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

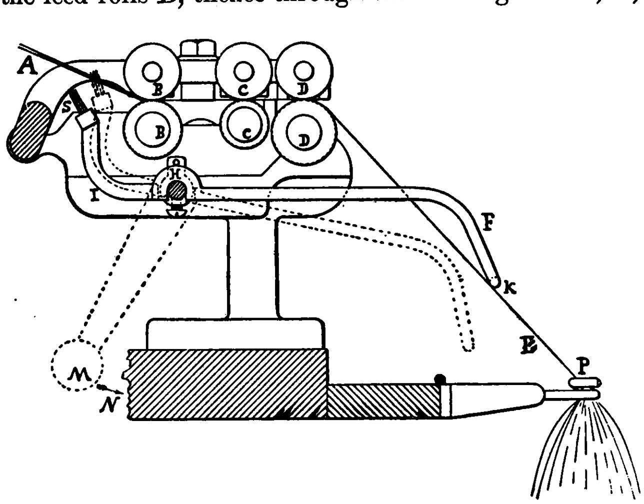

FIG. 100.

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

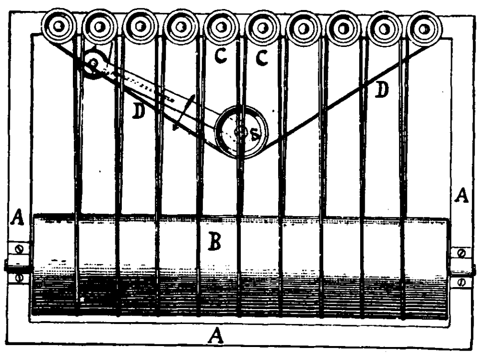

FIG. 101.

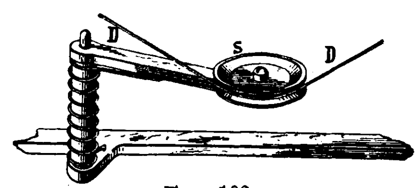

FIG. 102.

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

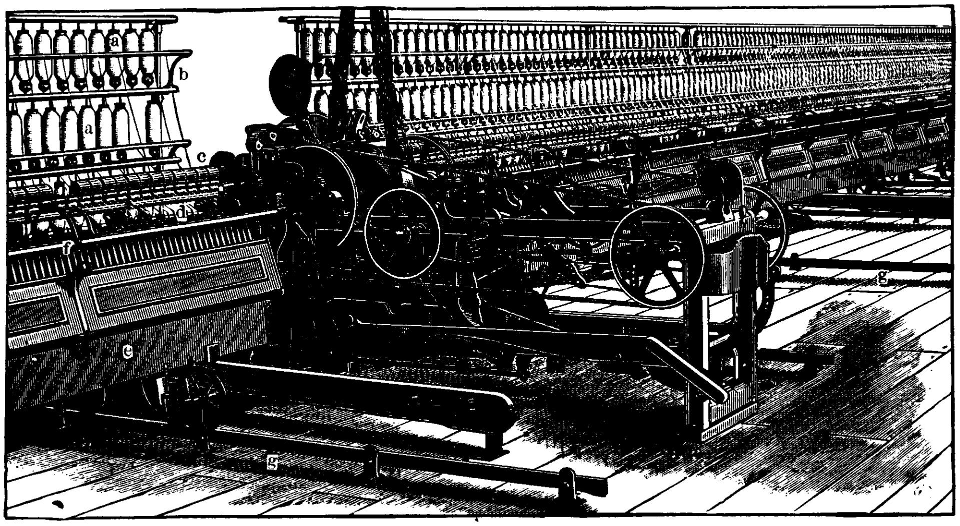

Fig. 103.

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

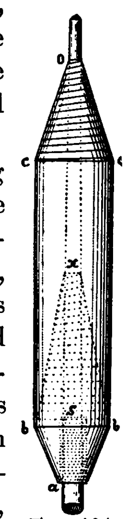

Fig. 104.

For guiding the threads to be wound on the spindles, or tubes in the shape (or building up) of *cops*, two movable guides known as *fallers*, see *f*, are brought into requisition. One is known as the under or *counter-faller*, with the wire beneath the yarn (about two and one-half inches below the spindle points), and the other is known as the upper or *winding-faller*, about one and one-quarter inches above the spindle points. The operation of these fallers is thus: When the carriage is run out to its outermost position, to the end of the *stretch*, and the required amount of twist is put in the thread, the driving strap of the carriage is automatically changed from the fast to the loose pulley, and the reversal of the tin roller causes the spindles to turn in an opposite direction, unwinding at the same time the spiral of yarn previously wound upon the spindle above the top of the cop thus far produced. The *backing-off* (running in) of the carriage now commences, at the same time the counter-faller rises, and the winding-faller is brought down, both wires coming in contact with the yarn, and acting against each other, regulating its tension and preventing it from slacking and thus from kinking. As already mentioned when the carriage runs in, the thread is wound upon the spindle or a tube, and this in the shape of what is known as a cop. The building up of the cop is done by the shaper. Fig. 104 illustrates the gradual building up of the cop. To allow for the increasing diameter of the cop, the successive layers of threads are wound in more open

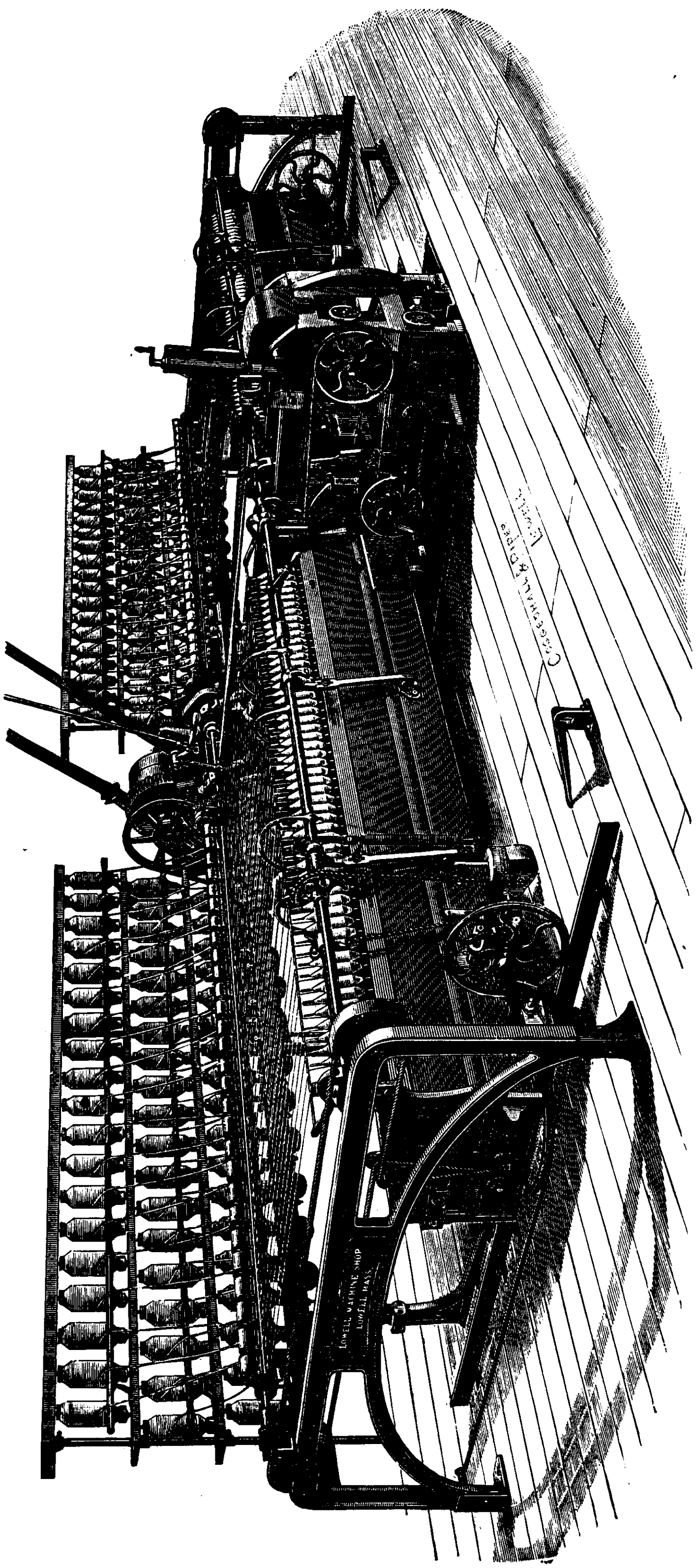

Fig. 105.

coils as the size increases (see broken lines in illustration) which is obtained by gradually increasing the range of the faller wires; at the same time the ends of the cop are made in the conical form shown in full lines in the illustration. In commencing to build up the cop on the bare spindle or tube the range of the fallers is such as to produce bobbins shown from *a* to *s*. The range then is gradually increased until the cop is built up to its full diameter, see *b*, *b*, when the range of the fallers is the widest building cop as shown by broken lines from *b* to *x*. From now the range of the fallers gradually diminishes until it arrives at a range corresponding to the building of bobbin shown in illustration from *c* to *o*.

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

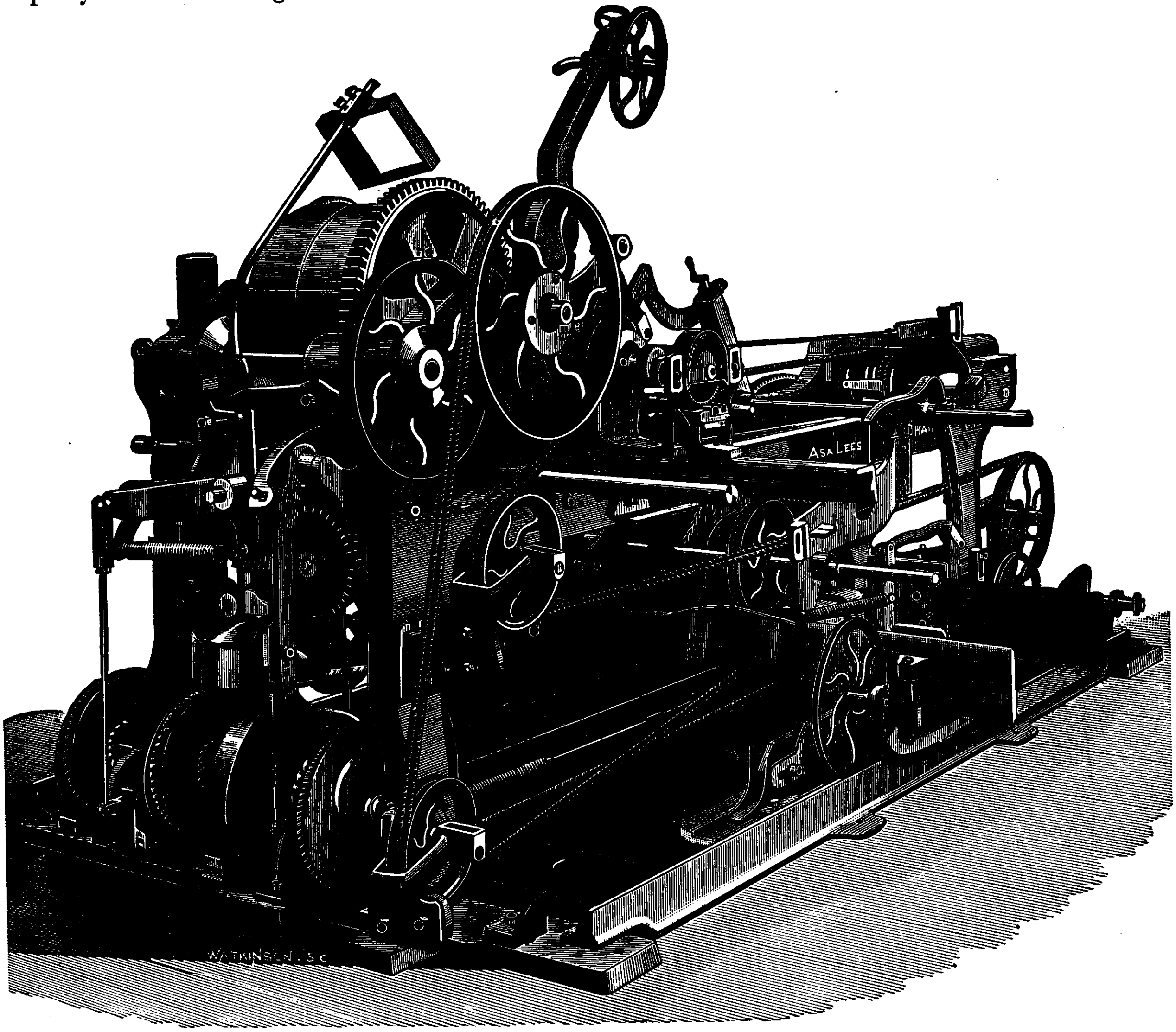

FIG. 106

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

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

Counts	√	Extra Warp Twist.	Warp Twist.	Extra Mule Twist.	Mule Twist.	Filling Twist.	Twist for Doubling.	Twist for Hosiery Yarn.
1	1.0000	**4.75**	**4.50**	**4.00**	**3.75**	**3.25**	**2.75**	**2.50**
2	1.4142	6.72	6.36	5.66	5 30	4.60	3.88	3.53
3	1.7321	8.23	7.79	6.93	6.50	5.63	4.76	4 33
4	2.0000	9.50	9.00	8.00	7.50	6.50	5.50	5.00
5	2.2361	10.62	10.06	8.94	8.39	7.27	6.14	5 59
6	2 4495	11.64	11.02	9.80	9.19	7.96	6.73	6.12
7	2.6458	12.57	11.91	10.58	9.92	8.60	7.27	6.61
8	2.8284	13.44	12.73	11.31	10.61	9.19	7.77	7.07
9	3.0000	14.25	13.50	12.00	11.25	9.75	8.25	7.50
10	3.1623	15.02	14.23	12.65	11.86	10.28	8.79	7.90
11	3.3166	15.75	14.92	13.27	12.44	10.78	9.12	8.29
12	3.4641	16.45	15.59	13.86	12.99	11.26	9.52	8.66
13	3.6056	17.13	16.22	14.42	13.52	11.72	9.91	9.01
14	3.7417	17.77	16.84	14.97	14.03	12.16	10.28	9.35
15	3.8730	18.40	17.43	15.49	14.52	12.59	10.65	9.68
16	4.0000	19.00	18.00	16.00	15.00	13.00	11.00	10.00
17	4.1231	19.58	18.55	16.49	15.46	13.40	11.33	10.30
18	4.2426	20.15	19.09	16.97	15.91	13.79	11.66	10.60
19	4.3589	20 70	19 62	17.44	16.35	14.17	11.98	10.89
20	4 4721	21.24	20 12	17.89	16.77	14.53	12.29	11.18
22	4.6904	22.28	21 11	18.76	17.59	15.24	12 89	11.72
24	4.8990	23.27	22.05	19.60	18.37	15.92	13.47	12.24
26	5.0990	24.22	22.95	20.40	19.12	16.57	14.02	12.74
28	5.2915	25.13	23.81	21.17	19.84	17.20	14.55	13.22
30	5.4772	26.02	24.65	21.91	20.54	17.80	15.06	13.69
32	5.6569	26.87	25.46	22.63	21.21	18.38	15.56	....
34	5.8310	27.70	26.24	23.32	21.87	18.95	16.03	....
36	6.0000	28.50	27.00	24.00	22.50	19.50	16.50	....
38	6.1644	29.28	27.74	24.66	23.12	20.03	16.95	....
40	6.3246	30.04	28.46	25.30	23.72	20.55	17.39	....
45	6.7082	31.86	30.19	26.83	25 16	21.80	18.44	....
50	7.0711	33.59	31.82	28.28	26 52	22.98	19.44	....
55	7.4162	35.23	33.37	29.66	27.81	24.10	20.39	....
60	7.7460	36.79	34.86	30.98	29 05	25.17	21.30	....
65	8.0623	38.30	36.28	32.25	30.23	26.20	22.17	....
70	8.3666	39.74	37.65	33.47	31.37	27.19	23.00	....
75	8.6603	41 14	38 97	34 64	32 48	28.15	23.81	....
80	8 9443	42.49	40.25	35 78	33.54	29.07	24 59	....
85	9.2195	43.79	41.49	36 88	34 57	29 96	25 35	....
90	9.4868	45.06	42 69	37.95	35 58	30 83	26.08	....
100	10.0000	47 50	45 00	40 00	37 50	32.50	27 50	....
110	10.4881	49 82	47 20	41.95	39.33	34.09	28.84	....
120	10.9545	52 03	49 30	43.82	41 08	35.60	30 12	....
130	11.4018	54.16	51.31	45.61	42 76	37 06	31.35	....
140	11.8322	56.20	53.24	47.33	44.37	38 45	32.54	....
160	12.6499	60.08	56.91	50.59	47.43	41 10	34.78	....
180	13 4164	63.72	60 37	53.66	50 31	43.60	36.89	....
200	14.1421	67.17	63.63	56.56	53.03	45.96	38.89	....

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

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

The rule for finding the (average) amount of twist to put in two or more ply twist is as follows: Extract square root for equivalent in single yarn, and multiply root thus obtained with $3\frac{3}{4}$ for warp twist, and $3\frac{1}{4}$ for filling twist.

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

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

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

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

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

Answer.— 16¼ (say 16) turns per inch.

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

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

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

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

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

30.73

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

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

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

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

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

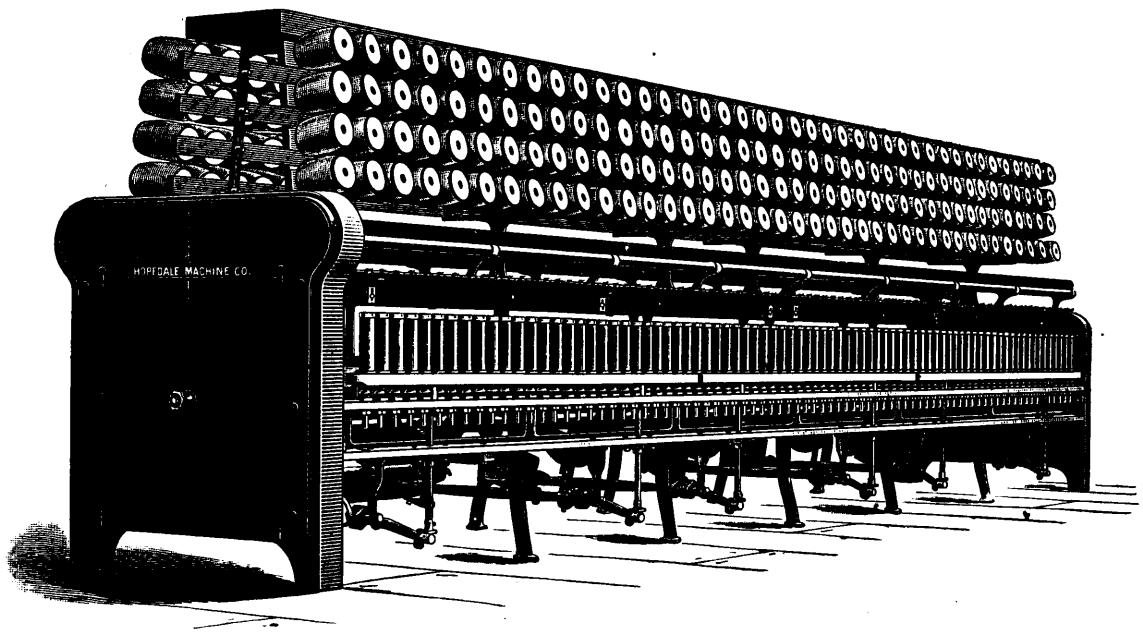

FIG. 107.

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

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

Wool.

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

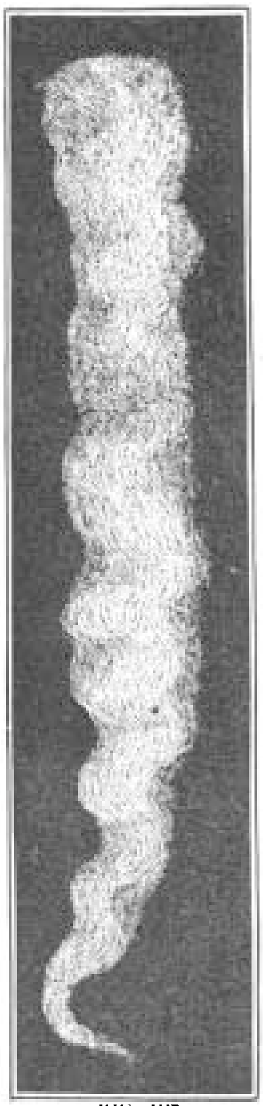

Fig. 108.

Fig. 109

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

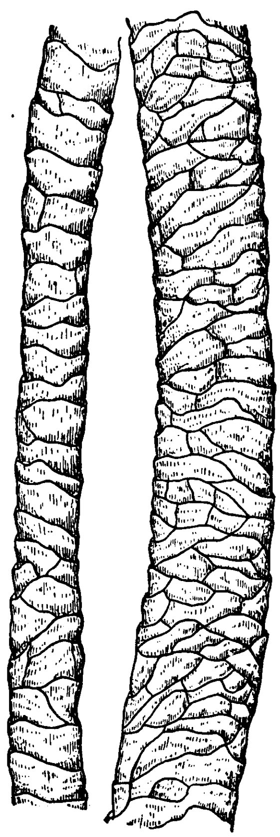

Fig. 110.

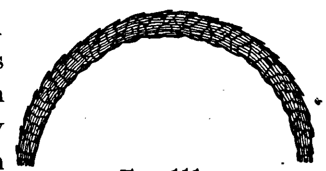

Fig. 111.

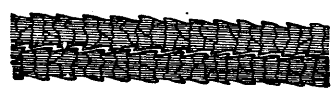

Fig. 112.

Felting Properties.—This serrated or toothed surface confers upon wool its felting property, since during the process of carding the wool, the fibres are mixed up and twisted in all possible directions, and the points of the scales projecting as so many small hooks hold the tangled mass closely and firmly together. The felting properties of wool are also greatly increased by the wavy structure of the fibres, which will press the serrations of the one fibre as close as possible into the serrations of other fibres. This will explain that the fulling or felting quality of wool is determined by the amount of serrations per inch in the fibres, since the absence of such serrations would imply a fibre of little or no fulling properties. These scales are very minute and numerous; for example, in a fine Saxony wool there are not less than 2700 scales per inch found in each fibre.

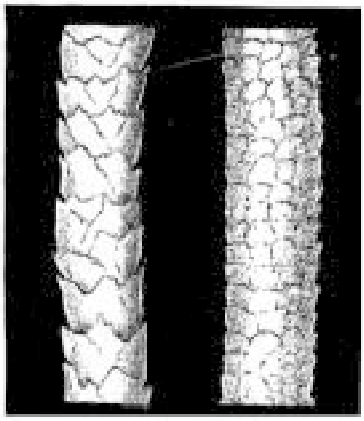

FIG. 113. FIG. 115.

In the fibres of the varieties of the common sheep (*Ovis rusticus*) we only find from 1500 to 2000 of those scales in every inch. Upon the whole surface of a fibre of Saxony wool one inch long and $\frac{1}{750}$ of an inch in diameter there are over 23,000 of those minute points of scales to be found. In the finest grade of our domestic merino it is claimed that there are about 6000 of these scales per inch of fibre. In wool, when on the body of the animal, the serrations of the fibres are naturally all pointing in the same direction, hence the chances for felting when on the animal are little if any. The great amount of dirt and grease filling up the serrations of the wool fibre when the latter is on the animal also prevents any possible chance of felting. From explanations given it will thus be readily seen why woolen cloths can be felted, fulled, or milled. The serrations of the fibres, after being previously cleaned or scoured, fitting into each other, will lock fast under the pressure of the fulling process, hence the fabric composed of separated threads will appear after fulling as a solid felt. The process of fulling, as no doubt is generally known, is carried on when the cloth is wet. Warm water, if not injurious to the colors, will assist fulling to a greater extent than cold water. The reason for wetting the cloth in the process of fulling is: the wool fibres are composed of endless numbers of small dried up cells composed of a soft gelatinous membrane, and when put in hot water (for even cold water will heat during the fulling operation) those cells will become soft and expand. In this state, during the fulling process, they are pressed as closely as possible together, and thus actually, one might say, the fibres are glued together uniting in this manner all the different threads of which the cloth is composed in a solid mass. During the fulling operation the individual threads will shrink in their length, which is also a well known fact to the manufacturer.

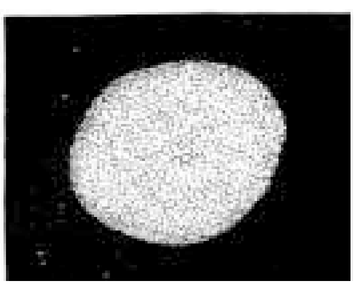

FIG. 114.

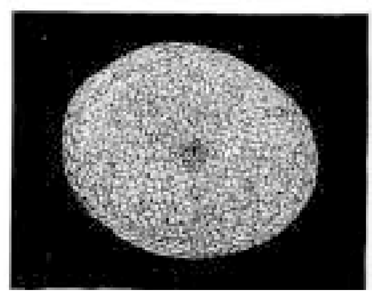

FIG. 116.

The cells of the wool fibres, after being once softened, do not return to their former state when dry, they shrink into each other, and the threads get heavier in size, a (practical) point that must be well examined and studied when ascertaining the counts of yarns in a finished sample of cloth, given for analysis. The felting properties of the wool fibre make the cloth as produced out of it the most advantageous article for clothing, since after the cloth is fulled the air cannot so easily penetrate, hence the human body is well protected against any influence of the change of climate. The wool fibre is not hollow or tubular but full of cells, and consists of three portions: First, the scales; second, the cortical substance which is the thickest portion of the fibre, and also contains the coloring matter. It is fibrous and striped lengthways. The third or central portion of the fibre is the medullary substance or marrow which occupies a narrow and irregular cavity. The last mentioned portion is not found in all wool fibres.

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

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

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

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

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

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

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

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

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

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

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

* And above.

Jeppe gives the following classification and value:

Grade.	Measurements of Fineness.		
	In Centimillimetres.	In Thousandths of an Inch.	In Fractions of an Inch.
Super Electa	1.65 to 1.90	0.6496 to 0.7480	$\frac{1}{1539}$ to $\frac{1}{1336}$
Electa	1.90 " 2.09	0.7480 " 0.7909	$\frac{1}{1336}$ " $\frac{1}{1264}$
(1) Prima	2.09 " 2.15	0.7909 " 0.7983	$\frac{1}{1264}$ " $\frac{1}{1260}$
(2) Prima	2.15 " 2.58	0.7983 " 0.9960	$\frac{1}{1260}$ " $\frac{1}{1003}$
Secunda	2.58 " 2.66	0.9960 " 1.0496	$\frac{1}{1003}$ " $\frac{1}{952}$
Tertia	2.66 " 3.29	1.0496 " 1.2952	$\frac{1}{952}$ " $\frac{1}{771}$
Quarta	3.29 " 4.05	1.2952 " 1.5767	$\frac{1}{771}$ " $\frac{1}{634}$

And Welcherlin gives the following:

Grade.	Measures of Fineness.		
	In Centimillimetres.	In Thousandths of an Inch.	In Fractions of an Inch.
(1) Super Electa	1.26	0.4960	$\frac{1}{2019}$
(2) Super Electa	1.52	0.5984	$\frac{1}{1670}$
(1) Electa	1.52 to 1.77	0.5984 to 0.6968	$\frac{1}{1670}$ to $\frac{1}{1434}$
(2) Electa	1.77 " 2.08	0.6968 " 0.7885	$\frac{1}{1434}$ " $\frac{1}{1267}$
(1) Prima	2.08 " 2.28	0.7885 " 0.8976	$\frac{1}{1267}$ " $\frac{1}{1113}$
(2) Prima	2.28 " 2.53	0.8976 " 0.9960	$\frac{1}{1113}$ " $\frac{1}{1003}$
Secunda	2.53 " 2.785	0.9960 " 1.0964	$\frac{1}{1003}$ " $\frac{1}{911}$
Tertia	2.785 " 3.04	1.0964 " 1.1826	$\frac{1}{911}$ " $\frac{1}{845}$
Quarta	3.04 " 3.54	1.1826 " 1.3936	$\frac{1}{845}$ " $\frac{1}{717}$

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

The Chemical Composition of Pure Wool is:

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

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

FIG. 117.

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

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

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

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

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

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

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

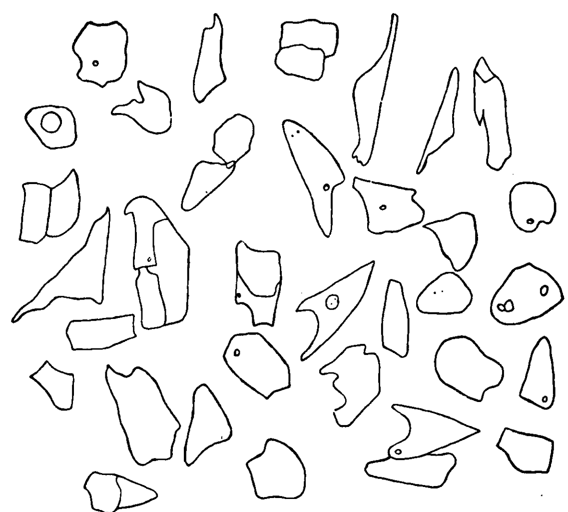

FIG. 118.

especially in the coarser wools. In some cases we may detect markings which seem like *nuclei*, but these are so ill defined, and appear so much like particles of fatty or other extraneous matter, often attached to the fibre in the raw condition, that we can scarcely accept them as nuclei. Many of these scales are entirely free from any such markings, and probably represent the true character with this regard.

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

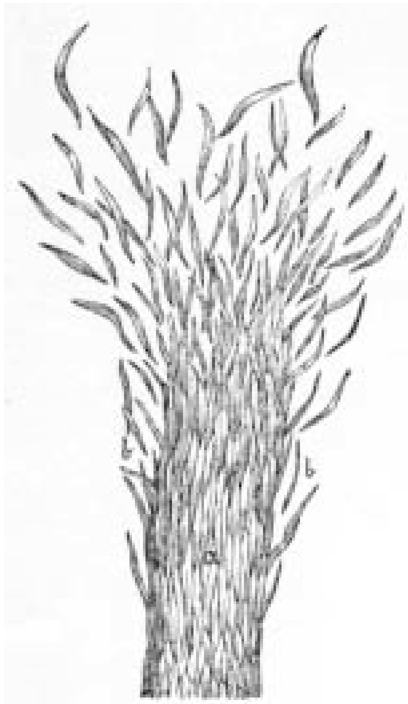

FIG. 119.

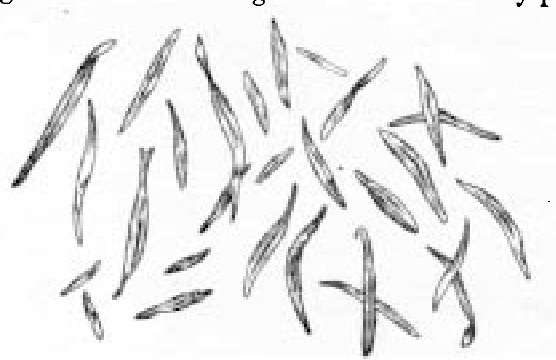

FIG. 120.

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

FIG. 121.

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

FIG. 122.

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

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

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

FIG. 123.

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

FIG. 124.

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

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

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

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

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

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

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

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

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

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

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

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

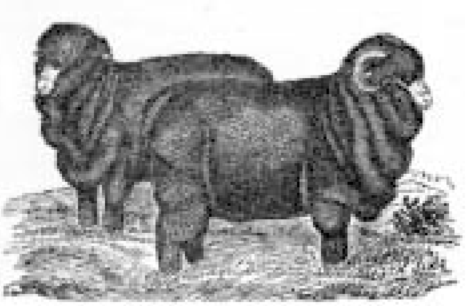

FIG. 125.

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

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

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

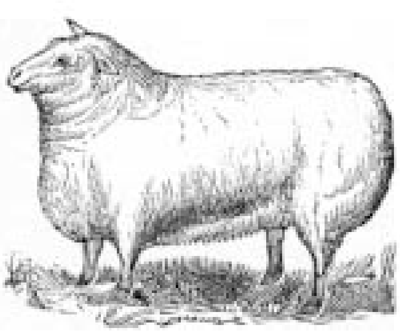

FIG. 126.

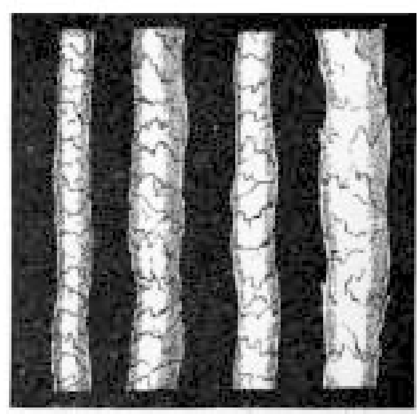

FIG. 127. FIG. 128. FIG. 129. FIG. 130.

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

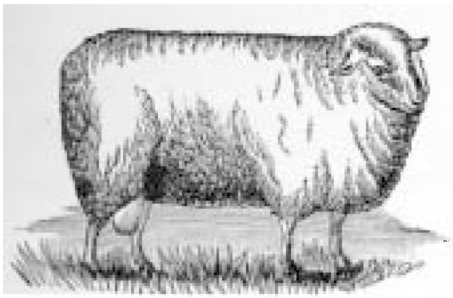

FIG. 131.

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

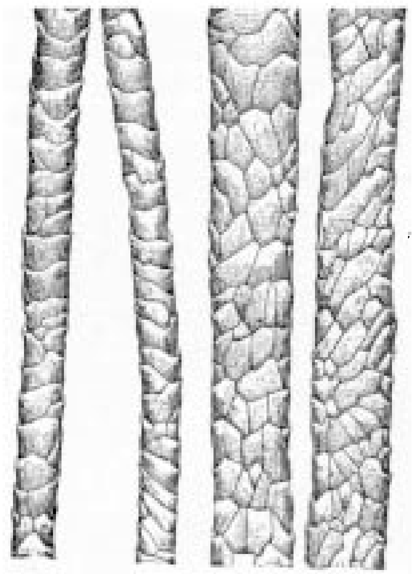

FIG. 132.

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

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

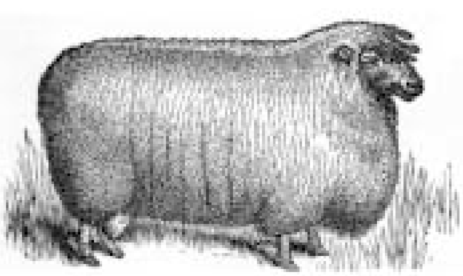

FIG 133.

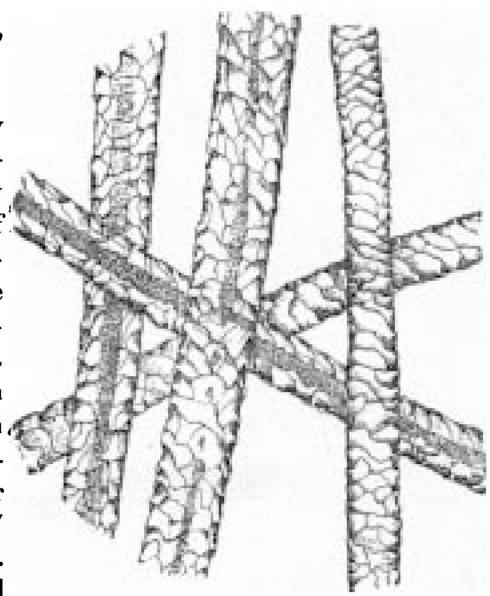

FIG. 135.

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

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

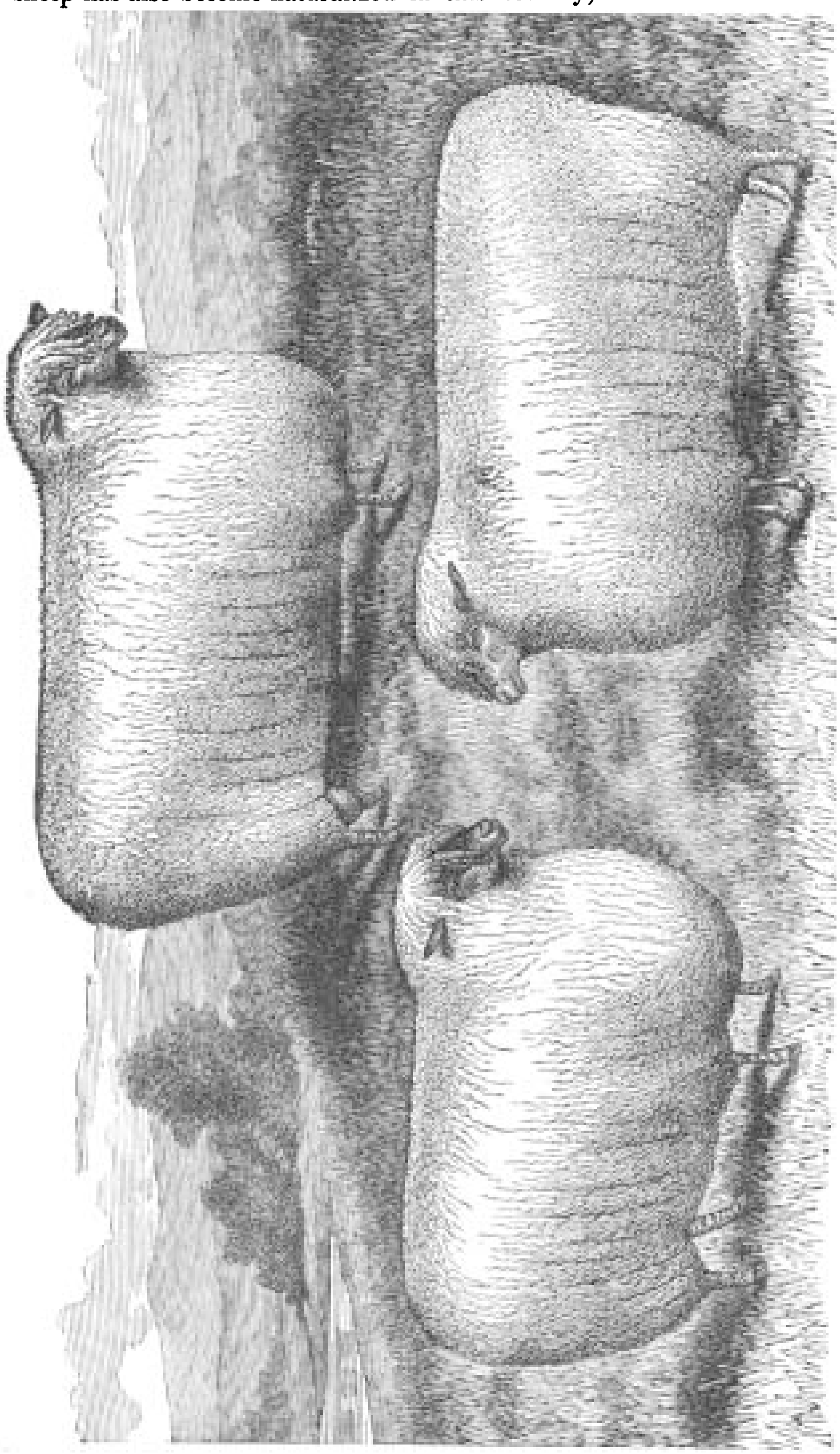

Fig. 134.

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

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

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

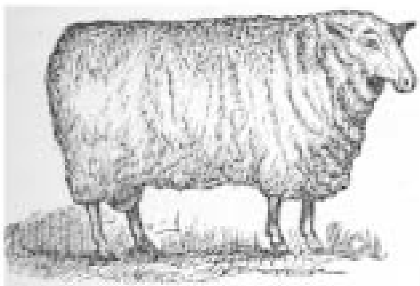

FIG. 136.

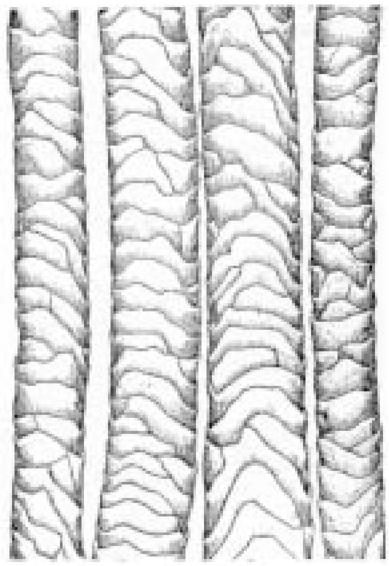

FIG. 137.

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

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

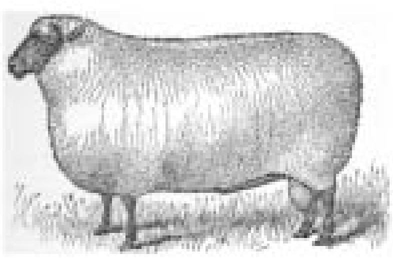

FIG. 138.

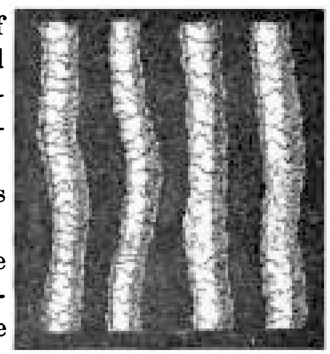

FIG. 139. FIG. 140.

Amongst other English breeds of any consequence are:

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

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

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

The Exmoor sheep, found in Cornwall and Devon.

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

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

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

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

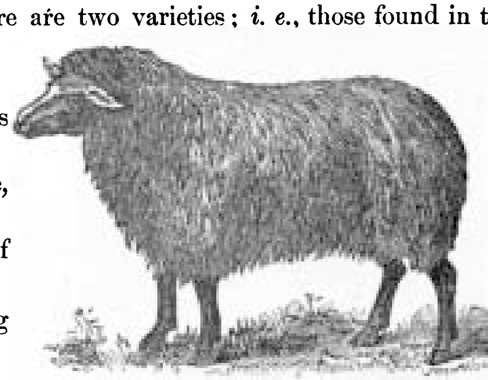

FIG. 141.

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

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

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

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

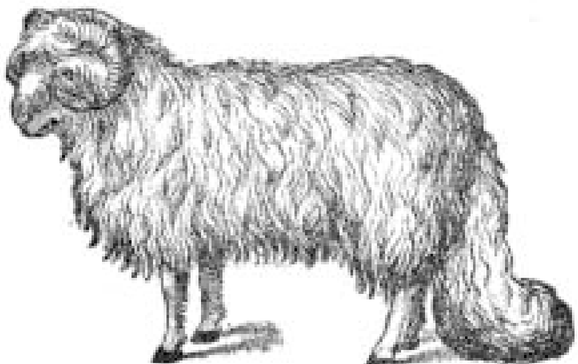

FIG. 142

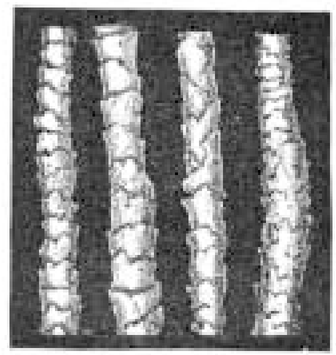

FIG. 143.

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

FIG. 144.

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

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

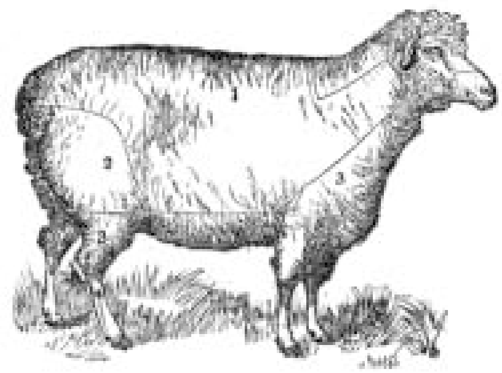

FIG. 145.

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

1. *The refina* or the choicest wool (pick-lock), begins at the withers and extends along the back to the setting on of the tail, reaches only a little way down at the quarters, but dipping down at the flanks, takes in all the superior part of the chest, and the middle of the side of the neck to the angle of the lower jaw.
2. *The fina,* being a valuable wool but not so deeply serrated or possessing so many curves as the first mentioned sort; it occupies the belly, and the hind-quarters and thighs down to the stifle-joint.
3. *The terceira,* being found on the head, the throat, the lower part of the neck and the shoulders terminating at the elbow; also the wool yielded by the legs, and reaching from the stifle to a little below the hock.
4. *The inferior* grade of wool procured from the tuft as growing on the forehead and cheeks from the tail and from the legs below the hock.

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

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

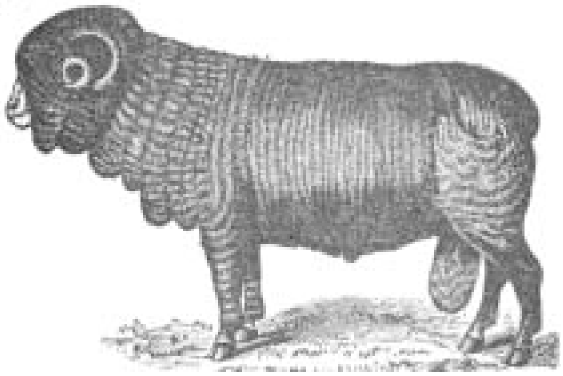

FIG. 146.

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

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

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

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

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

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

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

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

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

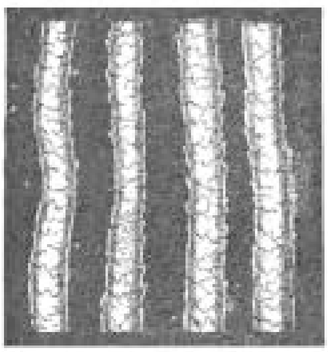

FIG. 147. FIG. 148.

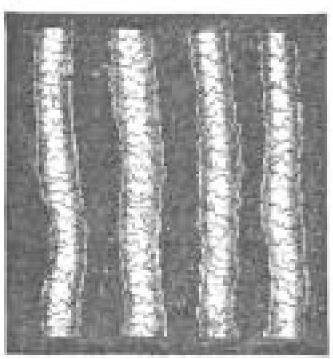

FIG. 150. FIG. 151.

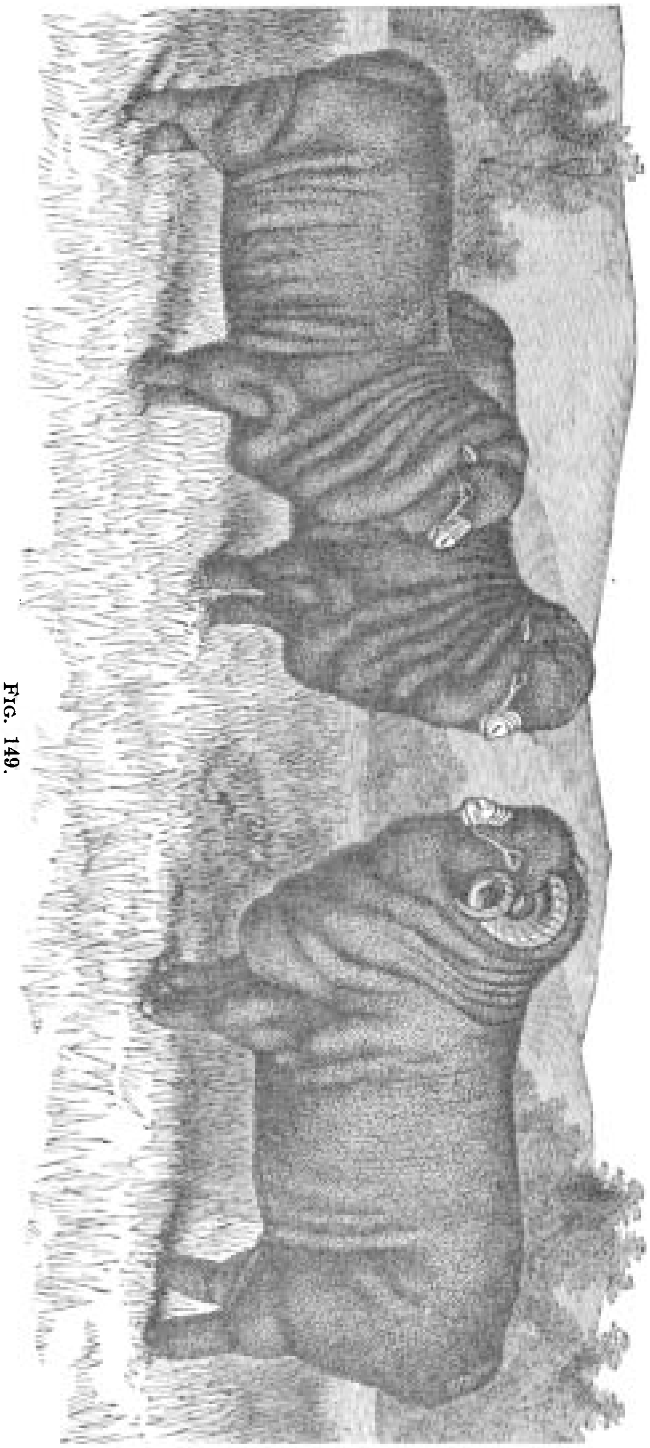

FIG. 149.

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

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

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

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

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

FIG. 152.

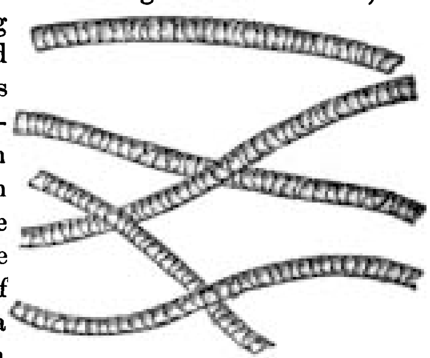

FIG. 153.

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

FIG. 154.

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

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

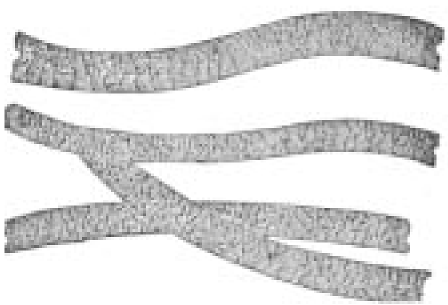

FIG. 155.

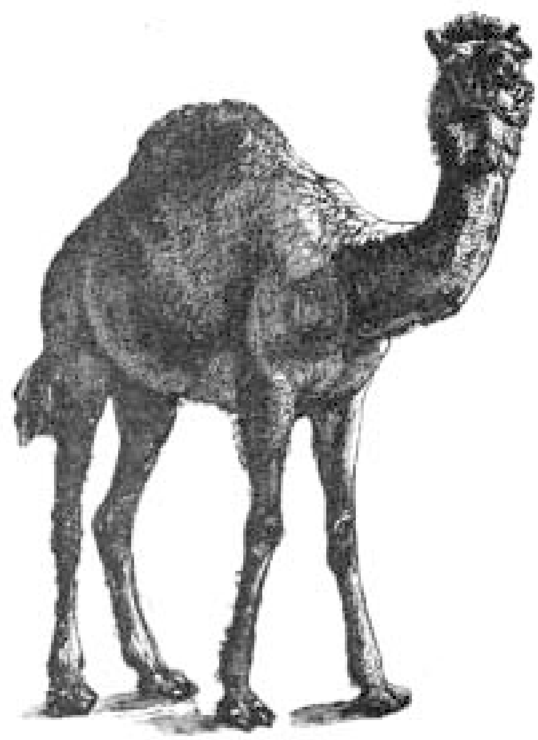

FIG. 156.

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

The Vicugna is found in the most elevated localities of Batavia and Northern Chili, and so far has been found to be very wild and untamable. It lives in herds, near the regions of perpetual snow. The short, soft, silky fur of this animal is very valuable causing the death of thousands, which are slain merely for the sake of their coats. The color of the Vicugna is a nearly uniform brown, tinged with yellow on the back and fading into gray on the abdomen. Fig. 157 gives a good illustration of the animal, its average height at the shoulder being about $2\frac{1}{2}$ feet. Fig. 158 shows the hair of the Vicugna as visible when examined by means of the microscope.

FIG. 157.

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

The Yamma or Llama (see Fig. 159) is

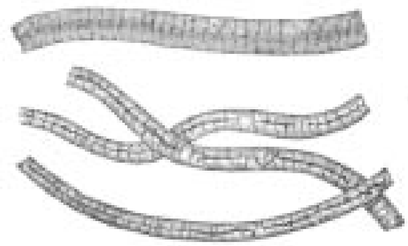

FIG. 158.

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

FIG 159.

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

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

FIG. 160.

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

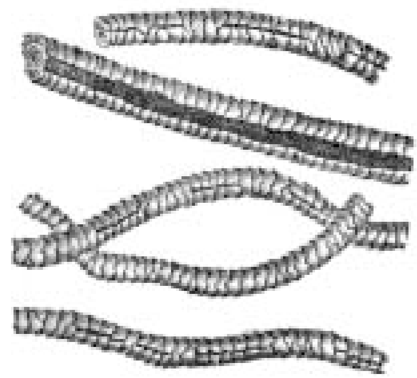

FIG 161.

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

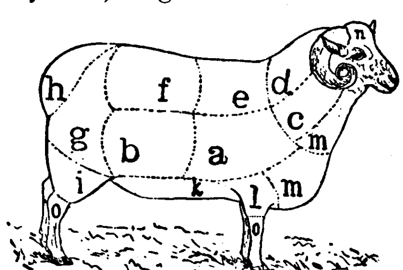

FIG. 162.

The fibres of fine wool are very closely seated upon the skin. The pure merino has from 40,000 to 48,000 fibres to a single square inch; coarse wool breeds contain only from 5,000 to 6,000 fibres to the square inch. The twentieth cross of a pure merino ram upon a coarse wool race had no more than 25,000 fibres to the square inch, which shows plainly how long a period it may take to remove the effects of one cross, for the presence of only $\frac{1}{1048687}$ part of impure blood is sufficient to reduce the fineness of the fleece from 48,000 to 25,000 fibres per square inch, or nearly one-half.

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

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

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

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

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

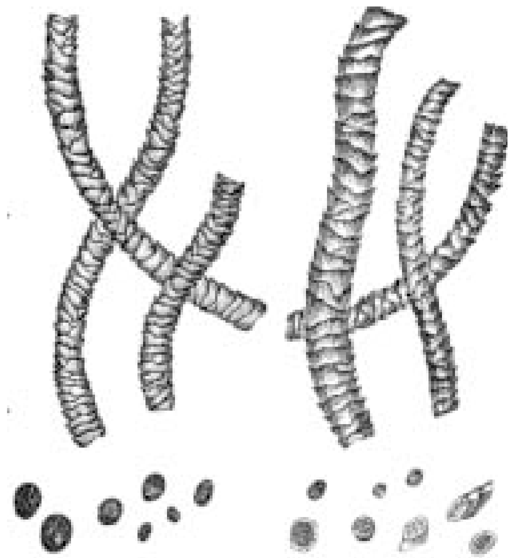

FIG. 163. FIG. 164.

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

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

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

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

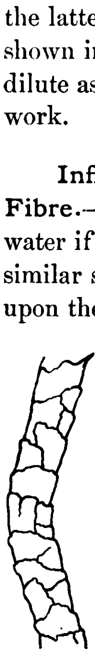

FIG 165.

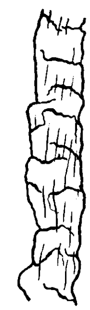

FIG. 166.

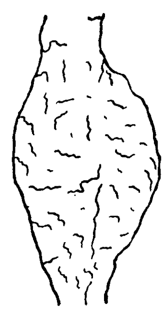

FIG. 167.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

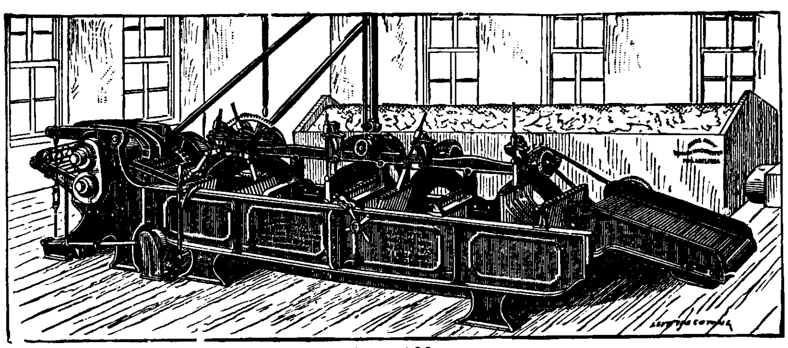

FIG. 168.

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

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

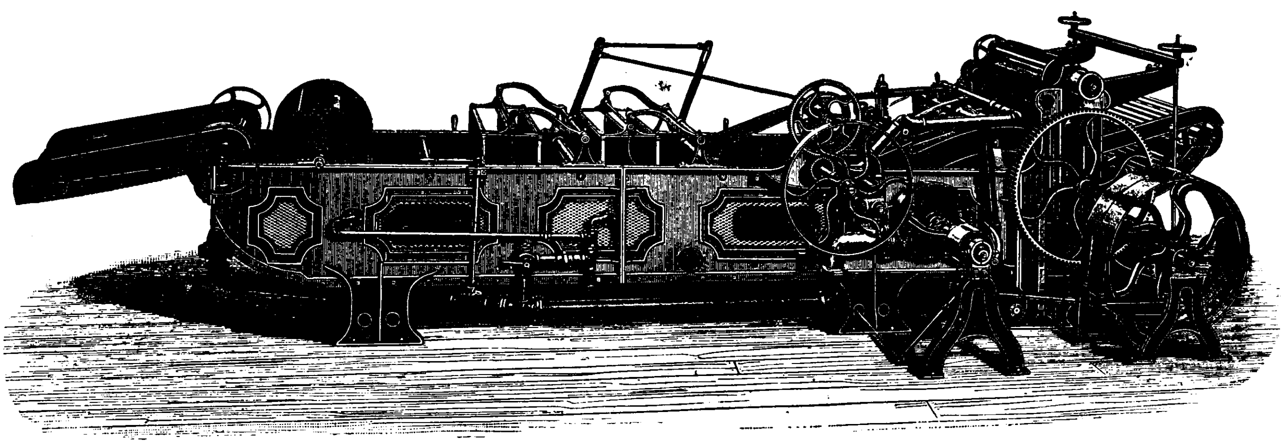

FIG. 169.

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

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

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

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

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

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

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

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

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

** Up to 100° F.

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

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

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

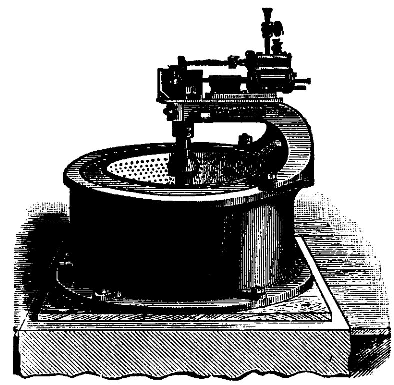

Fig. 170.

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

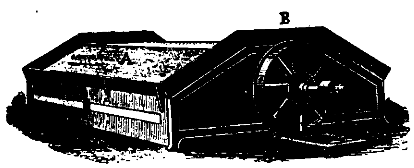

Fig. 171.

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

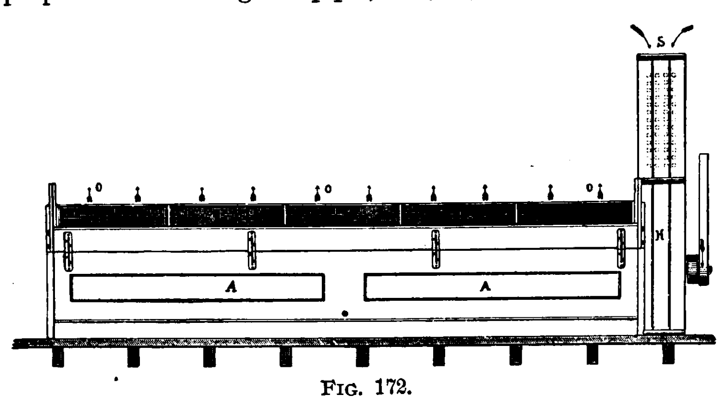

Fig. 172.

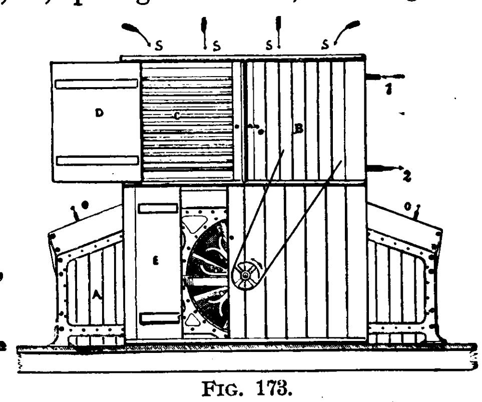

Fig. 173.

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

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

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

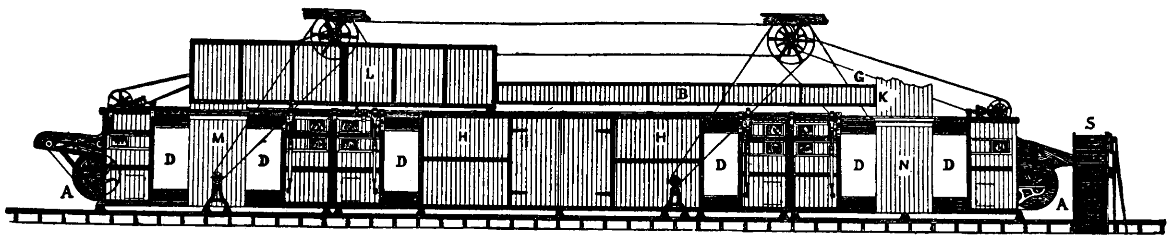

FIG 174.

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

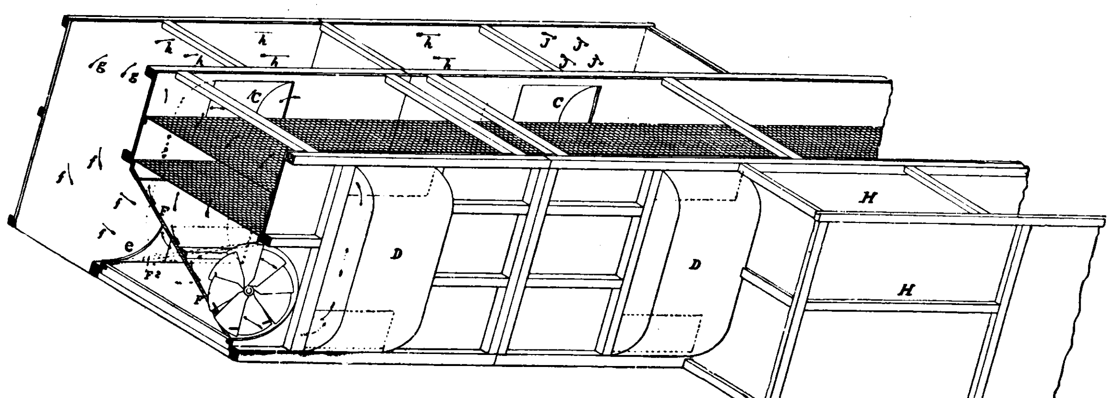

FIG. 175.

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

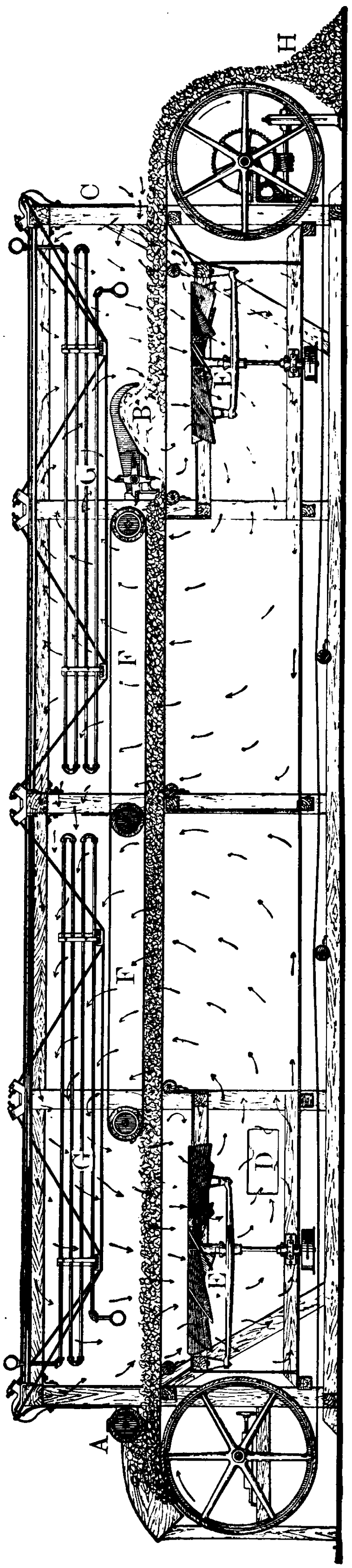

Fig. 176.

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

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

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

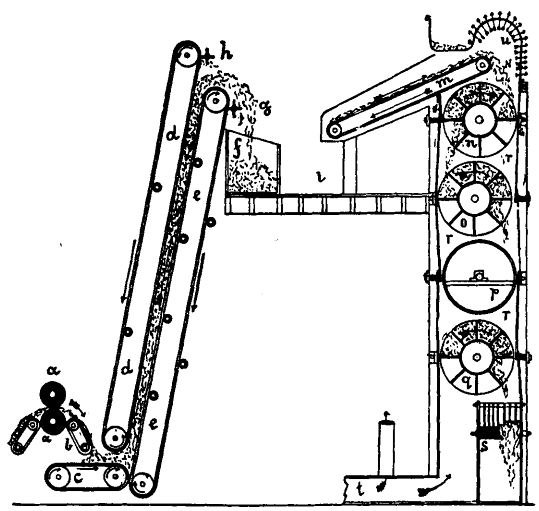

FIG. 177.

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

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

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

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

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

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

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

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

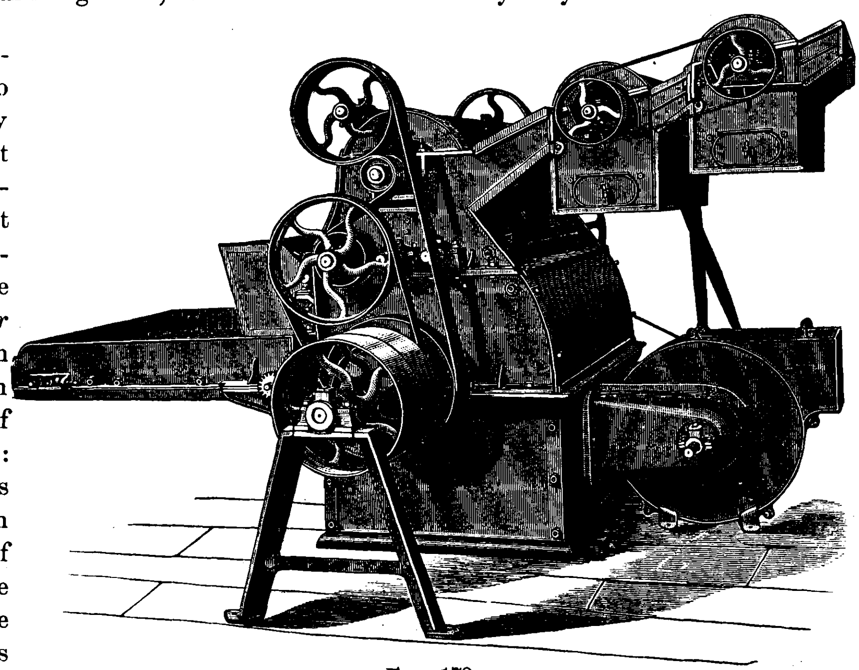

FIG. 178.

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

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

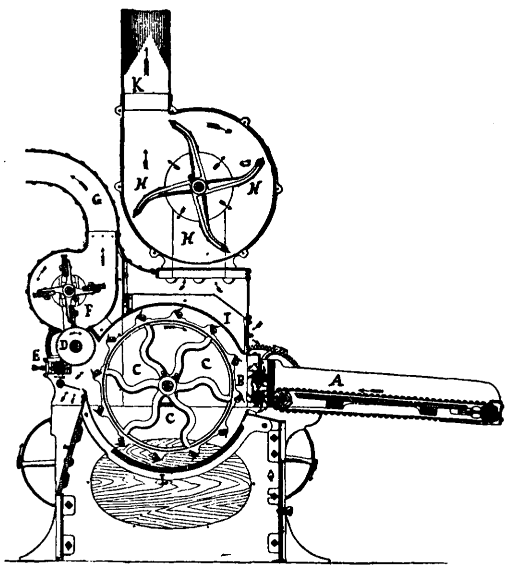

FIG. 179.

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

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

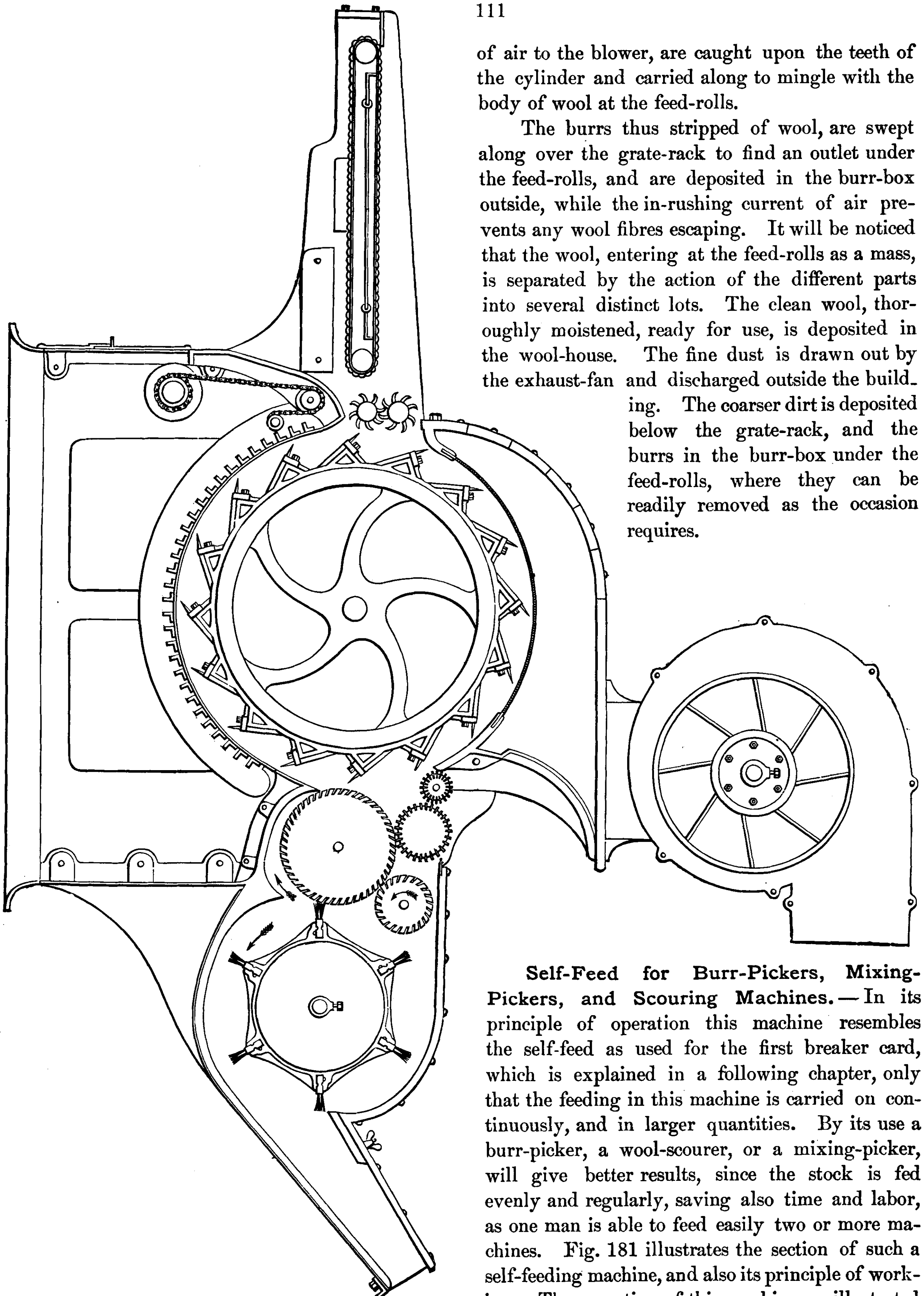

Fig 180.

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

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

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

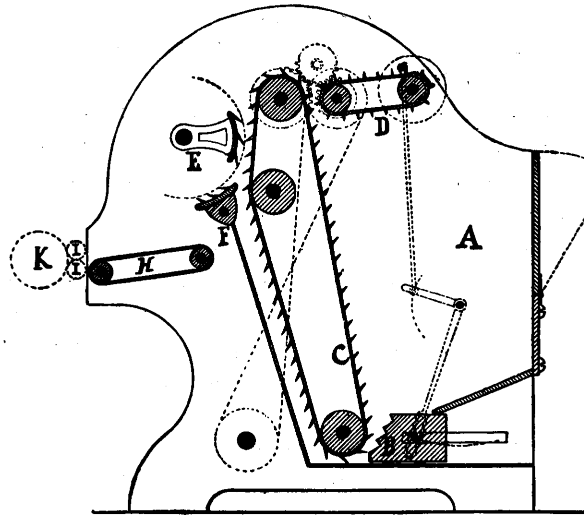

FIG. 181.

Wool-Duster.—Another machine, also frequently used in connection with a burr-picker, is a wool-duster. It can also be used independently from the picker, and the stock after being dusted

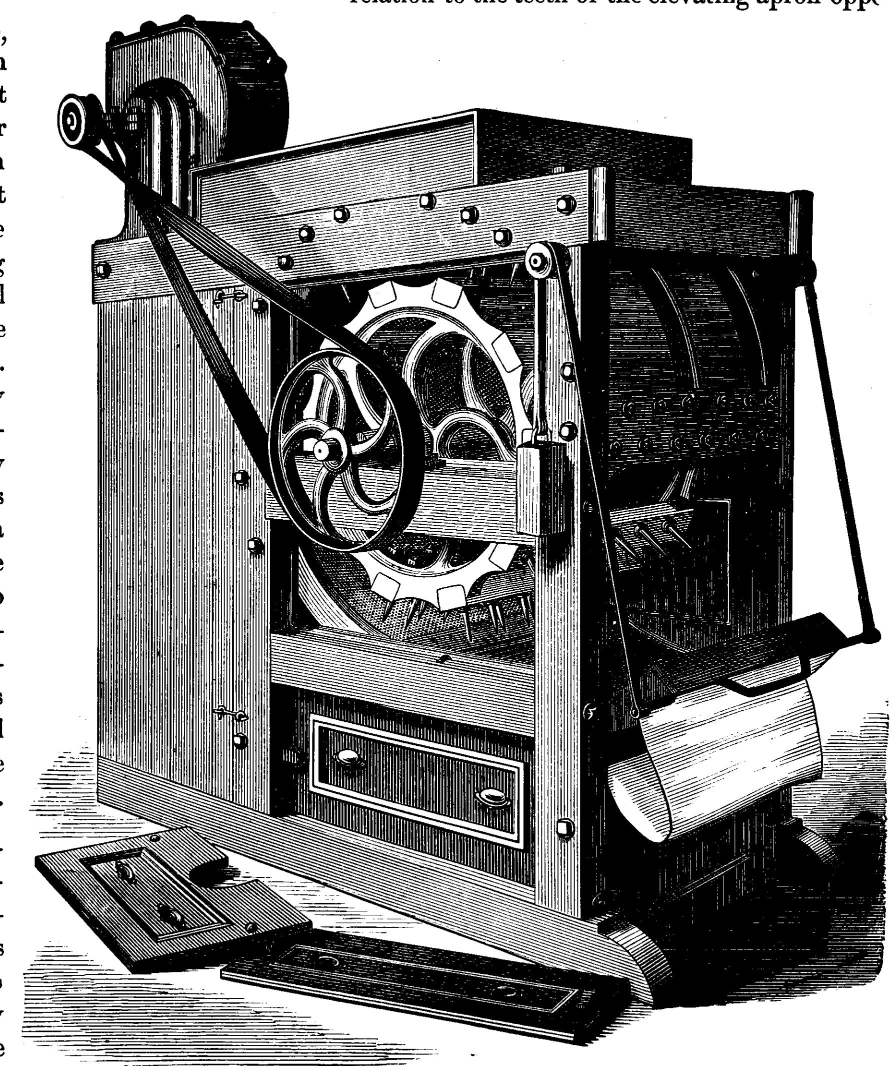

FIG. 182.

(*i. e.*, any dust or dirt adhering to the fibres removed) transferred either to the self-feed or direct to the feeding apron of the burr-picker. If the wool requires no burr-picking, the same is, after being dusted, transferred to the mixing department. Two different styles of wool-dusters are in most general use, the straight-duster and the cone-duster.

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

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

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

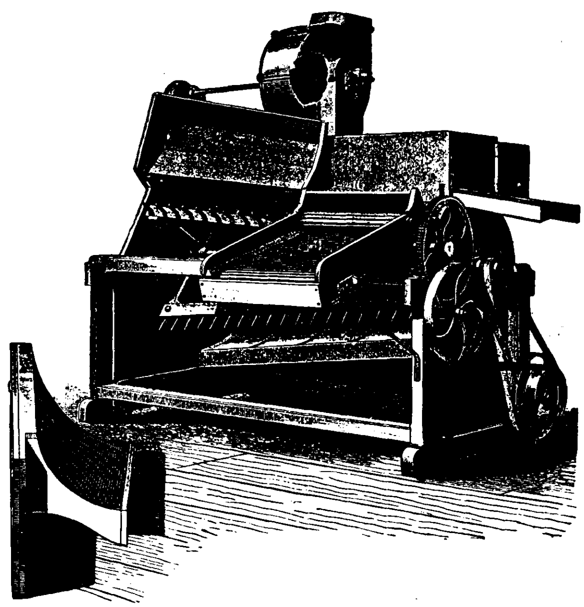

FIG. 183.

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

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

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

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

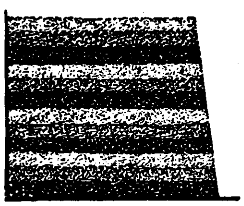

FIG. 184.

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

Prepare temporary mix of 100 lbs. white, and
200 " black,

300 lbs. amount of temporary lot,
which mix with 700 " black, giving

1,000 lbs. as the amount of material to use in the second or final mixing.

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

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

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

Atomizing Wool Oiler for First Breaker Cards.—By oiling the previously mixed stock at the feed of the carding engine by this device, the oil is completely broken into fine particles, like a mist, and is precipitated with force into the evenly spread wool, and as the wool passes the feeding rolls the oil and wool are thoroughly mixed, and if oil-emulsion be used, the chance for evaporation is but slight, as the wool is only exposed to the evaporation while passing through the cards. The arrangement of these oilers is very simple, and the amount of oil put on, can be varied from one quart to ten quarts per hundred pounds of stock to suit the work in process, and is completely under the control of the carder. Figs. 185 and 186 are given to illustrate such an oiler as built by Sargent & Sons. Fig. 185 represents an end elevation of the device; Fig. 186 is a plan of oiler section showing dipper or bucket, for lifting the oil from tank on brush for atomizing. Letters of reference in Fig. 185 indicate as follows: *A*, is one of the side stands that support the end of the machine. There are two of

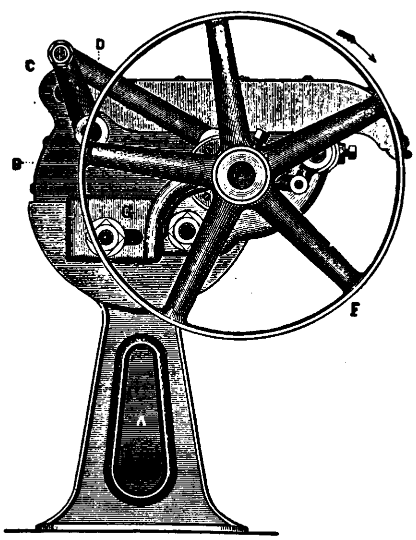

FIG. 185.

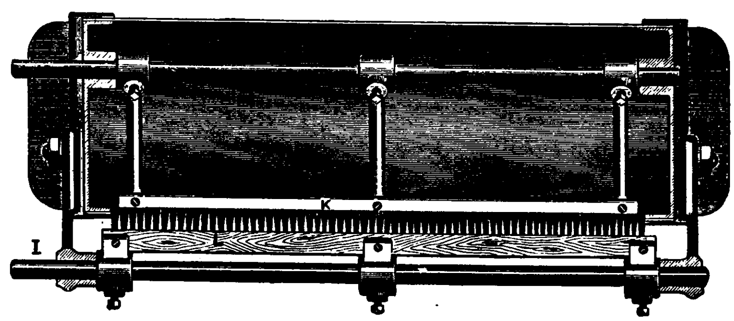

FIG. 186.

these stands, one at each end, which set outside of the feed sides of the carding engine. *B*, is the oil tank which extends across the feed from side to side, and stands about eight inches above the wool on the feed-table. It holds about four gallons of oil. It also contains the dipper-shaft and buckets, as seen in Fig. 186. *C*, is a lever-arm on the dipper or bucket-shaft, which is adjustable with set screws. *D*, is a connecting link, one end of which is connected by a stud to end of lever-arm *C;* the other is connected to the crank pin on an eccentric which gives the vibrating motion to the bucket. This eccentric is on the end of the driving shaft, and communicates motion to all parts of the machine. An eccentric strap connects by a stud to the lever-arm on the brush-shaft and gives to the brush-shaft a backward and forward motion. *F*, is the driving pulley and has motion in the direction indicated by arrows. On cards using large amounts of wool, such as carpet filling wool, this pulley should run about thirty-two turns per minute and on cards using fine wools, about twenty turns per minute.

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

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

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

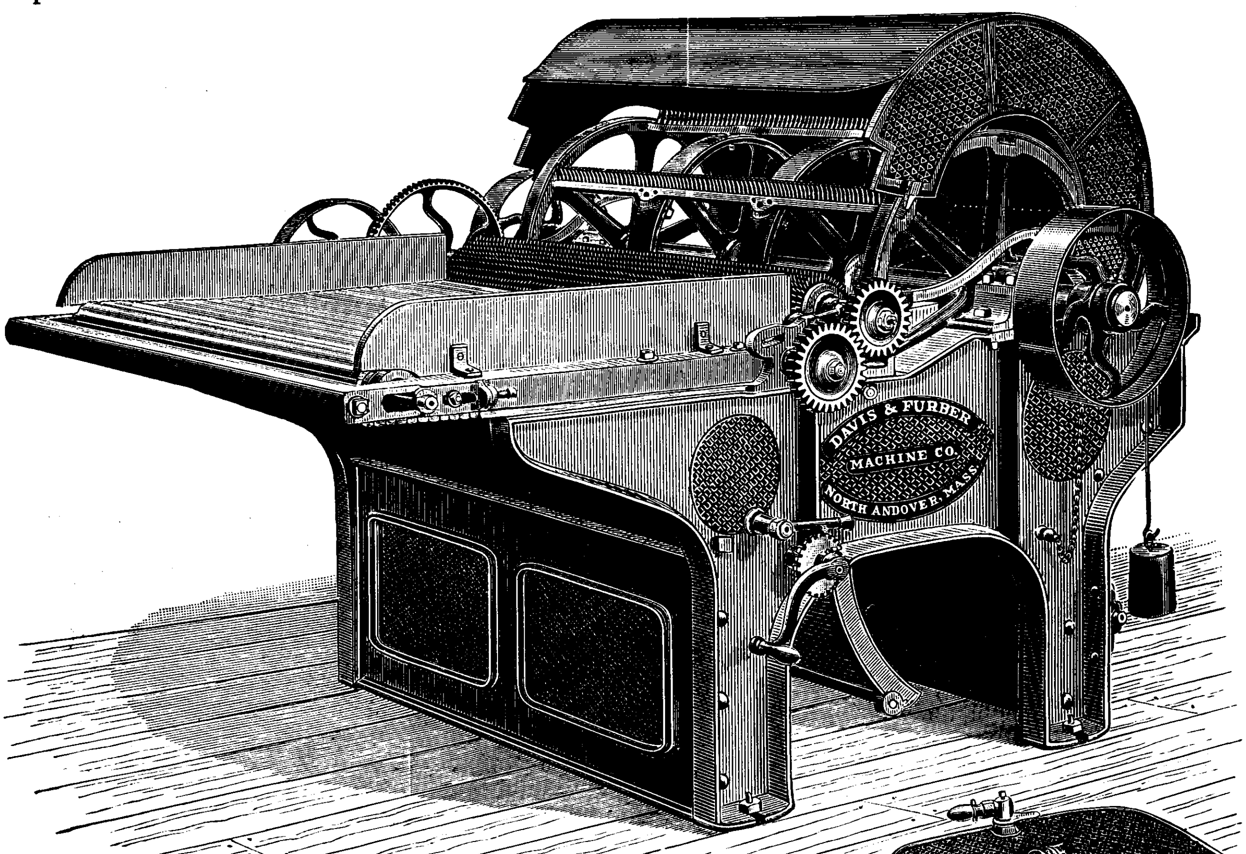

Fig. 187.

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

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

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

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

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

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

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

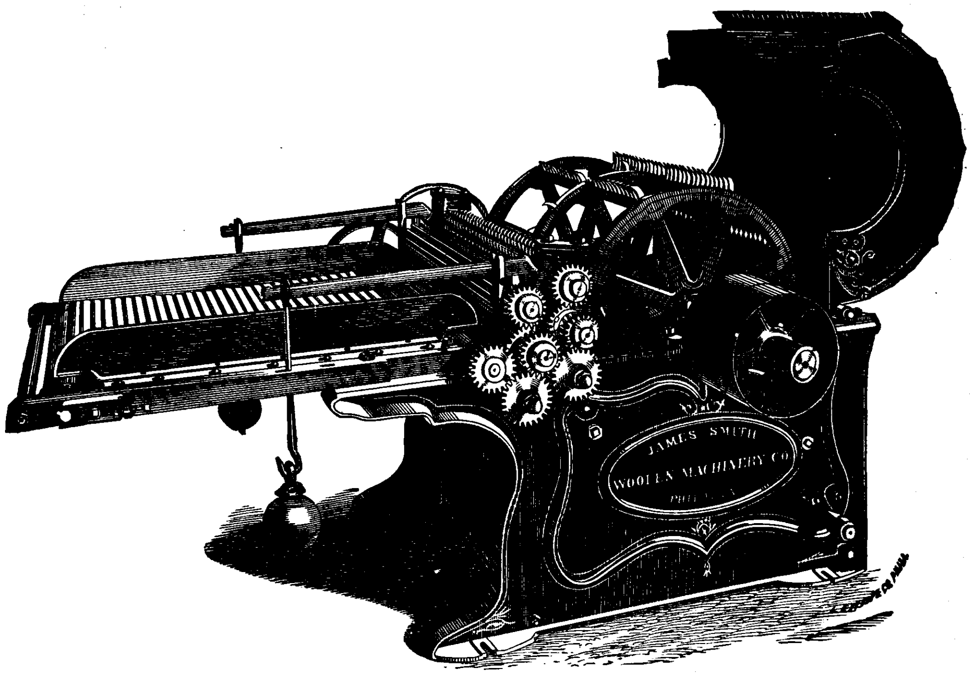

FIG. 188.

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

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

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

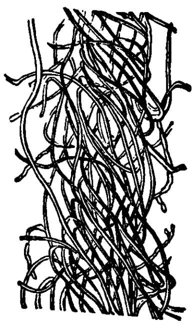

FIG. 189.

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

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

FIG. 190.

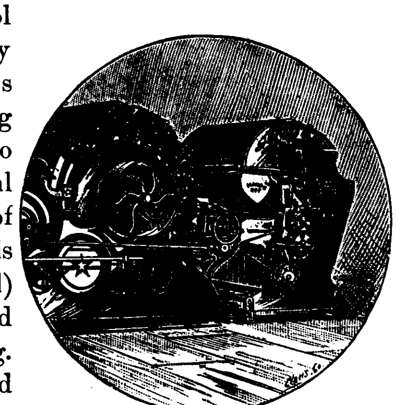

FIG. 191.

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

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

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

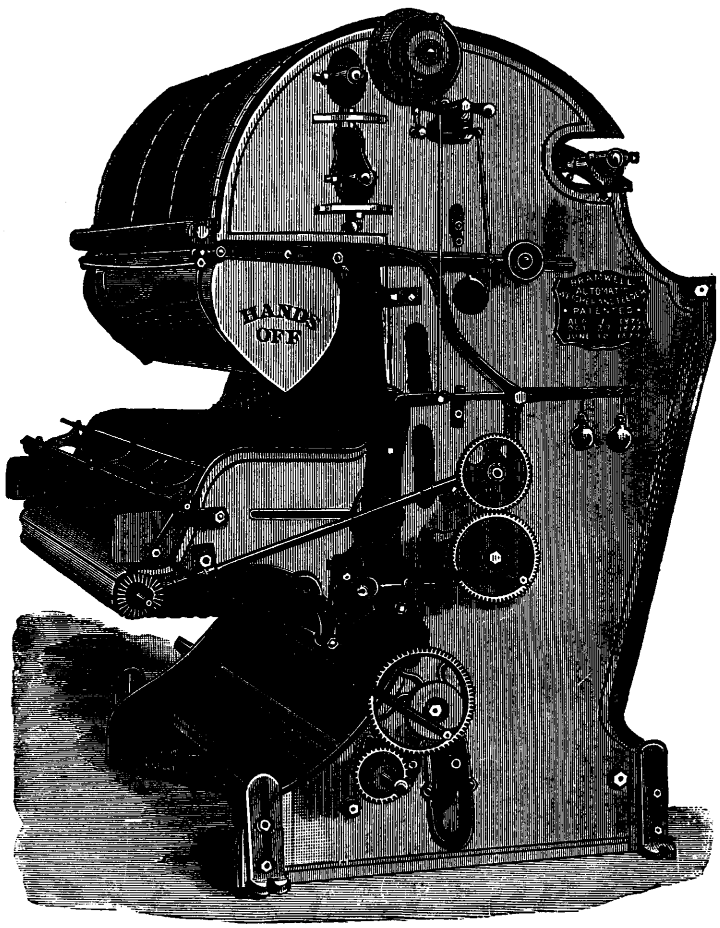

FIG. 192.

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

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

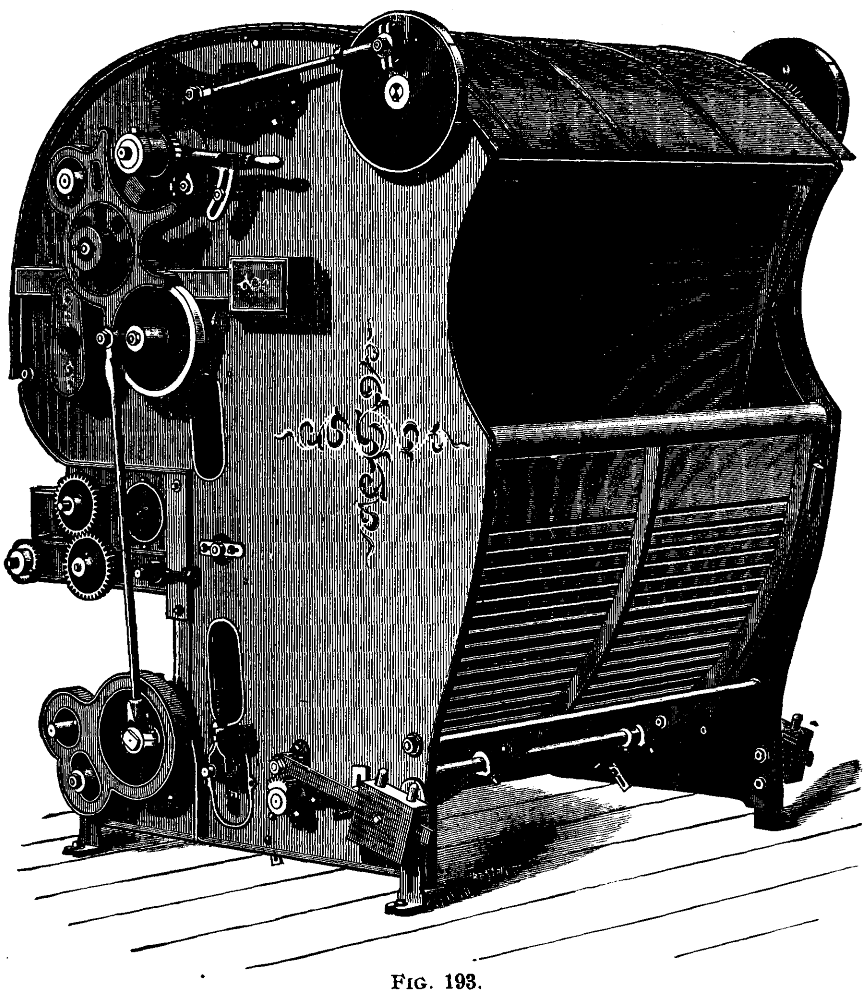

FIG. 193.

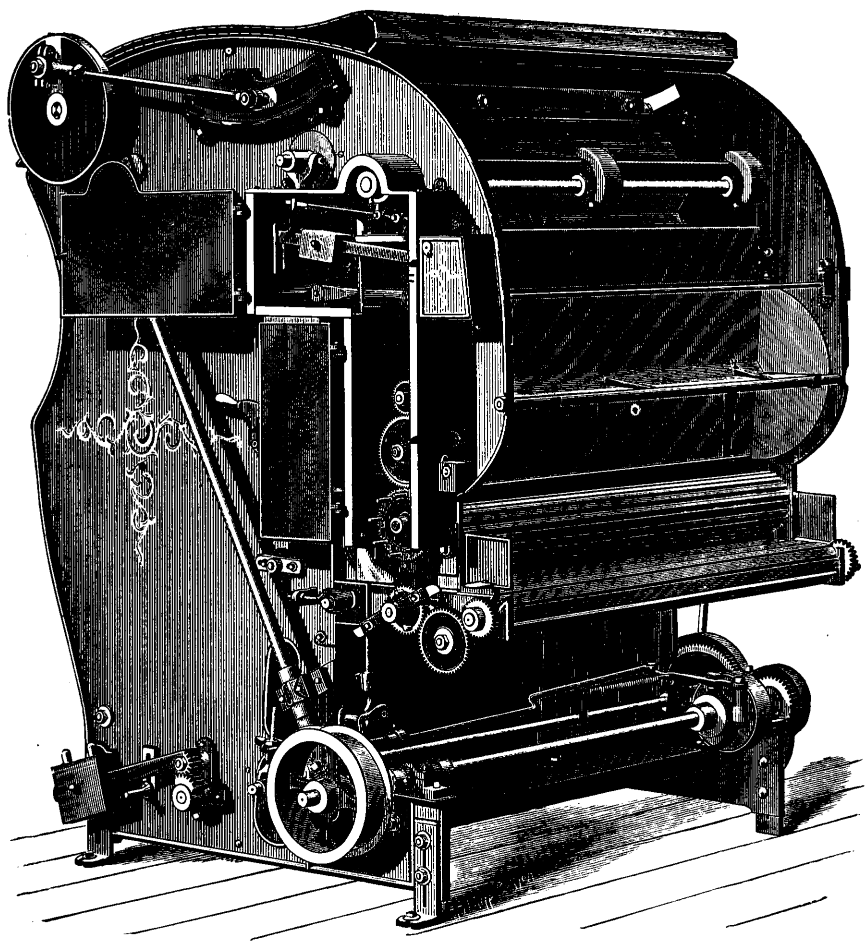

FIG. 194

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

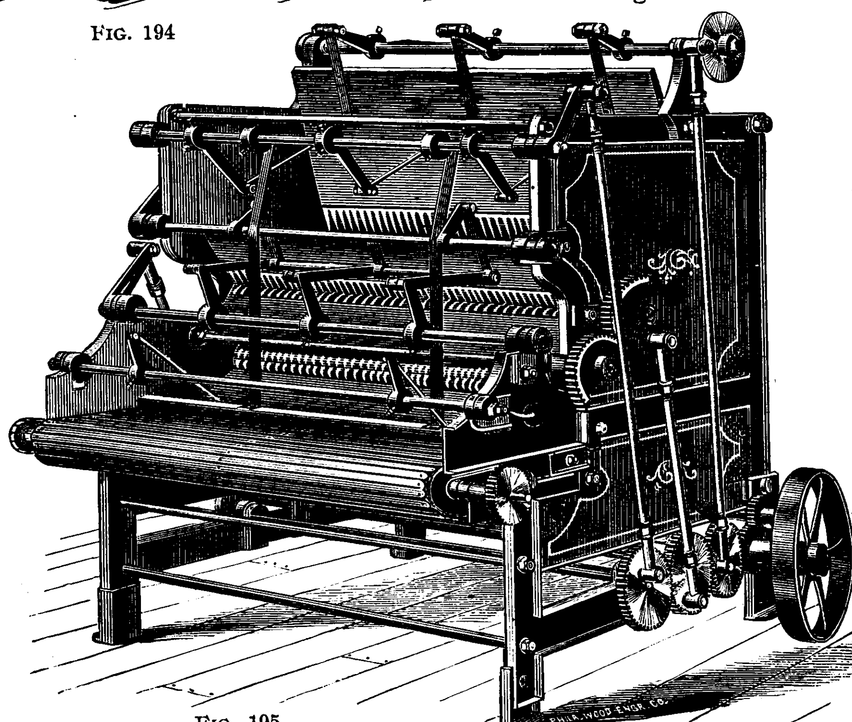

FIG. 195.

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

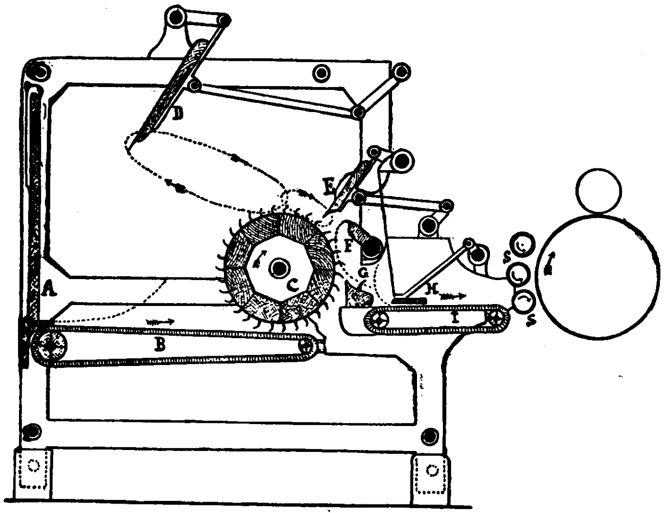

FIG. 196.

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

FIG. 197.

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

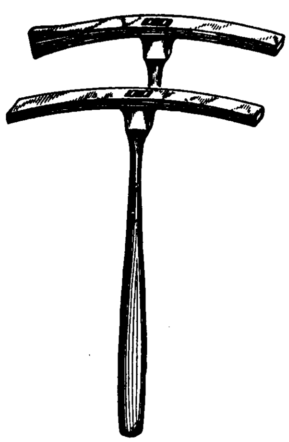

FIG. 198

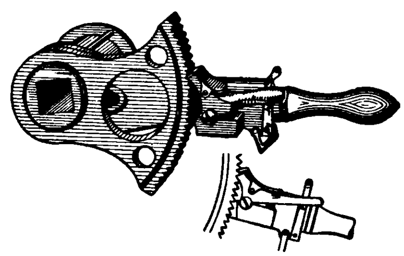

FIG. 199.

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

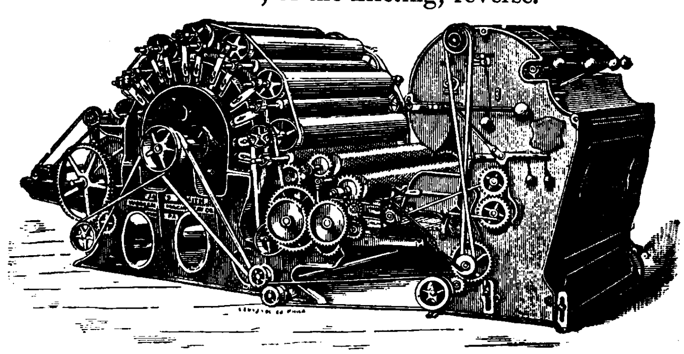

FIG. 200.

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

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

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

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

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

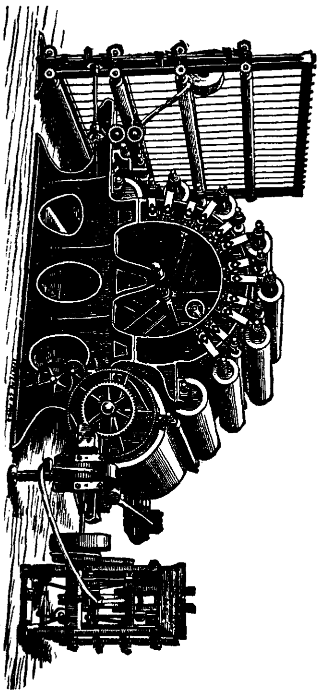

FIG. 201.

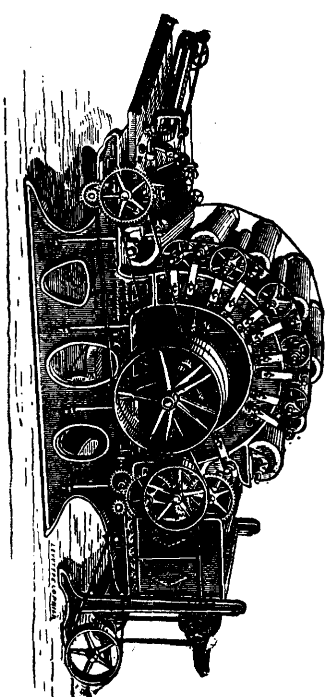

FIG. 202.

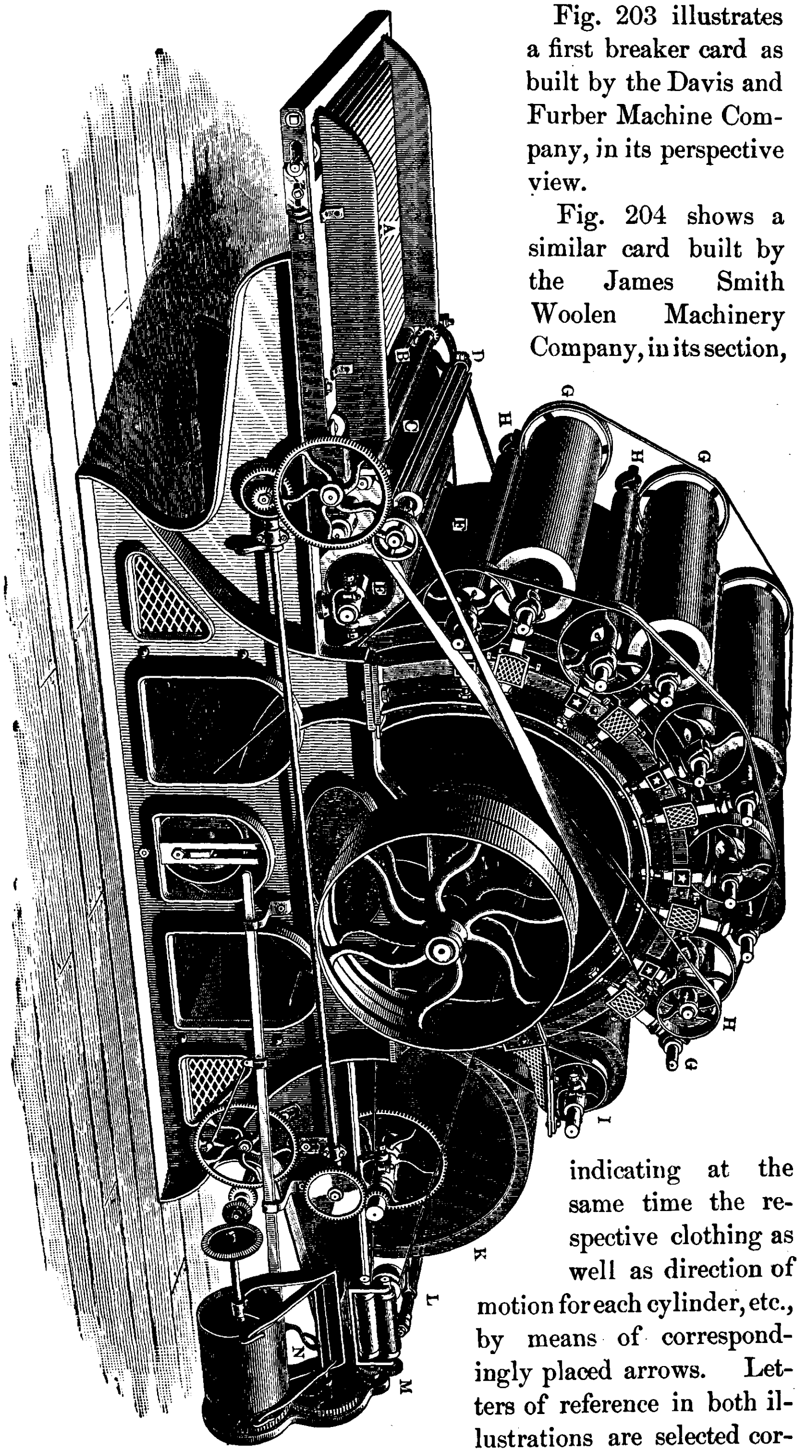

FIG. 203.

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

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

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

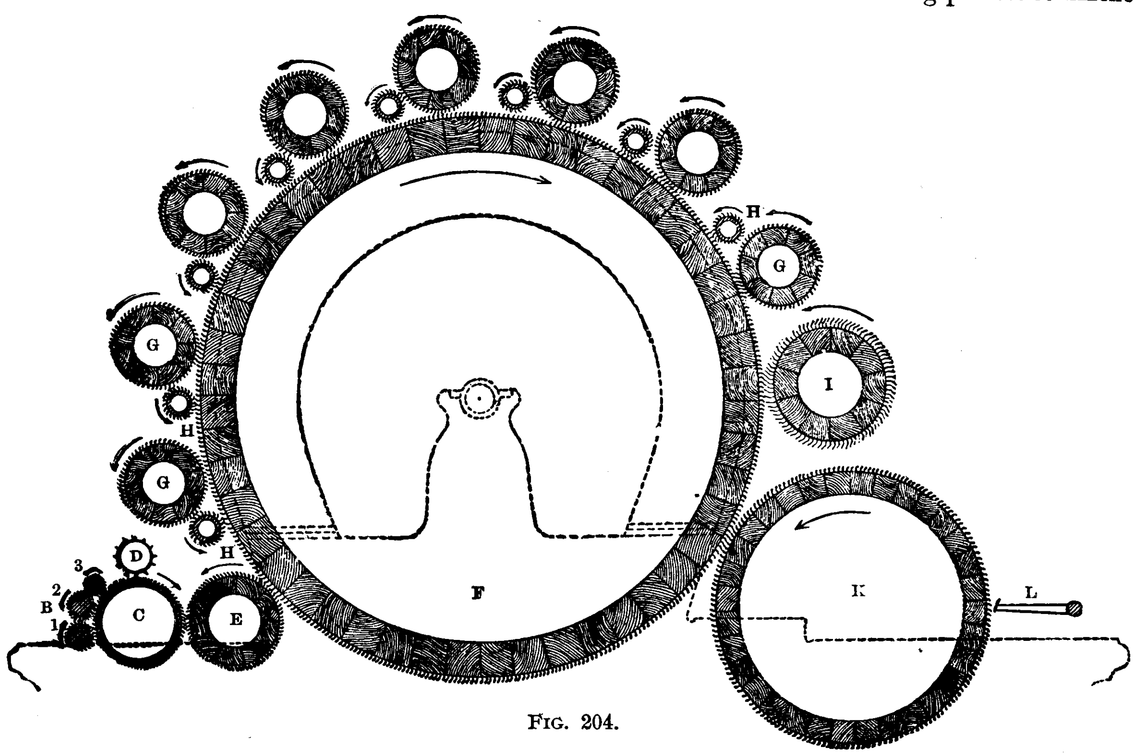

FIG. 204.

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

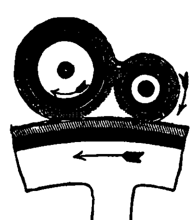

FIG. 205.

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

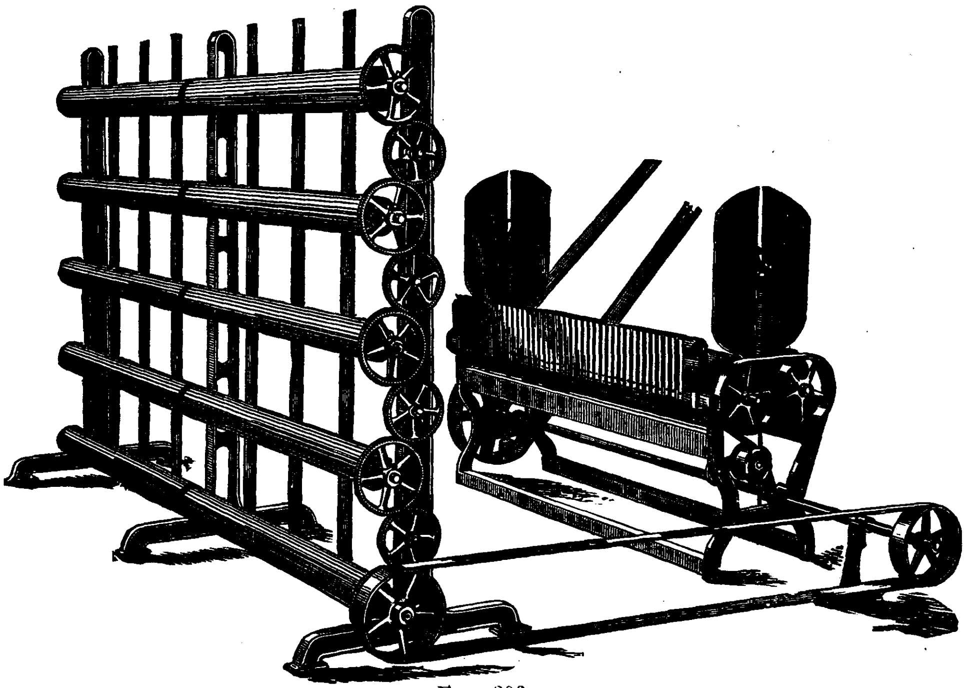

FIG. 206.

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

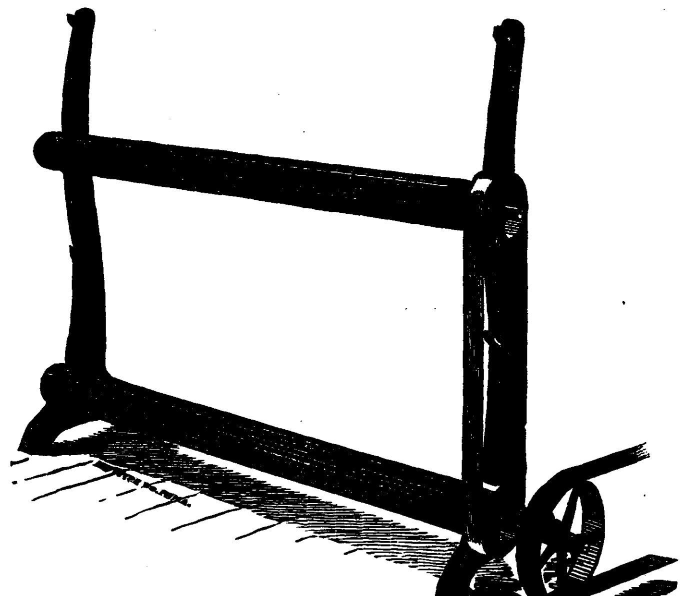

FIG. 207.

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

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

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

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

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

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

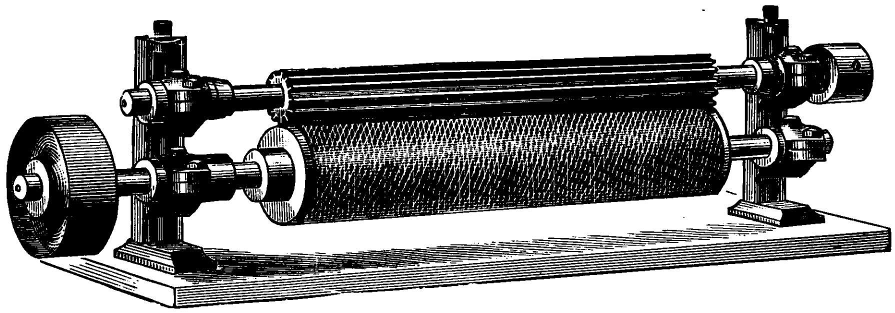

FIG. 208.

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

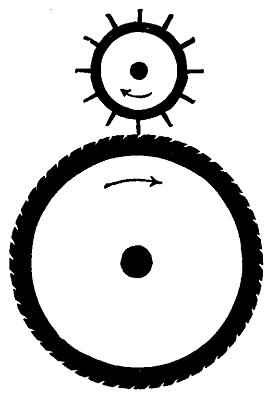

FIG. 209.

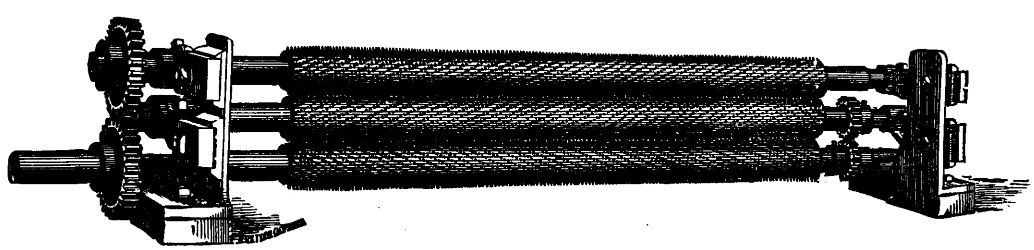

FIG. 210.

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

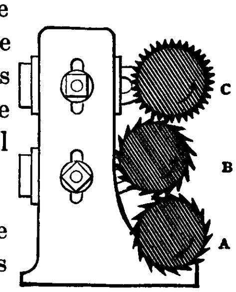

FIG. 211.

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

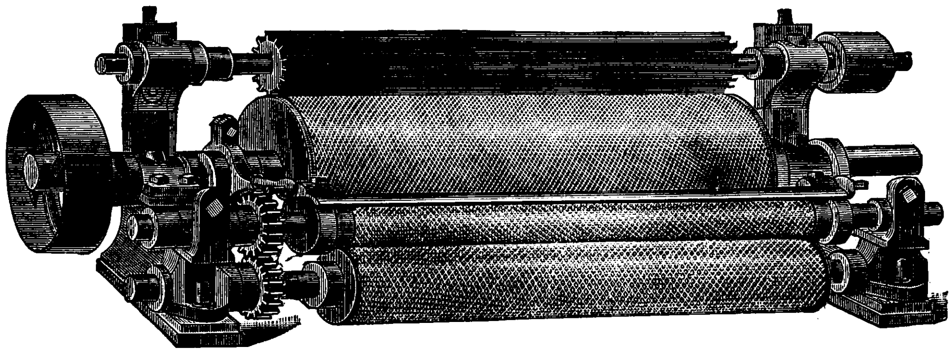

Fig. 212.

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

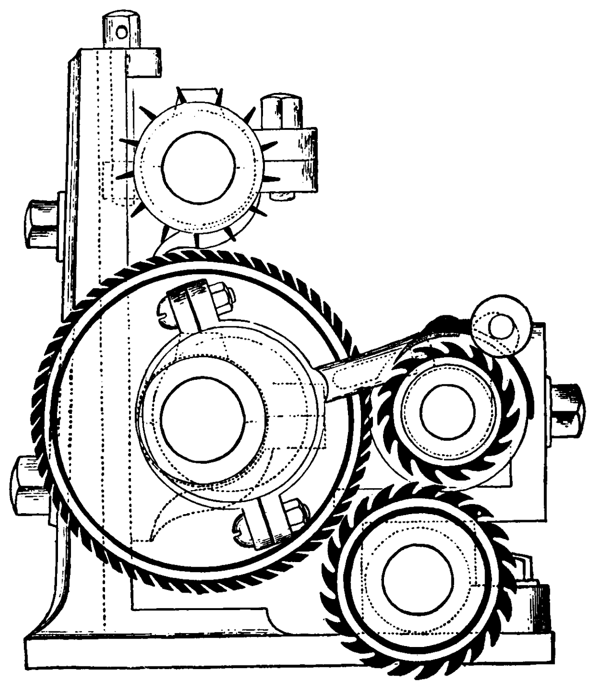

Fig. 213.

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

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

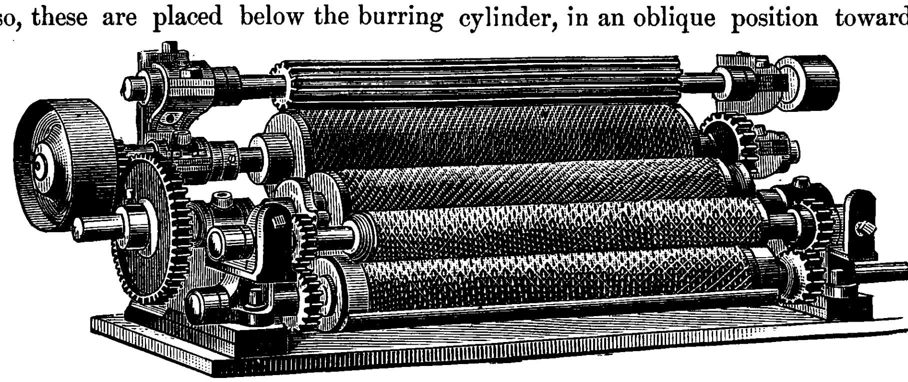

Fig. 214.

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

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

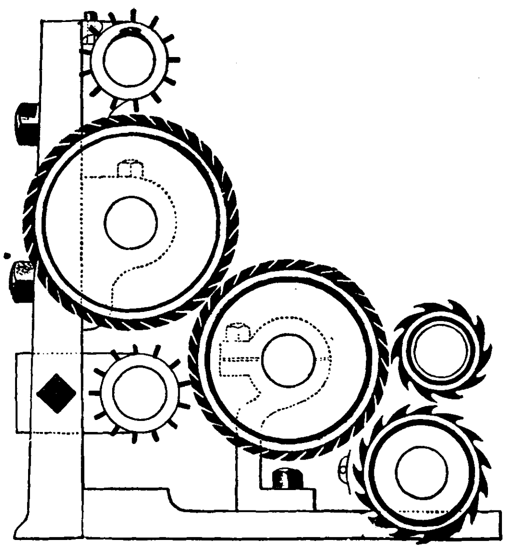

Fig. 215.

The work for the feed-rolls in a carding engine (also in a Garnett machine) is to hold the material, and slowly and evenly deliver it to the licker-in, or to the burring-cylinder of the card. The perfection of the carding operation is largely due to the proper performance of this duty by the feed-rolls. In practice however, it is sometimes found that with one or the other kind of material the feed-rolls do not properly perform the work for which they are intended. For instance when the material contains small and compact masses of fibre, such as are variously called bunches, snarls, clots, lumps, etc., such masses pass through the feed-rolls and are drawn into the machine without being properly combed, while in other classes of material naturally free from such masses, but having long fibres clinging together in disordered condition, such fibres on passing the feed-rolls and being caught by the burr-cylinder, the licker-in or carding engine, are drawn rapidly forward between the feed-rolls with the result that neighboring fibres which had not yet reached the feed-rolls, but which adhere to or touch the rapidly moving fibres, are drawn prematurely up to the feed-rolls, often in quantities sufficient to form clots of considerable size, which pass into the machine, as previously described, and produce the same bad result. In order to overcome these objections the inventor provides what he calls a *retainer-roll* which acts upon the fibres before the latter reach the feed-rolls, this retainer-roll being toothed and so operated, that it serves to comb out or straighten the clots, bunches, snarls, or other masses of fibre, and to prevent the drawing of loose fibres up to the feed-rolls by contact with long strands drawn rapidly between said rolls, as before described. In the illustration: *A*, represents part of a carding engine; *B*, part of the licker-in or first taker of the machine; *D*, *D*, the usual feed-rolls, and D^1 a clearer-roll (placed below in this case). On the frame *A*, is supported the frame *E*, which has bearings for the rolls *F*, *F*, of the feed-apron *G*. Immediately behind the feed-rolls and above the feed-apron is placed the *Retainer-roll H*, which is provided with hooked teeth arranged so that they project rearwardly when acting upon the fibre upon the feed-apron, the roll being constructed, and the teeth applied thereto in any desired manner. As shown in the present instance, the roll is made of segments and covered with clothing, which may be similar to that of an ordinary carding engine. This retainer-roll has a surface-speed somewhat less than that of the feed-rolls, so that it serves to catch any compact masses of fibre that may be carried forward on the feed-apron and prevents such masses from passing directly to the feed-rolls, the effect of the toothed retainer-roll being to loosen, comb or straighten these fibres to a certain extent before they reach the feed-rolls, and to catch and retain any loose fibres that may be adhering to long strands drawn rapidly through the feed-rolls by the action of the rapidly moving

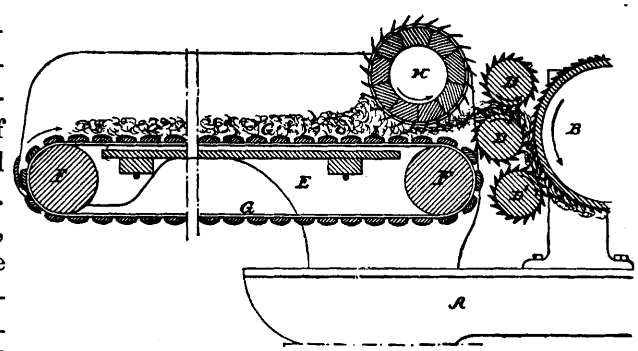

Fig. 216.

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

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

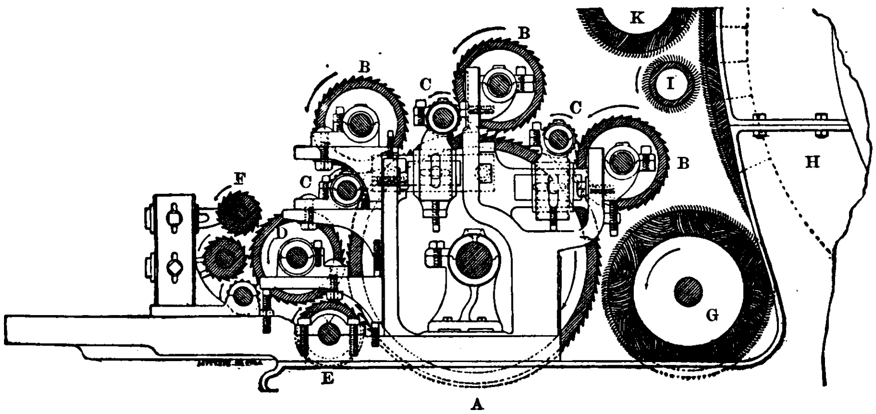

FIG. 217.

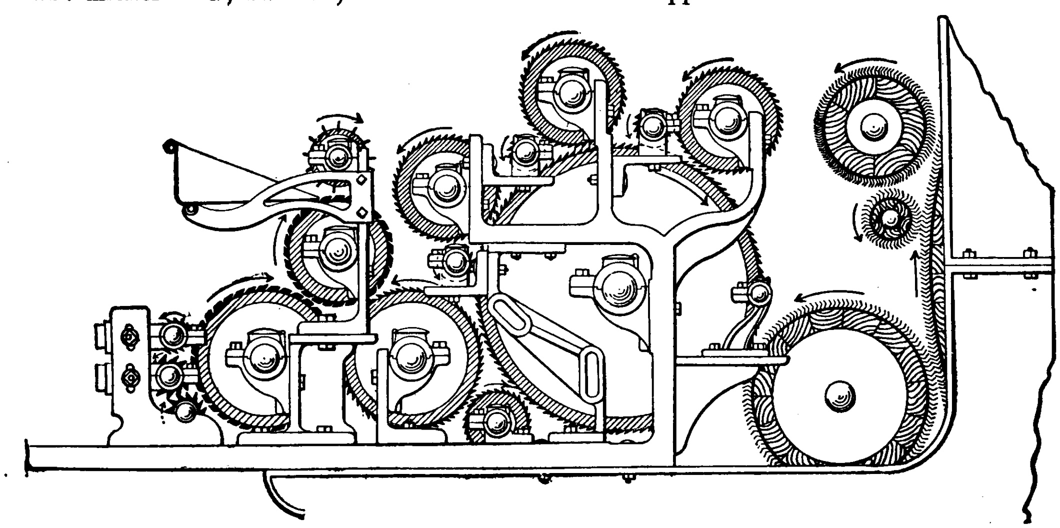

FIG. 218.

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

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

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

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

Ribbon System.—This attachment is also known as *Scotch-feed.* In the same the film is combed off the doffer-cylinder by means of the doffer-comb, is laid upon an endless apron traveling across the card parallel to the doffer, and drawn off in a flat sliver (being about three inches wide) by means of two rollers. The sliver is afterwards conveyed overhead from the doffer end of one carding engine to the feeding-apron of the next card, upon which it is passed, flat side down, backwards and forwards parallel with the feed-rolls. Each ribbon is laid in such a way that each crossing overlaps the preceding one about $1\frac{1}{2}$ inches, thus producing a continuous lap for the feed-rolls of the receiving carding engine to work on.

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

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

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

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

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

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

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

FIG. 219.

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

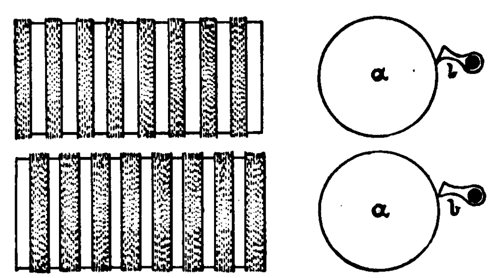

FIG. 220.

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

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

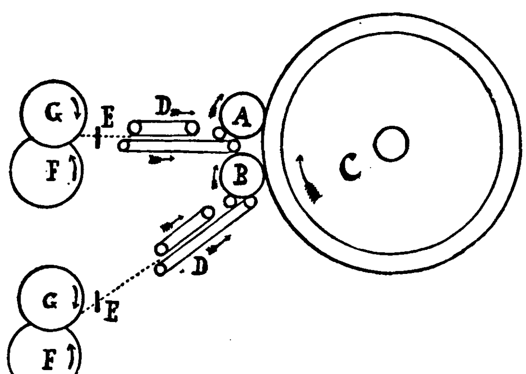

FIG. 221.

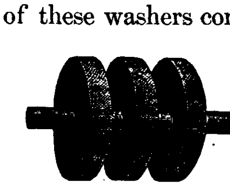

FIG. 222.

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

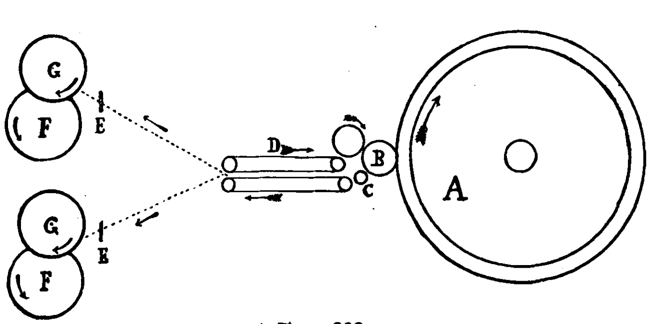

FIG. 223.

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

FIG. 224.

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

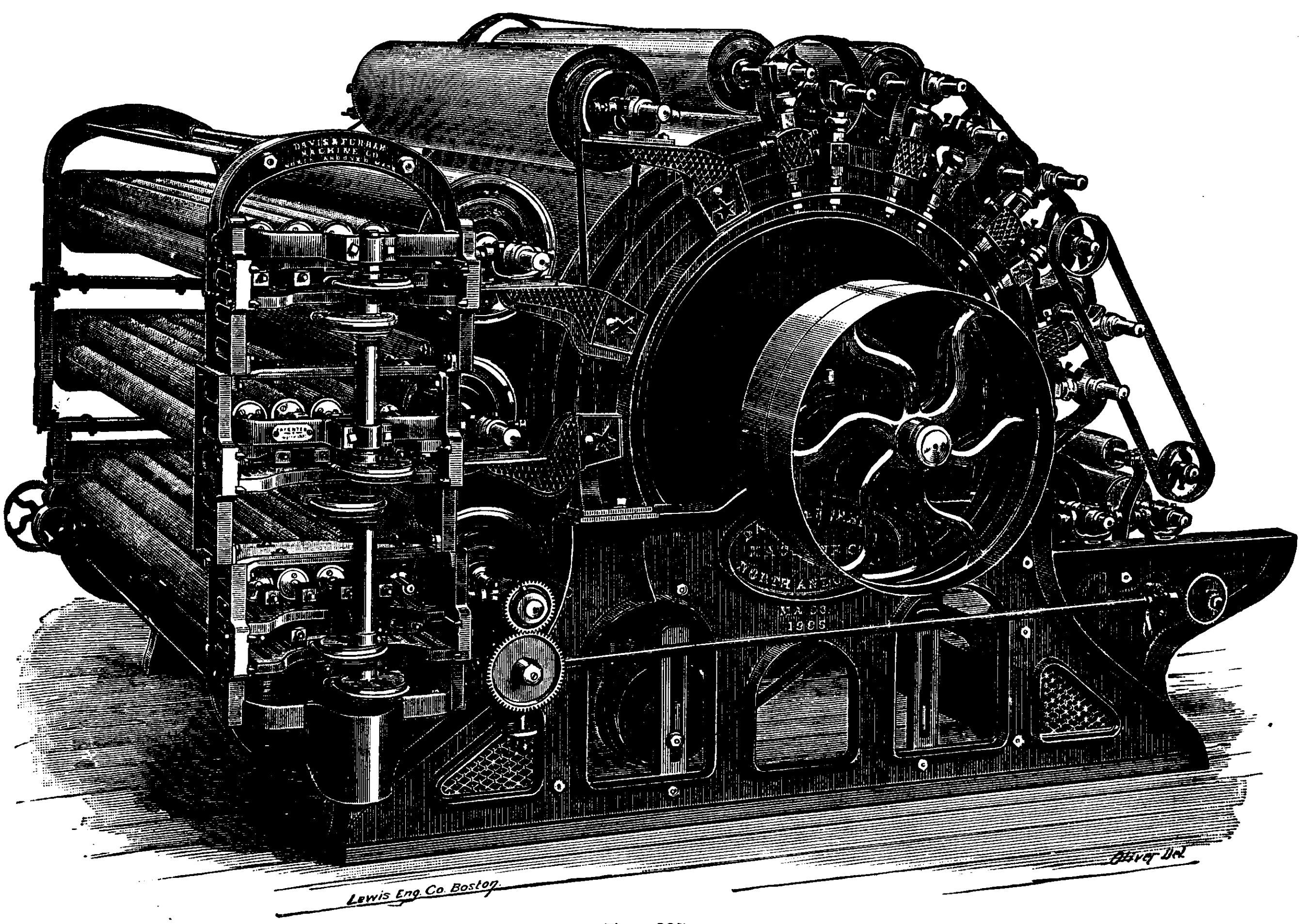

FIG. 225.

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

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

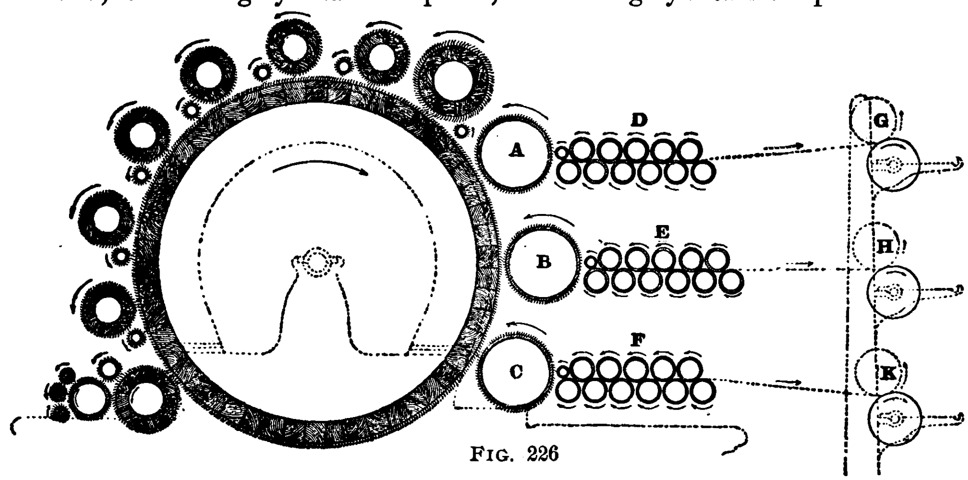

FIG. 226

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

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

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

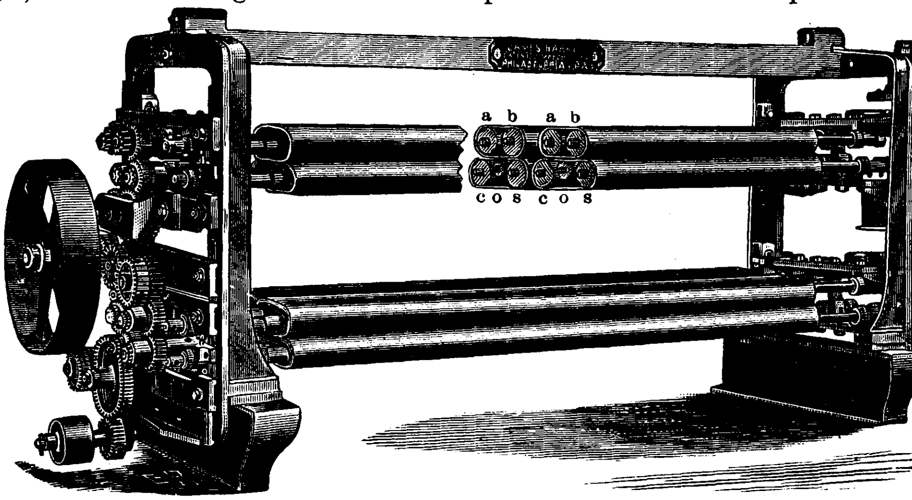

FIG. 227

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

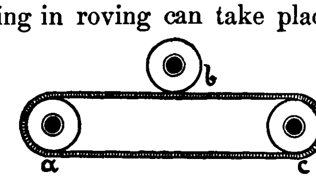

FIG. 228

Condensing by Means of Apron and Rolls.—This method, illustrated in Fig. 228, only finds limited use. In it the rolls (only one of