in its lowest terms (*i. e.*, cannot be reduced) when the numerator and denominator have no common factor except unity, or in other words, when both terms are not dividable by any number except one. For example. $\frac{5}{12}$, $\frac{3}{7}$, etc.

Thus, to reduce a fraction to its lowest terms, use

Rule.—Divide the numerator and the denominator by their highest common factor.

The highest common factor of a fraction is the highest number which will exactly divide each of the terms of a fraction; for such small numbers, as are generally used for fractions, the highest common factor is found at a glance. For example: $\frac{6}{8}$. Readily the student will see that both the 6 and the 8 can be divided by 2. Thus: $\frac{6}{8} \div 2 = \frac{3}{4}$, or $\frac{6}{8} = \frac{3}{4}$.

If dealing with large numbers, the highest common factor cannot always be determined by inspection, but is found by

Rule.—Divide the higher number of the fraction by the lower, and the latter (the divisor of the first operation) by the remainder; continue the process until no remainder is left, the divisor used last being the highest common factor for the fraction.

Example.—Reduce to its lowest terms $\frac{2166}{2888}$; *i. e.*, find the highest common factor for 2166 and and 2888, by previously given rule.

$$\begin{array}{l} 2166)2888=1 \\ \quad 2166 \\ \quad \overline{} \\ \quad 722)2166=3 \\ \quad\quad 2166 \\ \quad\quad \overline{} \end{array} \Bigg\} \text{ or, 722 is the highest common factor.} \qquad \begin{array}{l} 2{,}166 \div 722 = 3 \\ 2{,}888 \div 722 = \overline{4} \end{array}$$

Answer.— $\frac{2166}{2888}$ expressed in its lowest terms equals $\frac{3}{4}$

Frequently we must change a given fraction to terms of a known denominator; if so, proceed as follows: Divide the required denominator by the denominator of the given fraction and multiply by the quotient thus obtained with both terms of the given fraction.

Example.—Change $\frac{5}{12}$ to equivalent fraction expressed in 60's.

$$60 \div 12 = 5 \text{ and } \frac{5 \times 5}{12 \times 5} = \frac{25}{60}$$

Answer.— $\frac{5}{12}$ equals $\frac{25}{60}$ in value.

If two fractions are to be changed to equivalent fractions (fractions having the same denominator) find the lowest common multiple (see * below for explanation for lowest common multiple) for the two given denominators, which is the new denominator for each fraction. Next find the new numerators for both fractions, by means of previously given method for changing a given fraction to terms of a known denominator. This rule also applies for three or more fractions.

Example.—Change $\frac{3}{4}$ and $\frac{5}{7}$ to equivalent fractions, having the same denominator.

4×7 (prime numbers) $= 28$, new denominator.

$$28 \div 4 = 7 \qquad 28 \div 7 = 4$$

$$\frac{3 \times 7}{4 \times 7} = \frac{21}{28} \qquad \frac{5 \times 4}{7 \times 4} = \frac{20}{28}$$

Answer.— $\frac{3}{4} = \frac{21}{28}$ and $\frac{5}{7} = \frac{20}{28}$.

Example.—Change $\frac{2}{3}$, $\frac{3}{4}$ and $\frac{5}{7}$ to equivalent fractions, having the same denominator.

$3 \times 4 \times 7$ (prime numbers) $= 84$, new denominator.

$$84 \div 3 = 28 \qquad 84 \div 4 = 21 \qquad 84 \div 7 = 12$$

$$\frac{2 \times 28}{3 \times 28} = \frac{56}{84} \qquad \frac{3 \times 21}{4 \times 21} = \frac{63}{84} \qquad \frac{5 \times 12}{7 \times 12} = \frac{60}{84}$$

Answer.— $\frac{2}{3} = \frac{56}{84}$ $\qquad \frac{3}{4} = \frac{63}{84}$ $\qquad \frac{5}{7} = \frac{60}{84}$

* *The lowest common multiple* of two or more numbers is the lowest number which is exactly dividable by each of them, and is obtained for two numbers by dividing one of the numbers by the highest common factor, and multiplying the quotient by the other number. If numbers are prime, their product is the lowest common multiple.

If we have to find the lowest common multiple of three or more numbers, find the lowest common multiple of any two, next find the lowest common multiple of the resulting number, and of a third of the original numbers, and so on, the final result being the lowest common multiple wanted.

ADDITION OF COMMON FRACTIONS.

Only fractions having the same denominators can be added; thus, change fractions given to equivalent fractions having the lowest common denominator. Next add the numerators of the equivalent fractions and place the result as the numerator of a fraction whose denominator is the common denominator of the equivalent fractions.

Example.—Find sum of $\frac{1}{8}$ and $\frac{1}{3}$ oz.

$8 \times 3 = 24$, lowest common denominator.

$$24 \div 8 = 3 \qquad 24 \div 3 = 8$$

$$\frac{1 \times 3}{8 \times 3} = \frac{3}{24} \qquad \frac{1 \times 8}{3 \times 8} = \frac{8}{24} \qquad \frac{3}{24} + \frac{8}{24} = \frac{11}{24}$$

Answer.— $\frac{1}{8}$ oz. $+ \frac{1}{3}$ oz. $= \frac{11}{24}$ oz.

Example.—Find sum of $\frac{3}{20}$, $\frac{4}{15}$ and $\frac{1}{10}$ inches.

The lowest common denominator of 20, 15 and 10 is 60, since

$$60 \div 20 = 3 \qquad 60 \div 15 = 4 \qquad 60 \div 10 = 6$$

$$\frac{3 \times 3}{20 \times 3} = \frac{9}{60} \qquad \frac{4 \times 4}{15 \times 4} = \frac{16}{60} \qquad \frac{1 \times 6}{10 \times 6} = \frac{6}{60} \qquad \frac{9}{60} + \frac{16}{60} + \frac{6}{60} = \frac{31}{60}$$

Answer.— $\frac{3}{20} + \frac{4}{15} + \frac{1}{10} = \frac{31}{60}$ inches.

Example.—Find the total yards for the following three pieces of cloth containing respectively $3\frac{7}{16}$, $8\frac{2}{16}$, and $108\frac{4}{20}$ yards.

The lowest common denominator of 16 and 20 is 80, since $80 \div 16 = 5$ and $80 \div 20 = 4$.

$$\frac{7 \times 5}{16 \times 5} = \frac{35}{80}, \text{ thus: } 3\tfrac{7}{16} = 3\tfrac{35}{80} \qquad \frac{2 \times 5}{16 \times 5} = \frac{10}{80}, \text{ thus: } 8\tfrac{2}{16} = 8\tfrac{10}{80} \qquad \frac{4 \times 4}{20 \times 4} = \frac{16}{80}, \text{ thus: } 108\tfrac{4}{20} = 108\tfrac{16}{80}$$

$$3\tfrac{35}{80} + 8\tfrac{10}{80} + 108\tfrac{16}{80} = 119\tfrac{61}{80}$$

Answer.—The total yards for the three pieces cloth given in question are $119\frac{61}{80}$ yards.

If the sum derived is an improper fraction, the same can be changed (if required) to a mixed number, by dividing the numerator by the denominator, the quotient obtained being the integer. The remainder is the numerator of the fraction which has the given denominator of the improper fraction for their denominator.

Example.—Find sum of $\frac{5}{7}$ and $\frac{8}{9}$ lb.

The lowest common denominator of 7 and 9 is 63, since $63 \div 7 = 9$, and $63 \div 9 = 7$.

$$\frac{5 \times 9}{7 \times 9} = \frac{45}{63} \text{ and } \frac{8 \times 7}{9 \times 7} = \frac{56}{63} \qquad \frac{45}{63} + \frac{56}{63} = \frac{101}{63} \ (101 \div 63) = 1\tfrac{38}{63}$$

Answer.— $\frac{5}{7}$ lb. $+ \frac{8}{9}$ lb. $= \frac{101}{63}$, or $1\frac{38}{63}$ lbs.

Previously given rule also applies if adding improper fractions.

Example.—Find sum of $\frac{8}{5}$ and $\frac{7}{3}$ yards.

The lowest common denominator of 5 and 3 is 15, since $15 \div 3 = 5$, and $15 \div 5 = 3$.

$$\frac{8 \times 3}{5 \times 3} = \frac{24}{15} \qquad \frac{7 \times 5}{3 \times 5} = \frac{35}{15} \qquad \frac{24}{15} + \frac{35}{15} = \frac{59}{15} \ (59 \div 15) = 3\tfrac{14}{15}.$$

Answer.— $\frac{8}{5}$ yard $+ \frac{7}{3}$ yard $= 3\frac{14}{15}$ yards.

If adding mixed numbers, first add the fractions; if their product is a proper fraction, reduce the same to their lowest equal terms; but if an improper fraction, change the same to a mixed number and put the fraction part down for the fraction of the sum. Next add the integral parts of the given mixed numbers plus the integral part from the addition of the fractions.

Example.—Find the sum of $3\frac{2}{3}$, $4\frac{6}{8}$ and $2\frac{1}{7}$ inches.

The lowest common denominator of 3, 8 and 7 is 168, since $168 \div 3 = 56$; $168 \div 8 = 21$; $168 \div 7 = 24$.

$$3\tfrac{2}{3}\left(\tfrac{2}{3} \times \tfrac{56}{56}\right) = 3\tfrac{112}{168}$$

$$4\tfrac{6}{8}\left(\tfrac{6}{8} \times \tfrac{21}{21}\right) = 4\tfrac{126}{168}$$

$$2\tfrac{1}{7}\left(\tfrac{1}{7} \times \tfrac{24}{24}\right) = 2\tfrac{24}{168}$$

$$9\tfrac{262}{168}$$

$$9\tfrac{262}{168} = \left\{ \begin{array}{r} 262 \div 168 = 1\tfrac{47}{84} \\ +9 \\ \hline 10\tfrac{47}{84} \end{array} \right\} 10\tfrac{47}{84}$$

Answer.— $3\frac{2}{3} + 4\frac{6}{8} + 2\frac{1}{7}$ inches $= 10\frac{47}{84}$ inches.

SUBTRACTION OF COMMON FRACTIONS.

Only fractions having the same denominator can be subtracted; thus, change fractions given to equivalent fractions having the lowest common denominator. Next deduct the numerator of the smaller of the equivalent fractions from the numerator of the greater fraction. The difference place as the numerator of a fraction whose denominator is the common denominator of the equivalent fraction. This fraction is the difference of the given two fractions (can be reduced to its lowest terms by previously given rule).

Example.—Find the difference between $\frac{6}{8}$ and $\frac{2}{7}$.

The lowest common denominator of 8 and 7 is 8×7, or 56; and $56\div8=7$; $56\div7=8$.

$$\frac{6\times7=42}{8\times7=56} \qquad \frac{2\times8=16}{7\times8=56} \qquad \Big| \quad \frac{42}{56}-\frac{16}{56}=\frac{26}{56}=\frac{13}{28}$$

Answer.— $\frac{6}{8}-\frac{2}{7}=\frac{13}{28}$.

Example.—Find the difference between the weight of two pieces of cloth weighing respectively $23\frac{5}{7}$ and $20\frac{2}{9}$ lbs. The lowest common denominator of 7 and 9 is 7×9 or 63.

$$63\div7=9 \qquad 63\div9=7.$$

$$23\tfrac{5}{7}=23\tfrac{45}{63}$$
$$20\tfrac{2}{9}=20\tfrac{14}{63}$$
$$-$$
$$3\tfrac{31}{63}\text{ lbs.}$$

Answer.—The difference between the two pieces of cloth given in example is $3\frac{31}{63}$ lbs.

Previously given rule also applies, if dealing with improper fractions. In some instances we may have to deduct a fraction or a mixed number in which the value of the fraction of the subtrahend is greater than the one of the minuend. If so, we must change the fraction by adding one unit of the integer (changed to a fraction of the same denominator) to the fraction of the minuend.

Example.—Find the difference between the weight of two pieces of cloth weighing respectively $28\frac{3}{7}$ and $28\frac{6}{8}$ ounces. The lowest common denominator of 7 and 8 is 8×7, or 56.

$$28\tfrac{3}{7}=28\tfrac{24}{56}=27\tfrac{80}{56}$$
$$22\tfrac{6}{8}=22\tfrac{42}{56}=22\tfrac{42}{56}$$
$$-$$
$$5\tfrac{38}{56},\text{ or }5\tfrac{19}{28}\text{ oz.}$$

Answer.—The difference in weight between the two pieces of cloth, given in example, is $5\frac{19}{28}$ ozs.

MULTIPLICATION OF COMMON FRACTIONS.

A fraction is multiplied by an integer, by multiplying the numerator of the fraction by the integer and leaving the denominator of the fraction unchanged, or divide the denominator of the fraction by the integer and leave the numerator unchanged.

Example.—Multiply $\frac{3}{8}$ with 2.

$$\frac{3}{8}\times2=\frac{3\times2}{8}=\frac{6}{8}\text{ or }\frac{3}{4}$$

Or,
$$\frac{3}{8}\times2=\frac{3}{8\div2}=\frac{3}{4}$$

Example.—If 1 lb. filling weaves $\frac{5}{8}$ yards cloth, how many yards will 26 lbs. weave?

$$\frac{5}{8}\times26=\frac{5\times26}{8}=\frac{130}{8},\text{ or }130\div8=16\tfrac{1}{4}.$$

Answer.—26 lbs. filling will weave $16\frac{1}{4}$ yards cloth.

A fraction is multiplied by a fraction by writing the product of the numerators over the product of the denominators. The product thus divided change either to a fraction of the lowest term, or, if an improper fraction to a mixed number.

Example.—Multiply $\frac{3}{13}$ by $\frac{4}{15}$ inches.

$$\frac{3}{13} \times \frac{4}{15} = \frac{3 \times 4}{13 \times 15} = \frac{\not{3} \times 4}{13 \times \underset{5}{\not{15}}} = \frac{4}{13 \times 5} = \frac{4}{65}$$

Answer.— $\frac{3}{13} \times \frac{4}{15} = \frac{4}{65}$.

Example.—Multiply $\frac{7}{8}$ by $2\frac{3}{7}$.

$$\frac{7}{8} \times 2\frac{3}{7} = \frac{7}{8} \times \frac{17}{7} = \frac{7 \times 17}{8 \times 7} = \frac{\not{7} \times 17}{8 \times \not{7}} = \frac{17}{8} \text{ or } 17 \div 8 = 2\frac{1}{8}$$

Answer.— $\frac{7}{8} \times 2\frac{3}{7} = 2\frac{1}{8}$.

Example.—If one pound of filling weaves $\frac{5}{8}$ yards of cloth, how many yards will $38\frac{3}{4}$ lbs. filling weave.

$$\frac{5}{8} \times 38\frac{3}{4} = \left(\frac{5}{8} \times \frac{155}{4}\right) = \frac{5 \times 155}{8 \times 4} = 775 \div 32 = 24\frac{7}{32}$$

Answer.— $38\frac{3}{4}$ lbs. of filling will weave $24\frac{7}{32}$ yards.

Previously given rules also apply to improper fractions. In the application of the rules to mixed numbers, change the latter to their equivalent value in improper fractions and proceed as in the foregoing example.

Example.—Find square inches for a sample cut to the rectangular shape of $3\frac{2}{5} \times 4\frac{1}{6}$ inches.

(Mixed numbers.)		(Improper fractions.)
$3\frac{2}{5}$	=	$\frac{17}{5}$
$4\frac{1}{6}$	=	$\frac{25}{6}$

$$\frac{17}{5} \times \frac{25}{6} = \frac{17 \times \overset{5}{\not{25}}}{\not{5} \times 6} = \frac{17 \times 5}{6} = \frac{85}{6} \text{ or } 85 \div 6 = 14\frac{1}{6}.$$

Answer.—The surface of the sample in question is ($3\frac{2}{5} \times 4\frac{1}{6}$) $14\frac{1}{6}$ inches.

DIVISION OF COMMON FRACTIONS.

A fraction is divided by an integer by multiplying the denominator of the fraction by that number, leaving the numerator unchanged; or by dividing the numerator of the fraction by the integer, and leaving the denominator unchanged.

Example.—(Fraction ÷ Integer.) Divide $\frac{4}{9}$ by 2.

$$\frac{4}{9} \div 2 = \frac{4}{9 \times 2} = \frac{4}{18} = \frac{2}{9}, \text{ or } \frac{4}{9} \div 2 = \frac{4 \div 2}{9} = \frac{2}{9}$$

Answer.— $\frac{4}{9} \div 2 = \frac{2}{9}$.

Example.— $\frac{7}{8}$ lb. of filling weave 3 yards cloth, ascertain amount used per yard.

$$\frac{7}{8} \div 3 = \frac{7}{8 \times 3} = \frac{7}{24}$$

Answer.—The amount of filling used per yard, is $\frac{7}{24}$ lb.

If we have to divide an integer by a fraction, we must change the integer to a fraction, and use the same rule as given next for

Dividing Fractions by Fractions.

Rule.—Invert the divisor and proceed as in multiplication of fractions.

Example.—(Fraction ÷ Fraction). Divide $\frac{11}{12}$ by $\frac{3}{15}$.

$$\frac{11}{12} \div \frac{3}{15} = \frac{11}{12} \times \frac{15}{3} = \frac{11}{12} \times \frac{\overset{5}{\cancel{15}}}{\cancel{3}} = \frac{11 \times 5}{12} = \frac{55}{12} \text{ or } 4\tfrac{7}{12}$$

Answer.— $\frac{11}{12} \div \frac{3}{15} = 4\frac{7}{12}$.

Proof.—The product of the quotient and the divisor must equal the dividend, thus:

$$4\tfrac{7}{12} \times \tfrac{3}{15} = \frac{55}{12} \times \frac{3}{15} = \frac{\overset{11}{\cancel{55}} \times \overset{1}{\cancel{3}}}{\underset{4}{\cancel{12}} \times \underset{3}{\cancel{15}}} = \frac{11 \times 1}{4 \times 3} = \tfrac{11}{12} \text{ or}$$

$4\frac{7}{12} \times \frac{3}{15} = \frac{11}{12}$, the same as $\frac{11}{12} \div \frac{3}{15} = 4\frac{7}{12}$

Example (Integer ÷ Fraction). Divide 8 by $\frac{3}{9}$.

$$8 \div \tfrac{3}{9} = \frac{8}{1} \div \frac{3}{9} = \frac{8}{1} \times \frac{9}{3} \text{ or } \frac{8 \times \overset{3}{\cancel{9}}}{1 \times \cancel{3}} = \frac{8 \times 3}{1} = 24$$

Answer.— $8 \div \frac{3}{9} = 24$.

In the application of the rules for mixed numbers, change the latter to an improper fraction, and proceed as in the foregoing examples.

Example.—(Mixed Number ÷ Fraction. Divide $9\frac{3}{8}$ by $\frac{7}{9}$.

$$9\tfrac{3}{8} \div \tfrac{7}{9} = \frac{75}{8} \div \frac{7}{9} = \frac{75}{8} \times \frac{9}{7} = \frac{75 \times 9}{8 \times 7} = \frac{675}{56} = 12\tfrac{3}{56}$$

Answer.— $9\frac{3}{8} \div \frac{7}{9} = 12\frac{3}{56}$.

Example.—(Mixed Number ÷ Mixed Number). Divide $4\frac{7}{8}$ by $1\frac{4}{9}$.

$$4\tfrac{7}{8} \div 1\tfrac{4}{9} = \frac{39}{8} \div \frac{13}{9} = \frac{39}{8} \times \frac{9}{13} = \frac{\overset{3}{\cancel{39}} \times 9}{8 \times \cancel{13}} = \frac{27}{8} = 3\tfrac{3}{8}$$

Answer.— $4\frac{7}{8} \div 1\frac{4}{9} = 3\frac{3}{8}$.

DECIMAL FRACTIONS.

A decimal fraction is a fraction whose unit is divided into tenths, hundreths, thousandths, ten-thousandths, hundred thousandths, etc. and is expressed without a denominator by means of the decimal point.

Value of decimal fractions commonly termed decimals.

Decimal point. Tenths. Hundredths. Thousandths. Ten-thousandths. Hundred-thousandths. Millionths.

.123456 (. 1 2 3 4 5 6) and so on, each digit decreasing tenfold advancing to the right.

Above number reads: One hundred twenty-three thousand four hundred fifty-six millionths.

The denominator of a decimal fraction (which as already mentioned, is not put down, but indicated by the decimal point) is 1 plus as many zeros annexed as there are places in the fraction.

Hence: .4 reads, 4 tenths, $\frac{4}{10}$.

.73 seventy-three hundredths, $\frac{73}{100}$.

.821 eight hundred twenty-one thousandths, $\frac{821}{1000}$, etc.

Some parties also use a zero one point to the left to indicate that the fraction contains no integer parts; thus, foregoing fractions may also be written 0.4, 0.73, 0.821, without changing their value or their reading.

Zeros affixed to a decimal do not change its value.

Hence, .38=.380=.3800, etc., 0.693=0.6930=0.69300 etc.

Mixed numbers are made up of an integer and a decimal. For example: 3.25 read, three and twenty-five hundredths. 347.3 reads, three hundred forty-seven and three tenths. 1873.472 reads, one thousand eight hundred seventy-three and four hundred and seventy two thousandths.

To change a decimal fraction to common fraction of equivalent value, omit the decimal point and write the proper denominator as explained previously, next change the fraction to its lower terms.

Example.—Change .25 to a common fraction.

$$.25 = \frac{25 \div 25}{100 \div 25} = \frac{1}{4}.$$

Answer.— .25 equals $\frac{1}{4}$.

Example.—Change 43.625 to a mixed number having a common fractional part.

$$43.625 = 43\tfrac{625}{1000} = \left(\tfrac{625}{1000} \div \tfrac{125}{125} = \tfrac{5}{8}\right) \quad 43\tfrac{5}{8}.$$

Answer.— 43.625 equals $43\frac{5}{8}$.

To change a common fraction to a decimal fraction, add decimal ciphers to the numerator, divide by the denominator, and point off as many decimal figures in the quotient as there are ciphers annexed.

Example.—Change $\frac{1}{4}$ to a decimal.

1.00÷4=0.25

```
 10
  8
 --
 20
 20
 --
```

Answer.— $\frac{1}{4}$ equals .25 or 0.25.

Example.—Change $43\frac{5}{8}$ to a decimal.

$\frac{5}{8}$=5.000÷8=0.625.

```
 50
 48
 --
  20
  16
  --
   40
   40
   --
```

```
  43.000
+  0.625
--------
  43.625
```

Answer.— $43\frac{5}{8}$ equals 43.625.

If the division does not terminate, or has been carried as far as necessary, the remainder may be expressed in the result as a common fraction, or may be rejected if less than $\frac{1}{2}$, or unimportant, and the incompleteness of the result marked at the right of the fraction by +. If $\frac{1}{2}$, or more than $\frac{1}{2}$, the last digit of the decimal may be made to express one more.

Example.—Change $\frac{7}{9}$ to a decimal.

7.000÷9=0.777+

```
70
63
--
 70
 63
 --
  70
  63
  --
   7
```

Answer.— $\frac{7}{9} = 0.777\frac{7}{9}$, or $\frac{7}{9} = 0.777+$, or $\frac{7}{9} = 0.778$.

ADDITION OF DECIMAL FRACTIONS.

Rule.—Place the decimals to be added one under another, decimal point under decimal point. Next add the figures as if dealing with whole numbers, and place the decimal point for the sum under the others.

Example.— Add 0.22, 0.384, and 0.054.

$$\begin{array}{r} 0.220 \\ 0.384 \\ +\ 0.054 \\ \hline 0.658 \end{array}$$

Answer.— 0.22 + 0.384 + 0.054 = 0.658.

If the numbers to be added be mixed numbers, place integers in front of the decimals, in their proper position, and proceed as before.

Example.— Add 3468.12; 483.39; 27.0003 and 3.18

$$\begin{array}{r} 3468.1200 \\ 483.3900 \\ 27.0003 \\ +\ \ 3.1800 \\ \hline 3981.6903 \end{array}$$

Answer.— 3468.12 + 483.39 + 27.0003 + 3.18 = 3981.6903.

Find total cost of a piece of cloth in which the value of the warp is $22.32; of the filling, $16.02; of the selvage, $0.64, and (general) manufacturing expenses are $5.00.

$$\begin{array}{r} \$22.32 \\ 16.02 \\ 0.64 \\ +\ 5.00 \\ \hline \$43.98 \end{array}$$

Answer.—The total cost of the piece of cloth in question is $43.98.

SUBTRACTION OF DECIMAL FRACTIONS.

Rule.—Place the subtrahend below the minuend, keeping the different values of positions under each other, also point under point. Next subtract as if dealing with whole numbers, and place decimal point for the difference under point of the subtrahend.

Example.—Subtract 0.27 from 0.473

$$\begin{array}{r} 0.473 \\ -0.270 \\ \hline 0.203 \end{array}$$

Answer.— 0.473 — 0.270 = 0.203.

If dealing with mixed numbers, place integers in front of the decimals, in their proper place, and proceed as before.

Example.—Find cost of filling in a cut of cloth in which the value of warp and filling is $56.32, and the value of the warp is $32.19

$$\begin{array}{r} \$56.32 \\ -\ 32.19 \\ \hline \$24.13 \end{array}$$

Answer.—The value of the filling in example is $24.13

MULTIPLICATION OF DECIMAL FRACTIONS.

Rule.—Multiply as if dealing with whole numbers, and point off in the product a number of decimal places equal to the sum of the number of decimal places in both factors. If there are not figures enough in the product, prefix the deficiency with zeros, and put the point on the left of these factors. Whole numbers and mixed numbers are dealt with alike.

Example.—Multiply 0.26 by 0.35.

```
0.26 × 0.35
 ___
 130
 78
 ___
 910
```

Four decimal places are in both factors; hence
Answer.— 0.26 × 0.35 = 0.0910, or 0.091.

Example.—Multiply 4.32 by 2.81.

```
   4.32 × 2.81
  _____
    432
  3456
  864
  _____
 12.1392
```

Four decimal places in factors; hence
Answer.— 4.32 × 2.81 = 12.1392.

Example.—Ascertain value of 432 lbs. of wool, costing $1.31 per lb.

```
  432 × 1.31
  _____
   432
  1296
  432
  _____
  565.92
```

Answer.—The value of the lot of wool in question is $565.92.

DIVISION OF DECIMAL FRACTIONS.

Rule.—If the dividend is a mixed number, or a fraction, and the divisor an integer, divide as if dealing with whole numbers, and mark off in the quotient as many decimal places as there are decimal places in the dividend.

Example.—Divide 39.42 by 2.

```
39.42 ÷ 2 = 19.71
2
___
19
18
___
 14
 14
___
 002
   2
___
   0
```

Answer.— 39.42 ÷ 2 =19.71.

Example.—Divide 0.84 by 4

```
0.84 ÷ 4 = 0.21
 8
___
 04
  4
___
  0
```

Answer.— 0.84 ÷ 4 = 0.21.

Rule.—If the divisor is a decimal, change to a whole number by moving the decimal point a sufficient number of places to the right, annexing zeros if required, and then divide as if dealing with integers. If the dividend is an integer, the quotient will be an integer; and if the dividend is a decimal, the quotient will be a decimal of the same order.

Example.—Divide 0.924 by 0.033.

0.924 ÷ 0.033 = 924 ÷ 33 = 28
66
———
264
264
———

Here the quotient is an integer, because the dividend is an integer; hence

Answer.— 0.924 ÷ 0.033 = 28.

Example.—Divide 38.76 by 10.2.

38.76 ÷ 10.2 = 387.6 ÷ 102 = 3.8
306
———
816
816
———

In this instance the dividend is a decimal of the first order; hence, the quotient is a decimal of the first order, therefore

Answer.— 38.76 ÷ 10.2 = 3.8

Example.—Divide 3.876 by 10.2.

3.876 ÷ 10.2 = 38.76 ÷ 102 = .38
306
———
816
816
———

Here the dividend is a decimal of the second order; thus the quotient correspondingly also a decimal of the second order; therefore

Answer.— 3.876 ÷ 10.2 = 0.38

Example.—Divide 0.0924 by 3.3

0.0924 ÷ 3.3 = 0.924 ÷ 33 = 0.028
66
———
264
264
———

Here the dividend is a decimal of the third order, thus the quotient also a decimal of the third order, hence:

Answer.— 0.0924 ÷ 3.3 = 0.028

If the divisor does not terminate, or has been carried as far as necessary, the remainder may be expressed as a common fraction being part of the quotient, or may be rejected if less than $\frac{1}{2}$ or unimportant, and the incompleteness of the result marked at the right of the fraction by +, or if the remainder is $\frac{1}{2}$ or more, the last digit of the decimal may be made to express one more.

Example.—Divide 409.6 by 8.5 to three decimals.

409.6 ÷ 8.5 = 4096 ÷ 85 = 48.188
340
———
696
680
———
160
85
———
750
680
———
700
680
———
20

Answer.— 409.6 ÷ 8.5 = $48.188\frac{20}{85}$ = $48.188\frac{4}{17}$ or
409.6 ÷ 8.5 = 48.188 + or
409.6 ÷ 8.5 = 48.188

Example.—If $437\frac{3}{4}$ lbs. wool cost $\$529.67\frac{3}{4}$ what will one pound cost?

$529.67\frac{3}{4}$ ÷ 437.75 or 52967.75 ÷ 43775 = 1.21
43775
———
91927
87550
———
43775
43775
———

Answer.—The value of one pound of wool given in example is \$1.21

SQUARE ROOT.

The square root of a given number is such a number which, being multiplied by itself, will produce the given number. Hence, the square root of 36 is 6, because 6×6 (or the square of 6) is 36.

The symbol $\sqrt{}$ or $\sqrt[2]{}$ placed at the left of a number denotes that the square root of that number is to be taken; hence, $\sqrt{49}$ reads: take the square root of 49, which is 7, since $7 \times 7 = 49$.

The square root of a number contains either twice as many figures as the root, or twice as many less one. For example:

$\sqrt{64} = 8$ (since $8 \times 8 = 64$) 2 figures in square. 1 figure in root.

$\sqrt{100} = 10$ (since $10 \times 10 = 100$) 3 figures in square. 2 figures in root.

A small figure 2 placed to the right and above a number is the symbol that the square of that number is to be taken, hence 4^2 denotes the square of 4 or $4 \times 4 = 16$.

A number which has a whole number for its square root is termed a perfect square, and such perfect squares, not greater than 100, must be committed to memory; *i. e.*, $2^2=4$, $3^2=9$, $4^2=16$, $5^2=25$, $6^2=36$, $7^2=49$, $8^2=64$, $9^2=81$, $10^2=100$. An imperfect square is a number whose root cannot be exactly found.

Rule.—**For finding the square root for any number.**

Separate the given number into periods of two figures each, beginning at the unit places.

Find the greater square in the left hand period, and place its root as the first figure of the root; deduct its square from the first period, and to the remainder (if any), bring down the next period for a dividend.

Divide this new dividend, omitting the right hand figure by double the first figure of the root, and place the quotient to the right of the first figure of the root, and also to the right of the partial divisor. Multiply the complete divisor by the last figure of the root, subtract the product from the dividend, and to the remainder bring down the next period for a new dividend.

Divide this new dividend, omitting the right hand figure by double the whole root so far found, and place the quotient to the right of the root, and also to the right of the partial divisor. Multiply the complete divisor by the last figure of the root, subtract product from dividend, and to the remainder bring down next period for a new dividend.

Continue the operation as before until all periods are brought down.

If the last remainder is zero, the given number is a perfect square.

Example.—Find square root of 729.

```
   √7 | 29 = 27.
    4
    ___
47)329
   329
   ___
   000
```

Answer.— $\sqrt{729} = 27.$

Proof.— $27 \times 27 = 729.$

Example.—Find square root of 148,225.

```
√14 | 82 | 25=385
  9
  ___
68)582
   544
   ___
765)3825
    3825
```

☞ In dividing 58 by 6 the quotient is 9, but if we add this to complete the divisor (6 and 9=69 × 9=621) the latter would become 69, which if multiplied by 9 would give 621, a number larger than the dividend 582, thus 8 in place of 9 must be used.

Answer.— $\sqrt{14 \mid 82 \mid 25} = 385.$

Proof.— $385 \times 385 = 148{,}225.$

Example.—Find square root of 89,401.

$\sqrt{8 \mid 94 \mid 01} = 299$
4

49)494
441 ☞ The division of 49 by 4 illustrates the same remarks as made in previous example.

589)5301 ☞ The second remainder (53) is in this example greater than the divisor (49), a result not uncommon.
5301

Answer.— $\sqrt{89401} = 299$ *Proof.*— $299 \times 299 = 89401$.

If the dividend at any time does not contain the complete divisor, place a zero in the root, and add the next period for a new dividend.

If an integral number is not a perfect square and its root is to be found, annex as many periods of ciphers as there are to be decimal places in the root. The more periods of ciphers we use, the nearer approximation of the root is obtained.

Example.—Find square root of 36469521.

$\sqrt{36 \mid 46 \mid 95 \mid 21} = 6039$
36

1203) 4695 ☞ Here in the process as 0 occurs in the root, we annex the 0 to the divisor 12, and annex the next period to the corresponding dividend.
3609

12069)108621
108621

Answer.— $\sqrt{36469521} = 6039$.

Square Root of Decimal Fractions.

For finding the square root of a decimal fraction, make the decimal such that the index of its order is an even number; also, since every period of two figures in the square equals one figure in the root, we must use as many periods in the decimal part of the square as there are to be decimals in the root.

Example.—Find the square root of 0.139 to three places of decimals.

$\sqrt{0.13 \mid 90 \mid 00} = 0.372+$
9

67)490
469

742)2100
1484

616

Answer.— $\sqrt{0.139} = 0.372+$

Proof.— $0.372 \times 0.372 = 0.138384$
\+ Remainder, 0.000616

0.139000

The square root of a decimal of an odd order is always a non-terminating decimal. See symbol + for it at the right hand of the decimal fraction of the square root in previous example.

Example.—Find square root of 0.8436 to two places of decimals.

$\sqrt{0.84 \mid 36} = 0.91+$, or 0.92
81

181)336
181

155

For this example the index is of an even order but not terminating; hence, symbol + at the right of the root. The last figure of the root is $\frac{1}{100}$, which we may change to $\frac{2}{100}$, as the remainder, 155, is more than $\frac{1}{2}$ of the divisor, 181 ; thus:

Answer.— $\sqrt{0.8436} = 0.92.$

Square Root of Common Fractions.

If we have to extract the square root of a common fraction, change the fraction to its lowest terms; if both terms are perfect squares, take the root of each ; if imperfect squares, change the fraction to a decimal, and find root as before.

Example.— $\sqrt{\frac{9}{64}} \quad \frac{\sqrt{9}}{\sqrt{64}} = \frac{3}{8}$ *Answer.*— $\sqrt{\frac{9}{64}} = \frac{3}{8}$

Example.—Find square root of $\frac{39}{81}$

$$\sqrt{\frac{39}{81}} = \sqrt{\frac{13}{27}} = \frac{\sqrt{13}}{\sqrt{27}}$$

```
√13 =3.60555+
 9
 ---
66)400
   396
   -----
7205)40000
     36025
     ------
72105)397500
      360525
      -------
721105)3697500
       3605525
       -------
         91975
```

```
√27 =5.19615+
 25
 ---
101)200
    101
    ---
1029)9900
     9261
     ----
10386)63900
      62316
      -----
103921)158400
       103921
       ------
1039225)5447900
        5196125
        -------
         251775
```

$$\sqrt{\frac{39}{81}} = \sqrt{\frac{13}{27}} = \frac{3.60555}{5.19615} \text{ or } 3.60555 \div 5.19615$$

```
36055500000÷519615=0.69388+
3117690
-------
 4878600
 4676535
 -------
  2020650
  1558845
  -------
   4618050
   4156920
   -------
    4611300
    4156920
    -------
     454380
```

Answer.— $\sqrt{\frac{39}{81}} = 0.69388$

To prove the correctness of the above example, we will next find answer by changing the common fraction $\frac{39}{81}$, for which we have to find the square root in a decimal.

```
39/81 = 39.0 ÷ 81 = 0.481481+
   324
   ---
    660
    648
    ---
     120
      81
     ---
     390
     324
     ---
      660
      648
      ---
       120
        81
       ---
        39
```

```
√0.481481 = 0.69388+
  36
  --
129)1214
    1161
    ----
1383)5381
      4149
      ------
13868)123200
       110944
       -------
138768)1225600
        1110144
        -------
         115456
```

Answer.— $\sqrt{\frac{39}{81}} = 0.69388 +$ being the same result as before.

Another method of proving this example, is to find the square root out of the common fraction without reducing it to its lowest terms. If correct it will also demonstrate to the student that the reducing of a common fraction (for drawing the square root) to its lowest terms is correct, and either may be made use of or not.

$\sqrt{\frac{39}{81}} = \frac{\sqrt{39}}{\sqrt{81}}$

```
√39 = 6.24499+
 36
 --
122) 300
     244
     ---
1244) 5600
      4976
      ----
12484) 62400
       49936
       -----
124889) 1246400
        1124001
        -------
1248989) 12239900
         11241901
         --------
           997999

√81 = 9
 81
 --
```

$\sqrt{\frac{39}{81}} = \frac{6.24499+}{9}$ or $6.24499 \div 9$

```
9)6.24499=0.69388+
  54
  --
   84
   81
   --
    34
    27
    --
     79
     72
     --
      79
      72
      --
       7
```

Answer.— $\sqrt{\frac{39}{81}} = 0.69388+$ or the same answer as already proven.

Note.—This example will also demonstrate to the student that the reducing of a fraction to its lowest terms is not always the shortest course; *i. e.*, always examine in which fraction you find either one or both terms a perfect square; 81 is a perfect square, whereas 27 is not.

Square Root of Mixed Numbers.

If we have to extract the square root of a mixed number composed of an integer and a common fraction, change the same to its equivalent value either in an improper fraction, or a mixed number expressed by integer and decimals, and proceed as explained before.

Example—Find square root of $9\frac{36}{64}$. *a.* Use decimals. *b.* Use improper fraction.

a. $\sqrt{9\frac{36}{64}}$ $\quad \frac{36}{64} = 36 \div 64 = 0.5625$; thus: $9\frac{36}{64} = 9.05625$ and,

$\sqrt{9.56 | 25} = 3.092+$

```
        9
        ----
609)  5625
      5481
      -----
6182) 14400
      12364
      -----
       2036
```

Answer.— *a.* 3.092+ is the square root of $9\frac{36}{64}$.

b. $\sqrt{9\frac{36}{64}} = \sqrt{\frac{612}{64}} = \frac{\sqrt{612}}{\sqrt{64}}$

$\sqrt{6 | 12} = 24.739+$

```
       4
       ----
44)  212
     176
     ----
487)  3600
      3409
      -----
4943)  19100
       13929
       ------
49469) 517100
       445201
       ------
        71899
```

$\sqrt{64} = 8$
$\quad\;\; 64$

$\sqrt{9\frac{36}{64}} = \frac{24.739+}{8}$ and

$24.739 \div 8 = 3.092+$

```
24
--
 73
 72
 --
  19
  16
  --
   3
```

Answer.— *b.* 3.092 + is the square root of $9\frac{36}{64}$.

Table of Square Roots.

(From 1 to 240.)

Number	Square Root.	Number	Square Root.	Number	Square Root.	Number	Square Root.
1	1.0000	19	4.3589	37	6.0828	75	8.6603
2	1.4142	20	4.4721	38	6.1644	80	8.9443
3	1.7321	21	4.5826	39	6.2450	85	9.2195
4	2.0000	22	4.6904	40	6.3246	90	9.4868
5	2.2361	23	4.7958	41	6.4031	95	9.7468
6	2.4495	24	4.8990	42	6.4807	100	10.0000
7	2.6458	25	5.0000	43	6.5574	110	10.4881
8	2.8284	26	5.0990	44	6.6332	120	10.9545
9	3.0000	27	5.1962	45	6.7082	130	11.4018
10	3.1623	28	5.2915	46	6.7823	140	11.8322
11	3.3166	29	5.3852	47	6.8557	150	12.2474
12	3.4641	30	5.4772	48	6.9282	160	12.6491
13	3.6056	31	5.5678	49	7.0000	170	13.0384
14	3.7417	32	5.6569	50	7.0711	180	13.4164
15	3.8730	33	5.7446	55	7.4162	190	13.7840
16	4.0000	34	5.8310	60	7.7460	200	14.1421
17	4.1231	35	5.9161	65	8.0623	220	14.8323
18	4.2426	36	6.0000	70	8.3666	240	15.4919

CUBE ROOT.

If a number is multiplied twice by itself, the product is called the cube of the number; hence 216 is the cube of 6, since $6 \times 6 = 36 \times 6 = 216$.

To extract the cube root of a given number, is to find one of the three factors producing.

The symbol $\sqrt[3]{\ }$ placed before a given number, indicates that the cube root is wanted.

There are two kinds of cubes, perfect cubes, being such which have an integer for its cube root; and imperfect cubes, containing a mixed number or fraction for its cube root.

The following numbers of less than 1,000 are perfect cubes:

8 is the cube of 2; 27 is the cube of 3; 64 is the cube of 4; 125 is the cube of 5;
216 is the cube of 6; 343 is the cube of 7; 512 is the cube of 8; 729 is the cube of 9.

Rule for Finding the Cube Root of a Given Number.

Separate the numbers into periods of three figures each, beginning at units place.

Find the greatest cube root of the left hand period and place its root at the right. Subtract the cube of this root from the left hand period, and to the remainder annex the next period for a new dividend. Next place three times the first figure of the root to the extreme left and three times the square of the first figure of the root, with two ciphers affixed to it, to the left near the dividend for a trial divisor. Divide the dividend by this trial divisor and put the quotient at the right of the extreme left situated number and also as the second figure of the root.

Read extreme number and quotient as one number, and multiply the same by the second figure of the root. Put this product below the trial divisor and add both; multiply this sum again by the second figure of the root, and put product below the dividend. Next subtract, and if a remainder, annex a new period, form second extreme left number, second trial divisor and quotient (= next figure for root) and proceed as before.

Example.—Find cube root of 110,592.

(Extreme left number)	(Quotient)		(Cube root)	Specified figuring.
			$\sqrt[3]{110 \mid 592} = 48$	
			64	$4 \times 4 \times 4 = 64$
		4800		$4 \times 3 = 12$
12	8	1024	46592	$4 \times 4 = 16 \times 3 = 48$ (4800)
		5824	46592	$128 \times 8 = 1024$
			00000	$5824 \times 8 = 46592$

Answer.— $\sqrt[3]{110592} = 48$ *Proof.*— $48 \times 48 = 2304 \times 48 = 110592$

If required to extract the cube root of a decimal fraction, divide the fraction also into periods of three figures each, commencing from the decimal point toward the right. If in the last period only one figure is left, annex two ciphers; if two figures are left over annex one cipher, or in other words, the decimal fraction must be some multiple of 3.

Example.—Find cube root of 553.387661.

				Specified figuring.
			$\sqrt[3]{553.387 \mid 661} = 8.21$	$8 \times 8 \times 8 = 512$
			512	$8 \times 3 = 24$
24 —	2 —	19200		$8 \times 8 = 64 \times 3 = 192 = (19200)$
		484	41387	$242 \times 2 = 484$
		19684	39368	$19684 \times 2 = 39368$
				$82 \times 3 = 246$
246 —	1 —	2017200	2019661	$82 \times 82 = 6724 \times 3 = 20172$ (2017200)
		2461	2019661	$2461 \times 1 = 2461$
		209661		$2019661 \times 1 = 2019661$

Answer.— $\sqrt[3]{553.387661} = 8.21$. *Proof.*— $8.21 \times 8.21 = 67.4041 \times 821 = 553.387661$.

The cube root of a common fraction is found either by taking the cube roots of their terms or by reducing the common fraction to a decimal and proceeding as before.

Example.—Find cube root of $\frac{27}{343}$

$$\sqrt[3]{\frac{27}{343}} = \frac{\sqrt[3]{27}}{\sqrt[3]{343}} \qquad \sqrt[3]{27} = 3 \qquad \sqrt[3]{343} = 7 \text{; hence,}$$

$$\sqrt[3]{\frac{27}{343}} = \frac{3}{7}$$

or $\sqrt[3]{\frac{27}{343}}$ change $\frac{27}{343}$ to a decimal. ($27 \div 343 = 0.078717+$) and find

$$\sqrt[3]{0.078\,|\,717} = 0.42+$$

```
                        64
12  —  2  —  4800     ------
              244  |  14717
             5044  |  10088
                      ------
                       4629
```

Answer.— $\sqrt[3]{\frac{27}{343}} = 0.42+$

Proof.— Change $\frac{3}{7}$ to a decimal $3 \div 7 = 0.42+$

If we have to extract the cube root of a mixed number composed of an integer and common fraction, change the same to its equivalent value, either in an improper fraction or to a mixed number expressed by integer and decimals, and proceed as explained before.

Table of Cube Roots.

(From No. 2 to 50.)

Number	Cube Root.	Number	Cube Root.	Number	Cube Root.	Number	Cube Root.
2	1.259921	14	2.410142	26	2.962496	38	3.361975
3	1.442250	15	2.446212	27	3.000000	39	3.391211
4	1.587401	16	2 519842	28	3.036589	40	3.419952
5	1.709976	17	2.571282	29	3.072317	41	3.448217
6	1.817121	18	2.620741	30	3.107232	42	3.476027
7	1.912931	19	2.668402	31	3.141381	43	3.503398
8	2.000000	20	2.714418	32	3.174802	44	3.530348
9	2.080084	21	2.758924	33	3.207534	45	3.556893
10	2.154435	22	2.802039	34	3.239612	46	3.583048
11	2.223980	23	2.843867	35	3.271066	47	3.608826
12	2.289428	24	2.884499	36	3.301927	48	3.634241
13	2.351335	25	2.924018	37	3.332222	50	3.684031

AVERAGE AND PERCENTAGE.

Average.—The average of two, three or more groups of numbers, is found by adding the numbers and dividing the sum by the number of groups used.

Example.—Find average counts between 5 and 6-run yarn.

$$\begin{array}{r} 5 \\ +\,6 \\ \hline 11 \div 2 = 5\tfrac{1}{2} \end{array}$$

Answer.— $5\frac{1}{2}$-run.

Example.—Find average lengths of the following 5 pieces of cloth measuring respectively 42 yards, 43 yards, $42\frac{1}{2}$ yards, $41\frac{3}{4}$ yards, 42 yards.

$$\begin{array}{r} 42 \\ 43 \\ 42\frac{1}{2} \\ 41\frac{3}{4} \\ +42 \\ \hline 211\frac{1}{4} \end{array} \qquad 211\frac{1}{4} \div 5 = 42\frac{1}{4}$$

Answer.— The average length of the pieces of cloth in question, is $42\frac{1}{4}$ yards.

Percentage.—The symbol of percentage is %, and reads per cent. For example: 32% white wool, reads 32 per cent. white wool.

Per cent. means by the hundred, thus 32 % means 32 of every hundred. For example, we speak about a mixture of wool as gray mix, 40 % white, the remainder black; this means, that in every hundred pounds wool there are forty pounds white, and sixty pounds black; thus, if the lot of wool contains 450 lbs. wool, we used 180 lbs. white wool, 270 lbs. black wool.

The *Rate* per cent, is the number of hundreths.

The *Base*, is the number on which the percentage is estimated.

Rule for finding the percentage: Multiply the base by the rate per cent.

Example.—Find 12 per cent. of 430 lbs. $430 \times \frac{12}{100} = 51.60.$

Answer.— 12 per cent. of 430 lbs. is 51.6 lbs.

Proof.— 100

12 and 88 per cent. of 430 = $430 \times \frac{88}{100} = 378.40$

88 + 12 " of 430 = (See example.) = 51.60

430.00 lbs.

Rule for finding the rate per cent.—Divide the percentage by the base.

Example.—In a lot of wool of 400 lbs., there are 20 lbs. red wool and 380 lbs. black; how many per cent. of red wool are used in this lot?

$$20 \div 400 = \frac{20}{400} = \frac{5}{100}.$$

Answer.— 5 per cent. of red wool are used.

Proof.— $400 \times \frac{5}{100} = 20.$

Rule for finding the base.—Divide the percentage by the rate per cent.

Example.—Received 138 lbs. of yarn marked as 8 per cent. of the entire lot, how many pounds are in the whole lot?

$$138 \div \frac{8}{100} = 1725$$

Answer.— 1,725 lbs. yarn are in the entire lot of yarn.

Proof.— $138 \div 1725 = 0.08 = \frac{8}{100}$ or 8 per cent.

RATIO.

Ratio is the relation which one number (called the *Antecedent*) has to another number (called the *Consequent*) of the same kind, and is obtained by dividing the first by the second; thus, the ratio of 20 to 5 is 20÷5 or 4.

The symbol of ratio is a colon (:), or the ratio may be written as a fraction; thus, 20 to 5 may be expressed either as 20:5 or $\frac{20}{5}$.

Both terms of a ratio are called a *Couplet.*

Simple Ratio is the comparing of two numbers; for example, 18 : 6 = 3.

Compound Ratio is the comparison of the products of the corresponding terms of two or more ratios; *for example.*—find the ratio of 2:4, 8:3, and 6:2.

$$\left.\begin{matrix}2:4\\8:3\\6:2\end{matrix}\right\} = \frac{2\times8\times6}{4\times3\times2} = \frac{\overset{2}{\cancel{2}}\times\cancel{8}\times\overset{2}{\cancel{6}}}{\cancel{4}\times\cancel{3}\times\cancel{2}} = \frac{2\times2}{1} = \frac{4}{1} = 4$$

Answer.—The simple ratio for example is 4 : 1 or 4.

This example will give us the rule for changing a compound ratio to a simple ratio as follows: Multiply the antecedents together for a new antecedent, and the consequents for a new consequent, and reduce both to their lowest equivalent terms.

As previously mentioned the ratio is a fraction, consequently its terms may be treated like those of a fraction, thus the following

Principles of Ratio.

The ratio is equal to the antecedent divided by the consequent.
Multiplying the antecedent, multiplies the ratio.
Multiplying the consequent, divides the ratio.
Dividing the antecedent, divides the ratio.
Dividing the consequent, multiplies the ratio.
Multiplying or dividing the antecedent and consequent by the same number, does not effect the ratio.
The product of two or more simple ratios, is the ratios of their products.

PROPORTION.

Proportion consists in the equality of two ratios, and is expressed by the symbol of equality (=) or the double colon (: :).

Every proportion consists of two couplets, or four terms. For example.— 8 : 12 = 4 : 6.

The Antecedents are the first and third terms (8 and 4 in example).
The Consequents are the second and last terms (12 and 6 in example).
The Extremes are the first and last terms (8 and 6 in example).
The Means are the second and third terms (12 and 4 in example.)

Principles of Proportion.

In a proportion the product of the means is equal to the product of the extremes.

$$\left(\begin{matrix}12 \times 4 = 48, \text{ product of the means.}\\ 8 \times 6 = 48, \quad \text{“} \quad \text{“} \quad \text{extremes.}\end{matrix}\right)$$

The product of the extremes divided by either mean will give the other mean.

$$\left\{\begin{matrix}\text{Product of}\\\text{the extremes.}\end{matrix}\right\} \div \left\{\begin{matrix}\text{One}\\\text{mean.}\end{matrix}\right\} = \left\{\begin{matrix}\text{The other}\\\text{mean.}\end{matrix}\right\}$$

$$48 \div 12 = 4$$
$$48 \div 4 = 12$$

The product of the means divided by either extreme will give the other extreme.

$$\left\{\begin{matrix}\text{Product}\\\text{of means.}\end{matrix}\right\} \div \left\{\begin{matrix}\text{One}\\\text{extreme.}\end{matrix}\right\} = \left\{\begin{matrix}\text{The other}\\\text{extreme.}\end{matrix}\right\}$$

$$48 \div 8 = 6$$
$$48 \div 6 = 8$$

There are two kinds of proportions; single and compound proportion.

Single proportion is an equality between two simple ratios, and is used to find the fourth term of a proportion where the other three terms are given. Two terms of the given three must be of the same kind and constitute a ratio; and the third term (of the given three) must be of the same kind as the regular term, and constitute with it another ratio equal to the first.

Example.— 16,800 yards of yarn weigh 16 oz., find the weight of 3,900 yards.

Yards.		Yards.		oz.		oz.
16800	:	3900	::	16	:	x

{ Product of the means. } ÷ { The given extreme. } = { The other extreme. }

3,900 × 16 = 62400 (product of the means). 62400 ÷ 16800 = $3\frac{120}{168}$ or $3\frac{5}{7}$.

Answer.— 3,900 yards weigh $3\frac{5}{7}$ oz.

Proof.— 3,900 × 16 = 62,400 product of the means.
16,800 × $3\frac{5}{7}$ = 62,400 " " extremes.
(16,800 × $3\frac{5}{7}$ = 16,800 × $\frac{26}{7}$ and 16,800 × 26 = 436,800 ÷ 7 = 62,400.)

A Compound Proportion is a proportion in which either one or both the ratios are compound.

The rule for finding the answer is as follows: Place the number which is of the same kind or denomination as the answer required for the third term, form a ratio of each remaining pair of numbers of the same kind, the same as done in simple proportion, using each couplet without any reference to the other. Next, divide the product of the means by the product of the given extremes, and the quotient is the fourth term (= answer.)

Example.—If weaving 1,536 yards of cloth on 8 looms in 12 days, how many yards will be woven on 34 looms in 16 days.

(Looms to Looms.)
8 : 34
(Days to Days.)
12 : 16

(Yards to Yards.)
1,536 : x

$$\frac{16 \times 34 \times 1{,}536}{12 \times 8} = x \quad \text{or} \quad \frac{\overset{2}{\not{16}} \times 34 \times \overset{128}{\not{1536}}}{\not{12} \times \not{8}} = 2 \times 34 = 68 \times 128 = 8704$$

Answer.— 8,704 yards will be woven.

Proof.—8 looms 12 days = 8 × 12 = 96 looms running 1 day.
1,536 yards are woven on 96 looms in one day; thus, 1536 ÷ 96 = 16 yards per day (per one loom).
34 looms 16 days = 34 × 16 = 544 looms running 1 day; thus,
544 × 16 = 8,704 yards will be woven either on 544 looms in 1 day, or on 34 looms in 16 days.

Example.—If weaving 9,448 yards of cloth on 12 looms in 9 days, running the looms 10 hours per day, how many yards of cloth will 20 looms, running 11 hours per day, produce in 12 days.

(Looms to Looms.)
12 : 20
(Days to Days.)
9 : 12
(Hours to Hours.)
10 : 11

(Yards to Yards.)
9448 : x

$$\frac{11 \times 12 \times 20 \times 9448}{10 \times 9 \times 12} = x$$

$$\frac{11 \times \not{12} \times \overset{2}{\not{20}} \times 9448}{\not{10} \times 9 \times \not{12}} = \frac{11 \times 2 \times 9448}{9}$$

11 × 2 = 22 × 9448 = 207856

207856 ÷ 9 = $23095\frac{1}{9}$

Answer.—$23{,}095\frac{1}{9}$ yds. will be produced.

Proof.—12 looms, 9 days, 10 hours = 1,080 hours for one loom
9,448 are woven in 1,080 hours on one loom; thus,
$9,448 \div 1,080 = 8\frac{101}{135}$ yds. per hour on one loom.
20 looms, 11 hours, 12 days = 2,640 hours; thus,
$2,640 \times 8\frac{101}{135} = 23,095\frac{1}{9}$ yds. will be woven either in 2,640 hours on one loom, or on 20 looms running 11 hours per day in 12 days.

ALLIGATION.

Alligation has for its subject the mixing of articles of different value and different quantities.

Alligation Medial.

Rule.—Multiply each quantity by its value and divide the sum of the products by the sum of the quantities.

Example.—Find the average value per pound for the following lot of wool containing mixed:

380 lbs. @ 74¢ per lb.
400 " " 78 " "
200 " " 79 " "
20 " " 94 " "

380 × 74 =	$281.20	
400 × 78 =	312.00	
200 × 79 =	158.00	770.00 ÷ 1000 = 0.77
20 × 94 =	18.80	
1000	$770.00	

Answer.—The price of the mixture is 77¢ per lb.
Proof.— 77¢ × 1000 = $770.00.

Alligation Alternate.

Rule.—Place the different values of the articles in question under each other, and the average rate wanted to the left of them. Next find the gain or loss on one unit of each, and use an additional portion (of one, two or more) of any that will make the gains balance the losses.

Example.—How much of each kind of wool at respective values of 80¢, 84¢ and 98¢, must be mixed to produce a mixture to sell at 88¢ per lb.

88	80	+ 8 × 1 =	8	
	84	+ 4 × 1 =	+ 4	= 12 gain
	98	— 10 × $1\frac{1}{5}$ =		= 12 loss

Answer.—We must use 1 part wool from the lot @ 80¢.
1 " " " " " " 84
$1\frac{1}{5}$ " " " " " " 98 in
$3\frac{1}{5}$ parts, to produce a mixture to sell at 88¢ per lb.

Proof.— (By alligation medial.)
1 lb. × 80¢ .... 80¢
1 lb. × 84 84
$1\frac{1}{5}$ lbs. × 98 .... $117\frac{3}{5}$
$3\frac{1}{5}$ lbs. $281\frac{3}{5}$¢ and $3\frac{1}{5}$ lbs. × 88¢ = also $281\frac{3}{5}$¢

To Find the Quantity of Each Kind Where the Quantity of One Kind or of the Mixture is Given.

Example.—A manufacturer has 200 lbs. of wool of a value of 92 cents on hand which he wants to use up and produce a lot worth 80 cents per lb. He also has another large lot (2400 lbs.) of wool worth 73 cents per lb. on hand. How much of the latter must he use to produce the result; *i. e.*, a mixture worth 80 cents per lb?

$$80 \begin{cases} 92 & -\ 12 \times 200 = 2{,}400 \text{ loss.} \\ 73 & +\ \ 7 \times 342\tfrac{6}{7} = 2{,}400 \text{ gain.} \end{cases}$$

Answer.—He must mix 200 lbs. of the lot at 92 cents per lb. on hand and add $342\frac{6}{7}$ lbs. of the lot at 73 cents per lb. to produce a mixture worth 80 cents per lb.

Proof.— 200 lbs. × 92¢ = $184.00
$342\frac{6}{7}$ lbs. × 73¢ = $250.28\frac{4}{7}$
$542\frac{6}{7}$ — $434.28\frac{4}{7}$ and $542\frac{6}{7}$ lbs. @ 80¢ = also $434.28\frac{4}{7}$.

U. S. MEASURES.

Measures of Length.

12 inches (in.)	=	1 foot (ft.).
3 feet	=	1 yard (yd.).
$5\frac{1}{2}$ yards	=	1 rod (rd.).
40 rods	=	1 furlong (fur.).
8 furlongs	=	1 mile (mi.).
3 miles	=	1 league (lea.).
1760 yards	=	1 mile.
6 feet	=	1 fathom.

Avoirdupois Weight.

16 drachms (dr.)	=	1 ounce (oz.).
16 ounces	=	1 pound (lb.).
28 pounds	=	1 quarter (qr.)
4 quarters	=	1 hundred weight (cwt.).
20 hundredweight	=	1 ton.
1 pound *Avoirdupois*	=	7,000 grains, *Troy*.
1 ounce "	=	$437\frac{1}{2}$ " "

Surface Measure.

144 square inches (sq. in.)	=	1 square foot (sq. ft.).
9 " feet	=	1 " yard (sq. yd.)
$30\frac{1}{4}$ " yards	=	1 " rod (sq. rd.).
40 " rods	=	1 rood (ro.).
4 roods	=	1 acre (ac.).
4840 square yards	=	1 acre.
60 acres	=	1 square mile.

Measure of Capacity.

60 minims	=	1 fluid drachm (fl. dr.).
8 fluid drachms	=	1 fluid ounce (fl. oz.).
20 fluid ounces	=	1 pint (pt.).
2 pints	=	1 quart (qt.).
4 quarts	=	1 gallon (gall.).
2 gallons	=	1 peck (pk.).
4 pecks	=	1 bushel (bus.).
8 bushels	=	1 quarter (qr.).

1 minim equals 0.91 grain of water.

Cubic Measure.

1728 cubic inches (cu. in.)	=	1 cubic foot (cu. ft.).
27 cubic feet	=	1 cubic yard (cu. yd.).

Angle Measure.

60 seconds (″)	are	1 minute (′).
60 minutes	"	1 degree (°).
360 degrees	"	1 circumference (C).

Counting.

12 ones	=	1 dozen (doz.).
12 dozen	=	1 gross (gr.).
12 gross	=	1 great gross (gr. grs.).
20 ones	=	1 score.

Troy Weight.

24 grains (gr.)	=	1 pennyweight.
20 pennyweights	=	1 ounce.
12 ounces	=	1 pound.

Paper.

24 sheets	=	1 quire.
20 quires	=	1 ream.
2 reams	=	1 bundle.
5 bundles	=	1 bale.

Apothecaries' Weight.

20 grains	=	1 scruple.
3 scruples	=	1 dram.
8 drams	=	1 ounce.
12 ounces	=	1 pound.

METRIC SYSTEM.

The Metric System, of weights and measures, is formed upon the decimal scale, and has for its base a unit called a metre.

Units.—The following are the different units with their English pronunciation:

The Metre (meter).—The unit of the Metric Measure is (very nearly) the ten millionths part of a line drawn from the pole to the equator.

The Litre (leeter).—The unit for all metric measures of capacity, dry or liquid, is a cube whose edge is the tenth of a metre (or one cubic decimetre).

The Gram (gram).—The unit of the Metric Weights, is the weight of a cubic centimetre of distilled water at 4° centigrade.

The Are (air).—is the unit for land measure. (It is a square whose sides are ten (10) metres.)

The Stere (stair).—is the unit for solid or cubic measure. (It is a cube whose edge is one (1) metre.)

Measure of Length.

Metric Denominations and Values.				Equivalent in Denominations used in the United States.		
		Meters.		Inches.		
Myriametre (Mm.)	or	10000	equals	393707.904	=	6.21 miles.
Kilometre (Km.)	"	1000	"	39370.7904	=	3 280 ft. 10 in
Hectometre (Hm.)	"	100	"	3937.07904	=	328 ft. 1 in.
Decametre (Dm.)	"	10	"	393.707904	=	32.8 ft.
Metre (M.)	"	1	"	39.3707904	=	3.28 ft. almost 40 in.
Decimetre (dm.)	"	0.1	"	3.9370790	=	almost 4 in.
Centimetre (cm.)	"	0.01	"	0.3937079		
Millimetre (mm.)	"	0.001	"	0.0393707		

U. S. Measures.	Metric Measure.	U. S. Measures	Metric Measures.
1 Inch =	2.5399 Centimeters.	1 Foot =	3 0479 Decimetres.
1 Yard =	0.9143 Metre.	1 Mile =	1609.32 Metres.

Measure of Capacity.

Metric Denominations and Values.								Equivalent in United States Denominations.		
Myrialitre (Ml.)	=	10000	litres	=	10	cubic	meters	=	2200.9670	gallons
Kilolitre (Kl.)	=	1000	"	=	1	"	metre	=	220.0967	"
Hectolitre (Hl)	=	100	"	=	100	"	decimetres	=	22.0097	"
Decalitre (Dl.)	=	10	"	=	10	"	decimetres	=	2.2009	"
Litre (L.)	=	1	"	=	1	"	decimetre	=	1.7608	pints
Decilitre (dl.)	=	0.1	"	=	100	"	centimetres	=	6.1027	cubic inches
Centilitre (cl.)	=	0.01	"	=	10	"	centimetres	=	0.61027	" "
Millilitre (ml.)	=	0.001	"	=	1	"	centimetre	=	0.061	" "

Measure of Weight.

Metric Denominations and Values.									Equivalent in United States Denominations.
Myriagram (Mg)	=	10000	grams.	=	10	cu.	decimetres	of water	22 046 lbs., Avoir
Kilogram (Kg)	=	1000	"	=	1	"	"	" "	2.204 " "
Hectogram (Hg.)	=	100	"	=	100	"	centimetres	" "	3.527 oz., "
Decagram (Dg.)	=	10	"	=	10	"	"	" "	154.323 grams
Gram (G.)	=	1	"	=	1	"	"	" "	15 432 "
Decigram (dg.)	=	0.1	"	=	100	"	millimetres	" "	1.543 "
Centigram (cg)	=	0.01	"	=	10	"	"	" "	0 154 "
Miligram (mg)	=	0.001	"	=	1	"	"	" "	0.015 "

INDEX AND GLOSSARY.

Those marked thus * belong to Volume II, and those not marked belong to Volume I.

A

Abaca or *Manilla hemp.*—The woody fibre produced from the leaf-stalks of a *plantain* or banana, found in abundance in the Indian Archipelago, and extensively cultivated in the Phillipine Islands. The inner fibres of the leaf-stalks are used in India in the manufacture of the finest linens, muslins and other delicate fabrics, whereas the outer fibres are only fit for matting, cordage and canvas.

Acids.—Impart a red color to vegetable blues.

——— Possess an acid taste.

Alkalies.—Are distinguished by their alkaline taste. Potash, soda and ammonia are alkalies.

——— Change vegetable blues to green, and restore the blue to a substance which has been reddened by acid.

Alpaca.—The name of a thin kind of cloth produced from the wool of the Alpaco.

Ammonia can be prepared by heating in a glass flask one part of sal ammoniac and two parts of powdered quicklime.

Analysis.—The art of resolving a machine, fabric material, etc. into its constituent parts.

Analysis of Textile Fabrics.—See page 257 of Technology of Textile Design.

Anti-snarling Motion, *or Hastening Motion.*—A device of the improved mule; the same is actuated from the copping motion, and slightly increases the speed of the spindles at the end of the draw If a snarl is formed, this motion will throw the snarl onto the spindle point, when it will be taken out by the drag.

Anthracæmia.—Technically for wool-sorters' disease, derived from *anthrax* and *hæma* (or blood), the former being found in the latter.

Asbestus.—A mineral substance of fibrous texture, of which several varieties differing in color and composition are found, all of which are characterized of resisting the action of fire. By the ancients, asbestus cloth was used for enshrouding dead bodies during cremation, so that the ashes of the corpse might be preserved distinct from the wood composing the funeral pile. It is still manufactured into a material for packing purposes, by soaking the lumps of fibre for a long time in water, and by repeated washings separate the filaments from the earth which binds them together. The threads are then moistened with oil, and mixed with a small quantity of cotton, next spun and woven in the ordinary manner, after which the cloth is burnt so as to destroy the cotton and oil.

Astrakhan.—A warp pile fabric, used for ladies' cloakings, trimmings, etc. For the construction of these fabrics, see page 173 of Technology of Textile Design.

Avoirdupois Weight.—One pound avoirdupois is the weight of 27.7015 cubic inches of distilled water at 39.83° F., the barometer being 30 inches.

B

Backed Cloth.—This name applies to cloth which, in addition to the face fabric, bears bound underneath a layer either of extra filling, extra warp or another cloth.

Backing.—The filling which produces by interlacing with warp threads, the lower or back structure in a fabric.

Backwashing.—The process of washing wool a second time, i.e. after the same has been transferred by carding in a sliver.

Baize.—A coarse woolen stuff, principally manufactured for linings, and generally made either in scarlet or green.

Balling-Head.—The same is a modification of the common side-drawing spool-system, consisting in appliances for winding the sliver in balls, under considerable pressure.

Bandannas.—Handkerchiefs of cotton or silk, in which spots or figures are left in white or some bright color upon a ground of red or blue

Barras.—A coarse kind of cloth ; sack-cloth.

Barrege.—An open fabric resembling gauze, but more open in texture and stouter in thread. It was made of various materials, but is best known as made of silk warp and worsted filling. When it became fashionable, it was imitated in all-wool, and subsequently cotton warps were used. The fabric takes its name from the district in which it was first manufactured, the especial locality being a little village named Arosons, in the beautiful valley of *Barreges*, France.

Basket-weaves.—A sub-division of the plain weave.

——— For the construction of these weaves see pages 42 and 45 of Technology of Textile Design.

Batten.—A part of the Jacquard machine ; the frame which carries the cylinder in its motion to and from the needle-board.

Baudekin.—A very rich silk, woven with gold. A rich cloth now called *brocade*. The name originates from *Baldacus*, Babylon

Beaver. – A beautiful fur, once used exclusively in the manufacture of hats and now bearing a limited sale for articles of dress.

——— The name given at present also to smooth-face finished overcoatings made on the double cloth system.

Berlin Wool.—Known also as German wool. A material for working in needle-work.

Bicarbonate of Soda.—Is obtained by exposing the carbonate in an atmosphere of carbonic acid gas.

Binder-warp.—The warp threads producing the foundation of a fabric ; interior warp ; this warp is generally not visible in the finished fabric. Used in Astrakhans, Velvets, Brussels carpets, Upholstery fabrics, etc.

Blanket.—A woolen cover, soft and loosely woven.

Bleaching.—From the Fr. *blanchir*, to whiten. Originally known as whiting.

Blending.—Technically for mixing various materials or different qualities of the same material.

Bleach Cotton.—*Bucking.*—The cotton yarn or fabric is first boiled in water. When sufficiently boiled, 4 lbs. 7 oz. caustic soda and 4 lbs. 6½ ozs. silicate of soda, both previously dissolved, are added for each 220½ lbs. cotton material. Boiling preferably under pressure is continued for three or four hours. *Chloring.*—The material is rinsed, squeezed or wrung, and entered in the chloring vat, containing a solution of chloride of lime, ½ deg. to ¾ deg. B., at a temperature of 86 deg. F. The material remains in the bath for three or four hours. For 100 lbs. material, use about 4 lbs. chloride of lime. *Neutralising* —Take out the material, let it drip off well, and then enter it for thirty or forty minutes in a sulphuric acid bath, which, for each 100 lbs of material to be treated, contains about 6 or 8 lbs. of acid. Then take out, beat and wash carefully in cold water. Enter in a boiling soap bath containing a little soda, rinse and blue, after the material has been sufficiently boiled. If this is not sufficient, repeat the entire process. *Blueing* —For this process it is best to take a vat about 3 feet deep and 28 to 32 inches in diameter, fill it with water of 77 deg. to 86 deg. F., and add a proper quantity of ultramarine. The hanks are pressed through singly, and when the bath becomes too pale, add more ultramarine. The hanks are wrung out and placed upon a stand. When a certain quantity has been blued, it is entered in the press. Should the blue change, or should the material have a smell of sulphuretted hydrogen, it has been rinsed insufficiently.

Bleach Cotton Fabrics.—*1. With alkaline lye.*—Boil the cotton fabrics in water, after which add 2 lbs. of caustic soda, and same quantity of silicate of soda per 100 lbs. of material (the caustic soda and the silicate of soda should be previously dissolved). Then boil under pressure for three or four hours. *2. With chlorine.*—The goods are rinsed, pressed or wrung out, and placed in a chlorine vat, which has previously been prepared with a solution of chloride of lime, ½ to ¾ deg. B., at a temperature of 30 deg. They remain from 3 to 4 hours in the bath, 4 lbs of chloride of lime being used to each 100 lbs. of cotton. They are then acidified, by being first drained and then placed in a bath containing sulphuric acid, of the strength of 6 lbs. to 8 lbs. of sulphuric acid per 100 lbs of cotton. They should remain from 30 to 40 minutes in this bath, and when taken out, carefully washed in clean water and then placed in a boiling soap bath containing a small quantity of soda. They are again rinsed, and blued if required. If not sufficiently bleached, the chloring should be repeated *3. With chlorate of potash.*—First wash articles clean with soap. Afterwards dip into a bath of 100 to 104 deg. F., containing 1 lb of chlorate of potash per 100 lbs. of goods, and acidify with chemically-prepared, pure hydrochloric acid, until it obtains a distinctly acid smell, the trace of acid being afterwards removed by the goods being placed in a bath containing ½ per cent. of borax, after which rinse in flowing water, and dry in the air. With chlorate of potash great care is required. It should not be allowed to come in contact with concentrated acids or inflammable substances, such as sulphur or phosphorus, as accidents may occur. This process, though simple, meets with disfavor.

Bobbin.—The filling is wound on the bobbin, and the latter placed in the shuttle.

Bombasin.—A light silken stuff for mourning; also called bombazin or boratto.

Boss of a Roller.—The body of a roller, thus distinguished from the axle on which the same turns.

Bouchon.—The actual inventor of the principle of the Jacquard machine.

Brussels Carpet.—The same were introduced to Wilton, England, from *Tournai* Belgium, rather more than a century ago. For construction of the same, see my Technology of Textile Design, page 188.

Brocade.—A silk fabric with a pattern of raised figures.

Brocatel or *brocadel.*—A coarse brocade, chiefly used for tapestry.

Broken Twills.—Are twill weaves in which the direction of the characteristic twill line is arranged to run partways of the repeat in the weave from left to right, and partways from right to left. For their principle of construction, see page 52 of Technology of Textile Design.

Bur.—The prickly head of some plants which adheres to clothes like a flock of wool. The word *burr*, a peculiarity of speech, comes from the same source, and literally means to speak as if a flock of wool were in the throat.

Burring ... 107

Burring Device for First Breakers ... 125

Burring Machine and Metallic Breast Combined ... 129

Burr-Picker ... 109

Burl.—*Burling*, to pick the burrs or burls (also knots caused in spinning, dressing or weaving) from the surface of woolen cloth.

C

Caffa.—A rich *mediæval* stuff, probably of silk.

Calculations.—See Textile Calculations.

Calendering.—The process by which stuffs of various kinds are subjected to great pressure between rollers to make them smooth and finished.

Calico.—A common cotton cloth. The name is derived from *Calicut*, a city on the coast of Malabar, discovered by the Portugese in 1498, from where it was first imported. All early calicoes, until Hargreaves invention of the spinning jenny, were composed of linen warp yarn and cotton filling.

Cambric.—Derived from *Cambray*, a city in the French Netherlands, well known for its linen manufactures, especially cambrics.

Camel ... 93

Camel's Hair ... 93

Cam Loom.—A loom in which the harnesses are actuated on by cams.

Cancellation ... *90

Can Finisher.—A style of a gill-box used in balling or top making ... 167

Can Gill-box ... 167

Can Stop-Motion for Drawing Frames ... 51

Canvas.—From the *Lat. cannabis*; is literally hempen cloth.

Cap.—A steel cup (just large enough to cover the spinning bobbin) placed, mouth downwards, over the spindle of a cap frame.

Cap-Frame ... 173

Cap-Spinning.—For worsted yarns (English system) ... 172

Capuchin.—A hooded cloak for women, worn about the middle of the 18th century, and so called from resembling those worn by the order of friars of that name.

Carbonate of Soda.—Is obtained from sea salt by a series of chemical decompositions and processes.

Carbonization of Wool ... 107

——— with Acid Vapors ... 109

——— with Chloride of Magnesium ... 108

——— with Chloride of Aluminum ... 108

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——— with Sulphuric Acid ... 108

Card.—A toothed instrument for disentangling and laying parallel the fibres of wool or cotton, preparatory to spinning.

Card Clothing Mounting Machine ... 41

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Cardinal.—A short cloak, first worn with a scarlet hood, worn about the middle of the eighteenth century.

Carding, Combing, Spinning of Silk ... 189

——— Engines for Cotton Carding ... 30

——— Engine.—Its inventor is not positively known, Louis Paul patented in 1748 in England, two different machines for carding, in one of which the cards were arranged on a flat surface, and in the other on a drum.

Carding of Cotton.. 29
——— of Flax.. 201
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Carriage.—The technical name of a part of the Piano Card stamping machine ; see page 88 of The Jacquard Machine Analyzed and Explained.
——— The technical name of a part of the Repeating Machine ; see pages 93 and 96 of The Jacquard Machine Analyzed and Explained.
——— The technical name of a part of the Mule and Spinning machine.

Carriers.—Technically for carrying rollers; being small rollers supporting the slubbing or roving, between the front rollers of drawing machines, spinning frames, etc.

Carpet.—Carpets have been quite diverted from their original use, which was in covering tables (in this sense is derived the proverbial phrase "On the carpet" that is, brought to the table for discussion) sideboards, or cupboards. The manufacture of carpets so-called, is traced back in the records of French monastic orders as far as the tenth and eleventh centuries, but in all likelihood these were mere embroidered and not woven fabrics. The actual manufacture of carpets in Europe is assigned to the reign of Henry IV. of France, between 1589 and 1610, and is said to have been introduced there from Persia. An artisan, who had quitted France in disgust established the industry in England about 1750. (See Brussels carpet, Ingrain carpet, etc.)

Cartwright, Edmund.—The inventor of wool-combing and weaving by machinery.

Carrying Comb.—That portion of the nip-comb which carries the wool from the nip to the circle.

Cashmere Goat..

Cashmere Shawls.—These celebrated articles are made in the beautiful valley of *Cashmere*, in the northwest of India, and are produced from the woolly undercoat of the fur of the *Cashmere goat*. The high price of the fabric is due to two facts; first, in order to produce a single shawl 1½ yards square, at the least ten goats are robbed of their natural covering, since a single goat only produces from three to four ounces of it ; secondly, their high price is due to the slow and laborious process of manufacture, which is such that a fine shawl having a pattern over its entire surface is sometimes a year on the loom, and even an ordinary shawl will take from sixteen to twenty weeks. It is claimed that in some instances over $3,000 have been paid for a single shawl, that very few of the finest of them find their way into Europe or this country. The commonest qualities range in price as low as $50. The annual produce of the country is estimated at 30,000 shawls, occupying about 16,000 looms, and near 50,000 work-people. Under the Mogul emperors Cashmere found work for 30,000 looms. The fabric is principally woven in strips, which are afterwards ingeniously joined together; the borders are worked in needlework by hand, each color employed occupying a separate needle. No shawls are made except upon order, and according to patterns already approved. The French, in factories at Lyons, Nismes, and Paris, are believed to have been most successful in copying these fabrics, though very fair imitations have been produced in England, at Paisley, Norwich and Edinburgh.

Cassimere.—Derived from Kerseymere, a finer description of Kersey, which is said to have taken its name from the factory at which it was originally manufactured having stood on a *mere* or brook running through the village of *Kersey*. It is at present the common name for fancy woolen suitings and trouserings.

Cellulose.—The chemical composition of full ripe cotton ; being a combination of carbon, hydrogen and oxygen technically expressed by $C_6 H_{10} O_5$.

Centigrade and Fahrenheit Scales Compared, Approximate.

Centigrade		Fahrenheit.	Centigrade.		Fahrenheit.	Centigrade.		Fahrenheit.	Centigrade.		Fahrenheit.
100°	=	212°	80°	=	176°	60°	=	140°	40°	=	104°
98	"	208	78	"	172	58	"	136	38	"	100
96	"	205	76	"	169	56	"	133	36	"	97
94	"	201	74	"	165	54	"	129	34	"	93
92	"	198	72	"	162	52	"	126	32	"	90
90	"	194	70	"	158	50	"	122	30	"	86
88	"	190	68	"	154	48	"	118	28	"	82
86	"	187	66	"	151	46	"	115	26	"	79
84	"	183	64	"	147	44	"	111	24	"	75
82	"	180	62	"	144	42	"	108	20	"	68

Challis.—A fabric of silk and worsted, with designs either produced in the loom or printed, first introduced in 1832 at Norwich, England. In construction the fabric is similar to crape, only thinner and softer, composed of much finer materials, without gloss, and very pliable and clothy.

Chase.—The extent of the traverse of the winding faller wire on a mule.

Chenille.—A fringed thread used either for filling in the manufacture of rugs, curtains, coverlets; or in its first woven state in trimmings, fringes, etc. The name is derived from its resembling a caterpillar in softness, from the chenille or cotton caterpillar, a great enemy of the cotton plant. For construction see pages 153, 158 and 244 of my Technology of Textile Design

China-Grass.—Consists of the bast cells of Boehmeria nivea, belonging to the nettle family uticaceæ.

Chinchillas.—Filling pile fabrics, used for overcoatings. For their construction, see page 152 of Technology of Textile Design.

Chintz.—Printed or stained calicoes. A word of modern introduction from the Hindustanee, where it signifies spotted.

Coburg.—A modification of what had previously been known as *Paramatta* cloth.

Cocoa Matting.—Made from *coir-fibre*, obtained from the fibrous outer covering of the *cocoanut*, which is largely imported from India and Ceylon, in the shape of prepared yarn.

Colors.—*Primary*, blue, red, yellow; *Secondary*, purple, orange, green; *Tertiary*, *a*, russet, olive, citron; *Tertiary*, *b*, brown, maroon, slate.

Color Harmony.—Every color has its perfect harmony (contrast), and also other colors which harmonize with it in different degrees. When two colors are to be used in a textile fabric, which do not accord, the proper selection of a third may make a harmonious combination.

Comber-board.—Also called *Cumber-board* or *Compart-board*, a perforated board which guides and keeps the harness cords of the Jacquard harness in the required positions. For illustrations and explanations see pages 20, 21 and 22 of The Jacquard Machine Analyzed and Explained

Condenser.—That portion of a carding engine (for woolen yarns) which divides the fleece of fibres when leaving the doffer into a number of small roving strands ready for spinning.

Cop.—The spool of yarn formed on a mule.

Cop-Stopping Motion.—A device of the improved mule; the same stops the mule when the cops of any desired length are completed.

Corduroy.—Pile fabrics produced by an extra filling. A thick corded stuff of cotton. The name is of French origin, where it was originally *corde du roi*, the King's cord. For their construction see page 149 of Technology of Textile Design.

Corkscrew Weaves.—A sub-division of the regular twills. For their construction see page 68 of Technology of Textile Design.

Cotton.—The soft, downy substance growing around the seeds of various species of cotton plant, Gossypium O. Malvaceæ.

Counts.—The number given to any thread (except raw silk) according to the number of yards that weigh one pound.

——— The number of hanks of yarn in one pound weight.

——— The system of indicating the fineness of yarn, written by placing 's after the figures, signifying the number of hanks per pound ; thus, "60's" ; otherwise *number*.

Counterpane.—A corruption of counterpoint, the old name derived from the French *courtepoint* or *point contre*, stitch against stitch, denoting something sewed on both sides alike. This method was and is used when bed coverings were stuffed with some warm material, wadding, and were sewed through and through to keep the wadding in place.

Coverlet.—The outermost of the bed clothes. That cover under which the rest is concealed.

Crape.—A thin, transparent, crisp (crumpled) or smooth silk, worsted, or silk and worsted stuff, usually black, and used in mourning. If crisp or crumpled *double*, they express a closer or deeper mourning than if smooth or *single*. The invention of this stuff came originally from Bologna, Italy.

Creel.—A frame in which feed bobbins are placed.

Crochet.—Fancy knitting made by means of a small hook.

Cross-Weaving or Gauze.—The second main division of weaving. See page 228 of Technology of Textile Design.

Crown of Card Clothing.—The number of wires in one inch along a sheet of card clothing.

Curved-Twills.—Weaves produced by the combination of regular twills and steep-twills. For their construction see page 62 of Technology of Textile Design.

D

Damask.—A stuff denoting by its name the place where it was originally manufactured. It is true that figured fabrics have been known from time immemorial among the Chinese, and similarly can be traced among stuffs of Babylonian origin ; but it was not until the 12th century, when *Damascus* attained a perfection in weaving then unexampled, that we find splendid patterned stuffs becoming common or generally known Damascin or Damascus cloth became thus synonymous with excellence and splendor, and in time came to denote any stuff of rich working and elaborate design. Italy is the European home of this manufacture, and for a long period it flourished there exceedingly, so that as late as the 17th century, Genoa supplied nearly all Europe. True damasks are wholly of silk, but the term is now applied to any fabric of wool, linen or cotton, woven in the manner of the first damasks It is only since the manufacture has thus included all materials that it has been generally worn, those of silk being far too expensive for the average lot of people, and when purchased by the rich being handed down from generation to generation as heirlooms.

E

F

Floss-Silk.—The ravelled silk broken off in winding the *cocoons*, which is afterwards carded and spun, and known as spun silk.

Flyer.—A horizontal steel bar with two vertical arms, each with an eye or twizzle at their lower extremities, which is placed on the spindle. Around one arm the yarn is wound in its passage onto the bobbin. The rotary speed of the flyer being greater than that of the bobbin, puts the twist into the yarn.

Flyings.—The loose short fibres liberated during picking, carding, combing, drawing, spinning.

Fly-Shuttle.—Invented by John Kay, a native of Walmersley, Lancashire, England, in 1733. Previously to Kay's invention of the fly-shuttle it required two men to work a broad loom, one at each side of the loom, and the shuttle was thrown from one to the other alternately. The inventor died in France, in obscurity and poverty, to the disgrace of his countrymen. The invention has been described by him in his patent, No. 542, May 20th, 1733, as follows: "And that he hath likewise found out and contrived a newly-invented shuttle, for the better and more exact weaving of broad-cloths, broad-bays, sail-cloths, or any other broad goods, woollen or linen, which shuttle is much lighter than the former, and by running on four wheels moves over the lower side of the well spring, on a board put under the same and fastened to the layer, and which new contrived shuttle, by the two wooden tenders, invented for that purpose, and hung to the layer, and a small cord commanded by the hand of the weaver, sitting in the middle of the loom, with great ease and expedition, by a small pull at the cord, casts, or moves the said new invented shuttle, from side to side at pleasure, and also strikes the layer, by his pulling it in the middle, uniformly over the piece, making it unavoidably even, and much truer and better than any method hitherto used."

Foundation Weaves.—Plain, twill and satin weaves.

Frame.—Technical grading of Brussels carpets.

Fuller's Earth.—A species of clay, of a greenish white, greenish grey, olive and olive green and sometimes spotted color. It is usually opaque, very soft and feels greasy. It is used by fullers to take grease out of cloth before they apply the soap. When of a good quality it falls into powder in water, appears to melt on the tongue like butter, communicates a milky hue to water, and deposits very little sand when mixed with boiling water.

Full, Fulling.—To press cloth in a mill, to scour or thicken in a mill. The old method of fulling cloth was to tread it with the feet; hence come our surnames of *Fuller*, *Walker* and *Tucker*, fullers being known as walkers or tuckers, from walking on or kneading the cloth when under treatment. The object of fulling is to work the fibres so that the surface may not show the naked transverse threads, but form a felted mass, fulling being really only a kindred process to felting. Manual labor is of course superseded, and the old fulling or tucking mills have already years ago been replaced by vastly-improved machinery.

G

Garter.—A band or ribbon to tie up stockings from the Welsh *gar*, the shank, or Fr. *gartier*, *Jarretieres-Jarret*, the hough of the leg.

Gauge.—The distance from centre to centre of splindles or rollers.

Gauze.—A name given to a woven fabric of transparent texture, first introduced into Europe from *Gaza*, a city of Palestine. Gauzes are fabrics characterized by not having their warp threads parallel near each other, as observed in ordinary weaving. For construction of either plain or figured gauze see my Technology of Textile Design, page 228 to 250.

Gigging.—The process of producing a nap on cloths

Gill Box.—A machine used in the process of worsted spinning for elongating and levelling the sliver, either previously or succeeding the process of combing, by means of a pair of feeding and a pair of delivery rollers, with a set of fallers travelling between them by means of screws.

H

Holden, Isaac.—The inventor of the square motion comb.

Honeycomb-Weaves.—For their construction see page 98 of Technology of Textile Design.

I

Ingrain Carpets.—Ingrain as applied to carpets was originally intended for a fabric where the wool was colored before carding and spinning, but which is not true at present, as the yarn is mostly manufactured before coloring. The great variety of colors used in an ingrain carpet at the present time, the constant changing of styles, besides the saving of expense by coloring the yarn after spun, are the reasons for it. Ingrain carpet in our country means the same as Scottish or Kidderminster in Europe. For construction of the fabric, see my "Jacquard Machine Analyzed and Explained," pages 71, 72, 81, 82, 92, 106, 116 and my Technology of Textile Design, page 225.

J

Jack.—A part of the harness-motion in a loom.

Jacquard, Joseph Marie.—The inventor of the Jacquard machine, born in Lyons, France, 1752. For more details, see history of the Jacquard machine. in "The Jacquard Machine Analyzed and Explained"

Jacquard Loom.—A loom furnished with the Jacquard arrangement.

Jean.—A twilled cotton cloth, generally supposed to derive its name from *Jaen*, Spain.

Jersey Cloth.—A fabric characterized by its great amount of elasticity; generally produced by knitting.

Jute.—The name for the bast fibres of *corchorus olitarius* and *corchorus capsularis.*

Jürgen, Johann.—A native of Wolfenbüttel; the inventor of the spin-wheel.

K

Kemp.—A horny kind of hair, mostly found on poorly-bred sheep, resisting the amalgamation required by spinning. The same will neither take a uniform color with the rest of the wool in dyeing.

Knitting.—The formation of a continuous web or fabric by making loops in a single thread; the destruction of one loop threatens the structure of the whole piece, unless the meshes are reunited. The simplicity of the operation, and the ease with which it may be learnt and performed, make it probable that this kind of knitting (with needles), as well as others, was known and practiced, if not by the antediluvians, by their immediate descendants.

L

Lace.—There are two kinds of lace, point and pillow.

Point lace, which is a much more ancient art than the making of pillow lace, is made with the needle.

Point or needle-made lace is said to have been invented by the Italians at a very early period, and during the 16th and 17th centuries became of very general use in England, as may be observed in the huge frills, collars and ruffs worn in the time of Queen Elizabeth, Charles I., and Charles II.

On the other hand, pillow lace is of more recent date, and the history of its invention is known, for Beckmann, with evident satisfaction, says: "I will venture to assert that the knitting of lace is a German invention, first known about the middle of the 16th century; and I shall consider it as true, until it be fully contradicted, the account given us, that this art was found out before the year 1561, at St. Annaberg, by Barbara, wife of Christopher Uttmann. This woman died in 1575 in the sixty-first year of her age." The statement does not appear to have ever been disproved, and it is recorded upon her tomb. Uttmann was a master miner, and his wife, observing that the girls made caps for the miners, taught them to make them on this new plan. She afterwards set up a workshop at Annaberg for the making of lace of different patterns; and it is this description of lace, or pillow lace, with which we are now concerned. There are several varieties of it, such as Brussels, Alençon, Lisle, Honiton, etc., which differ according to the meshes, twistings, thick or thin threads, and other details, but not in the principle of the operation. The production of pillow lace is effected simply by twisting together a number of threads in the order and combination necessary to produce the desired pattern. To do this, the design is first drawn upon a piece of parchment, and holes are made in the outline of the design for the insertion of pins. Round these pins the threads are twisted, so as to form meshes. Thick and thin threads can be combined, or three or more together. As the lace is made the pins are moved. In the process of knitting the operation is different, in order to form the fabric. Knitting, in its simplest form, is effected by using one thread only, upon which a series of loops are made, and they are connected together by intersecting each other, as is well understood in the common process of knitting. Knitting and lace making are therefore widely different in their modes of production; but nearly all the first attempts for the making of lace were tried upon modifications of the stocking-frame.

In the production of figured lace it is requisite that the threads should be arranged in such manner that they can be twisted round each other any number of times, and in any quantity and arrangement. In bobbinet it is also requisite that the threads should be twisted around each other, and follow the arrangement necessary for the production of meshes of uniform size and order.

Lace-making.—Consists in twisting any desired number of threads round each other in such a manner as to form meshes, or, according to the definition given by Johnson, it is "Anything reticulated or decus ated at equal distances, with interstices between the intersections." The threads may be twisted either two, three or more together, or thick and thin threads may be so combined. For the formation of any desired pattern or figure, it is requisite that any one or more of the threads may be twisted round any one or more of the adjoining threads. It is not necessary that the threads should be able to pass completely from side to side of the lace and then be made to twist round the most distant threads, but so long as they can be moved a moderate distance, with perfect freedom, to be twisted together with one or more of the neighboring threads, that is all that is required for making ordinary lace.

Landtsheer's Decorticator 216

Lantern.—The iron extension put on the cylinder of Jacquard machines. The cylinder is turned by means of the catches working on the lantern.

Lap-feeding System 130

Lap-winder, or **Roving Spooler.**—For woolen carding........125–130

Lappet-weaving.—For illustration and explanation of same, see page 123 of Technology of Textile Design.

Lap-winder........ 40

Larva, or **Worm.**—The second stage of the silkworm........ 176

Lay, Lathe or **Batten.**—A part of the loom. To it are secured the shuttle-boxes and the reed.

Lawn.—A sort of fine linen cloth. The name is derived from the French *Linon*. Remarkable for being originally used in the sleeves of bishops.

Lead.—The excess of the revolution of a bobbin, flyer, or traveller over each other.

Leaf.—The same as harness; thus either 3-leaf twill or 3 harness twill, etc.

Leash.—Two or more harness cords combined and adjusted to one neck-cord.

Leicester Sheep........ 85

Lemaire Feeder........ 121

Length of Wool Fibres........ 75

Leonardo da Vinci.—The inventor (?) of the spindle (1452.)

Levantine.—A stout twilled silk, so named from having originally been brought from the Levant.

Licker-in.—The first roller of a carding engine, or a metallic breast, with which the wool, after leaving the feed-rolls comes in contact.

Lifter.—Also called carriage. The plate which travels up and down the spindles of a drawing box or spinning frame, and on which the bobbins rest.

Linsey Woolsey.—Cloth of linen and woollen mixed together, of different and unsuitable parts; vile, mean.

List (Listing)—Is derived from *liciæ*, which, in the age of corrupt Latin, was used for the inclosures of fields and cities, as being anciently made with cords interlaced; or from *listæ quia campum claudebant instar listarum panni;* as enclosing the ground after the manner that a list does a piece of cloth. List, in manufacturing, denotes the border of a stuff, or that which bounds its width on each side. In addition to being a necessity to the fabric, they contribute to good appearance. (See also Selvage.)

Loom.—Literally, *an utensil;* from the Anglo-Saxon *loma*, furniture utensils. (See also power loom.)

Lustre.—The glossy or shiny appearance which certain kinds of cotton, worsted, silk, flax and ramie yarns possess, and which causes fabrics made of them to look bright.

M

Mails—Are made of metal, and form the centre part of twine heddles; in the eye of the mail the warp threads are drawn.

Manufacture.—Derived from *manus*, the hand, and *factura*, a making. In its etymological sense means any system or objects of industry executed by hands; but in the vicissitude of language it has now come to signify every extensive product of art which is made by machinery, with little or no aid of the human hand, so that the most perfect manufacture is that which dispenses entirely with manual labor.

Mate Threads.—Technical name used in two-ply ingrain carpets, reversible overcoatings constructed upon the double cloth system, etc. One ground-thread and its corresponding figure thread.

Measure.—Derived from *mensura*, a measure. That by which extent is ascertained or expressed; a stated quantity.

Mitten.—Gloves (covering the fingers) made of linen or woollen, whether knit or stitched. Mittens have been in use from time immemorial.

Mitts.—Derived from *mitan*, middle, because they are *chirothecæ veluti dimidiatæ*, leaving the fingers unconfined.

Mohair.—Of *Mojacar*, an Indian word. The fine silken hair of the Angora goat of Asia Minor. It is largely used in the manufacture of light weight dress goods, characterized by their lustre. In pile fabrics, as plushes, velvets, Astrakhans, etc., of a plain or figured denomination, mohair is frequently used for pile-warp, while the ground or body is made of cotton.

Moire.—Watered silk, from *moirage*, the French term for watering of stuffs.

Monge.—A noted French savant. He discovered first the serrated surface of the wool fibres.

Motes.—Fragments of broken seeds or leaves in cotton.

Moth *or Adult.*—The fourth stage of the silk-worm.......... 177

Mouflons or Wild Sheep 81

Mountain Flax.—See Asbestos.

Mulberry Silk-Worm 176

Mule for cotton spinning.......... 66

Mule for worsted yarns.......... 175

Mule for wool spinning.......... 144

Multiplication *86

Multiplication of Common Fractions.......... *94

Multiplication of Decimal Fractions.......... *99

Mungo.—The waste produced from hard-spun or felted cloth, and which is used again in the manufacture of low grades of woollen fabrics.

Muslin.—A fine fabric of cotton having a downy nap upon its surface. The origin of the word has been traced to its downy surface through the French *mousse*, moss.

N

Nankeen, *Nankin, Nanquen.*—A stuff made from a cotton of brownish yellow tint. The fabric came originally from Nankin, China Blue, white and pink varieties have been made, but brownish-yellow variety, so often seen in wear for trousers by gentlemen, and known to be worn in corsets by ladies, is the Nankin with which the name is most generally associated.

Nap.—The woolly substance on the surface of cloth. The ends of fibres extending, fur-like, outside a thread; most prominently found in woollen yarn.

Napkin.—Derived from Fr. *nappe*. Literally means a little cloth.

Neck-Cord.—The cord combining leash and hook in a Jacquard harness.

Neps.—Small knots or tangles of fibres.

New Differential Motion 58

Nip-Comb.......... 157

Noble Comb.......... 162

Noble, James.—The same and G. E. Donisthorpe are the inventors of the Noble comb.

Noil.—The short wool fibres as separated from the long by means of combing.

Norfolk Sheep.......... 87

Nose.—The extreme upper point of a cop.

Nurmah *or Deo Parati.*—The Indian name for Gossypium arboreum.

O

Obtain Speed of a Machine, when speed of shaft, size of driving pulley and pulley on machine are given.—Multiply revolutions of shaft per minute by diameter of driving pulley in inches, and divide by the size of driven pulley in inches.

Example.—Speed of shaft, 100 revolutions per minute; size of driving pulley, 10 inches; size of driven pulley, 5 inches

$100 \times 10 = 1000 \div 5 = 200$, or speed of machine.

Obtain Required Speed of Shafting, when size of driving pulley and the required speed for machine, with size of driven pulley are given.—Multiply the speed of machine by the diameter of driven pulley in inches, and divide by the size of driving pulley in inches.

Example.—Speed of machine, 100; driving pulley, $12\frac{1}{2}$ inches; driven pulley, 10 inches.

$100 \times 10 = 1000 \div 12\frac{1}{2} = 80$, or required speed of shafting.

Obtain the Size Required for Driving Pulley when speed of machine and size of driven pulley, and speed of driving shaft are given.—Multiply speed of machine by diameter in inches of driven pulley, and divide by the revolutions per minute of the driving shaft.

Example.—Speed of shaft, 80 revolutions; speed of machine, 100; driven pulley, 10 inches.

$100 \times 10 = 1000 \div 80 = 12\frac{1}{2}$ inches, or size of driving pulley.

Obtain the Speed of a Driven Shaft.—Multiply the number of revolutions of driving shaft by the diameter of driving pulley in inches, and divide the product by the diameter of the driven pulley in inches.

Example.—Revolutions of driving shaft, 80; diameter of driving pulley, 12 inches; diameter of driven pulley, 10 inches. $80 \times 12 = 960 \div 10 = 96$. *Answer.*—96 turns is the speed of the driven shaft.

Oil.—Kinds to use: quantity to be used; testing 116

Oiling of Wool 115

Oiling Saws of Saw-Gins 19

Open Drawing-Boxes 168

Open Drawing for worsted spinning 167

Open-Shed Loom.—The name of a loom which by means of its harness motion changes the position of the harness only when so required by the weave, consequently acts as easy as possible on the yarn; and this with an additional allowance for high speed.

Opening of Cotton 24

Opening and First Picking of Cotton 24

Organzine Silk 185

Orleans Cloth.—Figured dress goods made of cotton warp and worsted filling, and first manufactured in *Orleans*, France.

Osnaburg.—A kind of coarse linen, principally made in and named from that province in Hanover.

Oxford-Down Sheep 85

P

Paco *or Alpaco* 94

Paramatta.—The name of a fabric which manufacture originated in Bradford, England, being an imitation in cotton and worsted of merino. The name is derived from Paramatta, a town in New South Wales, from where the first wool for the manufacture of these fabrics was imported.

Parenthesis or Brackets *89

Parkhurst Burr-Picker 109

Peckham Feeder 120

Penistone Sheep 87

Perfect Structure of Cloth *58

Piano-Feed 28

Pick.—The insertion of a thread of filling in the warp (at the loom).

Picking of Cotton.—Its principle 26

Piecing.—The uniting of two ends of sliver, roving or yarn.

Pile Fabrics.—Articles characterized by a soft covering overspreading the ground-structure of the fabric.

Plain-Weave.—Also called cotton weave; in this weave, warp and filling cross each other at right angles, and interweave alternately.

Ply.—The thicknesses or layers of fabrics—for example, two-ply, three-ply, etc. cloth referring to double or triple cloth.

Pointed Twills.—A sub-division of the regular twills. For their construction see page 80 of Technology of Textile Design.

Polishing—Of cotton yarns 72

Polyvoltines 177

Portland Sheep 87

Positive Motion.—A motion driven by gearing, distinct from one driven by friction or some non-positive force.

Potash—Is obtained principally from the ashes of burnt wood and plants. The ashes are boiled in water, and the solution is evaporated to dryness. This is ordinary pearl ashes.

Potash Soaps—Are made from carbonate of potash, causticised with lime or with pure caustic potash. A potash soap is a better cleanser than a soda soap.

Pot-Eye.—The small cup with a slit in it, set in a spinning-frame for the thread to run down, and to avoid friction.

Power Loom.—Automatic looms constructed to be worked by other than manual labor. Dr. Gennes, a French naval officer, published in 1768 the description of a "new engine to make linen cloth without the aid of an artificer," which practically anticipated the modern power loom, and to this futile endeavor to supersede hand labor is generally ascribed the honor of first attempting to facilitate production. Lewis Paul (a well-known English inventor), thirty years previous, had constructed and patented a machine with that object, although, as with that of Dr. Gennes, nothing came of it. About 1750, a swivel loom was produced by Vaucanson (the well-known inventor of the principle of the Jacquard machine), and tried in 1765 at Manchester.

The next endeavor was made in 1784 by an English clergyman, Dr. Edmund Cartwright, and with so much success that modern machines are only modifications of his first power loom, although, after spending a sum of from £30,000 to £40,000 in patent fees, experiments, and efforts to establish his inventions, he yet had ultimately to abandon all hope of success. The one obstacle which defied all efforts to obviate it was the tenderness of the warp yarn, which frequently broke, and then necessitated the stoppage of the machine to join it. Subsequently the warp was sized to strengthen it, but the machine still had to be stopped at intervals, and a man needed at each loom for this purpose. The cost of this still prevented the machines paying their way, and the difficulty was not overcome until 1804 by the invention of the dressing machine, which sized the warp before it entered the loom.

Dr. Cartwright has himself narrated the use and progress of his invention as follows: "Happening to be at Matlock, in the summer of 1784, I fell in company with some gentlemen of Manchester, when the conversation turned on Arkwright's spinning machinery. One of the company observed that as soon as Arkwright's patent expired so many mills would be erected, and so much cotton spun, that hands never could be found to weave it. To this observation, I replied that Arkwright must then set his wits to work to invent a weaving mill. This brought on a conversation on the subject, in which the Manchester gentlemen unanimously agreed that the thing was impracticable; and, in defence of their opinion, they adduced arguments which I certainly was incompetent to answer, or even to comprehend, being totally ignorant of the subject, having never at that time seen a person weave. I controverted, however, the impracticability of the thing, by remarking, that there had lately been exhibited in London an automaton figure which played at chess. 'Now, you will not assert, gentlemen,' said I, 'that it is more difficult to construct a machine that shall weave, than one which shall make all the variety of moves which are required in that complicated game.' Some little time afterwards, a particular circumstance recalling this coversation to my mind, it struck me that, as in plain weaving, according to the conception I then had of business, there could only be three movements, which were to follow each other in succession, there would be little difficulty in producing and repeating them. Full of these ideas, I immediately employed a carpenter and smith to carry them into effect. As soon as the machine was finished, I got a weaver to put in the warp, which was of such materials as sail cloth is usually made of. To my great delight, a piece of cloth, such as it was, was produced. As I had never before turned my thoughts to anything mechanical, either in theory or practice, nor had ever seen a loom at work, or knew anything of its construction, you will readily suppose that my first loom was a most rude piece of machinery. The warp was placed perpendicularly, the reed fell with the weight of at least half a hundred weight, and the springs which threw the shuttle were strong enough to have thrown a Congreve rocket. In short. it required the strength of two powerful men to work the machine at a slow rate, and only for a short time. Conceiving, in my great simplicity, that I had accomplished all that was required, I then secured what I thought a most valuable property by a patent, April 4th, 1785. This being done, I then condescended to see how other people wove; and you will guess my astonishment when I compared their easy modes of operation with mine. Availing myself, however, of what I then saw, I made a loom, in its general principles nearly as they are now made. But it was not till the year 1787 that I completed my invention, when I took out my last weaving patent, August 1st, that year."

The first endeavor to make use of this invention took place at Doncaster, where the principal part of Dr. Cartwright's expenditure occurred. Another effort was made on a large scale at Manchester in 1791, under a license from the patentee, but the mill, calculated to hold four hundred looms, was burned down by incendiaries.

Dr. Cartwright then gave up attempting profit by his discovery, but in 1808 a public grant of £10,000 was made to him as some compensation for his outlay and disappointments.

Selvage or **Selfedge.**—Derived from salvage, because it strengthened and preserved garments; but obviously self-edge, that which makes an edge of itself without hemming The edge of the cloth woven in such a manner as to prevent ravelling. Also called List or Listing.

Serge.—A twilled worsted fabric, which, according to some writers, was at one time made from silk, and thus through the Latin *sericum*, silk, derived its name.

Serrations.—The fine teeth-like points projecting from the body of wool fibres. The same interlock with each other in the process of felting.

Shaper or Copping-Rail.—A part of the mule; the same varies the backing-off of the cam as the building of the cop proceeds. The mechanism by which the shape of a cop is determined.

Shearing.—The process of clipping the fleece from a sheep. The process of cutting by machinery the superfluous nap of various fabrics.

Shed.—The opening made in the warp, when in loom, for the passage of the shuttle.

Shoddy.—Properly it means the waste thrown off in wool-spinning, but now applied to the disintegrated or shredded wool of old cloth, reduced to this condition to be remanufactured. The trade has assumed such proportions that at present large qualities of woolen rags are now annually imported to be made up again into cloth.

Shot-About.—The alternate exchange (filling ways) of figure up and ground-up in two-ply ingrain carpet.

Shuttle Raceway.—The part of the lay on which the shuttle travels to and fro.

Silk.—The pale yellow buff colored, or white fibre, which the silk worm spins around about itself, when entering the pupa or chrysalis state.

Single.—A length of sliver, roving or yarn, consisting of only one strand.

Sinkers.—Or filling up, or filling for face in a fabric

Sizing.—The procedure of coating a warp with a thin layer of flour, starch, glue, Irish moss, etc., to bind together all loose fibres, producing in this manner strength to the yarn.

Slackener or Easer.—An attachment on the loom necessary in gauze weaving to ease up the whip-threads when douping.

Skeining.—The winding of yarn into hanks.

Skeleton-harness.—The harness-frame to which is fastened the doup.

Skip-twills.—A sub-division of the regular twills. For their construction see page 63 of Technology of Textile Design.

Slipping Belts.—First cleanse the inside by brushing, and drop a few drops of castor oil on the inside of belt, or side next the pulleys. By no means use resin for belts when slipping, as it hardens the belt and causes it to crack.

Sliver.—A long ribbon of cotton, wool, flax, etc , drawn out by means of carding, combing or drawing, and run into a can or wound on balls. The same has no twist (or only very little) and clings together by the natural crimp the fibres possess.

Sliver-can.—A receptacle of tin, usually cylindrical, for holding slivers of cotton, wool, silk, flax, etc.

Slubbing.—The sliver of cotton, after having passed through the first roving machine.

——— A fine sliver, but with some twist in it ; produced by a flyer or speeder winding round a bobbin.

Smyrna Carpets and Rugs.—Are pile fabrics of a special method of construction, made upon the *Hautelisse loom* For their construction see page 221 of Technology of Textile Design.

Snarl.—A lump of hard spinning waste.

Snarls.—Small twisted loops of yarn.

Soda is manufactured from salt.

Soda Crystals are produced by introduction of water to impure carbonate of soda.

Soften Water.—Hard, calcareous water is softened most readily for industrial purposes in the cold way by precipitating the lime with *aqua ammonia*, 0 960 strong added to the water. In the course of about twelve hours the lime will precipitate in the receptacle, and the thus softened water may be decanted through a spigot or faucet at a certain height above the bottom. For about 270 gallons of water, one-quarter litre aqua ammonia of above strength will, in ordinary cases, suffice.

Standard Harness.—The harness frame carrying the standard heddle; through the latter the doup is threaded.

Staple.—The length of individual fibres.

Steep Twills, or **Diagonals**—Are a sub-division of the regular twills. For their construction see page 56 of Technology of Textile Design.

Stifling.—The process of destroying the vitality of the chrysalis 178

Stocking-Frame.—An invention of 1589, by which the operation of knitting was performed automatically, an invention the chief motive of which remains unchanged and unimproved upon to this day. The inventor was William Lee, an English clergyman.

The actuating motive has been variously assigned to a desire to aid his wife in her efforts to maintain them, in poverty, to which both had been brought by an unequal marriage, or to a similar desire to assist a lowly knitter to whom he was devoted, or to a wish to be revenged on being refused by her. The scene of his labors has been said at times to have been in Cambridge, Oxford, Sussex, Leicestershire, and Nottinghamshire. The history of his life has been given with great variation, and almost all particulars relating to the invention have at times been disputed or differently stated, so that the historian has had to sift the truth from a multitude of conflicting versions.

William Lee was a M. A. of St. John's College, Cambridge. After maturing his machine he resigned his office and commenced the manufacture of stockings at Calverton, the scene of his ministerial labors, but finding the prejudice against his work too strong to be overcome, went with his brother and chief helper, James, and other relatives to London, where, by the intervention of Lord Hunsdon, it was brought to the notice of Elizabeth, and her patronage requested. Elizabeth, finding the material used to be worsted, not silk, and so appearing likely in her opinion to deprive many of her poorer subjects of a means of subsistence, refused a monopoly, and Lee set to work to adapt the machine to silk hosiery. This he accomplished in 1598, but found that Elizabeth then was as little inclined to countenance this as the other. James was equally impracticable, and Lee, having offers of reward, privileges and honors from Henry IV. of France, went over to Rouen, and found there the favor denied him in England. It is even said that the French king and many of his nobles learnt the art; that a frame of silver was made for the royal use, and the honor of carrying a sword conceded to all who were willing to serve an apprenticeship to frame-work knitting. But the assassination of Henry by Ravaillac took place at the very time when Lee was in Paris waiting for a special grant of privilege. The new Regent, on account of his Protestantism, ignored Lee's claims and suspected his motives, and, finding himself unprotected and in danger in a foreign land, he fell into distress despair and poverty, and in 1610 died, after nearly twenty-five years of deferred hope, an outcast from his native land, and an alien in his adopted country.

His brother James then brought the art and his machines back to England, and was immediately successful. The trade increased rapidly, and early in the 17th century the frame-work knitters formed themselves into a trade association, regulating prices and resisting non-apprenticed workmen, the manufacture even at this early date settling in the shires of Nottingham, Derby and Leicester.

Stockings were first made of cotton in 1730, from cotton of four and five threads spun in India. The duplication of the number of threads caused the hose to be so costly that, to show the fact, the custom was established of putting as many eyelet holes in the welt as there were threads in the yarn, a plan which became universal, whatever the material; but these eyelet holes were not reduced in number when one-thread cotton was ultimately found to be workable.

Stretch. The longitudinal traverse of a mule carriage. The movement of the roving rolls, to and from the spindles in a spinning machine.

Strippers.—The small rollers of a carding engine which carry the wool from the workers back to the main cylinder.

Sulphate of Soda is obtained from a combination of common salt and sulphuric acid or vitriol.

Super.—A two-ply ingrain carpet constructed with 960 warp threads (36-inch wide fabric) exclusive of selvedge. For their construction see page 76 of The Jacquard Machine analyzed and explained.

Swift.—The largest roller, or the main cylinder of a carding engine.

Swivel Loom.—A loom capable of two different movements ; the swivel and the plain weaving movements.

Swivel-Weaving.—A method of weaving for producing figures upon fabrics otherwise interlaced with a regular warp and filling ; used in the manufacture of figured dress goods, ribbons, etc.

T

Tail-Cords.—The substitutes of the regular hooks as used in the ingrain carpet machine.

Tapestry.—Documentary evidence exists establishing in French convents the art of making a kind of carpet ornamented with designs of natural objects or religious subjects ; but the palm undoubtedly belongs to to the celebrated hanging representing the conquest of England by the Normans, and known as "The Bayeux Tapestry," or the tapestry of Queen Matilda.

Up to the latter end of the eleventh or beginning of the twelfth century, it is probable that all such works were laboriously worked with the needle, as no trace can be found proving the use of the loom. The first workmen after the new manner appear to have been called *Sarazins* or *Sarazinois*, and it is believed from this that the improvement was due either to its introduction into Europe by the Saracens of Spain, or was acquired by the Flemings, among whom it was first developed during one of the Crusades against the Saracens in the East. In 1344, Edward IV. passed a law regulating the tapestry manufacture.

Chaucer includes among his pilgrims "a tapisser," and pieces of English-made tapestry still preserved—one representing the marriage of Henry VI., now in St. Mary's Hall, Coventry, and another in the possession of the Vintners' Company, make it probable that the art continued to be practised through the fourteenth and fifteenth centuries. But the first attempt to give the manufacture "a local habitation and a name," does not appear to have been made before the reign of Henry VIII., when, in 1509, William Sheldon, with the assistance of the master tapestry maker, Robert Hicks, established a manufactory at Barcheston in Warwickshire, Eng. ; but this workshop did not assume any industrial importance until the following century.

In the reign of James I., the most famous tapestry factory, that at Mortlake in Surrey, was founded by Francis Crane, who was liberally patronized by the king, and afterwards by his son. James is said to have contributed £2,000 towards the expenses, and Charles I. not only allowed the founder £100 per annum, but gave orders so freely that he was in debt in the first year of his reign to the establishment to the extent of £6,000. In 1623, a famous artist named Francis Cheyne, a native of Bostock in Lower Saxony. was employed as limner, and he "gave designs both in history and grotesque which carried these works to great perfection." Workmen came over from the Continent and were employed in reproducing the cartoons of Raphael, and several of the royal seats—Windsor, Hampton Court, Greenwich, St. James' and Norwich—were furnished with hangings from Mortlake. The Civil War ruined the establishment, Parliament seizing it as the property of the Crown ; but after the Restoration, Charles II. accorded to the manufacture the same protection as his father, passing in 1663 two Acts for the several purposes of encouraging the tapestry manufactures of England, and for discouraging the "very great importation of foreign tapestry," which then appears to have come from Flanders, and to have been wrought "with hair," "with caddas," "with silk," "with gold or silver," and "with wool," being valued at from 2s. 8d. to £8, the Flemish ell.

Charles II. engaged Verrio to make designs, and sent again to the factory the cartoons of Raphael, which Cromwell, to preserve them for the nation, had bought at the sale of the effects of Charles I.

Mortlake continued to flourish, until the death of Francis Crane brought about the closing of the establishment, which has never been reopened.

There was a small atelier established at one time in Soho in London to compete with Mortlake, and afterwards another, principally producing furniture fabrics, at Fulham, but neither was successful. With the exception of a small factory first opened at the end of the seventeenth century, and subsequently transferred to Exeter, no effort was made to revive the manufacture of tapestry until the present reign of Queen Victoria, when a manufactory, under the patronage of Her Majesty, and with the aid of well-known artists, has been founded at Windsor.

Tapestry Carpet—A warp pile (terry pile) fabric, closely resembling Brussels carpet; in which the figures are produced by means of correspondingly printing the pile warp. For their construction see page 185 of Technology of Textile Design.

Teasel.—A kind of thistle, the flower-heads of which have long stiff bracts with hooked points. These points remain after the flowers have died, and are admirably adapted for raising or teasing the surface of cloth, to raise a nap upon it, for which purpose they have been used from time immemorial.

Temple.—Attachment to each side of a loom, on each side of the selvedge, for holding the last woven part of the fabric in even width with the width of the fabric in its reed, thus preventing as much as possible useless chafing of the warp.

Tension-Regulating Device for Spindle-Driving Bands.................... 65

Terry Pile.—The pile in a fabric in which the loop is left intact.

Testing of Hard Water.—Put a few drops of soap dissolved in alcohol into a glass of the water to be tested. If it is hard it will become milky.

Textile.—Derived from the Latin *textilis-texo*, *textum*, to weave, anything woven or suitable for weaving. Any kind of fabric woven in a loom. The first English invention with reference to textile fabrics on record is a patent issued to Abraham Hill, March 3d, 1664 No. 143, for "an instrument or an engine for breaking of hemp and flax, and dressing the same in a new way; as also for washing of all sorts of linen."

Textile Fabrics.—To change their texture without influence to appearance.................... *70
——— To change their weight without influence to appearance.................... *70

Textile Fabrics.—Their structure.................... *57
Also see for it my Technology of Textile Design and The Jacquard Machine Analyzed and Explained.

Texture.—Number of warp and filling ends to one inch in a fabric.
There are two textures, *a*, for the fabric from loom; *b*, for the finished fabric.

Texture.—Selection for fabrics interlaced with *plain weaves*.................... *67
——— Selection for fabrics interlaced with *twills*.................... *67
——— Selection for fabrics interlaced with *satins*.................... *75
——— Selection for fabrics interlaced with *ribs*.................... *75
——— Selection for fabrics interlaced with *corkscrews*.................... *76
——— Selection for *backing* (filling) *cloth*.................... *77
——— Selection for *backing* (warp) *cloth*.................... *79
——— Selection for *double cloth*.................... *82

Texture of Cloth.—To change the same from one weave to another.................... *70
——— To find.................... *67

Three-Doffer Condenser.................... 133

Three-Ply Cloth.—A fabric produced by combining three single-cloth fabrics into one structure.

Throstle.—A spinning frame, derived its name from a low musical hum, due to the high speed which it attains, which is supposed to resemble the note of the *throstle* or *thrush*.

Top.—A ball of combed wool from which the noil has been separated.

Top Flat Card.................... 37

Top Making or Balling.................... 167

Tram Silk.................... 184

Trap-Boards.—Or lifter-boards, used in the Jacquard machine as used for two-ply ingrain carpets.

Traveller.—A small steel hook, which runs round on the ring of a ring spinning frame by means of the yarn put through it.

Traverse Emery Wheel Card Grinder.................... 43, 139

Trevette—Or cutting knife used for cutting (by hand) the pile in warp-pile fabrics.

Tricot.—Fabrics more or less elastic as compared to other woven articles, and produced by a system of weaves known as tricot weaves. For their construction see page 126 of Technology of Textile Design.

Trueness of Wool Fibres.................... 77

Tussah Silk.................... 188

Twit.—A thin place in a piece of yarn, caused by uneven drawing or too much draft in the process of spinning.

Twist.—The number of turns per inch in a thread or yarn.

Twist of Yarn Required—By means of given counts and twist of another yarn. To find.................... *65

comparatively small length, it is put upon a roller and rolled under a calender of very great weight. When taken out, the strong threads of the filling are found to have impressed lines upon both surfaces, which are variously waved, in consequence of the foldings previously referred to. As it is only intended to have one side waved, the fabric is made up for the press with pasteboards between each second fold, so as to allow one side of the fabric to be wholly without the pasteboards. The fabric is next hot-pressed, and that side which was covered with pasteboard comes out glazed, while the other remains watered. When it is wanted to be creased, it is folded, in the first instance, selvage to selvage.

Weaving.—Pliny gives the honor of the invention of weaving to the Egyptians, but its origin is really unknown, and was certainly prehistoric. The Egyptians undoubtedly attained wonderful excellence in weaving. Many Biblical references prove the Hebrews to have been equally facile, and Persia, Babylon, and other ancient nations likewise earned fame in this particular. In England, the Anglo-Saxons were thoroughly acquainted with the making of cloth, and the weavers of London form the most ancient guild of that city.

Weft.—The English name for filling.

Weighting or *loading*, is to silk what sizing is to cotton. For explanation of process see page 186.

Whip Roll.—A part of the loom. The warp threads pass from the warp-beam over the whip-roll towards the harness.

Whip Thread.—Or douping warp, one of the systems of threads necessary for gauze weaving. The crossing thread in gauze weaving.

Whirl.—Also called *wharl*. The small pulley fastened onto the spindle, on which the band runs which drives the spindle.

Wool.—In the hairy covering of several species of *mammalia*; it is softer than the actual hair, also more flexible and elastic, besides having a wavy character.

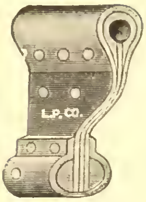
Worsted.—Fabrics made of yarn combed straightly and smoothly in their process of manufacture, as distinct from woolens, which are woven from yarn crossed and roughed in the carding and spinning process. Manufacture of worsted yarns........ 152

Worsted Coating.—A double cloth, in which the stitching is arranged to form designs. For their manufacture see page 138 of Technology of Textile Design.

Y

Yarn.—Any spun thread. The fully elongated and twisted roving.

Yolk.—A natural secretion from the glands of a sheep, on which the softness and flexibility of the living fleece depends, but which is an undesirable quality in the wool for commercial purposes, as if left in, it ferments, and leaves the wool in a hard and harsh state and unfit for spinning, consequently is removed by scouring previous to carding or gilling.



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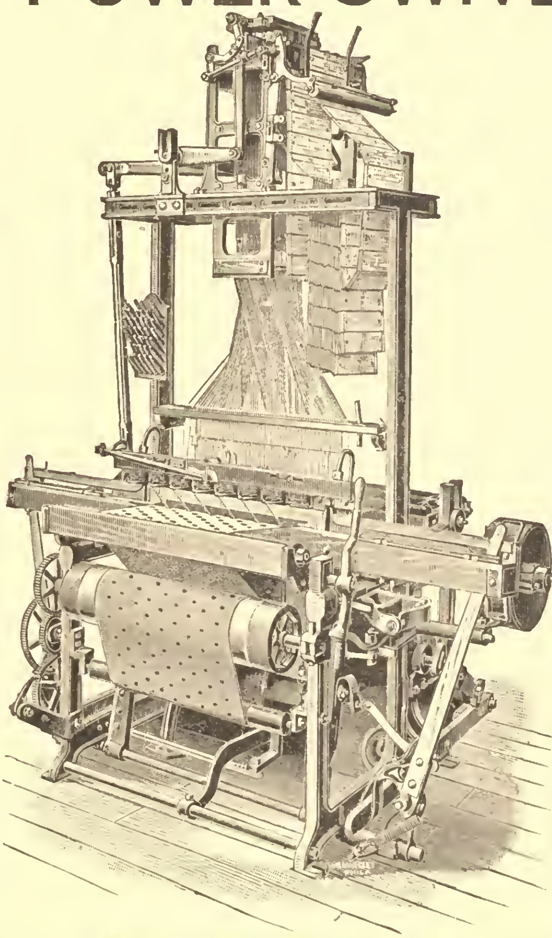

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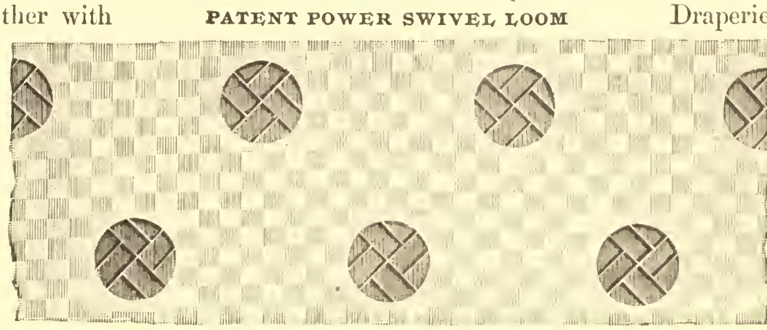

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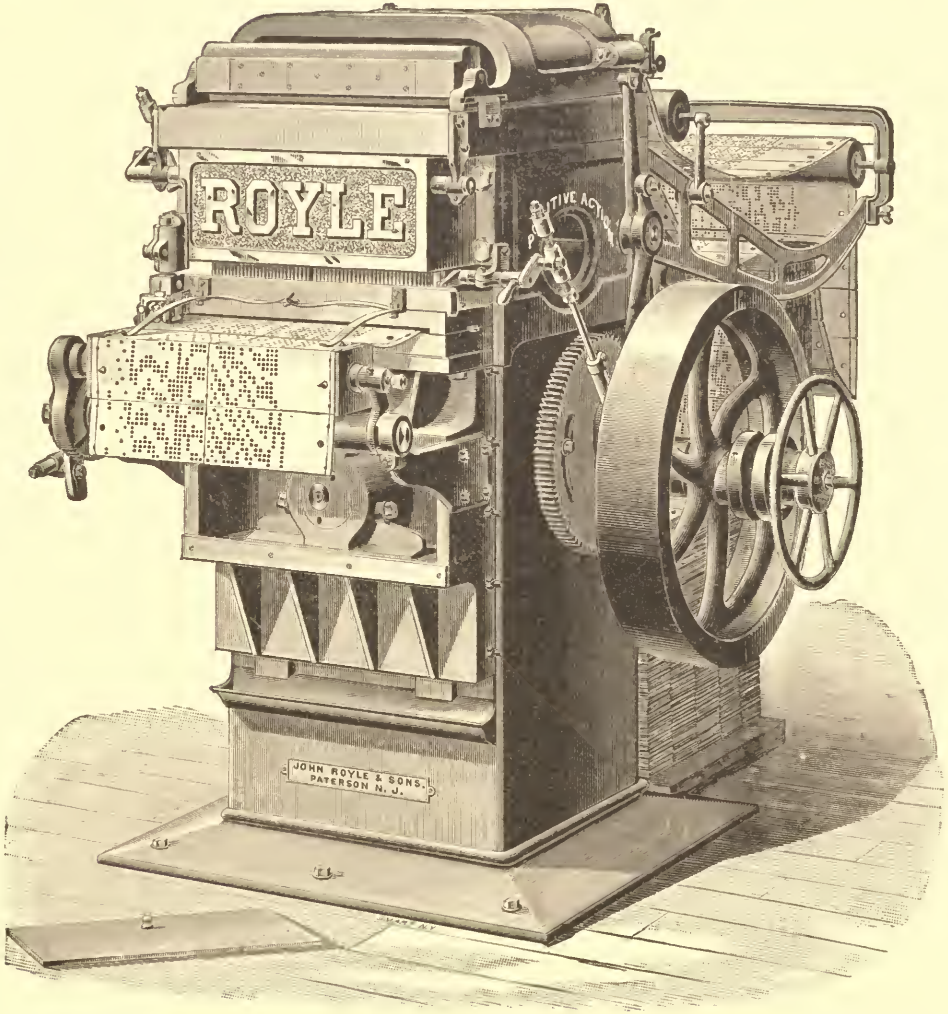
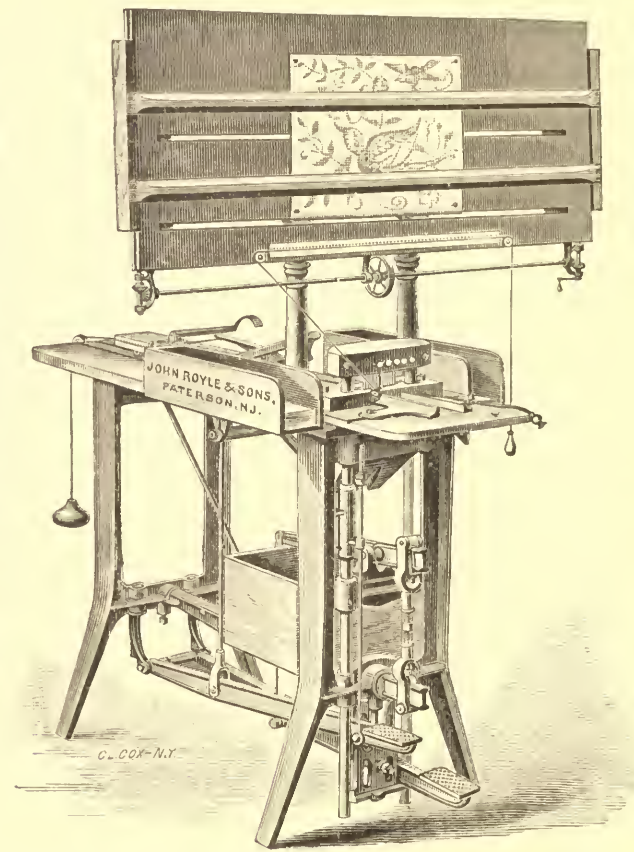


PIANO MACHINES, ETC.



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(Continued on next page.)

DERIVATIVE WEAVES.

FROM THE PLAIN OR COTTON WEAVE.

I. Common Rib-Weaves—II. Common Basket-Weaves—III. Fancy Rib-Weaves—IV. Fancy Basket-Weaves—V. Figured Rib-Weaves—Effects Produced by Using Two or More Colors in Warp and Filling of Fabrics Interlaced Upon Rib- and Basket-Weaves—VI. Oblique Rib-Weaves—VII. Combination of Common and Oblique Rib-Weaves.

FROM THE REGULAR TWILL WEAVE.

I. Broken-Twills—Using Two or More Colors for Producing Various Effects Upon Fabrics Interlaced with Broken-Twills—II. Steep-Twills of 63° Grading or Diagonals—III. Steep-Twills of 70° Grading—IV. Steep-Twills having a Grading of 75°—V. Reclining-Twills or Twills having a 27° Grading—VI. Curved-Twills—VII. Skip-Twills—VIII. Combination of Two Different Common Twills to Steep-Twills of 63° Grading—IX. Corkscrew-Twills—*A.* Derived from One Regular Twill—*B.* From Two Regular Twills—*C.* Figuring with the Filling Upon the Face—*D.* Curved Corkscrew-Twills—*E.* Corkscrew Weaves composed of Warp and Filling Twills—*F.* Corkscrew Weaves Figured by the Warp—*G.* Corkscrew Weaves in which the Face and Back of the Fabric is produced by the Filling—X. Entwining-Twills—XI. Twills having Double Twill-Effects—XII. Twill Weaves Producing Checkerboard Effects—XIII. Combination of Warp and Filling Effects from a 45° Twill Weave after a Given Motive—XIV. Fancy Twill Weaves—XV. Pointed-Twills.

DERIVATIVE WEAVES FROM SATINS.

I. Double Satins—II. Granite Weaves.

Combination of Different Systems of Weaves into One Weave—Figured Effects Produced by the Fancy Arrangement (of Two or More Colors) Upon Fabrics Interlaced with Derivative Weaves.

WEAVES FOR SINGLE CLOTH FABRICS OF A SPECIAL CONSTRUCTION AND PECULIAR CHARACTER.

Honeycomb Weaves—Imitation Gauze (Plain and Figured)—COMBINATION OF WEAVES FOR FABRICS CONSTRUCTED WITH ONE SYSTEM OF WARP AND TWO SYSTEMS OF FILLING—Combining Two Systems of Filling to One Kind of Warp for Increasing the Bulk of a Fabric—Figuring with Extra Filling Upon the Face of Fabrics Interlaced with Their Own Warp and Filling—Principles of Swivel Weaving—Explanation and Illustration of a Swivel Loom—COMBINATION OF WEAVES FOR FABRICS CONSTRUCTED WITH TWO SYSTEMS OF WARP AND ONE SYSTEM OF FILLING—Two Systems of Warp and One System of Filling for Producing Double-Faced Fabrics—Using an Extra Warp as Backing for Heavy-Weight Worsted and Woolen Fabrics—Figuring with Extra Warp Upon the Face of Fabrics Otherwise Interlaced with the Regular Warp and Filling—Principles of Lappet Weaving—Explanations and Illustrations of the Lappet Loom—TRICOT WEAVES.

DOUBLE CLOTH.

Description and Object of Making Double Cloth Fabrics—Rules for Designing Double Cloth Fabrics—DOUBLE CLOTH WEAVES DESIGNED WITH THE FOLLOWING PROPORTION OF FACE AND BACK IN WARP AND FILLING—*A.* Warp and Filling, One End Face to Alternate with One End Back—*B.* Warp One Face One Back, Filling Two Face One Back—*C.* Warp Two Face One Back, Filling One Face One Back—*D.* Warp and Filling Two Face One Back—*E.* Warp and Filling Two Face Two Back—*F.* Warp Two Face Two Back, Filling Two Face One Back—*G.* Warp and Filling Three Face One Back—DOUBLE CLOTH WEAVING WITHOUT STITCHING BOTH CLOTHS—Principle of Constructing Seamless Bags, Hose and Similar Fabrics—DOUBLE CLOTH FABRICS IN WHICH THE DESIGN IS PRODUCED BY THE STITCHING BEING VISIBLE UPON THE FACE OF THE FABRIC—Worsted Coatings—Matelasses—Quilts (Plain Pique Fabrics and Figured Pique Fabrics)—RIB FABRICS—THREE-PLY FABRICS—Four-Ply Fabrics, Etc.

PILE FABRICS.

PILE FABRICS PRODUCED BY THE FILLING.

Velveteens, Fustians, Corduroys—Chinchillas, Whitneys, Plain and Figured—Chenille for the Manufacture of Curtains and Rugs—Chenille Cutting Machine Illustrated and Explained.

CHENILLE AS PRODUCED IN THE MANUFACTURE OF FRINGES.

PILE FABRICS IN WHICH THE PILE IS PRODUCED BY A SEPARATE WARP IN ADDITION TO THE GROUND WARP.

Description of the Structure of Warp Pile Fabrics—Terry and Velvet Pile—Explanation and Illustrations of the Method of Operation Necessary in Producing Warp Pile Fabrics—VELVET AND PLUSH FABRICS—FIGURED VELVET—ASTRAKHANS, Their Various Methods of Construction—Illustrations and Explanations of Machines for Curling Warp-Threads for Astrakhans—TAPESTRY CARPETS—BRUSSELS CARPETS—DOUBLE-FACED CARPETS, in which the Pile is Produced by Inserting a Special Heavy Filling in Place of a Wire.

DOUBLE PILE FABRICS.

Principle of their Construction—Methods of Operation for Producing Double Pile Fabrics and Cutting the Same on the Loom During Weaving—Illustration of the Machine and Explanation of the Method of Operation for Cutting Double-Pile Fabrics After Leaving the Loom—Weaving Two, Three or More Narrow Widths of Double-Pile Fabrics At Once—"Let-Off" and "Take-Up" Motions of the Pile Warp in Double-Pile Fabrics—Double-Pile Fabrics as Produced with a Proportional Higher Pile—Figured Double-Pile Fabrics.

TERRY PILE FABRICS, IN WHICH THE PILE IS PRODUCED DURING WEAVING WITHOUT THE AID OF WIRES AS USED IN THE MANUFACTURE OF TUKKISH TOWELINGS AND SIMILAR FABRICS.

PILE FABRICS AND REGULAR DOUBLE CLOTH FABRICS OF A SPECIAL METHOD OF CONSTRUCTION.

Smyrna Carpets and Rugs—Imitation Turkey Carpets—Two-Ply Ingrain Carpet.

GAUZE FABRICS.

Principle of Construction of Gauze Fabrics—Combination of Plain and Gauze Weaving—Jacquard Gauze—Imitation of the Regular Doup—Cross-Weaving, as Used for Chenille and Loom for Producing the Same Illustrated and Explained—Cross-Weaving, as Used for the Manufacture of Filtering Bags—Cross-Weaving for Inside Fast Selvages of Fabrics Produced in Two or More Widths on the Loom.

THE JACQUARD MACHINE as Necessary for Figured Work—GOBELIN TAPESTRY.

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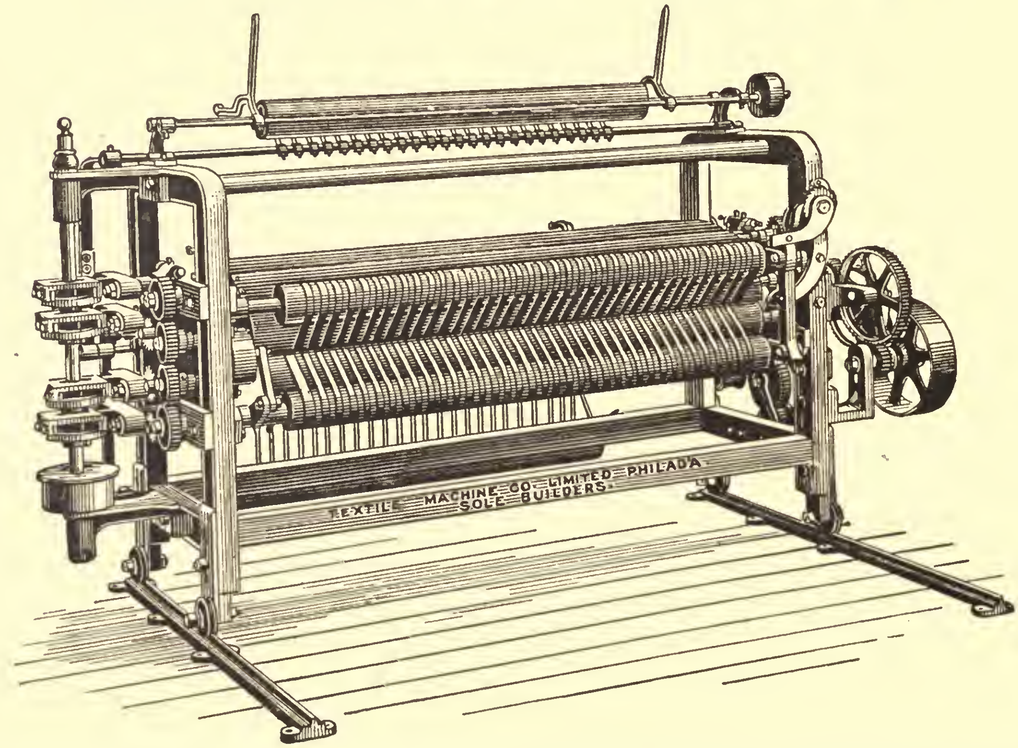

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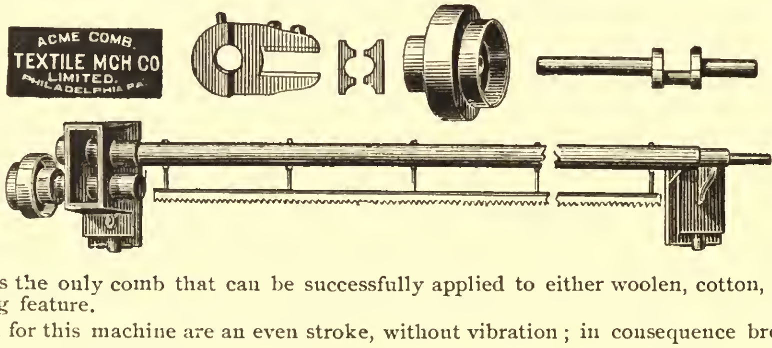

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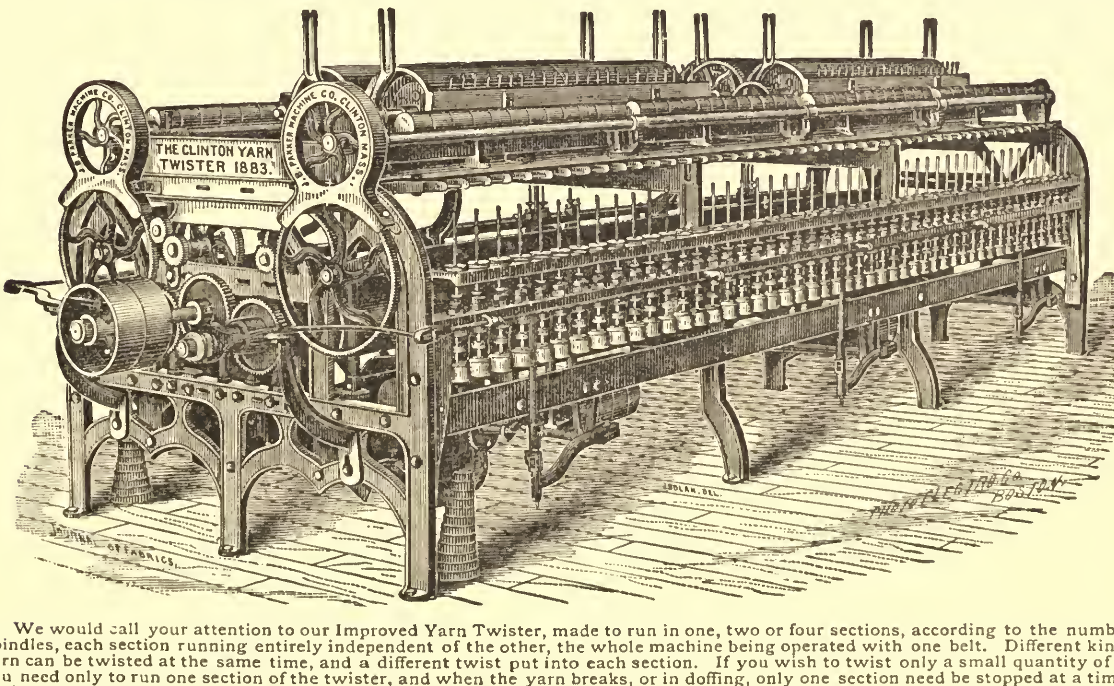

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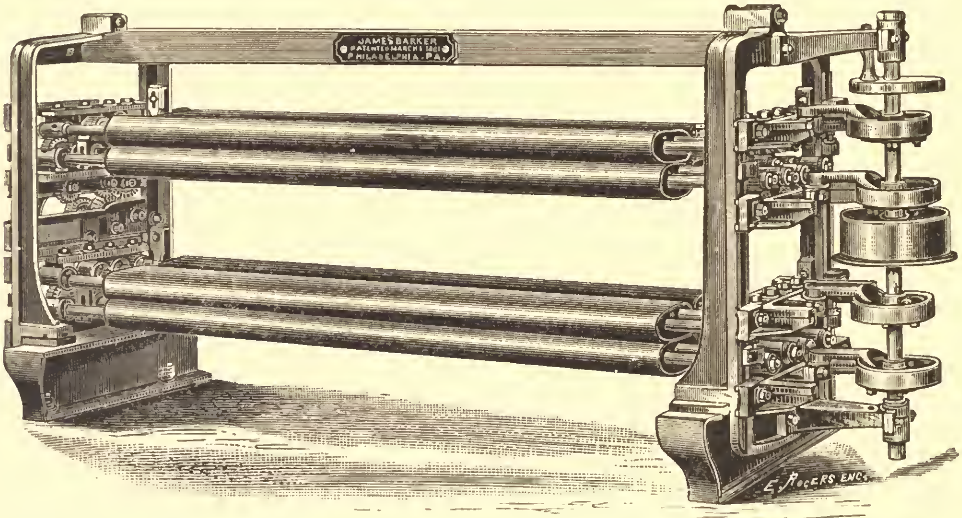

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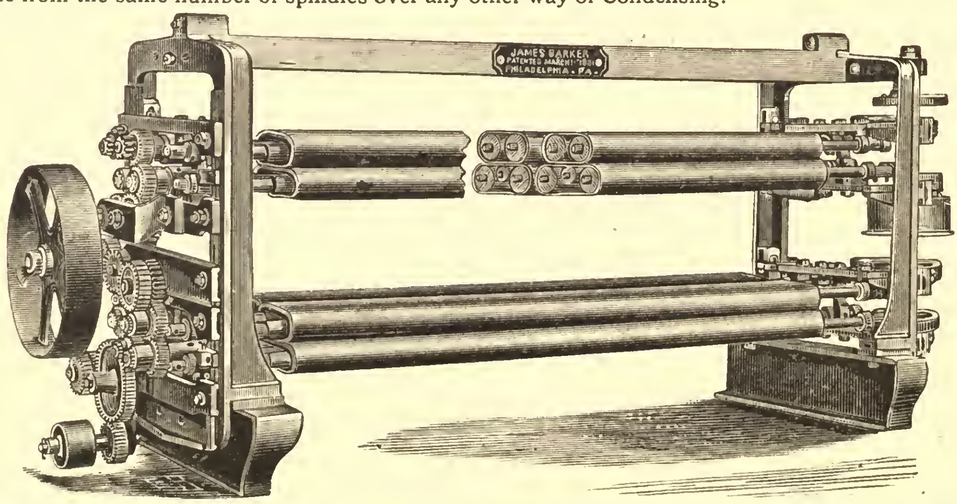

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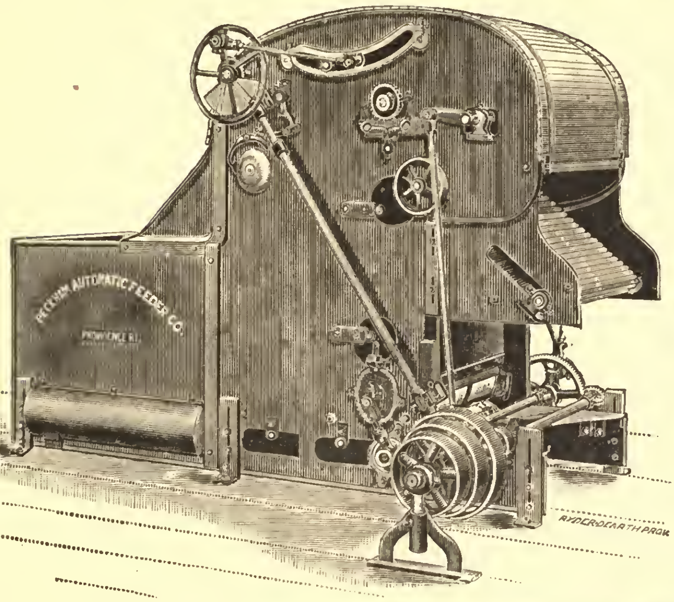

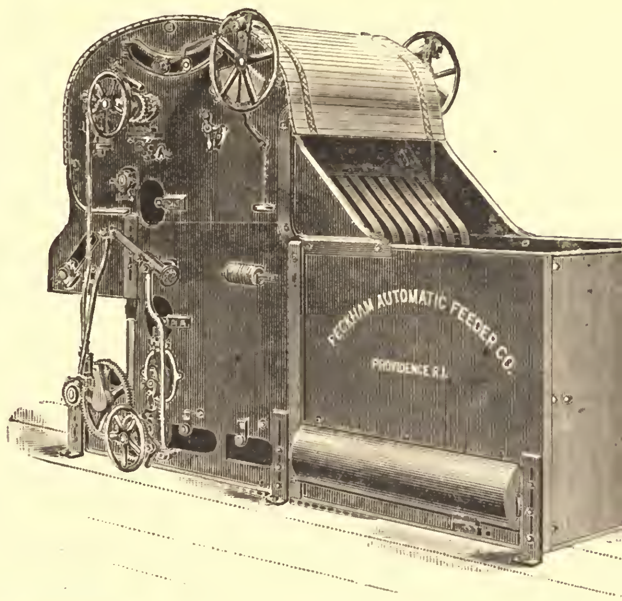

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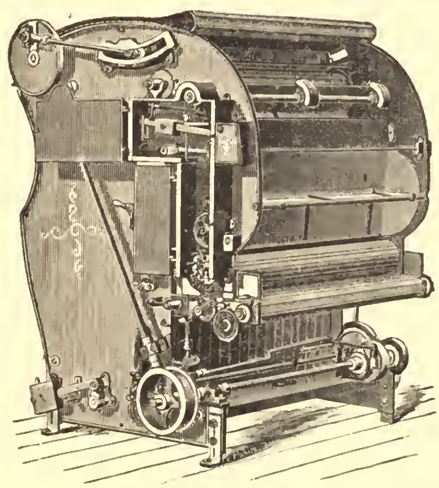

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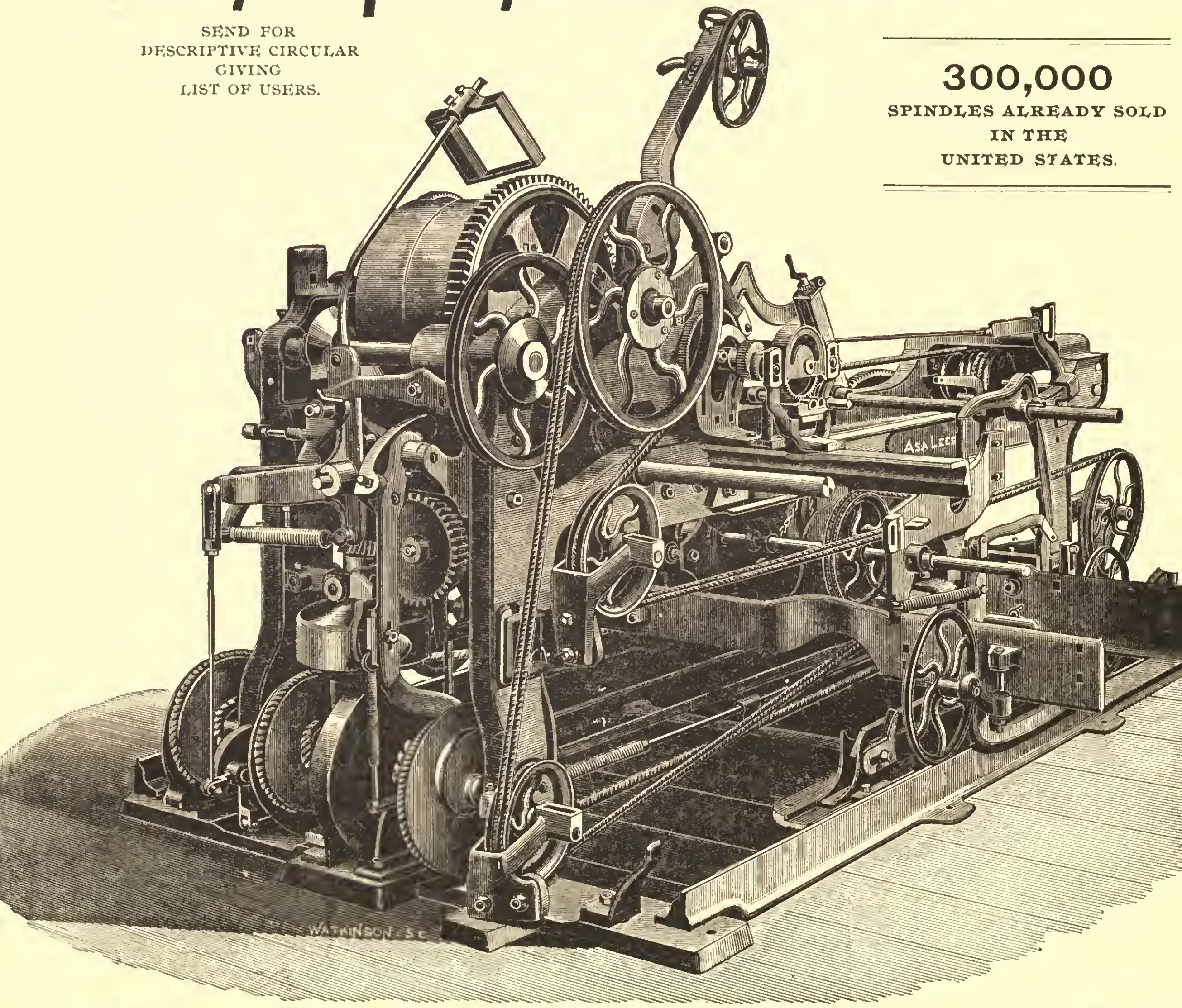

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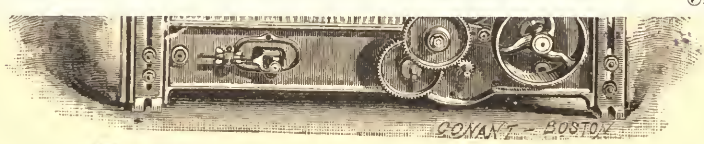

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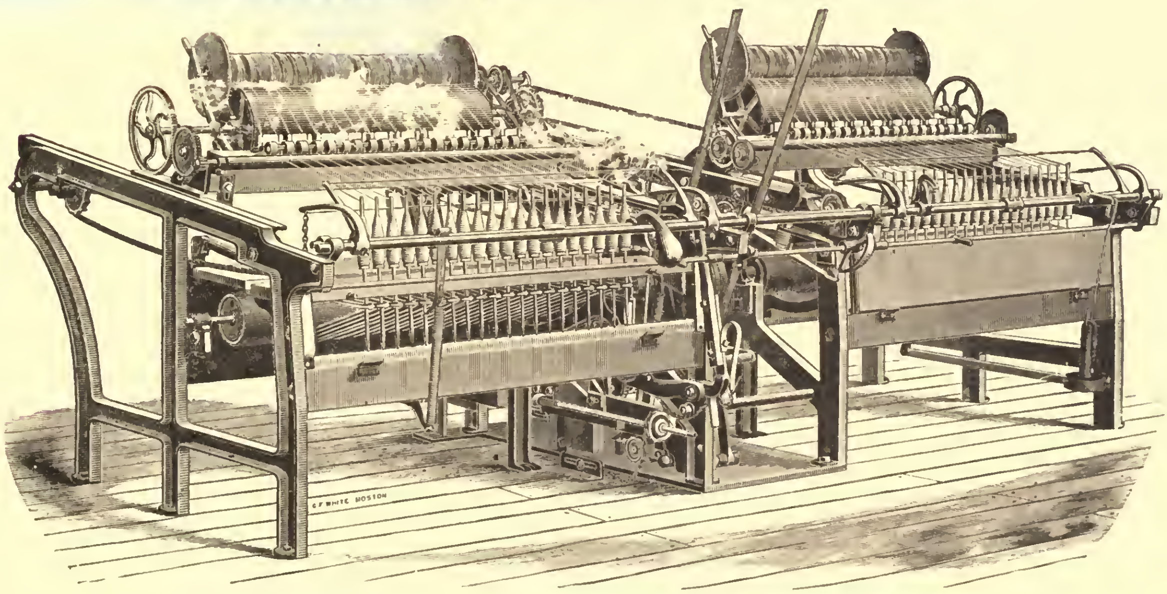
le without Patterns.

WRIGHT PATENT SPINNER



FRONT VIEW, SHOWING BUT TWO SECTIONS, OF THE NEW WRIGHT SPINNING MACHINE.

Carding Machines fitted with Patent Seven, Nine, Eleven and Fifteen Roll Rubber Condensers.

ALSO PATENT APRON AND ROLL RUBBER CONDENSER

Spinning Mules and Jacks, Card Grinders, Lathes for turning off Cylinders

WARP DRESSERS for Worsted and Woolen Yarns, **PATENT WARP REELS, PATENT WARP SPOOLERS,** Extra Heavy **BEAMING MACHINES** for placing the warp on Loom Beam, Cone Dusters, Wool Dusters, Waste Dusters, Broad and Narrow Flannel and Blanket Looms with or without Drop Boxes, Gigging Machines of all descriptions, including Double Reversible Continuous Gigs, Up and Down Gigs, Flannel Gigs and Blanket Gigs, Banding Machines, and **IMPROVED HEAVY MIXING PICKERS.**

All the above Machines from new designs and remodelled patterns.

We also make a specialty of **WORSTED CARDING MACHINES** built after the English plan.