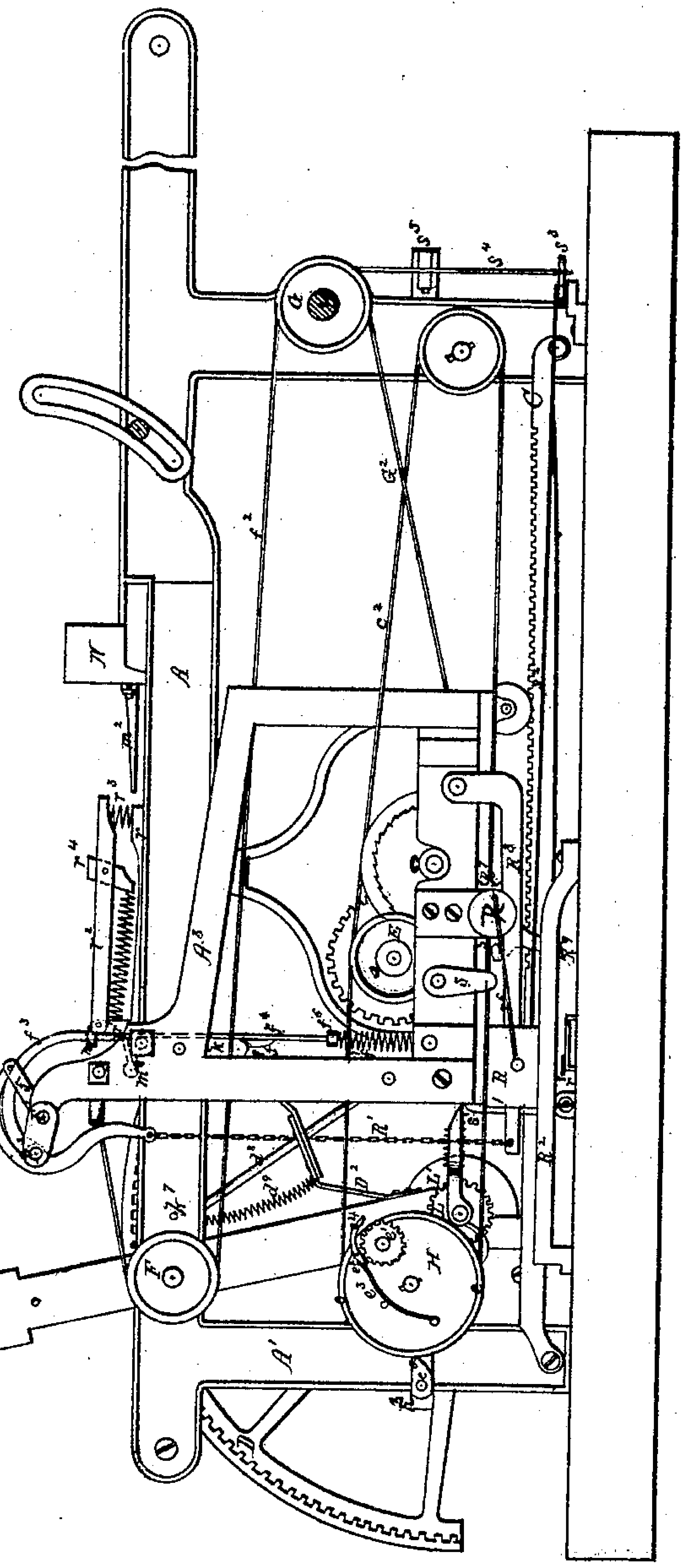
5, Sheets, Sheet. 1.

J. Sutherland,

Spinning Mule.

No. 113,814. Patented Apr. 18. 1871.

Fig. 1.



Witnesses.
H. J. Arct
Solon C. Kemon

Jas. Sutherland, Inventor
by Geo. E. Brown
his Attorney.

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J. Sutherland,

5. Sheets, Sheet. 2.

Spinning Mule.

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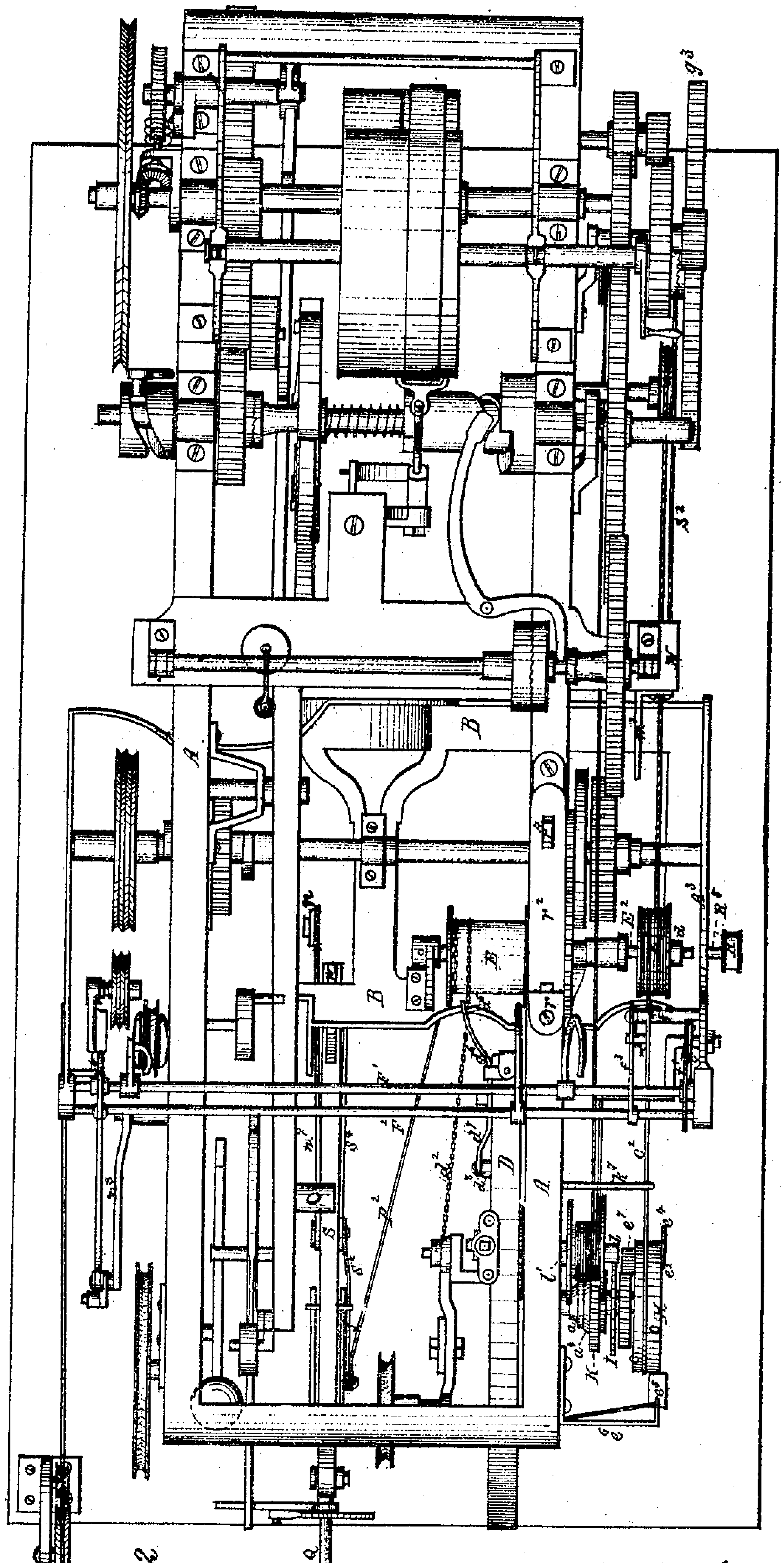

Fig 2

Witnesses

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J. Sutherland,

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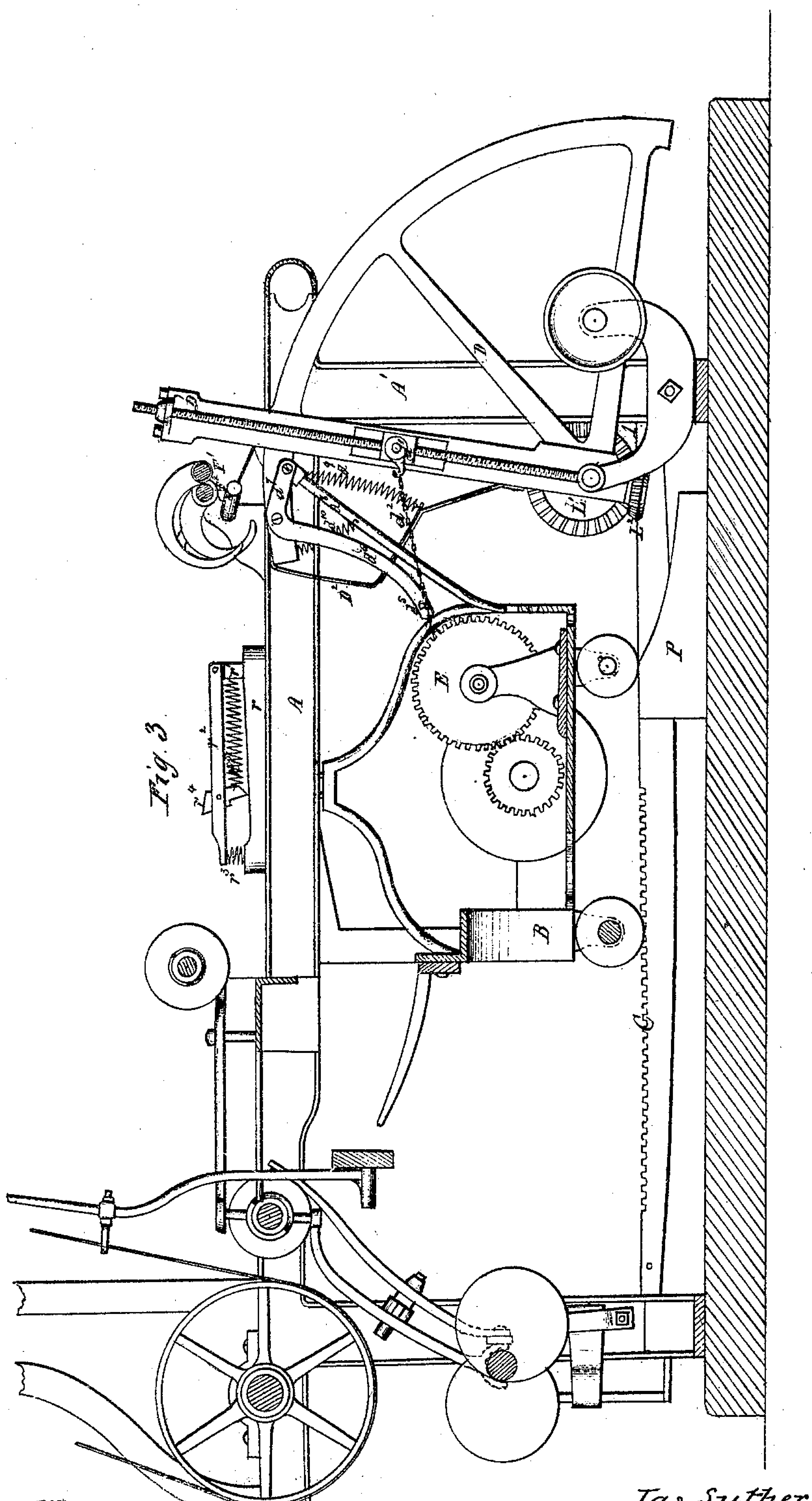

Fig. 3

Witnesses:
H. J. Aretz
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J. Sutherland,

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Fig: 16

Fig: 17

Fig: 4

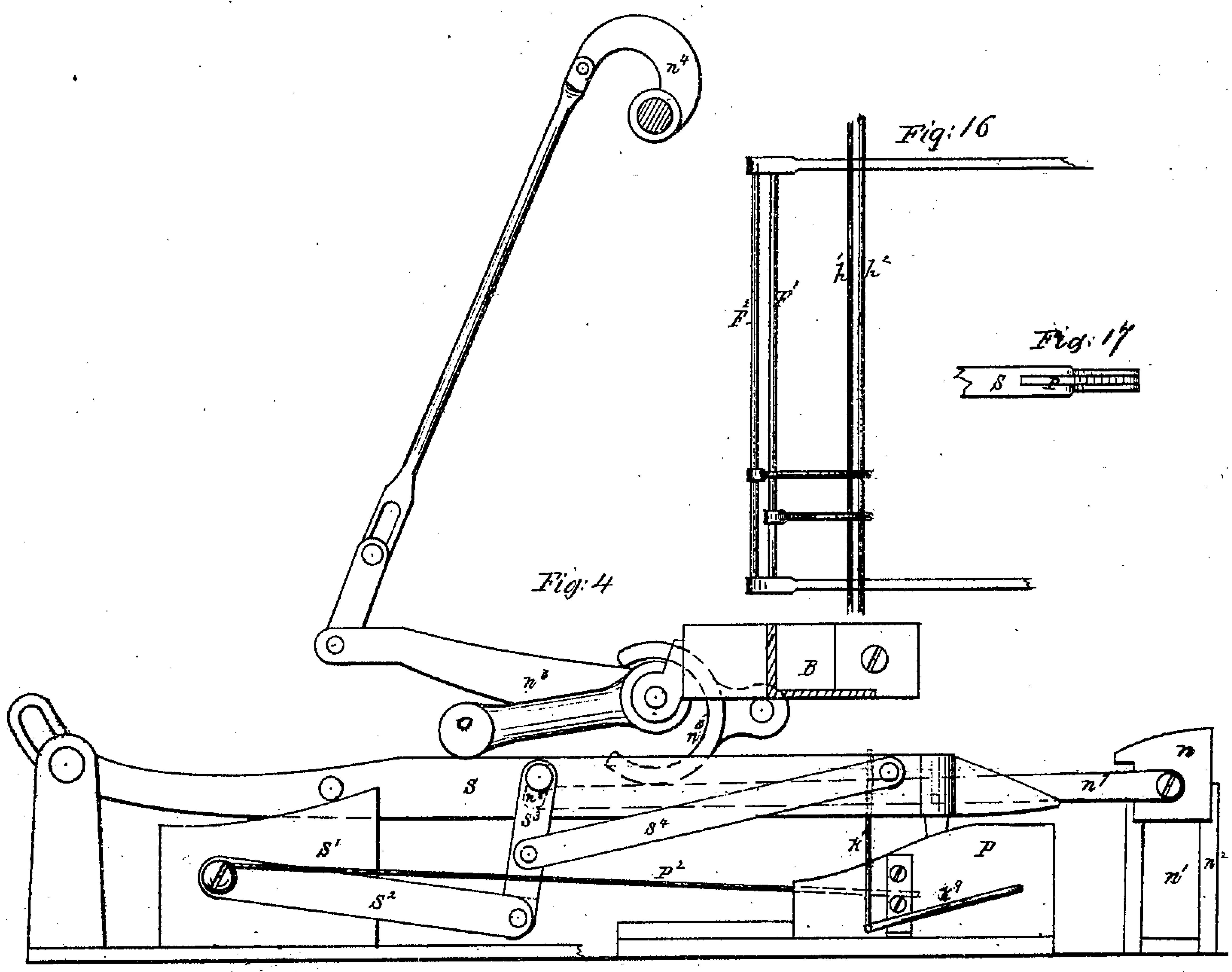


Fig: 5

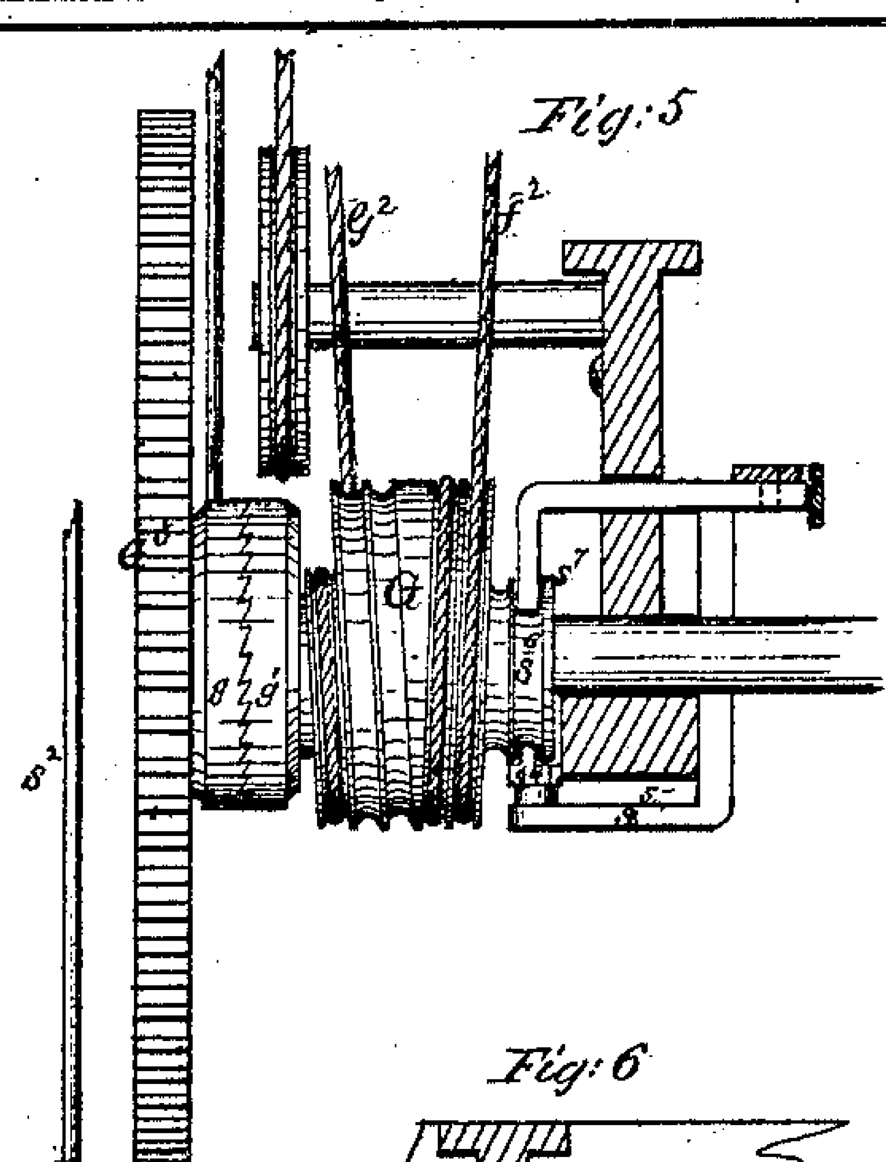


Fig: 6

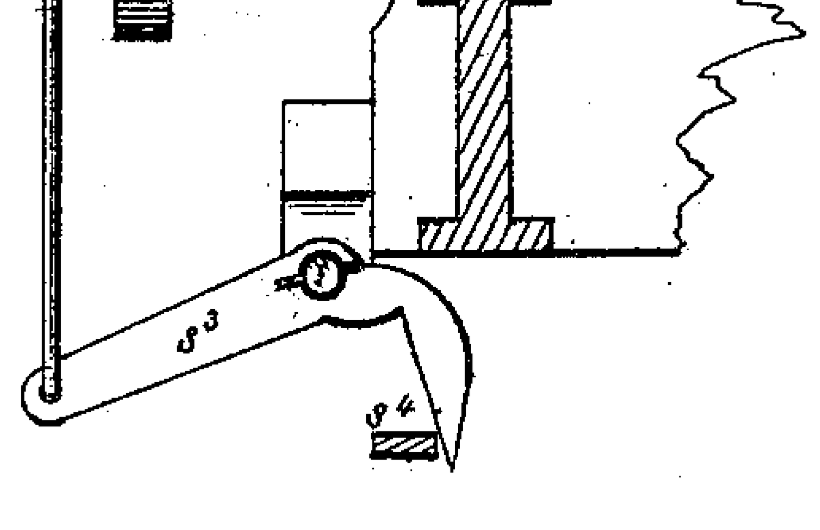


Fig: 7

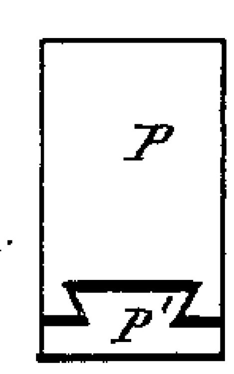


Fig: 9

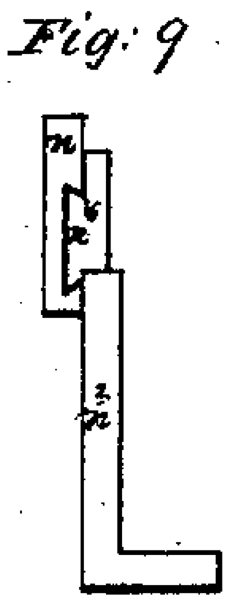


Fig: 8

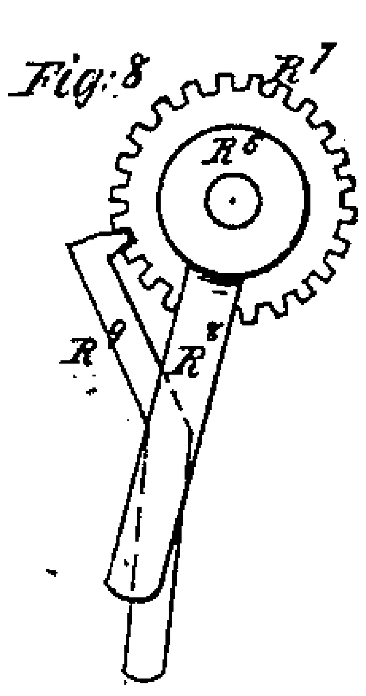
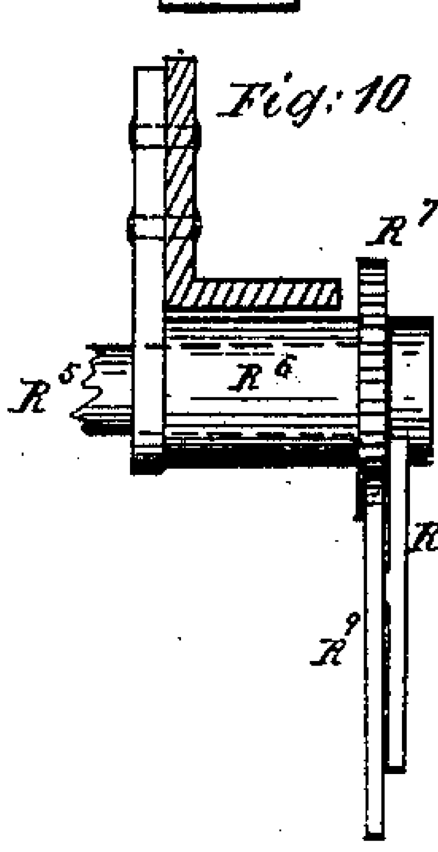


Fig: 10



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J. Sutherland, 5. Sheets. Sheet. 5.

Spinning Mule.

No. 113,814. Patented Apr. 18. 1871.

Fig: 11

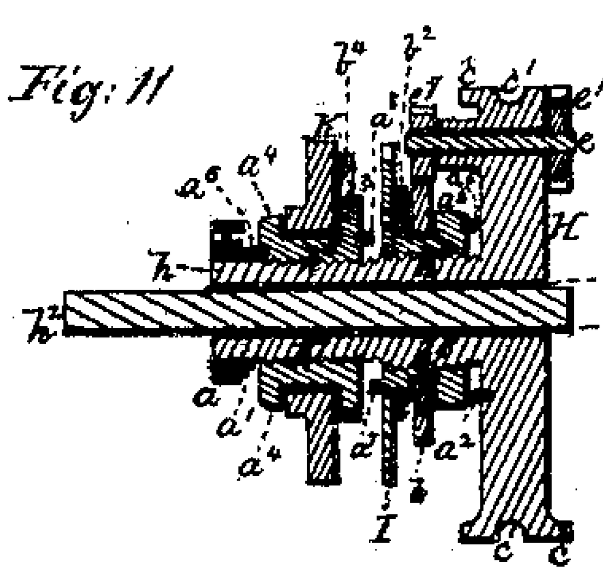


Fig: 12

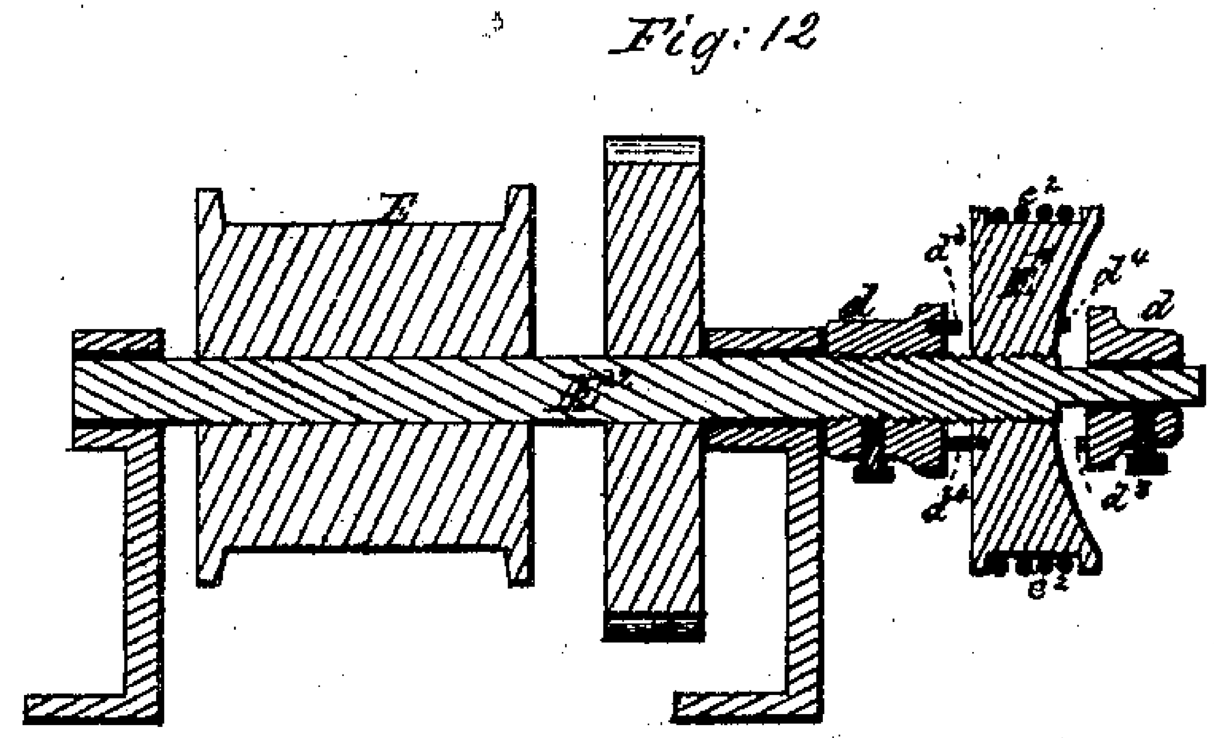


Fig: 13

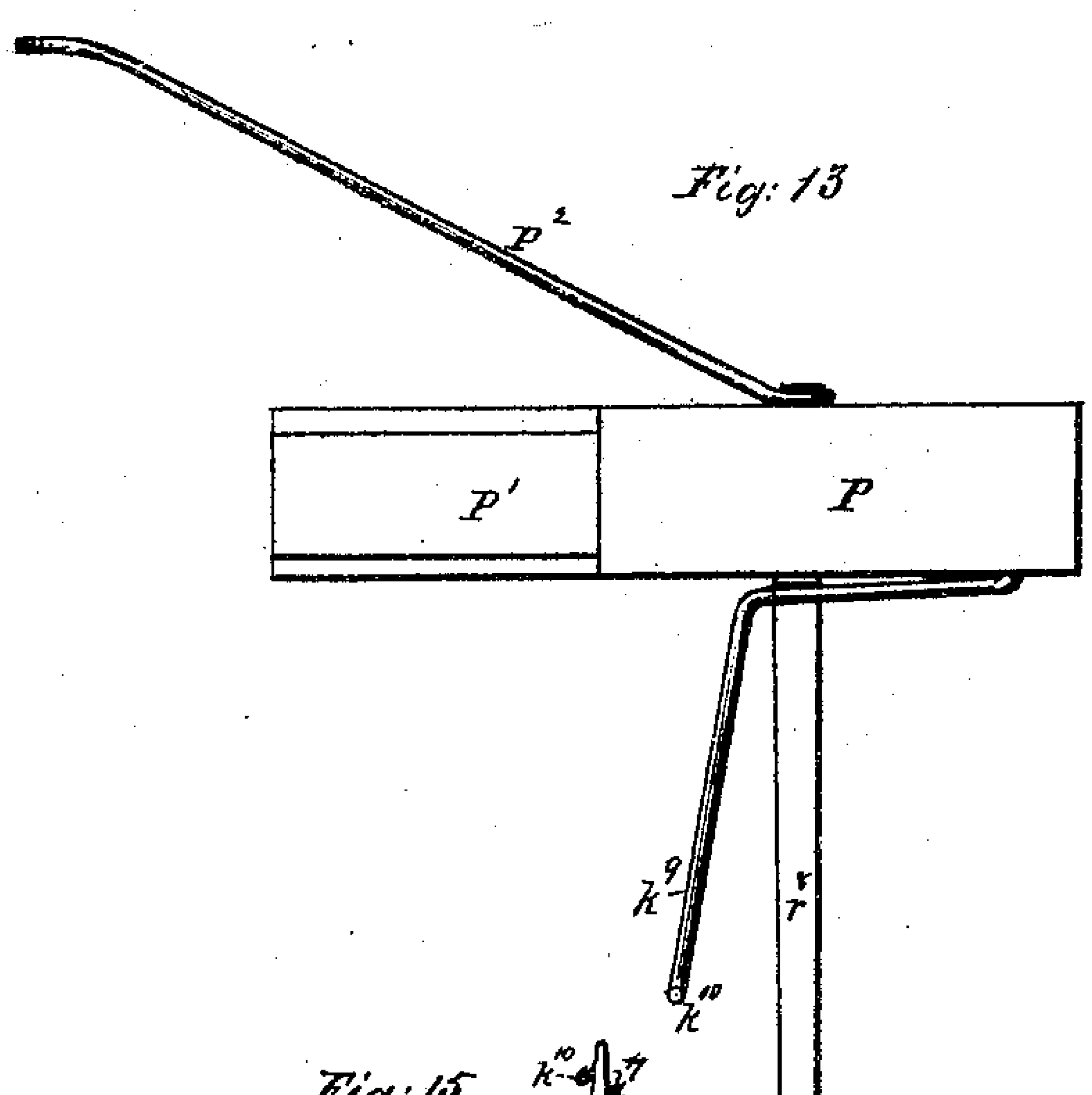


Fig: 14

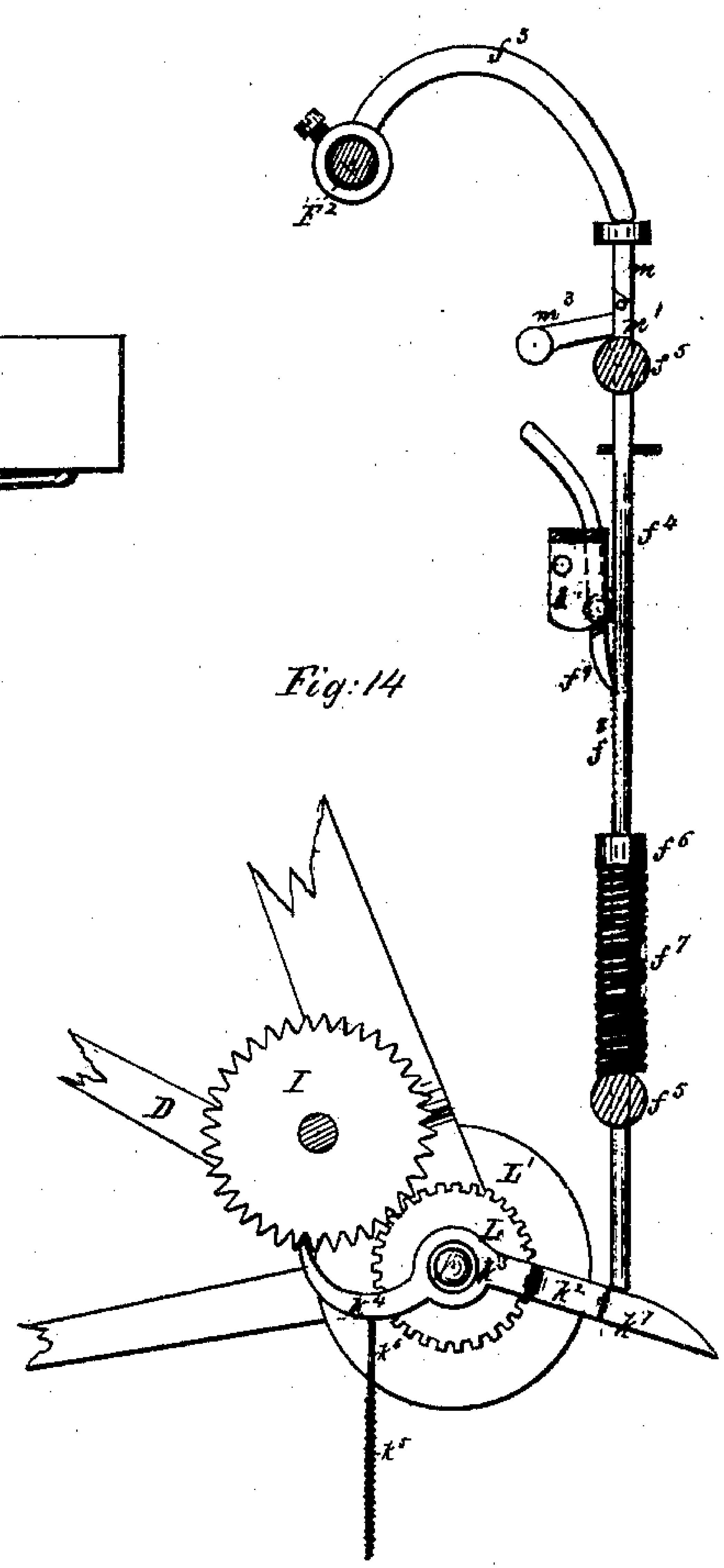
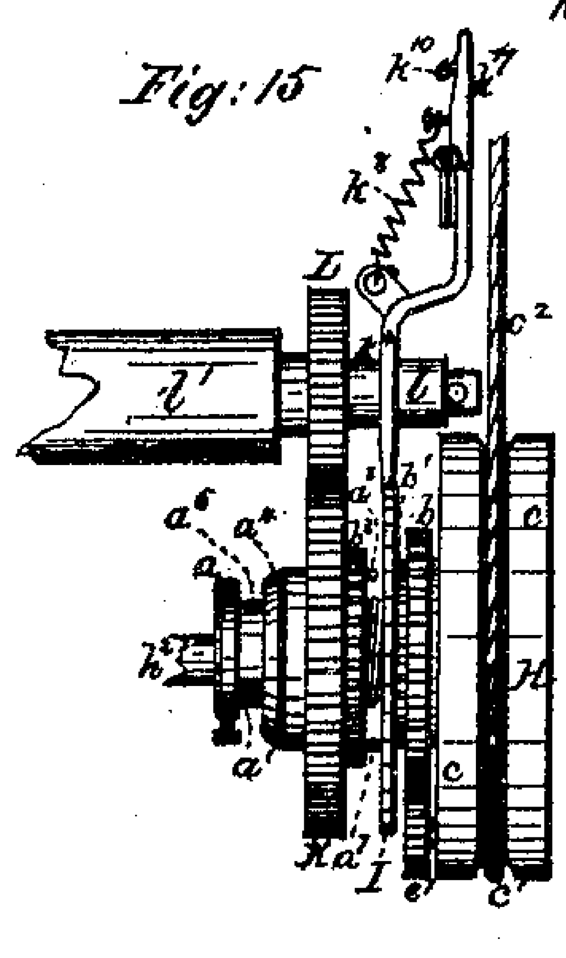


Fig: 15



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UNITED STATES PATENT OFFICE

JAMES SUTHERLAND, OF EAST HAMPTON, MASSACHUSETTS.

IMPROVEMENT IN SELF-ACTING MULES FOR SPINNING.

Specification forming part of Letters Patent No. **113,814**, dated April 18, 1871.

I, JAMES SUTHERLAND, of East Hampton, Hampshire county, Massachusetts, have invented certain Improvements in Self-Acting Spinning-Mules, of which the following is a specification:

Of the drawing, Figure 1 is a side elevation; Fig. 2, a plan view; Fig. 3, a sectional elevation; Fig. 4, a side elevation of the cop-builder, copping-rail, shoe P, knock-off, &c., all the other parts being removed. Fig. 5 is a plan of the scroll-drum G, &c. Fig. 6 is a detached plan of the elbow-lever s^3, &c. Fig. 7 is a detached end elevation of the shoe P, &c. Fig. 8 is a detached elevation of the mechanism by which the position of the weight is regulated. Fig. 9 is a detached end elevation of the knock-off, &c. Fig. 10 is a detached side elevation of the parts shown otherwise in Fig. 8. Fig. 11 is a detached sectional elevation of the mechanism by which the quadrant-nut is automatically operated. Fig. 12 is a sectional elevation of the drums E E^1, &c. Fig. 13 is a plan of the shoe P, &c. Fig. 14 is a detached elevation of the regulator mechanism. Fig. 15 is a plan of the apparatus shown otherwise in Fig. 11. Fig. 16 is a plan of the follower-rods F^1 F^2 and followers; and Fig. 17 is a detached plan of a part of the copping-rail, showing the extension-rail *v*.

The office of the spinning-mule is the proper building of the small cylindrical masses of thread or yarn having conical ends, which manufacturers term "cops."

My invention consists in divers improvements in the self-acting mule, whereby its efficiency is increased, and it is made capable of building cops cheaper than heretofore.

By way of introduction to the specification of these improvements a brief general description of the construction and operation of some of the more important of those parts of the mule which I acknowledge to be in common use, avoiding detail, will be serviceable.

Such parts are, first, a long vertical stationary frame, divided by horizontal parallel bars into spaces of equal size, within which spaces and between which bars are placed in a vertical position rows of bobbins, one row in each space, on which bobbins roving is wound, and from which the filaments or "slivers" of roving are led through little tubes placed in a row on the aforesaid frame in front of the bobbins, the number of slivers that are led through one tube depending upon the quality of the thread to be spun, all the slivers that pass through the same tube being drawn and twisted into one thread; second, the twisting mechanism, the chief element of which is a row of nearly vertical tapering spindles set on the top of, third, a carriage whose length is equal to that of the frame, and which is caused by mechanism which it is needless here to describe to move alternately toward the frame and away from it, or, in the language of mule-spinners, to "run in" and "run out," the spindles being made to revolve with extreme rapidity while the carriage is running out, and thus spin the slivers or "ends" of roving which the carriage draws out from the frame into thread, the movement of the carriage while running out or in being termed a "stretch," the rotary motion of the spindles ceasing for an instant when the carriage arrives at the end of the outward stretch, and commencing again in the opposite direction at the same moment that the carriage begins to run in, the rotary motion of the spindles being much slower while the carriage is running in than while it is running out, and the ends being all carried downward together, during the run of the carriage in by a device called, fourth, a "follower," and taken up by the spindles, building in this way the cop, laying upon the same one layer of thread at every stretch.

The foundation of the cop is a paper tube placed on the lower end of the spindle. Upon the upper part of the paper tube the base of the cop is built. As each successive layer of thread is wound upon the tube and spindle, the cop, of course, increases in size.

The speed of the carriage while running in being invariable in every stretch, and the same in all the stretches, it is necessary that the speed of the spindles while running in should be less during each stretch than during the one next preceding, because the cops take up the thread faster at every stretch, owing to their constantly-increasing size.

It is also necessary that this succession of decreases in the speed of the spindles should continue as long as the diameter of the cop keeps on increasing, which it does till the tapering base of the cop is completed, a conical mass of thread having been in the meantime built around the spindle above and resting upon said tapering base, the cop at this stage consisting, in fact, of two cones placed base to base on the same spindle. When the diameter of the joint base of these cones has attained the size of the diameter which the cop should have, the cylindrical part of the cop begins building, and this is done by causing the follower to place upon the upper of the cone aforesaid successive layers of thread, which are, in effect, hollow cones, all of equal dimensions, the diameters of which, at their bases, are the same as the diameter of the cylindrical part of the cop, and which are laid one above another till the cop is finished, when the cylindrical portion of the cop begins building; therefore the series of decreases in the speed of the spindles while the carriage is running in must come to an end, and the subsequent motion of the spindles remain uniform.

But the production of a series of decreases in the speed of the spindles was not enough. In order to the proper building of the cop it is necessary that the series of decreases be itself a regularly-decreasing one—*i. e.*, that the second decrease be less than the first, the third less than the second, and so on, so that there may follow in the cop the same effect that follows in the bobbin the travel of the belt that connects the concave and convex cones, each reversed with respect to the other, which communicate to the bobbin the motion by which it winds roving from the flier.

The old quadrant-screw may be depended on to produce a series of decreases in the speed of the spindles, but not a regularly-decreasing series of decreases.

The problem before me, therefore, and in the solution of which this invention mainly consists, was to superadd to the quadrant-screw some mechanism that would convert its irregular series of decreases into a regularly-decreasing series of decreases.

For a particular setting forth of this and the other mechanisms which constitute my improvements, I refer to the following description.

In the drawing, A is a mule-head frame, or that part which stands at right angles to the bobbin-supporting frame above mentioned, and also at right angles to the carriage, which runs on ways, half on one side and the other half on the other side of the mule-head frame, the adjacent ends of the two halves of the carriage being connected by the "center-head" B, which travels back and forth with the carriage on ways C.

D is the quadrant, which is of the usual construction, having a lower forked extremity, one branch of which is pivoted in an arm, 1, that extends from the upright A^1 of the mule-head frame. D^1 is the quadrant-screw; d^1, the quadrant-nut; E, a drum fixed on the shaft that turns the spindles while running in through the medium of the clip-spring and catch; d^2, the chain that connects the quadrant-nut with the spindle-shaft drum E; F, the drum that operates the quadrant, said drum being driven by the cord f^2, which is wound around the scroll-drum G, that receives motion immediately from the motor-shaft.

In all the foregoing there is nothing new; neither is there anything new in the function which the quadrant, quadrant-screw, and quadrant-nut discharge, which is, as the carriage runs in, to unwind the chain d'' from the drum E by the resistance of the nut d^1 moving downward and forward with the quadrant slower than the carriage moves, and thus rotating the drum E, and, through it, the spindles, in the right direction for winding the ends upon the cops, the decrease in the speed of the spindles at every stretch while thus winding being effected by turning the quadrant-screw D^1, and thus raising the quadrant-nut d^1 on the quadrant-screw, said nut, of course, traveling faster, when the quadrant comes down, the further it is moved on the screw away from the quadrant-pivot; said nut also, the faster it travels, dragging back less on the drum E, and the speed of the latter being reduced in proportion as the nut drags back less.

The first of my novel mechanisms which I shall proceed to describe is the one that so operates upon the quadrant-screw as to cause it to raise the quadrant-nut at every stretch in such a manner as to produce a regularly-decreasing series of decreases in the speed of the spindles while the carriage is running in and the thread is winding on the cops.

A disk, H, Figs. 1, 2, 11, and 15, is cast solid with a tube, h, that extends from one side of the disk, the bore of the tube being continuous with the axial hole h^1 of the disk, and the function of the tube h being to inclose the stud h^2, that projects outward from the forked extremity of an arm, h^3, which is bolted to the outer side of the standard A^1, the stud h^2 serving thus to support the tube h and disk H.

A collar, a, is placed around the tube h at the opposite end of the same from the disk H, and is provided with a set-screw, by which the collar may be made fast to the tube at any desired point. The collar a is also provided with a pin, a^1, which projects from its end in a direction parallel with the tube h and toward the disk H.

Upon the outside of the tube h a screw-thread, h^4, is cut over a space that abuts against the disk H at one side, the thread running out at its other end in the exterior of the tube h. From the inner side of the disk H a pin, a^2, projects toward the collar a and parallel with the tube h. A collar, a^3, is placed upon the tube h, said collar having an interior screw-thread, h^5, that fits the screw-thread h^4 of the tube h, and admits of running the collar a^3 upon the screw-thread h^4, whereon is its proper position.

Beyond the screw-thread h^4 the tube h is reduced in radius by an amount equal to the depth of said screw-thread. At an interval from the screw-thread of, say, three-quarters of an inch in the full-sized machine, a second screw-thread, h^6, is cut in the outside of the tube h, and from this screw-thread to the end of the tube the latter is again reduced in radius by an amount equal to the depth of said screw-thread.

A second collar, a^4, is placed upon the tube h, said collar having at one end an interior screw-thread, h^7, that fits the screw-thread h^6 of the tube, and admits of running the collar a^4 upon the screw-thread h^7, whereon is its proper place.

A pin, a^5, extends from one end of the collar a^3 toward the disk H. A pin, a^6, extends from one end of the collar a^4 toward the collar a.

Fixed on the end of the collar a^3 farthest from the disk H, is a serrated disk, I, from which a pin, a^7, protrudes toward the collar a^4.

Parallel with the disk I, and at a little distance from it, a circumferential groove is formed in the collar a^3, in which groove sits loosely a gear, b. That part of the outside of the collar a^3 which lies between the gear b and the disk I is cut into a ratchet, b^1. A pawl, b^2, is pivoted at one end to the side of the gear b, and its other end engages with the ratchet b^1. The pawl b^2 connects the gear b and the collar a^3 whenever the latter is turned so as to cause the pawl to engage with the ratchet b^1. Springs recessed in the collar a^3 at the other side of the gear b press against the latter with such force that when the gear is rotated it carries the collar around with it.

Fixed on the end of the collar a^4 nearest to the collar a^3 is a ratchet, b^3. A circumferential groove is cut in the collar a^4 next to the ratchet b^3, in which groove sits loosely a gear, K.

A pawl, b^4, is pivoted at one end to the side of the gear K, and engages at its other end with the ratchet b^3, so as to connect the gear K and collar a^4 whenever the latter rotates in the right direction.

Springs recessed in the collar at the opposite side of and pressing against the gear K serve to connect the collar and gear with such tenacity that when the gear is held stationary while the tube a revolves the collar a^4 is held stationary also.

A horizontal pin, a^7, extends from the side of the serrated disk I toward the ratchet b^3. and a similar pin, a^8, extends from the side of the ratchet b^3 toward the disk I.

The pins a^1 of the collar a and a^6 of the collar a^4 are placed at the same distance from the tube h. The same is true of the pins a^7 of the disk I and a^8 of the ratchet b^3; also of the pins a^5 of the collar a^3 and a^2 of the disk H.

The gear K engages with a gear, L, which is fixed on a shaft, l, that is located in a tube, l^1, which extends horizontally from the same arm to which one of the branches of the quadrant is jointed.

Fixed on the opposite extremity of the shaft l, between the two branches at the lower end of the quadrant, is a bevel-gear, L^1, and this engages with the bevel-gear L^2, that is placed on the lower end of the quadrant-screw.

The disk H is provided with circumferential flanges c, projecting horizontally to each side of its rim, and with a circumferential groove, c^1, in which lies the cord c^2, by which the disk H is driven, one branch of said cord being wound around a drum, E^1, that sits loosely on the drum-shaft, the other branch of the cord c^2 passing on thence to the belt-stretcher that keeps the cord taut.

A stud, e, is loosely placed in an orifice that runs transversely through the disk H near the periphery of the same.

On the outer end of the stud e is fixed a ratchet, e^1, which is of such a diameter as to project slightly beyond the rim of the disk H, through an opening in the outer circumferential flange, c, of the disk.

On the inner end of the stud e, at the opposite side of the disk H, a pinion, e^7, is fixed, so as to engage with the gear b.

A pawl, e^2, is pivoted to the outer side of the disk H; and from the same side of the disk, at a point diametrically opposite from the pawl-pivot, a pin projects, to which one end of a curved spring, e^3, is secured, that presses about at its middle against another projecting pin, and at its end against the pawl e^2, so as to keep the latter in place between any two of the teeth of the ratchet e^1.

The pawl e^2 is provided with a curved arm, e^4, which extends outward by the side of the ratchet e^1 through the opening in the flange c.

A horizontal arm, e^6, extends outward from the standard h^3, said arm, at a point near its outer end, being bent at right angles to itself, so as to form a tongue, to which a latch, e^5, is jointed, said tongue entering a slot in the butt of the latch, and thus preventing the latter from falling beyond a horizontal position.

The latch e^5 extends so far toward the rim of the disk H that its point meets the arm e^4 of the pawl e^2, and also meets the ratchet e^1 during each revolution of the disk H.

The foregoing is a full description of the construction of the mechanism that so operates upon the quadrant-screw as to cause it to raise the quadrant-nut at every stretch in such a manner as to produce a regularly-decreasing series of decreases in the speed of the spindles, while the carriage is running in, from the time when the cop begins building to the time when its tapering base, with its surmounting cone, is completed.

I will now proceed to describe the operation of said mechanism.

The time at which this description begins is after a "doffing" has taken place—that is, after a set of finished cops has been removed from the spindles, the carriage in the meantime standing still at the end of about the first half of its run inward, at or near which point the carriage is always stopped prior to doffing. The first thing to be done is to set the collar a at the proper point on the tube h, which point must vary according to the quality of the thread, a fine grade requiring the collar to be set farther out on the tube than a coarse grade, which will be made plain as the description advances.

The next operation is to turn the serrated disk I with one hand forward, at the same time holding the disk H stationary with the other hand until the pin a^7 of the disk I strikes the pin a^8 of the ratchet b^3, when, the rotation of the disk I being continued, the collar a^4 is also turned forward until its pin a^6 strikes the pin a^1 of the fixed collar a.

The term "forward," as applied to the rotation of the disk I, or any of the pieces that are mounted on its tube h, is intended to mean the direction in which they revolve when the carriage is running in, and the term "backward" therefore signifies the direction in which these parts revolve when the carriage is running out.

The turning forward of the collars a^3 and a^4, as above described, so as to bring the latter into contact with the fixed collar a and the former into contact with the collar a^4, I term "winding them up."

A fresh set of paper tubes having been placed upon the spindles and the pawl b^2 of the gear b having been raised from the ratchet b^1 of the collar a^3, in order to break the connection between the gears b of the collar a^3 and K of the collar a^4, to the end that the latter may not be rotated, the carriage is set in motion to complete its unfinished inward stretch. When the carriage strikes the beam it is stopped, the pawl b^2 let down upon the ratchet b^1, and the carriage started again to make its first outward stretch for the building of the next set of cops. The cord c^2 very soon, though not immediately, sets the disk H in rotation. The rotation of the disk H brings the arm e^4 of the pawl e^2 around against the point of the latch e^5, whereupon the latch presses the arm e^4 inward until it disengages the pawl e^2 from the ratchet e^1. Immediately thereafter the ratchet e^1, in its turn, strikes the latch, and is by the latter, which still presses the arm e^4 inward, turned forward until two teeth have passed the latch. By this time the disk H has carried the arm e^4 and ratchet e^1 both at the same moment past the latch, whereupon the spring e^3 presses the pawl e^2 between two of the teeth of the ratchet, and the latter is consequently held fast, not being rotated again till it strikes the latch e^5 in the course of the next backward revolution of the disk H.

The turning forward of the ratchet e^1 also turns the pinion e^7 forward, and the turning forward of the pinion e^7 turns the gear b backward; but the gear b was already partaking of one backward rotation—namely, that imparted to it by the disk H through the medium of the pinion e^7 and the ratchet e^1, held fast by the pawl e^4. If the ratchet e^1, while held fast, be the means of communicating a backward rotation to the gear b, the ratchet, when set in motion in such direction as to communicate additional backward rotation to the said gear, must accelerate the movement of the latter. As the original backward rotation of the gear b was of the same velocity as that of the disk H, the additional rotation imparted to the gear must give it a higher velocity backward than that of the disk. Such higher velocity, in common with its original one, the gear b imparts to the collar a^3, in which it sits, through the medium of the springs recessed in the latter and pressing against the gear, and also through the medium of the spring that presses the pawl b^2 of the gear b upon the ratchet b^1 of the collar a^3.

The collar a^3, on receiving a higher velocity backward than that of the tube h, which has, of course, the same speed that the disk H has, turns on the screw-thread h^6 and moves toward the disk H as long as such higher velocity continues, or, in other words, until the ratchet e^1 has cleared the latch e^5. Then the collar a^3 ceases moving toward the disk H, remaining, however, upon the tube h in the position it had reached when such movement ceased.

While the collar a^3 has been gaining ground toward the disk H in the manner above described, the collar a^4 has been merely revolving with the tube h, being carried around by the contact between its pin a^6 and the pin a^1 of the fast collar a, its gear K meanwhile sitting motionless in the collar, being held stationary by its connection with the gear L and the springs that are recessed in the collar a^4 and press upon the gear K, as well as the spring that presses the pawl b^4 of the gear K against the ratchet b^3 of the collar a^4, allowing the collar to slip past the gear and the ratchet to slip under the pawl; but, as one collar moves toward the disk H and the other does not, a gap is thus formed between the two collars that were at first wound up so close together; or, to use the term which I employ to signify the same thing, a "falling-off" takes place between the collars a^3 and a^4. Three such fallings-off occur during every outward run of the carriage.

When the carriage has reached the end of its outward stretch it stops, and the usual changes take place in the mule-head. Then the carriage enters upon its home-stretch or run inward.

As during the run out, very soon, though not immediately, the cord c^2 sets the disk H in rotation; but this time forward, instead of backward. During the forward rotation of the disk H its ratchet e^1 and the arm e^4 of the pawl e^2 slip under and raise the latch e^5 without being operated by it, and the pawl e^2 holds the ratchet e^1 fast. The ratchet e^1, therefore, through the medium of the pin e^7, binds the gear b of the collar a^3 fast to the disk H for the whole period of the forward rotation of the latter—that is to say, during the whole of the inward run of the carriage; and as the recessed springs hold the gear b and collar a^3 together, the collar a^3 revolves with the tube h, and at the same velocity.

Looking, now, to the collar a^4, it will be seen that two changes have occurred with respect to it since the carriage began to run in.

Instead of revolving with the tube h, the collar a^4 is now sitting upon the tube without revolving; and instead of remaining in contact with the collar a, the collar a^4 is now moving away from it toward the collar a^3. Both these changes are due to the reversing of the motion of the disk H and tube h, together with the holding of the gear K stationary by the gear L.

The reversing of the motion of the tube h turns the pin a^1 of the collar a away from the pin a^6 of the collar a^4, and leaves the latter in the gripe of the stationary gear K, which immediately clamps said collar a^4 by means of its recessed springs.

The collar a^4, being thus held fast while the tube h is revolving, is moved endwise toward the collar a^3 by the screw-thread h^6. The movement of the collar a^4 endwise continues until the pin a^8 of the ratchet b^3 meets the pin a^7 of the serrated disk I as the latter is revolving forward, which meeting of the pins is, in effect, a collision between the rotating collar a^3 and the non-rotating collar a^4, in which one or the other must give way. On the instant of the collision the pawl b^2 of the gear b seizes the ratchet b^1 of the collar a^3, and thus re-enforces said collar with all the power of the disk H. The collar a^3, thus strengthened, immediately overcomes the resistance of the collar a^4, and sets the latter in rotation forward with itself and the tube h. The collar a^4 having thus gone over to the side of the collar a^3, without any delay the ratchet b^3 thrusts itself against the pawl b^4 of the gear K, and compels the latter to rotate forward with the rest. The rotation of the gear K effects the rotation of the gear L, and, in train, of the shaft l, bevel-gears L^1 L^2, and the quadrant-screw. The quadrant-screw continues rotating with the rest until the carriage has struck the beam, and during the whole period of its rotation it raises the quadrant-nut d^1. The carriage having gone over its inward stretch, the forward rotation of the disk H ceases, the usual changes take place in the mule-head, and the carriage starts to run out again. During this second run-out the gear K is withheld from rotation by the gear L, and, consequently, the screw-thread h^6 draws the collar a^4 endwise away from the collar a^3, and into contact once more with the fast collar a, thus restoring the gap that was formed during the first run-out by the falling off of the collar a^3 from the collar a^4; but this gap is increased during the second run-out by three more fallings-off of the collar a^3. When, therefore, the second run-in is made, the collar a^4 has a wider space to move through before colliding with the collar a^3 than it had during the first run-in.

As the speed of rotation of the tube h is uniform, the time occupied by the collar a^4 in traversing the gap must therefore be greater during the second run-in than during the first; but the longer the collar a^4 is in traversing the gap the less time does it have wherein to rotate the gears K and L, and, by consequence, to raise the quadrant-nut, because the time of making the run-in is invariable for every stretch. It follows, then, that during the second inward stretch the quadrant-nut is raised less than it was during the first, and it is easy to see that during the third inward stretch the quadrant-nut will be raised less than it was during the second, and generally that during every inward stretch the quadrant-nut is raised less than during the one immediately preceding, until, finally, it altogether ceases to rise, the base of the cop being fully built. This gradually-decreasing series of rises of the quadrant-nut produces necessarily the gradually-decreasing series of decreases in the speed of the spindles, which was the object sought to be obtained.

In order to the proper building of the two inverted cones which form the base of a cop—say of No. 120 yarn—it is required that the quadrant-screw should make during the first stretch one and one-half turn and during the last stretch but the one-hundred-and-twentieth part of one turn, and that between these two extremes the turns of the screw should decrease in extent in a regular series; or, to put it in another way, in building the base of the cop the carriage has to make thirteen hundred and twenty home-stretches, and the quadrant-nut has, consequently, to make thirteen hundred and twenty movements, each of less extent than the preceding one, in passing over a space of twenty inches on the quadrant-screw.

The bare statement of these conditions shows how impossible it is that a human operator should fulfill them, and how necessary it is that machinery should be employed to comply with them.

It has been stated that the fixed collar a must be placed nearer the end of the tube h for spinning a fine grade of thread than for a coarser one. The reason is that the finer the thread the longer it takes to build the base of the cop, and therefore the greater should be the number of the rises of the quadrant-nut and the consequent number of fallings-off of the collar a^3 from the collar a^4.

When the base of the cop is finished it is unnecessary that the quadrant-screw should be further operated. The fallings-off of the collar a^3 finally, and at the proper time, enlarge the gap between it and the collar a^4 to such an extent that the endwise movement of the collar a^4 is not sufficient to bring it into collision with the collar a^3 during the forward rotation of the disk H. The means thus failing whereby the said forward rotation is communicated to the quadrant-gear L, the latter, of course, ceases to receive positive motion, and the quadrant-nut ceases to rise.

The pin a^2 of the disk H is, in the end, overtaken by the pin a^5 of the collar a^3 in the course of some one of the fallings-off of the latter, and this falling-off is, consequently, its last one. It is best, then, to throw back the latch e^5 so that it may cease to operate the ratchet e^1; but if this be not done, no harm ensues beyond the mere wearing of the parts, inasmuch as when the latch turns the ratchet forward, and thus accelerates the backward rotation of the gear b beyond that of the disk H, the collar a^3 is held back by the pins a^5 and a^7 to just the speed of the disk, the recessed springs of the collar a^3 yield, and the gear b slips round on the tube h without producing any effect until the ratchet e^1 clears the latch e^5.

It has also been stated that after the beginning both of the inward and outward runs of the carriage, "very soon, though not immediately, the cord c^2 sets the disk H in rotation."

The cause of the cord c^2 not setting the disk H immediately in rotation is that the drum E^1, over which the upper branch of the cord c^2 is wound, sits loosely in a screw-thread cut on its shaft E^2, and when the latter begins to revolve the drum E^1 is turned for about two and one-half revolutions in an opposite direction, owing to its connection with the belt-tightener on one side and the disk H on the other, neither of which receives motion from any other source than the drum E^1.

On the shaft E^2 two collars, d, are fixed by means of set-screws, one at each side of the drum E^1, a pin, d^3, extending from the inner end of each collar toward the drum, and a pin, d^4, likewise extending from each side of the drum toward the collars, and the pins d^3 and d^4 being all at the same distance from the shaft E^2.

As soon as the drum E^1, by its contrary rotation to that of the shaft E^2, is secured along the latter so far that its pin d^4 meets the pin d^3 of the collar d, the drum begins to be rotated in the same direction as the shaft E^2, and consequently to set the disk H in rotation.

The more idle revolutions the drum E^1 makes the later is the moment in the run when the disk H begins to revolve. If, say, two and a quarter revolutions of the disk H are found sufficient to give the quadrant-screw the proper extent of turn during the first inward stretch and all the subsequent stretches, the collars d are placed at such a distance from each other that all the time of the run is consumed by the idle motion of the drum E^1, except the time required for making two and a quarter revolutions of the disk H.

The description of the operation of the mechanism which actuates the quadrant-screw is now complete.

The next in order of my improvements is the apparatus for automatically regulating this same mechanism in such a way as, during the inward runs of the carriage, to reduce the speed of the spindles whenever they revolve so rapidly as to wind the thread too tightly upon the cops, as it is only during that time, when the spindles are revolving at varying rates of speed, that the size of the cops is liable to be such as to cause them to take up thread faster than it is delivered from the feeding-rolls.

The extent of the regulation required by spindles that are already regularly reducing their speed thirteen hundred and twenty times in the course of eleven hours must, it is evident, be exceedingly slight. The best indication of the degree of tightness to which the threads are being wound is obviously supplied by the threads themselves, and my aim was, therefore, to make the threads accomplish their own regulating. The problem before me, then, was to apply to the falling-off mechanism an apparatus, to be automatically operated by the threads, that shall convert the series of decreasing speeds in which the spindles are running at the time they are winding the threads too tightly upon the cops into another series having a more rapid rate of decrease.

The winding of the ends upon the spindles is brought about by the upper follower, f^1, a section of which, together with a section of the lower follower, f^2, is seen in plan at Fig. 16, these sections being those central parts of the followers that span the space wherein is the mule-head B, between the two halves of the carriage, it being understood that the followers, with their rods F^1 F^2, extend to each side of the mule-head from one end of the carriage to the other, the followers themselves, during the winding on, being just in front, and the follower-rods F^1 F^2 being just in rear, of the row of spindles, which row does not extend across above the mule-head. The ends pass between the followers on their way to the spindles. Soon after the carriage arrives at the end of the run-out the upper follower, f^1, is made to descend between the spindles and the lower follower, f^2, below the latter, and carry the ends down with it for the purpose of placing them in the proper position to be wound upon the cops. During this descent the follower f^2 keeps its place above the follower f^1, and consequently receives a pressure from all the ends together, which pressure continues during the whole time of the run-in, or, in other words, of the winding on, gradually lessening as the follower f^1 rises, and finally ceasing when the follower f^1 flies above the follower f^2, and thus allows the ends to rise to the points of the spindles.

A weight hung to the follower-rod F^2 counterpoises the pressure of the threads upon the follower f^2.

The upper and lower followers and the operation of the same, as thus far described, are well known in the art of mule-spinning.

My improvement consists in converting the pressure of the ends upon the follower f^2 into a force that operates to diminish this very pressure when it becomes excessive. When the ends are wound too tightly upon the cops they draw the follower f^2 lower, and consequently turn the follower-rod F^2 farther round than usual.

On the rod F^2, near the mule-frame B, is fixed a curved finger, f^3, the point of which, when the rod F^2 is turned far enough, strikes the top of a vertical rod, f^4, that is loosely placed in pins f^5, which project inwardly from the carriage a^3. A collar, f^6, is fixed on the rod f^4, and on the rod, between the collar and the lower pin, f^5, is a spiral spring, f^7.

A series of teeth is cut in one side of the rod f^4, so as to form a ratchet, f^8; and a lever, f^9, having its fulcrum on a pin that extends horizontally from an arm, k, which likewise projects inward from the carriage a^3, is connected with a spring that presses the lower end of the lever f^9 against the ratchet f^8, and causes said lever to operate as a pawl and hold the rod f^4 at whatever point it may be pressed downward to by the finger f^3.

The rod f^4 is of such length that, when pressed downward to any extent at all by the finger f^3, its lower end, as the carriage runs out, strikes the horizontal arm k^2, that extends from a collar, k^3, which is loosely placed on the shaft l. From the opposite side of the collar k^3 an arm, k^4, extends, curving under the serrated disk I, and pointed at its extremity, so as to enter between any two of the teeth of the same.

The curved arm k^4 is connected in any suitable manner with a spiral spring, k^5, which is placed upon a vertical stem, k^6, that extends upward from the floor beneath the said curved arm, the spring k^5 tending to keep the curved arm, and also the horizontal arm k^2, in proper position.

The arm k^2, when struck by the rod f^4, is depressed so far as to raise the curved arm k^4 until the pointed extremity of the latter meets and stops the serrated disk I during the course of the backward rotation of the latter. The disk I and the collar a^3, being thus checked, while the tube h continues to revolve, move endwise along the latter toward the collar a^4, or are "wound up" for but a slight distance, however, as the carriage is nearly at the end of its outward run before the rod f^4 strikes the arm k^2. The winding up of the collar a^3 in this manner diminishes its falling off, and consequently causes the quadrant-nut to be raised higher than it would have been had the disk I not been thus checked, and the speed of the spindles during the next run-in to be decreased to a greater extent than they otherwise would have been, or, in other words, converts the series of decreasing speeds in which the spindles were running when the ends were being wound too tightly upon the cops into another series having a more rapid rate of decrease; and this was the object to be obtained. This regulation of the falling-off mechanism takes place at about every fourth stretch.

After the rod f^4 has discharged its office by depressing the arm k^2, it is necessary that it should rise to the position it occupied when pressed down by the finger f^3, both that it may be in its place ready for the next pressing down by the said finger, and also that it may not impinge upon the arm k^2 prior to the next tightening of the ends. A horizontal pin, k^7, is therefore fixed in the outer side of the mule-head frame a in such position that it may be struck by the upper arm of the lever f^9 just as the carriage arrives at the end of its outward run. The striking of the lever f^9 against the pin k^7 disengages the lever from the ratchet f^8, and also allows the spring f^7 to throw the rod f^4 upward. At the same time the spring k^5 draws the arms k^2 and k^4 into position.

I have found it desirable during the run of the carriage in to cause the follower f^2 to be held at a higher point than it has been usual heretofore to hold it, in order to reduce the strain of the follower upon the ends. At the close of the run-in, therefore, the follower f^2 has to be brought down to a point where it shall be below the ends during the run-out. The mechanism by which the follower is thus brought down imparts to it a swift and sudden motion that carries it lower than it should go, so that it has then to rise into its proper position; but this prolonged descent of the follower is sufficient to cause the finger f^3 of the follower-rod F^2 to strike the top of the regulator-rod f^4, and thus press the same downward so far that it will impinge upon the horizontal arm k^2 during the next run-out, and, in the manner above described, effect a reduction in the speed of the spindles beyond what is required. To prevent such a result the rod f^4 is divided into two portions, the upper portion or head, m, being two or three inches in length, and jointed to an ear, m^1, that extends upward from the lower portion in such a manner that the head, when vertical, forms a part of the main rod f^4, and may be operated by the finger f^3 in the usual way.

An arm, m^2, extends horizontally outward from the roller-beam N far enough to strike the lower end of the head m when the carriage has arrived at a point about five inches from the beam, and throw said head into a position so far inclined that it is out of the reach of the finger f^3, however far the same may descend, in which position the head m is held by the arm m^2 until the carriage has completed its run-in and proceeded on its run-out far enough to carry the head clear of the arm. The head is then restored to the vertical position by means of a weighted rod, m^3, that extends from its lower end in a direction away from the arm m^2.

As before observed, the regulation of the falling-off mechanism, for the purpose of preventing the ends from being too tightly wound upon the cops, needs only to take place during the time when the double conical bases of the cops are building. Some apparatus is, therefore, needed which shall automatically render the regulator inoperative as soon as the base is finished.

In a subsequent part of this specification will be found a description of a certain traveling block, P. Without at this point anticipating that description, it is sufficient to state that it is the block P which is made use of to render the regulator inoperative, and this in the following manner: The arm k^2, like the rod f^4, is constructed in two parts, the end piece or head k^7 being jointed at its rear extremity to the front end of the main arm, and being also connected with the main arm by a spiral spring, k^8, which is extended whenever the head k^7 is turned forward into line with the main arm, and which, therefore, turns the head k^7 backward toward the main arm whenever the force that turned it forward is withdrawn. This force is supplied by an inclined rod, k^9, that extends horizontally backward from the side of the block P, and is turned up vertically near its rear end, so as to form an arm, k^{10}, that is high enough to operate as long as the block P is sufficiently near as a stop to hold the head k^7 in line with the main arm k^2, and thus keep good the connection between the regulator-rod f^4 and the falling-off mechanism.

The block P remains sufficiently near the arm k^2 to enable the arm k^{10} to operate in this way until the base of the cop is finished, by which time the block P has traveled onward so far as to carry its arm k^{10} clear of the head k^7, which thereupon flies back, drawn by the spring k^8, thus breaking the connection between the rod f^4 and serrated disk I, or, in other words, rendering the regulator mechanism inoperative.

Having thus completed the description of the construction and working of the regulator mechanism, I propose now, by way of preface to the explanation of the next of my improvements, to advert once more to the manner of operation of the upper follower during the winding of the ends upon the cops.

Beginning at the point in the cop where it places the bottom of the layer of thread at the commencement of the run of the carriage in, the follower rises slowly till it reaches the top of the cop. At this point it is my object to impart to the follower a quicker movement as it rises past the lower portions of the naked parts of the spindles, and before it reaches the tops of the spindles, to impart to it the still quicker motion by which it arrives at its original position above the spindles just as the carriage strikes the beam. These three separate movements of the follower I call its first, second, and third rises, respectively, and it is during the second and third rises that the threads are wound spirally upon the naked parts of the spindles up to their very points, in order that the ends may be properly twisted during the next drawing out.

The first rise of the follower is effected in the ordinary manner by the use of the copping-rail S, the sinking of which at the end of each outward run causes the roller o, through the intermediate mechanism, to place the upper follower opposite a higher point in the base of the cop at the beginning of each successive inward run, thus enabling said follower to place the top of each successive layer of thread at a higher point on the spindle, whereby the cop grows in height at every stretch.

It is evident that the first rise in every inward run should continue until all of each end is wound upon the cop, except just enough to compose the spiral around the spindle, and that then the second rise should begin. The second rise cannot begin till the roller o has traversed the length of the copping-rail.

The length of the copping-rail must be such as will produce a first rise of the right length for the first inward run, in which the amount of thread required for the spiral coil is greater than in subsequent runs.

In the ordinary copping-rail there is made no provision for producing a subsequent first rise of greater length than that in the first inward run, it having been supposed that first rises may be invariable as to length without detriment.

Experiment, however, has proved that every first rise should be of greater length than the one immediately preceding it, for the reason that the cops, being always conical where the layers of thread are laid on, take up the ends with a speed that diminishes as the ends approach the tops of the cops, so that each first rise should be prolonged till the carriage has run in so far as to leave between itself and the beam only just sufficient length of ends to form the spiral coils; and as the length of ends requisite for the spirals is less at each successive stretch, the length of the first rises must be greater at each successive stretch. If the first rise ends too soon, the spiral coils are wound loosely on the spindles, and kinks are consequently formed in the ends. It was, therefore, necessary for me to provide an apparatus whereby every first rise of the followers may be prolonged till all of each end has been wound upon its cop except what is required to form the spiral coil upon the naked part of the spindle.

The device by which this object is accomplished I term the "extension-rail." It consists of a block of metal, p, Figs. 2 and 17, placed in a longitudinal groove made for its reception in the upper side of the copping-rail S, at the inner end of the same. The upper side of the extension-rail is at its rear part horizontal, and always flush with the upper surface of the copping-rail. At its front part the upper side of the extension-rail is beveled to such an extent that when set back far enough in its groove its incline face is flush with the inclination at the end of the copping-rail. When in this position the extension-rail forms merely a constituent part of the copping-rail, having no function of its own to discharge, and this is its position at the placing of the first layer of thread upon the paper tubes and spindles.

In order to cause the follower f^1 to rise higher while placing the second layers of thread upon the cops than it did while placing the first ones, the roller *o* must run farther out upon the copping-rail before beginning to descend; but the roller *o* ran to the end of the copping-rail during the first stretch, and to enable it to run any farther out the copping-rail must, it is obvious, be extended. To extend the copping-rail for this purpose is the office of the rail *p*, which office it fulfills by moving out in its groove a very slight distance at the end of each outward run. The source of this intermittent motion of the extension-rail is the traveling shoe S^1, on the inclined upper surface of which the copping-rail S rests. To the side of the shoe S^1 one extremity of a rod, S^2, is jointed, the other extremity of which is connected with the lower end of a lever, S^3, that has for its fulcrum, near its upper end, a stud passing transversely through the copping-rail S. To the lever S^3, at a point between its fulcrum and the connecting-rod S^2, is jointed one extremity of another connecting-rod, S^4, the other extremity of which is connected with the extension-rail *p* by a pin that projects from the side of the latter through a slot in the side of the copping-rail.

When the shoe S^1 is moved slightly forward, in the usual manner, by the turning of the screw Q it imparts a still slighter movement, through the medium of the lever S^3 and connecting-rods S^2 S^4, to the extension-rail *p*, which movement, minute as it is, is still amply sufficient to extend the copping-rail all that is necessary for the prolongation of the first rises of the follower f^1 during each successive inward run, until the length of ends between the carriage and the feeding-rolls is only just enough to form the spiral coils without producing kinks.

The distance traversed by the extension-rail during the building of one set of cops is one and three-quarter inch. In spinning 120-yarn the number of inward runs made by the carriage during that time is two thousand six hundred and forty. The movement of the extension-rail at every run is, therefore, .00066 of an inch.

The first rise of the follower f^1 being completed, its second rise at once begins. This is produced by the running of the roller *o* down the inclined face of the extension-rail.

The second rise, of course, begins at a later moment in each successive stretch, owing to the prolongations of the first rise; and this it should do, as the bases of the naked parts of the spindles are changed to higher points during every inward run. The second rises must, it is obvious, gradually decrease in extent as the cops grow in height; but notwithstanding this no second rise should terminate till it has reached a higher point of the spindle than the one immediately preceding it, for the reason that, as the speed of the spindles is regulated to give the requisite velocity to the outside of the largest part of the cop, it is not sufficient to take up the ends into the spiral coils on the naked parts of the spindles to the degree of tightness necessary to prevent the formation of kinks without prolongation of the second rises. Nor is even this sufficient, a quickening of the speed of the spindles during the second and third rises of the follower being also necessary, as will be explained hereinafter. Each third rise should, therefore, begin at a later moment in every successive stretch than the one immediately preceding it.

To produce the third rise I make use, in a novel manner, of the old device known as the "knock-off," (shown in Figs. 4 and 9,) and consisting of a block, *n*, the upper surface of which is formed precisely like that of the extension-rail, its incline face being turned toward the copping-rail. Formerly the knock-off was rigidly connected with the copping-rail, and received no motion except what it derived therefrom. The office of the knock-off then, as now, was to raise the fork n^5 as the lower finger of the same was drawn over it by the carriage during its inward run, the rising of which fork effects the release of an arm, n^3, that is connected with one of the curved fingers n^4 of the follower-rod F^1 from a pin which holds said arm in lock. On the release of the arm n^3 the weight R rotates the follower-rod F^1 suddenly backward, and thus puts the follower f^1 through its third rise. The knock-off was found to operate in the same faulty manner as the copping-rail, to which it was attached—that is, it released the upper follower too soon in all the stretches subsequent to the first, and allowed kinks to form in the ends. I therefore found it necessary to devise some method whereby the knock-off may be made to throw the upper follower out of lock, or, in other words, to cause each third rise of the follower to begin at a later moment of each successive stretch. The best way of accomplishing this object seemed to be to cause the knock-off to move forward a little at every stretch in the same manner as the extension-rail, and the same source of motion—namely, the intermittent movements of the shoe S^1 of the copping-rail—was as ready to hand in the one case as in the other; but it was necessary that the motion drawn from this source for the knock-off should be less at every stretch than that for the extension-rail, for the reason that inasmuch as the actual extent of each second rise of the follower must diminish at every stretch, while at the same time each second rise must end at a higher point in each successive stretch, the decrease at the end of each second rise must be less than that at its beginning, and consequently the device which ends each second rise must move less at every stretch than the device which begins it.

The device that begins each second rise is the extension-rail. The device that ends it is the knock-off; and the knock-off must, therefore, move less at every stretch than the extension-rail.

In order to render the knock-off movable lengthwise a dovetail groove is formed in it longitudinally of one side, by means of which groove the knock-off is slipped upon a horizontal tongue, n^6, Fig. 9.

The tongue n^6 is bolted at a suitable height to the side of a vertical tongue, n^1, that is placed in a groove which runs lengthwise of a vertical standard, n^2, that extends upward from the floor at a point over which the fork n^5 passes during the runs of the carriage in and out.

In order to impart to the knock-off the requisite movements to its outer side, one extremity of a connecting-rod, n^7, is jointed, the other extremity of said rod being pivoted, to the lower end of an arm, n^8, that extends downward from a stud, which passes transversely through the copping-rail S, said stud being the same to which at its opposite end, on the other side of the copping-rail, the upper extremity of the lever S^3 is affixed.

By means of the stud the motion derived by the lever S^3 from the shoe S^1 is communicated to the knock-off. The arm n^8 is made as much shorter than the distance on the lever S^3 from its fulcrum to the point of its connection with the pitman S^1, as may be necessary to make the movement of the knock-off at every stretch less to the proper degree than the movement of the extension-rail.

The functions of the extension-rail and knock-off having been thus explained, the next of my improved mechanisms to be taken up is that which quickens the speed of the spindles during the second and third rises of the upper follower, f^1. As above stated, the necessity for such quickening arises from the fact that the fastness of rotation required to give the proper velocity to the outside of the largest part of the cop, which is the one the spindles have during the first rise of the follower, is not sufficient to enable them to wind the spiral coils around the naked parts of the spindles tightly enough to prevent the formation of kinks in the ends. It is obvious that the said quickening should begin at the moment in each inward run of the carriage when the ends have risen to the top of the cop, or, in other words, should follow the course of the first rises of the follower. It must, therefore, be of greatest duration in the first stretch, and decrease in duration at every successive stretch. To accomplish this object I make use of the shoe P, Figs. 4, 7, 13, referred to above in the course of the explanation of the regulator mechanism.

The shoe P has a dovetail groove running lengthwise of its under straight side, by means of which groove the shoe is slipped upon a dovetail rail, P^1, that is secured to the floor in the path which the shoe should travel. The upper surface of the shoe is inclined backward and downward. A rod, P^2, jointed at each extremity, connects it with the copping-rail shoe or cop-builder S^1, by which rod the intermittent motion of the cop-builder is communicated to the shoe P.

To one side of the upper curved rail of the quadrant D, and near the forward corner of the same, a bent lever is pivoted, its fulcrum being at its angle, the longer curved arm d^6 of which lever is bent laterally so far as to pass above the quadrant-chain d^2, the major portion of said lever being on the opposite side of the chain. A pin, d^5, extends horizontally from the curved arm d^6, near the outer end of the same, so far as to pass above the chain d^2. The shorter arm d^7 of the bent lever is straight, and extends backward along the curved rail of the quadrant. To the outer extremity of the arm d^7 is jointed the upper end of a rod or striker, d^8, which is of such length and is set in such position that its lower extremity strikes the shoe P just as the roller begins to descend the inclined face of the extension-rail. A spiral spring, d^{10}, fastened at one extremity to the quadrant and at the other to the striker d^8, tends to keep the latter always in proper position, and a spiral spring, d^9, fastened at one extremity to the outer end of the shorter arm d^7, and at the other extremity to the front rail, D^2, of the quadrant, tends to keep the bent lever in proper position.

The operation of the above-described mechanism is as follows: The shoe P having, be it understood, been so set that its highest point shall be struck by the rod d^8 at the end of the first rise of the follower f^1 in the first stretch, the impact of the striker against the shoe throws the former upward, and also throws upward the outer extremity of the shorter arm d^7. The elevation of the arm d^7 causes the depression of the arm d^6, and the latter is so much longer than the former that the pin d^5 moves downward considerably faster than the end of the arm d^7 moves upward, and, therefore, speedily strikes the chain d^2 and drives the same downward before it. Before the chain d^2 receives the stroke of the pin d^5 it is already tautened by the draft of the drum E moving forward with the carriage, and, therefore, before the bending of said chain downward by the pin d^5 can be effected there must be a yielding of the chain d^2 at one end or the other. Such yielding takes place at the end wound on the drum E, the latter revolving with a suddenly-increased velocity in order to let off the chain. This suddenly-increased velocity of the drum E produces the quickening of speed in the spindle, which was the object to be obtained, said quickening beginning at the same time with the second rise of the follower f^1, and continuing as long as the quadrant descends—that is, till the end of the stretch. At every inward run the shoe P is moved as far forward as the other shoe, S^1, moves, and, therefore, by reason of the inclination of the upper surface of the shoe P, the latter is struck by the rod d^8, and the chain d^2 is struck by the pin d^5, each at a later moment of every successive stretch, and the duration of the quickened speed of the spindles, therefore, decreases at every run. A certain amount, however, of quickening is essential to the proper operation of the spindle, even to the very last stretch. The moving of the extension-rail, knock-off, and shoe P, all by the shoe S^1, which is usually called the "cop-builder," renders it easy to regulate the motion of each in its proper relation to the motions of the others. During the building of one set of cops of 120-yarn, or, in other words, the running of two thousand six hundred and forty stretches, the shoe P moves lengthwise five inches. The height of the incline in the upper side of the shoe is 1.25 inch. The extent of the movement of the shoe at every stretch is, therefore, .00189 of an inch, and the average decrease of length in the movements of the arm d^6 at every stretch is .00047 of an inch. As the carriage runs in after completing the second stretch the drum G is revolved backward by the cords f^2 and G^2.

The drum G is connected with the large gear G^3 by two interlocking ratchets, g g^1, one fixed concentrically upon the inner side of the gear, and the other connected by a collar with the drum. The gear G^3 turns only forward, and the drum G must, therefore, be disconnected from it before said drum can be revolved backward. The disconnecting of the drum and gear stops both the drum and the carriage, and therefore should not take place till the carriage has completed the second stretch. It is at this precise moment that it does take place, and the mechanism by which it is accomplished is one of my improvements, the ratchets g g^1 themselves being old.

An arm, s, extends downward to a suitable distance from the bottom rail of the carriage a^3, and from said arm, near its lower end, a horizontal pin projects inwardly.

A lever, s^1, is jointed at its lower extremity to a lug that extends upward from the floor directly beneath said bottom rail of the carriage. The lever s^1 is of such length that when it stands upright the pin of the arm s strikes it and throws it backward just as the carriage completes the second stretch.

A horizontal rod, s^2, connects the lever s^1 with the outer end of a horizontal elbow-lever, s^3, pivoted upon a vertical fulcrum that extends upward from the floor directly beneath the drum G, by which connecting-rod the backward movement of the lever s^1 is communicated to the elbow-lever s^3, causing the inner arm of the same to swing outward till it strikes and throws forward the lower end of a vertical rocking-bar, s^4, that is pivoted to a horizontal arm, s^5, which projects from the adjacent standard of the mule-frame.

From the upper end of the bar s^4 a pin extends backward, entering a circumferential groove, s^6, in the collar s^7, that is attached to the inner end of the drum G. The throwing of the lower end of the bar s^4 forward draws the collar s^7, and with it the drum G, inward till the collar strikes the mule-frame, and this drawing of the drum throws out of gear the ratchets g and g^1, and leaves the drum free to rotate idly on its shaft as the carriage runs in. The means for throwing the ratchets into gear again are old.

The sixth of my improvements is the apparatus whereby, when the carriage strikes the beam at the end of the run inward, it is prevented from suddenly recoiling with such force as to break the ends.

To the upper surface of either of the side rails of the mule-head frame a block, r, is secured in position where it may form the foundation of said mechanism.

To a vertical lug, r^1, that springs from the upper side of the block r, the rear extremity of a latch-bar, r^2, is jointed, which latch-bar rests, near its front end, upon a spiral spring, r^3, that is supported upon the block r.

A latch, r^4, passes vertically through a slot in the latch-bar r^2, and a horizontal pin running transversely through the latch-bar, slot, and latch forms a pivot upon which the latter may be turned.

A spiral spring, r^5, connects the lower part of the latch r^4 with the lug r^1, said spring tending to draw the lower part of the latch backward, and thus throw its upper part forward.

The latch r^4 should be pivoted at such an elevation as to stand directly in the path of the follower-rod F^1 as the latter moves backward and forward with the carriage.

The operation of the above-described mechanism is as follows: When the follower-rod F^1, in running in, strikes the latch r^4 it throws the same forward, depresses the latch-bar r^2, and passes on beyond the latch, whereupon the latch-bar is thrown upward by the spring r^3 to its original position, carrying up with it the latch and placing the latter directly in rear of the bar F^1. No sooner has the latch reached this position than the recoil of the carriage brings the follower-bar back against it, which recoil is checked by the resistance offered by the spring r^5 to the pushing back of the upper part of the latch.

When the carriage runs outward the follower-bar overcomes the resistance of the spring r^5, pushes back the latch, depresses the latch-bar, and passes clear of the latch, which thereupon is again elevated to its original position.

The seventh of my improvements relates to the manner of keeping the pressure of the weight R off from the arm t until the same has been raised past the center of the follower-rod F^1, the necessity for which improvement arises from the fact that, prior to such passing the center, the pressure of the weight, if not taken off, would tend to draw the arm t downward at the very time when it is necessary that it should move upward.

I have therefore provided a rail, R^2, beneath the carriage for the weight R to travel on, said rail being fastened to the floor in a direction parallel to the motion of the carriage, and being inclined at its inner end to such an extent and at such a point that the weight reaches the incline just before the knock-off throws the upper follower out of lock, and travels down the incline fast enough to impart to the follower a third rise of the requisite velocity. As long as the weight is on the horizontal part of the rail it is wholly sustained thereby.

The last of my improvements relate to the means whereby the weight R is made to retard the second rise of the upper follower to an extent that increases directly as the cops grow in height. The necessity for such increase of the retardation grows out of the fact that if the upper follower were to move at a uniform speed during all its second rises it would get into position for the outward run sooner and sooner at every stretch, by reason of the constant decrease in the length of the second rises. But it is essential that the follower should get into position for the outward run at the same moment in every stretch, which moment is the same at which the carriage strikes the beam, in order that it may put the proper amount of thread into the spiral coils. The weight R therefore is placed loosely on an arm, R^3, the forward extremity of which is jointed to the carriage, while to its rear extremity the lower end of the chain R^1 is fastened. The weight is connected, by a rod, r^6, with the periphery of a drum, R^4, that is fixed on a shaft, R^5, which passes horizontally through a sleeve, R^6, that is secured to the bottom rail of the carriage, and also through a ratchet, R^7, fixed on the inner end of the sleeve R^6.

An arm, R^8, extends radially from the part of the shaft R^5 that projects beyond the ratchet R^7, to the outer side of which arm is pivoted a pawl, R^9, which pawl a spring, r^7, affixed at one end to the arm R^8, presses upon, thereby causing the pawl to engage with the ratchet R^7. When the pawl is thus engaged with the ratchet the arm R^8 is locked to the same.

An arm, r^8, projects horizontally outward from the shoe P, directly in the path of the arm R^8 as the latter moves back and forth with the carriage. As the carriage runs in, the lower arm of the pawl R^9 first strikes the arm r^8, and the pawl is thereby disconnected from the ratchet, thus releasing the arm R^8 from lock, and admitting of the throwing of the lower end of said arm backward until it clears the arm r^8. The throwing back of the arm rotates the drum R^4 backward, and this, by means of the connecting-rod, strikes the weight R back on the arm R^3.

The arm r^8 is provided with a jointed head, that is kept in line with the arm by a spring. When the carriage runs out the spring yields and allows the jointed head to turn backward as the arm R^8 strikes it until the latter passes clear of the arm r^8, when the spring throws the jointed head forward again into position for the next throwing back of the arm.

By each successive movement of the drum the weight is pushed backward, and as the distance between the weight and the pivot of the arm R^3 increases the pressure of the weight upon the chain R^1, and, by consequence, upon the arm t^1 of the follower-rod f^1, increases also. By reason of the increasing pressure of the weight upon the follower-rod as the lengths of the second rises of the follower decrease, the times of said rises remain the same.

Another advantage of this gradual retardation of the rises of the follower is the winding of the threads tightly upon the apexes or noses of the cops. The rail R^2 serves to support the weight during that part of the run when the retardation of the follower is not necessary and would be injurious.

I deem it a suitable conclusion to this specification, notwithstanding it has already attained an unusual length, to state that my object in making the above-described improvements was to contrive machinery that should automatically imitate, as closely as possible, the action of the hand-mule spinner, and also to set forth the resemblances which I have succeeded in producing between the movements of the man and the machine.

The hand-mule spinner is the only source of the rotary motion of the spindles while the carriage is running in, which motion he produces by turning with his hand a fly-wheel mounted on the drum-shaft with which the spindles are connected.

He also has to operate the upper follower by depressing it just prior to the starting of the carriage to run in, by allowing it to move gradually upward as the carriage advances, and by letting it rise suddenly into position for the run-out as the carriage strikes the beam.

In the operation of the spindles the mule possessing my improvements does perfectly what the human spinner aims to do, but with only partial success.

First, by producing a regularly-decreasing series of decreases in their speed, so that not only do they rotate more slowly during the second stretch than during the first, and during the third stretch than during the second, and so on till the bases of the cops are built, but also is the difference between the respective velocities of the second and third stretches less than the difference between the respective velocities of the first and second stretches, and so on; also, by diminishing their speed, when they are running too fast, just as much as may be necessary to prevent them from winding the ends too tightly upon the bases of the cops. These things the hand-spinner did, so far as he could, by slowing his fly-wheel from stretch to stretch, and in the course of those stretches in which the tightening took place to what, in his judgment, was the proper extent.

Second, by imparting to the spindles at every inward run a quickened speed of less and less duration at every stretch, just as the spiral coils commence winding upon the naked parts of the spindles. This the hand-spinner did by increasing the velocity of his fly-wheel in the course of the stretch at a moment and to an extent depending entirely upon his own judgment.

In the operation of the upper follower my improvements perform the work of the ideal spinner, first, by changing to a later moment in every successive stretch both the time of beginning and of ending the quickened movement of the follower that lays the spiral coils upon the naked parts of the spindles, and by giving to this movement the degree of quickening requisite to form the coils without allowing kinks to come in the ends; second, by retarding the speed of the successive rises of the the upper follower directly as their lengths decrease, by just so much as may be necessary to produce uniformity in the times of said second rises; third, by changing to a later moment in every successive stretch the time when the weight is allowed to draw the follower suddenly upward into position for the outward run of the carriage.

All these matters in the hand-mule are left entirely to the head that dictates and the hand that regulates the rise of the follower.

In preventing the recoil of the carriage after it strikes the beam my improvement imitates the pressure of the knee and hand of the human operator, by opposing to the follower-rod a force that checks it temporarily, and is withdrawn when the carriage starts to run out.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. The fall-off mechanism herein described, substantially as set forth.

2. The combination of the quadrant-screw with the winding-on drum and with the falling-off mechanism, as described, for the purpose of producing a regularly-decreasing series of decreases in the speed of the spindles.

3. The combination of the mechanism herein described which automatically turns the quadrant-screw with a regulating apparatus, substantially such as is herein set forth, that, during those inward runs of the carriage in which the spindles revolve too fast, is automatically operated by the ends in a manner that diminishes the falling off of the collar a^3 to such an extent as to cause the mechanism of which said collar forms a part to decrease the speed of the spindles during the next inward run after such diminution more than it would otherwise have been decreased, and enough to prevent the spindles thereafter from winding the ends too tightly upon the double conical bases of the cops until such time as they again revolve too fast.

4. The combination of the vertical regulator-rod f^4 with the jointed head m, weighted rod m^3, and horizontal arm m^2, in the manner described, and for the purpose of preventing the depressing of the regulator-rod out of season.

5. The arrangement of the horizontal arm k^2, jointed head k^7, spring k^8, or its equivalent, and rod k^9, projecting from the shoe P, in the manner described, and for the purpose of automatically rendering the regulator apparatus inoperative after the double conical bases of the cops have been built.

6. The extension-rail, combined with the copping-rail and cop-builder in the manner herein described, by which the intermittent motion of the latter imparted to the extension-rail may cause the same to practically lengthen the copping-rail at every inward run as much as may be necessary in order to prolong the first rise of the upper follower, until all of each end has been wound upon its cop, except just enough to make the spiral coil upon the naked part of the spindle without allowing the formation of kinks in the thread.

7. A knock-off separated from the copping-rail, and operated by a mechanism substantially such as herein described, which causes it to advance at every stretch a less distance than the extension-rail advances, but at the same time as far as may be necessary to prolong the second rise of the upper follower at each inward run, until the spiral coils have been wound upon the naked parts of the spindles tightly enough to prevent the formation of kinks in the ends.

8. The combination, with the quadrant and quadrant-chain, of the inclined traveling shoe P, and the mechanism consisting substantially of the lever d^6 d^7 and striker d^8, all constructed and operating in the manner described, and for the purpose specified.

9. The combination of the cop-builder, extension-rail, knock-off, and shoe P, in the manner described, and for the purpose of causing them all to move in unison.

10. The combination of the scroll-drum with the rocking-bar s^4, elbow-lever s^3, connecting-rod s^2, vertical lever s^1, and carriage-arm s, in the manner described, and for the purpose of throwing the scroll-drum out of gear at the completion of the second stretch.

11. The combination, with the mule-carriage, of a latch mechanism consisting, essentially, of the block r, lug r^1, latch-bar r^2, latch r^4, and springs r^3 r^5, as and for the purpose specified.

12. The combination of the weight R with the rail R^2, when the same is provided with an inclination at its inner end, in the manner described, and for the purpose of keeping the pressure of the weight off from the upper follower until the latter has been thrown out of lock.

13. The combination of the weight R with a mechanism, substantially such as is herein described, that automatically serves to increase the pressure of said weight upon the upper follower directly as the lengths of the second rises of said follower decrease, in the manner described, and for the purpose of causing the times of said second rises to remain uniform.

JAMES SUTHERLAND.

Witnesses:

CHARLES MELLEN,
WILLIAM STRATTON.