The Structure of Fibres, Yarns and Fabrics

E. A. Posselt

(See opposite Title Page)

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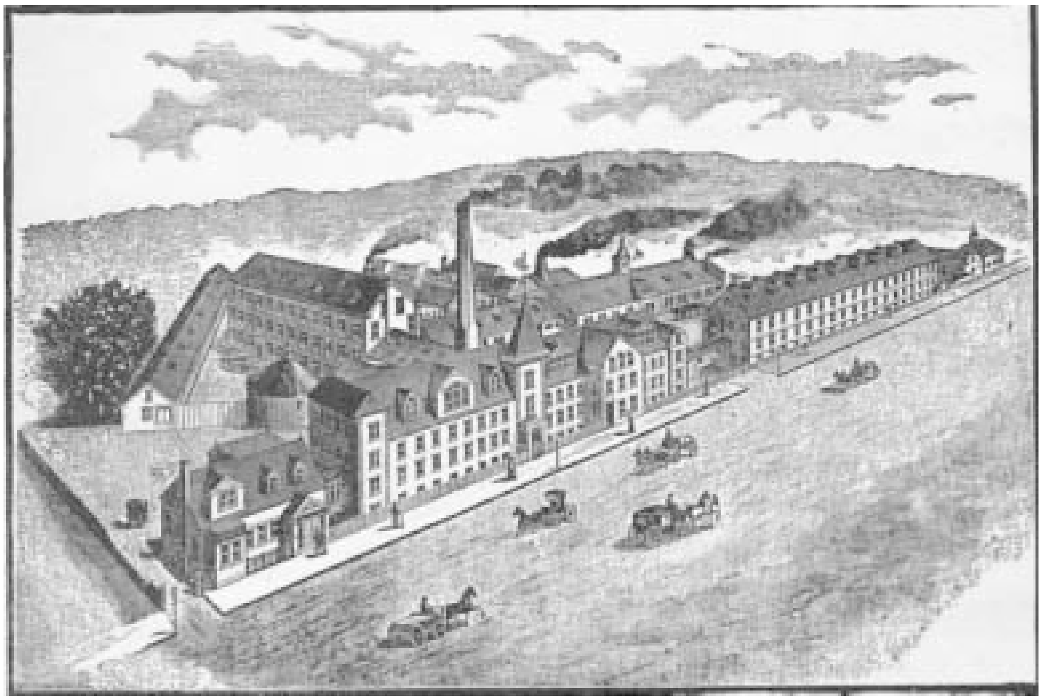

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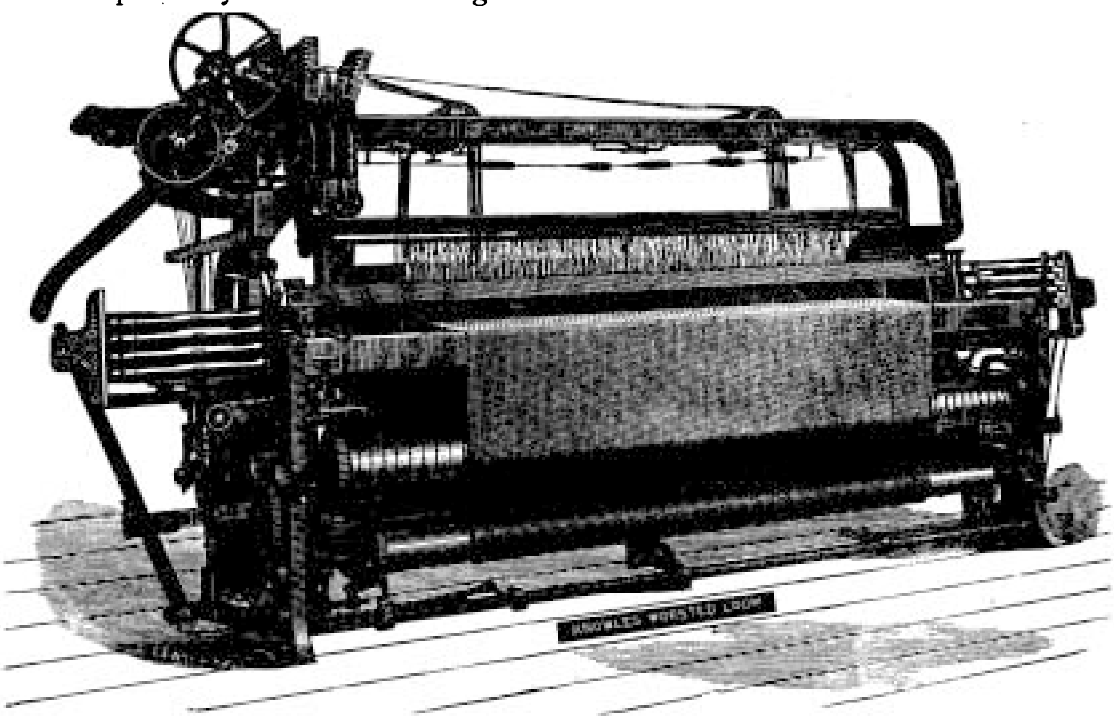
These Combs are illustrated on pages 163 and 166 of this work. Correspondence solicited.



(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

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ACCOMPANIED BY OVER 400 ILLUSTRATIONS

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1891.

PHILADELPHIA
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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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STRUCTURE OF FIBRES AND YARNS.

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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.

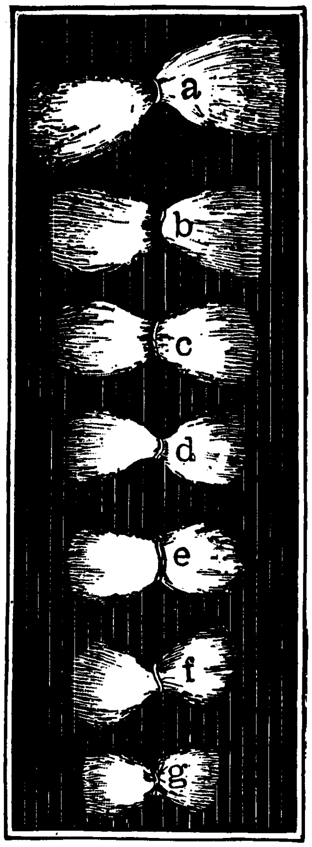


FIG. 5.

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.	$\frac{1}{1520}$
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.

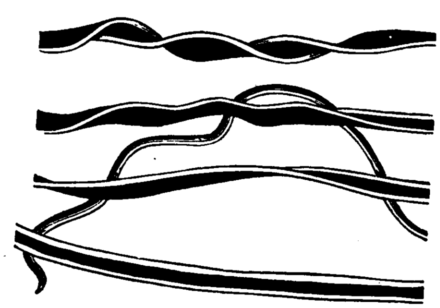


FIG. 6.

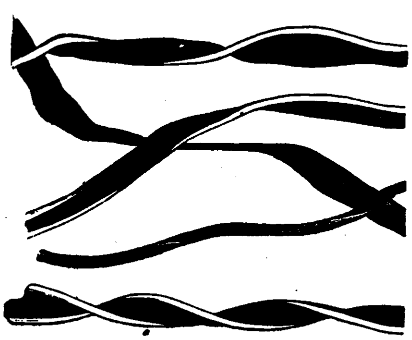


FIG. 7.

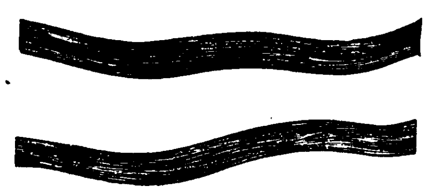


FIG. 8.

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.

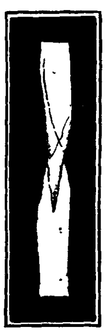


FIG 12.

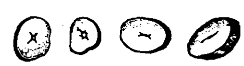


FIG. 13.

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.

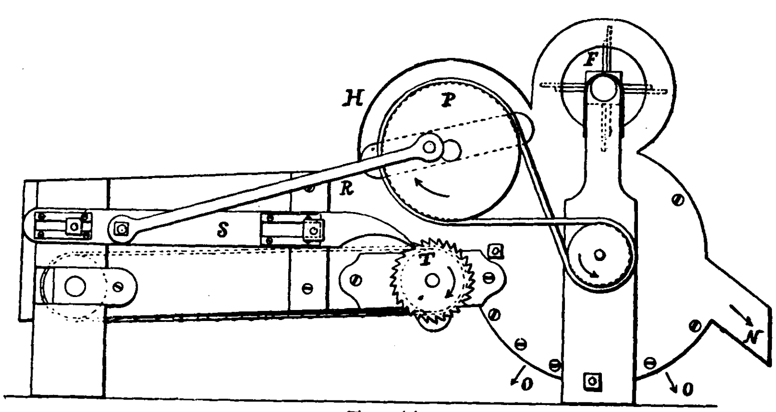


FIG. 14

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.

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

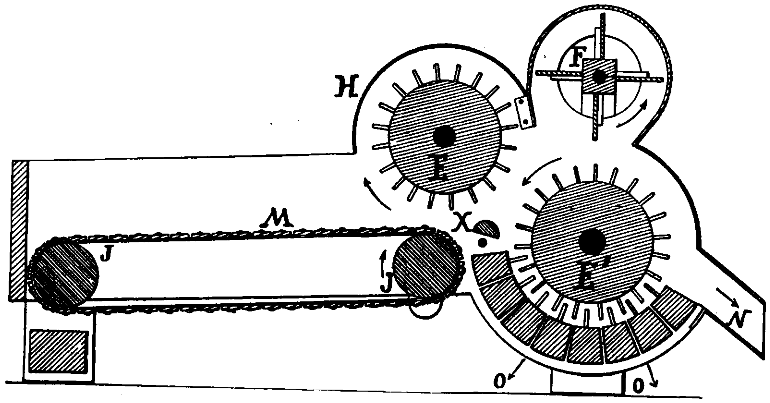


FIG. 15.

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.

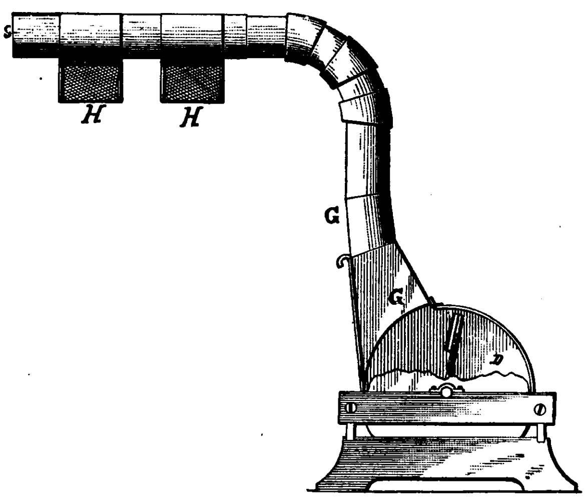


FIG. 16.

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

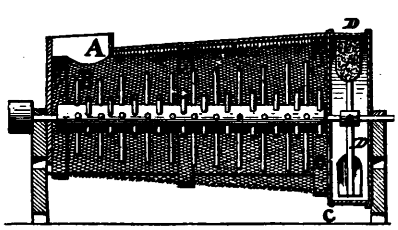


FIG. 17.

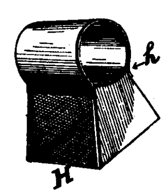


FIG. 18.

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.

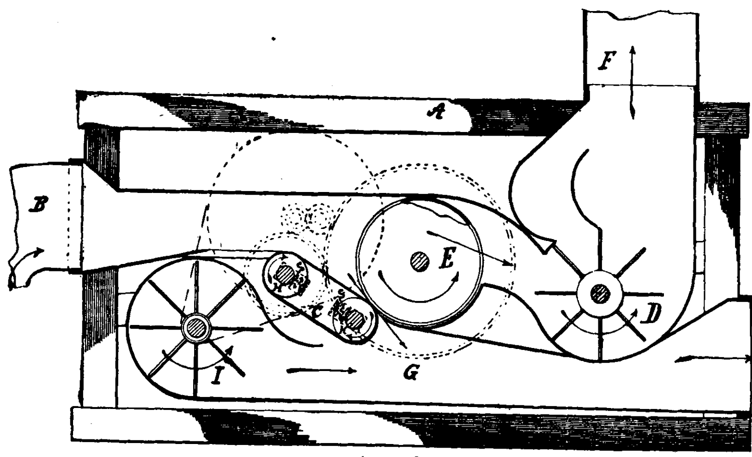


FIG. 19.

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.

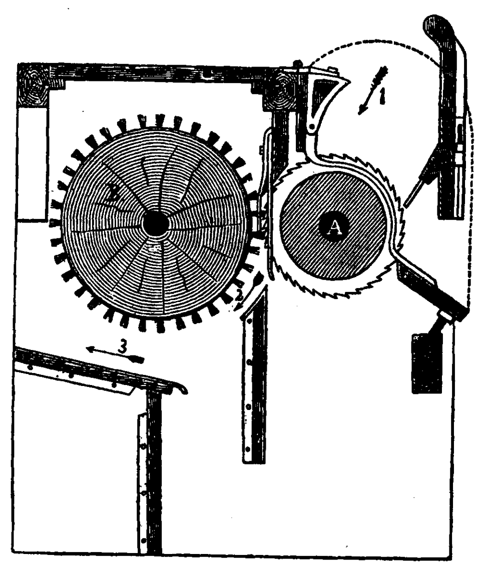


FIG. 20.

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.

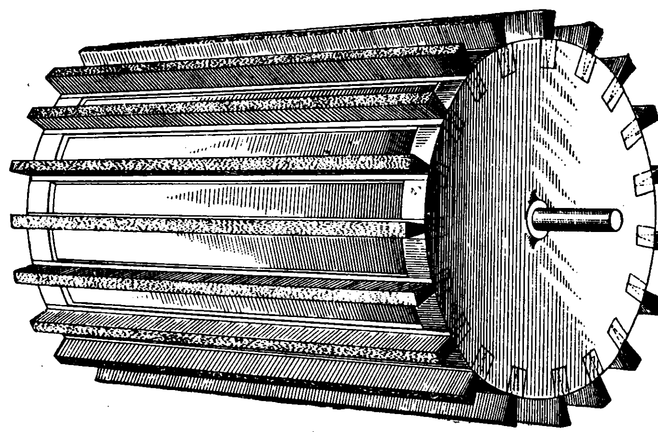


FIG. 21.

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.*

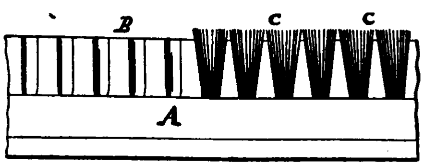


FIG. 22.

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 re-enforced 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.

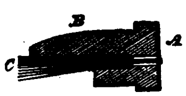


FIG. 23.

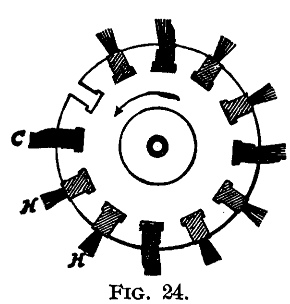


FIG. 24.

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.

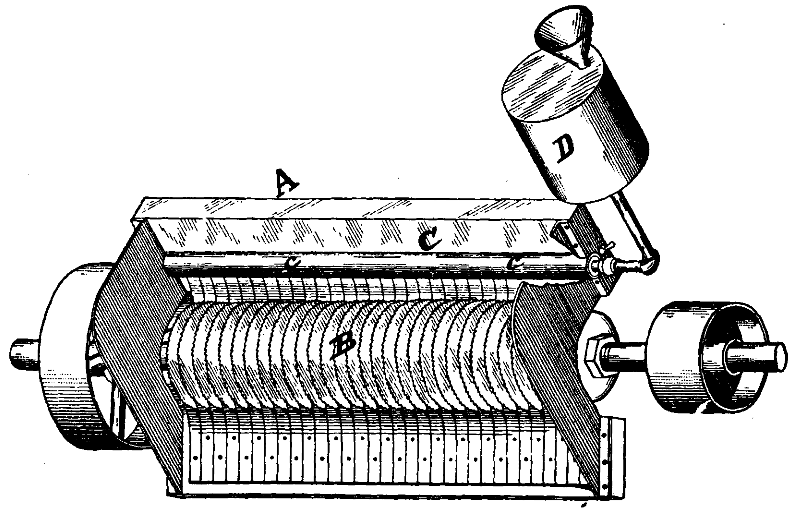


Fig. 25.

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

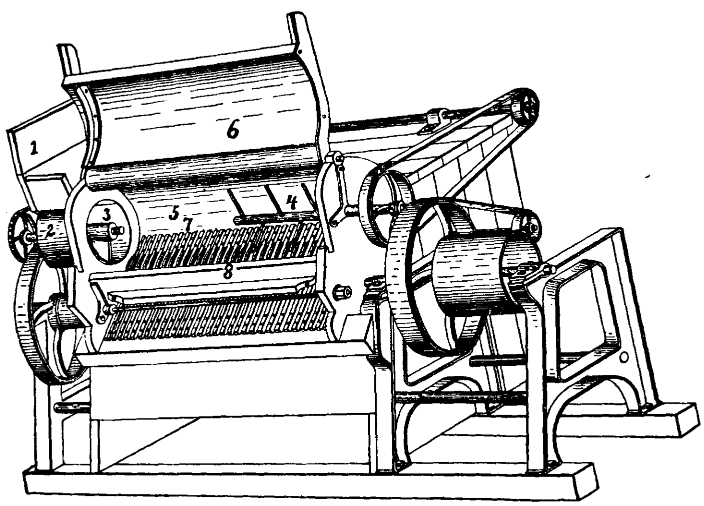


Fig. 26.

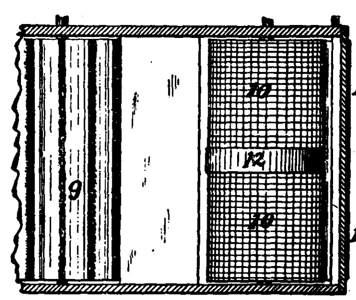


Fig. 27.

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.

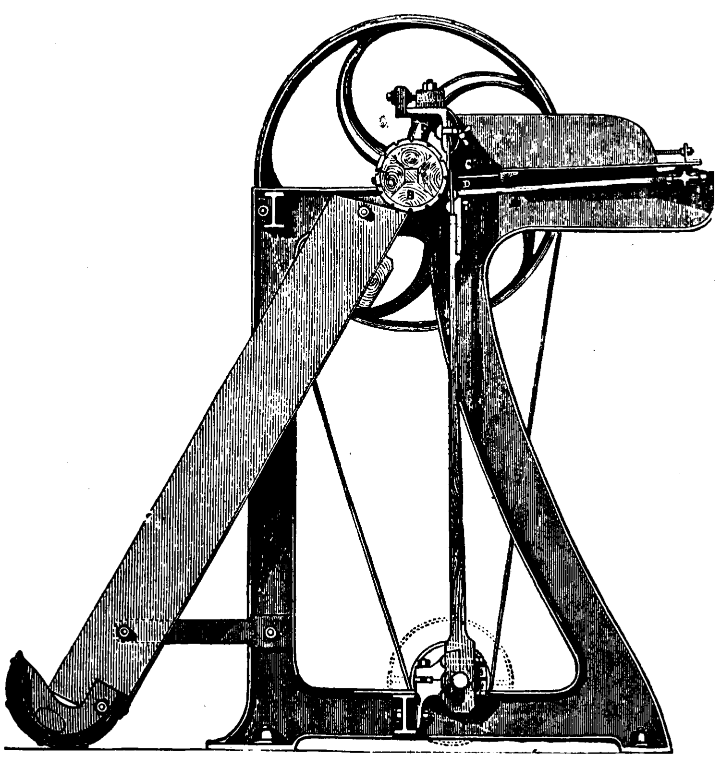


FIG. 28.

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.

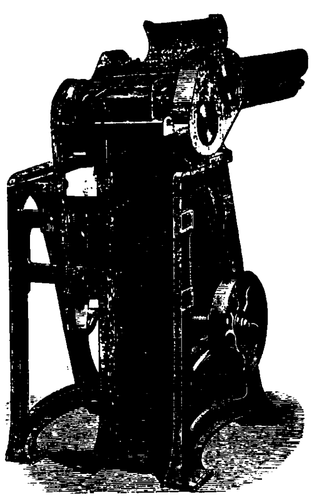


FIG. 29.

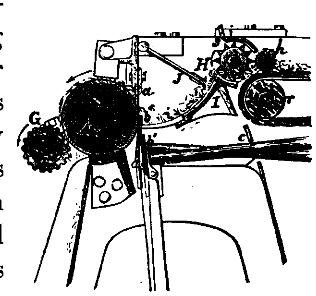


FIG. 30.

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.

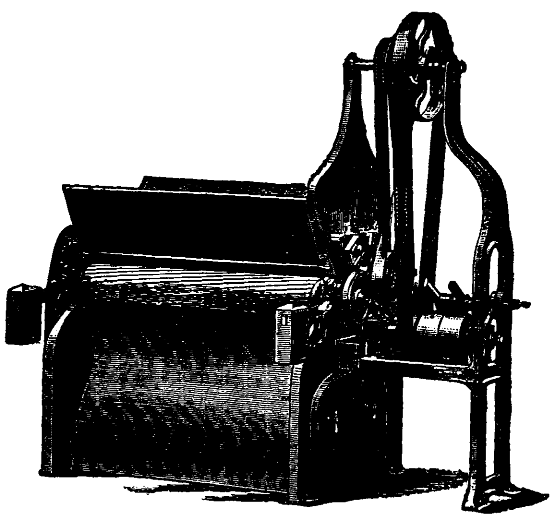


FIG. 31.

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.

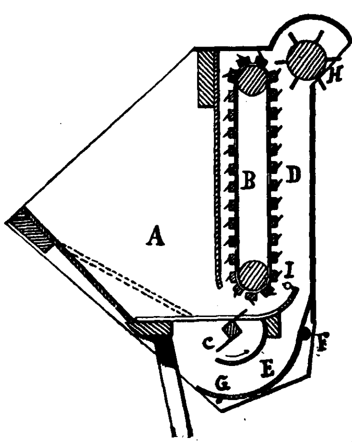


FIG. 32.

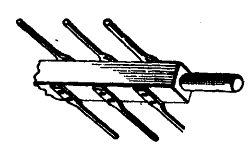


FIG. 33.

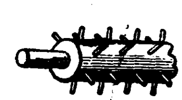


FIG. 34

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.

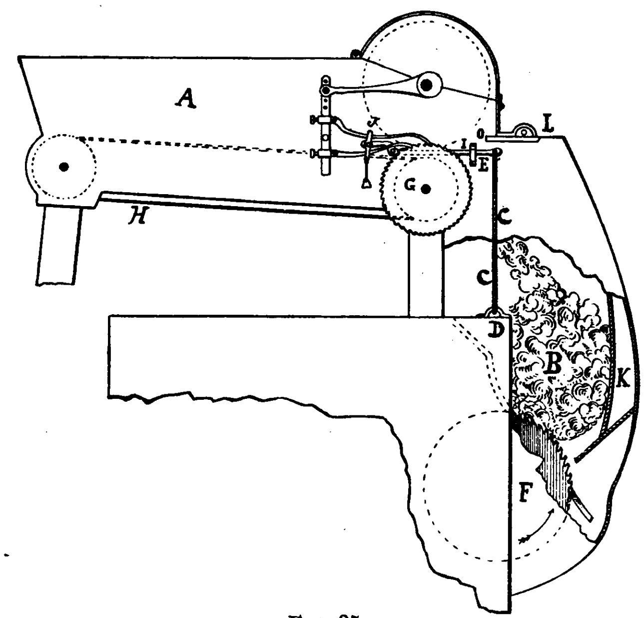


FIG. 35.

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;

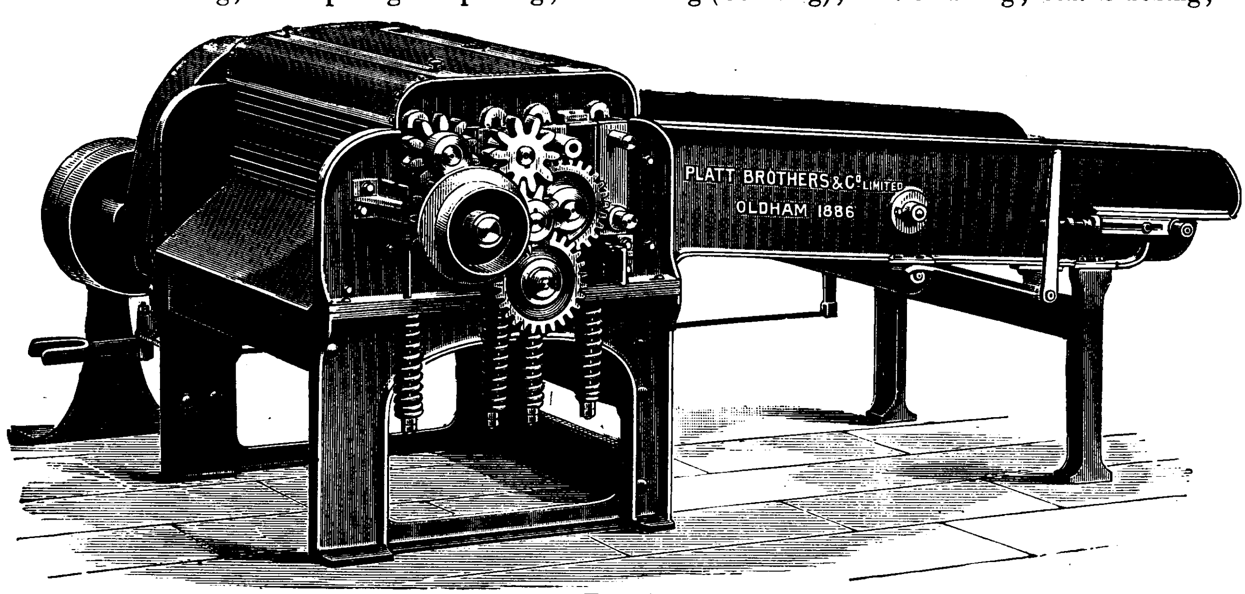


FIG 36.

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.

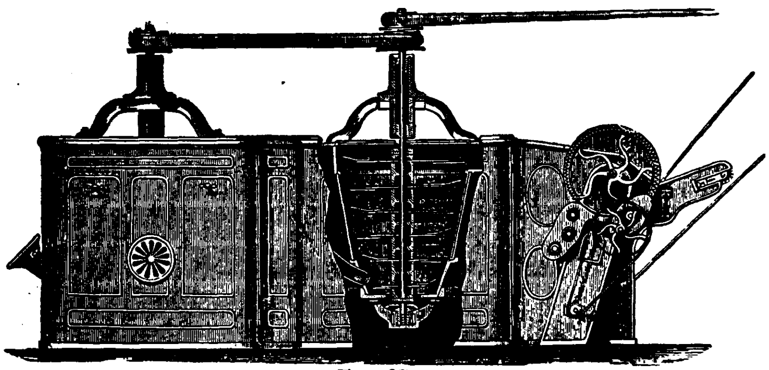


FIG. 37.

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.

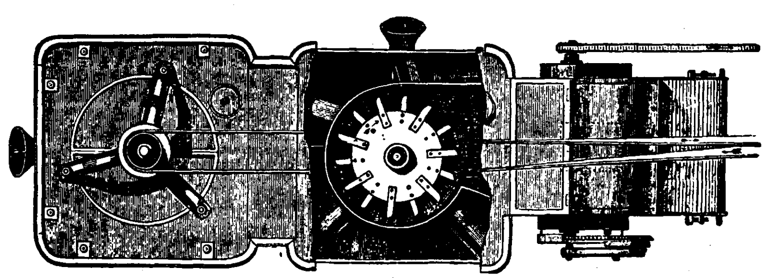


FIG 38.

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

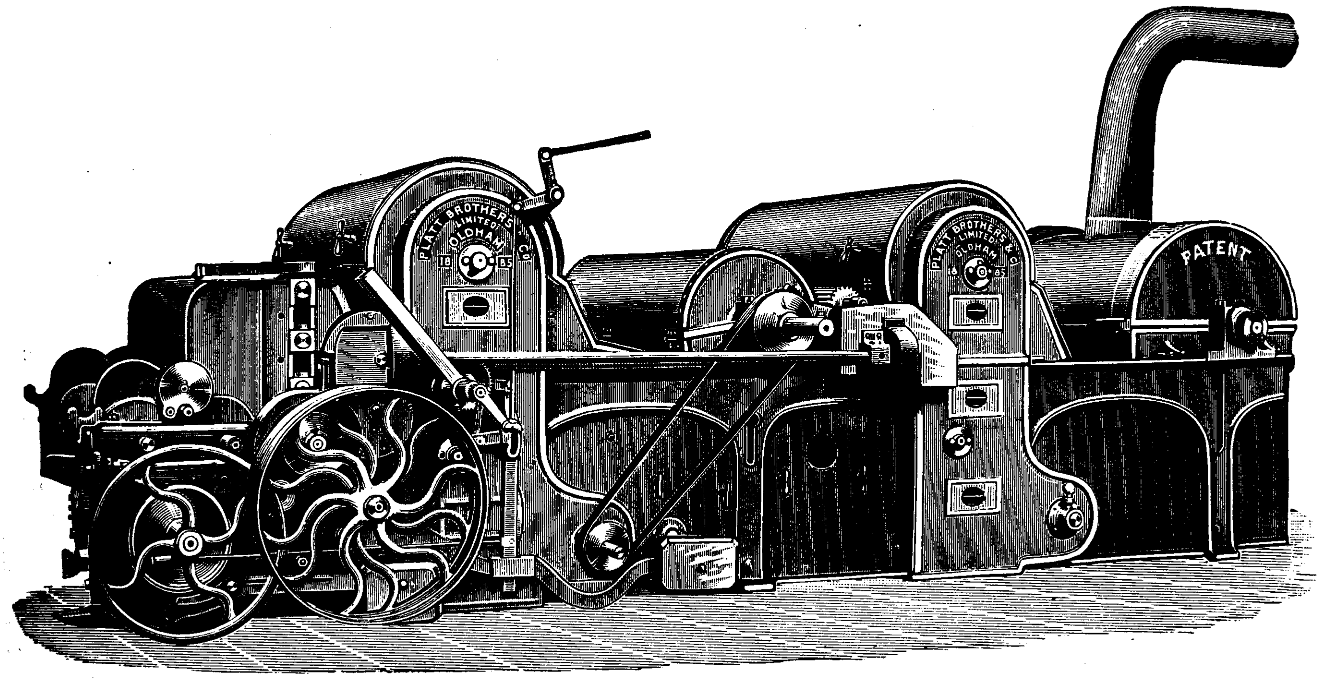


Fig 39.

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.

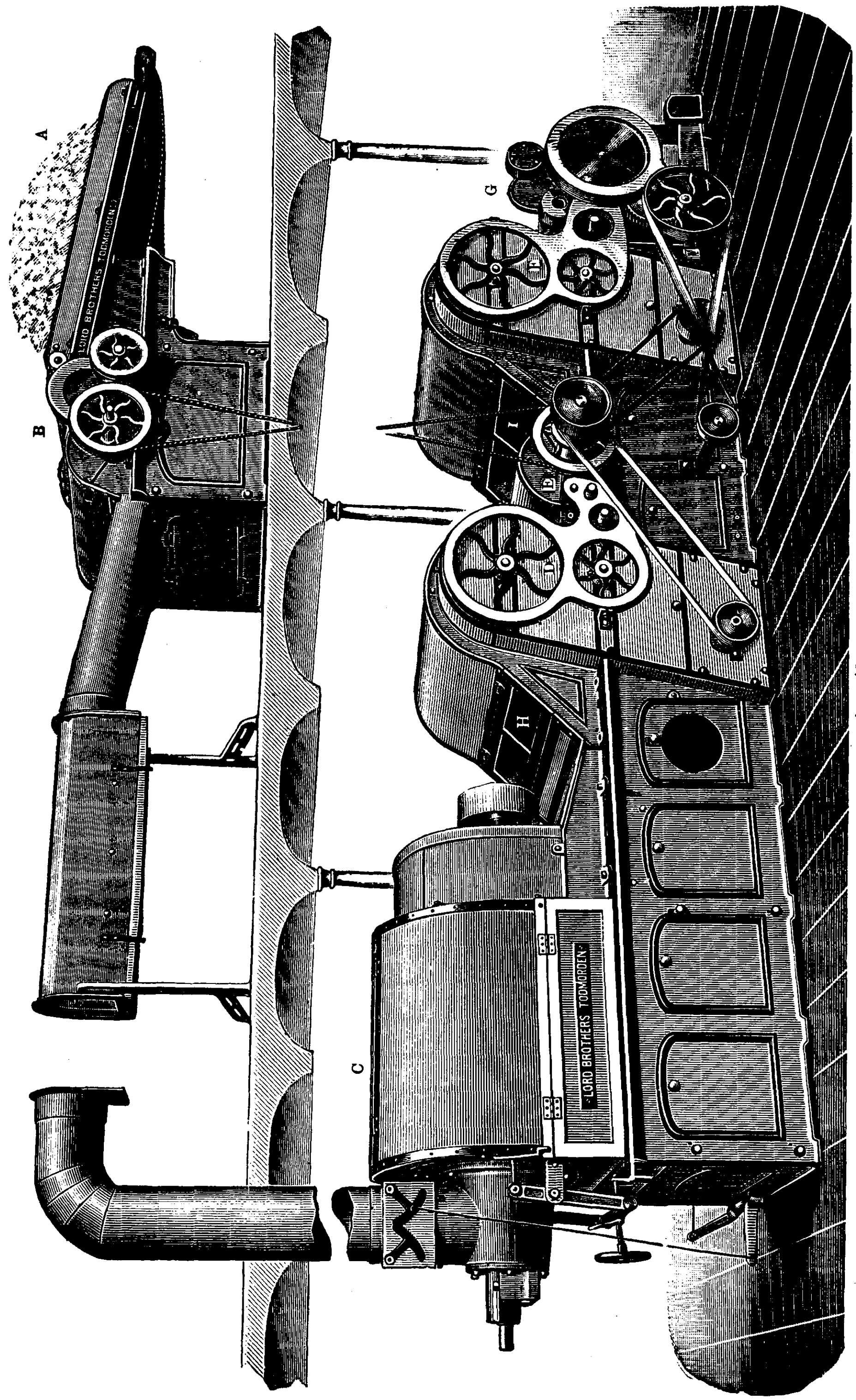


FIG. 40.

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 beater *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*.

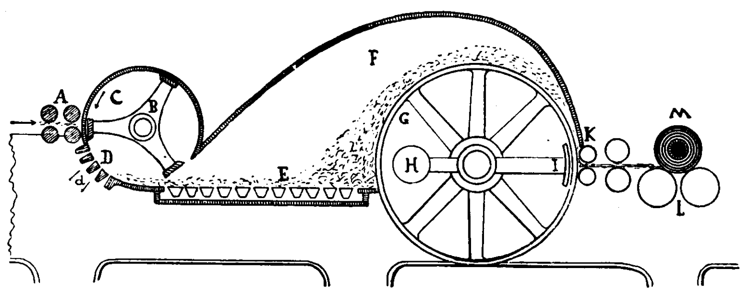


FIG. 41.

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.

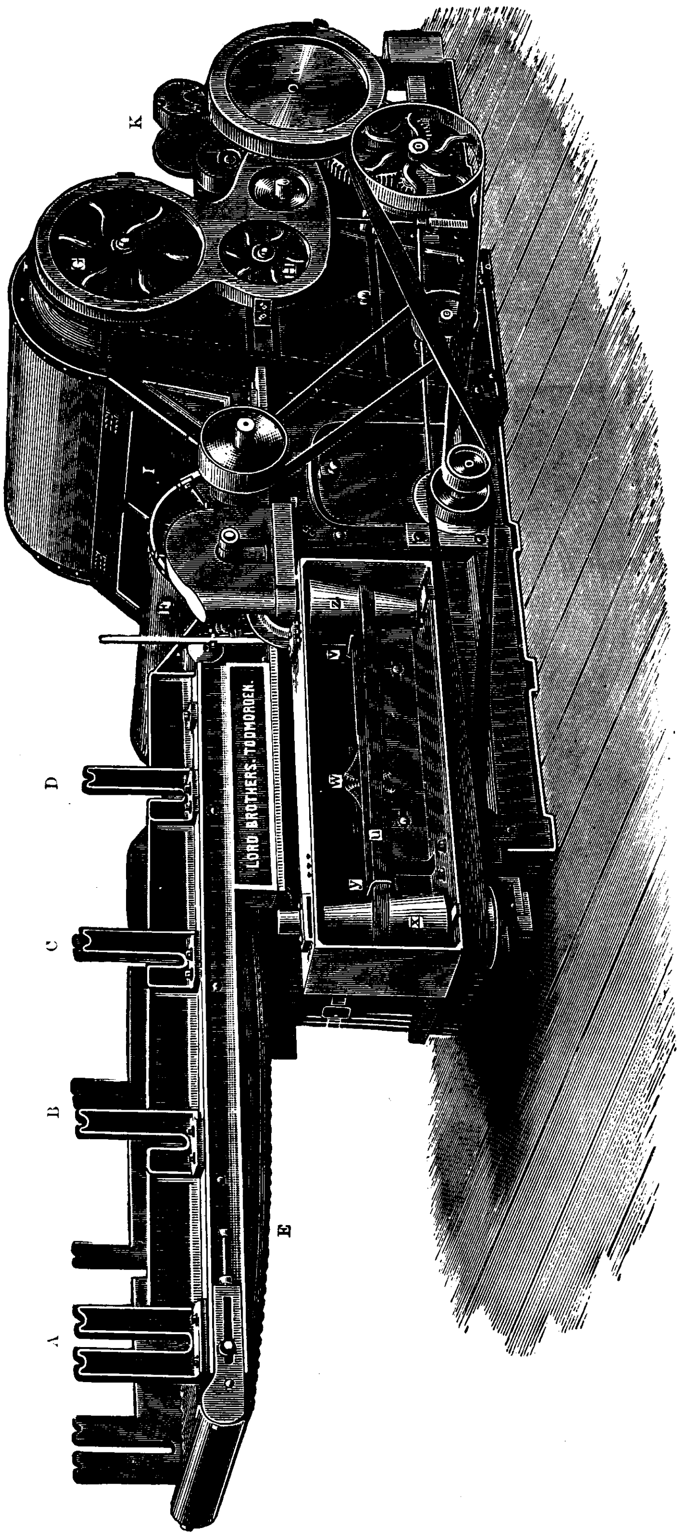


FIG. 42.

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.

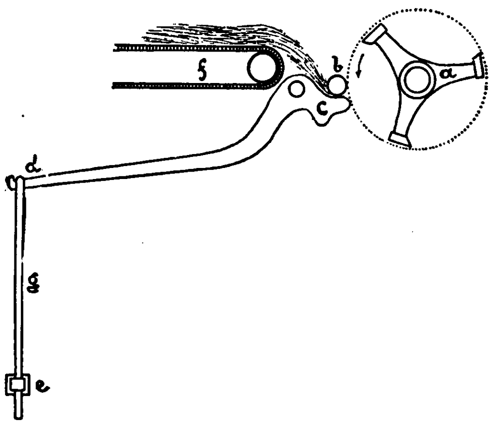


FIG. 43.

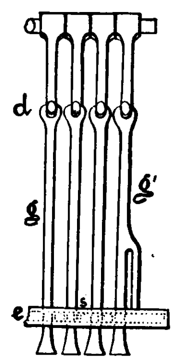


FIG. 44.

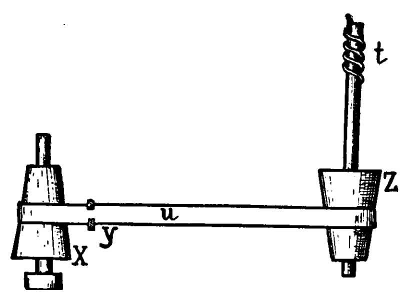


FIG. 45

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

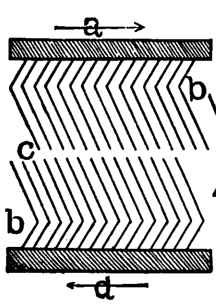


FIG. 46.

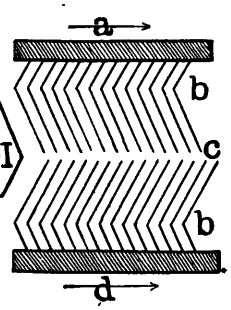


FIG. 47.

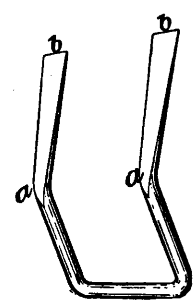


FIG. 48.

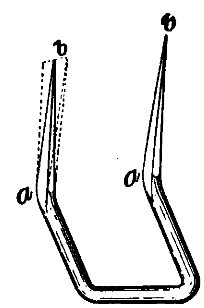


FIG. 49.

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

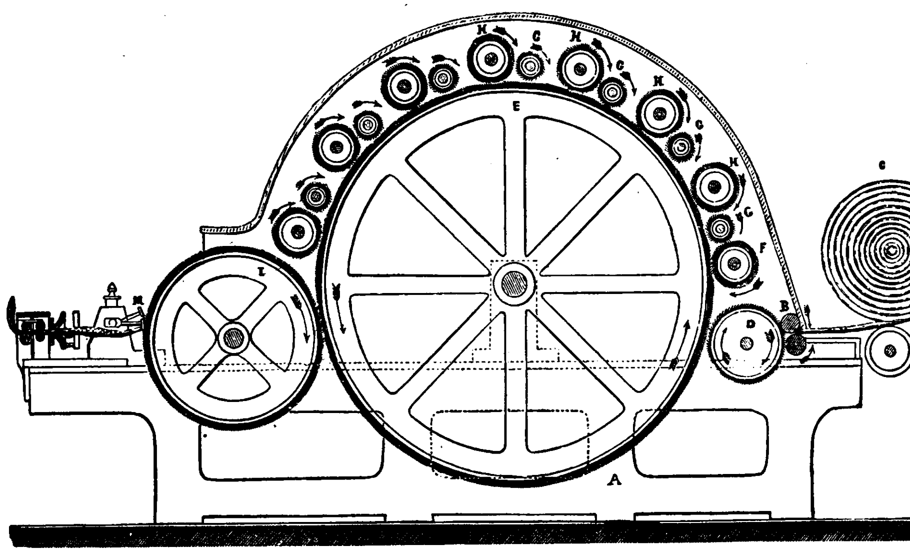


FIG. 50.

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.

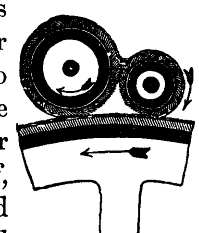


FIG. 51.

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

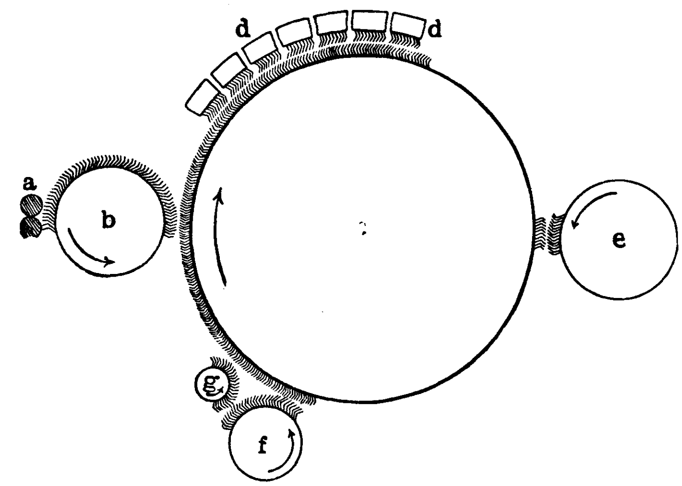


Fig. 52.

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

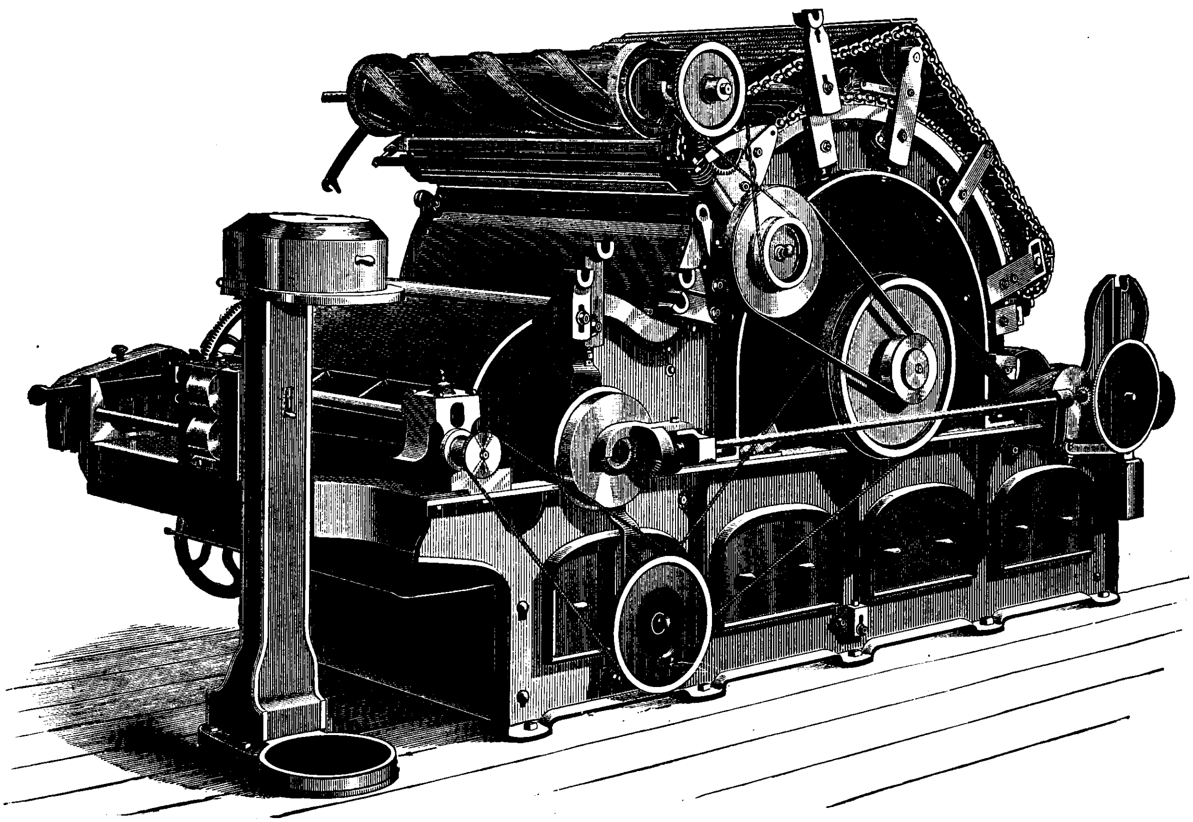


FIG 53.

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.

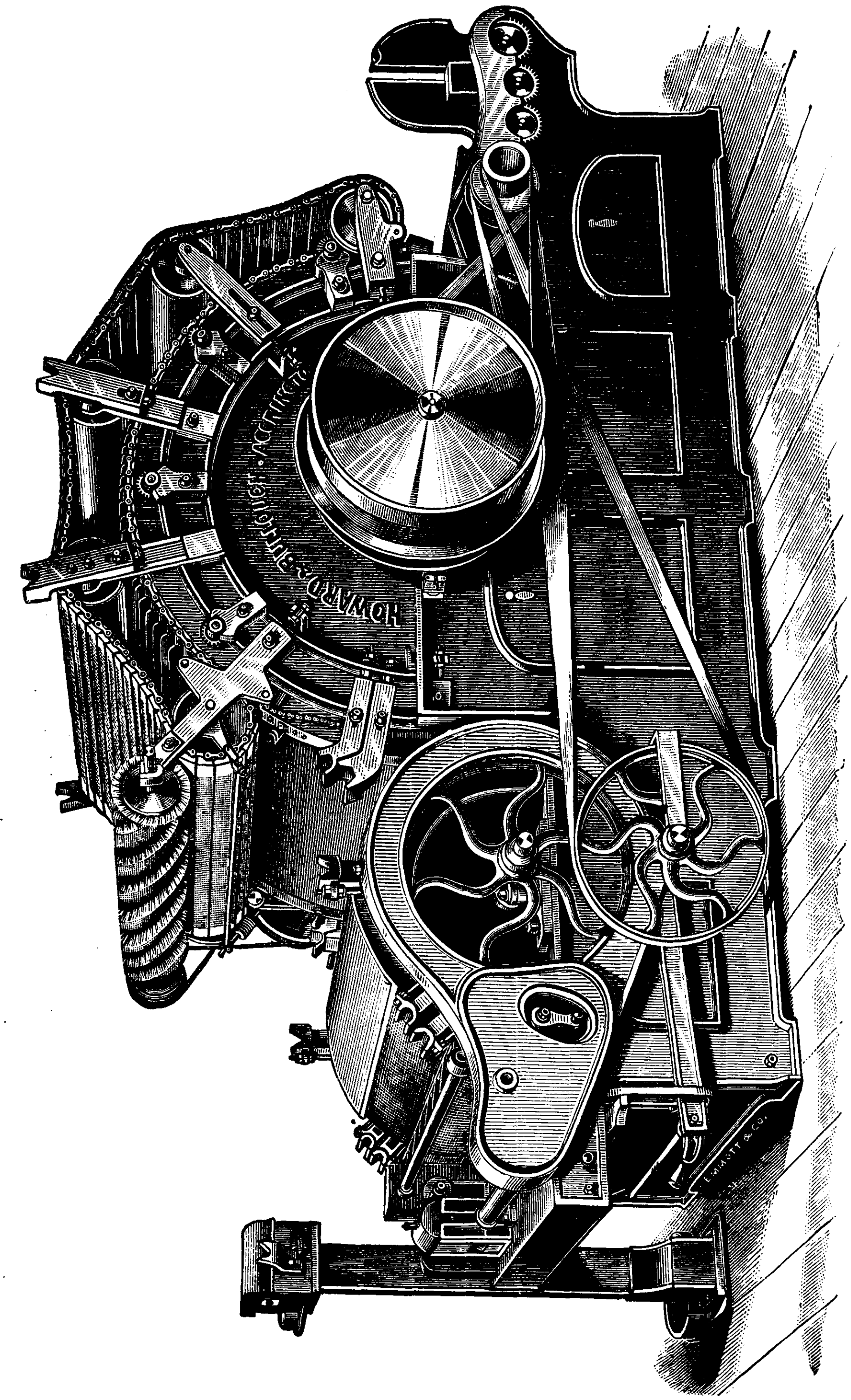


FIG. 54.

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. 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

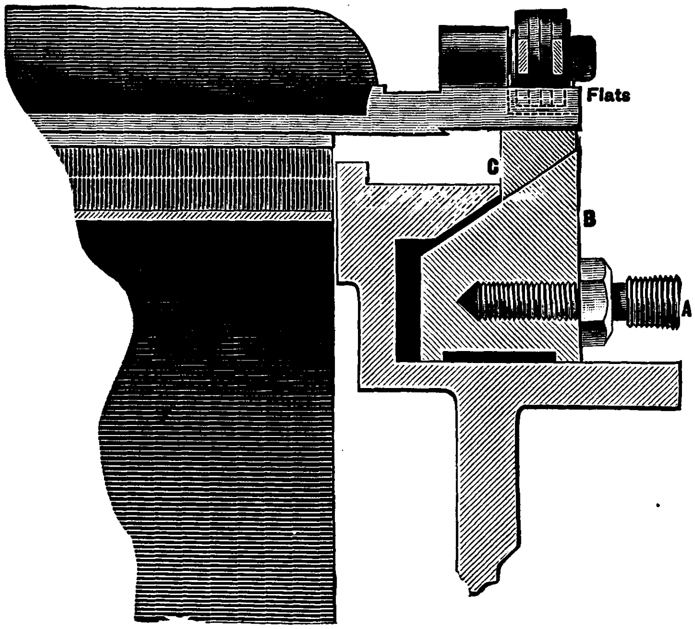


FIG. 55.

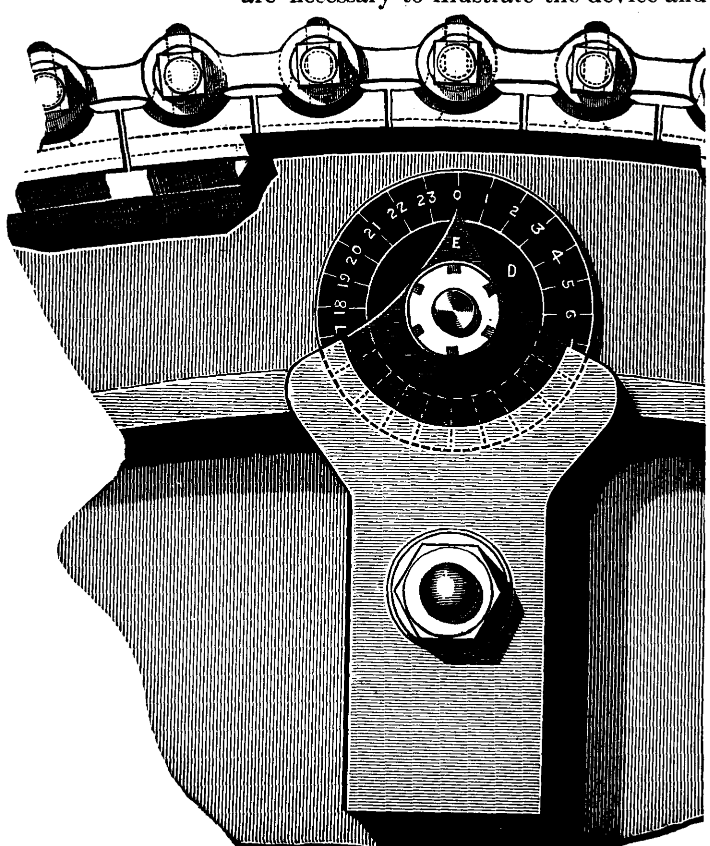


FIG. 56.

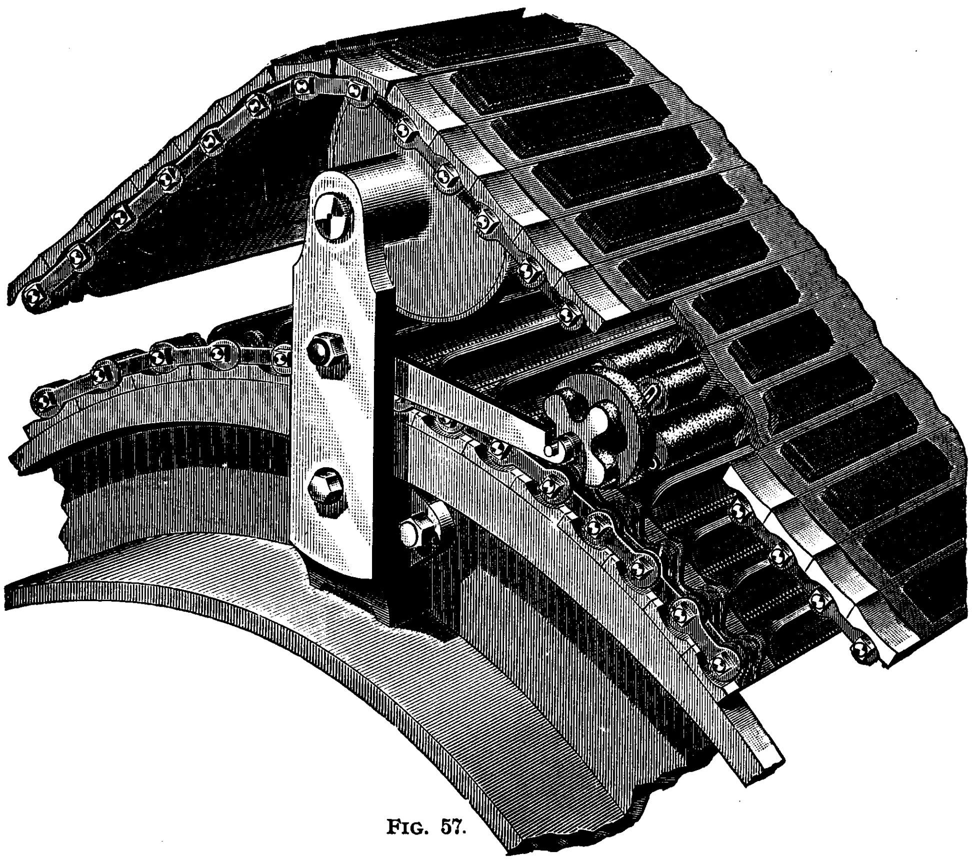


FIG. 57.

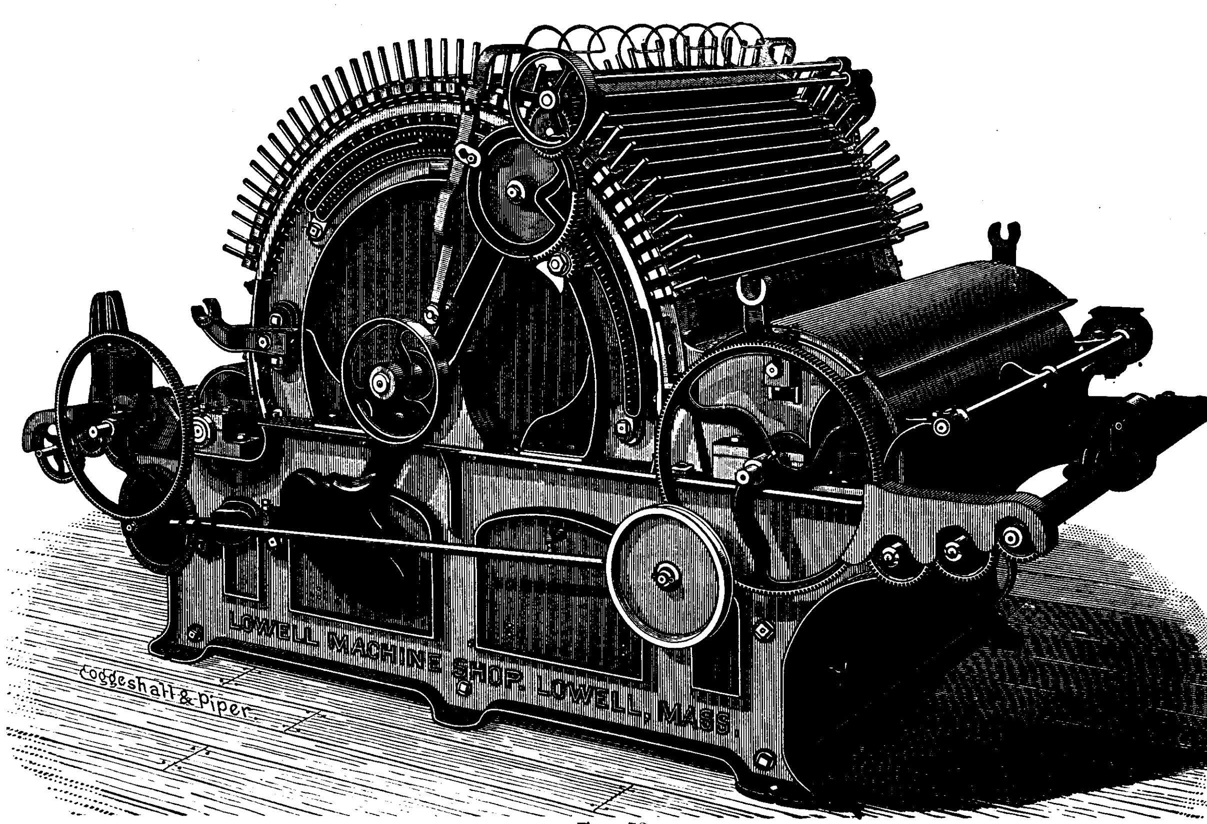


FIG 58.

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-

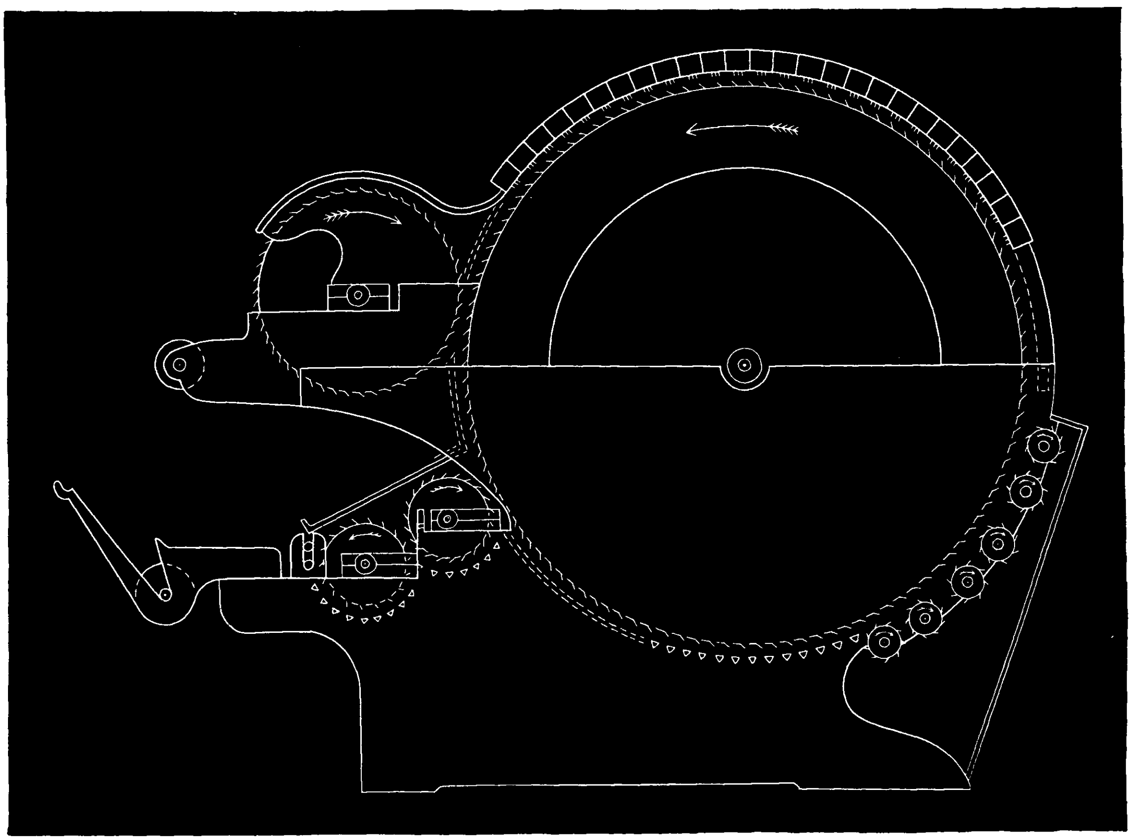


Fig. 59.

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-

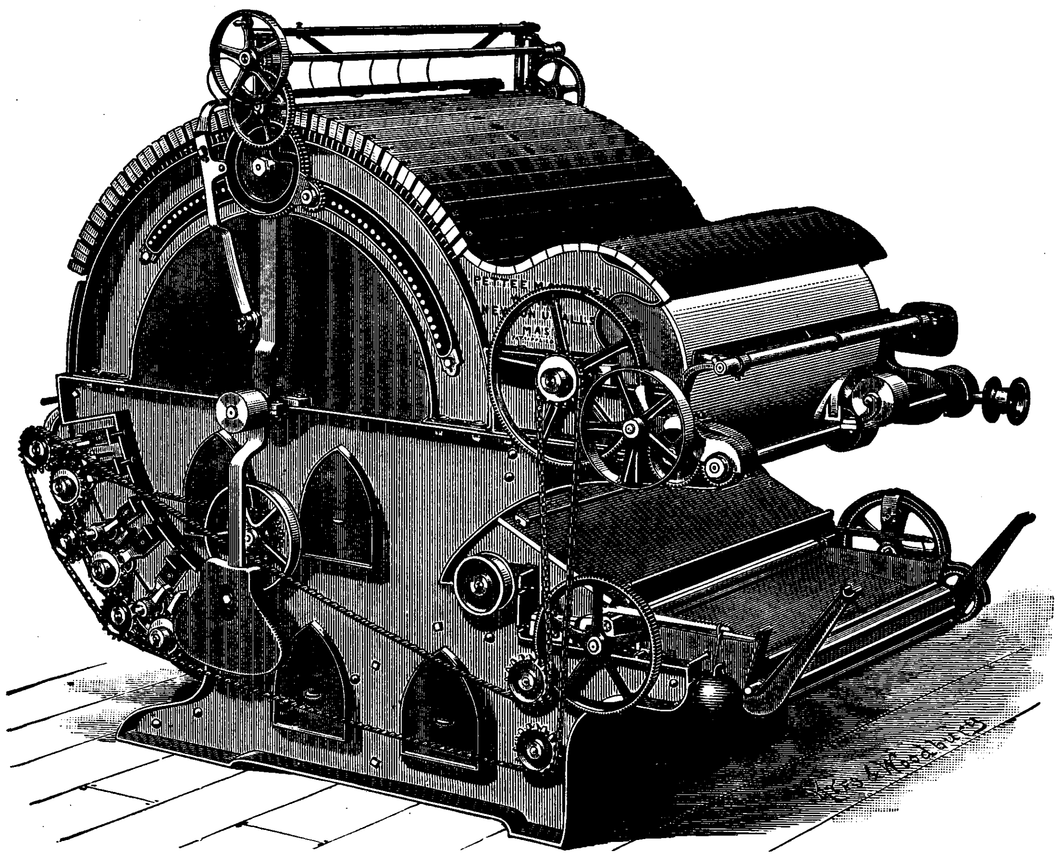


FIG 60

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.

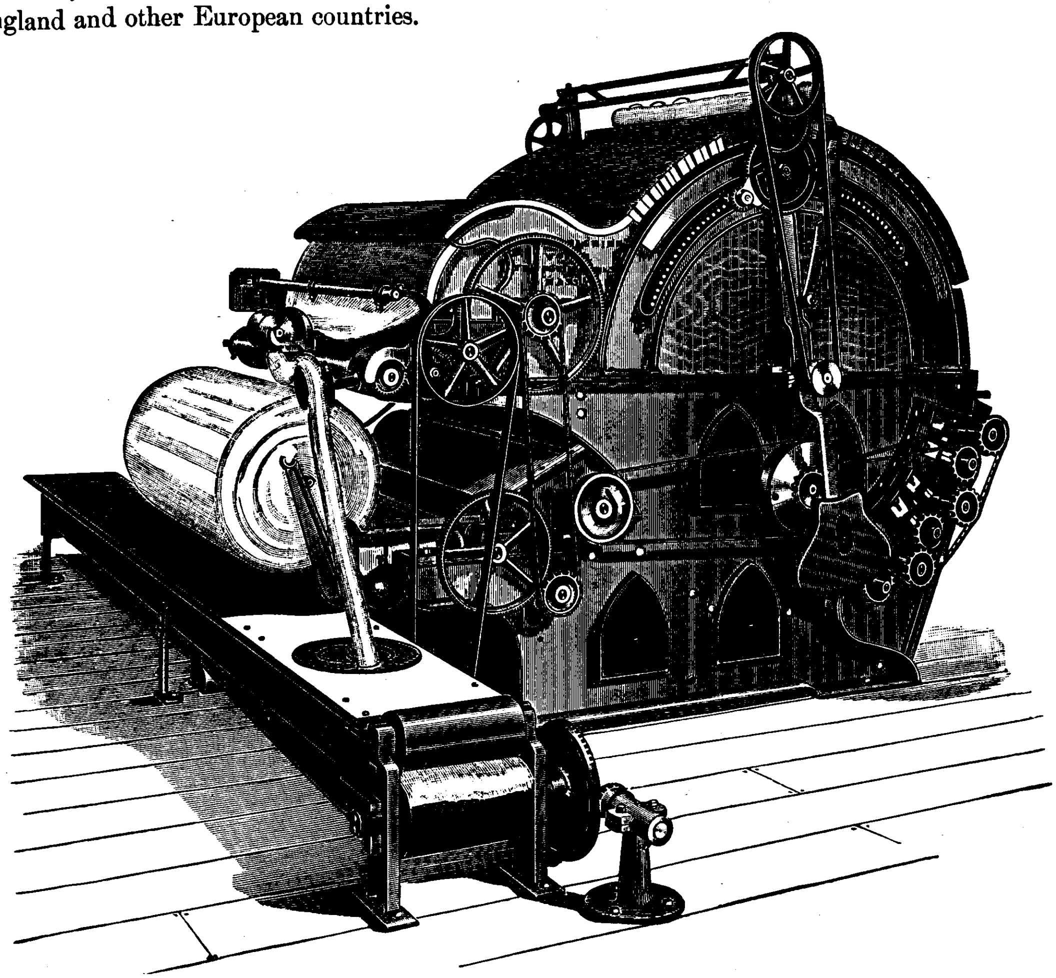


FIG. 61.

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

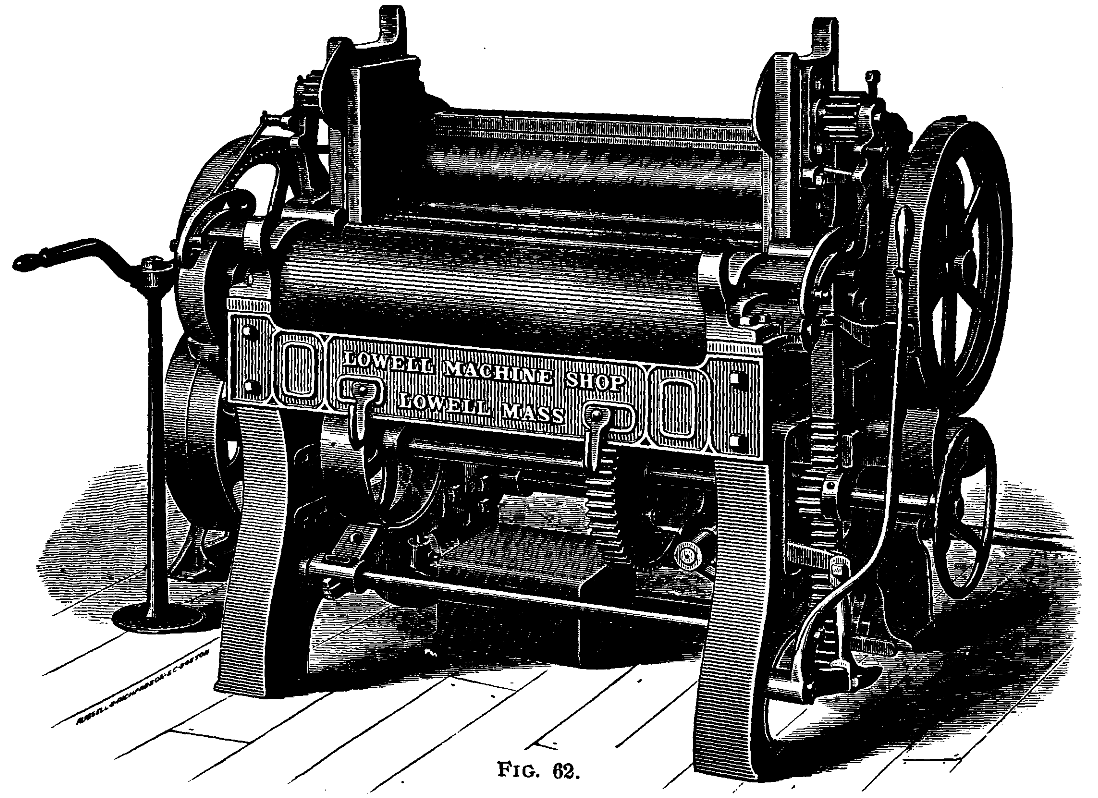


FIG. 62.

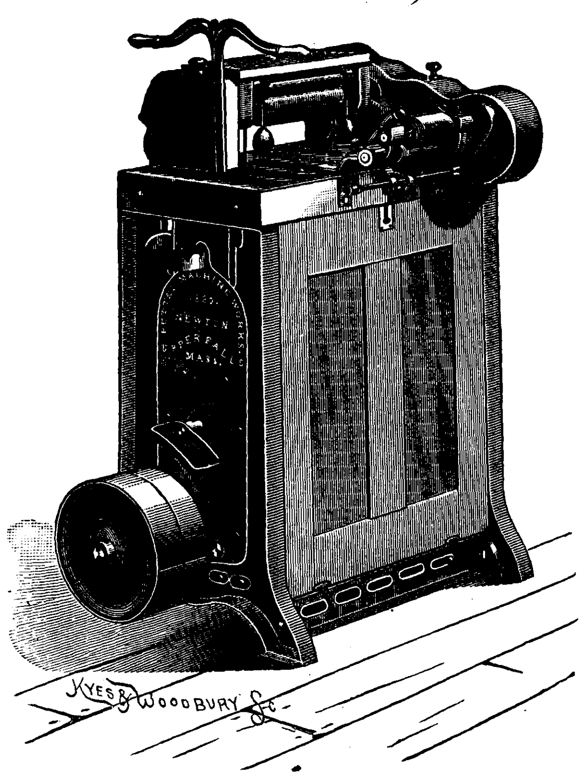


FIG. 63.

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.

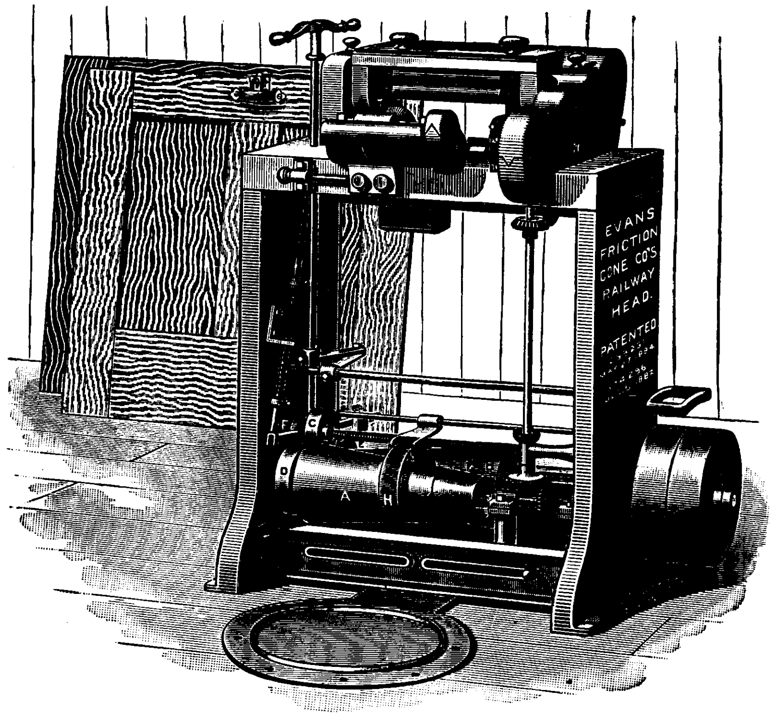


FIG. 64.

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

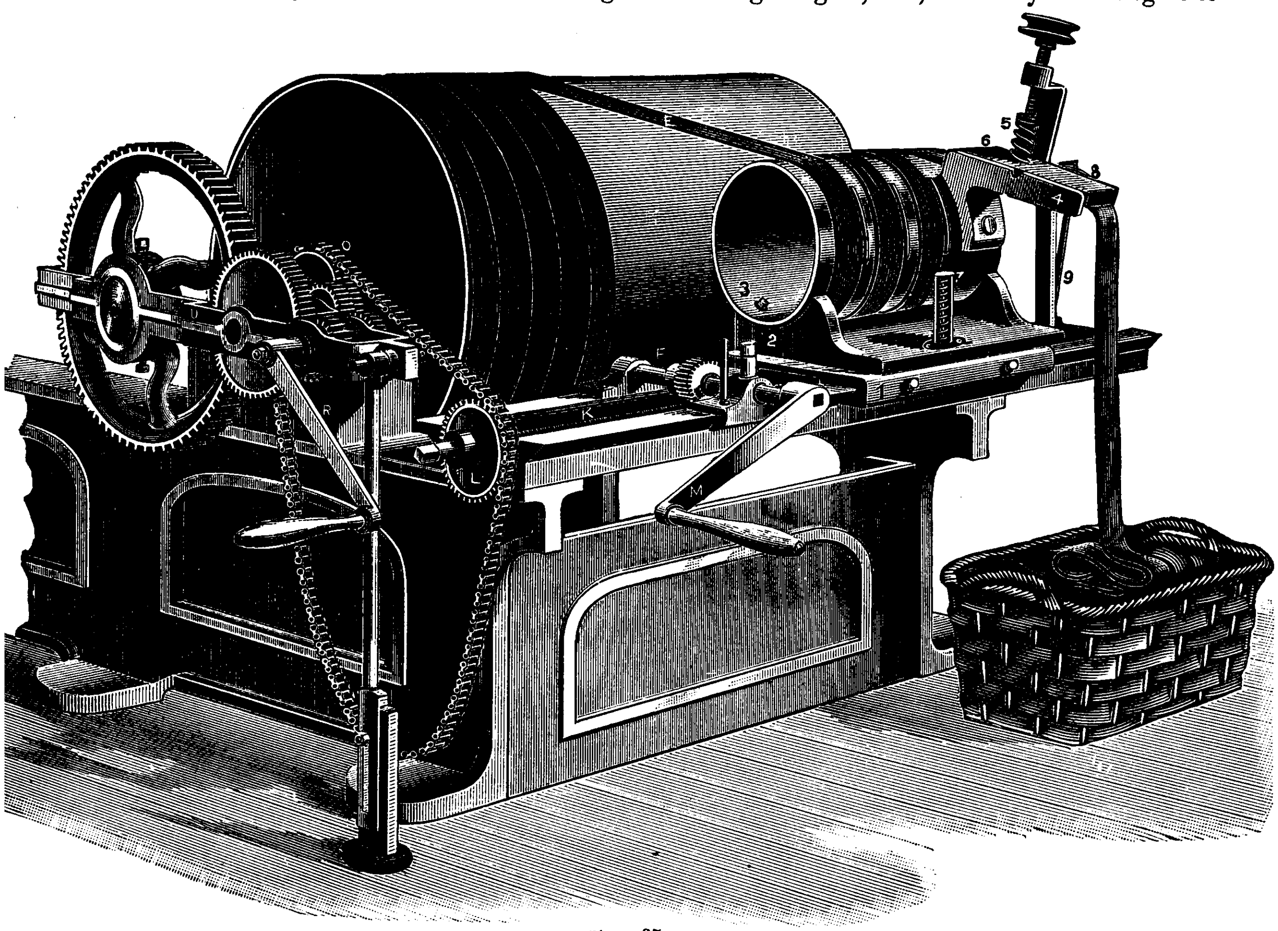


FIG. 65.

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.

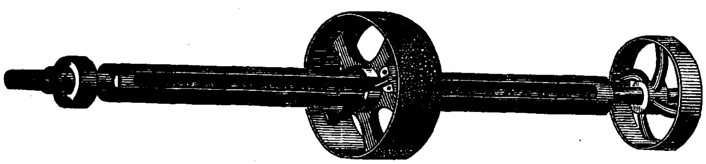


FIG. 66.

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.

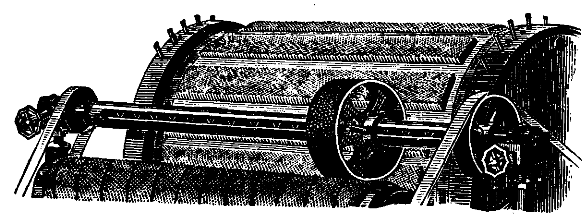


FIG. 67.

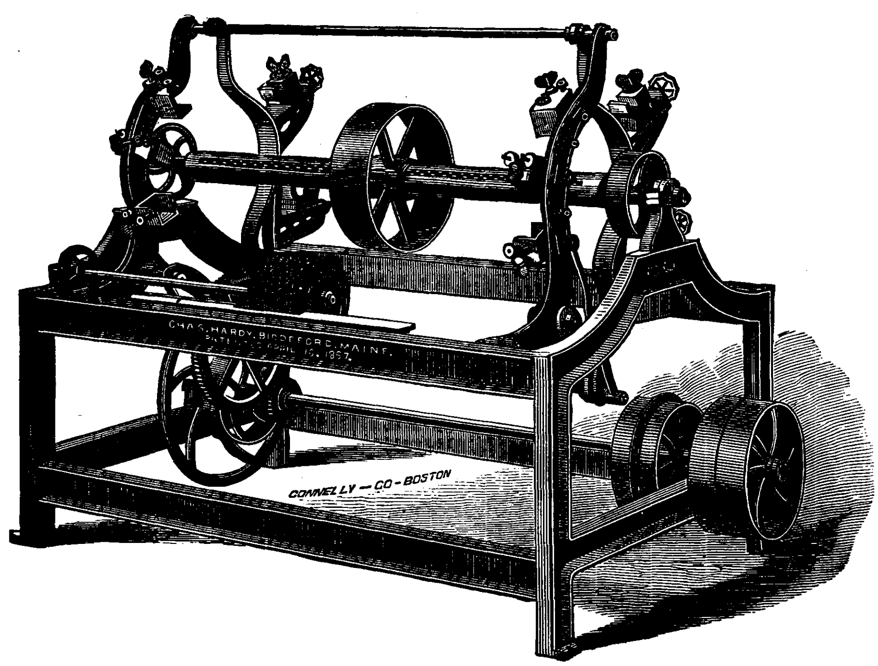


FIG. 68.

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.

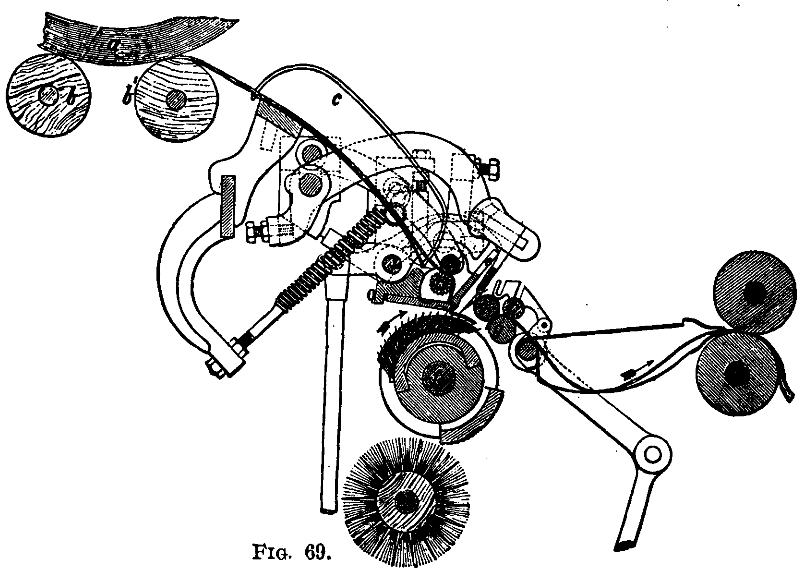


Fig. 69.

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.

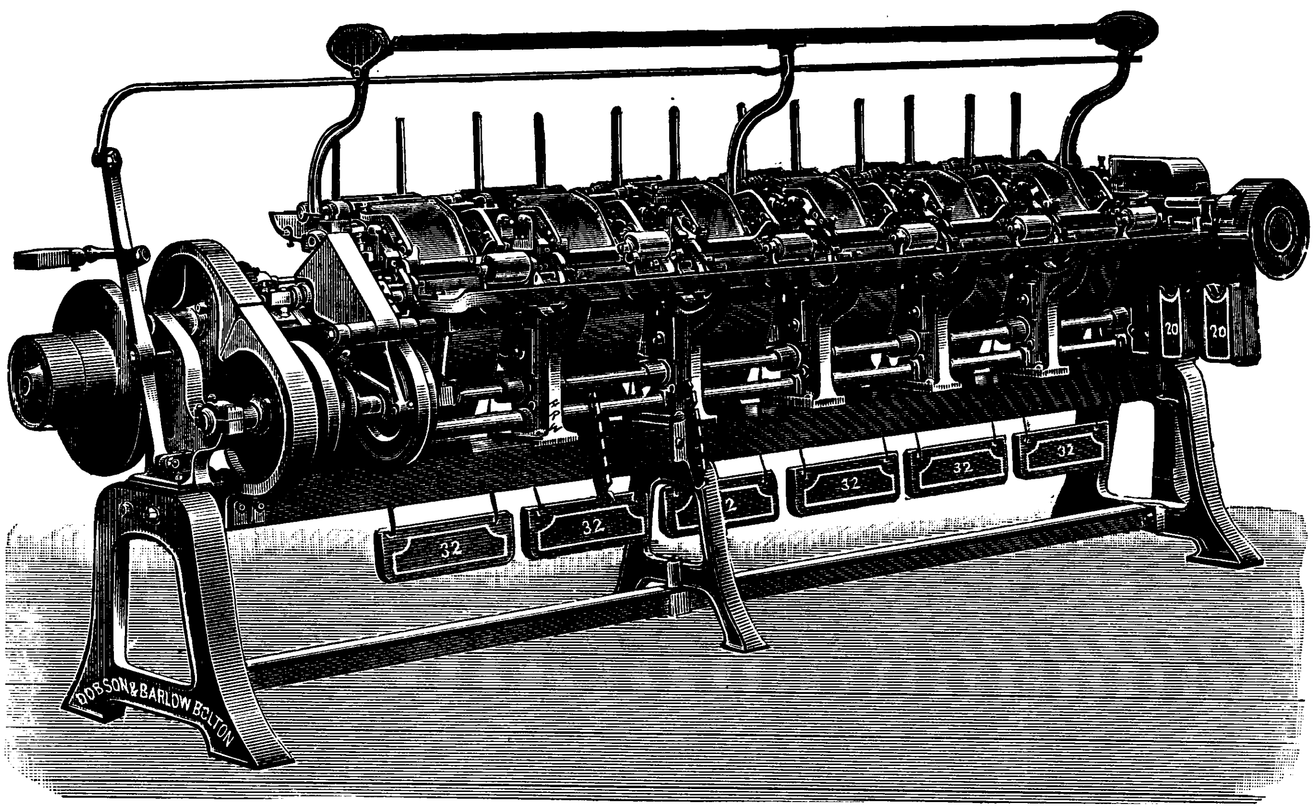


FIG. 70.

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

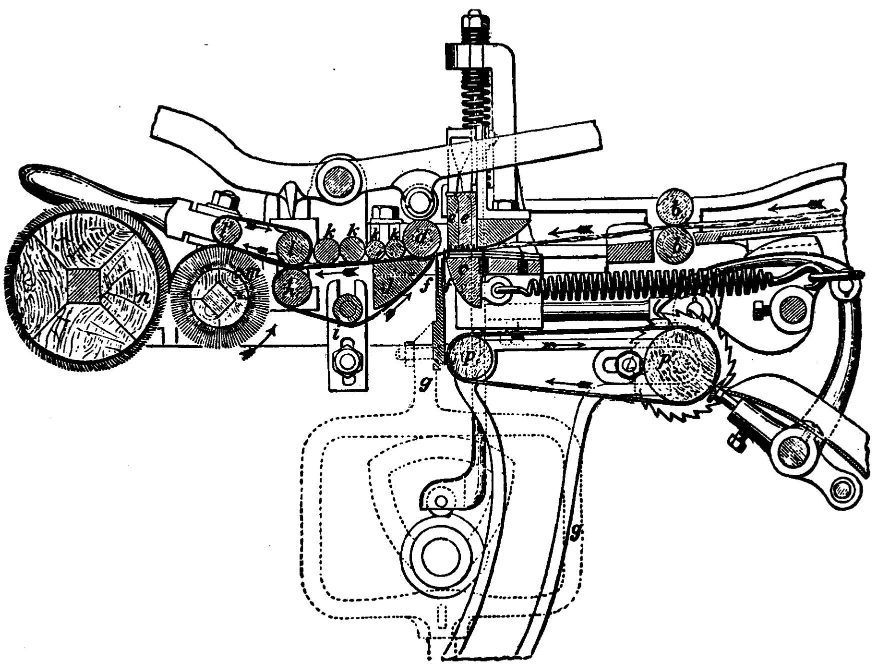


FIG. 71.

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.

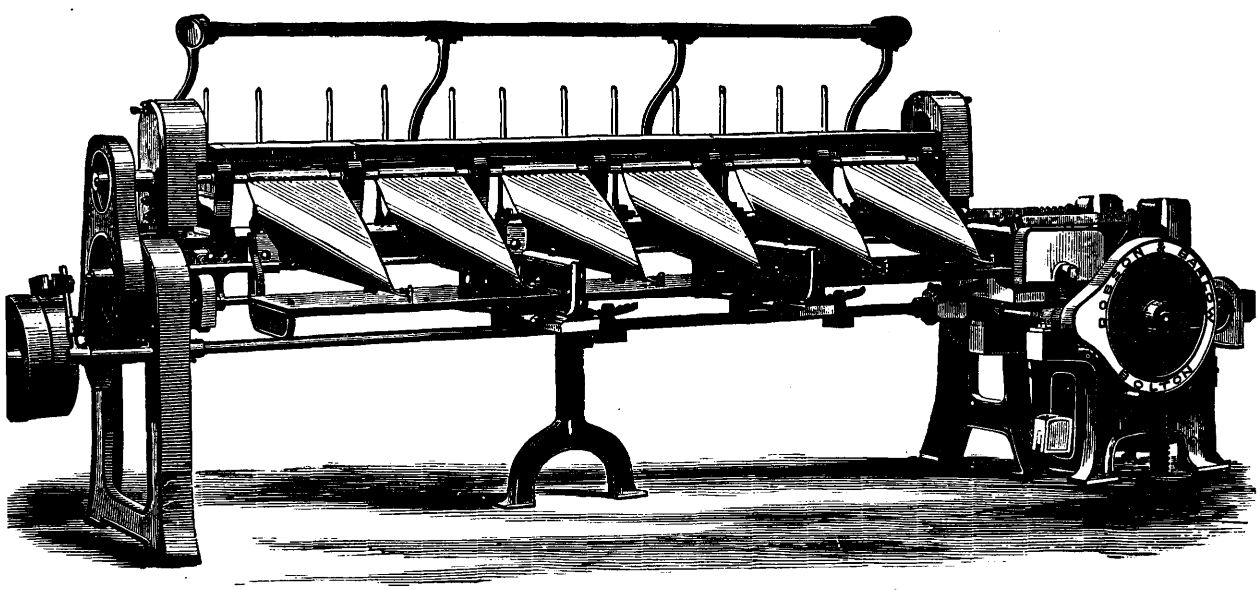


Fig. 72.

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.

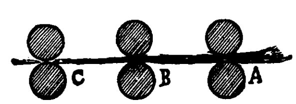


FIG. 73.

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-

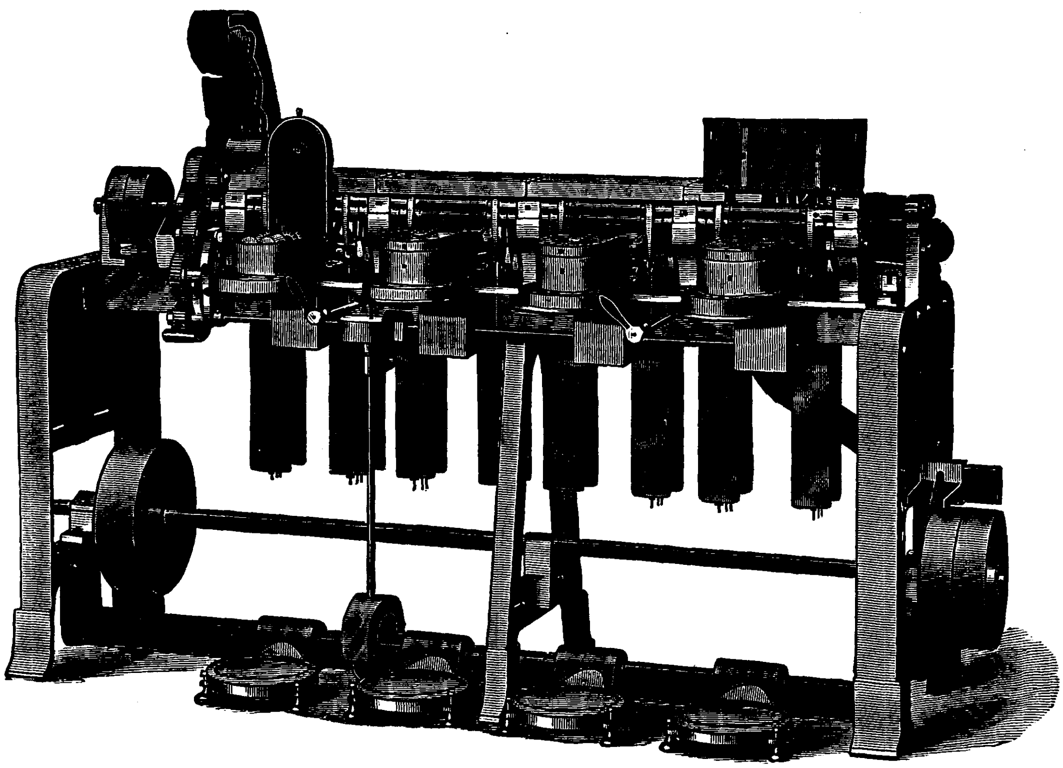


FIG. 74.

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

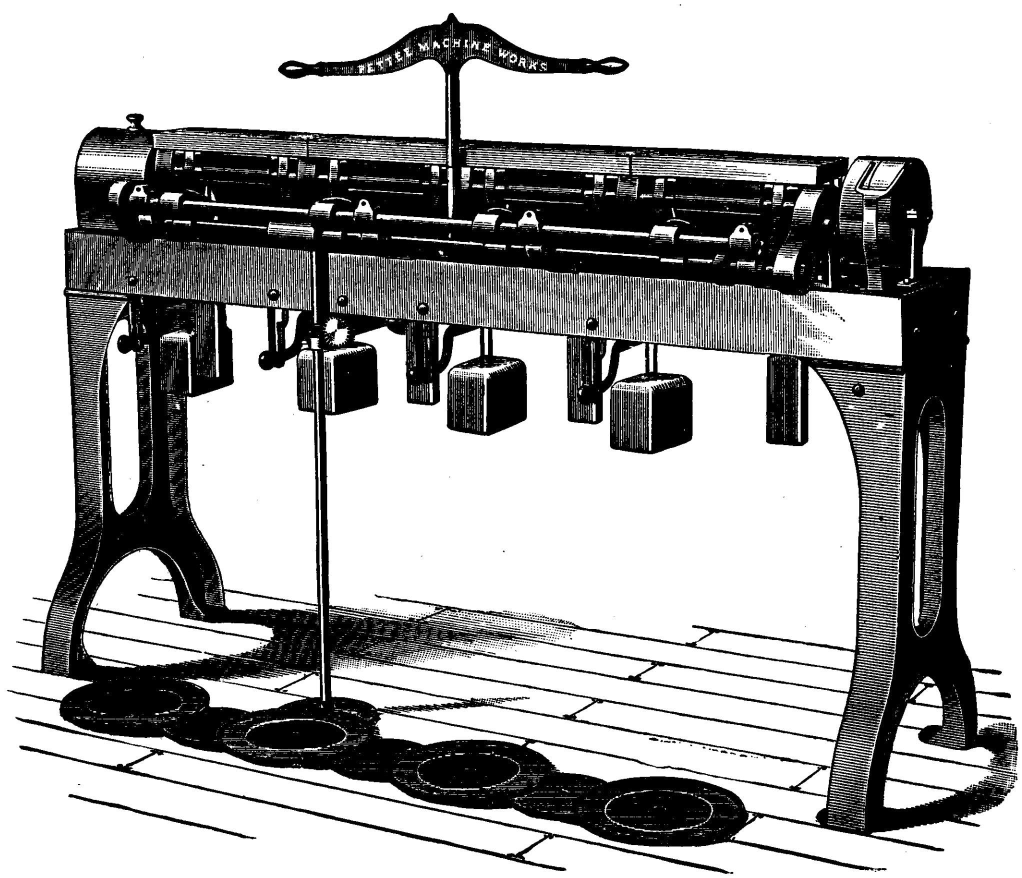


FIG. 75

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.

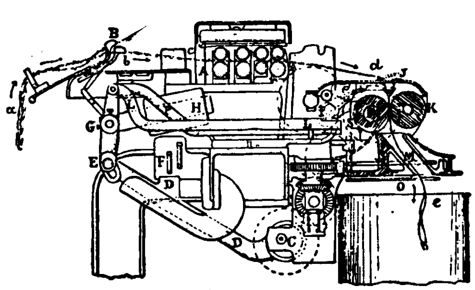


FIG. 76.

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.

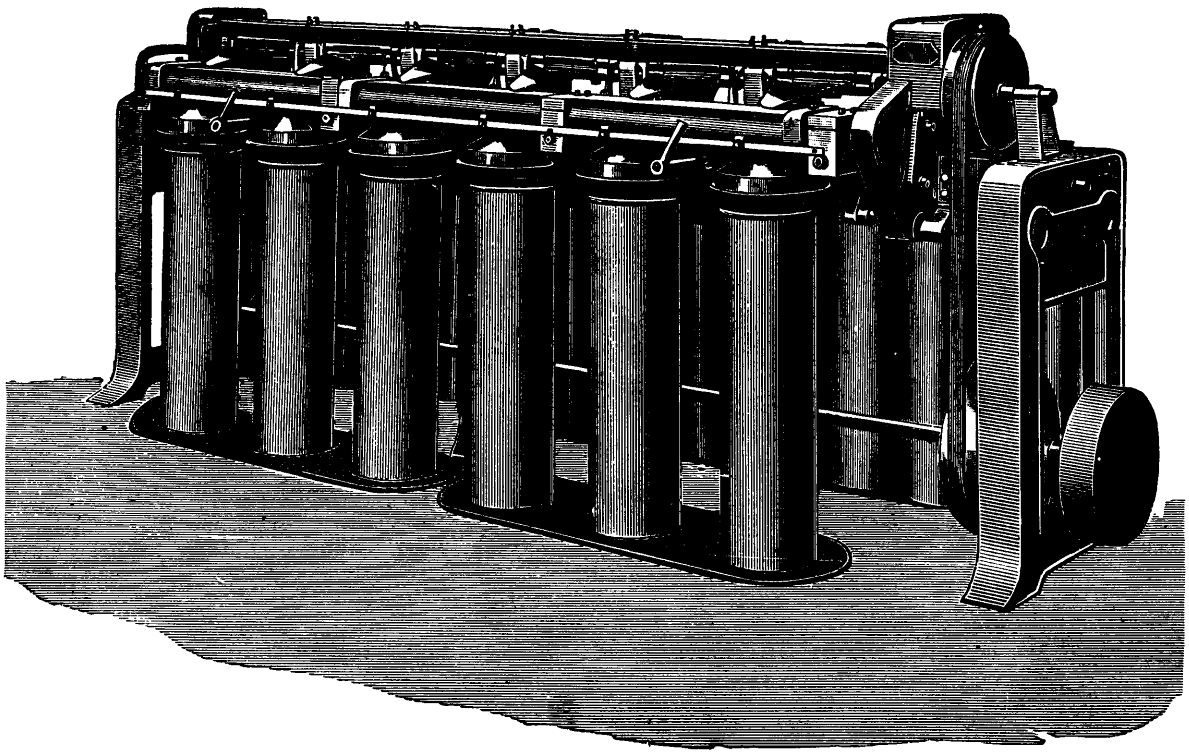


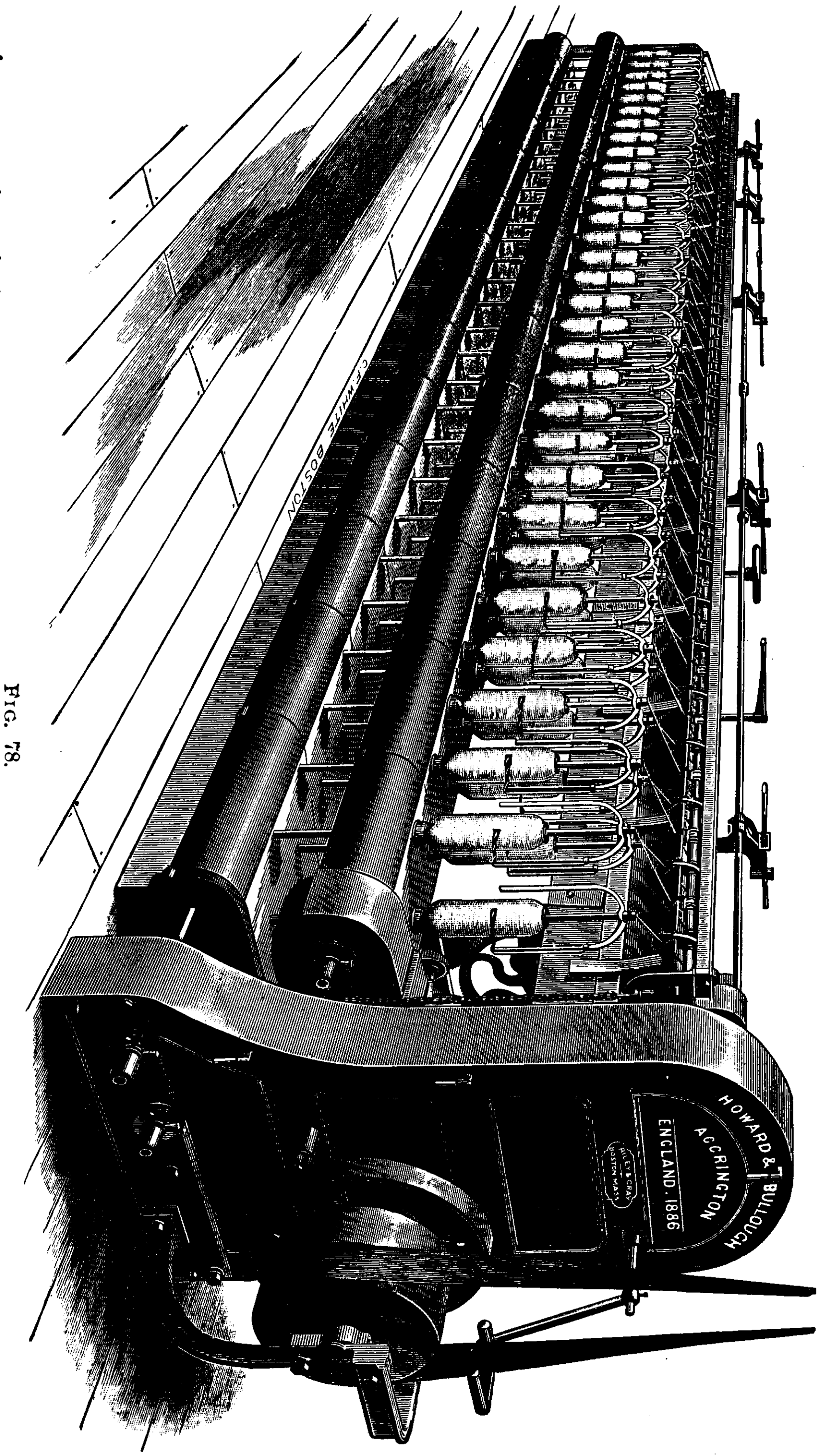
FIG. 77

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*).

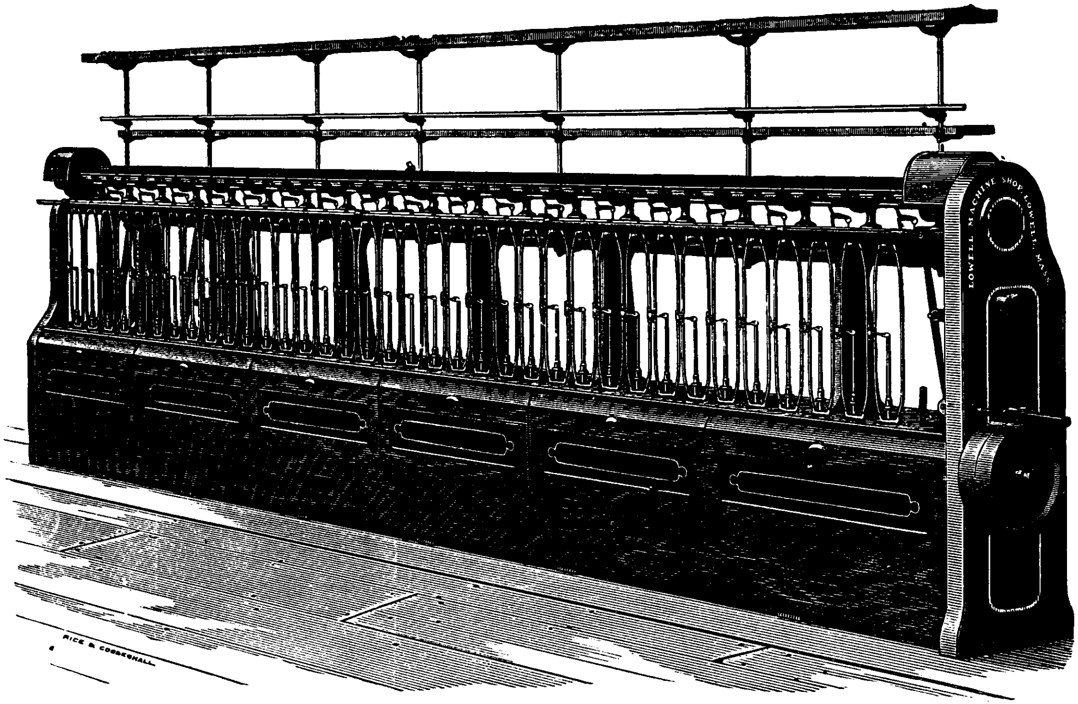

LOWELL MACHINE SHOP LOWELL MASS.
RICE & COGGESHALL

Fig. 79.

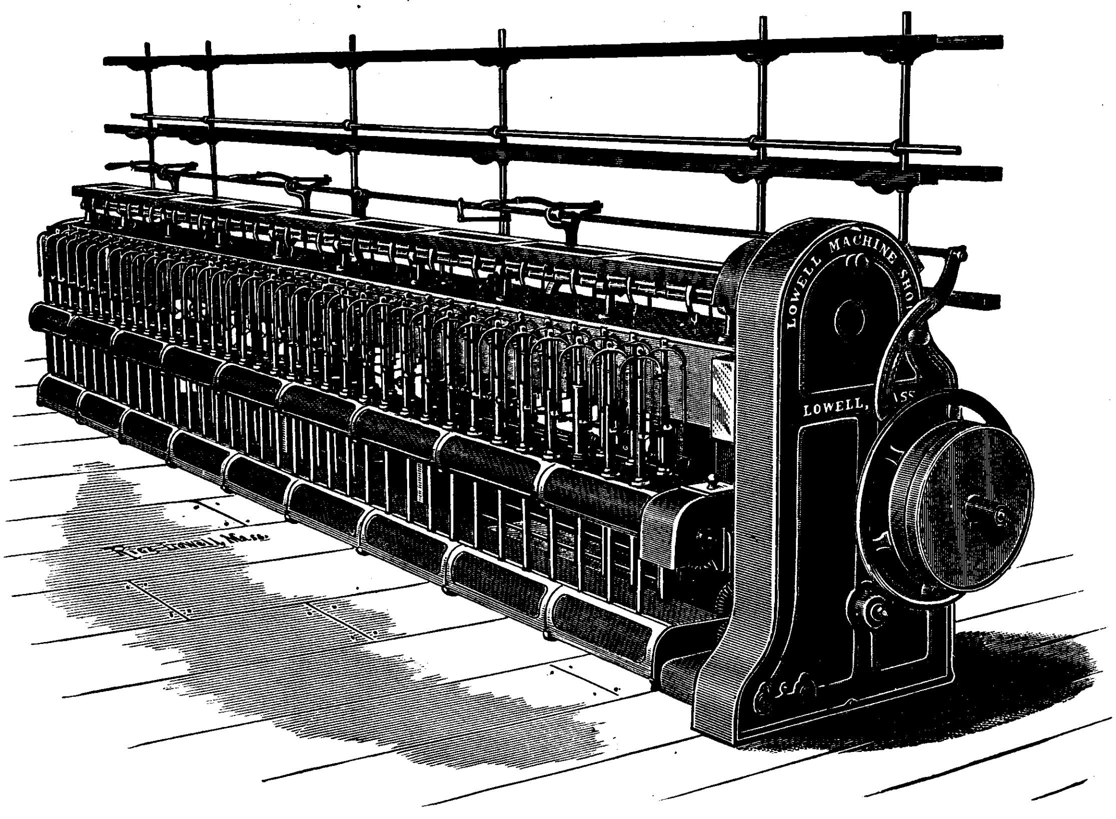

LOWELL MACHINE SHOP
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Fig. 80.

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*

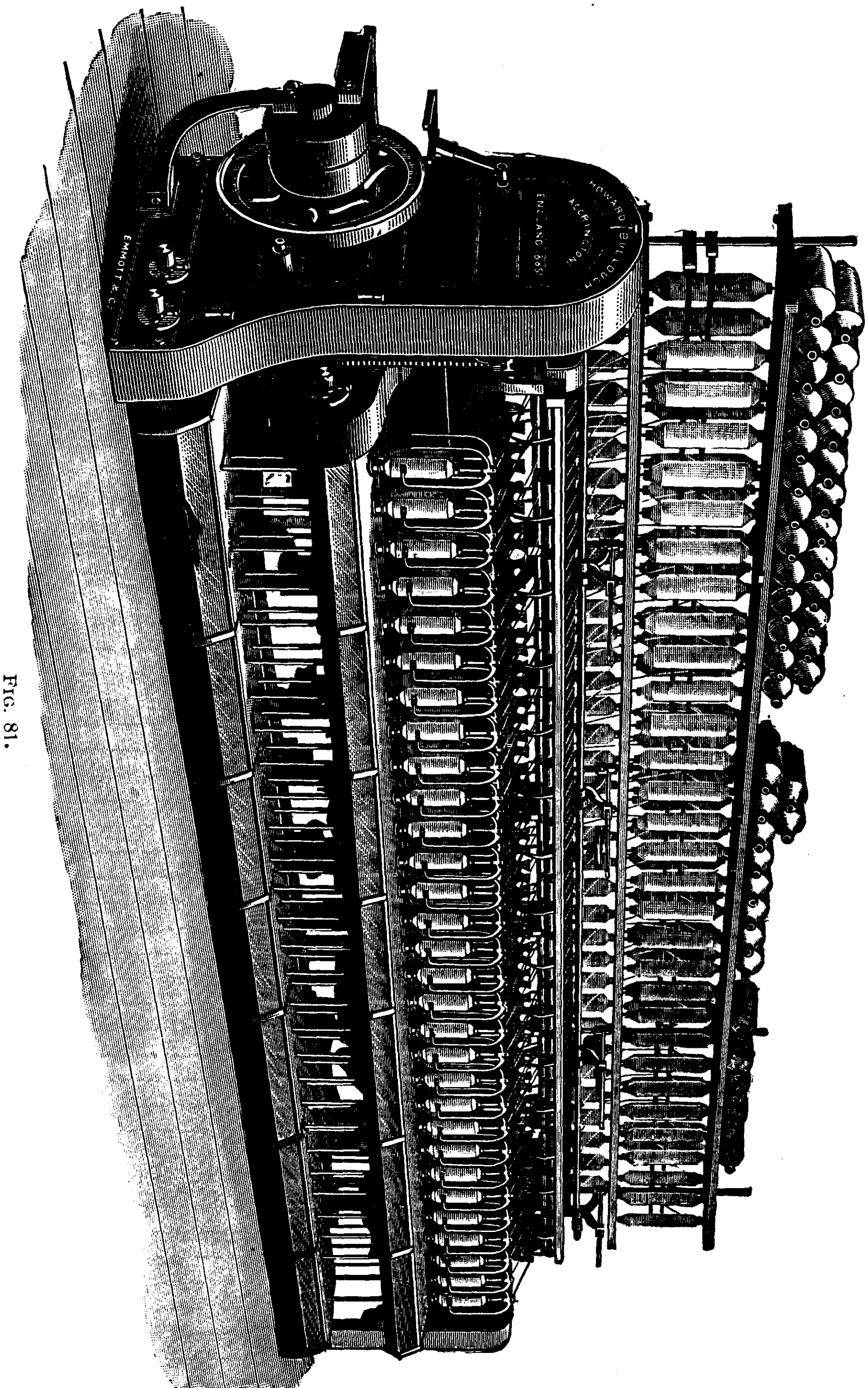

FIG. 81.

slubbing between the front drawing-rollers and the head of the flyer is turned once around its axis everv 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.*

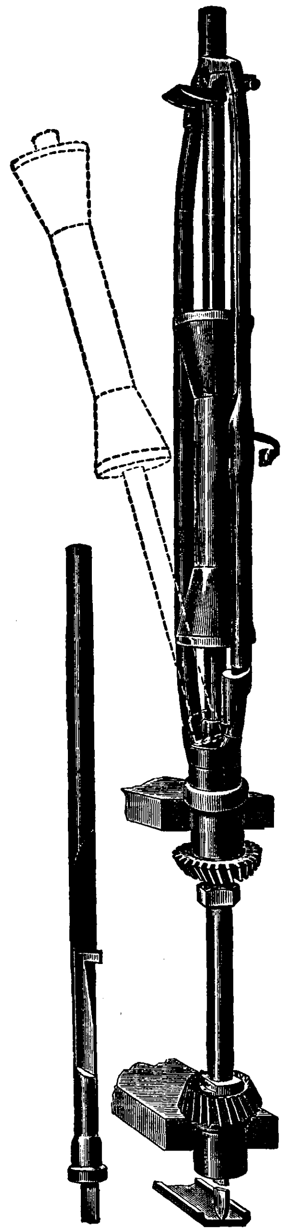
FIG. 82.

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.

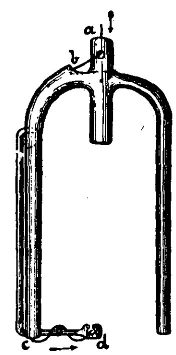
FIG. 83.

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-

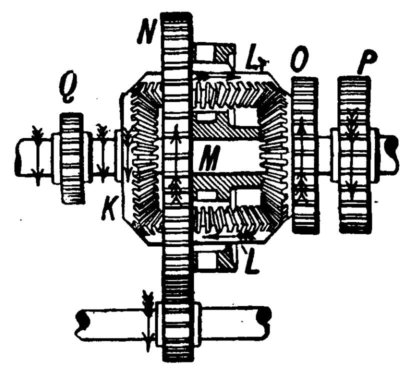

FIG. 84.

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

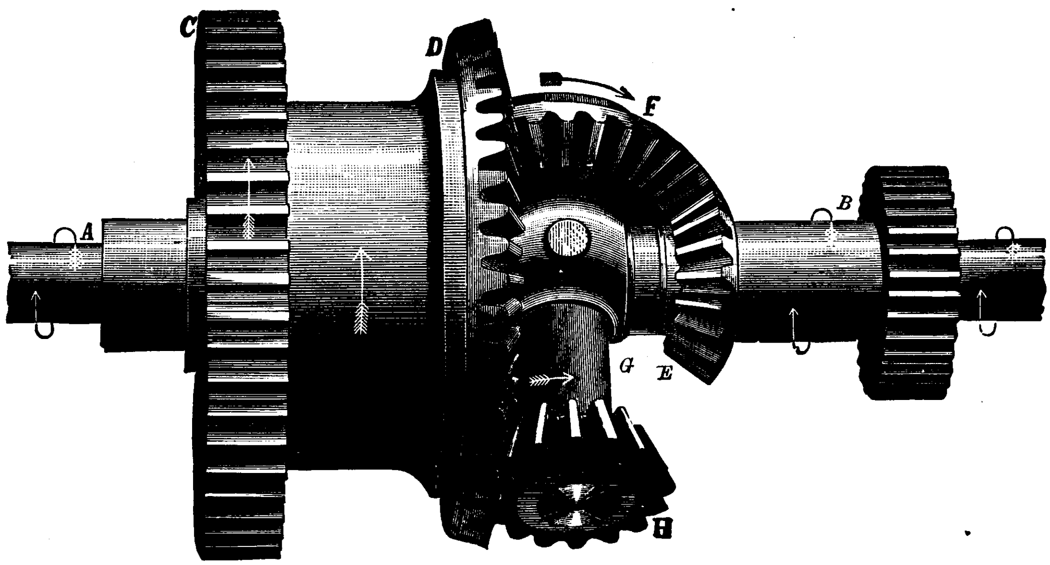

FIG. 85.

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.

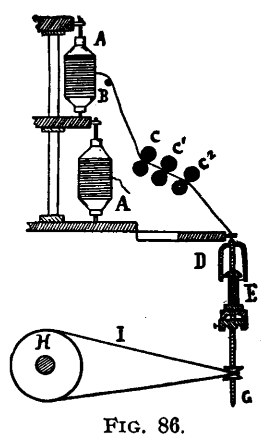

Fig. 86.

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.

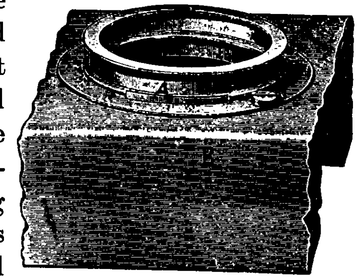

Fig. 88.

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

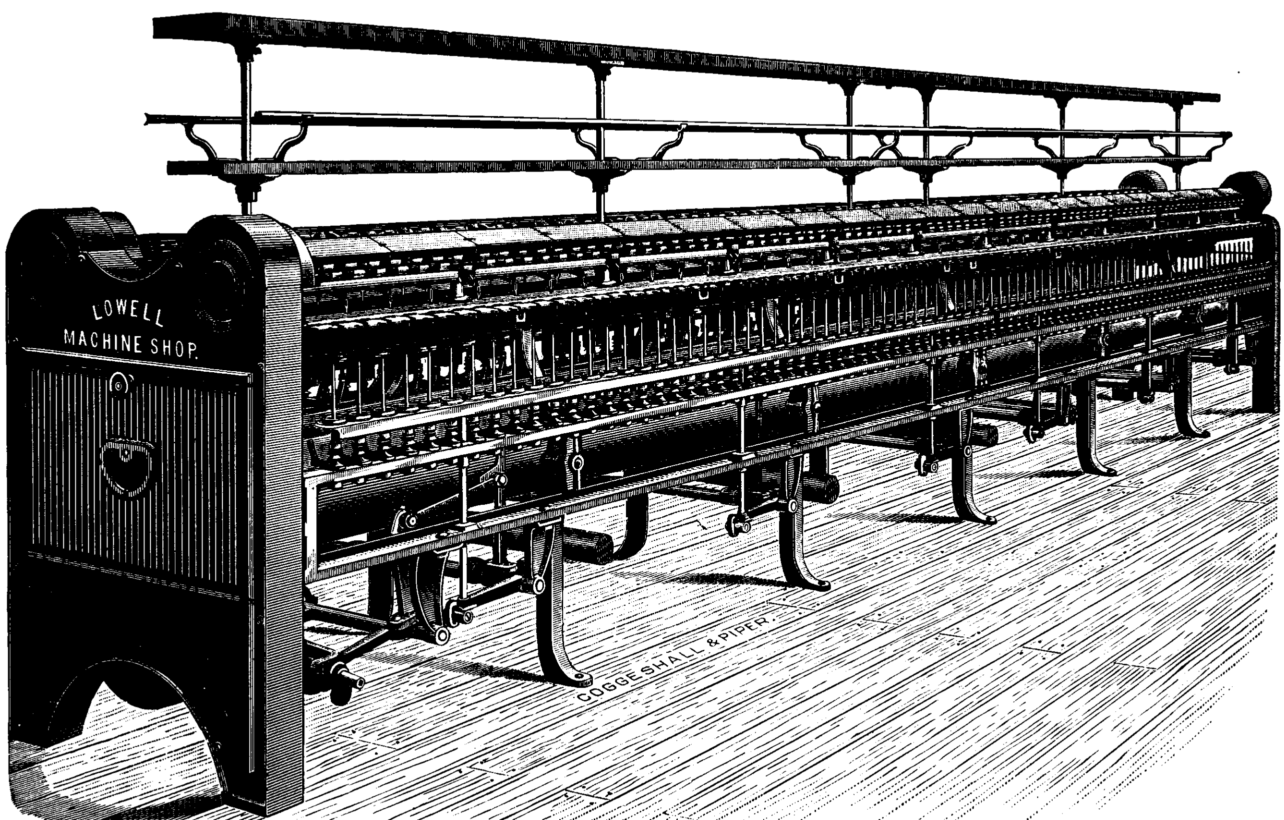

Fig. 89.

slowly to this system of spinning, hanging more or less to their old slow and expensive throstle spinning 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.

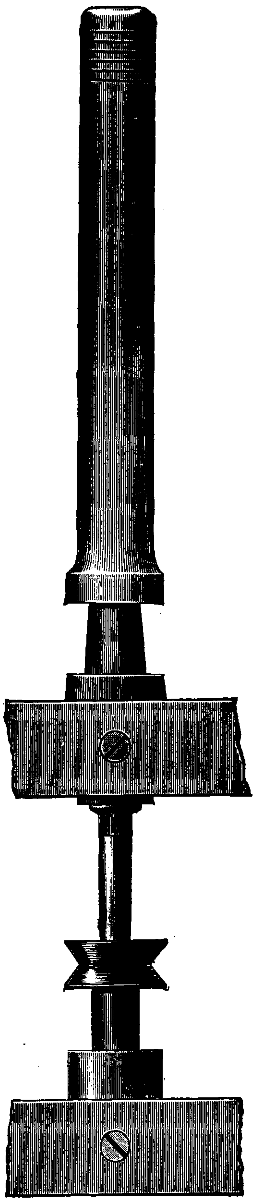

FIG. 90.

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.

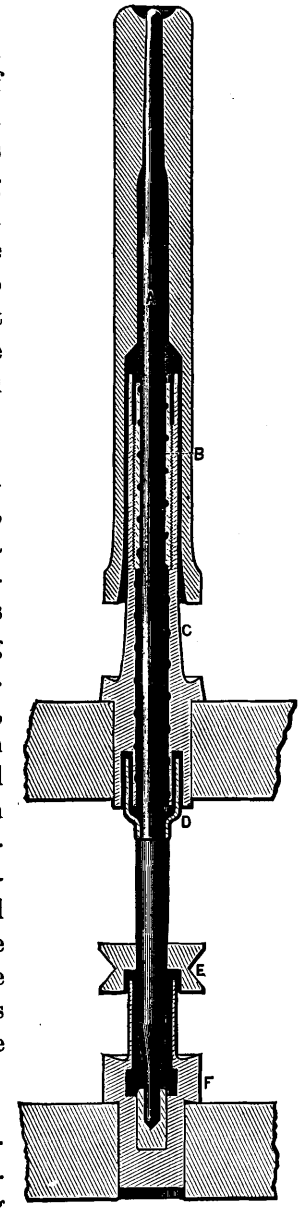

FIG. 91.

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

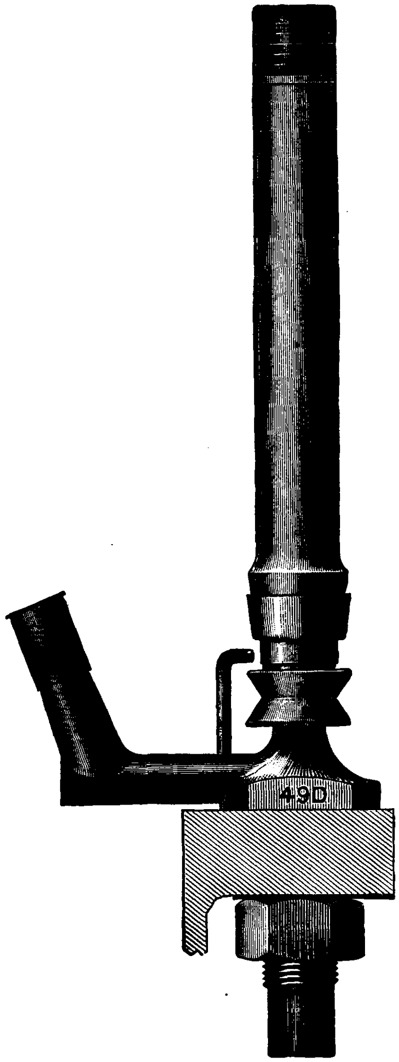

FIG. 92.

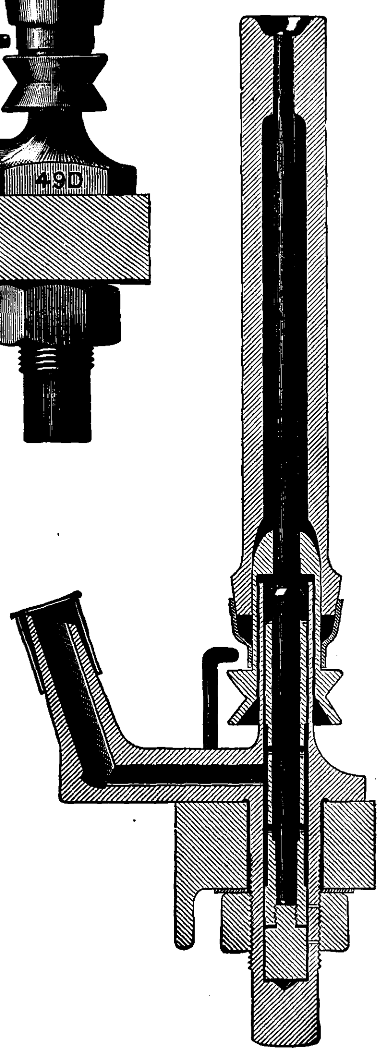

FIG. 93.

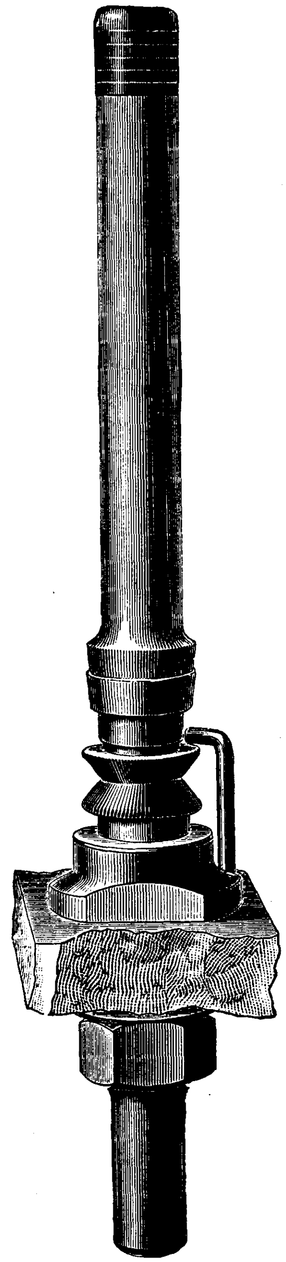

FIG. 94.

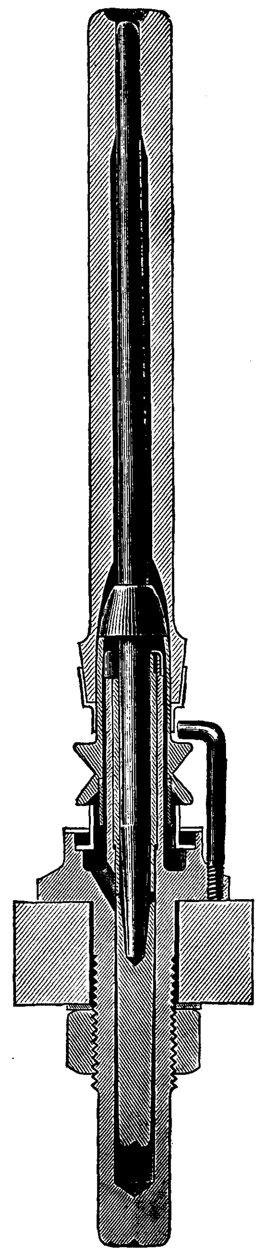

FIG. 95.

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.

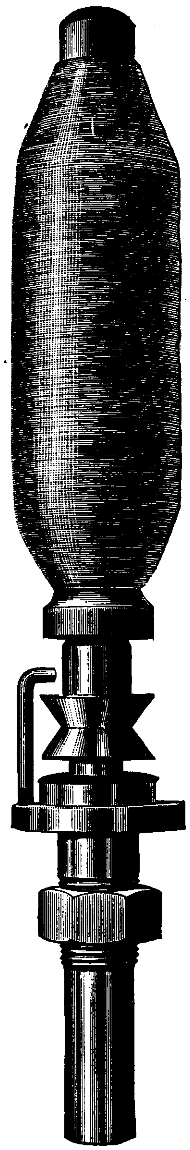

FIG. 96.

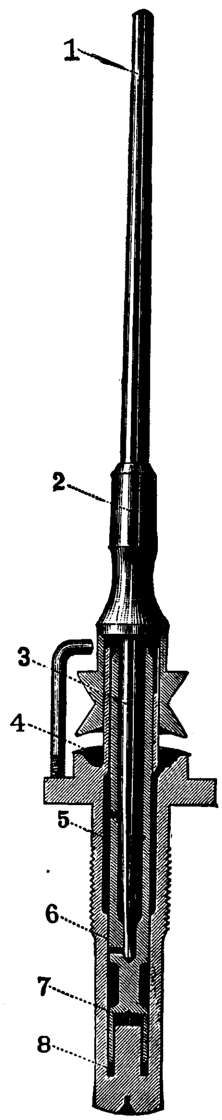

FIG. 97.

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*.

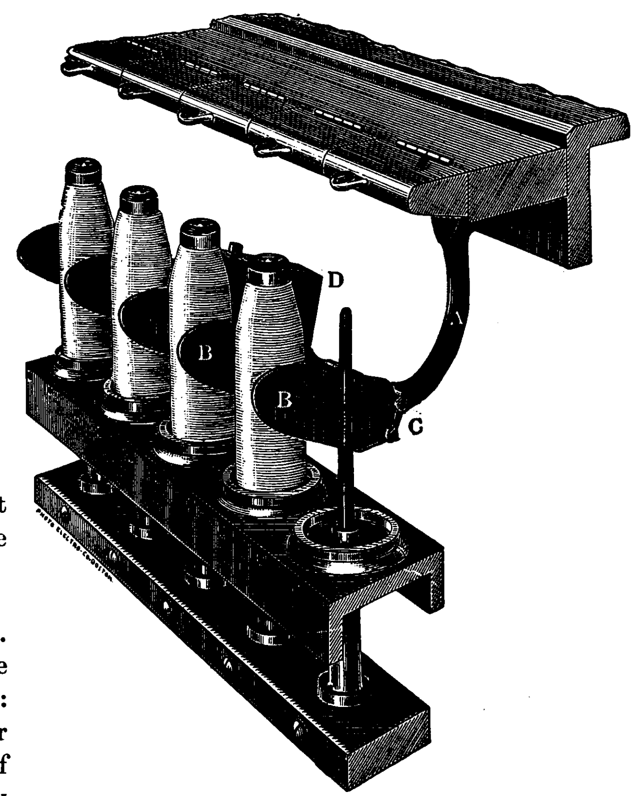

FIG. 98.

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 refering 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

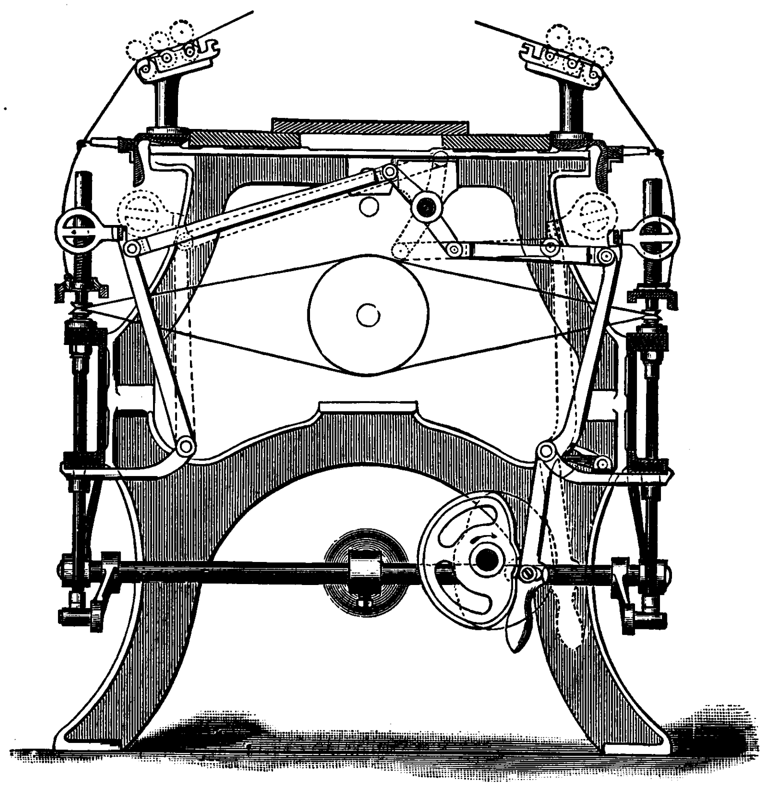

FIG. 99.

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.