FLAX, MACHINERY FOR PREPARING AND SPINNING. To prepare flax for manufacture, the stalks with the roots are pulled and set up in bundles to dry. The seed is then removed by rollers which act upon the bolls. The retting process follows. This consists in steeping the stalks in partially stagnant water for about three weeks, during which time fermentation takes place. The flax fibre being the bark or rind of the flax plant, of which the interior or core is a semi-wooden substance called *boon*, the object of retting is partially to decompose this woody substance so that it becomes brittle when dry; and the fermentation should not be continued so long as to injure the strength of the fibre, but long enough to loosen the gum which causes the bark to adhere to the woody portion. When thoroughly dried, the flax is ready to be broken. This is done in the *breaking* machine, which has fluted or grooved rollers, between which the flax-stem is made to pass, so that the woody fibre becomes well broken without being cut. Next comes the *scutching* machine, in which revolving blades or arms beat out the woody fragments, and the fibres are to a certain degree separated. In some processes the flax is now directly hackled; but since the introduction of the principle of spinning flax wet, various methods have been adopted to render the fibre finer, or in other words to split it up into a greater number of fibres, by the hackling operation. In order to obtain the finest fibre, it was found necessary to break or cut the flax into three lengths, and this is done in a cutting machine which contains a circular saw about 20 inches in diameter, constructed of three or four plates of steel, each about a quarter of an inch thick, and armed with angular teeth projecting from their circumference. This circular saw revolves with considerable velocity. A boy, grasping a handful of flax firmly at both ends, passes it between two pairs of grooved pulleys, which revolve slowly on either side and carry it against the saw, which tears off first the root end and then the top of the stem from the middle. The flax is thus divided into three lengths: the coarse and strong root-ends, the fine and strong middle, and the still finer but less strong tops. These lengths are collected into separate heaps, "stricks," or "locks," of which there are 300 or 400 to the cut.

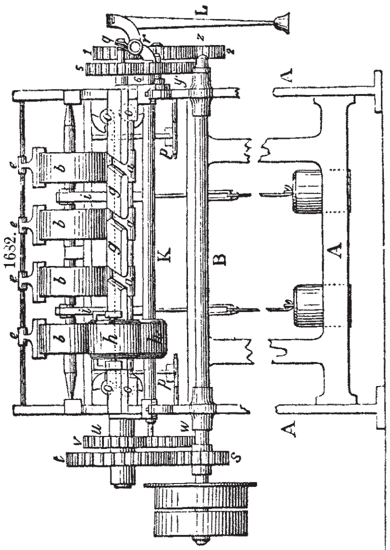
HACKLING.—Flax may be either hand-hackled or machine-hackled. The operation of hand-hackling requires much experience in order to attain dexterity. The first tool used by the workman is the *ruffer*, which is a rude kind of comb, consisting of a tin-covered stock of wood three-quarters of an inch thick, studded with iron or steel teeth. Each tooth is about a quarter of an inch square at the base and 7 inches long, tapering to a fine point. The stock is screwed to a board a little broader and some inches longer than itself, which again is fixed to the bench slantwise. The points of the teeth incline from the hackler, and a sloping board at a still greater inclination is placed behind the teeth, to prevent the flax from entering them too far. The hackler grasps one of the handfuls of flax by the middle, spread out as flatly as possible, between the forefinger and thumb, and, winding the top end about his right hand to prevent it from slipping, he proceeds by a circular sweep of his hand to lash the root end of the flax into the teeth of the ruffer, commencing as near the extremity as possible, and gradually working up to his right hand, collecting now and then the fibres by holding his left hand in front of the ruffer and turning the flax from time to time. When the hackler has ruffed the root end, he seizes the flax by the part that has been ruffed, and proceeds in a similar manner to ruff the top end. As it is impossible to ruff entirely up to the hand, there must of necessity be a certain space left to be subsequently passed through the ruffer; this is called the "shift"; but the less length that is required for this purpose the better. The next tool used by the workman is the "common eight," which is similar in form to the ruffer, except that the pins are much closer placed and are not more than 5 inches long. The flax is not wound round the hand, but is laid upon the back board with the left hand, over the points of the pins, a slight lowering of the right hand and the angle of inclination of the instrument causing it to enter the pins sufficiently on being drawn forward. From the "common eight" the flax can be taken to other tools, called the "fine eight," the "ten," the "twelve," and the "eighteen," to be still further hackled. The object of this process is to split the filaments of the flax into their finest fibres arranged in parallel order, and, so to speak, combed. The flax is divided by this process into two kinds of fibre, called the "line" and the "tow." The longer fibres (or "line") remain in the hand of the hackler as he proceeds; the shorter fibres (or "tow") adhere to the teeth of the instrument, and require to be removed from time to time. In the hands of an unskillful operative the best flax will all be converted into tow. A good hackler feels at once the degree of resistance, and draws the flax with suitable force and velocity, and throws it more or less deeply among the teeth, according to circumstances. It was thought at one time that the requisite delicacy of manipulation could only be secured by manual dexterity; and even after the introduction of machine-spinning, hand-hackling was solely employed. The progress of invention has, however, in recent years enabled the spinner to substitute, to a very large extent, machines for hand-hackling. The flax, divided as previously mentioned into stricks, is spread out and placed between a pair of short iron bars, which are screwed together and hold it firmly, like the hand of the hackler. Each pair is called a "holder," the screws of which are 4½ inches apart. A number of these holders are fixed to a cylinder at distances a few inches apart. The root ends of the flax fall upon an inner cylinder covered with sharp teeth, which revolves slightly and hackles the flax, while the outer cylinder revolves slowly in the opposite direction. When the holders have passed through about half a circle, they are deposited by the outer cylinder upon a kind of rail. The machine-minder, generally a girl, then removes them to another machine similar to the first, where the uncombed ends fall upon an inner cylinder, and are hackled like the ends previously combed. Sometimes the entire process is performed by one machine, the holders being opened by the machine-minder, after the root ends have been hackled, and the flax turned the other way. To cleanse the points of the hackling teeth from tow, a series of brushes, fixed upon wooden cylinders, are provided; these brushes pass between the points and remove the tow. One of the best hackling machines is Ardell's intersector, in which two hackling cylinders operate upon the strick of flax, and hackle it on both sides at the same time. Combe & Co., of Belfast, manufacture a self-acting sheet machine, very suitable for hackling the coarser kinds of flax. The hackles are placed upon a flat surface or "sheet," as the cylinder is not well adapted for hackling large uncut flax. The nature of the operations in the "circular" and "flat" machines is the same, except that in the circular the flax is acted on by hackles fixed on the circumference of a cylinder, and in the flat by hackles fixed on an endless sheet.

The appearance of the flax after hackling is much changed: the line consists of long, fine, soft, and glistening fibres of a bright silver-gray or yellowish color, and when seen from a short distance having very much the appearance of silk.

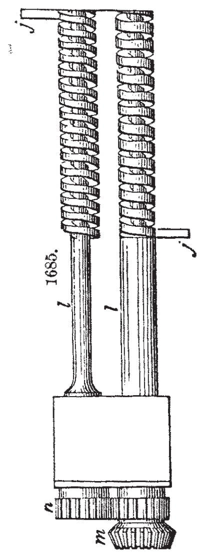
Sorting.—The next operation is called *sorting*. The hackled flax is taken to the sorting room, where the stacks are separated into various divisions, according to the degrees of fineness. Before the line-sorter is placed a kind of table, containing a number of boxes for receiving the various qualities of line. These boxes are respectively labeled 2 lb., 3 lb., 3½ lb., 4 lb., 5 lb., 5¾ lb., 6½ lb., etc., from an old system of comparing fineness with weight. He judges of the various degrees of fineness by the touch, as well as by the eye. A block hackle stands on the table, through which he frequently draws the line, to keep the fibres parallel.

Spreading and Drawing.—Each of the stricks of flax is subdivided into two or three portions, which are arranged longitudinally on the creeping-sheet (or feeding-cloth) of a spreading machine, the ends of the successive portions overlapping each other about three-fourths of their length. The construction of a spreading machine which produces the *sliver* or foundation of the future yarn is shown in Figs. 1682 to 1687. Fig. 1682 is a front elevation of the spreading machine; Fig. 1683 a side elevation; Fig. 1684 a general plan; and Figs. 1685, 1686, and 1687 detached views, on an enlarged scale, of the spirals and fallers. *A A A*, the cast-iron framework of the machine. *B B*, the driving shaft, fitted with a fast and loose pulley. *C C*, the feeding or *spreading* table; it is divided into two compartments, the one being considerably longer than the other, for the convenience of the attendants who spread the flax. *D D D*, rollers situated at each end of the feeding-table; over these pass four endless leather straps, upon which the stricks of flax are spread. *E E*, a polished iron plate, upon which are fixed the guides which serve to conduct the flax to the back or detaining rollers. *F*, a cylindrical tin can, placed in front of the machine to receive the sliver. *a a a*, the front or lower *drawing roller*. *b b b*, the top drawing or *pressing* rollers, made either of wood or iron, and covered with leather. *c c c*, the back or *detaining* rollers. *G G*, two weighted levers for imparting the requisite pressure to the top drawing rollers. *H H*, two weighted levers bearing in a similar manner upon the top detaining roller. *d d*, the *fallers* or *gill-bars*, forming a sheet of advancing hackles between the detaining and drawing rollers; these are for the purpose of producing great regularity in the draught, and a perfectly parallel distribution of the fibres. *e e e*, the *rubbers* for clearing the top drawing rollers from adhering fibres. *f f f*, brass guides for conducting the sliver to the drawing rollers. *g g*, the *sliver-plate*, formed with beveled openings for the sliver to pass through toward *h h*, the *calender rollers*, by which the four slivers are compressed into one, and delivered in the form of a ribbon into the can *F*. *K*, the calender rolling shaft. *i i*, cast-iron hangers for transmitting the pressure of the weighted lever *G* to the top drawing rollers. *k k* are similar hangers attached to the lever *H*. *l l*, the spirals or screws, into the spaces between the threads of which the ends of the fallers are inserted. *m m*, two pairs of small bevel-wheels by which the lower spirals are driven from the *back shaft*. *n n*, two small spur-wheels communicating motion from the lower to the upper spirals. *o o*, the tappets or *cams* by which the fallers are elevated in succession from the lower to the upper spirals, and *vice versa*. *p p*, small weighted levers for guiding the fallers between the threads of the spirals. *q*, a small endless screw cut upon the extremity of the axis of the lower drawing rollers *a a*; it works into *r*, a worm-wheel on the axis of which is another endless screw, driving a similar wheel, called the *bell-wheel*; at every revolution of this last wheel, a pin fixed into its rim acts upon a spring *L*, to the end of which a bell is attached, the ringing of which serves to register the length of the sliver delivered into the can.

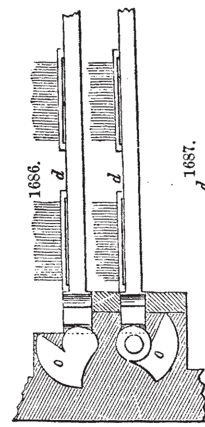
The following is the detail of the wheel-work in this machine: On the driving-shaft *B* is fixed the spur-pinion *s*, working into the wheel *t* on the lower drawing-roller shaft; to this latter axis is affixed the wheel *u*, whose motion is communicated by the movable intermediates *v* and *w* to the change-pinion *x* on the back shaft; the relative diameters of these wheels regulating the amount of draught or the degree of extension which the flax sustains in passing between the detaining and drawing rollers. The opposite end of the back shaft carries the pinion *y* working into the stud-wheel y', having on its boss the pinion *z*, which, by means of a movable intermediate z', drives the wheel $1'$ on the



1682.

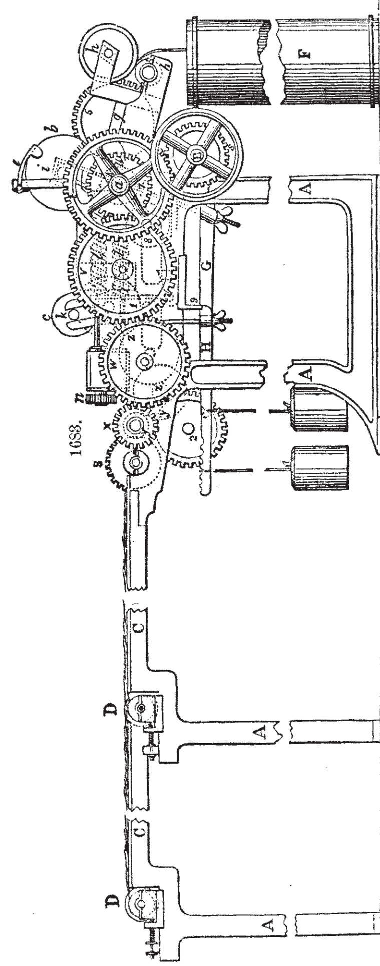


1685.

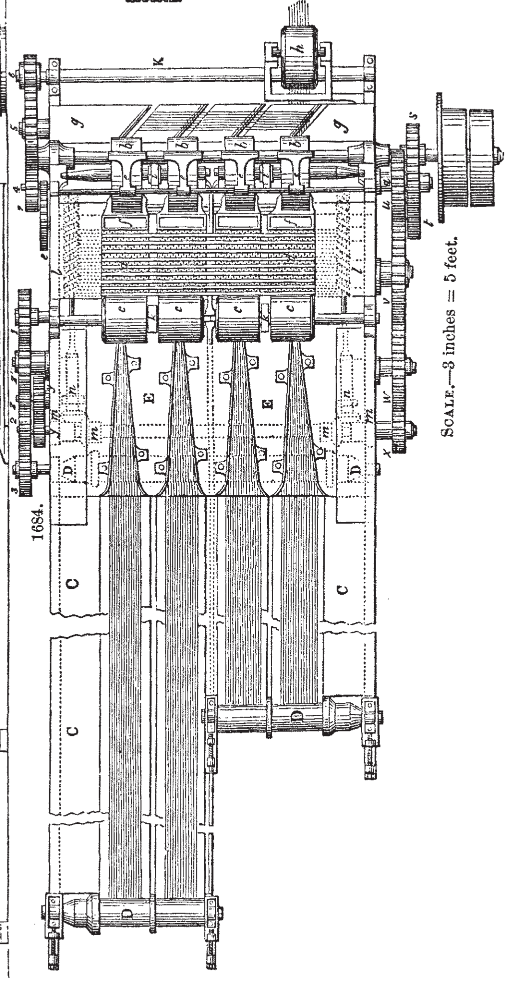


1686.

1687.



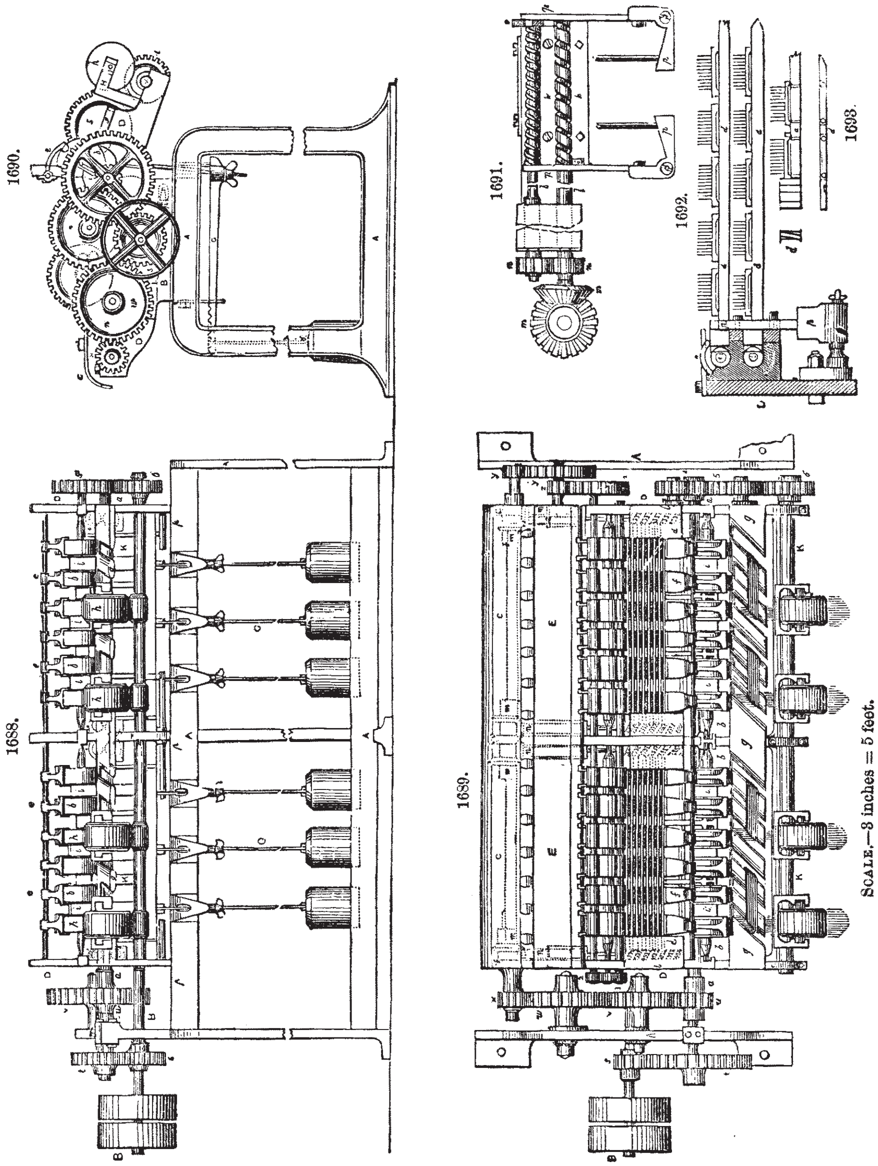
1683.



1684.

SCALE.—3 inches = 5 feet.

axis of the detaining roller. This train of wheel-work is calculated to produce a nearly uniform surface speed of the rollers and the sheet of hackles. A slow motion is communicated to the *sheet roller D*, over which the feeding-bands pass, by means of the spur-wheel 3 working through an intermediate 2 into the pinion *z*. A uniform velocity is imparted to the lower drawing- and calender-roller shafts *a* and *K*, by a pinion 4 on the extremity of the former, working through an intermediate wheel 5 into a similar pinion 6 on the end of the latter. And lastly, a revolving brush situated under the lower range of fallers, for the purpose of clearing away the dust, is driven by the stud-



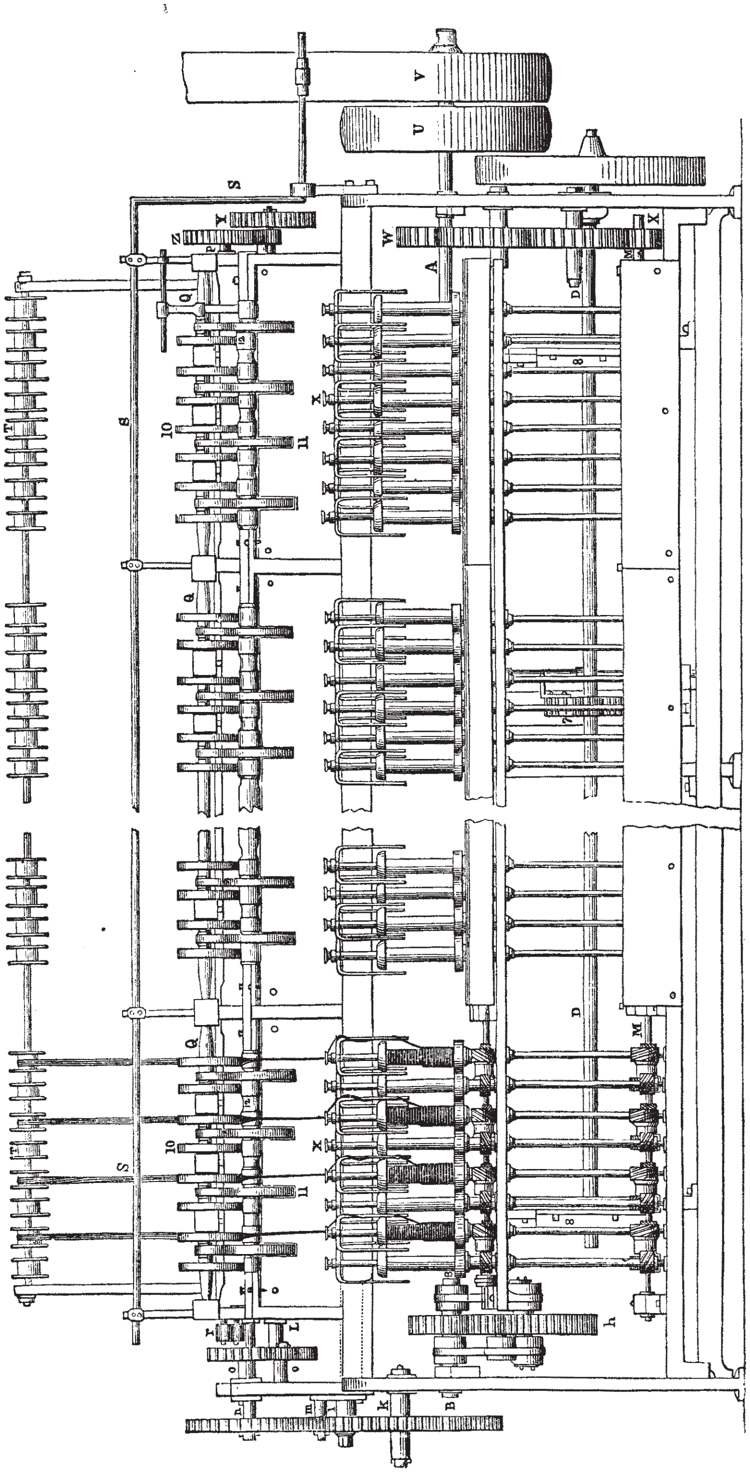
1690. 1691. 1692. 1693. 1688. 1689.

SCALE.—3 inches = 5 feet.

wheel 7, gearing with the pinion 4, and having on its boss a small pinion working into the wheel 8 on the end of the brush-shaft.

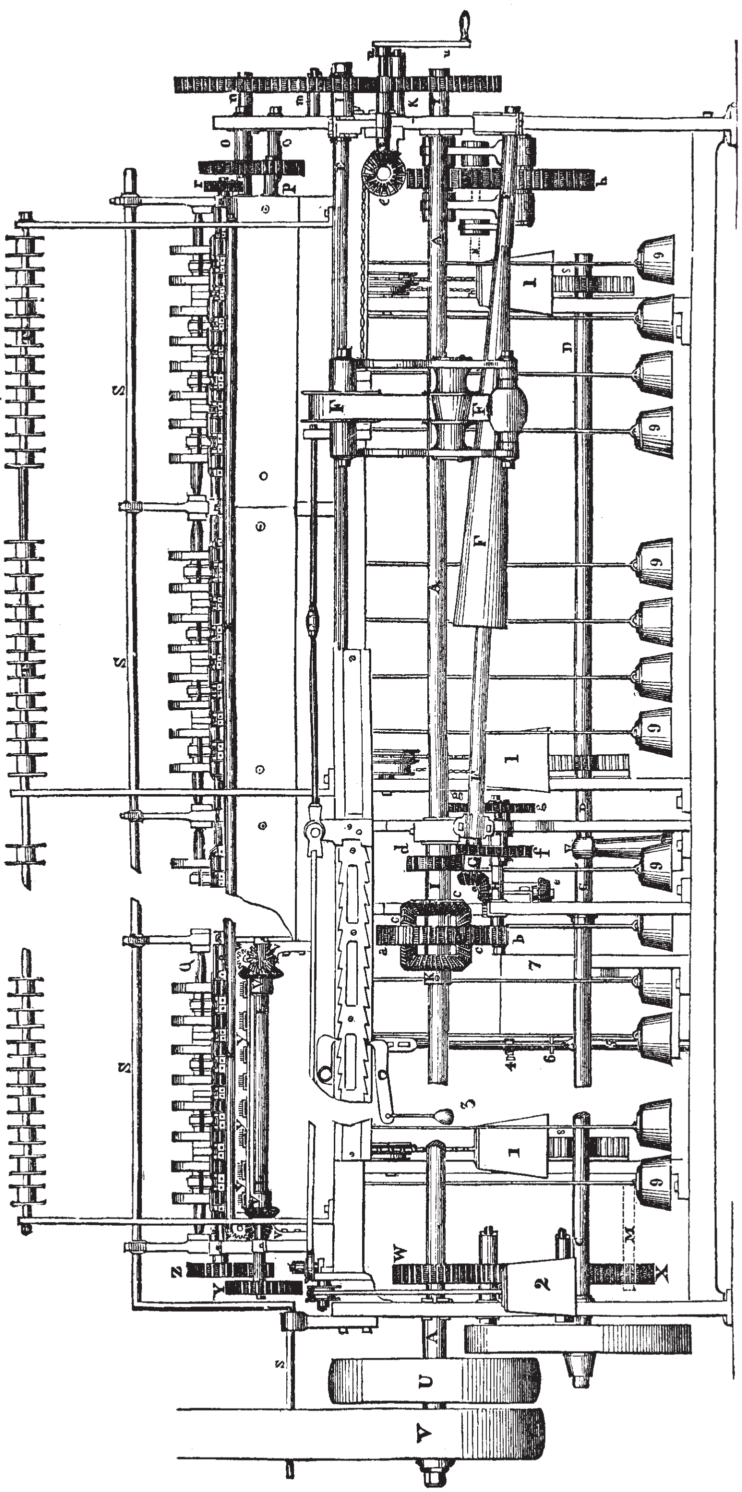
Action of the Machine.—The flax is placed in the sheet-iron guides behind the detaining rollers and along the endless bands or feed-sheets, by laying down one handful after another, so that the points of the second strick reach to about the middle of the first, and thus preserve a uniformity of thickness in the feeding. By the motion of the machine it is introduced between the back rollers *c c*, and carried forward by the sheet of hackles *d d* toward the front or drawing rollers *a a b b*, which, revolving at a velocity considerably greater than the former, lengthen or draw it out to a proportional extent; the hackles at the same time combing, separating, and straightening the fibres. The

1694.

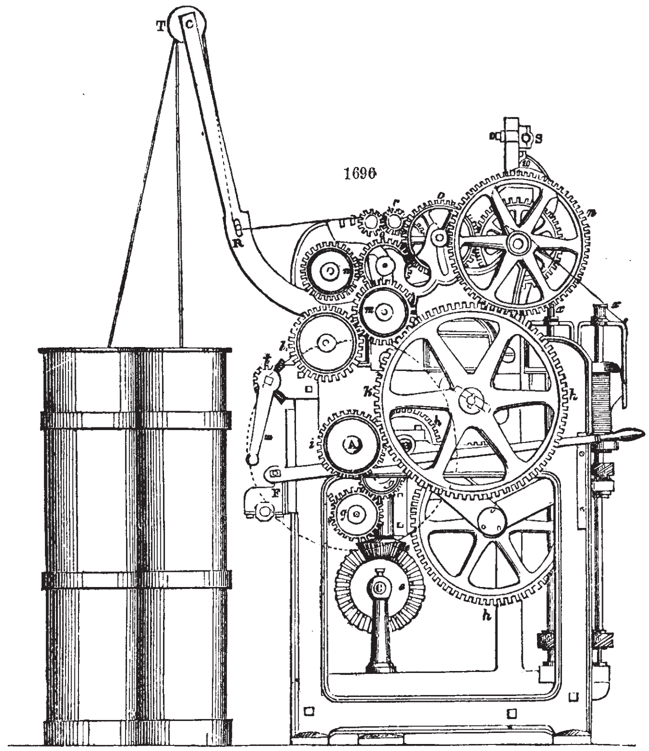


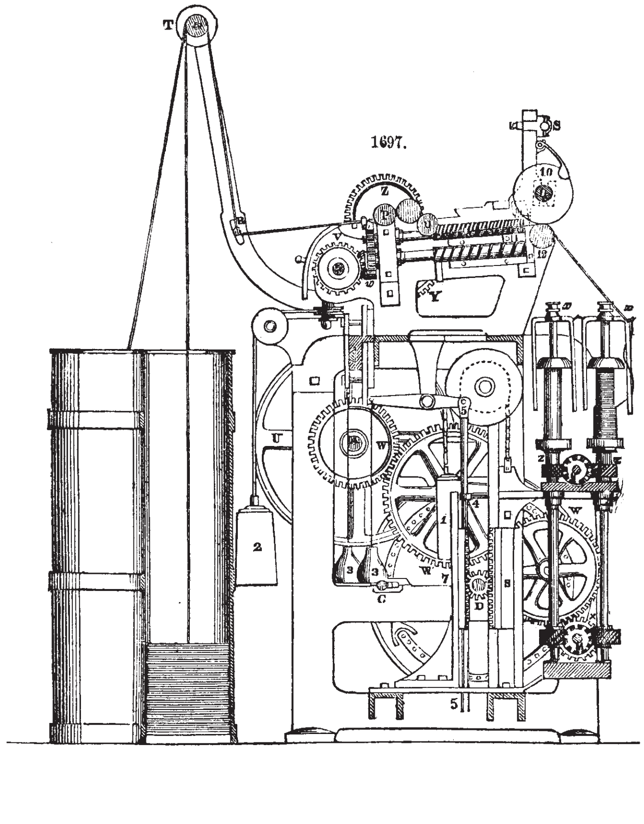
SCALE.—3 inches = 4 feet.

1695.



SCALE.—3 inches = 4 feet.

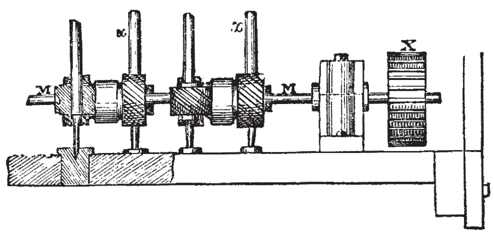

1696


1697.

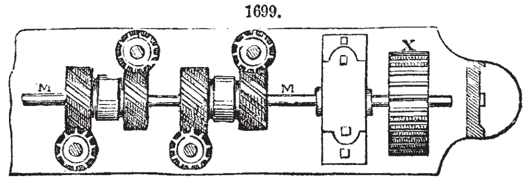
slivers from the four drawing rollers are then passed through the bevel-slits in the sliver-plate *g g*, and united into one by the calender rollers *h h*, where they are subjected to a gentle pressure and delivered into the can *F*. This union of the slivers is necessary in order that the varying thickness of each may be compensated and perfect uniformity attained. When the can has received its destined supply, the ringing of the bell warns the attendant to break the flax, remove the can, and substitute another.

The Drawing-Frame.—The next process in the preparation of flax consists in causing it to pass twice in succession through the drawing machine, for the purpose of still further increasing the fineness and uniformity of the sliver. These machines, which are represented in Figs. 1688, 1689, and 1690, are in principle identical with, and in the details of their construction very similar to, the spreading machine already described. They contain, as will be seen by the drawings, two sets of fallers and rollers, and the place of the feeding-table and guides is supplied by a bent plate of polished sheet-iron *C*, extending across the entire breadth of the machine, over which the slivers glide in passing from the cans to the detaining rollers. These latter differ slightly from those used for the same purpose in the spreading machine; here they are three in number, and coupled together by small pinions, 1, 2, and 3, and disposed in a triangular form, the sliver being made to pass under the first, over the second, and under the third. With these exceptions there is no essential difference between the present machine and that last described; and as the same or analogous parts are designated in both by the same letters, it will be unnecessary to repeat the description.

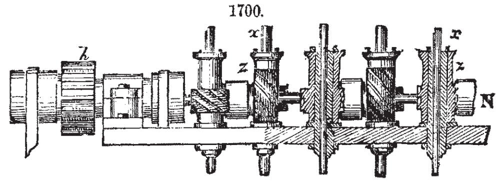
1698.



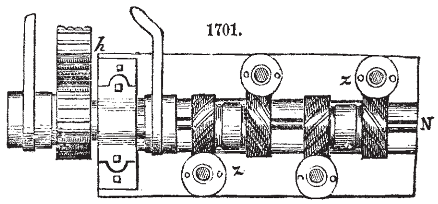
1699.



1700.

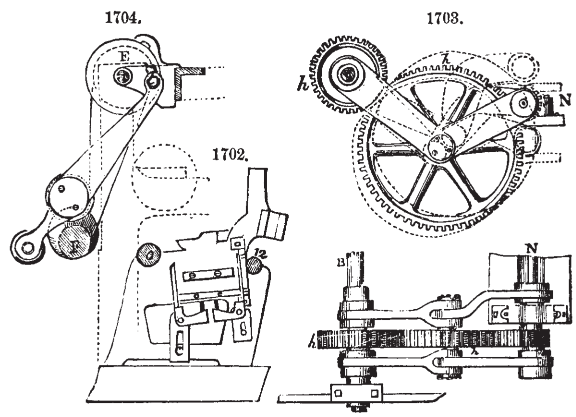


1701.



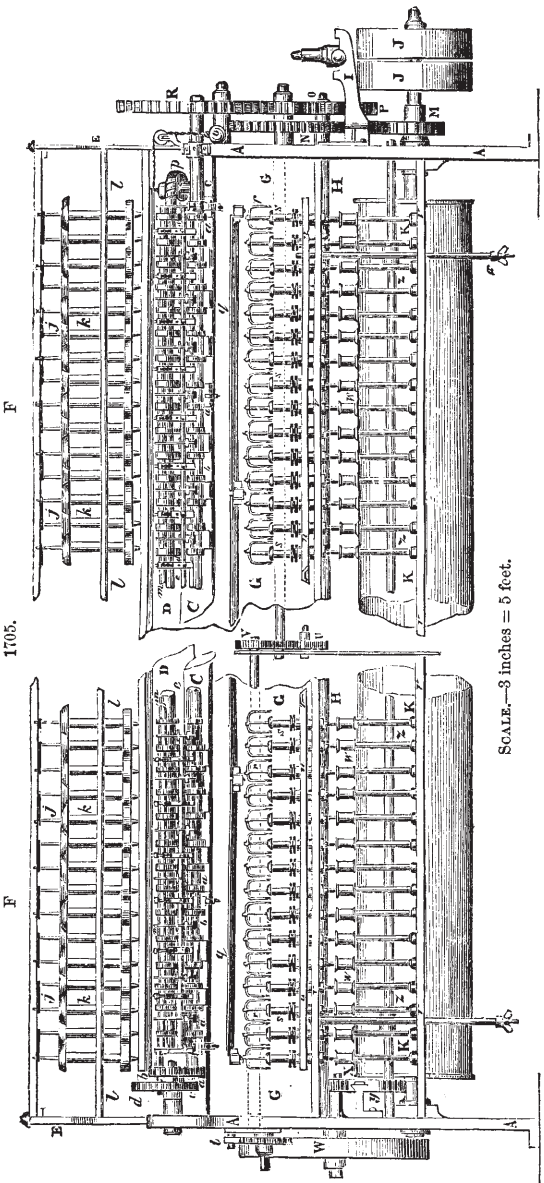
Spiral or Screw Gill.—Figs. 1691, 1692, and 1693 give a representation of a very interesting and important piece of mechanism which enters largely into the construction of modern flax machinery. This ingenious contrivance has in a great measure superseded all former modes of effecting the same object, which is combing and separating the fibres of the flax, in order to facilitate the drawing and to give uniformity to the sliver. The fallers or hackle-bars *d d*, Fig. 1692, are supported at both extremities by the horizontal steel guide-rails *k k*, screwed to the insides of the sockets in which the spirals or screws *l l* work; these sockets being bored in projecting parts cast upon the stands *D D*. The lower screw is driven from the back shaft by a bevel-wheel and pinion *m m'*, and a small spur-wheel *n*, on the back of the bevel-pinion, works into a corresponding wheel on the top screw, driving both screws at equal velocities but in contrary directions. In the sides of the sockets in which the screws revolve, openings are formed, parallel with their axes and coinciding with the surfaces of the guide-rails *k k*; through these openings the ends of the gill-bars (which are steeled and beveled to compensate for the angle of the threads) are inserted into the helical grooves of the screws. Thus the rotary motions given to the spirals cause the fallers to be driven along the guide-rails in a vertical position, and with a uniform simultaneous movement; the top sheet in the direction of the drawing rollers, and the lower toward the detaining rollers. On reaching the front part of the machine, close behind the drawing rollers, the fallers are depressed and put out of operation by means of the rotary cams *o o*, fixed to the ends of the top screws; being guided vertically downward between the ends of the upper guide-rails and the weighted levers *p p*. They are thus engaged in the threads of the lower screws, which carry them to the opposite end, where similar cams *o o*, and weighted levers *p p*, raise them successively into their original position on the upper guide-rails, where they are traversed forward as at first. It is usual to make the lower spiral with the threads considerably wider than those of the upper, which arrangement diminishes the total number of fallers requisite for the due performance of the work.

Self-regulating Spiral Roving Machine.—Fig. 1694 presents a general elevation of the entire machine as seen in front; one of the plates which protect the spiral pinions being removed in order to show the mode of giving motion to the spindles, fliers, and bobbins. Fig. 1695 is a corresponding general elevation of the back of the roving frame, exhibiting the cone and differential movements, and, by the removal of one of the covering plates, exposing a part of the back shaft and gearing for working the fallers. Fig. 1696 is an end elevation, showing the principal gearing employed in this machine. Fig. 1698 is an elevation, partially sectioned, of a portion of the spindle rail or beam, and Fig. 1699 is a plan corresponding. Fig. 1700 is an elevation, also partially sectioned, of part of the bobbin-lifter, with its attached gearing; and Fig. 1701 is a plan of the same. Fig. 1697 is a transverse section of the machine, exhibiting some of its internal arrangements, and showing the course of the sliver from the cams to the bobbins. Fig. 1702 is an elevation of part of one of the stands, showing the slides, springs, and weighted levers used for defining the course of the fallers. Fig. 1703, an elevation and plan of the contrivance for transmitting motion to the axis of the spirals on the bobbin-rail. Fig. 1704, a cross section of a part of the machine, showing the apparatus for maintaining constant tension upon the strap driving the cone-pulley of the traverse and equa tional bobbin motions.



A A, the driving-shaft, situated toward the back of the machine and extending throughout its entire length. *B B*, a shaft parallel and near to the driving-shaft, extending from the centre to one end of the machine. It carries a spur-wheel at each extremity, one of which is commanded by the equational bobbin motion, while the other, by means of a peculiar arrangement of gearing, to be hereafter described, transmits the motion to the spiral shaft on the bobbin-rail. *C C*, the mangle-pinion shaft, worked by a train of bevel-wheels from the cone shaft, and, through the mangle-wheel, situated at one end of the machine, close to the driving pulleys, working. *D D*, the mangle-wheel shaft, extending the whole length of the machine, and carrying pinions working into racks 8, 8, 8, attached to vertical slides; these slides are furnished with projecting arms fixed to the bobbin-rail, which is traversed up and down by the mangle-wheel, causing the fliers to wind the roving between the flanges of the bobbins with all the regularity of a screw. Counterbalance weights 1, 1, 1, attached to the bobbin-lifter by means of chains passing over pulleys, serve to relieve the racks from all unnecessary strain. *E*, a short shaft situated at the back of the machine, and driven by a train of spur-wheels from the driving-shaft at the same velocity as the latter. Upon this shaft is suspended a species of frame, fitted to slide longitudinally upon it, and carrying two pulleys and a weight at the extremity; the first pulley being adapted to rotate with the shaft *E* by means of a long slot and sunk feather, and the other being merely a conical friction-roller, for the purpose of maintaining a constant tension upon the strap driving the cone *F*, Fig. 1704. The frame, with its appendages, is traversed along the shaft by means of a weight 2, situated at the opposite end of the machine, and attached by a chain and adjustable rod to the frame and to a rack working in a slide fixed to the back of the roller-beam, Fig. 1697. This rack is serrated on both edges, the teeth of the upper alternating with those on the lower edge, and the pawls are alternately disengaged at every revolution of the mangle-wheel in such a manner as to allow the drag-weight to advance the rack and pulley frame by half the distance between two contiguous teeth. The mechanism by which the pawls are disengaged is as follows: At the back of the rack-slide a short rectangular bar is fitted to slide vertically, having two projecting pins acting upon the points of the clicks, Fig. 1697. This bar is worked by the end of a lever inserted through its lower extremity, and having its fulcrum under the roller-beam; to the other end is attached the vertical rod 5, carrying two adjustable catches 4, 4, which at every alternate movement of the mangle-wheel are struck by an arm 6 extending from the rack 7. Thus one of the pawls is constantly in gear to prevent the rack and attached pulley frame from being drawn beyond the prescribed limits for each stroke. The lower pawl is kept pressed against the rack by a counterweight 3, while the upper one merely rests on it by its own gravity. The pitch of the teeth on the rack must be varied according to the degree of fineness of the roving. *F*, the cone driven by a strap belt from the pulley on the shaft *E*, and communicating a gradually retarding motion at once to the bobbins themselves and to the traverse of the bobbin-rail, the velocity of the spindles and fliers remaining constant. This is necessary in order to compensate for the continually increasing diameter of the bobbins as the roving is wound upon them. The cone is set at a slight inclination, in order to allow the belt to act upon a greater part of its periphery toward the apex than toward the base, where, on account of the increased diameter, this precaution is less necessary to insure the rotation of its shaft. A lever handle (seen in the end elevation, Fig. 1696) is attached to the carriage of the cone-shaft, for the purpose of raising its outer extremity previously to winding back the pulley-frame. *G H*, two short shafts situated toward the centre of the machine, and carrying gearing, to be hereafter specified, for transmitting the motion of the cone-shaft *F* to the traverse and equational bobbin motions respectively. *I*, a hollow boss fitted to rotate upon the driving-shaft *A*, with a motion independent of that of the latter, and carrying at one end a spur-pinion working into a wheel on the shaft *B*, and at the other a bevel-wheel, being part of the equational bobbin motion. *K* is a similar bevel-wheel fast upon the driving-shaft *A*. *L L*, the back shaft, traversing the entire length of the machine, and carrying the bevel-wheels for working the mechanism of the fallers. *M M*, a longitudinal shaft working in bearings on the spindle-rail, and carrying the spiral pinions for conveying motion to the spindles and fliers, Figs. 1697, 1698, and 1699. The spindles are disposed in two rows, so that each spindle in the back range stands opposite to the interval between two in the front range. The object of this distribution is economy of space, as the machines would require to be greatly longer if the spindles stood all in one line. The shaft *M* is situated between the two rows, and drives both rows in the same direction. *N N*, a longitudinal shaft working in bearings on the bobbin-rail, and carrying the spiral pinions for working the bobbins, Figs. 1697, 1700, and 1701. The spindles pass through brass sockets fixed to the bobbin-rail to hold them steady as the latter traverses up and down. These sockets serve also as pivots for the spiral pinions to revolve upon; it being understood that the motion of the bobbin spirals is totally independent of that of the spindles. A small flange on the top of each spiral carries two projecting pins fitting into corresponding holes in the bottom of the bobbins, and causing both to revolve together. *O P*, the back detaining rollers, having the iron pressing rollers between them, which are cut into short lengths, and are carried round by the friction caused by their own gravity. *Q Q*, the axes of the pressing or top drawing rollers marked 10, which are usually made of wood, and are pressed against the lower drawing rollers 12, 12, by hangers 11, 11, resting in necks cut in the axes and attached to weighted levers 9, 9, passing under the roller-beam. *R R*, a slender rod extending the entire length of the machine, for conducting the slivers to the detaining rollers. They pass under this rod, and slide over a polished sheet-iron plate covering the back shaft and bevel-gearing for driving the gill-screws. *S S*, a rod by which the attendant is enabled at any part of the machine to stop or set it in motion. *T T* are a set of friction-pulleys placed upon a rod surmounting the machine, for the purpose of guiding the slivers as they are drawn out of the cans by the action of the machine. *U V*, the fast and loose pulleys on the end of the driving shaft for starting and stopping the machine. *W W W* is a train of spur-wheels conveying the motion of the driving-shaft *A* to *X*, a spur-pinion on the end of the shaft *M*, which drives the spindles and fliers with a uniform motion. *Y Z*, the draught-gearing between the drawing and detaining rollers, the particulars of which will be given below. *a b*, *c c*, and *d* are spur and bevel wheels and pinions, the combination of which forms the differential motion for driving the bobbins. Supposing that the large spur-wheel *a*, which, through the pinion *b*, receives its motion from the cone, were driven at the same velocity as the driving-shaft *A*, then it is obvious that no motion whatever would be imparted to the bobbins. On the other hand, if the wheel *a* were held absolutely immovable, the bevel *K*, which is fixed upon the driving-shaft, would convey, through the pinions *c c*, a motion equal to its own, though in the contrary direction, to the boss *I* and attached gearing; consequently, in the case we have last supposed, the motion communicated to the bobbins would be uniform. Hence, by combining the two extreme cases, and supposing the wheel *a* to be driven in the direction of the driving-shaft, but with a slower velocity, it will be understood that the boss *I* will be made to revolve at a speed which, if added to that of the wheel *a*, will be exactly equal to that of the driving-shaft *A*. Thus, when the driving-strap is at the apex or starting-point of the cone *F*, the wheel *a* is at its maximum velocity, and the boss *I* with the train of wheels to the bobbins at their minimum, causing the fliers, which revolve at a considerably greater *uniform* speed, to coil the given quantity of rove upon the bobbins; then as the strap advances toward the base of the cone (every point in this advance being simultaneous with the commencement of a fresh layer of roving), the speed of the wheel *a* is diminished, causing that of the boss *I* to *increase* in the same ratio, and thus approximating the speed of the bobbins to that of the fliers, at every alternate motion of the traverse. In this way the irregularity due to the varying diameters of the bobbins is compensated, and a uniform very slight tension maintained upon the slivers between the fliers and the drawing rollers. *e e e*, a train of bevel-wheels and pinions for conveying the motion of the short shaft *G* to the mangle-pinion shaft *C*. *f g g*, a train of spur-wheels and pinions (including change pinions) for conveying the motion of the cone *F* at once to the traverse and equational motions. It is obvious that to preserve the regularity of the winding, the speed of the traverse or copping motion, as well as that of the bobbins themselves, must be progressively retarded. *h h h*, a train of spur-wheels for conveying the differential motion to the bobbin-shaft *N*. The pinion *d* on the boss *I* works into a wheel fixed to the end of the shaft *B*; this shaft has another spur-wheel *h*, Figs. 1696 and 1703, upon its opposite extremity, which gears with *h*, an intermediate wheel suspended in a joint formed by the meeting of two pairs of arms, one of which have their centre of motion on the shaft *B*, and the other on the shaft *N*. Thus, when the latter ascends and descends in obedience to the traverse motion, the arms move in a radial direction round their respective centres, and consequently the suspended wheel *h* is kept constantly in gear both with the wheel on the end of the shaft *B* and with the pinion on the shaft *N*. This will be clearly understood by observing the dotted lines in Fig. 1703, which denote the different positions of the bobbin-lifter, and the corresponding positions of the arms and intermediate wheel. *i k l m*, a train of spur-wheels for conveying the motion of the driving-shaft to the shaft *E* working the cone motion, Fig. 1696. *n* is a spur-wheel on the end of the drawing roller, also working into the movable intermediate *k*, which thus commands the drawing, bobbin, and traverse motions. The train *i k n* is called the *twist-gearing*, and its object is to vary the speed of the front roller while the speed of the spindles remains the same, and thus to put more or less twist into the rove as may be required. *o o p*, a train of wheels between the drawing rollers and the back shaft—*p* being a change pinion; these, together with the train *Y Z*, at the opposite end of the machine, constitute the draught-gearing. *r r*, small pinions connecting the detaining rollers together. *t u*, a handle and small bevel-wheels working a barrel round which is coiled a chain attached to the pulley-frame for winding the rack, etc., toward the apex of the cone *F*. *v v*, *w w*, *y y*, the fallers and gearing for working them, as minutely detailed in a preceding description. *x x x*, the fliers fixed upon the top of the spindles for twisting, guiding, and winding the rove upon the bobbins.

Spinning.—The preliminary processes through which the line passes after it is hackled and before it is spun are termed, collectively, *preparing*. The rove-bobbins are now taken to the spinning room. Spinning consists in drawing the roving down to the last degree of tenuity desired, and twisting them into hard cylindrical cords, which are called yarns. The spinning of flax does not differ essentially from the spinning of cotton on the "throstle" principle. Mule-spinning, which is so well suited for a weak material like fine cotton, is not suited for the strong fibre of flax. In hand-spinning, the housewife used to moisten the fibres with her saliva, to make them adhere to each other, and also to make them more pliable and easy to twist; and in imitation of this practice, the fibres were formerly wetted in cold water previous to being spun by machinery. For cold water, water heated to a temperature of 120° is now substituted. This has been found to be a great improvement: a given weight of flax can be spun to double the length that it formerly could, and the thread that is produced is finer, smoother, and more uniform in texture than formerly. The hot water is contained in a trough which runs the whole length of the spinning frame. A dewy spray is continually thrown off by the machinery, against which the attendants protect themselves by waterproof aprons. Probably line which, when spun dry, would produce only 20 leas of yarn, would when wetted yield 70 leas or more, and be proportionately more remunerative.



1705.

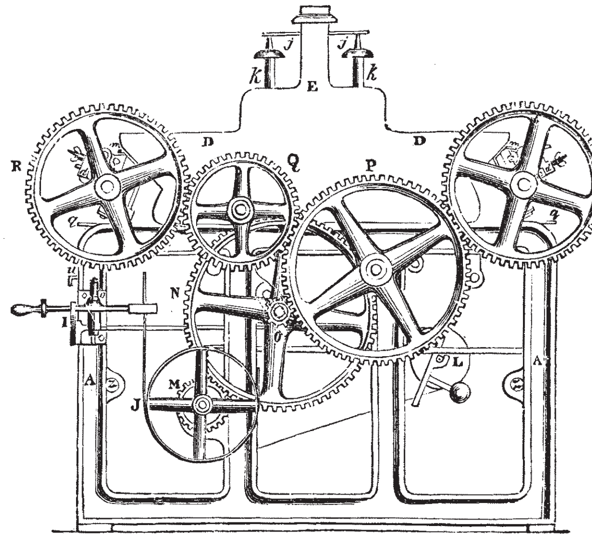
Scale.—3 inches = 5 feet.

The Wet Spinning Frame.—With the exception of the hot-water trough and its adjuncts, this machine bears a close resemblance to the throstle frame of the cotton manufacture, and like it is employed for the completion of the yarn, after being subjected to the processes of drawing and roving. Although the principle of its operation is for the most part the same as that of the roving machine, it is much less complicated than the latter, inasmuch as it dispenses with the gill apparatus (which is, of course, only applicable to parallel slivers), and with the equational bobbin motion, which is rendered unnecessary by the circumstance of the yarn itself having attained a sufficient degree of cohesive force to enable it, with the aid of a simple contrivance, to regulate the drag upon the bobbins.

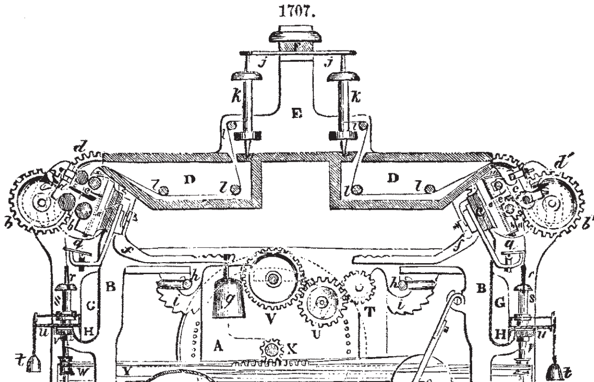
Fig. 1705 is a front elevation, broken in the middle, for the purpose of exposing part of the gearing for working the traverse motion; Fig. 1706 is an elevation of the gearing end of the machine; and Fig. 1707 is a transverse section of the entire machine.

Literal References.—*A A*, the frame ends or standards of cast-iron. *B B*, the middle support. *C C*, longitudinal beams of cast-iron, on which are supported *a a*, the stands or framing of the rollers. The bottom or drawing-roller journals are fixed, while the top or detaining-roller journals slide on the upper part of the stands, and are regulated by screws (see dotted lines in Fig. 1707), so as to adapt the *reach* or distance between the drawing and detaining rollers to the various lengths of fibres. This distance should always be a little more than the average length of the filaments. *b b*, the bottom or drawing rollers, usually called the *front* rollers. *c c*, the top or detaining rollers, usually called the *back* rollers. Both front and back rollers are made of brass cast upon a wrought-iron shaft or axle, and fluted. *d d*, the *saddles* for retaining the pressing rollers in their proper places. The bushes or bearings of the top pressing rollers are made to slide upon projecting arms, in order to suit the various lengths of reach. The top pressing rollers are generally made of brass and the bottom of boxwood, and both are fluted. *e e* are bolts fitted with adjusting thumb-screws for attaching the saddles *d d* to *f f g g*, levers with weights for giving the requisite pressure to the pressing rollers. *h h*, cranked axles extending the entire length of the machine for relieving the pressing rollers from the strain of the weighted levers when the machine is at rest. *i i*, ratchet-wheels fixed upon the end of the cranked axles for maintaining them in the position in which they may be placed. *D D*, the wooden troughs surmounting the machine, and through which the rovings pass before reaching the detaining rollers. These troughs are supplied with hot water, and kept at a high temperature by steam from a boiler. *E*, the *creel* in which the roving bobbins are placed vertically, in alternating rows. *F*, a wooden rail surmounting the creel, to which are attached *j j*, the slender sheet-iron supports for the top of the roving-bobbin spindles, the lower ends revolving in foot-steps on the top of the trough, Fig. 1707. *k k*, the bobbins, as filled with loose yarn by the roving machine. *l l l*, longitudinal brass rods for conducting the rovings into and through the troughs *D D*. *m m* is a flat brass rod, placed immediately above the detaining rollers, and extending the entire length of the machine; opposite to each boss of the detaining rollers an indentation is cut in the rod *m*, for the purpose of guiding the rovings. A small endless screw is cut on the end of the detaining-roller shaft, and gears with a worm-wheel *p*, Fig. 1705, which works on a stud fixed to the beam *C*, and has a small *heart-wheel* formed upon its upper surface. A small steel pin *n* is fixed to the end of the rod *m*, and is pressed against the heart by a drag-weight *o*, attached to it by a chain passing over a small pulley. As the roller revolves, it produces a slow motion of the heart, causing the rod *m m* to traverse nearly the whole length of the boss, and thereby preventing the roving from wearing the surface of the rollers unequally. *q q*, the thread-plates or guides, having small notches opposite to each bobbin through which the threads pass on their way from the drawing rollers to the eyes of the fliers. These plates are made in separate lengths as may be convenient, and are hinged in order to enable the bobbins to be inserted into or withdrawn from the spindles. *G G* are sheet-iron linings extending from the beam *C* to *H H*, spouts formed under and within the rows of bobbins. These linings and spouts serve to collect and withdraw the water which is thrown off by the centrifugal force of the bobbins. *r r*, the fliers for guiding and winding the yarn on *s s*, the bobbins, formed with a species of pulley on their lower flanges. In this machine the bobbins are not driven independently of the spindles, for a reason which we have specified in our introductory remarks. The natural tendency of the bobbins to wind on the yarn regularly is assisted by the following contrivance: *t t* are drag-weights, attached by pieces of string to loops on the back of the bobbin-lifter; these cords pass across to a plate with a serrated edge fixed to the front of the bobbin-lifter, and press against the grooves formed in the lower flanges of the bobbins. The friction thereby occa-

1706.



1707.



sioned, which may be varied by changing the length of leverage at which the weights act, gives the bobbin the requisite retardation for winding on the yarn. *u u*, the bobbin-beams or lifters supported by the traverse rods *x x*, which are attached to bosses upon the traverse shaft *z z*, by chains furnished with adjusting thumb-screws for adapting the bobbins to the height of the fliers. *v v* are the spindle rails or beams, in which are inserted the steps and collars for the spindles to run in. *w w*, the spindles themselves, with their driving wharves or pulleys fixed to them. *I* is a bracket upon which works the strap-guide for starting and stopping the machine. *J J*, the fast and loose pulley fitted to the end of *K K*, a long cylinder constructed of tin plates and extending the entire length of the machine, forming a continuous drum for driving the spindles. *L*, a balance-pulley round which the tape passes for driving the spindles, and which keeps it at the proper tension. The tape passes over the cylinder *K*, then over the balance-pulley *L*, and round two spindles on each side of the frame, thus causing one belt or tape to drive four spindles. Previously to the introduction of this method, each spindle was impelled by a separate tape. *M N O P Q R S*, a train of spur-gearing (*O* being a change-pinion), constituting the twist-gearing, and conveying motion from the driving-shaft to the front rollers on both sides of the frame. *T U V*, a train of spur-wheels situated at the middle of the frame, and constituting a part of the traverse-gearing. *T* is a pinion fast upon the end of the shaft, which carries the intermediate twist-wheel *P*, and which has a bearing in the middle support *B*. This wheel works through the intermediate *U* into *V* upon the mangle-pinion shaft. *W* is the mangle-wheel, situated at the opposite end of the frame to the twist-gearing, and actuated alternately in both directions by the mangle-pinion. *X*, a small spur-pinion fixed to the axis of the mangle-wheel, and working into a rack formed on the top edge of *Y*, a cast-iron horizontal bar working transversely in slides bolted to the inside of the end framing *A A*. Each extremity of this bar is formed into a radial rack; these work into the eccentric spur-wheel *y y*, fixed upon the traverse-shafts *z z*, imparting to the latter a *graduated* motion of rotation, which is communicated to the bobbin-lifter by the mechanism previously described, causing the flier to wind the yarn upon the bobbin in a slightly spherical form. *a′ b′ c′ d′*, a combination of wheels forming the draught-gearing, precisely similar to the draught-gearing in the other machines which have come under our notice.

Reeling.—The bobbins are conveyed from the throstle-frame to the reeling room, where the yarn is unwound from the bobbins and measured on reels, the lowest denomination being the "lea" or "cut." The standard lea contains 300 yards. The next higher denomination is the "hank." Each hank contains 10 leas, or 3,000 yards; 20 hanks contain consequently 60,000 yards; and these constitute one bundle. It is by the standard lea of 300 yards that the description of yarn is known. Thus "No. 20" contains 20 leas per pound weight. The bundles are arranged in bunches, containing 3, 6, 9, or 12 bundles apiece, according to the fineness of the quality.

The *drying* of the wet-spun yarn is effected either in lofts, heated by steam up to 90° F., or by exposure in the open air upon poles. When brought from the drying, the yarns are *made up*, so as to feel soft and supple, by twisting them backward and forward and stretching them. They are then folded and are ready for sale.

Thread, in its technical sense, is the compound cord produced by doubling and twisting two or more single lines of yarn. The thread-frame closely resembles the throstle-frame used for spinning linen yarn, but the water-troughs are smaller, and there are only two rollers, which are placed one above the other. The lines of yarn delivered by the bobbins (which are set closely upon their respective skewers on a creel, or shelf, extending along the whole length of the machine) descend over a glass rod into the water-trough, where they get wetted. On emerging, they are guided along the bottom of the under roller, and, passing between it and the upper roller, turn round the top of the latter, whereon they are laid parallel. From the upper roller the parallel lines of yarn pass obliquely downward, through an eyelet-hole, to the flier of the spindle, the rapid revolution of which twists them into a solid cord or thread. The thread then works itself upon the bobbin, which is fitted as usual on the spindle.

Preparation of Warp.—As in the case of cotton, linen yarn goes through a series of processes, called *warping*, *sizing*, *beaming*, and *drawing in*, necessary for the purpose of preparing the warp for the weaver.

The object of *warping* is to arrange all the longitudinal lines of yarn, or warps, evenly alongside of each other, in one parallel plane. The bobbins, filled with the yarn intended for warps, are taken to the warp-mill, and placed in the warping-frame, called a "travers." One-sixth of the number of bobbins that will furnish the quantity of warp required for the length of the intended web of cloth is usually mounted in the warping-frame. The bobbins are set loosely in a horizontal position, upon wire skewers or spindles attached to the frame, so that they may revolve and give off the yarn freely. The principal machine in the mill is the warping-mule, which consists of a large reel of wood with 12, 18, or more sides, and about 7 feet in height and 6 in diameter. The external framework of the reel is mounted upon a vertical shaft, which rises in its centre. An endless band passes round the lower part of the vertical shaft, and also round a wheel placed at some little distance outside the reel, and worked by a handle. Standing (or sitting) beside the wheel, the warper turns it round, and causes the reel to revolve on the vertical shaft. The reel can be turned from right to left, or *vice versa*. The warps, converging to a focus, pass from the warping-frame to the reel through a small machine called a "heck-box," which contains 120 or more pins, made of finely-polished and hard-tempered steel. There are, in fact, as many pins as there are separate lines of warp. At the top of each is a minute eyelet-hole, through which the line of warp passes in its progress to the reel from the warping-frame. The pins are inserted alternately in two separate pieces of wood, either of which may be raised, independently of the other, by means of a small handle below. The heck-box slides up and down one (or in some mills two) of the upright posts of the warping-mule, by a simple contrivance. The top of the vertical shaft is connected with the heck-box by means of a cord, which passes over a pulley at the top of the post. As the reel revolves from right to left, the heck-box is thus gradually raised to the top of it; and when it revolves from left to right, the heck-box is gradually lowered to the bottom. The turning of the handle of the mill therefore unwinds the warp from the bobbins in the warping-frame, and winds it spirally up and down the circumference of the reel. The use of the heck-box, with its two separate pieces of wood and their alternate rows of pins, is to divide the warps into two alternate sets of threads, one set for each of the two healds or heddles of the loom. This separation is called the "lease," and without it there would be difficulty in weaving the yarn into cloth. The process by which the lease is formed is thus described by Mr. Warden in his work on "The Linen Trade": "In commencing to wind the yarn on the reel, the threads which pass through each of the two pieces of the heck are separated by raising one piece on its slide, and they are then passed, the one portion over and the other under a guide-pin attached to the reel. The other piece of the heck is then raised, and the threads in it passed over another pin in the reel, while those in the other piece go under the same. This process is repeated each time the chain or warp is wound up or down the reel, by which means the whole warp is separated thread by thread, so as to facilitate their alternate arrangement in the heddles of the loom. At the bottom of the reel a few threads are alternately passed together in 'pinfuls' over and under two other pins, which enables the weaver, by means of an evener or very open reed with a movable top, in each opening of which a pinful of yarn is placed, to spread the warp regularly in winding on the yarn-beam of the loom. Before the warp is taken off the reel, a piece of cord is passed carefully through the yarn, close to the pins, to preserve the separation of the threads, at both ends of the warp, which separation is called the lease. In rolling the warp on the yarn-beam, the weaver begins at the end where it is divided into small pinfuls, and terminates where it is separated into alternate threads. He takes care to preserve the lease perfect throughout the entire weaving of the web by passing two lease-rods between the alternate threads and keeping them there." It only remains to add that the weaver, as he removes the warp from the guide-pins of the reel, winds it, in the form of a huge ball, round his left hand.

The next process is that of *sizing* the warp, which is subject to considerable tension and friction, and would be very likely to break if stretched in the loom in the same state in which it is spun. A dressing of size is therefore given to it, to glue together the minute fibrils of which it is composed, and thus increase its strength, tenacity, smoothness, and elasticity. Warps may be sized either by the hand or by a sizing machine. The size consists of a paste of fine flour, to which a little brine is sometimes added. The method of sizing generally used by the hand-loom weaver is to put the dressing on carefully with hand-brushes, spreading it as evenly as possible over the surface. He then employs a fan for the purpose of drying the warp. Sometimes the weaver has recourse to the more primitive method of dipping the warp into a trough filled with warm size, and then squeezing it, repeating the process until the warp is completely saturated with the size, after which he spreads it out to dry in a field or drying loft. When warps are sized by a machine, the rollers containing them are mounted on a frame at one end of it. The lines of warp pass through a kind of reel to keep them distinct, and then between two rollers covered with felt. The lower roller dips into a trough filled with size, and applies the dressing to the yarn, while the upper one squeezes out the superfluous moisture. The size is rubbed into the fibrils of the yarn, and smoothed over by means of cylindrical brushes, one of them over and the other under the yarn, and moving in an opposite direction to it. The dressed yarn is then dried by being passed over a steam-box and subjected to a current of air caused by a revolving fan. In some machines there are several steam-boxes.

The next process, that of *beaming*, consists of winding the warp round the warp-beam, better known as the "weaver's beam." The weaver unrolls the bundle of warp-yarn, passes one end of it over two slings attached to the roof, then through a funnel-mouth round a series of pegs, then backward and forward over rollers, gradually spreading it more and more open until it arrives near the warp-beam, which revolves upon iron pivots. The weaver stands beside the extended lines of warp, holding in his hand an instrument called a ravel or separator. It is a rude kind of comb composed of a block of wood, into which pieces of cane are fastened. The lines of yarn are passed between the teeth of the ravel, and by this means are distributed evenly over the warp-beam to the width to which it is desired to make the cloth.

The last process preparatory to weaving consists in drawing each separate thread of the warp first through the corresponding loop of the heddles, and then through the teeth (or dents) of the reeds. The warp-beam is suspended by its ends so as to allow the lines of warp to hang down perpendicularly. The heddles are also hung up in front of the warp-beam. The weaver sits in front of the heddles and opens their loops; his assistant sits behind, and, selecting the appropriate thread of the warp, delivers it to the weaver, who draws it through the corresponding loop of the heddles. The threads of the warp are then drawn through the teeth of the reed by a hook called the reed-hook, two threads being passed through each reed-split.

Works for Reférence.—"Flax and its Products in Ireland," Charley, London, 1863; "The Linen Trade, Ancient and Modern," Warden, London, 1867; "British Manufacturing Industries," Bevan (from which copious extracts are embodied in the foregoing article), London, 1876. See also paper by Mr. Thomas Greenwood, "Proceedings of the Institute of Mechanical Engineers," 1865.