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S. G. HALL.

CIRCULAR KNITTING MACHINE.

No. 384,621. Patented June 19, 1888.

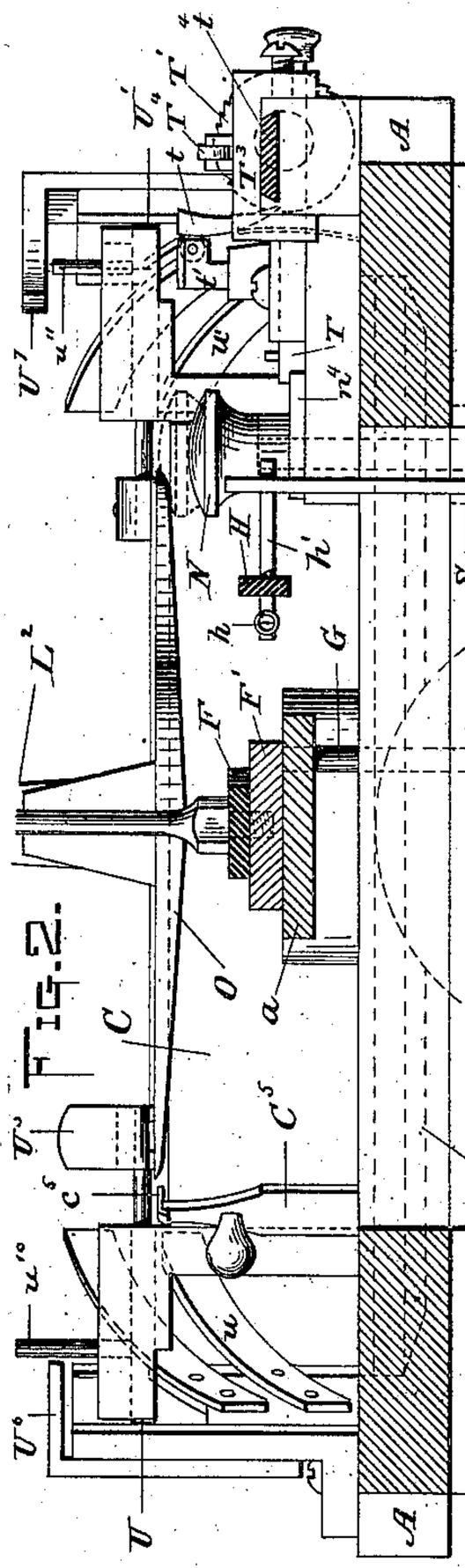

FIG. 2.

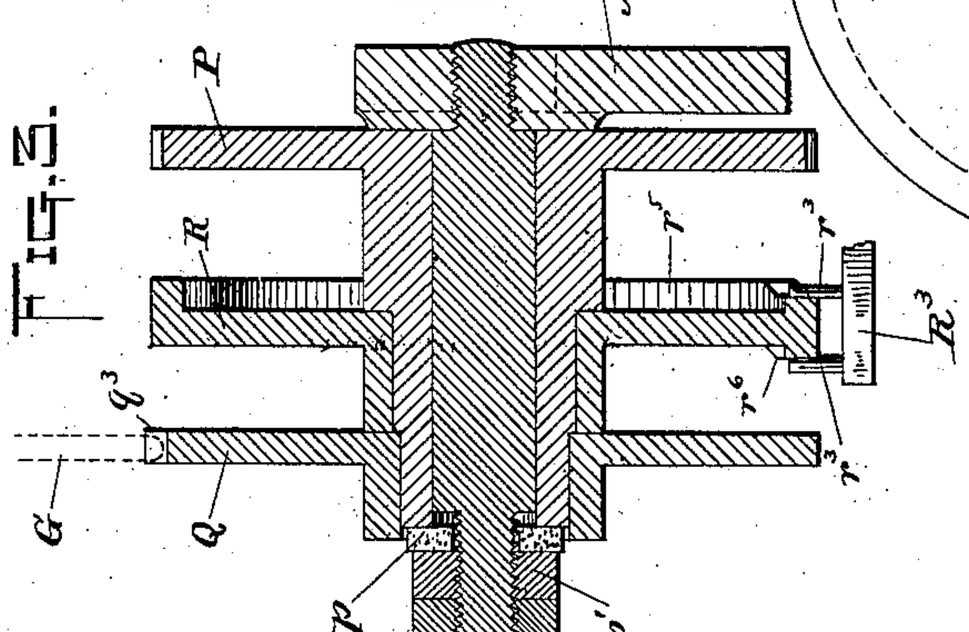

FIG. 3.

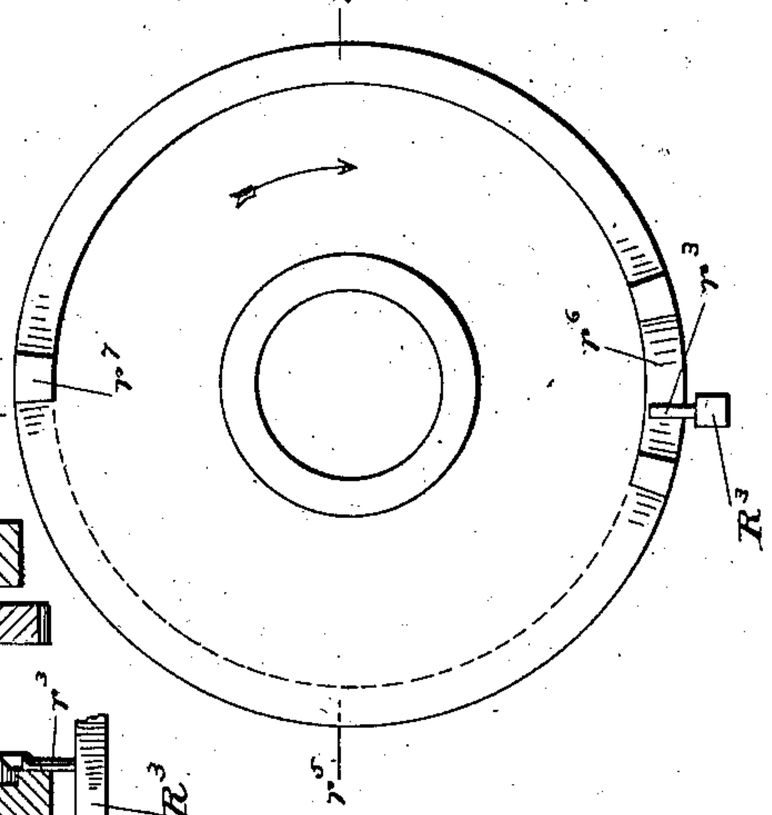

FIG. 4.

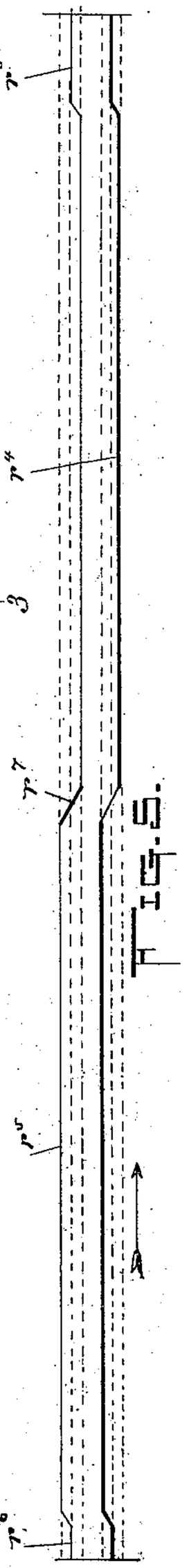

FIG. 5.

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CIRCULAR KNITTING MACHINE.

No. 384,621. Patented June 19, 1888.

Fig. 1.

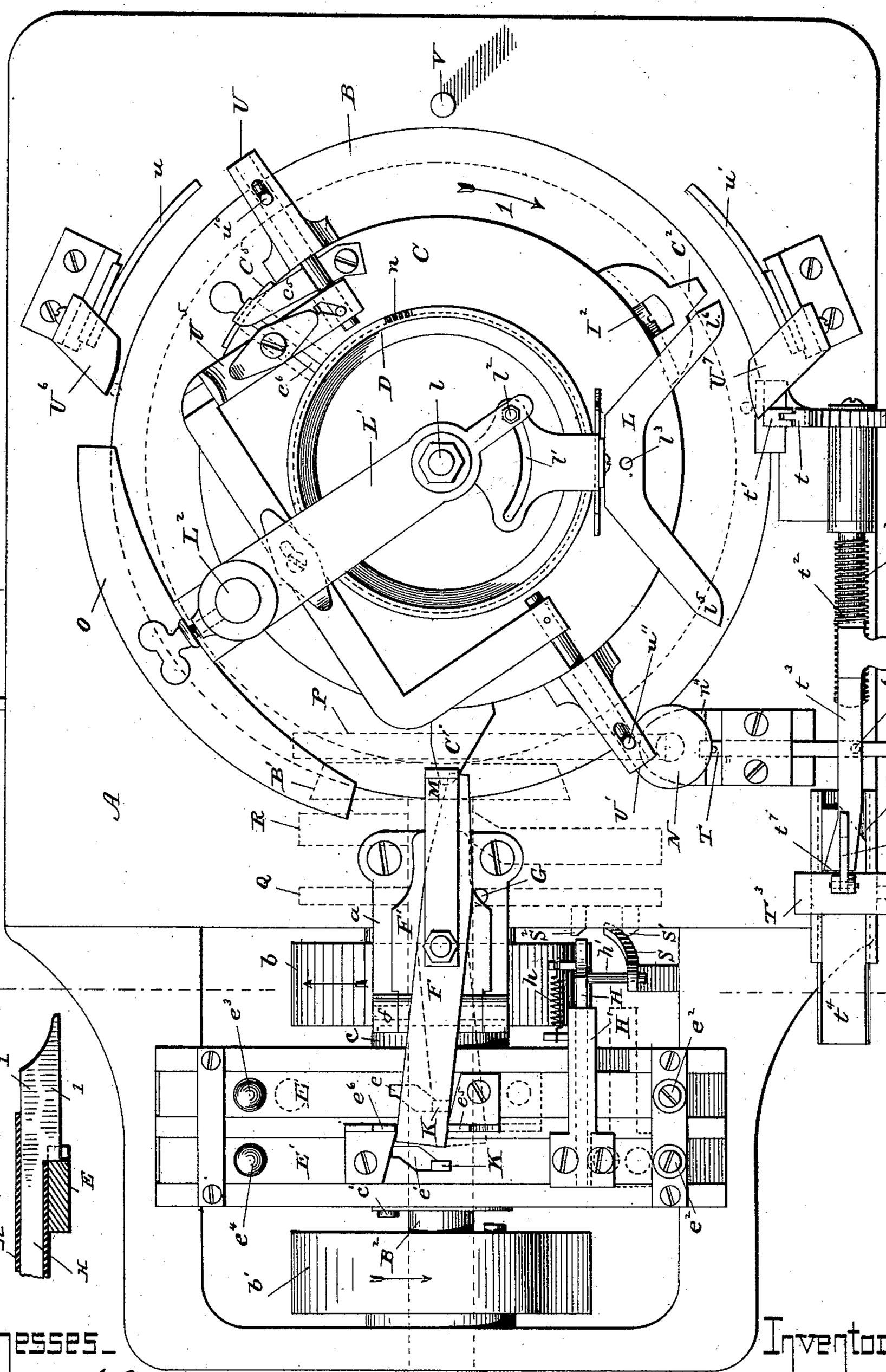

Fig. 1a.

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(No Model.) 5 Sheets—Sheet 3.

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CIRCULAR KNITTING MACHINE.

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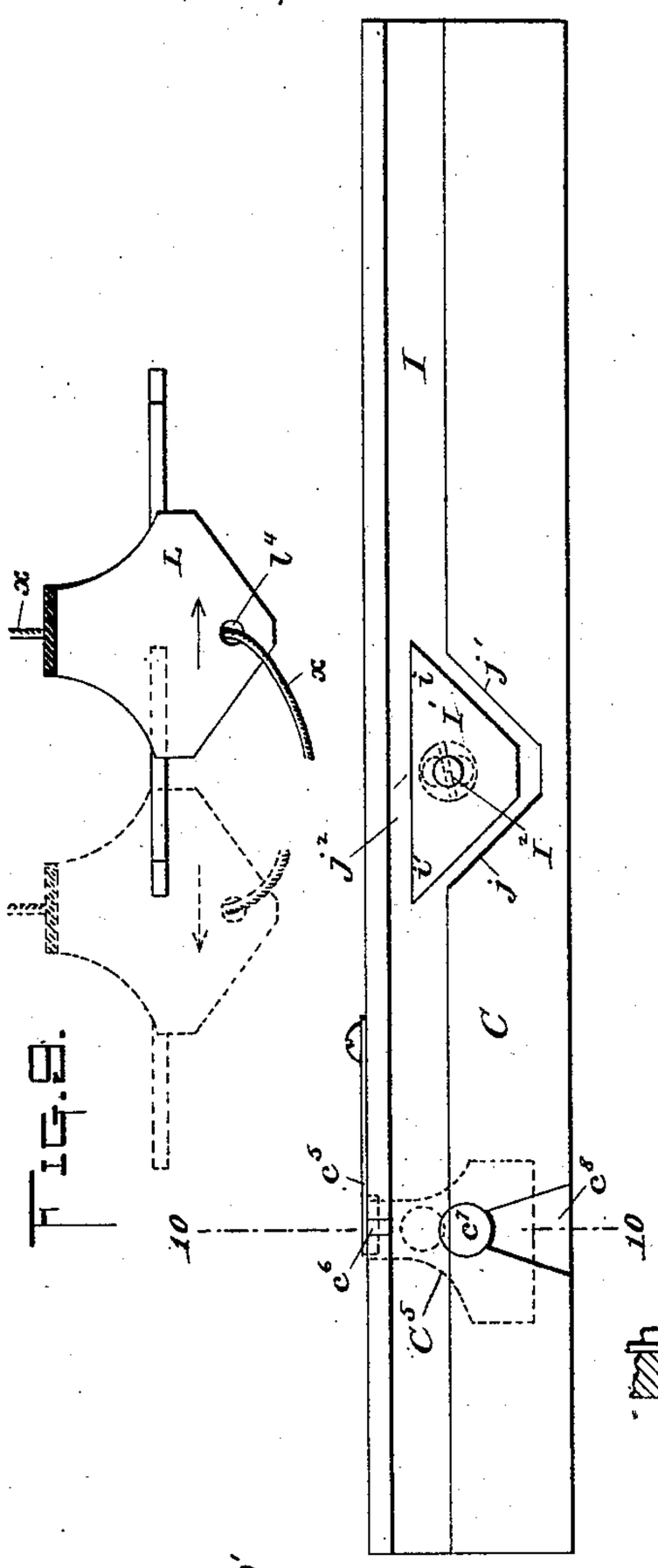

FIG. 9.

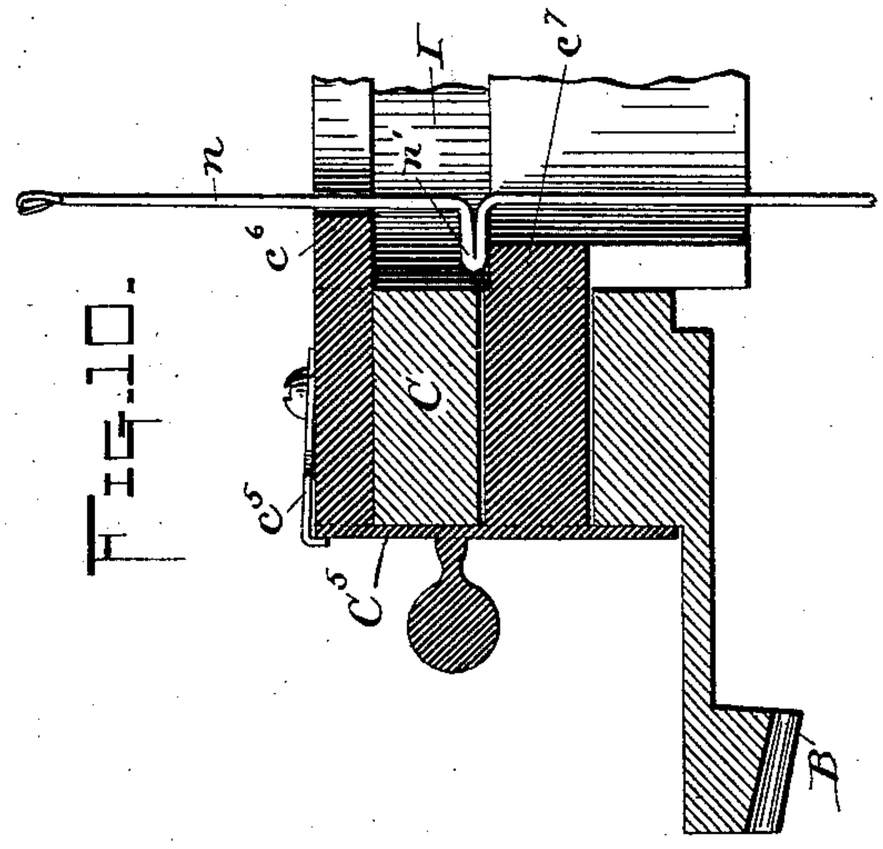

FIG. 10.

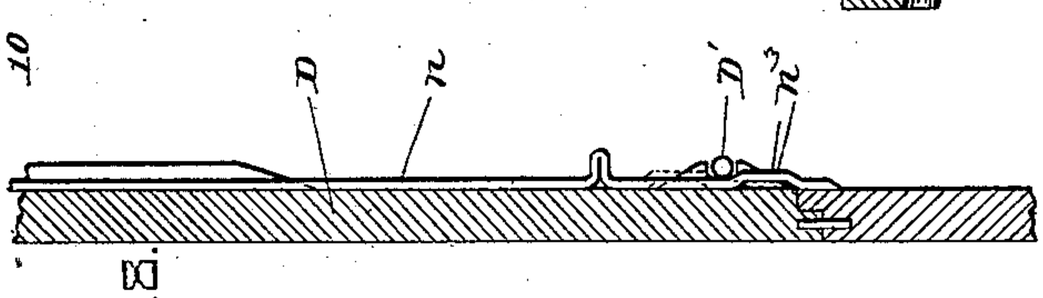

FIG. 8.

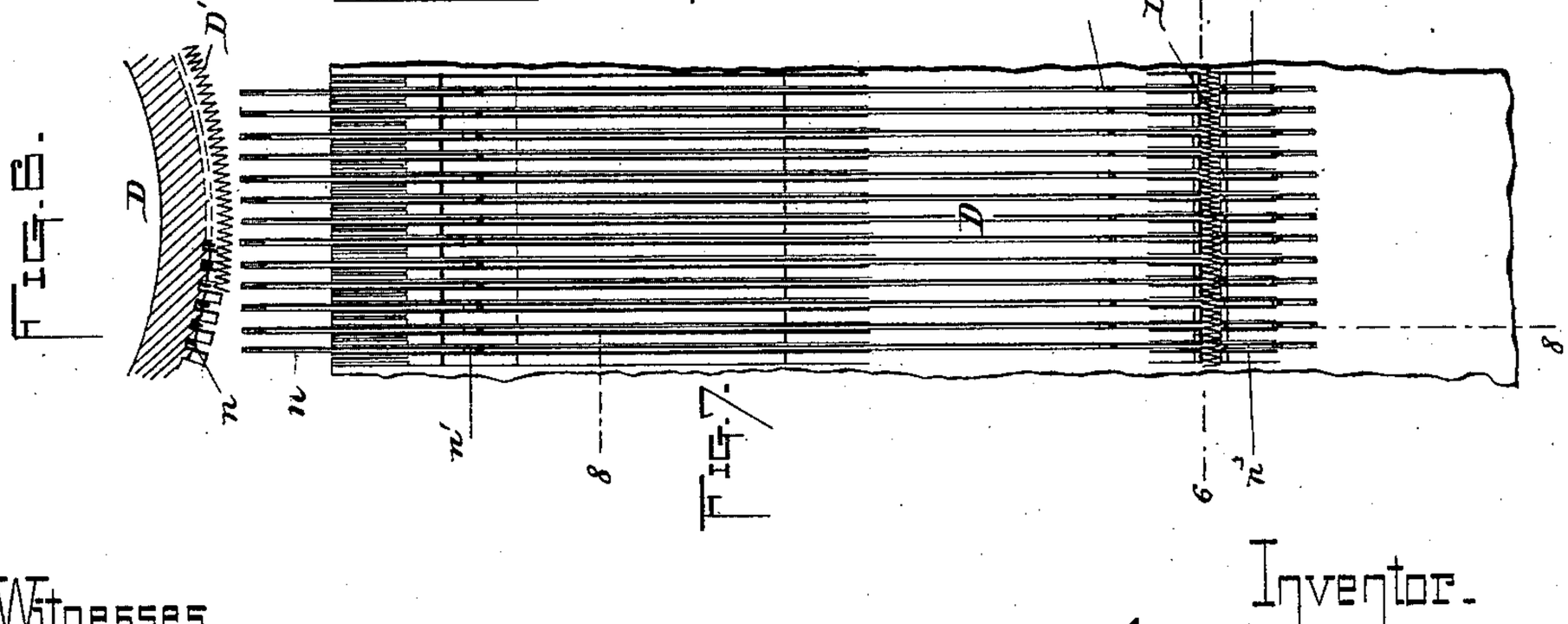

FIG. 7.

FIG. 6.

Witnesses.

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CIRCULAR KNITTING MACHINE.

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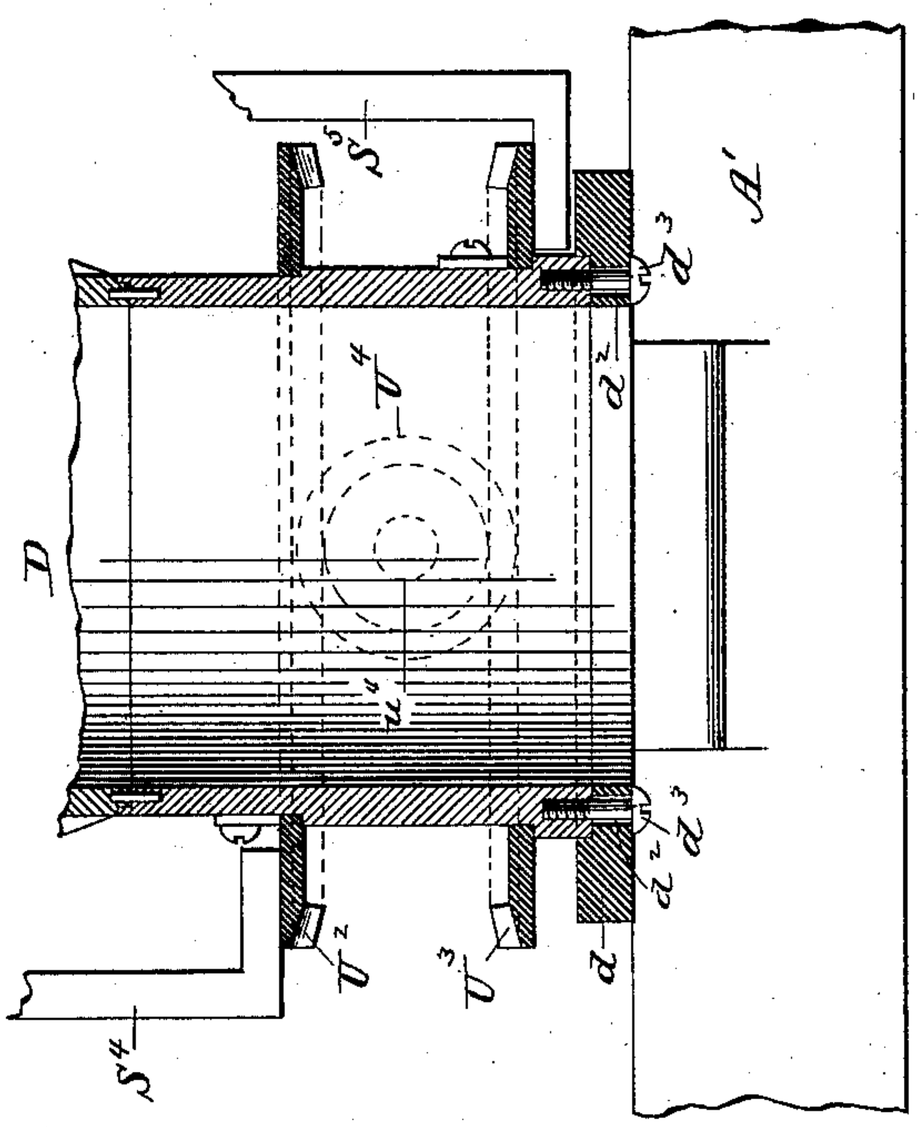

FIG. 12.

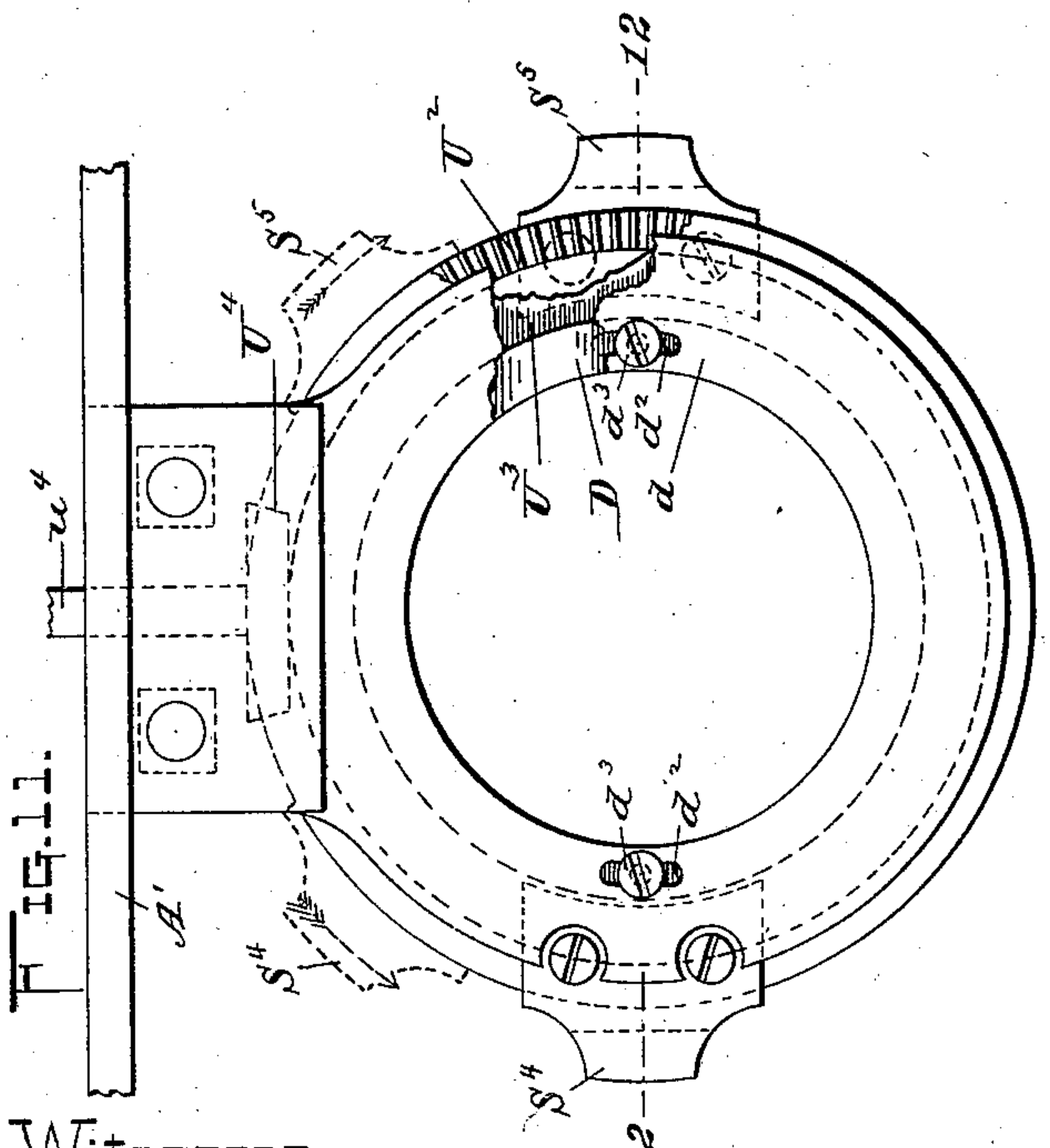

FIG. 11.

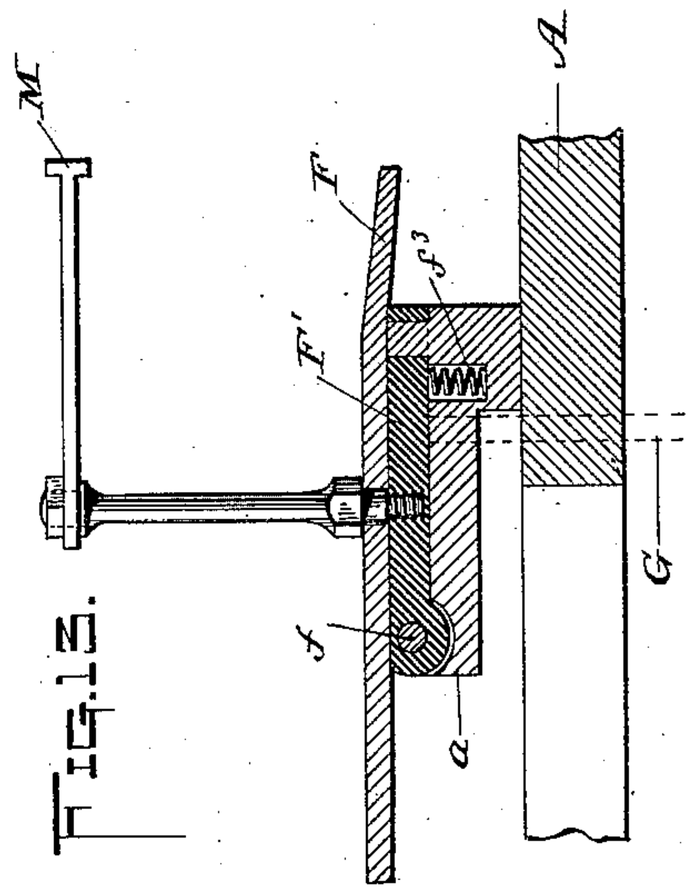

FIG. 13.

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(No Model.) 5 Sheets—Sheet 5.

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CIRCULAR KNITTING MACHINE.

No. 384,621. Patented June 19, 1888.

Fig. 17.

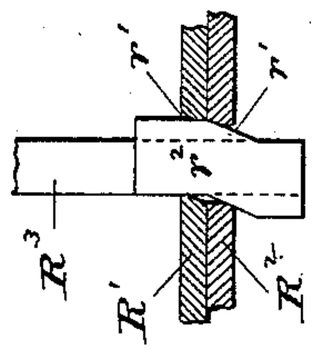


Fig. 16.

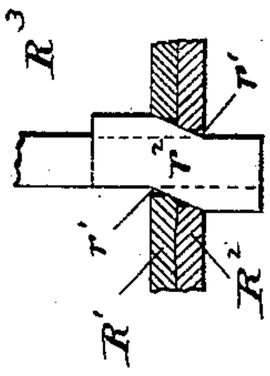


Fig. 15.

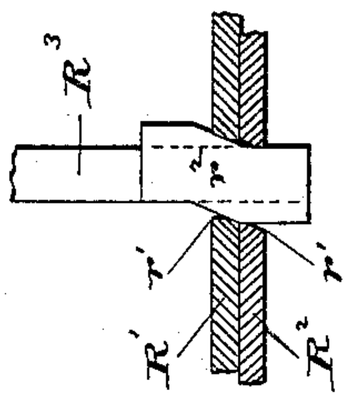


Fig. 18.

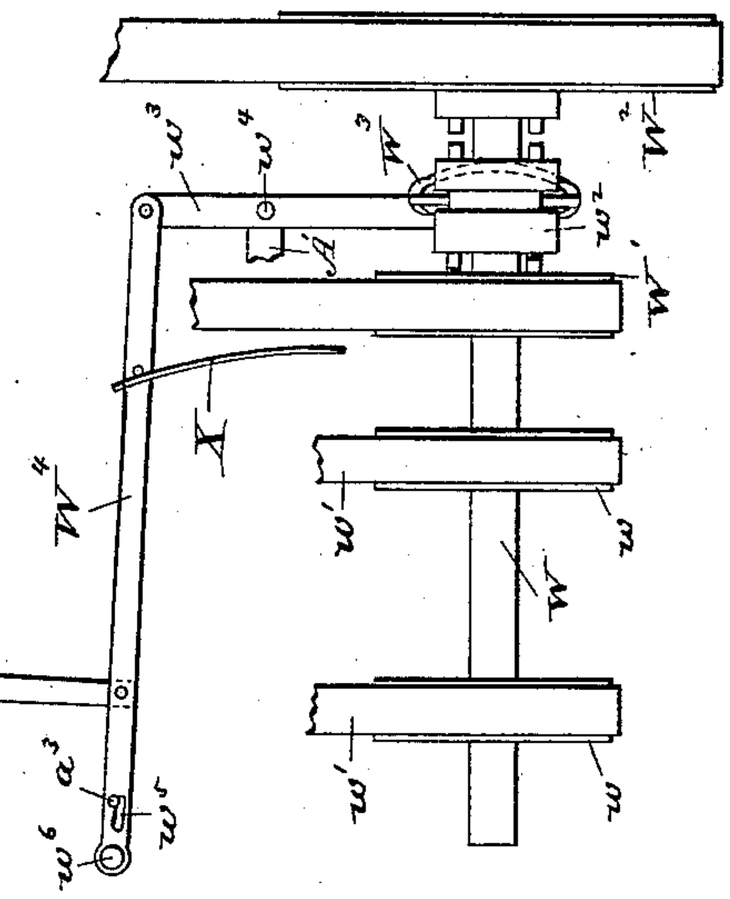


Fig. 19.

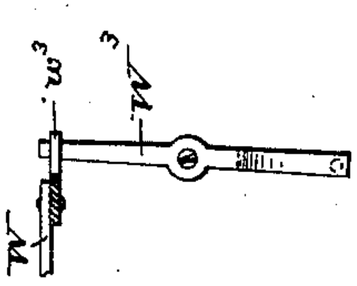
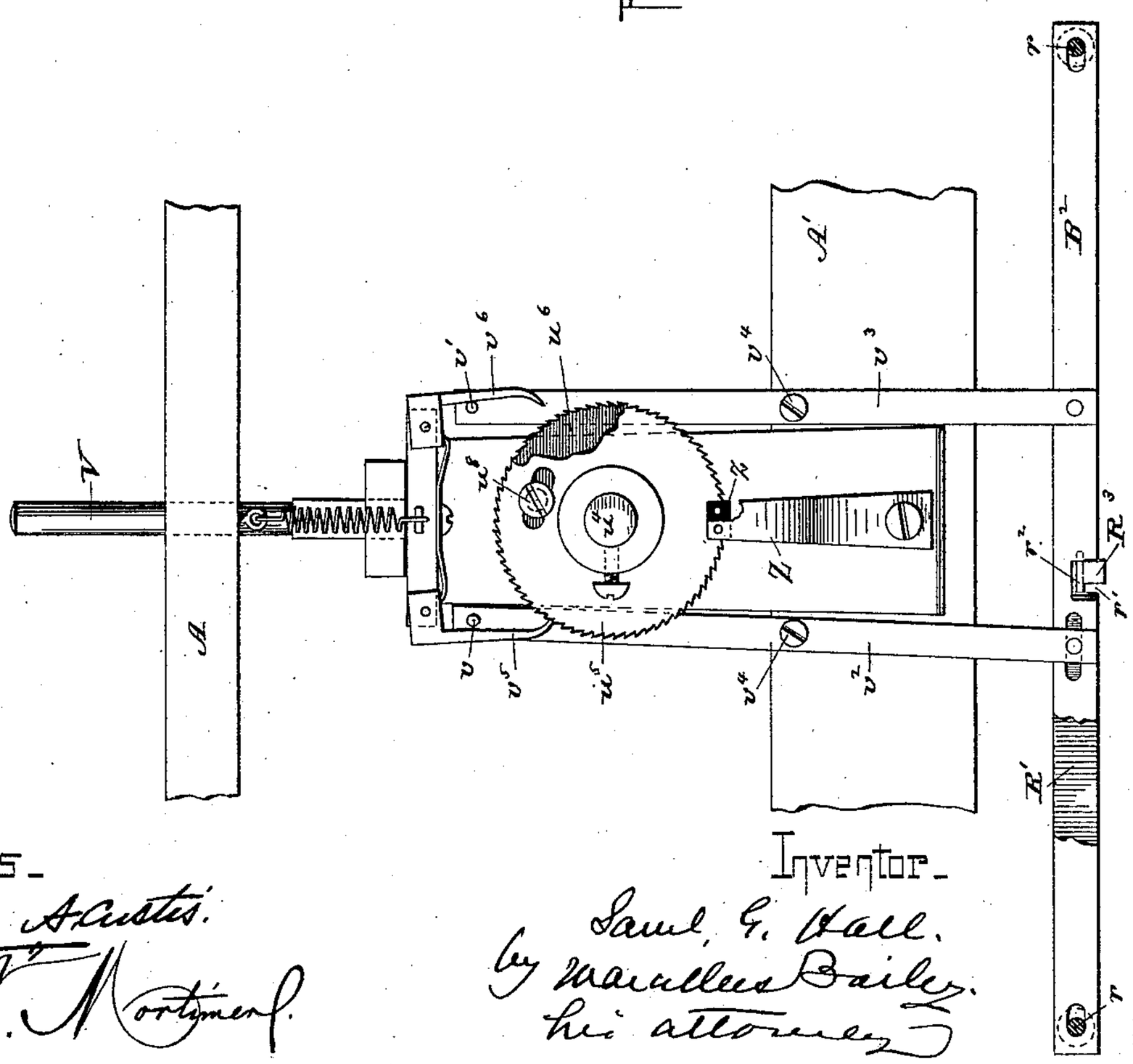


Fig. 14.



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Inventor—
Saml. G. Hall.
by Marallus Bailey.
his attorney

UNITED STATES PATENT OFFICE.

SAMUEL G. HALL, OF COHOES, NEW YORK.

CIRCULAR-KNITTING MACHINE.

SPECIFICATION forming part of Letters Patent No. 384,621, dated June 19, 1888.

Application filed June 29, 1887. Serial No. 242,865. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL G. HALL, of Cohoes, in the State of New York, have invented certain new and useful Improvements in Circular-Knitting Machines, of which the following is a specification.

My invention relates to circular-knitting machines in which, after a straight knit tube has been produced by the ordinary action of the machine, a rounded portion—for instance, the heel or toe of a stocking—is formed by the oscillation of the needle-cam and the action of a part of the needles first in successively decreasing and then in successively increasing numbers. It has heretofore been proposed to obtain such an action of the needles automatically by the use of a "pattern mechanism"—such as a chain having lugs or projections at various points and distances between said lugs proportionate to the lengths of the different parts of the article to be produced—for example, the leg, heel, foot, and toe of a stocking. Many revolutions of the needle-cam are necessary to produce such an article, and as the pattern-chain is ordinarily in movement during the production of the entire article a great length of chain has been required. Moreover, the lost motion, which is also rapidly increased by wear, attending the use of such a pattern mechanism makes the latter wholly undesirable for so delicate an operation as the selecting of the desired needles and the depressing and raising of them at the proper times. In practice such mechanism is very apt to fail in properly taking the needles out of and bringing them into operation, with the result of producing holes in the knitted fabric.

My invention is directed, first, to doing away with the greater part of the pattern-chain—namely, the portion which corresponds with the plain portion of the article, such as the leg of a stocking—by the use of a secondary feed-movement; and, second, to dispense with the pattern-chain entirely by employing in the place of the remaining portion of it a pattern substantially all parts of which are rigid with each other and move together with no lost motion. In the construction hereinafter described and illustrated such a rigid mechanism is furnished by cam-wheels.

My invention consists, also, in certain other novel features, hereinafter described.

In order that my invention may be more clearly understood, I have shown in the accompanying drawings a means for carrying it into effect.

In the drawings, Figure 1 is a plan view of a knitting-machine embodying my invention. Fig. 1ª is a detail sectional view of a portion of the slide E and the bolt H, which engages the same. Fig. 2 is a transverse vertical section on line 2 2, Fig. 1, showing a portion of the same. Fig. 3 is a vertical longitudinal section on line 3 3, Fig. 2. Fig. 4 is an elevation of one of the cam-wheels. Fig. 5 is a diagram showing the development of the same. Fig. 6 is a horizontal section of a portion of the needle-cylinder on line 6 6, Fig. 7. Fig. 7 is an elevation of the same. Fig. 8 is a vertical section on line 8 8, Fig. 7. Fig. 9 is a diagram showing the development of the interior of the outer revolving cam-cylinder and the two positions of the thread-guide relative to the needle-cam. Fig. 10 is a cross-section on line 10 10, Fig. 9, showing the means for removing broken or imperfect needles. Fig. 11 is a bottom plan view of the needle-cylinder and its supporting-ring. Fig. 12 is a transverse vertical section of the same on line 12 12, Fig. 11. Fig. 13 is a sectional view of a clutch-reversing lever and its support, showing also the thread-guide stop. Fig. 14 is an elevation of a portion of the mechanism for automatically raising and lowering the needles. Figs. 15, 16, and 17 are plan views, partly in section, illustrating the shifting of the pawls shown in Fig. 14. Fig. 18 is an elevation of the power-shaft and devices carried thereby, showing a means for automatically changing the speed of the needle-cam. Fig. 19 is a plan view of the clutch-shifting lever shown in Fig. 18.

Referring to the drawings, A indicates the bed-plate of the machine; A′, frame-bars connected therewith; B, the gear-wheel mounted to rotate in said plate; C, the outer cylinder or needle-cam ring carried by said gear; D, the grooved needle-cylinder mounted stationarily upon the bracket-ring *d*, Figs. 11 and 12, and *n* the needles.

The gear-wheel B may be driven in the usual manner from a shaft, B², through the medium of a pinion, B′. For obtaining a reversal of the direction of rotation of the outer cylinder, C, any suitable means may be em-

ployed. The devices shown in the drawings for this purpose are of a known character and are substantially those shown in Patent No. 350,466.

b b' are pulleys loose upon shaft B^2 and adapted to be constantly driven in opposite directions by a belt or belts. Clutches *c c'*, mounted on a spline upon shaft B^2 and adapted to be thrown into engagement with corresponding clutch-faces upon pulleys *b b'*, serve to communicate the motion of either pulley to the shaft and through pinion B' to the outer cylinder. Slides E E', operated by the outer cylinder, as hereinafter described, engage by inclined slots *e e'* with the upper ends of levers K. The lower ends of the latter rest in grooves in the clutches, and, when oscillated by the slides E E', shift the clutches to the right or left, according to the direction of movement of the slides. When both slides are thrown outward—that is, when slide E', Fig. 1, is in its present position and slide E is in the position shown in dotted lines—both clutches will be out of engagement, both pulleys free, and the machine at rest. The devices thus far described for changing the direction of rotation are, however, well known and are fully shown in the patent already referred to. It has, however, been found in practice that the clutch-slides E E', when suddenly thrown from side to side in the operation of the machine, will often rebound, fail to properly engage the clutches with the pulleys, and produce imperfections in the fabric. I have therefore combined with the slides friction-screws e^2, preferably bearing upon a leather pad, which in turn presses upon the slides, by which the latter may be prevented from being accidentally displaced or from moving, except when positively actuated.

E^2 is a wheel by which the machine may be driven by hand for adjustment or other purpose, and e^3 e^4 are handles upon the clutch-slides for bringing by hand the clutches into any desired position.

F is a lever, pivoted vertically upon a plate, F', the latter being hinged horizontally at *f* to a bracket, *a*, secured to the bed-plate. A vertical lifting-pin, G, passing up through the bed-plate and bracket, bears against the under side of the hinged plate F' and is adapted when forced upward to lift said plate and raise the inner end of the lever F to a higher horizontal plane. The outer end of the lever is situated between lugs e^5 e^6, secured, respectively, to the slides E E'.

H is a bolt fitted to slide in a bracket, H', carried by the slide E' and adapted to engage with a notch or projection on the slide E, in which engagement it is held by spring *h*, thus locking the two clutch-slides together. (See Fig. 1^a, which is a detail view showing in cross-section a portion of the slide E, together with the bolt H, provided at its outer end with a downwardly-extending tongue, 1, on its under side, which enters a notch in the edge of the slide.) When so locked, it is evident that the oscillation of lever F will throw both clutches, carrying one out of engagement with its pulley and the other into operative contact with its pulley, thus reversing the direction of movement of the needle-cam. When the bolt H is drawn inward (toward the right-hand of Fig. 1) and the clutches unlocked from each other, the oscillation of the lever F in the proper direction will throw one clutch out of engagement without throwing in the other, leaving both pulleys *b b'* loose on their shaft and bringing the machine to rest.

When the pin G, plate F', and the inner end of lever F are in their lowermost position, the outer cylinder, C, is left free to revolve continuously in the same direction. When, however, the pin G is raised—say a quarter of an inch—the inner end of lever F is brought into the horizontal plane of the stop C', carried by the revolving cylinder C. If at such time the lever be in the proper position and the bolt H be for the moment withdrawn, the clutch-slides will be separated by the oscillation of the lever F under the impact of stop C', the clutch in engagement with its driving-pulley will be disengaged, and the machine will thus be automatically brought to rest. When the pin G is raised to an intermediate position—say an eighth of an inch above its lowermost position and an eighth of an inch below its highest position, just referred to—the inner end of lever F will be in the horizontal plane of stop C^2, also carried by the outer cylinder. If at such time the slides E E' be locked together by bolt H, both slides will be shifted by the impact of the stop C^2 against the inner end of the lever F, with the effect of disengaging the clutch from that driving-pulley which was rotating the outer cylinder, C, and stop C^2 in the direction they were pursuing when the latter struck the lever, and by the same movement engaging the other clutch with its oppositely-rotating drive-pulley. This shifting of both clutches causes an instantaneous reversal of the direction of rotation of cylinder C, which carries the stop C^2 around into contact with the opposite side of the inner end of lever F, whereupon another reversal occurs. It will thus be seen that when the pin G and lever F are raised from their lowermost to their intermediate position the continuous rotation of the cylinder C is changed immediately to an oscillatory movement.

An important part of my invention relates to the means by which the lever F and bolt H are operated at the proper times with the above results; but it will be convenient to describe at this point the construction and operation of the needle-cam and thread-guide.

In knitting, the vertical reciprocation of the needles to make the stitches takes place just behind the guide, which has in its passage laid the thread under the hooks of the needles—that is to say, each needle is depressed and raised just after the guide has passed it in its circular path. To enable the knitting to be done in either direction of rotation, instead of

providing two cams, one at each side of the thread-guide, (the cam behind the thread-guide being thrown into operation and the other out by a switch mechanism,) I employ a single stationary cam of very simple construction and reverse the position of the thread-guide relative to this cam at each reversal of the direction of rotation.

Referring to Figs. 1, 9, and 10, I is the usual horizontal groove in the inner face of the outer cylinder, C, on the under side of which groove the outward projections n' of the needles n ride when the latter are in their normal position. I′ is the needle-cam of substantially V shape, its upper corners, i i', projecting into the groove I and above the plane of the projections n'. As the cam proceeds in its circular path in either direction, its forward corner, i or i', catches the projections n' of the needles successively and forces them downward. The cam rides over the projections, which are forced up again behind the cam by the incline j or j' of the cylinder C.

By means of a slot in the cylinder C and a screw, I^2, passing through the slot and engaging the cam, the latter may be adjusted vertically to regulate the length of stitch. Between the cam I′ and the top of the groove I there is left a space, j^2, of a sufficient height to admit the projections n' of the needles. If any of the latter, therefore, be raised and supported in the usual manner with said projections in the horizontal plane of the space j^2, the needles so situated will remain inoperative.

The reciprocation of the needles by the cam I′ in whichever direction the latter rotates will produce a knitted fabric if the thread has been previously laid in the proper direction beneath their hooks.

L is the thread-guide, pivoted vertically at l to the inner end of an arm, L′, which latter is supported above the needles by a post, L^2, carried by the cylinder C. A segmental slot, l', in the thread-guide plays upon a screw-pin, l^2, in the arm L′ and regulates the throw of the thread-guide. By tightening the screw l^2, so as to draw the thread-guide against the arm L′ or against an interposed spring or washer, the guide may be steadied in its oscillation and maintained in either of its two positions from accidental displacement. The thread-guide is provided with one or more eyes, l^3 l^4, which deliver the thread x to the needles against their outer faces and below their hooks. The pin l^2 is about opposite to the cam I′, and when the guide L is in the position shown in Fig. 1 it is properly situated to precede the cam in the direction of the arrow 1 in that figure. If the other end of the slot l' were against the pin l^2, the arrangement would be that for knitting in the other direction.

Various devices may be employed to shift the position of the thread-guide relative to the cam. A simple means consists of a stop, M, carried by the hinged plate F′. These parts are so arranged that when the said plate and the lever F are in their intermediate position and the lever in line with stop C^2 the stop M will be in line with the arms l^5 l^6 of the thread-guide. Thus, by the time that the stop C^2 has caused the reversal of direction of rotation the forward arm, l^5, Fig. 1, of the guide will have been arrested by the stop M and held while the pin l^2 moved to the forward end of the slot l'. As the cam-cylinder C starts back, therefore, at each reversal, the thread-guide will be in proper position in advance of the needle-cam.

To recur now to the devices by which, after the desired length of straight-knit tube has been produced by the continuous rotation of the kneedle-cam, the motion is automatically stopped and changed to an oscillation of the cam past a part only of the needles to form a bend in the fabric, as for the heel or toe of a stocking.

N is a pin mounted so as to reciprocate vertically in the bed-plate in proximity to the cylinder C. It is normally held up by a spring, N′, to such height as to bring the head of the pin within the path of a double-incline cam-plate, O, carried by the cylinder C, by which latter, if the pin is in said normal position, it is depressed whenever the cam-plate passes over it, going in either direction. The lower end of the pin N carries a pawl, N^2, which rests upon the edge of a ratchet-wheel, P, and is adapted to rotate the latter one tooth at each depression.

The ratchet is provided with an adjustable friction device—such as a leather washer, p, compressed by a nut, p', Fig. 3—to limit its movement to the distance to which the pawl N^2 actually forces it. It is very important that such a friction device be provided, as if the ratchet-wheel gets out of time imperfections in the fabric are likely to be produced. The ratchet-wheel P carries with it in its rotation a rigid pattern mechanism, which takes the place of the pattern-chain heretofore employed. It consists, in the construction shown, of an edge cam-wheel, Q, and a side cam wheel, R, having projections so arranged as to produce the proper length of "rounded" knit fabric.

The edge cam, Q, is situated in line with and beneath the lifting-pin G, which latter rests upon its periphery. The wheel is provided with four surfaces, q q' q^2 q^3, Fig. 2. Of these the surface q is the lowest or nearest the center, and permits pin G and lever F to fall to their lowest position for the continuous rotation of the needle-cam. Surface q' is of, say, a quarter of an inch greater radius, and is adapted to raise the lever F into line with stop C′ to bring the machine to rest. Surface q^2 is of a radius intermediate between surfaces q and q', and is adapted to lift the lever F and stop M into line, respectively, with stop C^2 and thread-guide arms l^5 l^6, to cause the oscillatory movement of the needle-cam, and surface q^3 is similar to q'. A spring, f^3, Fig. 13, balances the weight of the hinged plate F′ and parts carried thereby, relieving the cam Q of much friction and giving ease of operation to the machine.

The surfaces q' and q^3 are each of a length equal to one tooth of wheel P. q^2 is of a length to permit as many oscillations of the needle-cam as are necessary to knit the rounded portion of the article to be produced—say seventy—and q is equal to five or six teeth, though this is not strictly material, the object being to obtain a few rotations at the lower rate of speed, as hereinafter explained, before the oscillation commences, as hereinafter explained.

The disengagement of the clutch-slides E E′ from each other by the withdrawal of bolt H, so that both clutches may be thrown out and the machine stopped, is effected as follows:

S is a lever pivoted to the frame at s and engaging the bolt H through the medium of a pin, h', of such length as to permit of the reciprocation of the slide E′ without the disengagement of said pin from the lever. Cams or pins S′ S², carried by the ratchet-wheel P or by cam-wheel Q, pass within operating distance of the lower end of lever S, and as each pin passes it oscillates the lever upon its pivot s and against the stress of spring h, so as to withdraw the bolt H and free the clutch-slides E E′ from each other. The position of the pins S′ S² relative to the surfaces q' q^3 is such that this is done at the time when said surfaces have brought the lever F into position to be struck by stop C′.

As soon as the first step of surface q^2 has been brought beneath the pin G, the straight knitting by rotation ceases and the rounded knitting by oscillation and the reciprocation of a part only of the needles commences, through the operation of the devices already described. In order to measure the length of the straight fabric desired—as the leg of a stocking—before the formation of the heel begins, I have devised a secondary feed, which takes the place of the greater part of the pattern-chain already referred to.

T is a trigger, Figs. 1 and 2, adapted to engage a shoulder, n^4, on the pin N when the latter is depressed. The pin may thus be held down out of the path of cam-plate O, as shown in full lines in Fig. 2. When the pin is so held down, the ratchet-wheel P and cams Q and R will remain at rest, and if at the same time the surface q be under the pin G the continuous rotary knitting will, if power be applied to the machine, proceed indefinitely. As soon, however, as the trigger T is withdrawn, the pin N will fly up under the stress of spring N′, and will then be caused by cam-plate O to feed the ratchet-wheel P. A few steps will carry the surface q^3 under pin G, with the effect of stopping the machine, after which, by properly manipulating the pin N and clutch-slide E, (as hereinafter more fully described,) the machine may again be set in operation with the surface q^2 under the pin G for the purpose of knitting by oscillatory movement. The withdrawal of the trigger may be effected by various means. In the construction shown T′ is a ratchet-wheel engaged by a pawl, t, upon a vertically-reciprocating spring-controlled pin or slide, t', which is depressed at each rotation or oscillation of cylinder C, for convenience, by the same cam-plate, O, that forces down pin N. The ratchet T′ carries a worm, T², engaged by a hook, t^2, upon a spring-arm, t^3. The said arm is secured to a slide, t^4, having an incline or cam face, t^5, adapted to engage a pin, t^6, upon the trigger T.

T³ is a stop, preferably adjustable relative to the slide t^4, against which a shoulder, t^7, upon the slide abuts. The stop T³ having been secured in such position that when abutted by shoulder t^7 the desired number of worm-threads will be left beyond the hook t^2, depending upon the length of straight-knit tube desired, the hook t^2 is lifted by the operator before starting the machine out of the worm-thread, and the slide t^4 moved back as far as permitted by stop T³, when the hook is suffered to spring back into engagement with the worm. At every revolution during the straight knitting the pin t' is depressed, the ratchet and worm rotated one step, and the slide t^4 slightly advanced. As soon as the hook t^2 has reached the end of the worm, the incline t^5 has forced out pin t^6 and trigger T, thus permitting the pin N to fly up and the feeding of ratchet P to begin. After the rounded knitting has been produced, the stop motion just described will be reset. If the leg and heel of a stocking have just been knit and a straight portion of short length is desired for the foot, the pivoted stop T⁴ is dropped into the position shown in Fig. 1 and the shoulder t^7 brought against it, thus leaving a shorter distance of the worm T² to be traversed by hook t^2 before the pin N is again released to cause the rounded knitting for the toe to be produced.

Any well-known or suitable means may be employed to throw out of operation the desired number of needles—say that half of their whole number which is upon the left hand of Fig. 1—by raising them until the cam I′ will pass under their projections n'; also any suitable means may be used to throw a part of the remaining needles out of operation one by one and to again bring them into operation gradually during the progress of the oscillatory knitting. I prefer to employ the devices set forth in the patent already referred to, (No. 350,466;) but such means are well known and need not be here shown or described, except so far as is necessary to make known certain improvements which I have devised in them.

The means for raising one-half of the needles at the end of the straight knitting may consist, simply, of a clasp to engage at once all of the needles to be raised, and a lever for elevating the clasp when so engaged with the needles. Such a device is shown in the patent referred to.

The lifters for engaging the needles one by one alternately at each end of the rank of needles which remain in operation may also be of the character shown in said patent. In Fig. 12 of my drawings are shown the two posts S⁴ S⁵, upon the upper ends of which the

lifters are carried, so as to be reciprocated vertically by pins U U', Figs. 1 and 2, which, as they oscillate with the cylinder C, engage with inclined slots in the upper ends of the lifter-slides u u', alternately raising and depressing them in a well-known manner. The lifters are carried from one needle to the next by geared segments U^2 U^3, to which the posts S^4 S^5 are secured and which are supported so as to revolve in opposite directions upon the needle-cylinder D when actuated by the beveled pinion U^4. Upon the shaft u^4 of this pinion are mounted two oppositely-toothed ratchets, u^5 u^6, Fig. 14. Two corresponding pawls, v^5 v^6, carried by a spring-controlled pin, V, mounted to reciprocate vertically in the bed-plate and adapted to be depressed by the cam-plate O, serve to rotate the shaft u^4 one space at each oscillation of the cam-plate, provided that one of the pawls is in engagement. The direction of feed of pinion U^4 and of the lifter-posts S^4 S^5 depends upon which pawl is so engaged. The positions of the pawls are controlled by pins v v', carried by levers v^2 v^3, pivoted to the frame at v^4 v^4. The lower ends of the levers are connected with bars R' R^2, mounted to slide on pins r, secured to the frame. Said bars are recessed at r', so as to fit closely a cam-plate, r^2, Figs. 15 to 17, carried by a bar, R^3, which latter is adapted to be reciprocated in said recesses r' transversely to bars R' R^2. When bar R^3 is in the position shown in Fig. 15, bar R' is forced far enough to the left by the cam-plate r^2 to leave the pawl v^5 in engagement with its ratchet, while the bar R^2 is in such position as to disengage pawl v^6 from its ratchet. In Fig. 16 the bar R^3 is thrust farther outward, bringing both bars R' R^2 to an intermediate position and throwing both pawls out of engagement, so that the depression of the pin V will have no effect to change the position of the lifter-posts S^4 S^5. In Fig. 17 the bar R^3 is thrust still farther out, in which case the pawl v^5 would be out of and the pawl v^6 in engagement.

The features just described for feeding the needle-lifters from one needle to another are well known, with the exception of the positive action of the cam-plate r^2 upon the bars R' R^2 in each direction, and have been used with a pattern-chain, by which the bar R^3 was operated. The lifters must, however, be fed with much nicety, especially where the cylinder is finely grooved and the needles thin and close to each other, and the chain has been found unreliable for this purpose. I therefore operate the bar R^3 by rigid pattern mechanism, furnished in the construction shown by the side cam-wheel, R, Figs. 2, 3, and 4. The end of the bar R^3 opposite to that which carries the cam-plate r^2 engages with this cam-wheel by pins r^3. The wheel has two lateral surfaces, r^4 r^5, upon opposite sides, the former serving to bring the bar R^3 into the position shown in Fig. 15 and the latter to thrust it out, as shown in Fig. 17. The wheel has also two intermediate spaces, r^6 r^7, both of which bring the bar to the position shown in Fig. 16. The space r^6 is in operation at the same time with the surface q of the wheel Q, and holds both pawls v^5 v^6 out of engagement during the straight knitting by rotary movement. The space r^7 is a space of transition, during which said pawls are again disengaged for one oscillation of the cylinder C in the middle of the rounded knitting, the desired number of needles (of those with which the rounded knitting was begun) having been raised out of operation one by one, and the same needles being about to be depressed again in reverse order by the reverse action of the lifters. When the space r^7 has passed the bar R^3, and space r^5 has thrown the pawl v^6 into operation, the posts S^4 S^5 will be fed away from each other in the directions in dicated by the dotted arrows in Fig. 11. The space r^7 operates when the middle of surface q^2 is under the pin G and the rounded knitting half done.

In order to prevent the ratchets u^5 u^6 from moving otherwise than as intended and getting out of time, I apply a friction device consisting of a spring-arm, Z, carrying a leather pad, z, which presses upon the face of one of the ratchets and maintains it in the exact position to which it is fed.

The adjustment of the ratchets u^5 u^6 relative to each other, so that each lifter may be brought accurately in line, first with a needle and then with a space between needles, is a matter of much nicety. I have materially facilitated it by providing one of the ratchets with a slot and the other with a set-screw, u^8, by which the proper mutual relation of the ratchets may be attained and preserved. I have also provided for an expeditious adjustment of the needle-cylinder in its supporting-ring d, Figs. 11 and 12, thus enabling the proper position of the cylinder relative to the segments U^2 U^3 and to other parts to be secured by means of slots d^2 in the bracket and set-screws d^3, passing through the slots and engaging with the needle-cylinder.

An efficient means for securing the needles in either their raised or their depressed position, preventing them from getting out of place and so causing imperfections in the work, is provided by making the needles with slight projections n^3, having an incline at each end and surrounding the grooved cylinder D by a tension-spring, D', in such position that when the needles are raised said projections n^3 will be just above the spring and resting upon it, and when the needles are down they will in a similar manner be held in place, Fig. 8.

To enable the needles when broken or imperfect to be readily replaced by new ones, I have fitted the cylinder C with a slide, C^5, Figs. 9 and 10, which may be easily drawn out when a retaining-spring, c^5, is lifted, but which when in place completely fills out and makes continuous the top and bottom walls of the groove I by portions c^6 c^7. A V-shaped slot,

c^8, leading to the opening left by the withdrawal of slide c^5 facilitates the extraction of a bent needle.

The plain knitting by the rotary movement may be at a comparatively high speed; but I prefer to run the machine much slower for the oscillatory knitting, in order to prevent injuring the machine by too sudden reversals, and in order that the take-up, which will be applied in the ordinary way, may have time to operate. I have provided for effecting this change of speed automatically just before the end of the straight knitting, the mechanism for which will now be described.

W, Fig. 18, is a power-shaft having driving-pulleys $w\,w$, from which a belt or belts, w', pass to the pulleys $b\,b'$, already described.

W′ is a fast-power pulley loose on shaft W, and W^2 is a slow-power pulley, also loose on the shaft. A sliding clutch, w^2, splined to the shaft, serves to connect with it either pulley W′ or W^2, or to leave both disengaged.

W^3 is a shifting-lever, Fig. 19, adapted to operate the clutch w^2 when actuated by a second lever, w^3, pivoted to the frame at w^4.

W^4 is a link connected with lever w^3 and having a notched slot, w^5, and an operating-handle, w^6.

W^5 is a second link, secured to the link W^4, extending upward to the ratchet wheel P, and provided with a hook, w^7.

P′ is a pin or projection carried by the ratchet-wheel P or some part moving therewith.

a^3 is a fixed pin adapted to engage the notch in slot w^5 and hold the system of levers against the stress of a spring, X, which tends to throw the clutch w^2 into engagement with the slow-power pulley W^2. When the link W^4 is drawn by handle w^6 to the left in Fig. 18 and the notch is engaged with the pin a^3, the fast pulley will be driving the machine and the hook w^7 will be in the path of pin P′. Just before the oscillatory knitting begins—preferably five or six revolutions—the projection P′ reaches the hook w^7 and trips the bar W^4, whereupon the spring throws the clutch away from the fast pulley W′ and into engagement with the slow pulley W^2, immediately reducing the speed of the machine and preparing for the oscillatory movement. This change will ordinarily take place upon the first feed of the pin N after it is released by trigger T.

For convenience in changing the thread, if desired, applying the take-up, and setting the secondary feed-bar f^3, a full stop is caused at the end of the straight and at the end of the rounded knitting by the surfaces $q'\,q^3$ of cam-wheel Q. After each of these stops the operator depresses the pin N by hand and then by handle e^3 draws the clutch-slide E back into the position shown in full lines, Fig. 1, thus setting the machine again in operation.

Any suitable presser-wheels may be employed to travel upon the upper edge of the knitted fabric and keep it properly forced down upon the needles.

The machine being organized substantially as hereinbefore described, its series of movements in knitting, for instance, a stocking may be thus summarized. Starting from the position shown in Figs. 1 and 2, (with the exception that the lever F and slide E will be as shown in dotted lines,) the pin N will be depressed and secured by trigger T and the bar f^3 set for the proper length of leg. Both of the pawls $v^5\,v^6$ will be out of engagement. The operator threads the guide through eyes $l^3\,l^4$, and starts the machine in the direction indicated by the arrow 1 in Fig. 1 by drawing the slide E to the position shown in full lines. When this is done, the slides are automatically locked together by the bolt H. The operator now throws into engagement the fast-speed pulley W′ and engages the bar W^4 with the pin a^3. The straight knitting is now performed at full speed, no feed being in operation but the ratchet and worm T′ T^2. When the leg has been finished, the trigger T releases pin N, which flies up and is immediately depressed by the cam-plate O. This feed movement rotates ratchet P and wheels Q and R one space, carrying the pin P′ against the under side of the hook w^7, thus automatically tripping the bar W^4 and permitting the spring X to throw the clutch w^2 from the fast to the slow speed pulley. The revolution of the cylinder C and the straight knitting continues for a few feeds of the pin N until the surface q^3 and pin S^2, respectively, raise the lever F into line with stop C′ and withdraw bolt H. Immediately after this is done stop C′ oscillates lever F, shifts the slide E to the position shown in dotted lines in Fig. 1, throws out the clutch c, and stops the machine. The operator now changes the thread if a heavier yarn be desired for the heel of the stocking, places the usual take up in operative position, and is ready for the rounded knitting of the heel. He then forces down by hand the pin N, giving one feed to the ratchet P. This brings surface q^2 under the pin G, dropping lever F out of the path of stop C′, but maintaining it in line with stop C^2, and also bringing the stop M into the plane of the thread-guide arms. At the same time the pin S^2 releases lever S and bolt H, leaving the latter free to engage the slide E as soon as the slide is shifted. The same feed movement carries the part r^4 of wheel R into engagement with the bar R^3, shifting the latter into the position shown in Fig. 15 and permitting the pawl v^5 to engage its ratchet. The operator then thrusts out the pin U by means of slide U^5, said pin, together with the pin U′, being afterward alternately protruded in a well-known manner by the contact of inclines U^6 U^7, affixed to the bed-plate with posts $u^{10}\,u^{11}$, carried by the pins. The operator now raises about one-half of the needles—those at the left of Fig. 1 preferably by a clasp, which lifts them all at once—in which position the needles are sustained by the spring D′. The inner clutch-slide, E, is now shifted by hand so as to re-engage the clutch c, the bolt H immediately lock-

ing the slides together, whereupon the outer cylinder is set in motion, still in the direction of the arrow 1 in Fig. 1. The thread-guide carries the thread past the last of the depressed needles and strikes stop M and is arrested, while the rotation of the cylinder continues until the cam I′ passes the guide and the stop C^2 strikes the lever F. The reversal immediately takes place and the motion of the cylinder becomes a series of substantially complete revolutions in alternate directions, which continues until surface q^2 has passed from under the pin G. In the meantime the pawl v^5, by the operation of cam O upon pin V, feeds the lifter-posts S^4 S^5 step by step toward each other from one needle to the succeeding space and thence to the next needle, the lifters being alternately raised with the needles and depressed without them in a well-known manner by the pins U U′ and inclined slots in slides *u u′*. This continues until the space r^7 of wheel R engages the bar R^3, throwing out pawl v^5. By this time, say, eighteen needles have been taken from each end of the rank of depressed operative needles and added to the rank of those which are raised and inoperative. The space r^5 now comes into operation, throwing in pawl v^6 and feeding back the needle-lifters step by step away from each other. The lifters are now raised when in the spaces between the needles and depressed when in line and in engagement with them, thus carrying down the needles into operative position one by one in the reverse order to that in which they were raised. The oscillatory knitting with a constantly-increasing number of needles continues until the surface *q′* and space r^6 come into operation, by which time the needles at the right hand of Fig. 1 will have been all depressed and the rounded knitting finished. The machine now comes to a stop, the thread is changed, if desired, the shoulder t^7 is set against the stop T^4 to give the desired length of straight knitting for the foot, and the pins U U′ are thrust in. The operator now depresses the pin N once, which brings surface *q* under the pin G, dropping the lever F to its lowest position. The space r^6 of wheel R merely advances one step and still holds the bar R^3, so that both pawls v^5 v^6 will remain disengaged. When the pin N is thus depressed, it is secured by thrusting in the trigger T. The machine is now ready for straight rotary knitting, and is set in motion by shifting the clutch-plate E, so that its clutch *c* will engage the driving-pulley *b*. The rotary knitting now begins, and the fast-power pulley may be used by drawing the bar W^4 to the left and engaging it with the pin a^3, as shown in Fig. 18. As soon as the foot is finished, the trigger T will release pin N, which will be immediately operated upon by cam O, will throw out the fast-speed pulley, and will in a few revolutions bring the machine to a rest, as at the end of the leg. A rounded portion for the toe may now be knit in the same manner as that for the heel.

It will be understood that various styles of fabric may be produced by a rigid pattern mechanism such as I have devised, it being only necessary to shape the mechanism, as by providing cam-surfaces of various lengths in the proper manner.

Having described my invention, what I claim is—

1. The combination, with the hinged plate F′, the mechanism for controlling the position of the same, the stop M, carried by said plate, the lever F, mounted also on said plate, and the reversing mechanism controlled by said lever, of the needle-cylinder, the rotary cam-cylinder and needle-cam carried thereby, the driving devices between the cam-cylinder and the reversing mechanism, the shifting thread-guide adapted to take a position and to deliver thread to the needles at either side of the cam, and the stop C^2, carried by said cam-cylinder, substantially as and for the purposes hereinbefore set forth.

2. The combination, with the needle-cylinder, of the rotary cylinder provided with a horizontal internal groove, I, with portions of the top and bottom walls of the groove removed, so as to leave a vertical passage extending from the top to the bottom of the cylinder of the same depth as the groove, in combination with the slide C^5, provided with filling-plugs c^6 c^7, and a detent, c^5, as and for the purposes hereinbefore set forth.

3. The combination, with the pattern mechanism by which the sequence and duration of the movements of the cam-cylinder are determined and controlled, of a detent or trigger by which said mechanism is held in inoperative position, and trigger actuating and controlling mechanism, whereby said trigger is actuated at predetermined times to release and permit the operation of the pattern mechanism, substantially as and for the purposes hereinbefore set forth.

4. The combination, with the needle-cylinder, the rotating cam-cylinder having cam-plate O, and the mechanism for actuating said last-named cylinder, of the ratchet-wheel P for operating the pattern-cams, the depressible rod N and its pawl N^2 and spring N′, the trigger T for locking the rod N in depressed position, where it will not be acted on by cam-plate O, and the mechanism whereby said trigger is disengaged from and caused to release the rod N at the times and in the manner substantially as hereinbefore set forth.

5. The combination, with the needle-cylinder, the rotary cam-cylinder provided with stops C′ C^2, and the power mechanism for actuating said last-named cylinder, of the pattern cam-wheel Q, provided with surfaces *q q′* q^2 q^3, the rod G, the hinged plate F′, the lever F, and the reversing devices operated on by said lever, substantially as and for the purposes hereinbefore set forth.

6. The combination, with the needle-cylinder, the rotary cam-cylinder having stops C′ C^2, and cam-plate O, the lever F, its hinged

supporting-plate, the clutch-slides E E′, the reversing-clutch mechanism controlled by the same, and the bolt H, of the lifter-rod G, the lever S, the pattern-cam Q, provided with surfaces q q' q^2 q^3 and pins S′ S², the depressible rod N, pawl N², spring N′, and ratchet P, the trigger T for locking said rod N in depressed condition, and the mechanism whereby said trigger is caused to release said rod, substantially as and for the purposes hereinbefore set forth.

7. The combination, with the pattern-cam and the stop P′, carried by said cam or some part moving in unison therewith, of the driving-shaft, the reversing mechanism, the fast and slow pulleys W′ W², loose on said shaft, the clutch for connecting one or the other of said pulleys with the driving-shaft, the system of shifting-levers for said clutch, the link W⁴, spring X, stop a^3, and the link W⁵, connected to said system and arranged and adapted to be operated by the stop P′ at the time and in the manner substantially as hereinbefore set forth.

8. The combination, with the devices for feeding the needle-lifters and the grooved needle-cylinder, of a supporting-bracket for the latter and clamping devices for adjusting the needle-cylinder upon its support relative to said feeding devices, substantially as set forth.

9. The combination, with the ratchets and pawls for feeding the needle lifters, the bar R³, and the bars R′ R², of the double-incline cam-plate r^2, engaging the bars R′ R² and adapted to operate them positively in either direction, substantially as set forth.

In testimony whereof I have hereunto set my hand this 23d day of June, A. D. 1887.

SAMUEL G. HALL.

Witnesses:

CHARLES E. LANSING,

FRANK KNIFFIN.