KNITTING MACHINERY. Knitting consists in making a fabric by enchaining a single thread. In describing the machines used for this purpose we shall consider—I. Hand machines, and II. Power machines; subdividing these according to peculiarities of form and construction.

Knitting-Machine Needles.—The essential feature of a knitting-machine needle is, that it shall catch and draw the yarn to form the loop, and shall cast it off by allowing it to slip over at another part of the action. The devices for this purpose are flexible beards and loops.

Formerly the only spring-beard needles used were made of hard-drawn iron and brass wire. Needles of this description were used in this country as late as 1848. Those in present use are made from round steel wire, and as the value of the needle depends almost wholly upon the tenaciousness and flexibility of the beard, the manufacturers are content to pay well for a wire containing the desired qualities. Though the justly celebrated "Stubs steel" is excellent for many purposes, it will not do for this department, being too hard, while for needles the steel should be uniform in its temper and very soft; indeed, so pliable is this wire that but for the color one might easily imagine it to be copper. The wire reaches the needle manufacturer in coils, without a speck of rust on its silver-like surface. First comes the process of testing the temper. For this purpose a small piece is cut from each end of each coil and subjected to a test peculiar to the manufacturer. If this proves it faulty in any particular, the coil is laid aside to be used for some inferior purpose. If, however, it proves all right, the whole coil is unwound and straightened by passing it between rollers. It is then cut up into short lengths, generally each length right for two needles. Each end of each piece is now reduced in a milling machine which will mill from 12 to 50 ends at a time (the number milled

depends in a measure on the gauge). The eye is now punched, not sawed, as some suppose. The former plan is preferred, as it leaves the needle much stronger by reason of its condensing the stock instead of cutting it away. They are now reduced to a gauge at the point, head, and eye. This is done with a smooth file. The extra stock caused by the forming of the eye is now also filed off. Next they are polished on an emery-wheel. They are now ready for the machine which turns over the beard and shapes the same. Up to this time each small length of wire has a needle formed at each end. They are now cut in two and carried to another machine which makes several flat places on the shank, which insure its being held firmly in the metal when leaded. Now comes the hardening and tempering process, which in importance ranks next to the quality of steel. They are next dried in sawdust, and subjected to repeated processes of polishing. Then each needle is separately inspected and pliered, after which they are weighed out into parcels of 100 each, and these parcels counted and packed in boxes, each box containing 1,000, in which shape they are usually sold. For length and shape they are generally made to order, and to suit the various kinds of knitting machines. They will vary in length from 1½ in. to 3 in. The size of wire and cost of finished needles is about as follows, size according to the English wire gauge:

Knitting Gauge.	Wire Gauge.	Cost.	Knitting Gauge.	Wire Gauge.	Cost.
8	16½.....	$7 00	20	21.....	$4 75
10	17	6 25	22	22.....	5 75
12	18	5 50	24	22½.....	
14	18½ to 19		30	23.....	6 00
16	19½.....	4 75	36	24.....	
18	20½.....		40	25.....	

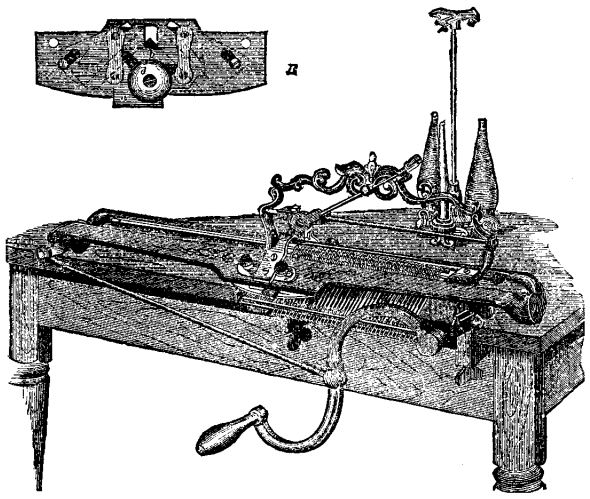
The life labor of a common gauge needle on a shirt-knitting cylinder is about 18 shirts.

Hosiery Yarn is designated by so many grains, which is determined by the weight in grains of 6 yards of yarn as reeled from the jack bobbin; that is, if 6 yards weigh 10½ grains, it is called 10½-grain yarn. In order to more nearly average the weight, 24 yards are for instance reeled off, and the weight in grains and fractions of grains is divided by 4. It is also a good plan to reel the yarn from several bobbins at once to facilitate matters, and a reel just one yard in circumference is most convenient. In one pound avoirdupois there are 7,000 grains troy or apothecaries' measure. In one run there are 1,600 yards.

I. HAND-KNITTING MACHINES.—These may be divided into—1, those in which the needles are placed in a straight row; 2, those in which the needles are circularly disposed; 3, those using but a single needle.

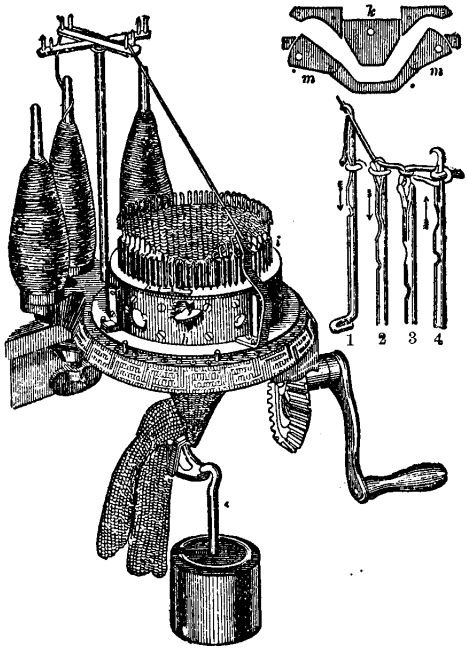
1. *Needles placed in a straight row.*—As an example of this type of machine Lamb's apparatus is presented in Fig. 2532. In this a tubular web is produced by the operation of two straight parallel rows of needles, widening and narrowing being accomplished by increasing or diminishing the number of needles in action. The frame is attached by thumb-screws to the edge of a table, and has its two upper sides inclined toward each other, their upper edges being separated far enough to allow the fabric produced to pass down between them. Supported by the needle-bed is a carriage reciprocated by a crank. The needles employed are self-knitting, being constructed in such a manner that when fed with yarn and carried an inch forward and back, they form the loops by their own action. The lower ends of the needles have an upright shank, extending above the face of the needle-bed, and are operated by cams that are attached underneath the centre of the carriage in such a manner as to move the needles forward and back. There are two sets of these cams, one for each row of needles. *B* is a representation of one of the sets of cams, which consists of the plate *a*, the two wing-cams *c c*, and the V-shaped cam *b*, which is held in place by the screws that pass through the washer *d* in the diagonal slot of the plate *a*. As the carriage to which these cams are attached is drawn back and forth over the needle-bed by the crank, the needles are carried up on one side of the V-shaped cam in the groove or space between that and the wing-cams, the yarn-guide at the same time delivering the yarn into the hooks of the needles, which are then drawn down by the wing-cam on the other side of the V-cam, thus forming the loops. By the adjustment of the cam-stops, either or both of the cams may be left open or closed at the same time, so as to operate the two rows of needles separately, alternately, or together, thus forming three entirely distinct webs—tubular web, plain flat web, and ribbed flat web.

2532.



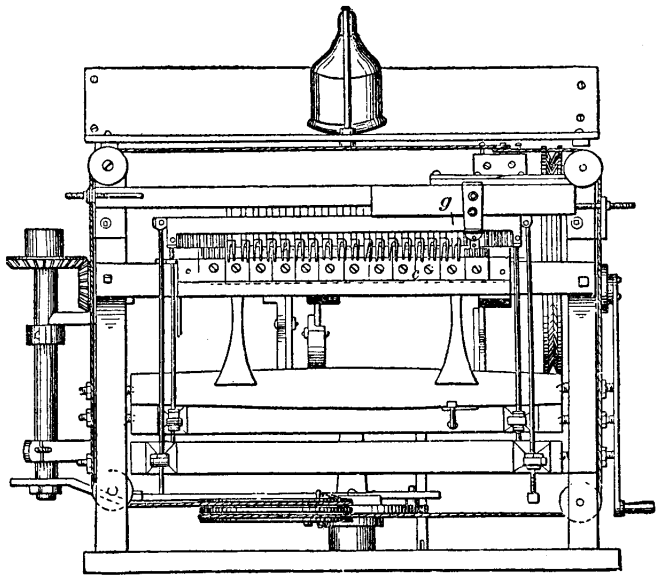
2. *Needles placed in a circle.*—Fig. 2533 represents the Bickford knitting machine. Fig. 2534 exhibits the arrangement of needles, from which the operation will be best understood. Four of the needles are here shown. The needle complete is represented at 1; a portion of the lower part of the others is broken away. The needle consists of a body, an angular bent portion, a foot, a hook, and a latch. The last is pivoted to the body of the needle, and works partly in a slot formed in the body. The latch has moreover a spoon-shaped end, which when the latch is closed, as shown in needle No. 2, meets and partly shuts over the point of the hook, so that the loop formed on the needle easily slips off when the latter makes its downward movement. Let the reader suppose one line of stitches already formed on these needles, as shown in the engraving, and the thread or yarn to be knit so held that the needle marked 1 will hook over it when the latter descends. The thread will be drawn down by the needle until the latch meets the loop previously formed. This loop, sliding along the body of the needle, lifts the latch and closes it into the position shown in No. 2. The loop then slides off the needle as it continues to descend, and the thread, being drawn down through the former loop, forms a new loop, through which the needle will pass in rising, as shown in No. 4, opening the latch and leaving the hook free to engage the yarn when the latter is brought under it again, and so on. It is obvious that if we supply mechanism that will bring the yarn under the hook at the proper moment, and move the needles up and down successively, and also provide a device for supporting each row of loops till the next row is formed, we shall have a machine that will knit a straight tube. The cams *m m* are screwed on the inside of the cylinder of the machine, which revolves. As these cams are carried around by the revolving cylinder, the angular bent part or foot of the needle passes through the curved space between the cams; and as the needles are held from moving sidewise by being placed in grooves formed in the needle-cylinder, they are forced up and down as desired. Each row of loops is also sustained until the next is formed by means of the needles themselves, as the needle-cylinder prevents their bending inward, and keeps them in a vertical position. The cam-cylinder is moved by a bevel-gear connected to a driving-crank, and when moved continuously in one direction knits a circular web, which may be narrowed as desired by removing needles and placing their loops on adjacent needles.

2533.



2534.

2535.

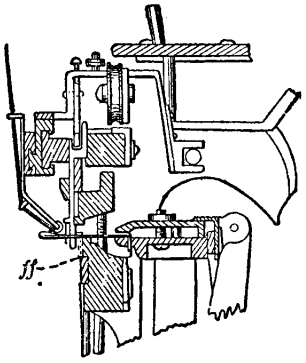


3. *Single-Needle Machines.*—The Hinkley machine is an example of this type. The driving-wheel drives a friction-pulley, and by it a grooved cam-disk by which a comb is operated (by means of a rack) backward and forward before the needle. The needle-bar, receiving its motion from the crank-pin in its slotted arm, advances with each revolution of the disk, and the needle, passing through the stitch immediately in front, under the tooth of the comb, removes that loop from its tooth; the revolution of the cam-slot brings the looper-hook forward in

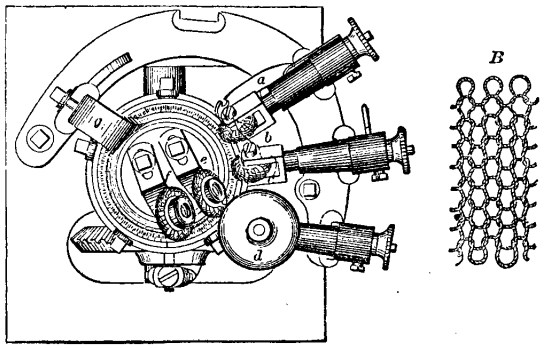
season to take up a new loop from the eye of the needle, and on its backward movement deposits it on the tooth which held its predecessor. The comb then traverses one tooth for the repetition of the stitch-forming.

II. Power Machines.—Fig. 2535 is an ordinary straight machine for producing a plain flat strip of fabric. The meshes being in their extreme forward position, and the last-formed row of stitches being near their rear ends, the guide *g* moves along the front of the machine, laying the yarn on the

2536.



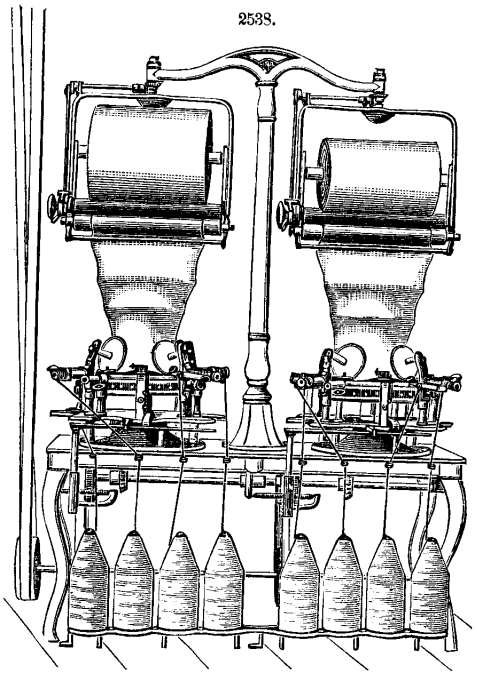
2537.



stems of the needles. The sinkers *c* are at the same time depressed, one after another, by the cam or *slur* above them, and in turn depress the yarn into loops between the needles. The latter are then drawn slightly backward, so that the yarn may pass under their beards. The presser-bar then descends upon and closes the beards, which then enter the old loops of the fabric, and the sinkers are raised in a body by the lifting-bar in their rear, shown in the sectional view. The needles receding to their extreme backward position, the old loops are thrown over their heads by being drawn against the plates *ff*, Fig. 2536. As the needles move forward the sinkers are all depressed in a body in front of the fabric by the bar in front of the sinkers, to keep the loops back on the needle-stems; the needles then move entirely forward and the looping operations are repeated.

The general arrangement of a machine of the ordinary circular kind is given in Fig. 2537. The needles are bearded and fixed around the periphery of a rotating cylinder. The yarn, delivered through the eye in the end of the guide *a*, is pushed by the notched wings on the loop-wheel *b* up under the beards of the needles. The wings of the sinker-wheel *c* then press the yarn in between the needles, to insure that there shall be a sufficient quantity to form the proper-sized loops. The needle-beards are then pressed in, so that their points enter a depression in the stems, by the presser-wheel *d*, the yarn being thus inclosed between the beard and the stem, the old loops being at the same time raised by the landing-wheel *e*, a short distance above and outside the points of the beards. The stripping or knocking-over wheel *f* then throws the old loop entirely over the tops of the needles, and the fabric with the newly formed row of loops is pressed down to the lower ends of the needles by the curved cloth-presser *g*.

2538.

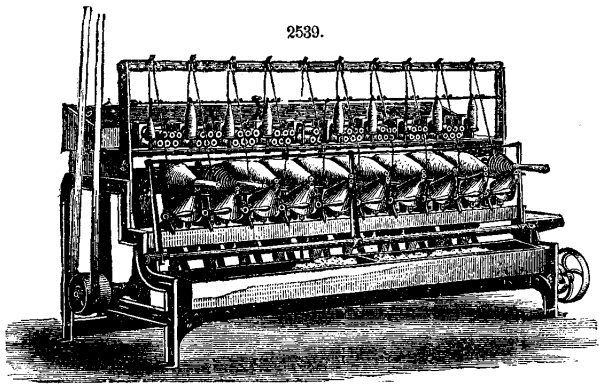


The Tompkins Upright Rotary Knitting Machine, manufactured by the Messrs. Tompkins of Troy, N. Y., is represented in Fig. 2538. The complete apparatus has two cylinders or heads. Each head generally knits four threads at once, and each thread, or the machinery necessary to knit it, is called a feed. One girl can attend to six cylinders. The needles used are the spring-beard, and they are placed in a mould in pairs, and leaded by having a composition consisting of equal parts of lead and tin poured around them. The gauge is determined by measuring the needles and counting the leads when set in the cylinder. For instance, 14-gauge has 14 leads or 28 needles, 3 in. in length, measured on the circumference. In regard to the proper speed of the needles for the different-sized cylinders, needles, and yarn, some believe a quick speed to be best, and others consider it policy to use more machinery and run it more slowly.

As regards the capabilities of the machine, the manufacturers state that a single-cylinder apparatus of 22 in. diameter, 20-gauge, 4 feeds, knitting common hosiery, yarn cotton and wool mixed, running 45 revolutions, has 920 needles, thus making 165,000 stitches per minute. A 16-inch cylinder, 20-gauge, 4 feeds, cotton yarn, has run 79 revolutions, and made 212,532 stitches per minute; and the same cylinder has been run as high as 85 revolutions on the same yarn, at which speed it made 228,480 stitches per minute. Usually an 18-inch cylinder, 15-gauge, is run 45 revolutions; and a table of two heads which turns off 160 lbs. of knit cloth per day of 11 hours, averaging 15 dozen goods exclusive of waste, is considered as doing fairly.

Cone-Winders are used in connection with knitting machinery, for rewinding the yarn as it comes from the spinning-jack bobbin or cop. The Tompkins cone-winder, Fig. 2539, is capable of winding the yarn from one 250-spindle jack. The bobbin runs in contact with the cone, directly in front of and below it, and is so held by a nicely-weighted lever bearing against the rear end of its spindle.

2539.



The thread or yarn, as it unwinds from the cop on its way to the winder-bobbin, receives first an adjustable tension which insures a firm body to the bobbin, and also causes any slack-twisted spot in the yarn to part and be mended here before it can do harm; from the tension it passes through a variable gauge or stripper, which cleans off cotton seeds, snarls, or unequal sizes in the yarn. The stripper is secured to the frame low down, in such a position that advantage is taken of the back-and-forth motion of the thread. There is also a wire fastened in such a manner as to cause extra friction on the thread while forming the noose. From this it runs on to the bobbin, which it reaches by first passing over the traverse arm, which has a quick motion, thus crossing and recrossing the thread, making it hardly possible for two circles or a double thread to run off while knitting. Each bobbin holds about 22 cops, or 1.8 lb. of yarn, 14-gauge, which will supply a knitting feed for about one hour. The speed of the drum-shaft is about 340 revolutions per minute.