E. E. KILBOURN.

CIRCULAR KNITTING MACHINE.

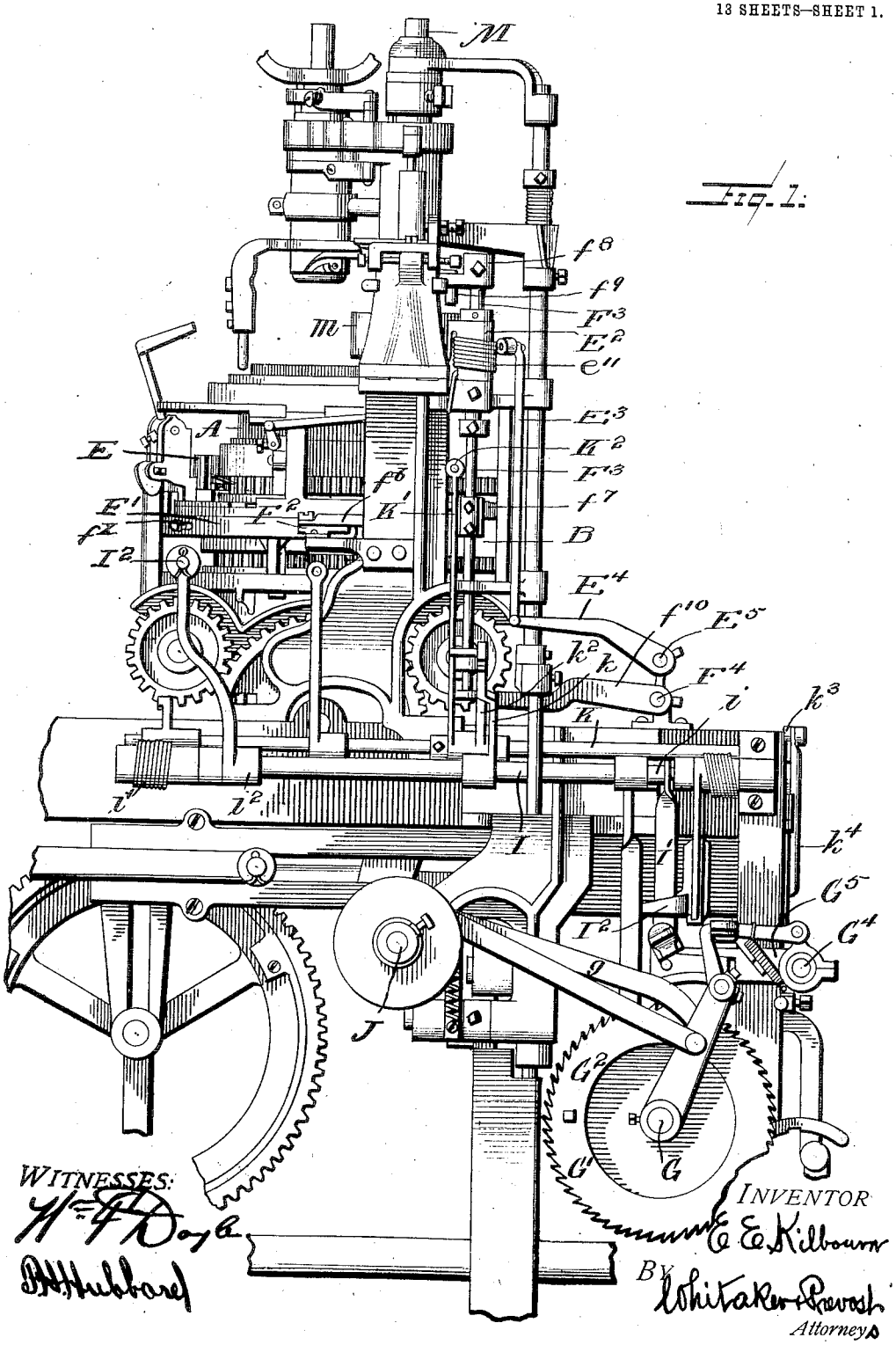
APPLICATION FILED OCT. 1, 1904.

1,044,537.

Patented Nov. 19, 1912.

13 SHEETS—SHEET 1.

Fig. 1.



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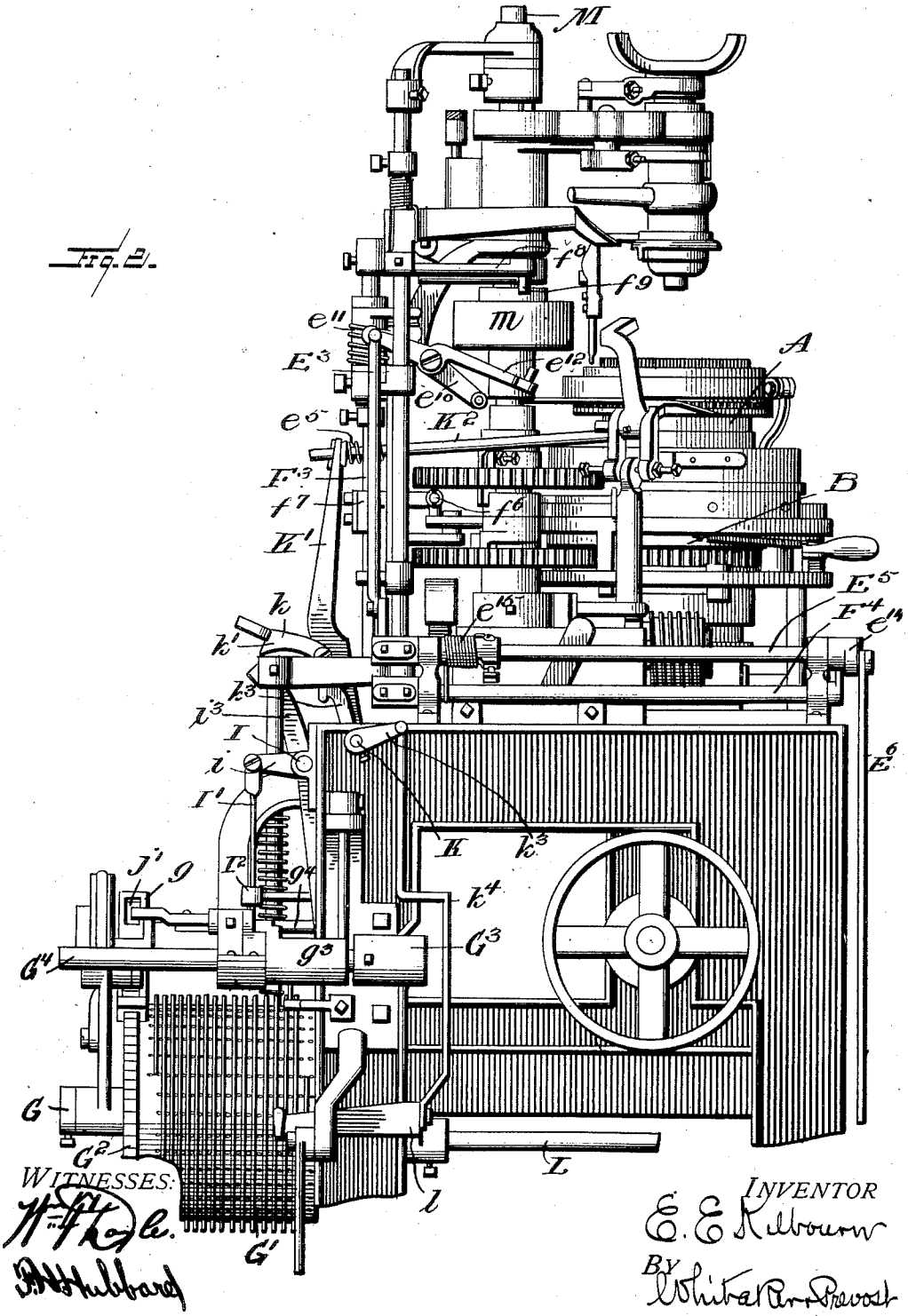
13 SHEETS—SHEET 2.

FIG. 2.



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13 SHEETS—SHEET 3.

Fig. 3.

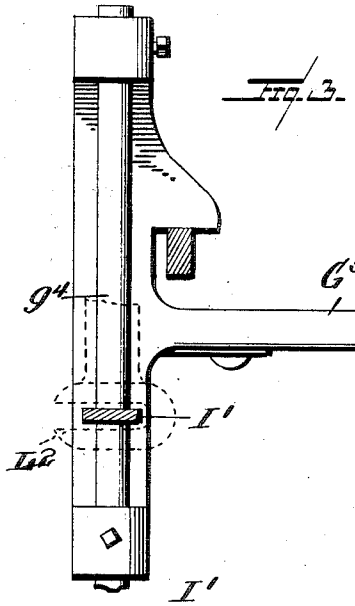
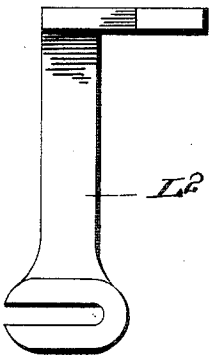


Fig. 5.



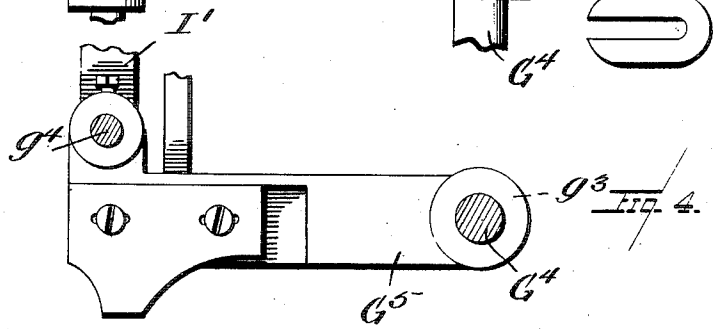
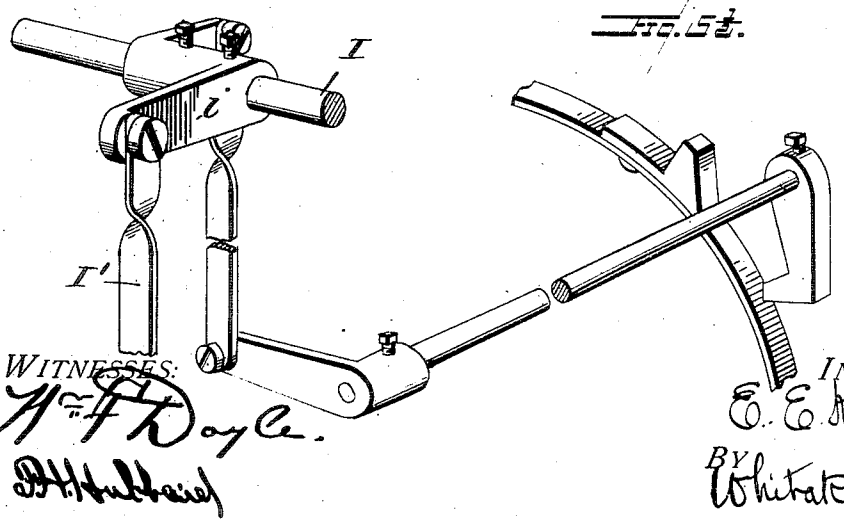


Fig. 4.

Fig. 5a.



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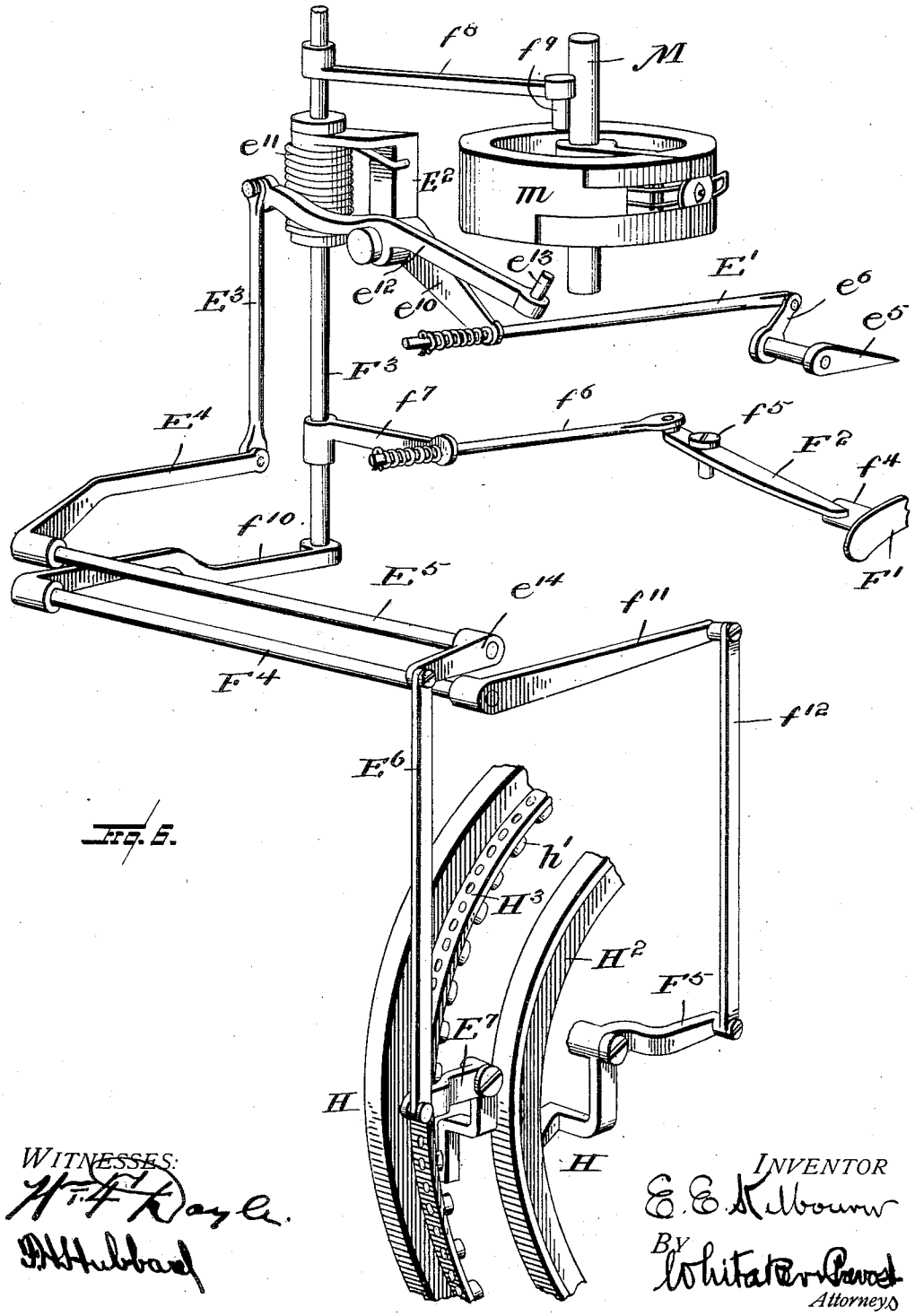

Fig. 5.

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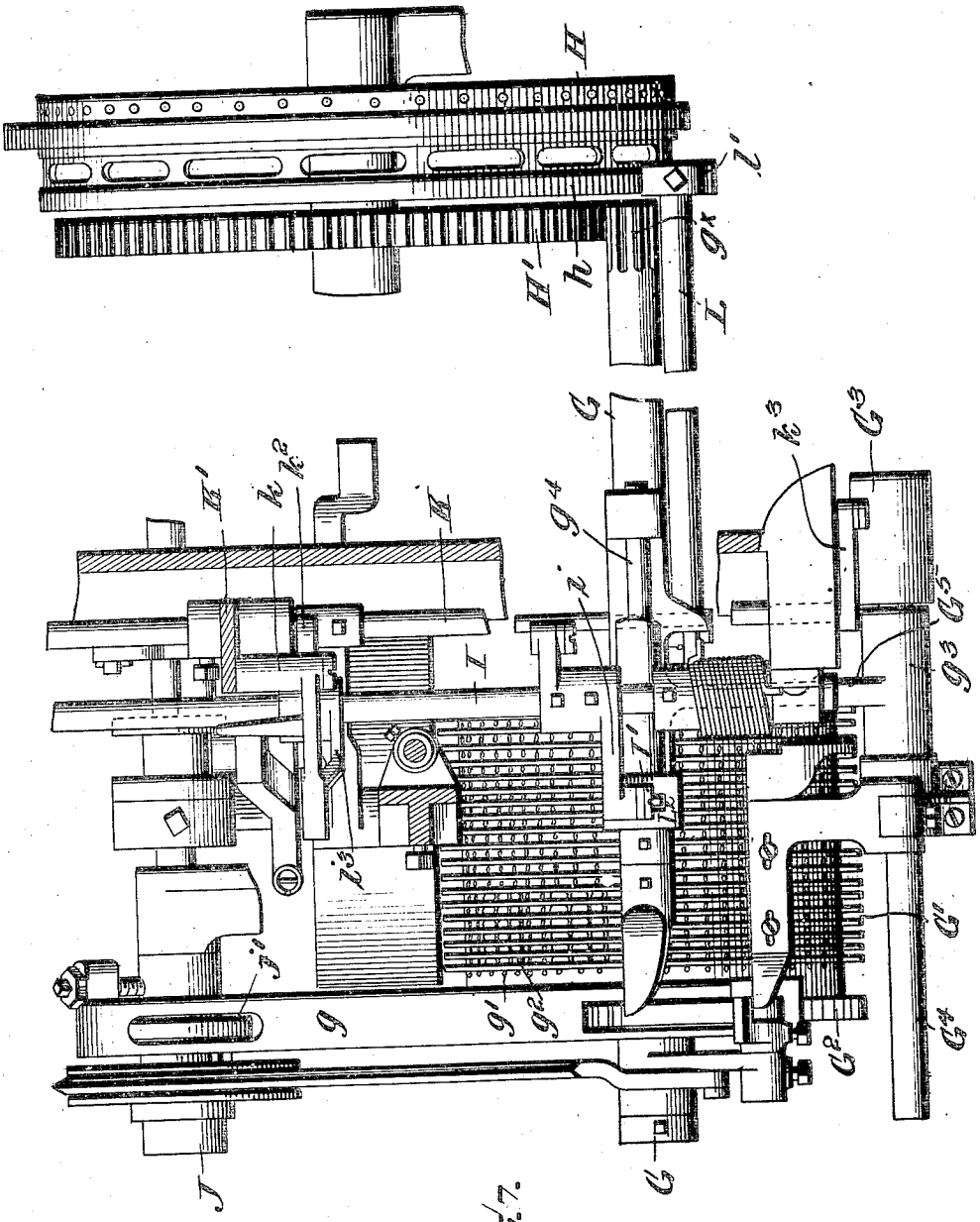

Fig. 7.

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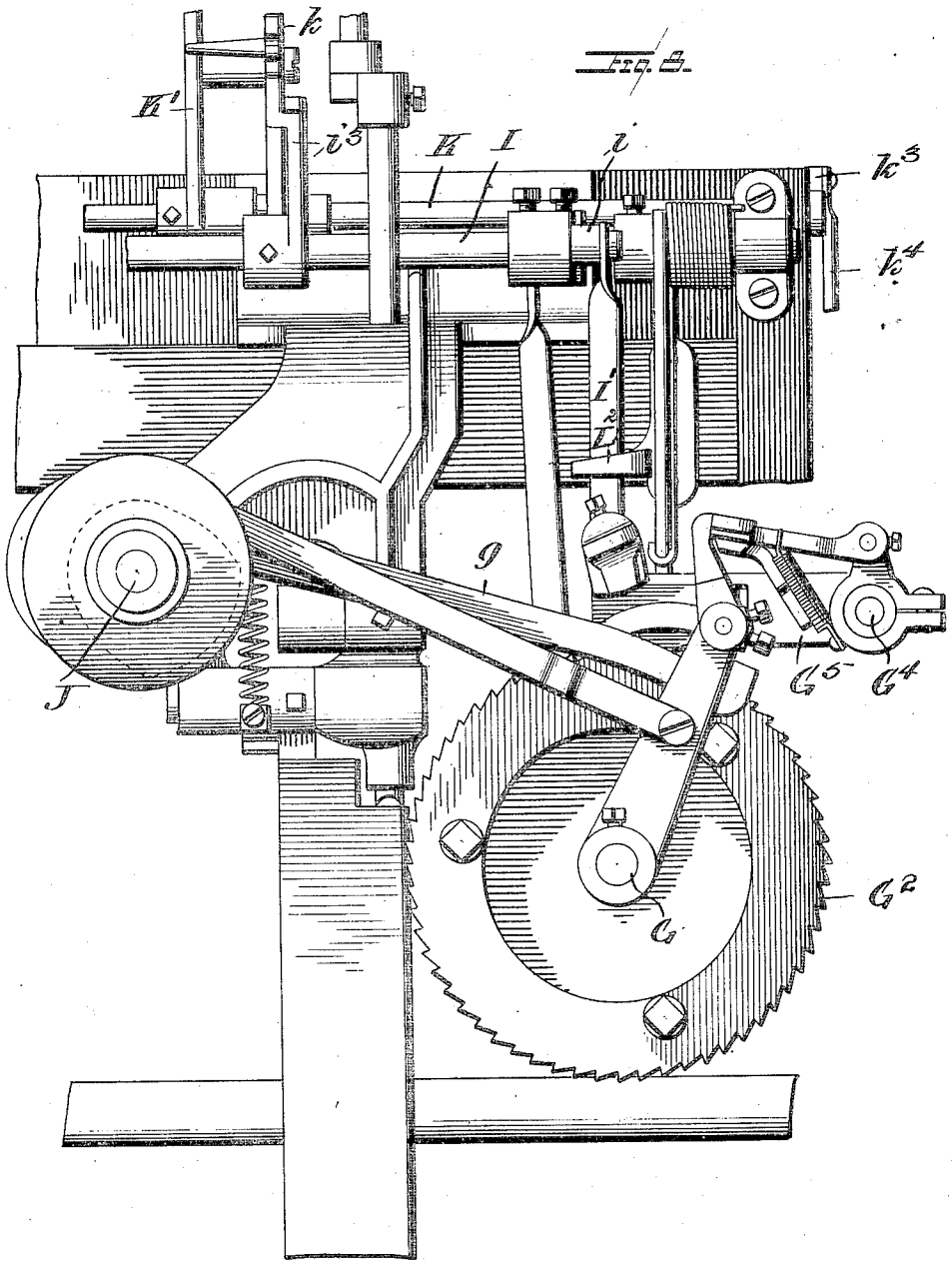
13 SHEETS—SHEET 6.

FIG. 8.



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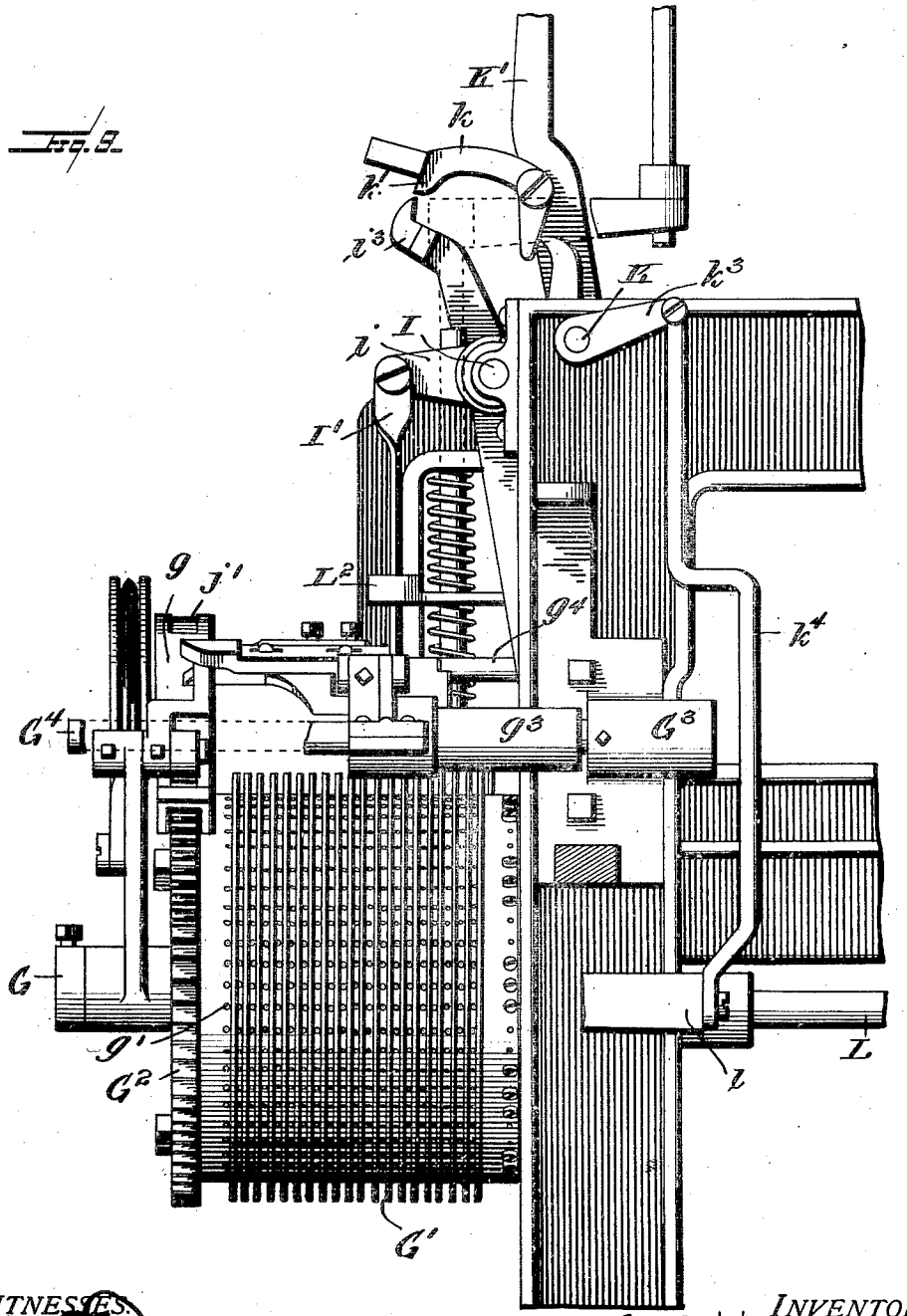
13 SHEETS—SHEET 7.

Fig. 8.



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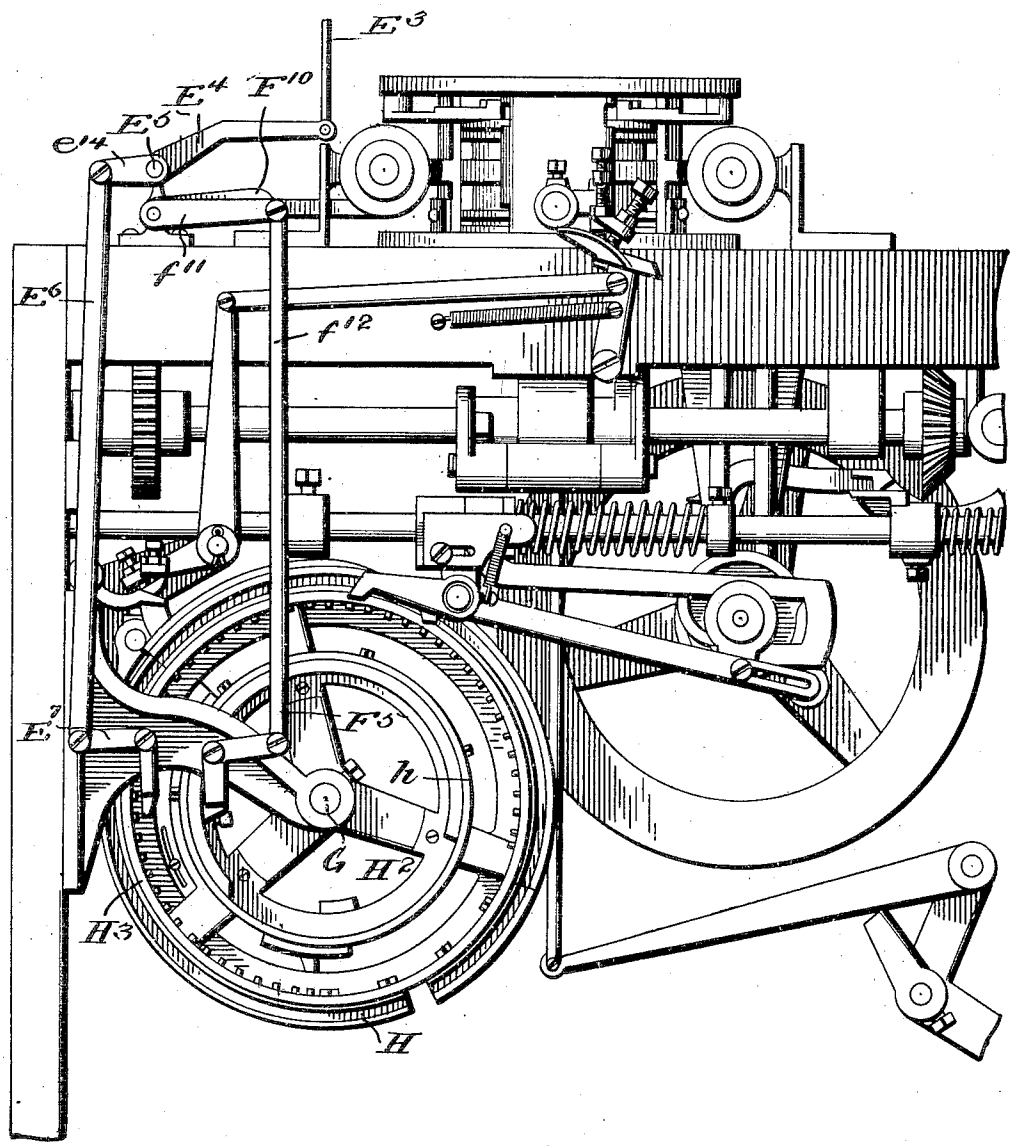
13 SHEETS—SHEET 8.

Fig. 10.



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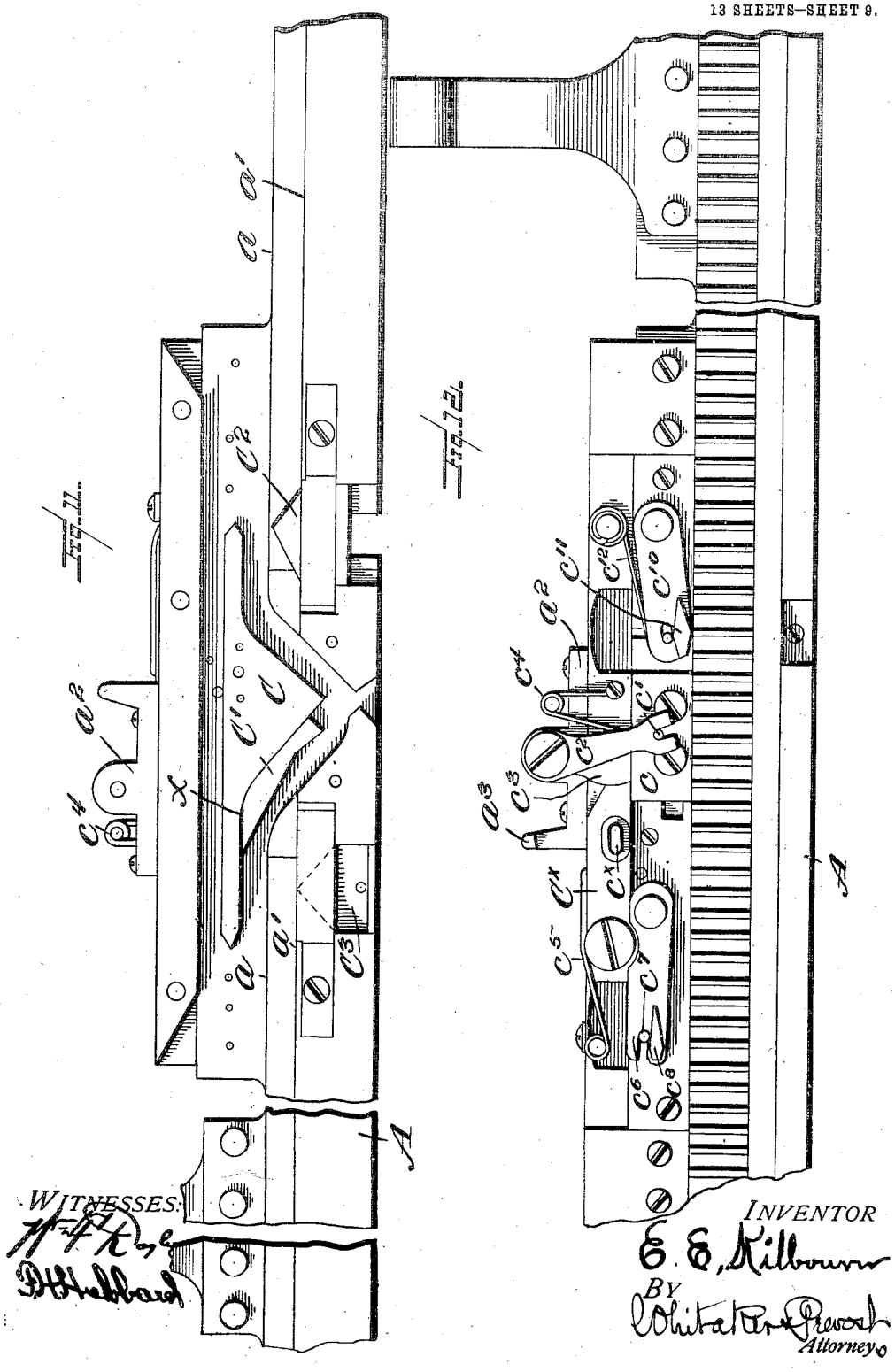
13 SHEETS—SHEET 9.



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13 SHEETS—SHEET 10.

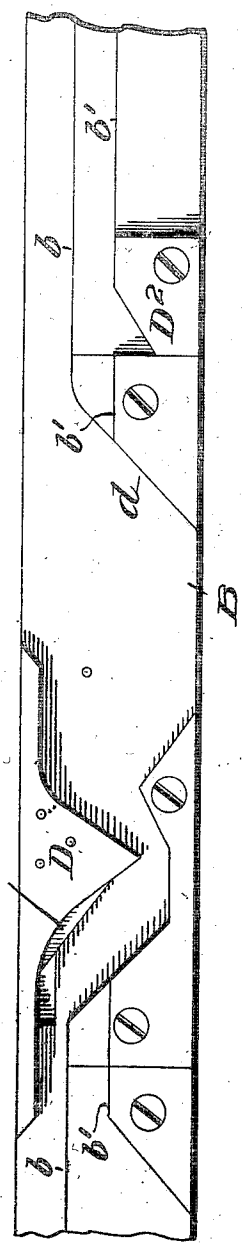

Fig. 14.

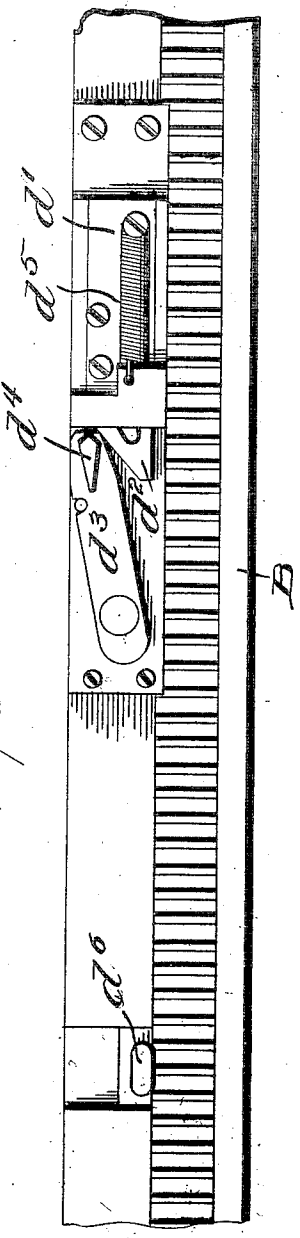

Fig. 15.

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13 SHEETS—SHEET 11.

Fig. 15.

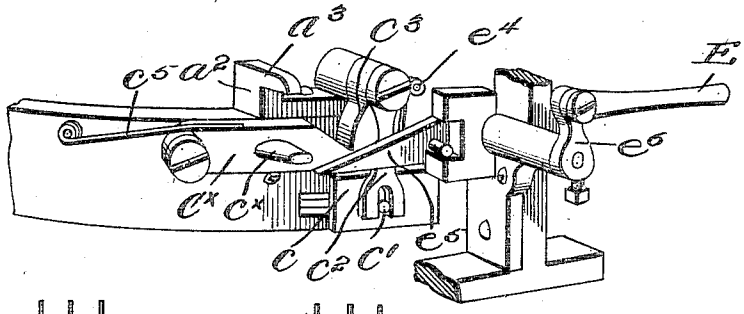


Fig. 22

Fig. 23

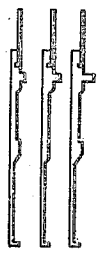


Fig. 24

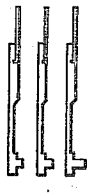
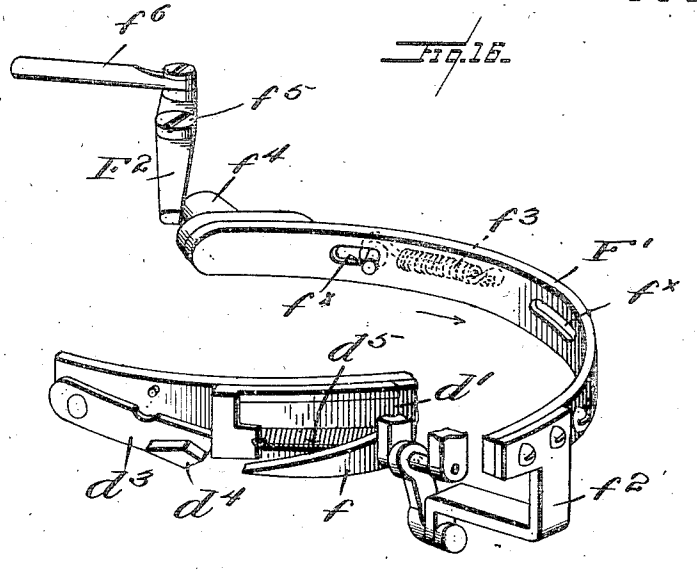


Fig. 16.



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APPLICATION FILED OCT. 1, 1904.

1,044,537. Patented Nov. 19, 1912.

13 SHEETS—SHEET 12.

Fig. 16.

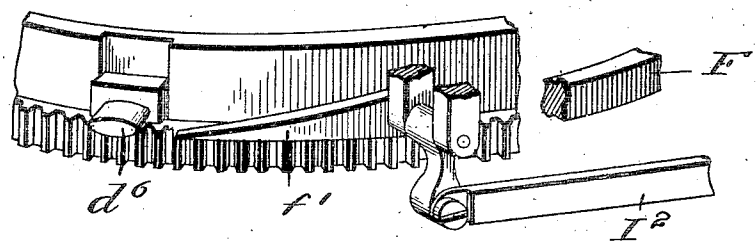
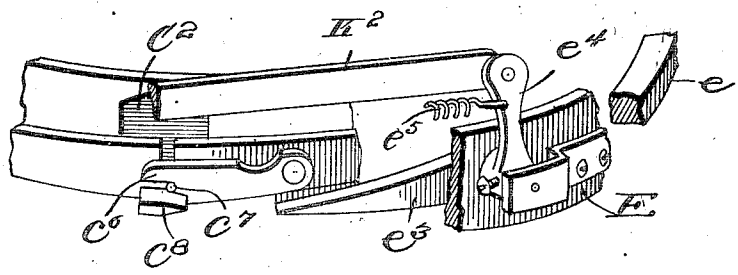


Fig. 17.



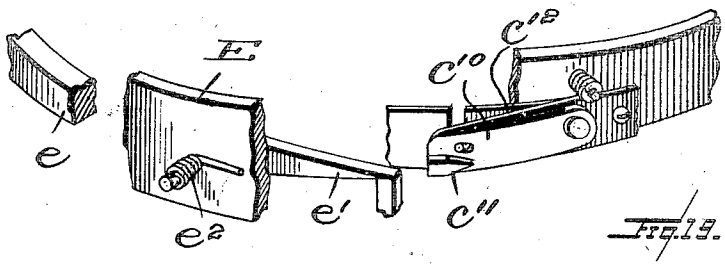


Fig. 19.

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APPLICATION FILED OCT. 1, 1904.

1,044,537. **Patented Nov. 19, 1912.**

13 SHEETS—SHEET 13.

Fig. 20.

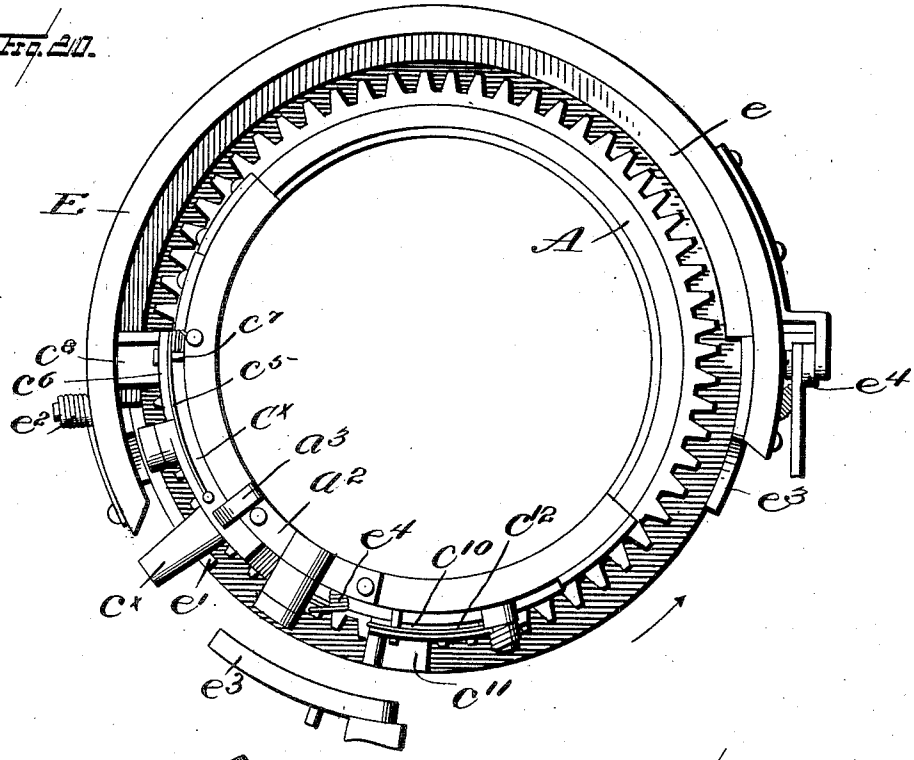
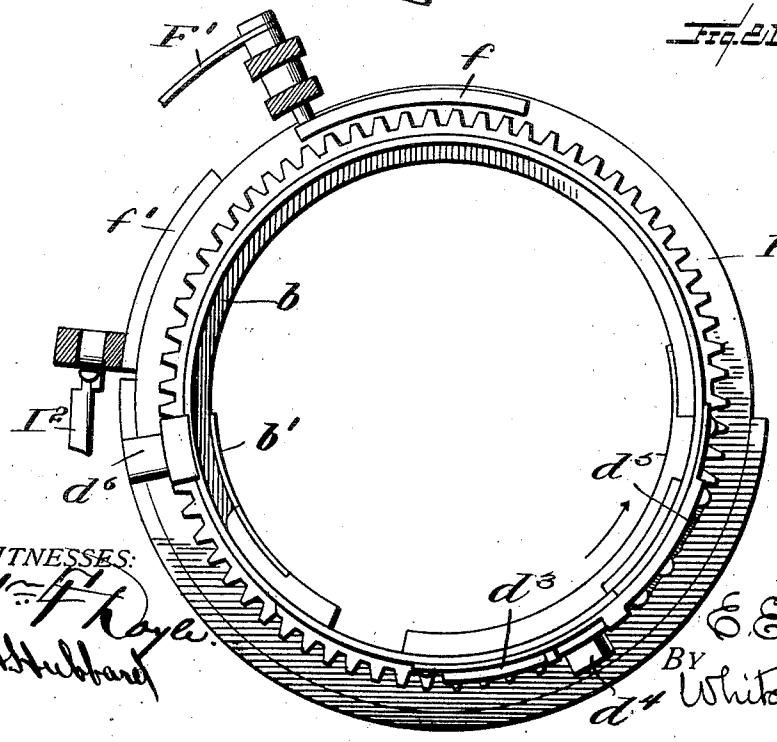


Fig. 21.



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Attorneys

UNITED STATES PATENT OFFICE.

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CIRCULAR-KNITTING MACHINE.

1,044,537. Specification of Letters Patent. Patented Nov. 19, 1912.

Application filed October 1, 1904. Serial No. 226,774.

To all whom it may concern:

Be it known that I, EDWARD E. KILBOURN, citizen of the United States, residing at New Brunswick, in the county of Middlesex and State of New Jersey, have invented certain new and useful Improvements in Circular-Knitting Machines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My present invention relates to the art of knitting and more particularly to the class of circular knitting machines.

It consists of an improved circular knitting machine wherein are embodied certain new constructions and combinations of parts whereby new and desirable results are produced.

In the accompanying drawings I have illustrated one form in which I have contemplated embodying my said invention and the same is disclosed in the following description and claims.

In the drawings, Figure 1 is a rear elevation of an automatic knitting machine with my invention applied thereto. Fig. 2 is a view in elevation of the left end of such machine. Fig. 3 is a top or plan view of the lever engaging the pattern cylinder. Fig. 4 is a side or end view of the same. Fig. 5 is a top view of the stationary guide coacting with said lever. Fig. 5½ is a perspective of the device for lifting the said lever. Fig. 6 is a view of the pattern wheel and connections for controlling the cams of the cam cylinders isolated from the machine. Fig. 7 is a top or plan view of the pattern cylinder and connections. Fig. 8 is a rear view of the said pattern cylinder and connected devices. Fig. 9 is a view of the pattern cylinder viewed from the left end of the machine. Fig. 10 is a view of the pattern wheel and coöperating devices viewed from the front of the machine. Fig. 11 is a view of the interior of the upper cam cylinder developed in a straight line. Fig. 12 is a similar view of the exterior of such cylinder. Fig. 13 is a similar development of the interior of the lower cam cylinder. Fig. 14 is a like view of the exterior of the lower cam cylinder. Fig. 15 is a detail of the cam plate and connections for moving the drop stitch cam of the upper cam cylinder. Fig. 16 is a like view of the cam plate for moving the drop stitch cam of the lower cam cylinder. Fig. 17 is a like view of the cam plate for moving the tuck stitch cam of the upper cam cylinder. Fig. 18 is a like view of the cam plate for moving the tuck stitch cam of the lower cam cylinder. Fig. 19 is a like view of the cam plate for moving the supplemental riser cam for the upper cam cylinder for reciprocating work. Fig. 20 is a plan view showing the relation of the cam plates to the upper cam cylinder. Fig. 21 is a like view showing relation of the cam plates to the lower cam cylinder. Figs. 22, 23 and 24 are views of the needles employed in the machine.

In the knitting of seamless hose of the open or lace work pattern, it is desirable to have open or lace work begin below the top of the leg of the stocking so that in case of full hose, a strong hem or welt can be secured, and in both full and half hose it is desirable that a strong union at the toe may be readily and easily made. It is also desirable to knit the open or lace work on the back of the leg of the stocking, and yet be able to knit the heel and bottom of the foot and toe of the stocking of solid plain knitting and to knit solid plain knitting on the top of the foot of the stocking before reaching the toe, so that there shall be solid plain knitting on both sides of the closure near the toe of the stocking. These results I accomplish by the improvements herein set forth and I am also enabled to knit drop stitch open work, lace work and solid plain knitting in any order or in such proportions as may be desired; to change on the back of the leg to solid plain knitting when desired without changing the work on the front of the leg of the stocking; and I am also able to knit a different pattern of open or lace work on the back of the leg from that on the front of the same. I can also knit tuck stitch, open lace work or solid plain knitting in any order or sequence upon the leg and can knit a different pattern of such various stitches upon the back from that knit upon the front of the leg of the stocking.

The features of novelty which constitute my present invention are here shown as applied to the type of automatic circular knitting machine shown and described in my former Patent, No. 669,730 granted Mar. 12, 1901 and my Patent No. 679,281

July 23, 1901 and I prefer to use said devices when applied to such a machine but I desire it to be understood that the principle of my invention and many of its details can be used in connection with other forms of knitting machines.

The knitting machine to which my novel features of construction are applied is provided with two cam cylinders, each actuating and controlling approximately one-half of the needles of the needle cylinder. The upper cam cylinder in this instance actuates the needles for knitting the rear half of the leg of the stocking and the lower cam cylinder actuates the needles for knitting the front half of the leg of the stocking.

In Fig. 1, A indicates the upper cam cylinder and B the lower cylinder. The construction and arrangement of the cams of cam cylinder A are shown in Fig. 11, while Fig. 13 shows the cams of cam cylinder B.

In Fig. 11, C is the knitting cam which is fixed and immovable. The side of this cam next to the interior wall of the cam cylinder is recessed to receive the sliding cam C'. This cam has a projection which extends outwardly through a slot in the cam cylinder and to this projection is secured the plate c which is provided with a pin c'. The pin c' is engaged by the bifurcated end of a short lever c^2, see Fig. 12, pivoted to a plate a^2 secured upon the upper edge of the cam cylinder. The lever c^2 is provided on one side with the cam lug c^3 and has its opposite side engaged by the free end of a spring c^4 whose opposite end is secured to the cam ring. On the side of the lever c^2 which is provided with the cam lug c^3 is the lever C^x which is pivoted to the cam ring, or some part rigidly connected thereto. The free end of this lever normally rests above the cam projection c^3 and is provided with an outwardly extending projection c^x. A spring c^5 bears upon the free end of the lever C^x and tends to press the same downward and to hold it down when in a depressed position. By pressing the lever downward, its free end engages the cam lug c^3 and forces the free end of the lever c^2 to the right as shown in Fig. 12 and moves the slide c and cam C' to the right or to the position shown in Fig. 11. When forced to this position the lever C^x becomes a lock holding the lever c^2 and cam C' in the positions shown in Figs. 11 and 12 until the lever C^x is raised to its upper position and the spring c^5 tends to hold the lever against accidental displacement. The plate a^2 is provided with a lug a^3 to engage the lever C^x and limit its upward movement. The needles which knit the back of the leg and the heel, bottom of the foot and toe of the stocking are themselves or their jacks provided with nibs which are acted upon by the cam C of this cam cylinder. The needles acted upon by this cylinder are shown in Figs. 22 and 23. The nibs of these needles are of three lengths. This series of needles includes the fashioning needles 1^a, 2^a and 3^a each having the additional nib 4 which is engaged by the pickers of the machine for throwing them out of and into action in narrowing and widening. The other needles 1, 2 and 3 are employed between the two series of fashioning needles. Of the needles operated by this cam cylinder the shortest nibs normally rest upon the ledge a'. In this position the latches of the needles are below the loop upon the needle, and when the nib engages the cam C the needle is depressed but fails to cast off by reason of the latch closing upon the loop. The nibs of the remaining needles normally rest upon ledge a. The nibs of these needles are of two lengths, a part having nibs long enough to engage the cam C' when in the position shown in Fig. 11, the others having a shorter nib which will only engage the cam C. Of these needles those having the shorter nibs do not engage the cam C' and at every revolution of the machine knit a plain stitch.

The machine preferably knits with what is termed a short lead, that is, with the thread guide but a short distance in advance of the knitting cam, or the knitting point. These needles take the thread at about the point x and are immediately drawn downward to make the stitch. The other, and longest nibbed needles before reaching the point x, when the cam C' is in the position shown in Fig. 11, engage such cam and are drawn downward before the thread guide has reached the point at which such needles would normally take the thread and continue to move downward below the cams C' and C, casting off the loops if any that may be upon them. Such needles so long as cam C' is in the same position, continue to engage the cam C' and do not take the thread though otherwise going through the movements of knitting.

The needles having the shortest nibs and which normally rest on ledge a' are at such height that the thread will be laid against such needles below the hook of the same on each revolution of the machine but as the latch is below the loop on the needle they will not knit when depressed by the cam C. When it is desired to have such needles knit their nibs will be raised to the level of the ledge a by the cam C^2. This cam when in its depressed position will have the apex of the same on a level with or slightly below the ledge a'. When it is desired to have these needles knit the cam C^2 is raised until the apex of the cam is on a level with the ledge a. In this position the needles will be raised and the latches of the same brought above the loop and threads on such needle and such needle will then take the

thread at the point x and knit a stitch locking the threads that have been laid below its hook, thereby forming tuck stitch knitting.

The cam C^2 is connected with a block sliding in a guide way in the cam cylinder and such block is operatively connected with the lever c^6. In this instance the said block is provided with a pin c^7 which engages with the bifurcated end of the lever c^6. This lever is provided with an outwardly extending projection c^8 by which the lever is moved to raise or lower the cam C^2. When the cam C′ is moved behind the cam C and the cam C^2 is maintained in its elevated position, the machine will when revolved knit solid plain knitting with all the needles actuated by the upper cam ring. When it is desired to reciprocate the cam cylinder to produce reciprocating knitting, another cam C^3 of like construction will be raised to the level of the ledge a. This cam is raised and lowered by a lever c^{10} provided with a projection c^{11}, similar to the lever for operating the cam C^2. A spring c^{12} bears upon the upper side of the lever c^{10} and tends to maintain it in its lower position.

The arrangement of cams in the lower cam cylinder B is simpler, for as the needles operated by this cam cylinder do not knit during reciprocating knitting, provision for such knitting is omitted. This cam cylinder is provided on the inside with the knitting cam D, which like the cam C of the upper cam cylinder may engage all of the needles provided with nibs for this cylinder. As in the case of the cam cylinder A, the needles of this cam cylinder are divided into three classes having nibs of different lengths. These needles are shown at 5, 6 and 7, Fig. 24, having nibs of different lengths corresponding to the lengths of the nibs of the needles actuated by the upper cylinder. The shorter nibs are normally raised by the riser cam d to the heigh only of the ledge b'. This does not raise the latches above the loops upon the needles, and as the thread guide and cam D approach these needles the thread is laid across the needles below the hook, the cam D then depresses them but owing to the latch being below the loop of the needle, the needles do not cast off. The other needles are provided with nibs of different lengths but both are raised by the riser cam to the height of the ledge b in which position the latches are above the needle loops. The cam D is directly below the cam C of the upper cam cylinder A and as D approaches these needles they take the thread at the same point and are forced downward to knit the ordinary plain stitch.

The cam D is provided with an auxiliary cam D′ bearing the same relation to the cam D that the cam C′ does to the cam C. This cam is shown in Fig. 13 in its withdrawn or retracted position. It has a projecting part extending outward into a slot in the wall of the cylinder B, and to this projection is secured the slide d' moving in a guide way on the outside of the cylinder. This slide is provided with the cam faced end d^2. A lever d^3 is pivoted to the cylinder having its free end normally above the cam faced end of the slide d' and said lever is provided with an outwardly extending lug d^4. A spring d^5 is so connected to the slide d' as to force the slide beneath the free end of the lever d^3, when such lever is in its raised position. In this position of the lever and slide the cam is in its retracted position behind cam D. By forcing the free end of the lever d^2 downward it engages the cam face of the slide d' and forces it to the right (see Fig. 14) and moves the cam D′ out from behind the cam D and into the position shown by dotted lines. When forced to this position the cam and lever are locked as the force of the spring d^5 tends to move the lever downward. In this position the cam D′ will engage the longer nibbed needles of the ledge b and begin to depress them before they have taken the thread from the thread carrier. It then moves them downward and causes them to cast off the loops that may be on them, thereby dropping their stitches, and while the cam D′ remains in this position the needles engaged do not knit.

D^2 is an auxiliary riser cam which engages only the nibs of the needles which rest on ledge b', and engages these only when in a raised position. This cam is secured to a slide in a vertical guide way in the cylinder, and this slide has a projection d^6 extending outwardly beyond the cylinder by which the cam may be raised and lowered. When this cam D^2 is in its raised position, and the cam D′ is in its retracted position, all of the needles take the thread from the thread guide and knit a course of plain stitches at every revolution of the machine. When the cam D^2 is in its lower or inoperative position the needles that are raised only to the height of ledge b' are not raised high enough to bring the latch of the needle above the loop on the needle and the downward movement of such needle by the cam D does not cause it to cast off its loop as the latch closes upon the thread in the hook. The needle is, however, raised so high that at every round of the thread guide a thread is laid across the needle below the hook and above the latch.

The needles of the needle cylinder are divided on a line running longitudinally of the machine into two sections, each containing about one-half of the needles of the machine. The section of the needles nearest the front of the machine or that side of the same shown in Fig. 10 are provided with

nibs to engage the cam constructions of the upper cam cylinder A, and the needle section that is near the rear side of the machine or that shown in Fig. 1, are provided with nibs to engage the cam construction of the lower cam cylinder B. It will thus be seen that at each rotation of the machine the cams of the cylinder A are for approximately one-half of its revolution out of contact with the nibs of the needles that are actuated by it. It is during this period of the revolution of this cam cylinder that the cams are moved from one position to the other.

The cams C′, C^2 and C^3 are moved into and out of operative position by cam plates located on stationary parts of the machine, so as to act upon said cams during the period that they are out of engagement with the nibs of their needles. These devices are more particularly shown in Figs. 15, 17, 19 and 20. In order that these cam plates may act each upon its cam without affecting the others, they are mounted in different vertical planes and the pins or projections for engaging with them are made of different lengths to engage therewith.

E is a stationary ring or casing which extends wholly or partially around the upper cam cylinder. It extends in this instance around the needle section operated by the upper cam cylinder and a little beyond each edge of the section. This casing E is provided on its inner side with a ledge or flange *e* extending inwardly toward the cam cylinder. A cam plate *e′* is pivoted in line with this ledge or flange and a spring e^2 serves to normally keep it in a depressed position. The inner side of this cam plate is flush with the inner face of the flange *e*. At the other end of the flange is pivoted the cam plate e^3. This cam plate is of half the thickness of the flange *e* and is so mounted that its outer side is against the inner side of the casing E, and therefore, extends inwardly only half the width of the flange.

The cam C^3 is to be operated only during reciprocating work. The projection c^{11} to operate such cam is of such length that it does not engage with the cam plate e^3 and as the cam cylinder is rotated in the direction shown by the arrow in Fig. 20, the projection c^{11} passes under the flange *e*. This flange, as will be seen, prevents the accidental shifting of the cam during the period that the active cams of the upper cam cylinder are in engagement with their needles as during such period the projection c^{11} is beneath the flange *e*. On leaving this flange the projection c^{11} passes under the pivoted cam plate *e′* which rises and permits the projection to pass, after which the cam plate is thrown down to its normal position by the spring e^2. As long as this operation is continued, the cam C^3 therefore remains in its depressed position.

When reciprocating work is begun on the first movement of the cam cylinder in a direction the reverse of its regular rotation, the projection c^{11} engages the cam plate *e′* and is raised upon the flange *e* which holds the lever c^{10} and the cam C^3 in their elevated positions. During this movement the cam C^3 is in rear of the cam C and the needles after knitting are all raised to the level of the ledge *a*. As soon as the projection c^{11} leaves the ledge *e* the lever c^{10} is depressed by the spring bearing upon the same. On the return movement the cam C^3 is not needed and the projection c^{11} passes below the ledge *e* and cam plate *e′*, as in circular knitting; on its next movement it is again raised by the cam plate *e′* and held during the period that it is required by the ledge or flange *e*.

The cam plate e^3, see Fig. 17, is rigidly secured to its pivot and on the outside of the casing E, such pivot has the arm e^4 secured thereto, this arm is connected by connections as hereafter set forth with pattern mechanism which control the position of the cam plate and the cam C^2. When the arm e^4 is moved and the point of the cam plate is raised, the projection c^8 of lever c^6 will engage the underside of the cam plate and the lever and cam C^2 will be depressed. When, however, the arm e^4 is moved so that the point of the cam plate is depressed, the projection c^8 engages the upper side of the cam plate and the lever and cam C^2 are raised. The projection c^8 after leaving the cam plate rests upon the ledge or flange *e* and the cam is thereby held in its elevated position. As the flange extends over the needles engaged by this cam the pressure of the needles upon it cannot move the cam from its position. While the projection c^8 is passing from one end of the flange *e* to the other the cam is free from all pressure which would serve to move it downward and it, therefore, remains in position. Should it be accidentally moved, however, the cam plate e^3 would again raise it before it would engage the needles. During reciprocating work, cam plate e^3 is held in position to raise the cam C^2. Such cam in case of accidental downward movement would be raised by cam plate e^3 when moving in one direction and by cam plate *e′* when moving in the other. In either case the cam would be held up by the ledge or flange *e*. A further cam plate e^5, see Figs. 15 and 20 is provided for moving cam C′ into and out of operative position. This cam plate has an arm e^6 secured to its pivot and this arm is connected with pattern mechanism by which it is controlled. When this cam is turned and its point raised, the projection c^x will engage the underside of the cam plate and the lever C^x will be depressed, moving the cam C′ into operative

position. When this cam plate e^5 is moved downward so that the projection c^x of the lever C^x engages the upper side of the same, the lever C^x will be raised and the spring c^4 will draw the cam back into inoperative position. The projection c^x is of such length that the cam plate e^5 is placed out of the path of the projections which actuate the cams C^3, C^2 and therefore, the cams C^3 and C^2 are never affected thereby, and as the projection c^x is in a plane above that of the projections c^3 and c^8, cam C′ is not affected by the other cam plates for this cylinder. For controlling the cams D′ and D^2 of the lower cam cylinder, certain other cam plates are provided. The needles actuated by the lower cam cylinder occupy the opposite half of the needle cylinder from those actuated by the upper cam cylinder, therefore, the cam plates for moving cams D′ and D^2 are on the opposite side of the machine from those which control the cams of the upper cylinder.

f is a cam plate for moving the cam D′. This cam plate is pivoted and the pivot is provided with a crank arm by which the plate may have its free end turned upward or depressed. When it is raised the projection d^4 will engage the underside of the same, the lever d^3 will be forced downward and the cam D′ moved into operative position, and when depressed the same projection will engage the upper side of the cam plate and lever d^3 will be raised permitting the spring d^5 to withdraw cam D′ from operative position.

An inwardly extending flange or ledge F is formed on the inner side of the ring or casing wholly or partially surrounding the lower cam cylinder. This flange extends around the needles actuated by the lower cam cylinder, and the cam plate f is located about midway between the ends of this flange, and thus moves cam D′ when the cams of the cylinder are out of contact with the nibs of their needles. The cam plate f' is employed to move the cam D^2. This is shown at the left in Fig. 21 with its free end extending toward cam plate f while the other end is pivoted close to the end of flange F at that side of the machine. The pivot of this cam plate f' is also provided with a crank arm by which the cam plate may have its free end moved upward or depressed. When it is depressed the projection d^6 of cam D^2 will engage the upper side of the cam plate and the cam will be raised into operative position and when the free end of the cam plate f' is raised, the said projection will engage the underside of the cam plate and the cam will be depressed.

The cam plate f' is placed farther away from the cam cylinder than cam plate f, and is in line with the ledge or flange F. When the cam D^2 is raised the projection d^3 is raised upon the ledge F and the cam is held in its upper or operative position, around the half circle of needles controlled by the lower cam cylinder. The projection d^4 for operating the cam D′ is of such length that it will not engage with the cam plate f' or with the ledge or flange F. The projection d^6 being longer than the projection d^4 may sometimes come in contact with the cam plate f, but as the cylinder moves in the direction of the arrow in Fig. 21, it will afterward come into engagement with the cam plate f' and be put in proper position thereby, before it reaches the needles of the cylinder.

It will thus be seen that it is only necessary to provide pattern mechanism to control the cam plates e^3, e^5, f and f' to effect such movements of the cams in the two cam cylinders as will produce the pattern of work desired. In the present instance, these cam plates are controlled by the following instrumentalities. As shown in Fig. 1 the machine near one end is provided with a pattern cylinder G′ which cylinder is mounted on a shaft G, extending transversely of the machine. The pattern cylinder is provided at its outer end with the ratchet G^2 by which it is revolved, through pawl g. This pawl has its upper end hooked and engages a cam or eccentric j' on the transverse shaft J through which motion is conveyed to the cam cylinder and is caused to have one reciprocation and move the pattern cylinder the distance of one tooth of the ratchet at each revolution of the cam cylinders. This pattern cylinder is provided with a spiral groove extending from one end to the other of the cylinder and in such groove, the cylinder is provided with holes g' to receive pins g^2.

A bracket G^3 is secured to the left end of the frame of the machine, see Figs. 2, 7 and 9. This bracket supports a rod G^4 rigidly secured to said bracket. A lever G^5 provided with an elongated hub g^3 is pivoted upon the rod G^4 so that it is free to swing and slide upon said rod. The free end of the lever has a downwardly extending projection of such width as to enter the groove of the pattern cylinder. The free end of the lever G^5 is extended laterally in both directions and at each end is provided with an upwardly extending ear in which is rigidly mounted a rod g^4. A rock shaft I is mounted in bearings and extends longitudinally of the machine. This rock shaft is provided with an arm i extending outward or rearwardly from the machine. A link I′ has is upper end pivotally connected with the outer end of the arm i, and its lower end is provided with an aperture through which the rod g^4 passes freely. The link I′ engages the slot of the slotted guide L^2 through

which it is free to move in a vertical direction, but which holds the link from moving toward or away from the machine. The rock shaft is provided with a spring i' (see Fig. 1) which tends to turn said shaft in a direction to maintain the projection of the lever G^5 down upon the bottom of the groove of the pattern cylinder or upon the top of pins g^2 in such groove. The rock shaft I is also provided with an upwardly extending arm i^2. The upper end of this arm is provided with an aperture through which passes a rod I^2 which is connected with the crank arm of cam plate f' for controlling cam D^2. As the spring i' tends to turn the shaft I, so as to move the arm i^2 outward, such action tends to draw the rod I^2 outwardly and maintain the cam plate with its free end depressed and keep the cam D^2 in its operative position. When the downwardly extending projection of the arm G^5 is engaged by a pin g^2 the arm is raised and through link I', arm i, rock shaft I, arm i^2 and rod I^2 the free end of the cam plate will be raised and the cam D^2 depressed into inoperative position.

As before stated, the cams of the lower cam cylinder coöperate only with one-half of the needles of the needle cylinder, the needles on the front half of the stocking. In order to effect a like control of the cam plate e^3 for moving cam C^2 of the upper cam cylinder, a rod K^2 is pivotally connected with the crank arm e^4 of the cam plate e^3 which extends rearwardly and passes through an aperture in the upper end of an arm or lever K' pivotally mounted on a rock shaft K, mounted on the same side of the machine and parallel with shaft I. To this lever K' is pivoted the bell crank lever k, provided with the shoulder k'. The outer end of the bell crank lever k normally rests on the upper end of an arm i^3 rigidly connected with the rock shaft I. The cam plate e^3 is normally held in its depressed position by a spring e^5. When the rock shaft I is turned to effect the raising of the free end of the cam plate f' the arm i^3 engages projection k' on the bell crank lever and the lever K' is moved inward moving the rod K^2 and raising the free end of the cam plate e^3. When the arm G^5 passes off from one of the pins g^2 and the arm drops to the bottom of the groove of the pattern cylinder the spring i' retracts the rod I^2 while the spring e^5 moves the rod K^2 and the leved K' outwardly, the free ends of the cam plates will thus be depressed and the cams D^2 and C^2 raised to operative position.

When it is desired to permit the cam D^2 to act independently of the cam C^2, the bell crank lever k is raised out of contact with the arm i^3. To accomplish this the shaft K is provided with an arm k^2 so placed on said shaft that the outward movement of the arm k^2 will engage the depending arm of the bell crank lever k and raise the other arm of such lever so that its projection k' will not be engaged by the arm i^3 of the shaft I. This movement of the shaft K and its arm k^2 is in this instance effected by a pattern wheel H on the opposite or front side of the machine. The shaft G on which the pattern cylinder is mounted extends across the machine from rear to front and at its front end is provided with a pinion $g^\times$ which meshes with a gear wheel H' connected to and moving with the pattern wheel H (see Fig. 7).

The relative sizes of the pinion and gear are such that the projection of the lever G^5 will traverse the entire length of the groove in the periphery of the pattern cylinder during the knitting of a single stocking and the pattern wheel will during the same time, make one complete revolution.

The shaft K extends beyond the left end of the machine and is there provided with a crank arm k^3. This crank arm is connected by a link k^4 with an arm l extending outwardly from a shaft L which is mounted in bearings transversely of the machine and this shaft has a downwardly extending arm l' lying in the plane of the tread h of the pattern wheel, so that the arm l' will be engaged by risers on the said tread. The tread h of the pattern wheel is, therefore, provided with a riser for engaging the arm l' at the point at which it is desired to have the cam C^2 raised, and to have the cam act independently of the cam D^2 of the lower cam cylinder and this riser is made long enough to continue this operation for such period as is desired.

Upon an outwardly extending flange of the casing surrounding the lower cam cylinder is mounted the curved slide F'. In shape it conforms to the flange upon which it is mounted and it is sustained upon the flange by two screws passing through two slots $f^\times$ $f^\times$ in said slide. The slide is thus mounted for a movement to the extent of the slots. This slide extends approximately half way around the cylinder and to the end near the front of the machine is secured the depending arm or bracket f^2, the lower end of which extends inwardly and is operatively connected with the crank arm of the cam plate f. A spring f^3 is connected with this slide and tends to draw the same toward the rear of the machine, in which position the cam plate f is depressed and the arm d^3 maintained in its elevated position, allowing the spring d^5 to draw the cam D' into its recess behind cam D, and consequently out of operative position. The rearward end of the slide is provided with an outwardly extending projection f^4, and it will be at once seen that when pressure is applied thereto in the direction of the arrow in Fig. 18 the crank arm of the cam plate f will be raised

and the lever d^8 will be depressed on the next revolution of the machine. The movement of this slide is effected at the proper times by the lever F^2 pivoted at f^5. To the shorter arm of this lever is pivoted the rod f^6 which passes through an aperture in an arm f^7 of a vertically disposed rod or shaft F^3, which is so mounted in its bearings as to be free to rotate or slide therein. The rod or shaft F^3 is near its upper end provided with an arm f^8 provided at its outer end with the depending pin f^9. The outer end of this arm extends forward over a disk m on the shaft M, which gives motion to the cam cylinders. This disk is similar to a disk shown in the Patent No. 669,730 hereinbefore referred to. This disk has a circular flange extending upwardly from the upper side of the disk. A part of this flange is hinged to open outwardly, forming a gate and is normally closed by a spring. A web extends from the hub of the disk to the gate, of such shape as to act as a cam to force anything coming in contact therewith out through the gate. The spring f^3 drawing the slide F′ toward the rear of the machine forces the projection f^4 against the inwardly extending end or arm of the lever F^2 and turns the rod or shaft F^3 so as to bring the free end of the arm f^8 and pin f^9 above the disk m.

The rod or shaft F^3 is maintained in its uppermost position by the arm f^{10} of a rock shaft F^4, the rod F^3 resting upon the flattened outer end of said arm. The rock shaft F^4 is mounted transversely of the machine above the bed of the same and has an arm f^{11} at its opposite end. This arm is connected by a link f^{12} with a bell crank lever F^5 which has its other arm bearing against the inner edge of the ring or annulus H^2 on the pattern wheel H. The weight of the rod and the parts connected therewith serves to keep the free arm of the bell crank lever F^5 against the inner side of the ring H^2. Risers of such extent as may be desired may be secured to the inner side of this ring. So long as a riser bears upon the free end of the bell crank lever the rod or shaft F^3 will be held in its uppermost position as shown in Fig. 6, but when such riser moves out from under the arm of the bell crank lever, the weight of rod or shaft F^3 will force down the arm f^{10} and this will cause the pin f^9 to drop down within the flange of the disk m. As the shaft M revolves the web within the flange will be brought into contact with the pin f^9 and the same will be forced out through the gate to the outside of the disk. This action turns the rod or shaft F^3 causing the arm f^7 to draw upon the lever F^2 and move the slide F′ so as to elevate the free end of the cam plate f and thereby force the cam D′ into operative position. So long as the bell crank lever F^5 is unaffected by a riser upon the ring H^2 the cam D′ will remain in operation, but as soon as it again engages a riser the rod or shaft F^3 will be raised and the spring f^3 will restore the parts to the position shown in Fig. 6.

A rod E′ is connected to the crank arm e^6 of the cam plate e^5. This rod passes through an aperture in the end of an arm e^{10} projecting from a frame or bracket E^2 that is pivotally mounted on the upright rod or shaft F^3. A lever e^{12} is pivoted to the bracket E^2. One end of this lever is provided with the upwardly extending pin e^{13} and a spring e^{11} is connected with said bracket in such a way as to tend to throw the end of the lever e^{12} provided with the pin e^{13} toward the shaft M and beneath the disk m. This disk has the lower side of the same constructed with the flange, gate and cam web corresponding to the several parts on the upper side of the disk. The other end of the lever e^{12} is connected by a link E^3 with an arm E^4 which is connected to one end of the rock shaft E^5 mounted in much the same manner as rock shaft F^4 and in close proximity thereto. The other end of the shaft E^5 is provided with the crank arm e^{14} and this crank arm is connected by a link E^6 to one arm of the bell crank lever E^7. The other arm of the bell crank lever is in position to engage the inner face of a ring H^3 of the pattern wheel H. This ring is constructed to receive risers h'. The shaft E^5 is provided with the spiral spring e^{15} (see Fig. 2) which is connected with the shaft E^5 in such a way that it tends to force the bell crank lever E^7 into contact with the ring H^3 or its risers, and to throw the free end of lever e^{12} upward so as to bring the pin e^{13} within the downwardly extending flange of the wheel m. So long as the bell crank lever E^7 engages a riser on the inside of the ring H^3, the free end of the lever e^{12} is below the disk m and is maintained in a position near the shaft M by the spring e^{11} acting on the bracket E^2, but when the bell crank lever E^7 passes from a riser or risers on the ring H^3 and moves against the inner side of said ring the spring upon the rock shaft E^5 moves the shaft to cause the arm E^4 to draw down one end of the lever e^{12} and raise its opposite end bringing the pin e^{13} within the flange on the lower side of the disk m. The rotation of that disk brings the pin at the proper time within the operation of the web and gate and the pin e^{13} is forced outward swinging the bracket E^2 and causing its arm e^{10} to move the rod E^2 and raise the free end of the cam plate e^5. So long as the bell crank lever E^7 remains in this position the cam plate e^5 will be in the raised position and the projection e^3 of the lever e will engage the under side of

the cam plate and the cam C′ will be moved into operative position, and when the bell crank lever again engages a riser the pin e^{13} will be lowered out of engagement with the disk m and the spring e^{11} will move the bracket E^2 so as to carry the pin under the disk m toward the shaft M and the arm e^{10} will move the cam plate to bring the free end of the same into its lowest position and the cam C′ will be returned to its inoperative position.

It will be seen that by the employment of the disk m, the cams D′ and C′ are brought into action at a certain definite period of the rotation of the cam cylinders. This avoids the necessity of absolute accuracy in the adjustment of the pattern wheel and its connections with the parts engaging the disk m. As the disk accurately times the point in the revolution of the cam cylinders at which the drop stitch cams are changed from inoperative to operative position it has been termed a "timing device".

It will be seen that in the connection of the rods E′, f^6, K^2 and I^2 with their actuating arms a spring is interposed on one side of the actuating arm between the arm and a cotter passing through the rod. This is done to give a yielding motion in one direction, for the purpose of avoiding breakage. It also avoids the necessity of adjusting the operative parts to so nice a degree of adjustment as would otherwise be required. A spring may be employed on each side of the arm instead of on one side only if preferred. The employment of the disk m and these elastic connections very greatly reduces the cost of construction.

In the operation of the machine, the lever G^5 is moved by the spiral groove from one end of the pattern cylinder G′ to the other, the hub of the lever sliding on the rod G^4 and the link I′ sliding on the rod g^4, the guide L^2 holding the link from moving out of its proper vertical plane under the friction with rod g^4. It is intended that this movement shall take place during the knitting of one entire stocking and that the pattern wheel shall, during the same time make an entire revolution. When a stocking has been finished the lever G^5 must be returned to the place of starting. I prefer to do this automatically but this is not essential.

The pattern wheel, as in my former Patents Nos. 669,730 and 679,281 in which it is termed a "cam wheel" regulates and controls most of the movements of the machine. This cam or pattern wheel is in this instance provided with additional treads as hereinbefore described, to effect a number of additional functions. The mechanism for forming the heel and toe commonly called "narrowing and widening" mechanism is the same as shown in my two former patents and will not be described particularly herein.

The pattern devices herein decsribed, are preferably prepared so that the machine will knit solid plain knitting at the top of the leg of the stocking and then at the desired point the cams C′ and D′ will be brought into operative position and their needles caused to drop their stitches to form open work. The pattern of this open work may be different at different parts of the same course of stitches by arranging the needles that are acted upon by these cams in a different order. The tuck stitch cams C^2 and D^2 are either brought into action at the same time to form tuck stitches or at the particular time thereafter necessary to form the pattern desired. I prefer to make one or more courses of tuck stitches before dropping the stitches as I have found that by so doing the drop stitches are secured and their raveling back into the plain knitting prevented. The pattern devices are also, by preference, so arranged that the cams of the upper cam cylinder A before beginning the heel, shall knit solid plain knitting, giving a solid plain heel, bottom of the foot and toe, and so that the cams of the lower cam cylinder B shall, before the toe of the stocking is reached, also knit solid plain knitting, so that there shall be solid plain knitting on each side of the closure at the toe of the stocking. For the rest of the stocking, such pattern or patterns on the front and on the back of the stocking may be adopted as may best suit the manufacturer.

By raising the lever K out of operative relation with the arm i^3 and withdrawing cam C′ out of operative position solid plain knitting may be made on the back of the stocking while lace work with drop stitches is made on the front half of the stocking or vice versa. The open or lace work may be again made at any point on the back of the stocking and a bar or band of solid plain knitting may be made at any point on the back. Or a band of tuck stitches may instead be made on the back without dropping any stitches. In other words every course of the knitting is controlled by the pattern mechanism and may be made different from the preceding course, and the needles of one cylinder may knit a different pattern from those of the other cylinder, so that the mechanism described not only provides for controlling the knitting of each course but provides for controlling the knitting in different parts of the same course.

It is obvious that the cams C^2 and D^2 can both be controlled directly from the pattern mechanism, if so desired. It is also obvious that more than two cam cylinders can be employed and that the cams of each can be

controlled by the pattern mechanism independently of the others. It will also be obvious that in place of an additional cam cylinder, one or more of the cylinders can be provided with more than a single needle groove or track, and the same results produced. It is also obvious that instead of having the cam plates f, f', e^3 and e^5 normally depressed they may normally be held with their free ends raised and that the cam plates may be held in normal position when not affected by the risers of the pattern wheel, should this be preferred.

What I claim and desire to secure by Letters Patent is:—

1. In a circular knitting machine having independently movable needles, the combination with a plurality of cam cylinders each having a knitting cam coöperating with a continuous series of needles less than the entire number of needles, to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam mounted in each cylinder coöperating with a less number of needles than its knitting cam, narrowing and widening devices coöperating with less than the whole number of cylinders, and means for rendering the tuck stitch mechanism belonging to the knitting mechanism coöperating with the narrowing and widening devices out of operation during the formation of the heel and toe pockets, substantially as described.

2. In a circular knitting machine having independently movable needles, the combination with two cam cylinders each coöperating with a continuous series of needles less than the entire number of needles, of a tuck stitch cam mounted in each cylinder, narrowing and widening devices coöperating with one cam cylinder in forming the heel and toe pockets of a stocking, and means for moving said tuck stitch cams into and out of operative position, said means including provisions whereby the tuck stitch cam of the cylinder operative while forming the heel and toe, is held out of operative position during the knitting of the heel and toe, substantially as described.

3. In a circular knitting machine having independently movable needles, the combination with a plurality of cams each coöperating with a continuous series of needles less than the entire number of needles, to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam for each knitting cam coöperating with a less number of needles than its knitting cam, and pattern mechanism controlling said tuck stitch cams to cause each of such cams to operate together with or independently of the others, substantially as described.

4. In a circular knitting machine having independently movable needles, the combination with a plurality of knitting cams each coöperating with a continuous series of needles less than the entire number of needles to produce solid plain knitting entirely around the knitted web, of narrowing and widening devices, coöperating with less than the entire number of cams to produce the heel and toe pockets, a tuck stitch cam for each knitting cam and means for maintaining the tuck stitch cam, of each knitting cam operative during the knitting of the heel and toe, out of operation while the machine is knitting the heel and toe, substantially as described.

5. In a circular knitting machine having independently movable needles, the combination with a plurality of cam cylinders each coöperating with a continuous series of needles less than the whole number of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam in each cylinder coöperating with a less number of needles than the knitting cam of its cylinder, and means for independently operating said tuck stitch cams, substantially as described.

6. In a circular knitting machine, the combination with two cam cylinders each having a knitting cam coöperating with a continuous series of needles less than the entire number of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam in each cam cylinder cooperating with a less number of needles than the knitting cam of its cylinder, and means for operating the tuck stitch cams including means for operating the tuck stitch cam of one cylinder together with or independently of the other, substantially as described.

7. In a circular knitting machine having independently movable needles, the combination of a plurality of cams each coöperating with a continuous series of needles less than the entire number of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam for each knitting cam, said cam coöperating with a less number of needles than its knitting cam, and pattern mechanism controlling said tuck stitch cams to cause one of them to operate together with or independently of the others, substantially as described.

8. In a circular knitting machine, the combination with a plurality of cam cylinders each provided with a knitting cam cooperating with a continuous series of needles less than the entire number of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam mounted in each cam cylinder and means for operating said tuck stitch cams, substantially as described.

9. In a circular knitting machine, the combination with two cam cylinders each

having a knitting cam coöperating with a continuous series of needles less than the entire number of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam mounted in each cam cylinder and means for independently operating said tuck stitch cams, substantially as described.

10. In a circular knitting mechine having independent needles, the combination with a plurality of needle actuating cams, each coöperating with a continuous portion of the needles for producing solid plain knitting entirely around the knitted web, of a cam movable into and out of operative position, coöperating with each knitting cam and a limited number of needles to produce drop stitches, substantially as described.

11. In a circular knitting machine having independent needles, the combination with a plurality of needle actuating cams, each coöperating with a continuous series of the needles to produce solid plain knitting entirely around the knitted web, of a drop stitch cam and a tuck stitch cam coöperating with each knitting cam and a predetermined number of its needles to produce open work having drop stitches therein, substantially as described.

12. In a circular knitting machine having independent needles, the combination with a plurality of cams, each coöperating with a continuous series of needles to produce solid plain knitting entirely around the knitted web, of a cam movable into and out of position to coöperate with each knitting cam and certain predetermined needles of the series to produce drop stitches in the work of said series, substantially as described.

13. In a circular knitting machine having independent needles, the combination of a plurality of cams, each coöperating with a series of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam coöperating with each knitting cam and a predetermined number of its needles to produce tuck stitch work when desired, substantially as described.

14. In a circular knitting machine having independent needles, the combination with a plurality of cams each coöperating with a series of needles to produce solid plain knitting entirely around the knitted web, of a drop stitch cam and a tuck stitch cam coöperating with each knitting cam and certain predetermined needles of its series to produce open work, substantially as described.

15. In a circular knitting machine having independent needles, the combination with a plurality of cams each coöperating with a continuous series of needles less than the entire number of needles to produce solid plain knitting entirely around the knitted web, of a tuck stitch cam coöperating with each knitting cam, and pattern mechanism controlling said tuck stitch cams to cause one of them to operate independently of the others, substantially as described.

16. In a circular knitting machine having independent needles, the combination with a plurality of knitting cams each coöperating with a series of needles less than the entire number of needles, to produce solid plain knitting entirely around the knitted web, of a drop stitch cam coöperating with each knitting cam and a predetermined number of its needles, and a pattern mechanism controlling the operation of the drop stitch cams, substantially as described.

17. In a circular knitting machine having independent needles, the combination with a plurality of cams each coöperating with a series of needles less than the entire number of needles, to produce solid plain knitting entirely around the knitted web, of a drop stitch cam coöperating with each knitting cam and a predetermined number of its needles, and an independent pattern mechanism controlling each drop stitch cam, substantially as described.

18. In a circular knitting machine having independent needles, the combination with needles having nibs of different lengths, one length of nib for actuating the needle to knit, and another for actuating the needle to knit and to drop stitches, of means for actuating the said needles, and pattern mechanism controlling said actuating mechanism to cause the said drop stitch needles to knit or to drop stitches wherever they may be located around the web.

19. In a circular knitting machine having independent needles, the combination with needles having different lengths of nibs, one length for knitting plain stitches and the other for knitting plain and tuck stitches, means for actuating said needles and pattern mechanism controlling said actuating mechanism to knit plain or tuck stitches at whatever point of the web they may be located.

20. In a circular knitting machine having a continuous circular series of independent needles, the combination with the knitting devices, of means for dropping stitches at any point around the web, including means for dropping the stitches of one section independently of another section.

21. In a circular knitting machine having a continuous circular series of independent needles, the combination with the knitting mechanism, of means for knitting tuck stitches at any point around the web, including means for knitting tuck stitches at one point independently of another point.

22. In a circular knitting machine having independent needles, the combination with the knitting devices, of means for dropping stitches and knitting tuck knitting at any point around the web, including means for

dropping stitches and knitting tuck knitting at one point independently of another point in the same course around the web.

23. In a circular knitting machine having independent needles, the combination with the knitting devices, of means for dropping stitches at any point around the web, including means for dropping stitches at one point independent of the means for dropping stitches at another point.

24. In a circular knitting machine having independent needles, the combination with a cam coöperating with a continuous series of needles to depress them, after they have taken the thread, to cause them to knit, of a cam adapted to be moved into a position to depress a predetermined part of said series of needles to cause such part of said series to miss the thread to drop the stitches on them and to continue this operation to continue the unknit space in the web until the position of the cam is changed.

25. In a circular knitting machine having independent needles, the combination with knitting devices coöperating with all of a continuous series of needles to depress them after taking the thread to cause them to cast off the loops thereon and form stitches, of a supplemental device adapted to be moved into position to coöperate with a predetermined part of said continuous series of needles to depress them before they engage the thread to cause them to miss the thread and drop any loops that may be on them and to continue to miss the thread to form a drop stitch space longitudinally of the web until the position of said device is changed.

26. In a circular knitting machine having independent needles, the combination with the knitting devices, of means for dropping stitches at any point around the web, including means for dropping stitches at one point independent of the means for dropping stitches at another point, and pattern mechanism controlling the dropping of stitches by said drop stitch needles.

27. In a circular knitting machine having independent needles, the combination with needles having nibs of different lengths, one length of nib for actuating the needle to knit and another for actuating the needle to knit and to drop stitches, means for actuating said needles and pattern mechanism controlling said actuating mechanism to cause said drop stitch needles to knit or drop stitches.

28. In a circular knitting machine having independent needles, the combination with needles having nibs of different lengths, one length for knitting plain stitches and another for knitting plain and tuck stitches, means for actuating said needles and pattern mechanism controlling said actuating mechanism to cause said tuck stitch needles to knit tuck or plain stitches.

29. In a circular knitting machine having independent needles, the combination with needles having nibs of different lengths, one length for knitting plain stitches and another for knitting plain and tuck stitches, means for actuating said needles including means for actuating the tuck stitch needles at one point around the web independently of the tuck stitch needles at another point of the web and pattern mechanism for controlling said actuating means to cause said tuck stitch needles to knit tuck or plain stitches.

30. In a circular knitting machine having independent needles, the combination with needles having nibs of different lengths, one length for actuating the needle to knit plain stitches and another length for actuating the needle to knit and to drop stitches, means for actuating said drop stitch needles at one point around the web independently of such needles at another point and pattern mechanism controlling said actuating mechanism to cause the said needles to knit or to drop stitches.

In testimony whereof I affix my signature, in the presence of two witnesses.

EDWARD E. KILBOURN.

Witnesses:
ROBT. G. MILLER,
WILLIAM SILZER.