4 Sheets—Sheet 1.

R. ROBERTS.

SELF ACTING MULE.

No. 2,305. Patented Oct. 11, 1841.

Fig. 1.

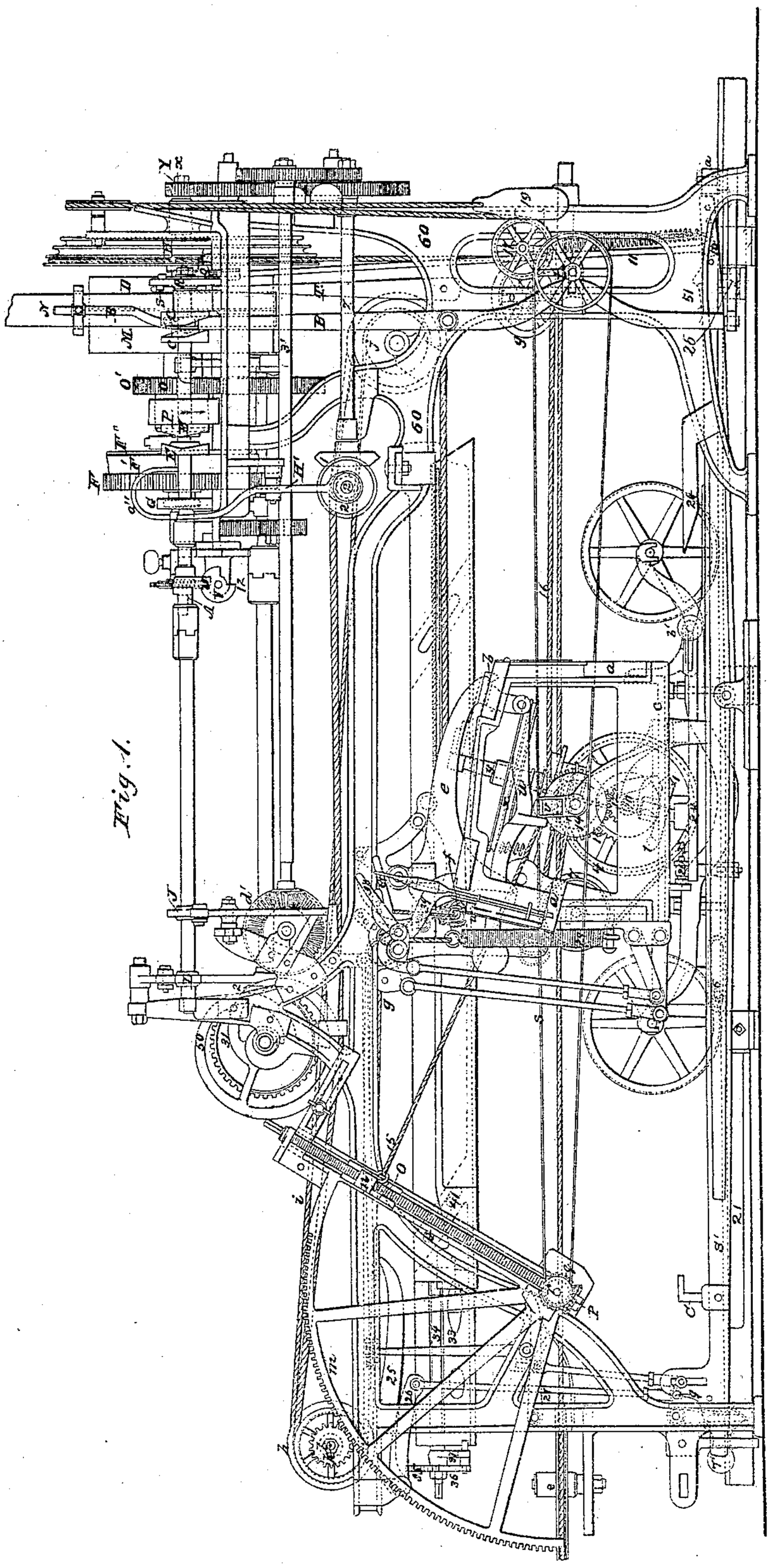

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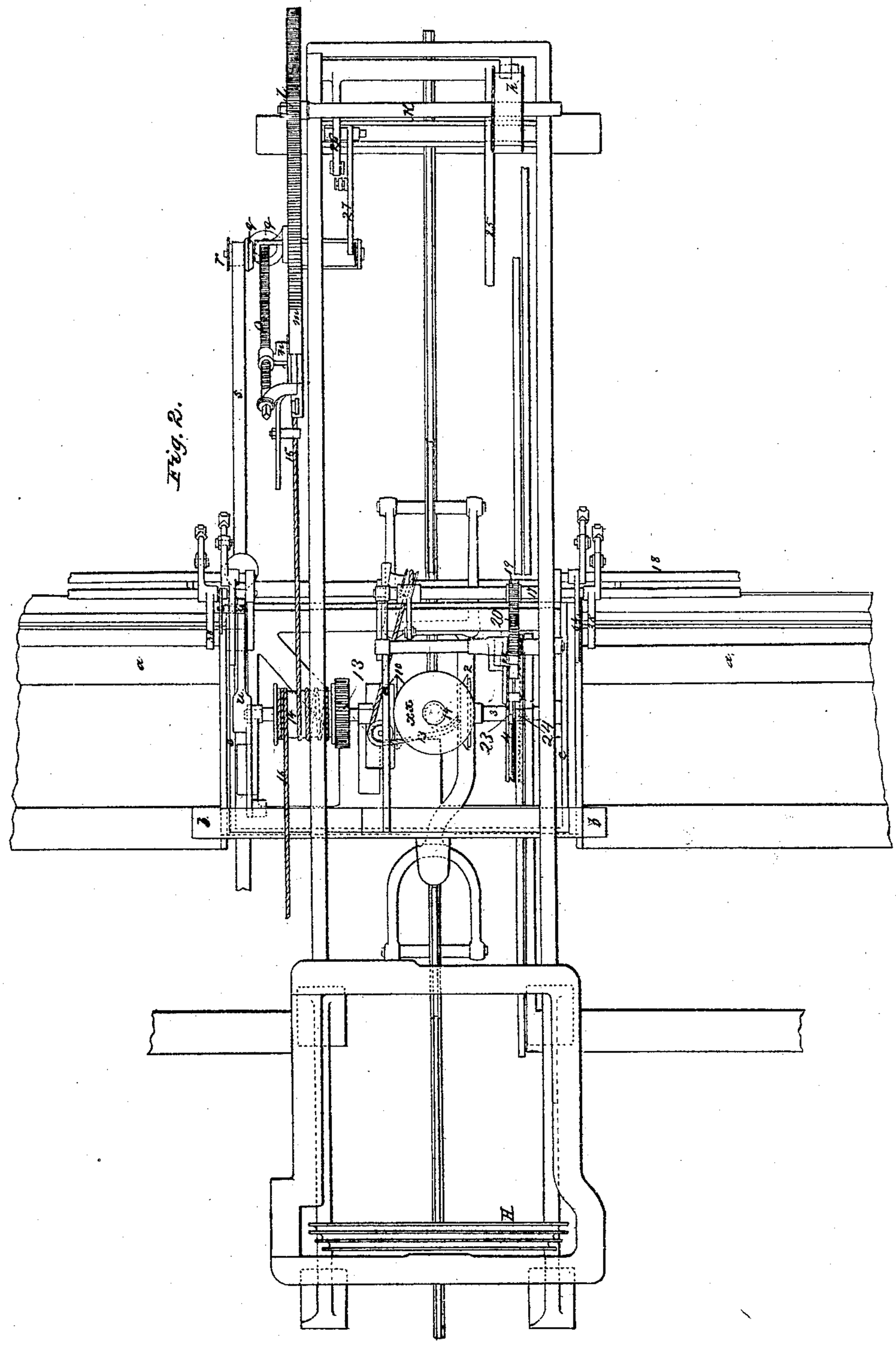
Fig. 2.



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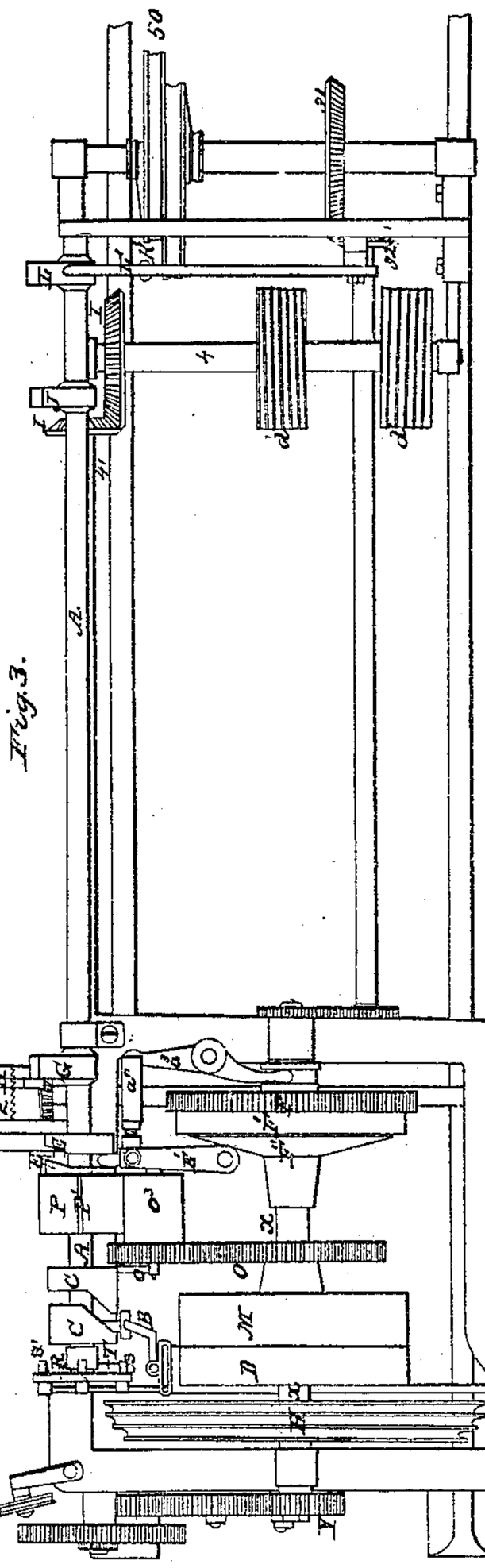

Fig. 3.

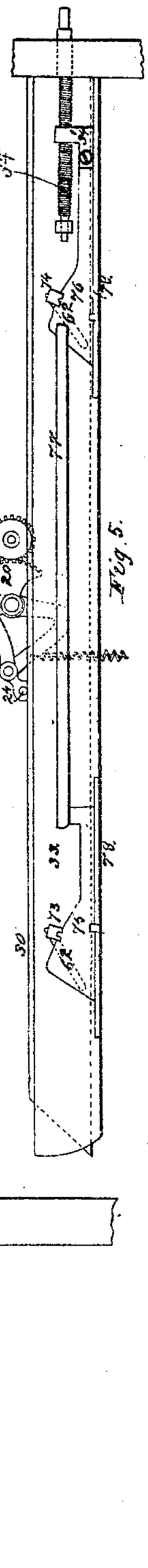

Fig. 5.

Fig. 4.

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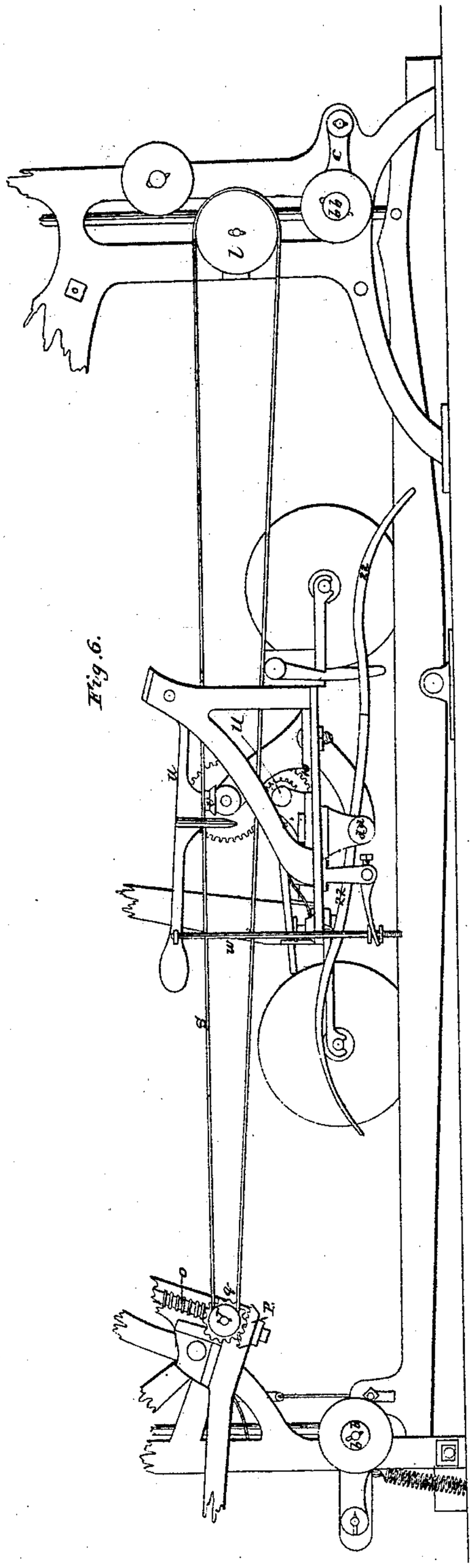

Fig. 6.

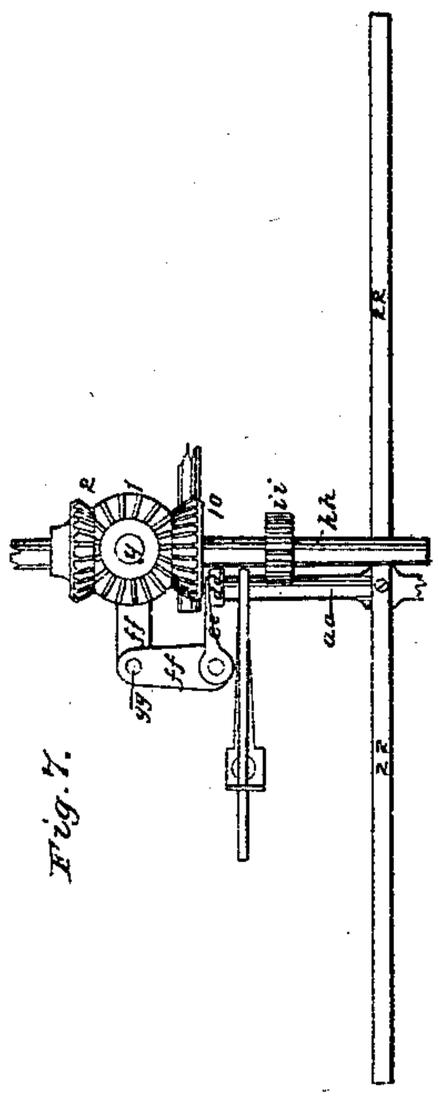

Fig. 7.

UNITED STATES PATENT OFFICE.

RICHARD ROBERTS, OF MANCHESTER, ENGLAND.

IMPROVEMENT IN SELF-ACTING MULES, BILLIES, JENNIES, JACK-FRAMES, OR STRETCHING-FRAMES.

Specification forming part of Letters Patent No. **2,305,** dated October 11, 1841.

To all whom it may concern:

Be it known that I, RICHARD ROBERTS, of Manchester, in the county of Lancaster and Kingdom of Great Britain and Ireland, civil engineer, have invented certain new improvements in the machine employed to render self-acting the machines known by the name Mules, Billies, Jennies, Jack-Frames, or Stretching-Frames, and all other machines of this class; and I do hereby declare that the following is a full and exact description.

The nature of my invention consists in the following, videlicet: In an improvement or certain improvements of, in, or applicable to the mule, billy, jenny, stretching-frame, or any other machine or machines, however designated or named, used in spinning cotton, wool, or other fibrous substances, and in which the spindles recede from and approach the rollers or other deliveries of the said fibrous substances, or in which such rollers or deliveries recede from and approach the spindles.

In order to render more intelligible the description of those parts or movements which I have invented, and which I claim as of my invention, and in order to show the mode in which they operate, I shall describe them in conjunction with the mule now in use for spinning cotton, or such parts thereof as may be necessary for that purpose, though they are equally applicable to the other machines hereinbefore enumerated; and I shall hereinafter point out the particular parts or movements which I have invented, and which I claim as of my sole invention.

I shall assume that in the building in which my improved mule is to be worked there is a main horizontal shaft running parallel with the side walls of such building and driven by any adequate power. For the purpose of connecting my improved mule with the main shaft I use such intermediate shafts, drums, or fast and loose pulleys as may be deemed necessary in ways well understood by machinists.

In the accompanying drawings, Figure 1 is a side view, and Fig. 2 a top view, of a part of my improved mule. The other figures, 3 and 4, represent certain parts in detail, which will be presently described.

In each of these figures like parts are designated by the same letters or figures.

In Fig. 1, D is a fast and M a loose pulley on the shaft X, which is commonly called the "rim-shaft." From this shaft motion is communicated to the respective parts of the apparatus by suitable gearing.

N is a strap connected with a drum on the line-shaft of the factory. This strap is made broad enough to partially cover the loose gearing-pulley M on the said shaft X, and thus keep it in continuous motion. On the rim-shaft is a pulley, H, which may have one or more grooves in it, as may be preferred. The pulley H is commonly called the "twist-pulley." Over this pulley is carried an endless band, which is conducted by carrier-pulleys, one of which is seen at 9. From these it passes round a pulley, 7, under pulley 4 on the horizontal shaft 3, thence again over pulley 7 and under pulley 4, thence around a sliding carrier-pulley, 8, and to the twist-pulley H. On the shaft *y*, within the square coupling-piece *c c*, to which the carriage is attached, is another grooved pulley, *x*, from which a band passes to the drums in the carriage, and thus gives motion to the spindles in the usual way.

On the shaft A, which I call the "cam-shaft," and which is parallel with the rim-shaft X, there are five cams for the purpose of connecting and unconnecting the different parts of my improved mule with the main shaft. Thus the strap-lever B (see also Fig. 3) is moved to and fro by the cams *c c*, and the strap is thus moved upon or off the fast pulley D, the cams E E acting upon a lever, E′, then through a horseshoe-spring, *a″*, and a second lever, a^3, moves the wheel F, with internal cone F′ attached firmly to it. F, I call the "backing off" wheel. G, another cam, acts upon lever H′, and puts the front roller catch-box in and out of gear. A pair of bevel-wheels, I I, for taking out the carriage, are alternately put in and out of gear by cam J and spring K, and a pair of bevel-wheels, 31 and 32, for taking in the carriage, are also alternately put in and out of gear by cam L and a spiral spring at K′, drawing down the lever L′; but in all these cases weights may be used as substitutes for the said springs. Attached to one side of the loose gearing-pulley M is a spur-wheel, O′, which is in great part hid by the wheel O, but is in part seen at O′, and shown in the top view, Fig. 3. This drives the spur-wheel O, fixed on the shaft of the leather contact-pulley. (Shown at O^3, Fig. 3.) On the cam-shaft is an iron pulley, P, fixed opposite to the

leather contact-pulley, which leather contact-pulley is in Fig. 1 hid by the iron pulley P, but is shown at O^s, in Fig. 3. The iron pulley P has four different portions of its periphery cut away, as at P′, in order to prevent contact except at particular times. The iron pulley P and the cam-shaft are carried by contact with the contact-pulley O^3 round in the direction of the arrow until they are stopped by the escape-lever Q acting against the projecting pieces on the escape-plate R.

The cam-shaft A is made to move on its axis in order to put the different parts of the mule in and out of gear in the following manner: On the back of the escape-plate R are four pins, S, successively acted upon by the spring T, which is placed in such a position with regard to those pins as to turn the iron contact-pulley a little in the direction of the arrow whenever the projection at the end of the lever Q is removed from being in contact with any one of the three projections on the escape-plate, which projections are at different distances from the center of the escape-plate R, or when the finger U on the end of the cam-shaft A passes through the notch in the stop-plate V, and when, by the action of the spring T the iron contact-pulley is so turned a little, the leather contact-pulley presses against it and turns it round until one of the four indents found in the periphery of the iron contact-pulley P arrives opposite the leather contact-pulley O^3. where it is again held either by the finger at the end of the cam-shaft A or by one of the projections on the escape-plate R coming against the projections on the escape-lever Q. On the back of rim-shaft X is a pinion, Y, which, through a train of wheels, turns a shaft, Z, on the other end of which is a miter-wheel, 1. This gives motion to the rollers through a miter-wheel and catch-box, 2, which catch-box is thrown in and out of gear as occasion requires by the action of the cam-shaft and cam G. Through the same train of wheels a shaft, 3′, is made to turn shaft 4′ by means of a pair of bevel-wheels, I I. On the shaft 4′ four scrolls are fixed, the outline of which is seen at *d′ d′*, and they are fully represented in Fig. 3. To two of these scrolls the bands for taking out the carriage are attached, and after having passed a sufficient number of times round them and over carrier-pulleys are each made fast to the carriage in the usual way, and thus the carriages are made to recede from the rollers. So soon as the carriage arrives at the end of the stretch its progress is arrested by a stud, 6, coming in contact with and disengaging drop-latch 7′, by which the long lever S′ on the floor is allowed to fall on the drop-latch 9′. At the other end of long lever S′ is a stud, 10. Attached to it is a rod, 11, which is joined to escape-lever Q. The other end of the long lever S′, having descended from the first to the second drop-latch, will have caused the opposite end to ascend, and thus by means of the rod 11 will have elevated the escape-lever Q, which allows the cam-shaft A to make one-quarter of a revolution. This disengages the bevel-wheels 1 and 2, and the catch-box 2 arrests the outward progress of the carriage and stops the deliveries of the rollers. The cam-shaft at the same time was arrested in its progress by the stop finger U coming against the stop-plate V. This remains there until a sufficient quantity of twist has been given to the yarn, which quantity is regulated by the number of teeth in the twist-wheel 12, which receives its motion from a worm fixed on the end of rim-shaft X. In the stop-plate V is a notch, through which the stop-finger U is allowed to pass so soon as the yarn has received a sufficient amount of twist. The cam-shaft, being now liberated, moves another quarter of a revolution, by which the cams *c c* move the driving-strap from fast pulley D to loose gearing-pulley M on rim-shaft X. The cams E E at the same time shift the backing-off wheel F, with internal cone F′ attached, which is made to revolve in an opposite direction through a train of wheels from the loose gearing-pulley onto the external cone F″, which is made fast to the rim-shaft, (the external cone F″ has its surface covered with leather,) and both surfaces, being thus brought into contact, have the effect of first arresting the progress of the rim-shaft X and preventing any more twist being given to the yarn, and afterward turning it in an opposite direction, by which the coils of yarn on the upper part of the spindles above the cop are unwound. While this is proceeding it is requisite that the faller and counter-faller, hereinafter to be described, should be made to act so as to take up the exact quantity of uncoiled yarn. This is accomplished in the following way: A cam or snail is fitted loose on the vertical shaft *y*. On a pin projecting from a plate seen at X X, Fig. 2, on the upper part of snail, is a pawl which is lifted out of the teeth of the ratchet-wheel attached to the vertical shaft *y*, when the rim shaft X is turned forward or giving twist to the yarn, but is made to take hold of the teeth when the motion of the rim-shaft is reversed for the purpose of backing off. This is effected by means of a very slender friction-clip on the nave of the ratchet-wheel taking hold of a pin in the tail of the pawl, which friction-clip has a tendency to turn in whatever direction the rim-shaft H is moving. One end of a chain, 13′, Fig. 2, is attached to the snail 14′. It is then taken over a carrier-pulley, 15′, and made fast at the other end to a short arm, 16, fixed to the faller. So soon as the backing off commences the faller-wire is made to descend by the action of the snail 14′ pulling the chain 15′. The snail requires to be proportioned to the quantity of yarn uncoiled. So soon as the faller 17 begins to descend the counter-faller 18 is liberated, and having counterbalance-weights attached keeps the yarn in a proper state of tension.

On the faller 17 is keyed a pinion, 19, which works in and gives motion to a sector, 20,

fixed loose upon a cross-shaft, 21. An end view of the shaft of the faller and of the sector is shown in Fig. 4. The faller descends after each stretch so far as to allow the notch in sector to be brought under a projecting part of the latch 22, which drops into it and then connects the crooked arm 23 with friction-roller 24, attached firmly together. At the same time the projecting piece on latch 22 drops into the notch O^4 in sector 20. It allows the arm 25 to fall, and also another arm, 26, fixed on the same shaft and connected with the second drop-latch, disengages it. The long lever S again falls and liberates holding-out latch 27. The opposite end of long lever S′, being once more elevated, lifts up escape-lever Q and allows the cam-shaft A to make another quarter of a revolution, in doing which it separates the backing-off cones, and thus arrests their further progress and puts into gear bevel-wheels 31 and 32, which give motion to the large scroll 50, Figs. 1 and 3, and by means of bands made fast to it at one end and to the carriage *a a* at the other, the carriage is taken in or made to approach the rollers. When it arrives within a short distance of the rollers, the faller-wire will have been elevated so far by the action of the anti-friction pin or roller on copping-rail 30 as during its ascent to direct the yarn onto the conical part of the cop, from which point the faller-wire is required to ascend more rapidly, which increased speed of elevation leaves the coils of yarn upon the upper part of spindle, which have to be unwound during the process of backing off. This is accomplished by the anti-friction pin or roller 24, Figs. 2, 4, and 5, moving down an inclined plane at the end of the copping-rail 30, and thus, communicating a more rapid motion to the sector 20, elevates the faller-wire, as before described. The carriage having arrived at its destination nearest the rollers, a finger bolted to the frame 60 disengages the catch 22 from sector 20 and allows the faller to be sufficiently elevated above the yarn. By the action of the springs 29 the counter-faller (at the same time the anti-friction pin or roller is moving down the inclined plane) is brought a little below the yarn from the point of the spindles by levers connected with the faller-arm at each end of the mule and acted upon by small rollers fixed to the framing just before the carriage arrives at its inward destination, and it is held there until the carriage is run out by a chain fastened to the counter-faller coupling-shaft at one end, and, passing over a grooved pulley, is made fast at the other end to faller coupling-shaft.

At the same time the anti-friction pin or roller is moving down the inclined plane at the end of the copping-rail 30, as the carriage is approaching the rollers, a bowl or roller, which is fixed loose upon a stud, 6′, and made fast to the back of square coupling piece *c c* in the carriage, is made to act upon an inclined plane or projection, 51, (shown by dotted lines,) on the upper surface of long lever S′, and, depressing it, causes the rod 11 to pull down escape-lever Q, and thus allows the cam shaft A to make another quarter of a revolution, which disengages bevel-wheels 31 and 32, by which the carriage was made to run in, and puts into gear, taking out bevel-wheels I I, front roller catch-box 2, and moves the strap onto fast pulley D on rim-shaft X, and thus the machine is now ready for performing another stretch.

The shaper-rail 33 is bolted to the framing of headstock or frame 60. Two shaper-plates, 75 76, Fig. 5, which are connected together by a bar, 77, are made to slide along the upper surface of the lower projecting rib, 78, on shaper-rail 33. Two forked guide-pins, 41, one fixed near each end of copping-rail 30, are passed through the inclined apertures 62 in the shaper-rail 33 and made to rest on the top of shaper-plates. At the outer end of the shaper-rail 33 a screw, 34, is fixed which works through a wing-nut, 34′. One of the shaper-plates is attached to the inner end of the winged nut 34′, and a ratchet-wheel, 35, is fixed on the outer end of said screw, on which operates a pawl, 36. To a convenient place in the carriage-front is bolted a finger, which may be so adjusted that at each stretch it may elevate the arm 37 so as to cause the ratchet-wheel 35 to be moved one or more teeth, as required, and, thus turning the screw 34, move the shaper-plates toward the rollers, which movement allows the copping-rail to fall, and also to move a little in nearly a horizontal direction toward the rollers, the copping-rail, which is set at a suitable inclination, having an unequal or undulatory surface at different times to the anti-friction pin or roller 24, and the faller is thereby progressively prevented from going so low at each succeeding stretch, and thus goes on until the cop is completed.

In Fig. 5 I have shown the inner side of the shaper-rail, with the shaper-plates and screw by which they are moved. 75 76 are the two shaper-plates, which are connected together by the bar 77. Two pins, 73 74, which pass the slots 62, rest upon the shaper-plates. The shaper-plate 70 is acted on by the screw 34, said screw passing through a nut, 34′. The ratchet-wheel 35, which is affixed to the end of the screw, is moved round to the distance of one or two teeth at each of its comings out.

The required size of the cop must determine the number of teeth in the ratchet-wheel 35; but it will be found, as a general rule, that for nearly every hank in a pound of yarn one tooth may be reckoned in the ratchet-wheel 35. That part of a mule which is usually called the "faller," 17, is composed in my improved mule, as in the common mule, of a shaft the length of the carriage. On one side of this shaft are fixed, at equal distances, a number of arms, 38, which support and keep in a state of tension a wire about one-tenth of an inch in diameter extending across the ends of all the arms. While the carriage is running

out the faller is kept up by the spiral springs 29, attached at one end to arms on the faller and at the other to a stud on the carriage parallel with the faller-shaft.

18 is another shaft, of the same strength as the faller-shaft, and which I call the "counter-faller shaft," supported by bearings in the brackets 39, which support the faller 17. This shaft has also a number of arms, 64, fixed at one side, at equal distances, carrying at their extremities a wire similar to that called the "counter-faller" in the common mule, and used by me for purposes nearly similar. The wire passes under the yarn at a short distance from the faller and nearer to the rollers, and, being overbalanced by a weighted arm on the other side of the shaft, has a tendency to raise the yarn while the faller is depressing it.

The counter-faller is connected with the winding-on mechanism in the following way: In Figs. 1 and, 2 *a a* is a mule-carriage in two parts, one on each side of the headstock, the parts being firmly united by *b b*, a connecting-bar of iron, and *c c*, an iron frame. To this is bolted in front a frame of iron, *d*, which, at its upper part, is supported by *e*, a spur-piece bolted to the bar *b* and to the frame *d*. On studs in the spur-piece are *f f*, two ratchet-tension barrels. To one of these is fastened, *g*, a cord, which, after passing over a notch in the spur-piece *e*, is wound round and fastened to *h*, a drum or barrel. This has also attached to and coiled round it *i*, another cord, which, after passing over *j*, a guide-pulley, and a notch in the spur-piece, is attached to the other ratchet barrel. A shaft, *k*, on which is keyed the drum *h*, has a pinion, *l*, working into *m*, the toothed quadrant, which receives an alternating motion on its center through an arc of about ninety degrees, while the carriage runs out and in—that is to say, at every stretch. In a groove in the inner arm of the quadrant is *n*, a sliding nut, moved by *o*, a double threaded leading-screw, on the lower end of which is keyed P, a miter-wheel gearing with *q*, another miter-wheel, the central stud of which is opposite to the center of the quadrant. Attached to the back of miter-wheel *q* is *r*, a pulley, which is turned at intervals by S, an endless strap, passing round it, and round *t*, a sliding pulley. A weighted lever, *u*, called the "governor lever," is movable on a stud in the back part of the carriage-frame, and forms the upper jaw of a pair of pinchers, the lower jaw being *v*, a stud in the carriage end. The lever *u*, when not intended to press upon the stud *v*, is carried by an adjustable nut on the lower end of *w*, a rod connected with the arm of the counter-faller and faller by means of a chain and pulley, and having free play through a hole in a side projection from the arm of the lever. When in winding on the tension of the yarn brings the faller-wires to nearly the same level, the dropping of the arm of the counter-faller allows the lever *u* to descend till it pinches the endless strap S against the stud *v*, and drags it along as the carriage runs in until the rise of the counter-faller arm again raises the lever and liberates the strap.

The spindles are banded in the ordinary way, and the drums are driven by a band, which, after taking both the grooves in *x*, the driving-pulley is spliced, instead of passing from the carriage to the twist pulley, as in common mules. The pulley *x* is keyed on *y*, an inclined shaft, the upper end of which turns in a swivel-collar and the lower end or foot in an arm of a bell-crank, 22. During the process of twisting and backing off, the shaft *y* receives motion through 1, a miter-wheel, which is keyed near its lower extremity and is driven by 2, another miter-wheel, fixed on 3, a shaft, on which is also keyed 4, a double-grooved driving-pulley receiving motion by an endless band from H, the twist-pulley above. This pulley-band passes under a carrier-pulley, and over a double-grooved carrier-pulley under the driving-pulley 4, again over pulley 7, and under pulley 4, round 8, a sliding carrier-pulley, under 9, a carrier-pulley, and thence to the twist-pulley. The miter-wheel 1 comes occasionally into gear with 10, another miter-wheel, keyed on 11, a shaft upon which is also keyed 12, a spur-wheel, which gears into 13, another spur-wheel firmly connected to 14, a drum or barrel, which is called the "winding-on barrel."

The diameters of the wheels 12 and 13 should be made to give as nearly as possible the proper amount of rotation to the spindles according to their diameters and those of the warves, the final adjustment being made in the diameter of the barrel 14, the whole being adapted to give so much motion to the spindles as will cause them to wind on the whole stretch at the first run in. There is a cord, 15, one end of which is tied to the sliding nut *n* in the arm of the quadrant *m*, and the other made fast to the barrel 14, after having made several coils round it, and 16 is an opposed cord, also coiled round and fastened to the barrel 14, and after passing under 17, a carrier-pulley, and over 18, another carrier-pulley, it sustains 19, a counterpoise, which causes the barrel to take up the cord 15, as the carriage recedes from the rollers.

When the process of backing off is completed, the mechanism for putting up or running the carriage in is put in gear, and simultaneously with it, and by the same or any other convenient means, the latch 20 is liberated. The spring 21 then moves the lever 22 so as to disengage the miter-wheels 1 and 2, and connect 1 with 10, the other miter-wheel. So soon as the carriage has run in about two inches, the latch 20 is allowed to drop against the catch 23, and thus hold the wheels firmly in gear until the carriage has completed the whole of its run in, when the latch 20 is disengaged from the catch 23 by the inclined plane 24. The lever 22 is then moved by the bell-crank 25 through the mechanism con-

nected with the cam-shaft, and thus disengages the miter-wheels 1 and 10, and connects again 1 and 2. So soon as the carriage has receded from the rollers one or two inches, the latch 20 is allowed to drop against the catch 23, and thus keep it to its place the remainder of the stretch.

The arrangement of the parts described in the last paragraph is that which I have sometimes used; but in the model which I have deposited in the Patent Office, and also in the mules as I now usually construct them, I vary this arrangement for changing the gear of the miter-wheels 1, 2, and 10, although the general construction and the end arrived at remain unchanged. In Fig. 6 I have given a side view of such portion of the mule as is necessary to explain the modification referred to, showing therein certain parts analogous to those shown in Fig. 1. I have also in Fig. 7 given a top view or plan of the miter-wheels 1, 2, and 10, and of the bell-crank and other parts of the apparatus, by which the pinion 1 is alternately thrown into and out of gear with the pinions 2 and 10. In each of these figures where the parts are similar to those shown in the other figures they are designated by the same letters or numbers. In each of these figures, 22 22 is a lever which is fastened onto a rock-shaft, *a a*, and which, as the carriage runs back and forth, is alternately brought into contact with friction-rollers *b b b b*, which cause it to move the rock-shaft. The friction-rollers *b b* are attached to arms *c c*, which allow them to yield by the action of weights or of springs, so as to cause them to operate without producing a sudden blow. An arm, the end of which is seen at *d d*, Fig. 7, rises vertically from the rock-shaft, and has attached to it by a joint-pin a link, *e e*, which is also attached by a joint-pin to the bell-crank *f f*, which bell-crank works upon a joint-pin at *g g*. The inner end of this bell-crank forms the step of the shaft *y*, Fig. 1, carrying the pulley *x*, and it will be manifest that by the motion of the bell-crank *f f* upon the pin *g g*, the step will be moved laterally, and that the miter-wheel 1 may be brought into gear with either of the miter-wheels 2 or 10. The shaft *h h* of the miter-wheel 10 has on it a pinion, *i i*, which drives the wheel 13, Fig. 2, giving motion to to the drum 14 and to the cords 15 and 16.

In the adaptation of the present improvements to the mule, billey, jenny, jack-frame, or stretching-frame, according to the diameter of the cop to be formed, or the length of the stretch made in the several machines, it may be requisite to vary the length of the grooved arm of the quadrant. While the carriage is running in, it turns the drum *h*, its shaft *k*, and the pinion *l*, which works in the quadrant *m*. When the quadrant *m* begins to move, its grooved arm stands twelve beyond the vertical position from the rollers, and during its action it turns on its center inward, through an arc of about ninety. At the commencement of a set of cops, the stud in the nut *n*, to which the cord 15 is attached, is set opposite, or nearly so, to the center of the quadrant, in which position it suffers no change of place by the motion of the quadrant. As the carriage recedes from the point of attachment of cord 15, it causes the rotation of the winding-on drum 14, round which the cord is coiled, and the drum, through the train of wheels 13, 12, 10, and 1, that of the pulley *x*, which by the spindle-drums gives motion to the spindles. The rotation of the spindles during the first run in of the carriage just suffices to wind on the stretch of yarn upon the bare spindles. As the diameter of the cop increases by each succeeding layer, fewer revolutions will be requisite to effect the winding on of the constant length, and therefore the whole quantity of motion imparted to the spindles during run in must undergo progressive diminution so long as the diameter of the cop is increasing, which goes on until the bottom is formed. The decrease of motion in the spindles is obtained by lessening the quantity of cord to be uncoiled from the winding-on barrel, an effect which results from the advance of the nut *n* along the arm of the quadrant, the amount of the effect being exactly commensurate with the advance, as is apparent when the grooved arm of the quadrant at the end of the run in nearly coincides with the line of traction of the cord 15.

The motion which slides the nut along the quadrant arm is produced in this way: During the process of backing off, the spiral coils of yarn are unwound from the ends of the spindles and the faller is depressed, when the counter-faller, by its balance-weight, rises and takes up the uncoiled or slack yarn, and thus the faller-wires keep up the tension as the yarn is uncoiled. While the carriage is running in, the spindles, in winding on the stretch of yarn, take up by degrees the coil yarn also, and as this is effected the faller-wires are brought to nearly the same level at the first run in. This approach of the faller-wires takes place only as the carriage comes up to the rollers.

The power of winding on increases as the diameter of the cop enlarges. In the subsequent stretches the coil yarn gets taken up before the carriage has run home, and when this occurs the descent of the counter-faller allows the governor-lever *u* to fall and to pinch the endless strap S against the stud *v*. With the motion of the carriage the strap is dragged along and turns the leading-screw *o*, which slides the nut *n* toward the circumference of the quadrant. The strap continues to be dragged until the retardation of the taking up from the diminished velocity of the spindles thus produced permits the counter-faller again to rise and relieve the strap from the pinch of the lever. In this way the nut *n* is made to advance upon the quadrant arm in proportion as the expanding diameter of the cop accelerates the action of

winding on, and a correspondent abatement in the whole number of revolutions of the spindles is the result. As soon as the cop has attained its full diameter—that is, when the bottom is formed—the winding-on power then remaining uniform, the governor-lever is no longer made to act upon the strap, and consequently the nut *n* travels no farther from the center of the quadrant during the completion of the cop. Besides the adjustment of the whole amount of winding-on motion, each stretch is adjusted to the growing diameter of the cop, which is effected by causing the point of attachment of the drag-cord 15 to advance progressively upon the rim of the barrel 14. The grooved arm of the quadrant by carrying the point of attachment of cord 15, after the first stretch, through an arc of about ninety degrees at each run in, causes the cord to be uncoiled from the barrel 14 by a ratio increasing as the carriage recedes from the quadrant, and this variable rotation of the barrel is increased by the successive shifts of the nut *n* from the center of the quadrant, thus adapting the rotation of the spindles to the winding on powers of the cop, its various diameters from the base to the summit of the cone.

Although I have included in the foregoing description many parts and devices which are well known and in common use in machines of this description, and have also embraced in said description the manner of producing the action of the fallers in the self-acting mule, and likewise many other mechanical devices of my invention, which were described and claimed by me in Letters Patent granted unto me in Great Britain on the 29th day of March, 1825, I do not make claim to any or either of these parts, devices, or mechanical contrivances, the same being now public property and free to be used by any person; nor have I deemed it necessary in the present instrument to furnish a minute description of the same, but have referred to them as known and understood by those conversant with machinery of this description, and for further explanations thereof I refer to the specification enrolled under said Letters Patent of the 29th of March, 1825, and also to the second volume of a published and well-known work entitled "The Cotton Manufacture of Great Britain," by Andrew Ure, M. D., F. R. S., published in the year 1836, and in which work is included also a description of the improvements which I now claim as not having been included in the above-named Letters Patent of 1825, and which relate exclusively to the quadrant *m* and its appendages, with the use to which they are applied.

Having also now described my improved mechanism for adapting the rotation of the spindles to the regular taking up of the yarn as the form and diameter of the cop changes throughout the operation of winding on, I do hereby declare that my invention consists in the method or means to be employed for that purpose, hereinbefore described.

The mechanism thus employed by me effects the rotation of the spindles in two ways—First. Rotary motion is given to a drum or barrel, which turns the spindles, while the carriage is running in, by uncoiling from it a portion of a cord, strap, or chain attached to the drum, and having its other extremity fastened at some point in a radial arm which describes an arc while the winding-on drum is receding from the point of attachment of the cord in a right line. This compound motion adjusts the rotation of the spindles to the varying power of taking up by the conical cop, as the yarn or rowing is being coiled on its different diameters during the winding on of each stretch.

Secondly. During the progress of the formation of a cop the situation of the point of attachment of the uncoiled end of the cord, strap, or chain on the radial arm is changed progressively, as the increasing bulk of the cop demands fewer revolutions of the spindles to take up the stretch, and consequently there is a shorter length of the cord to be uncoiled from the barrel.

And I declare that the form and proportions of the different parts of my improved mule, as well as the materials of which the same may be composed, may be varied according to the discretion of the workman employed in constructing the same without departing from the object and principle of my improvements.

RICHD. ROBERTS.

Witnesses:
JAMES HIBBERT,
BENJAMIN FOTHERGILL.