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WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

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Fig. 1.

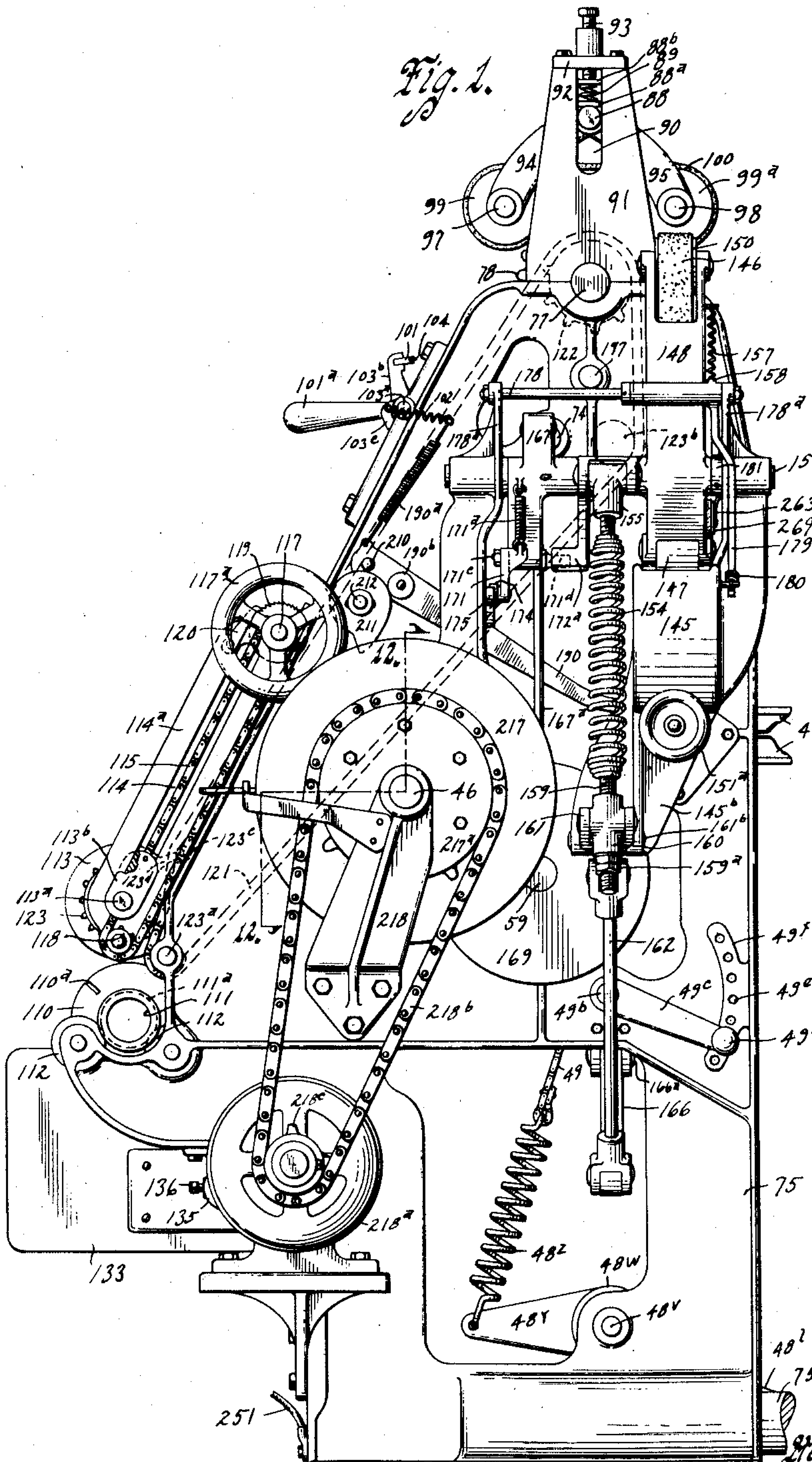

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Fig. 4.

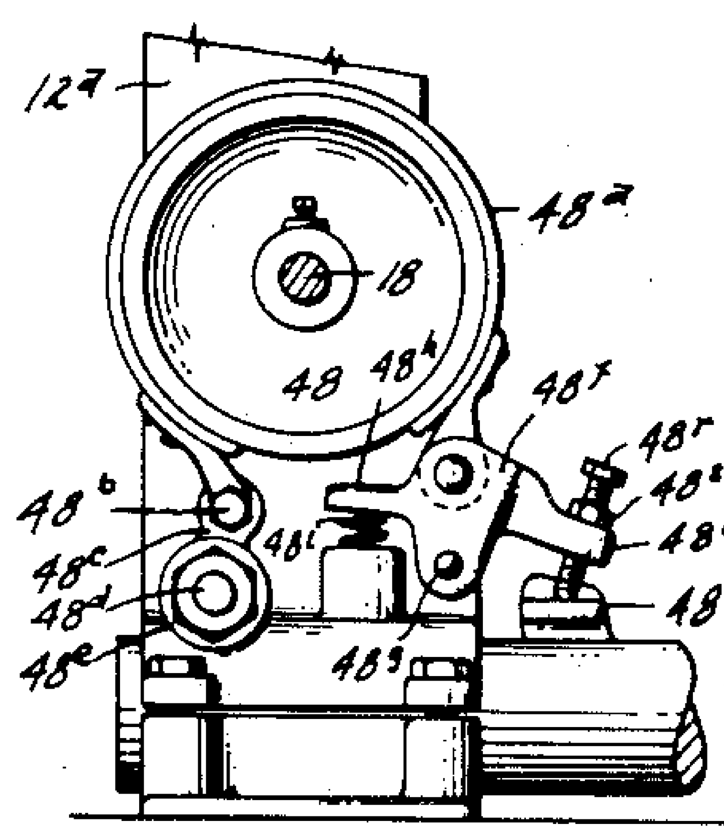

Fig. 2.

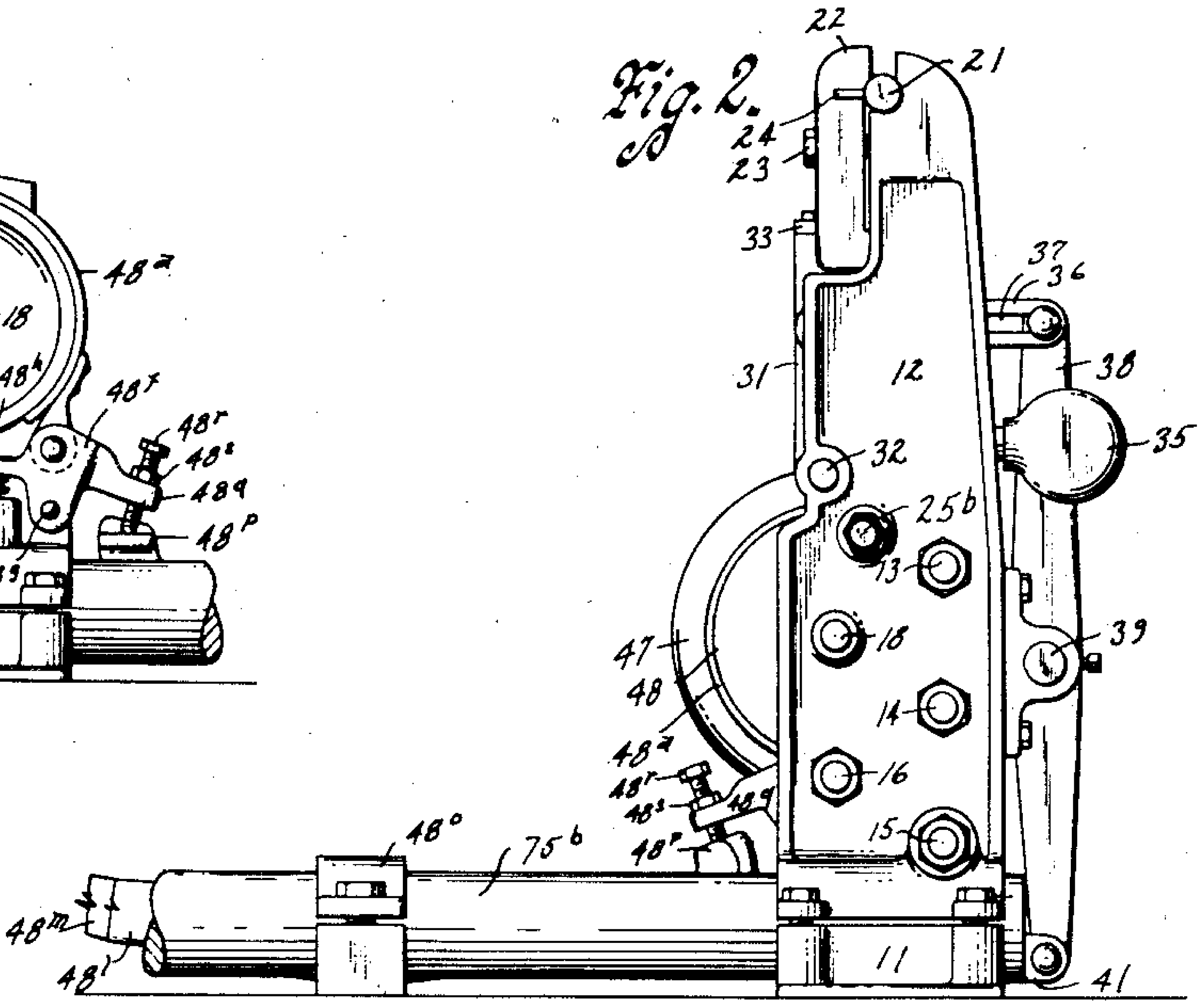

Fig. 3.

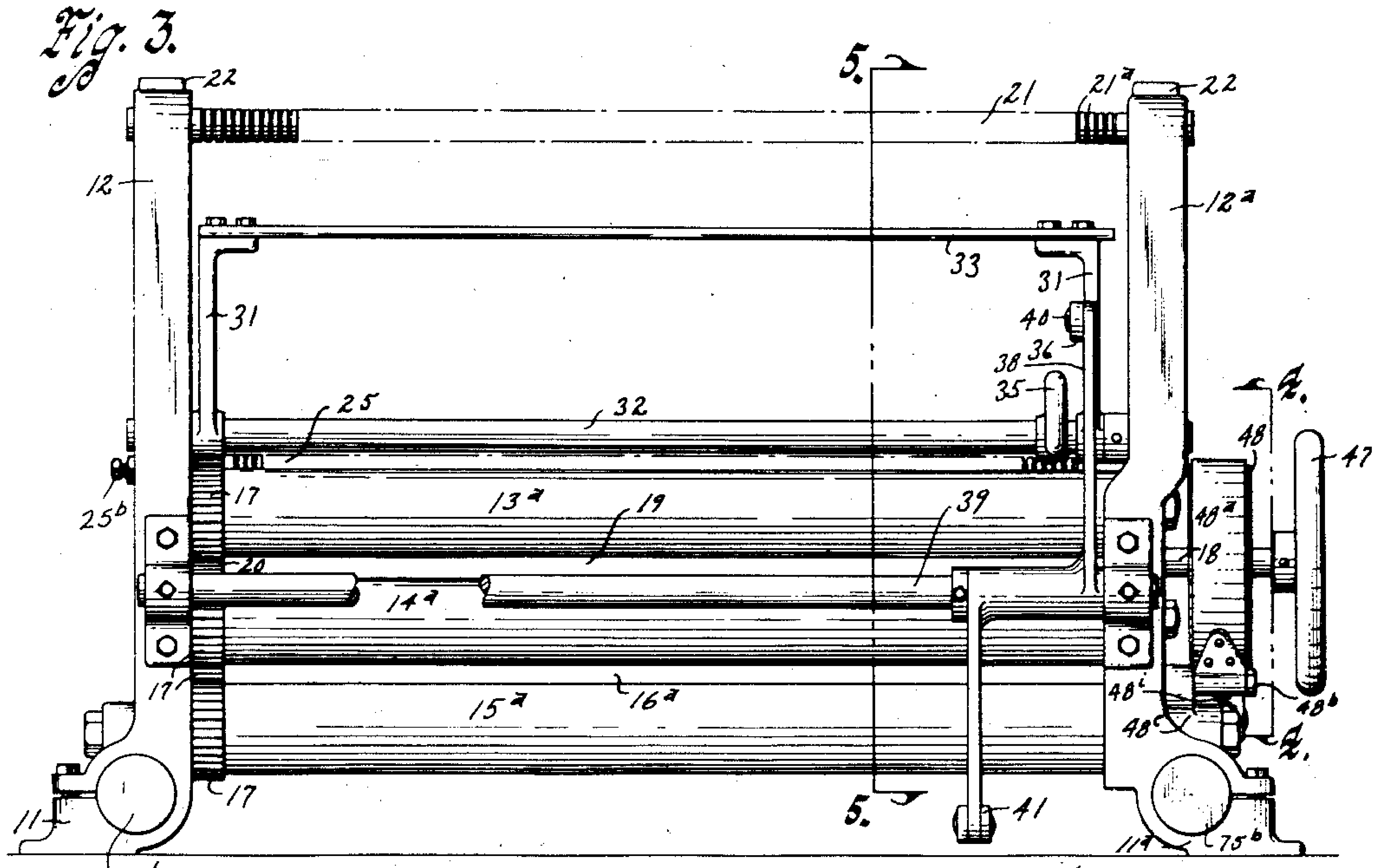

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Fig. 10D.

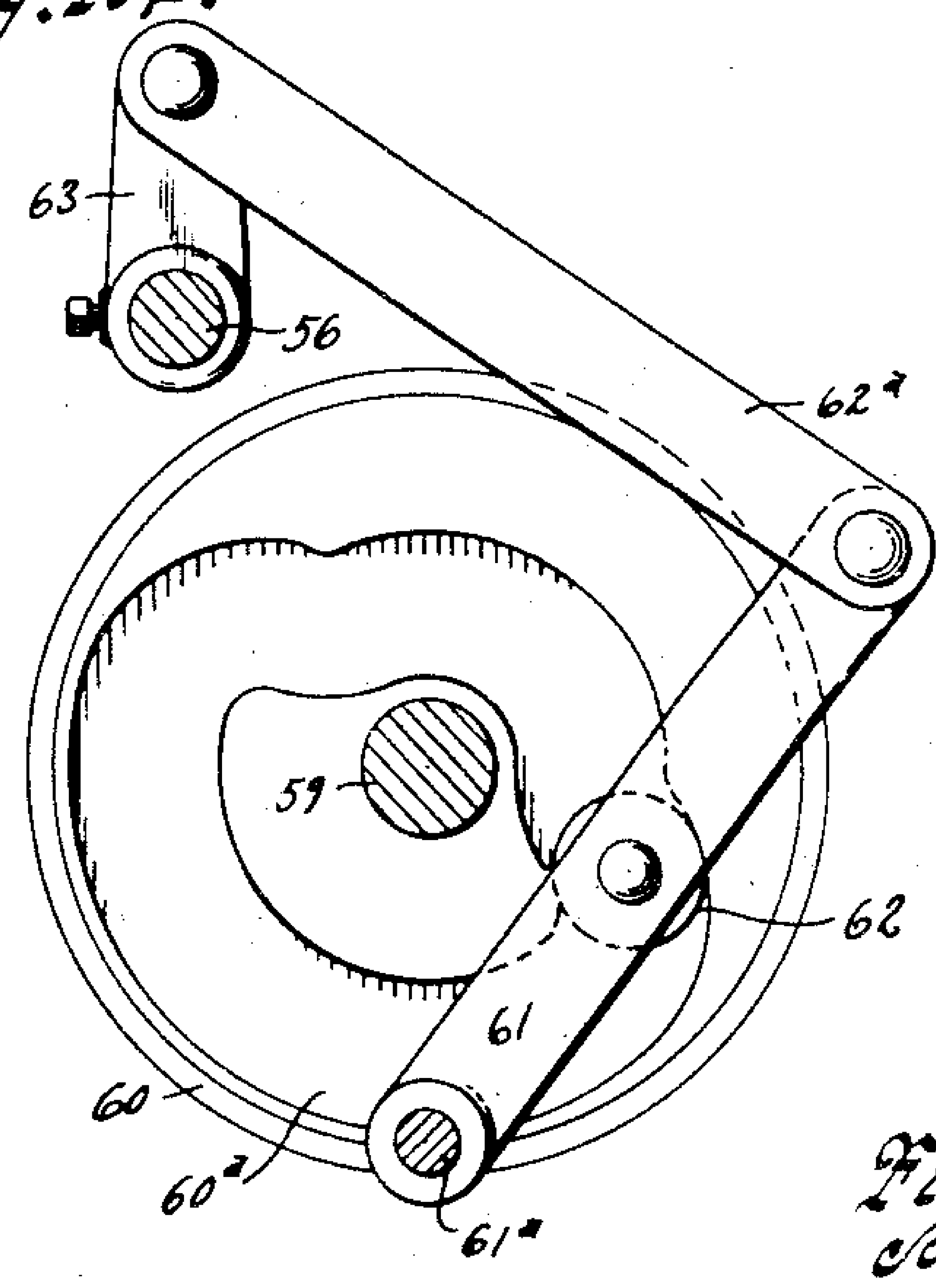

Fig. 13.

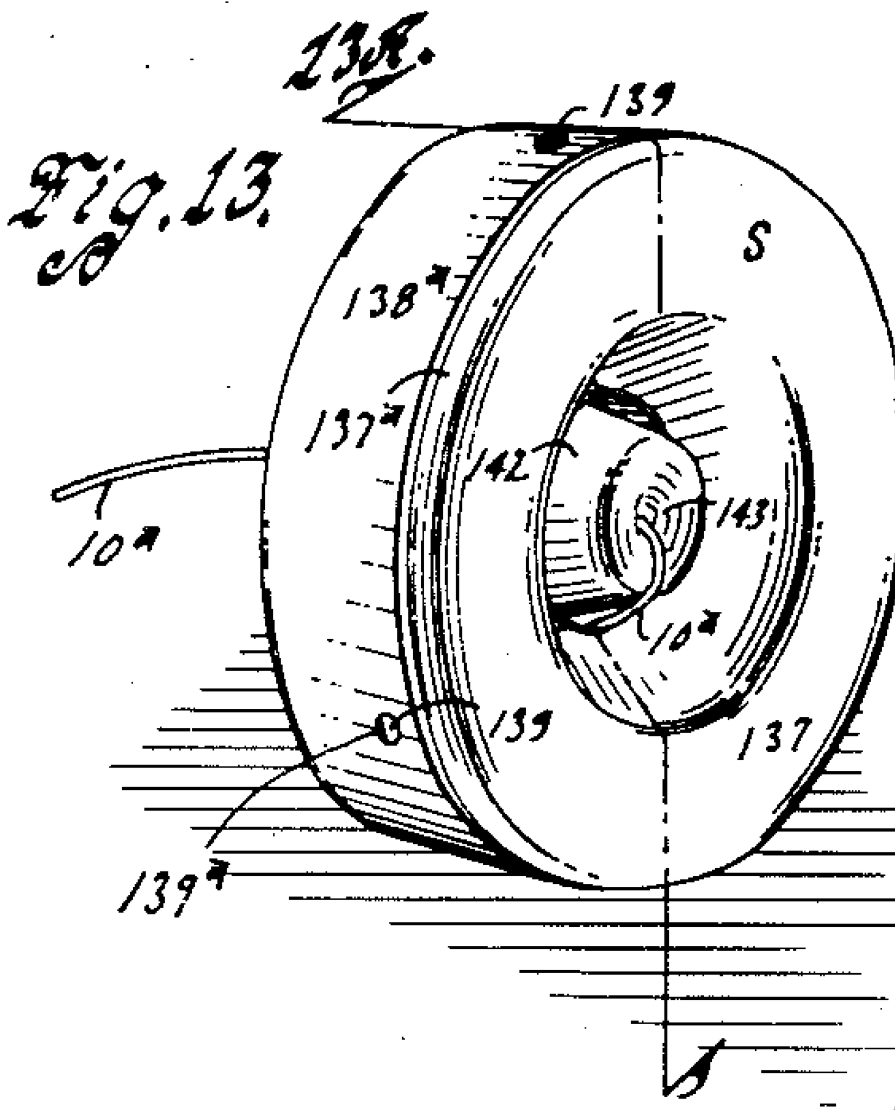

Fig. 13B.

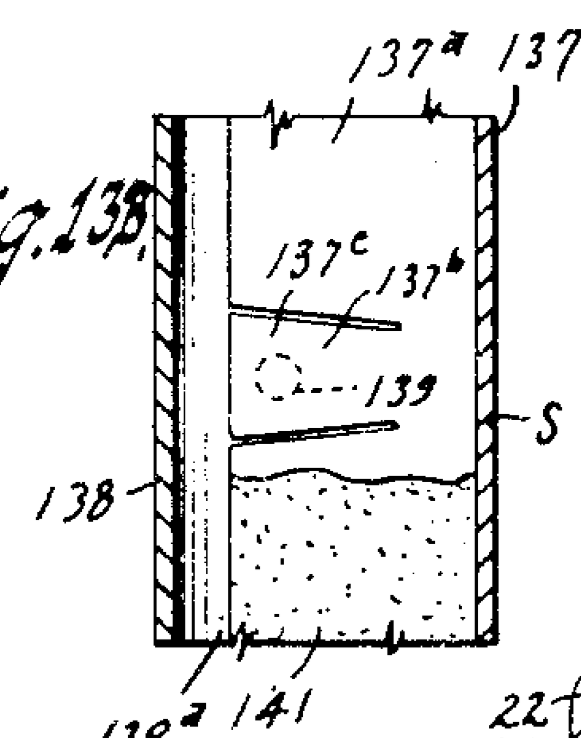

Fig. 5A.

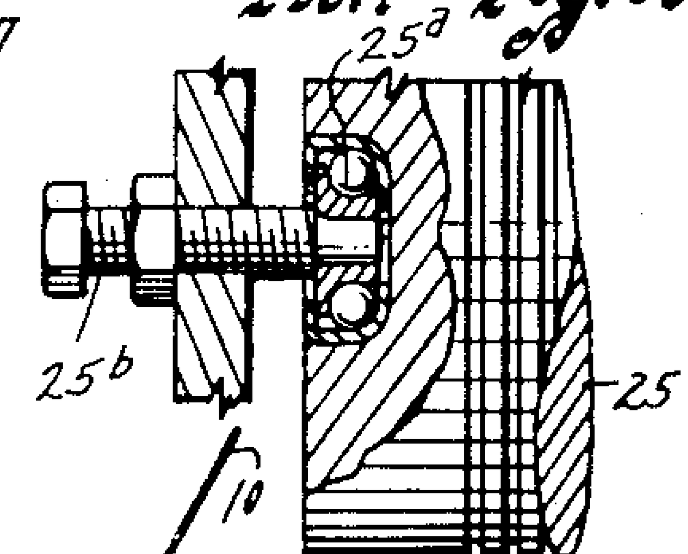

Fig. 13A.

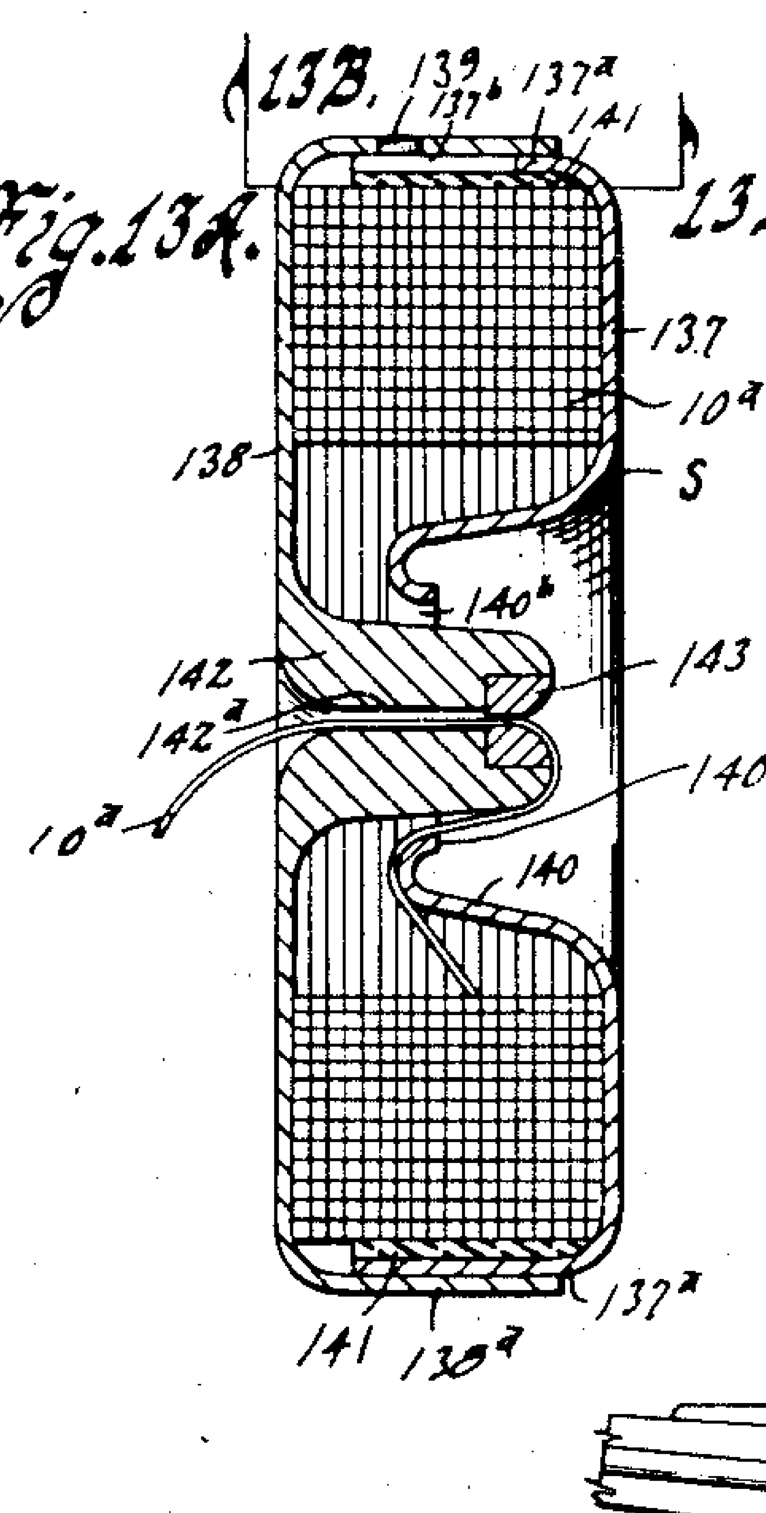

Fig. 5.

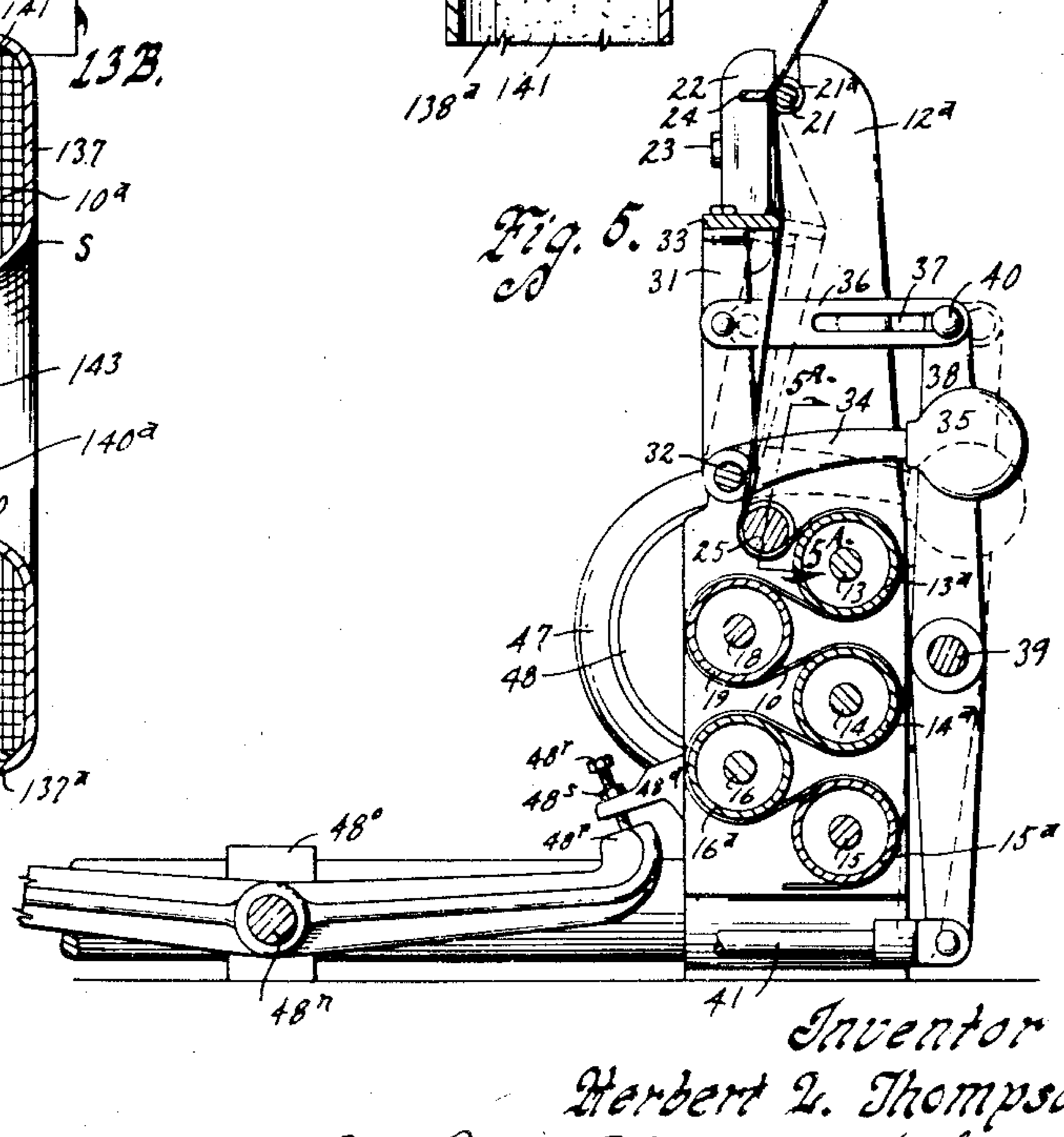

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Fig. 6.

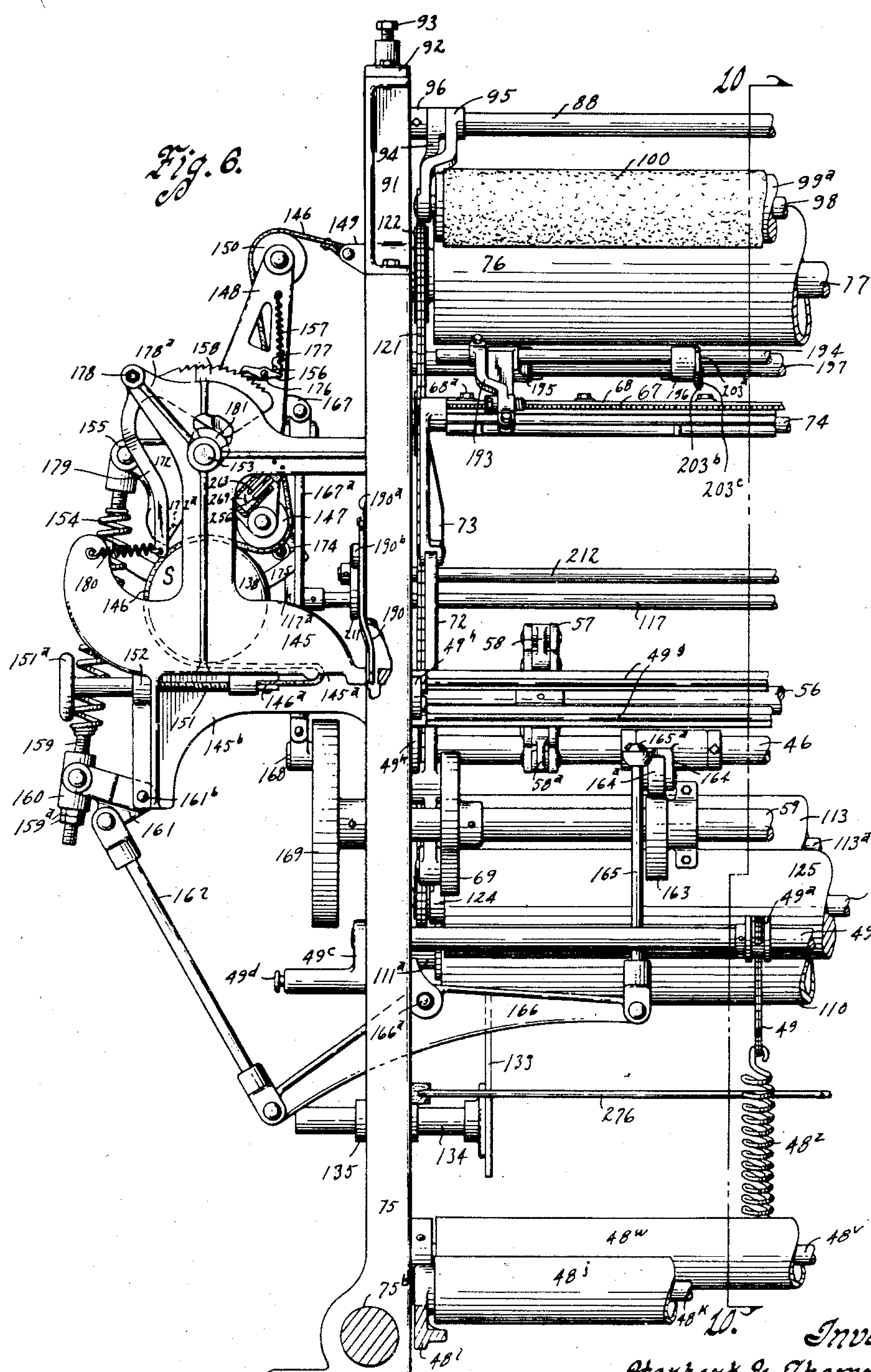

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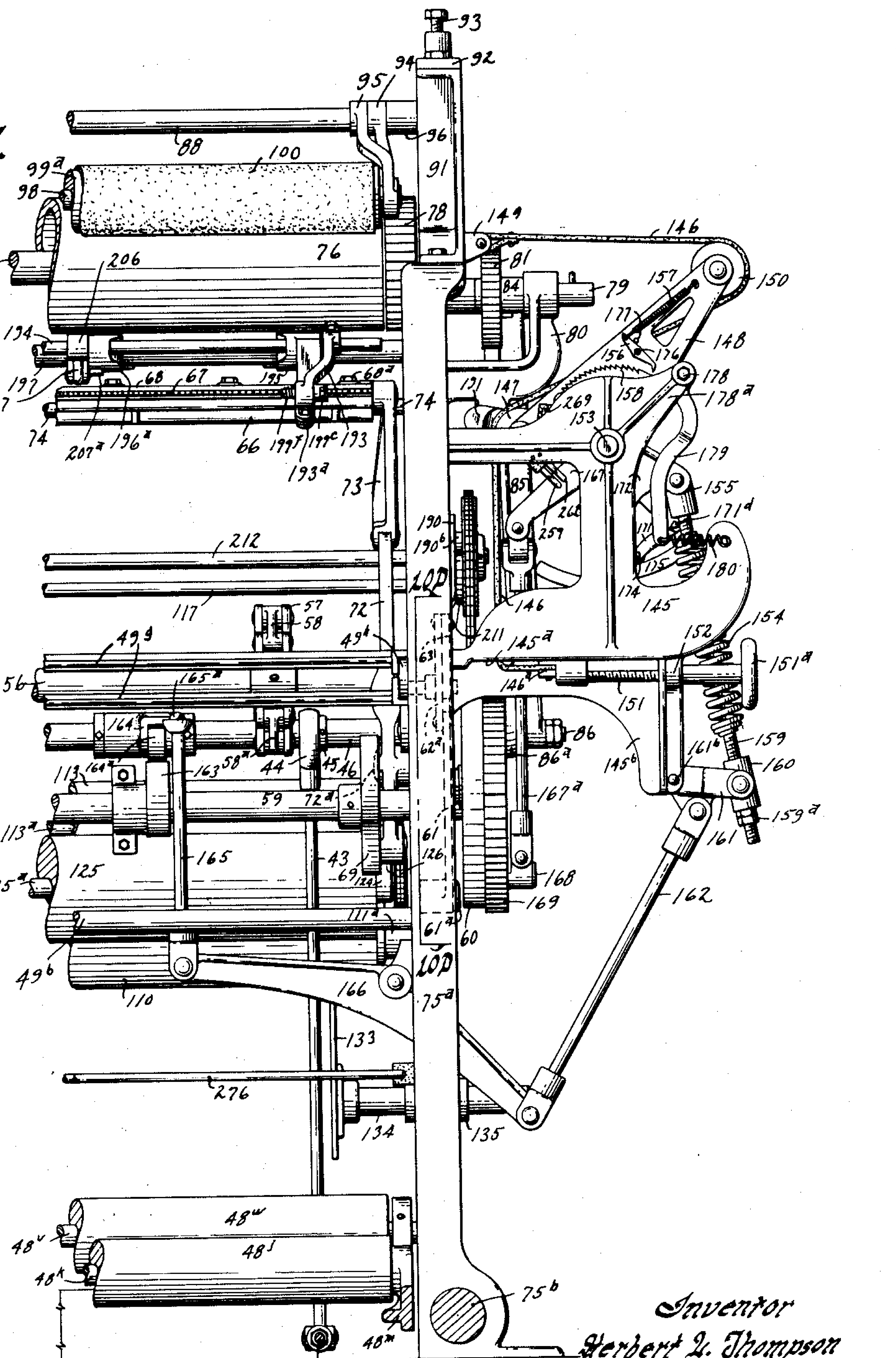
Fig. 7.



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WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

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Fig. 8.

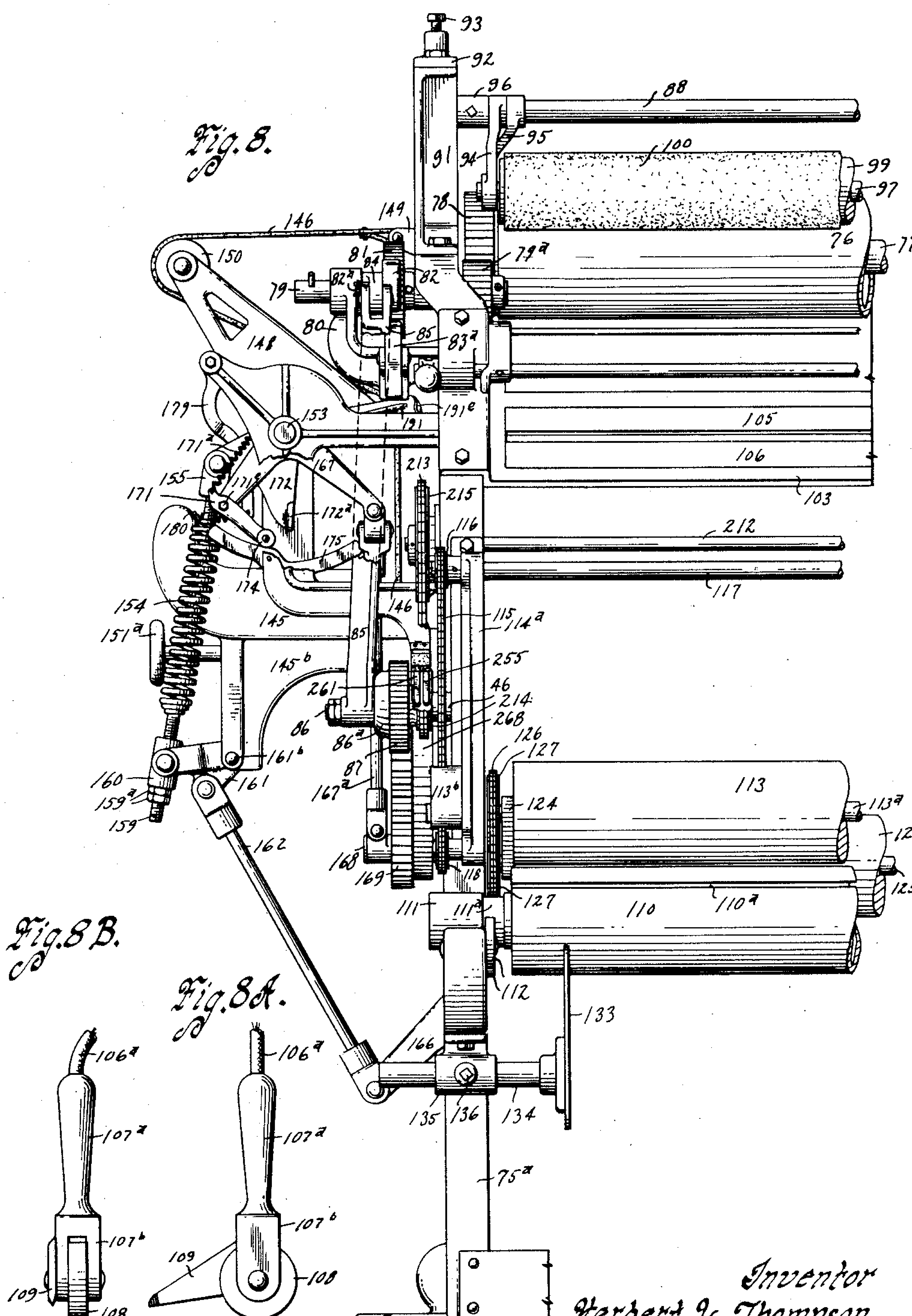

Fig. 8B.

Fig. 8A.

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WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

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Fig. 9A'.

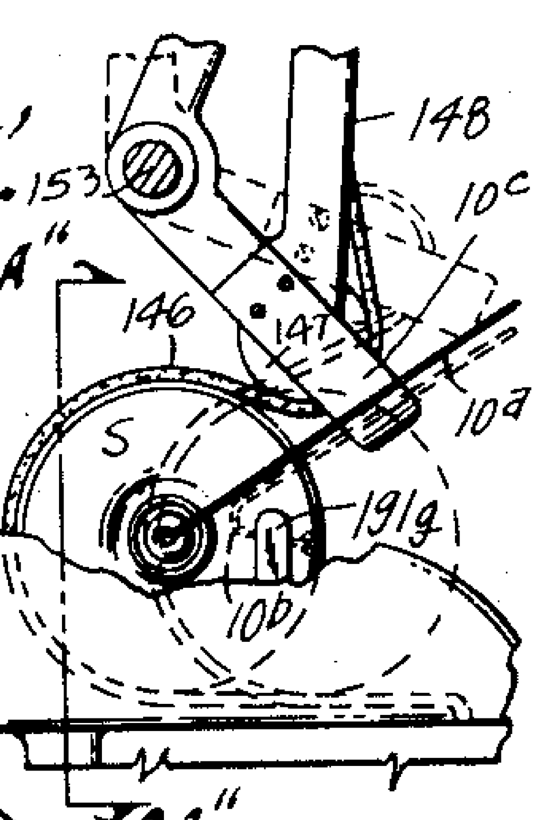


Fig. 9.

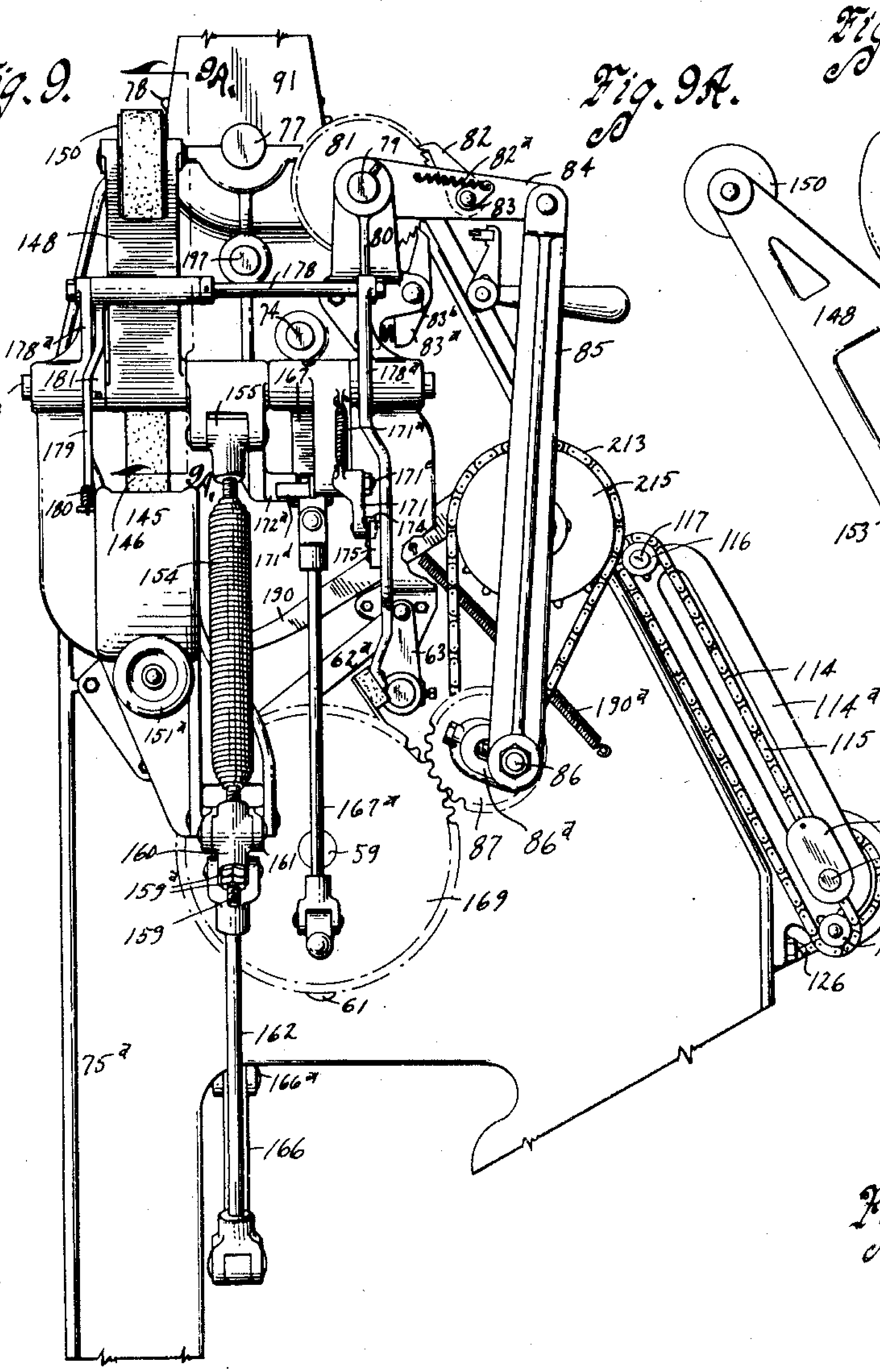


Fig. 9A.

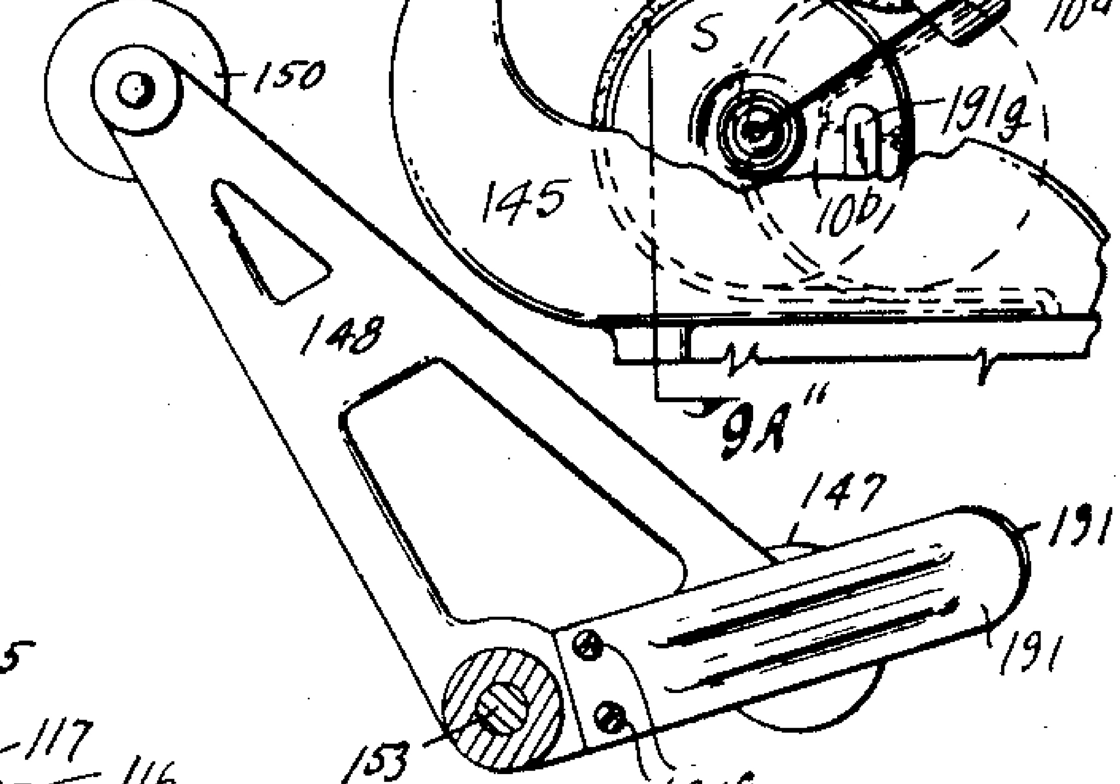


Fig. 9A''.

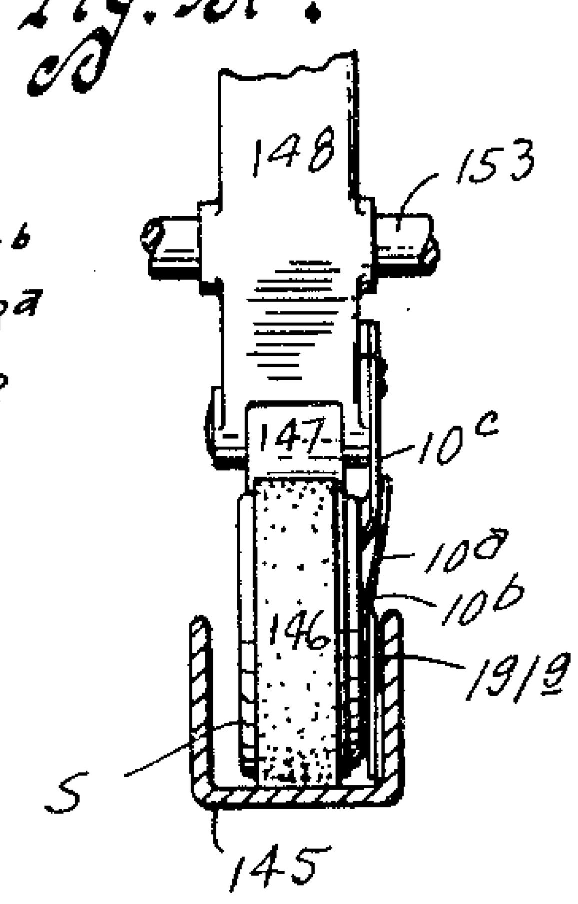


Fig. 9C.

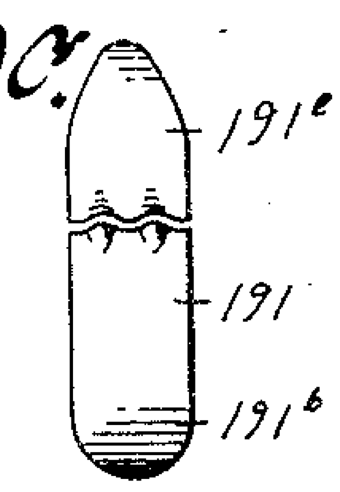
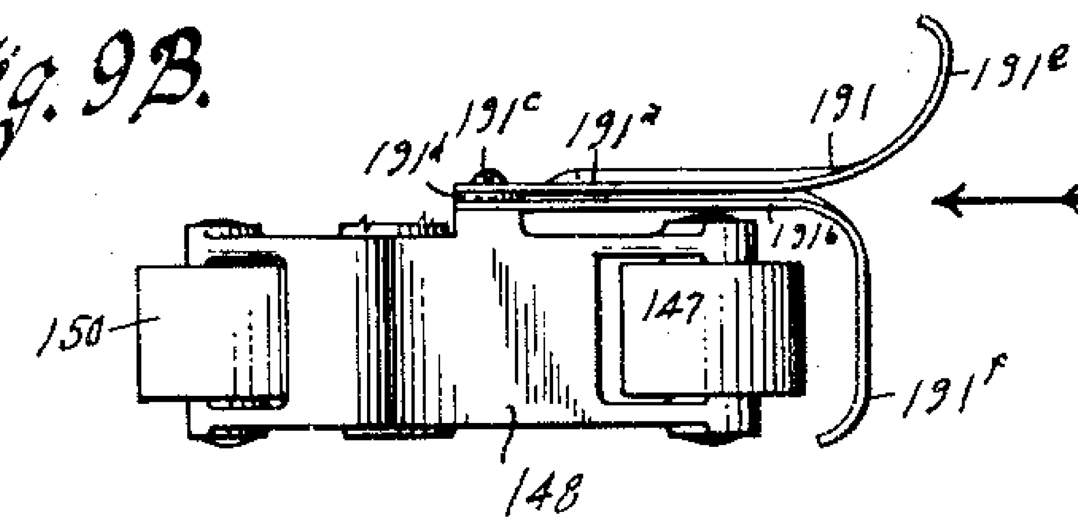


Fig. 9B.



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WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

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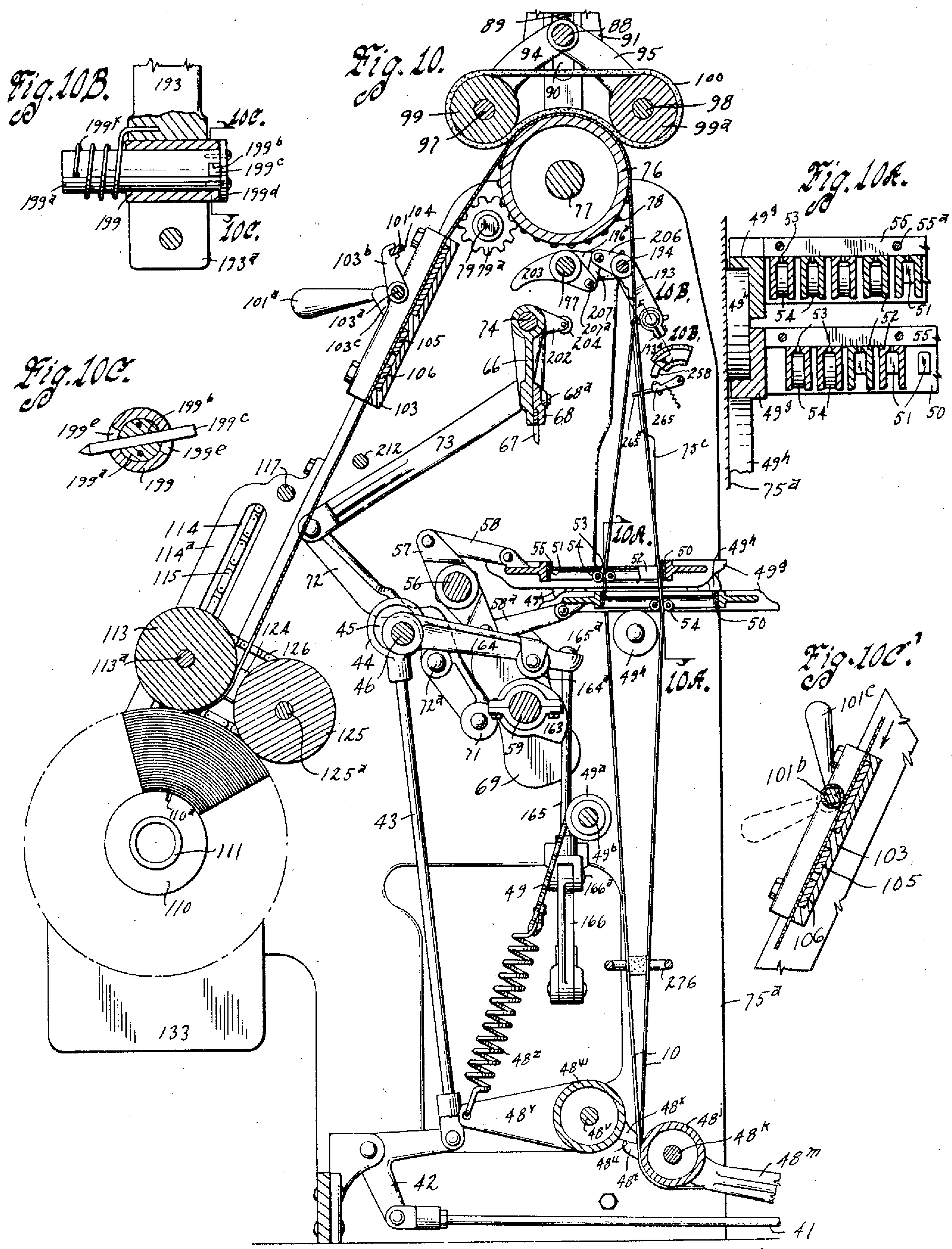

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WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

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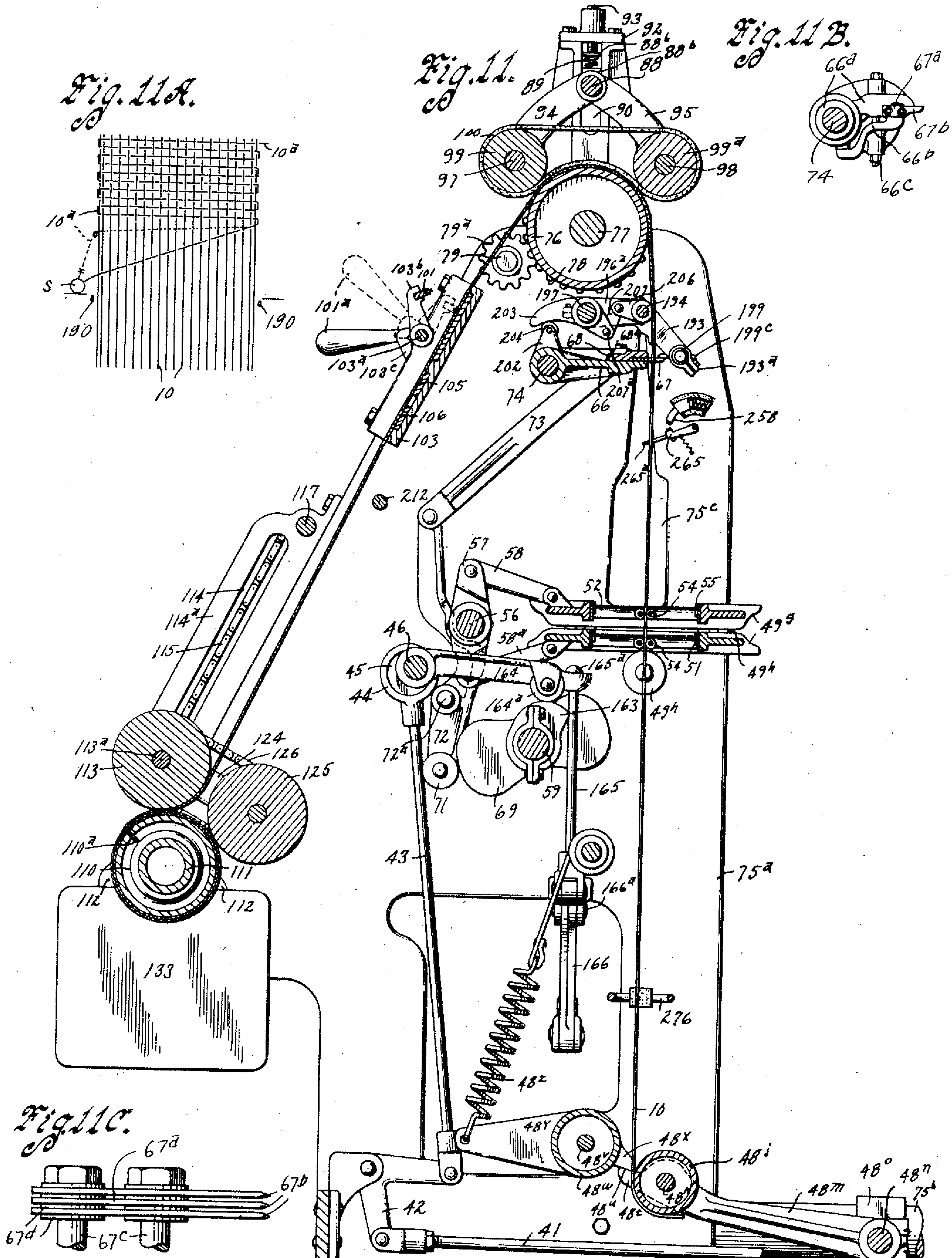

Fig. 11A. Fig. 11. Fig. 11B. Fig. 11C.

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Fig. 12.

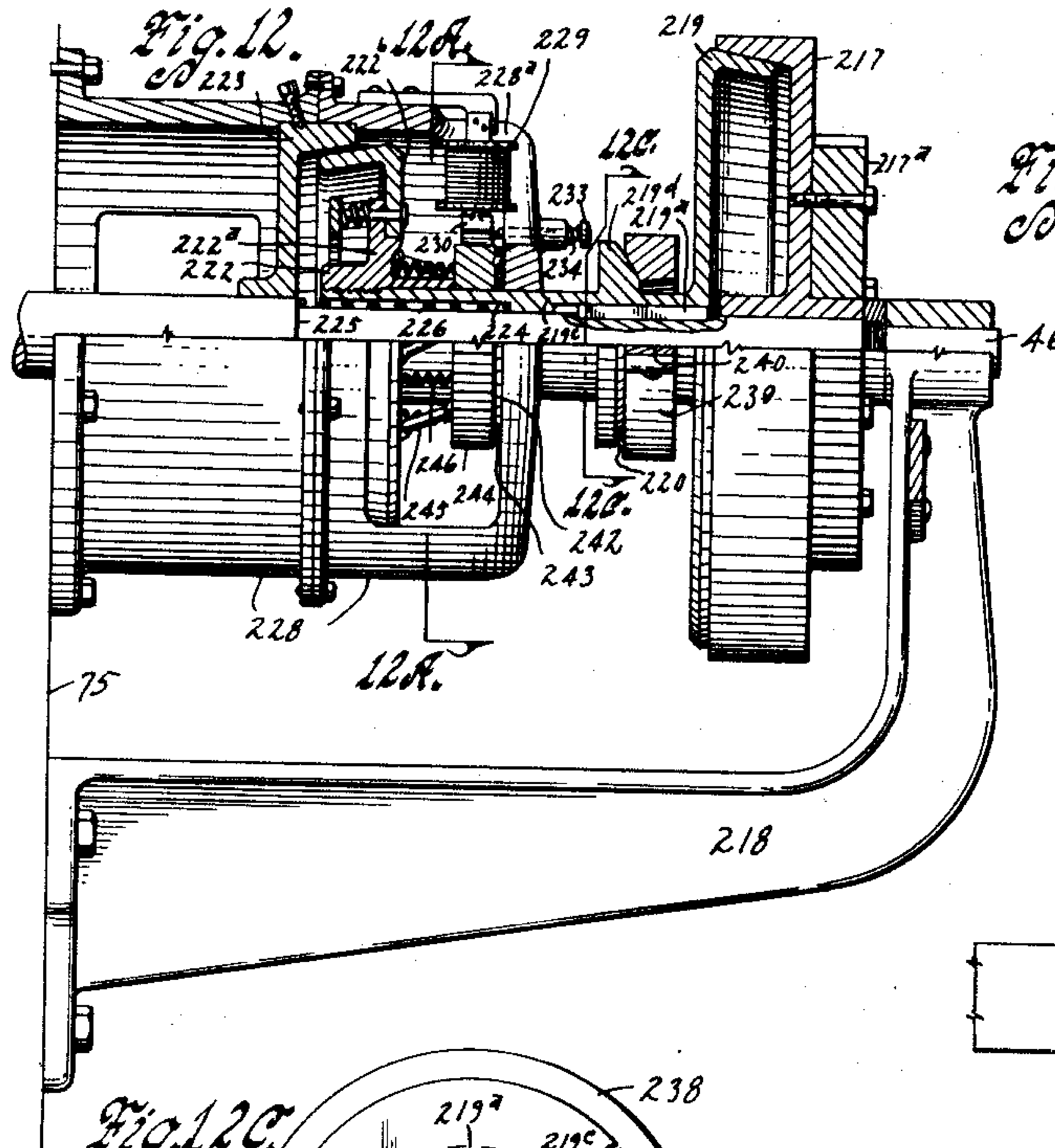


Fig. 12A.

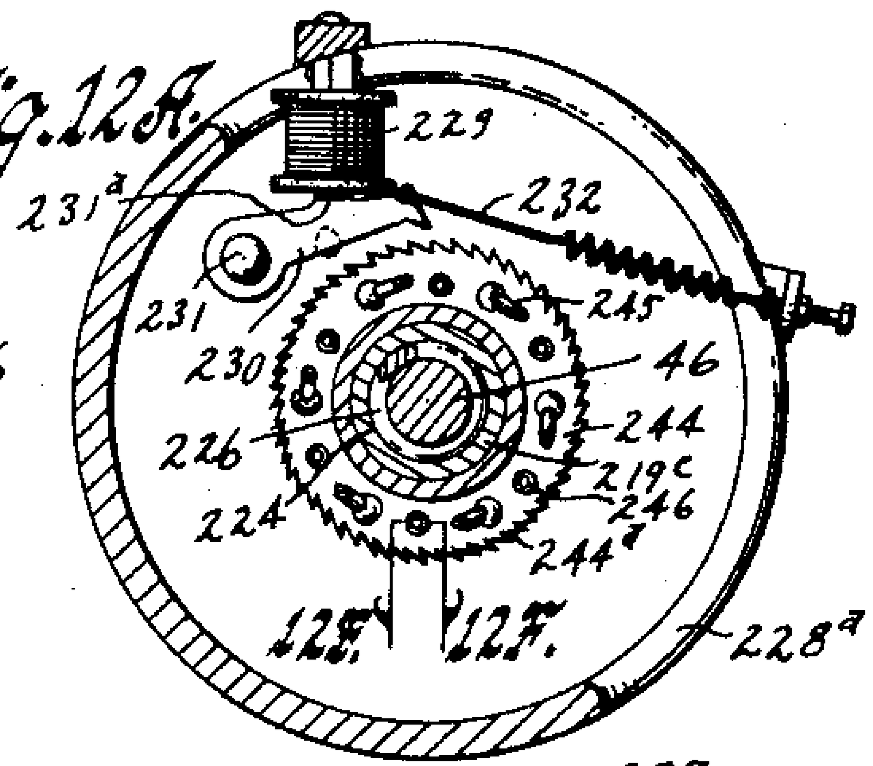


Fig. 12D.

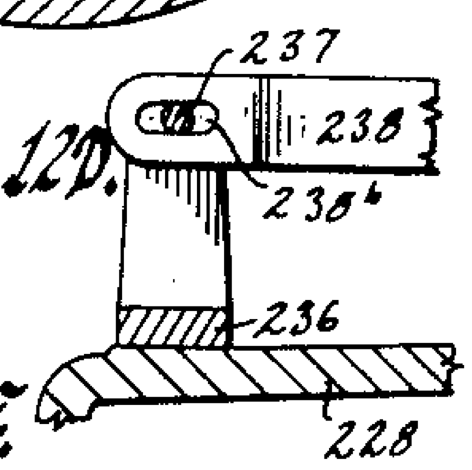


Fig. 12E.

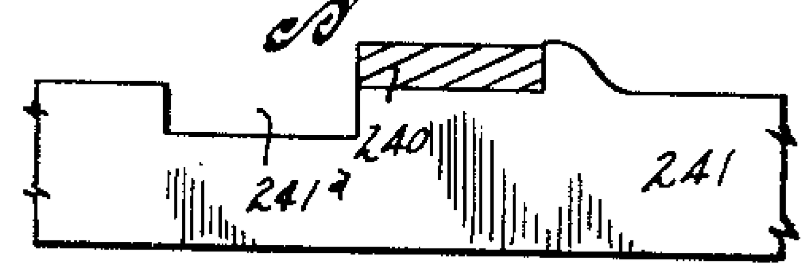


Fig. 12C.

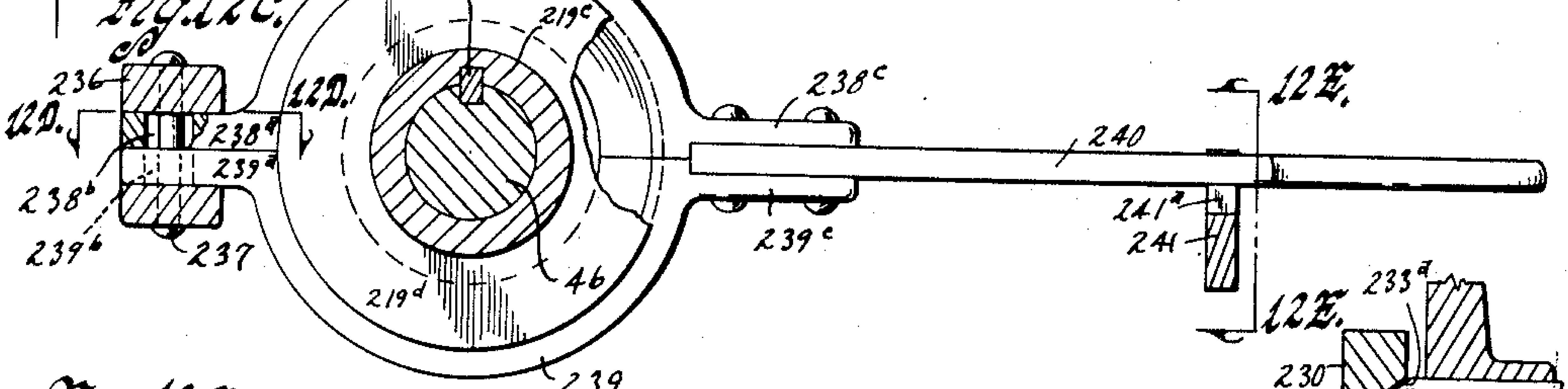


Fig. 12B.

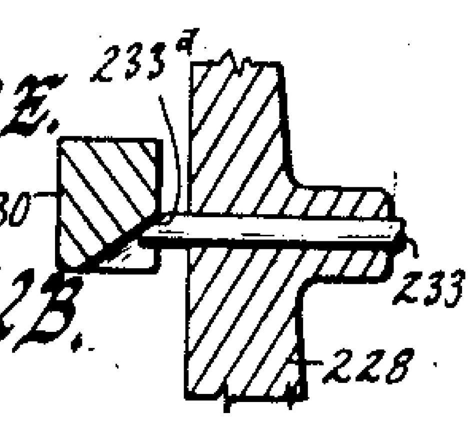


Fig. 12G.

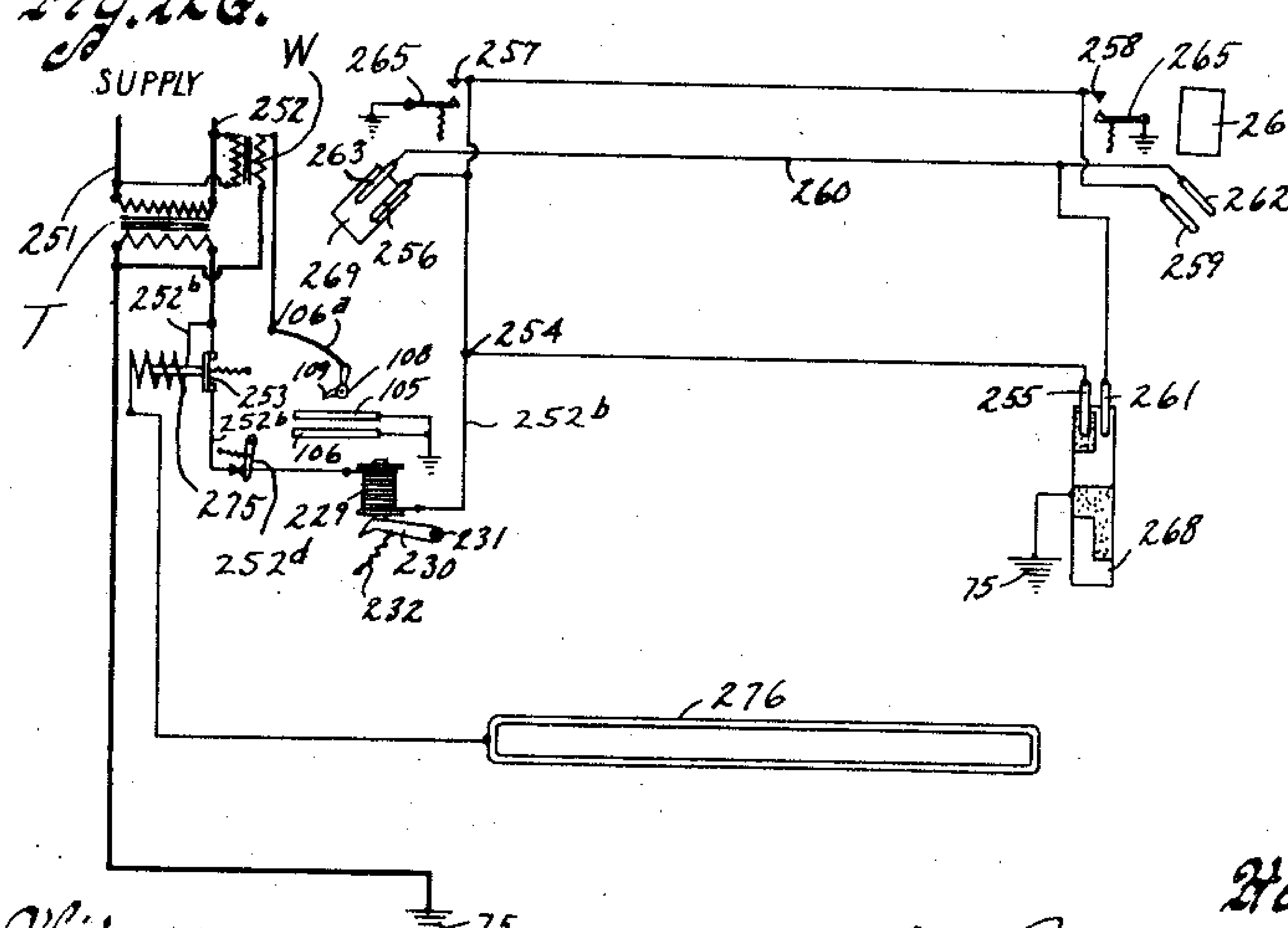
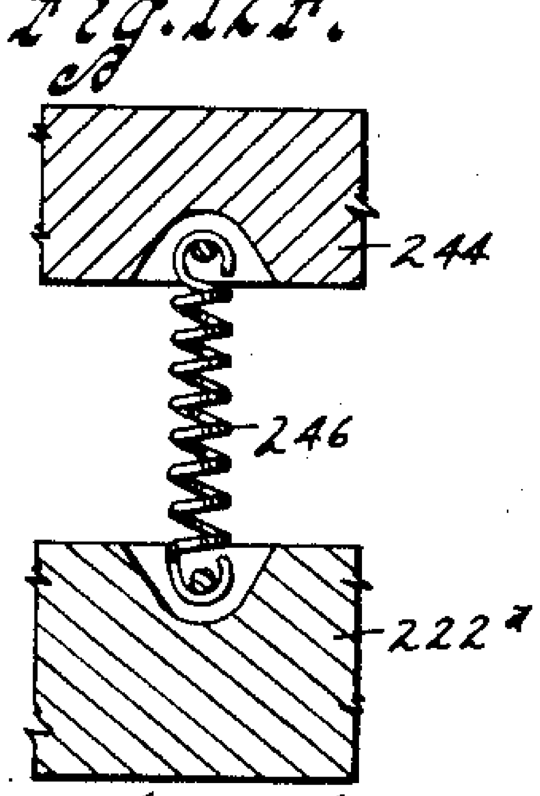


Fig. 12F.



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WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

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Fig. 16.

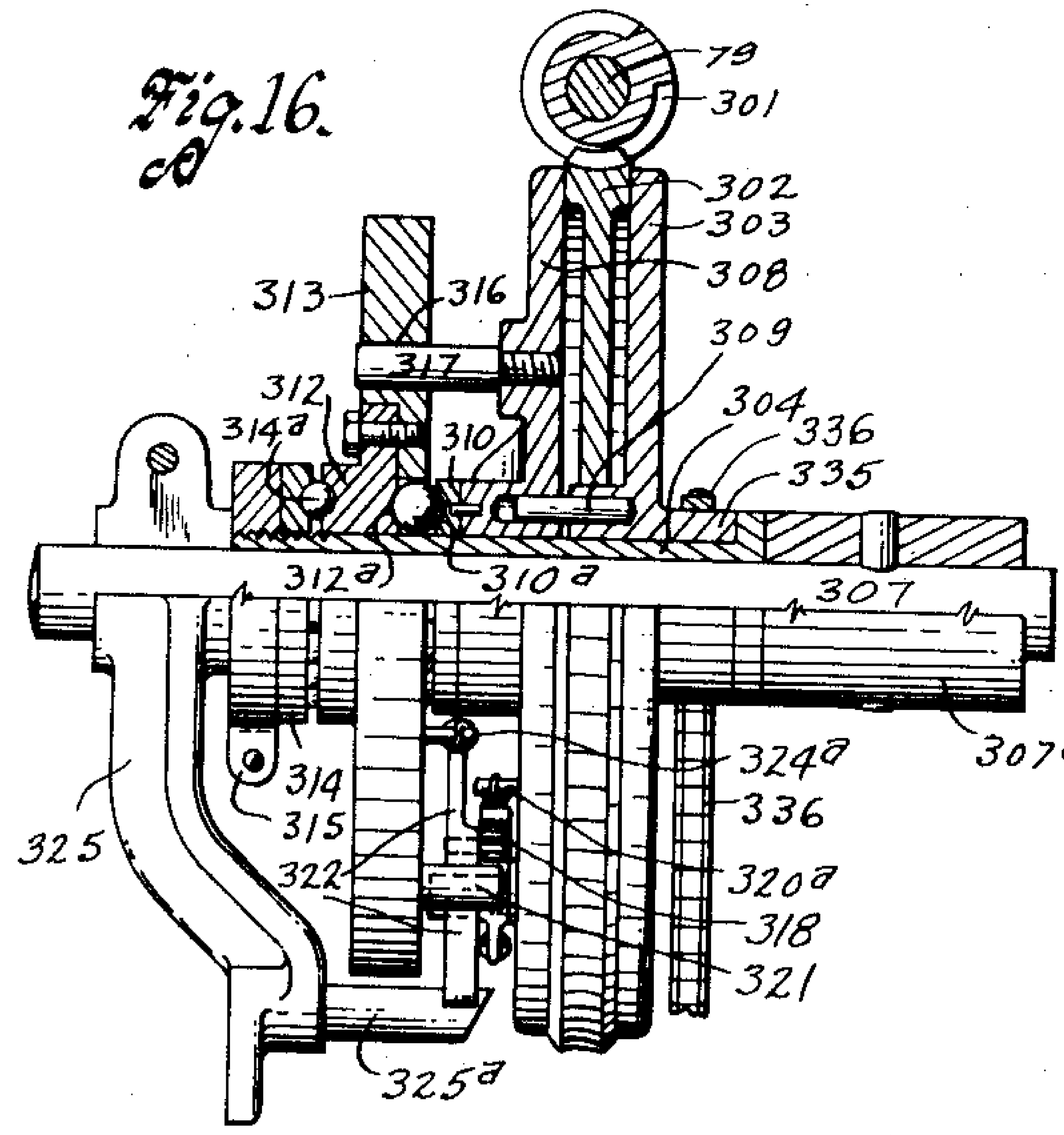


Fig. 14.

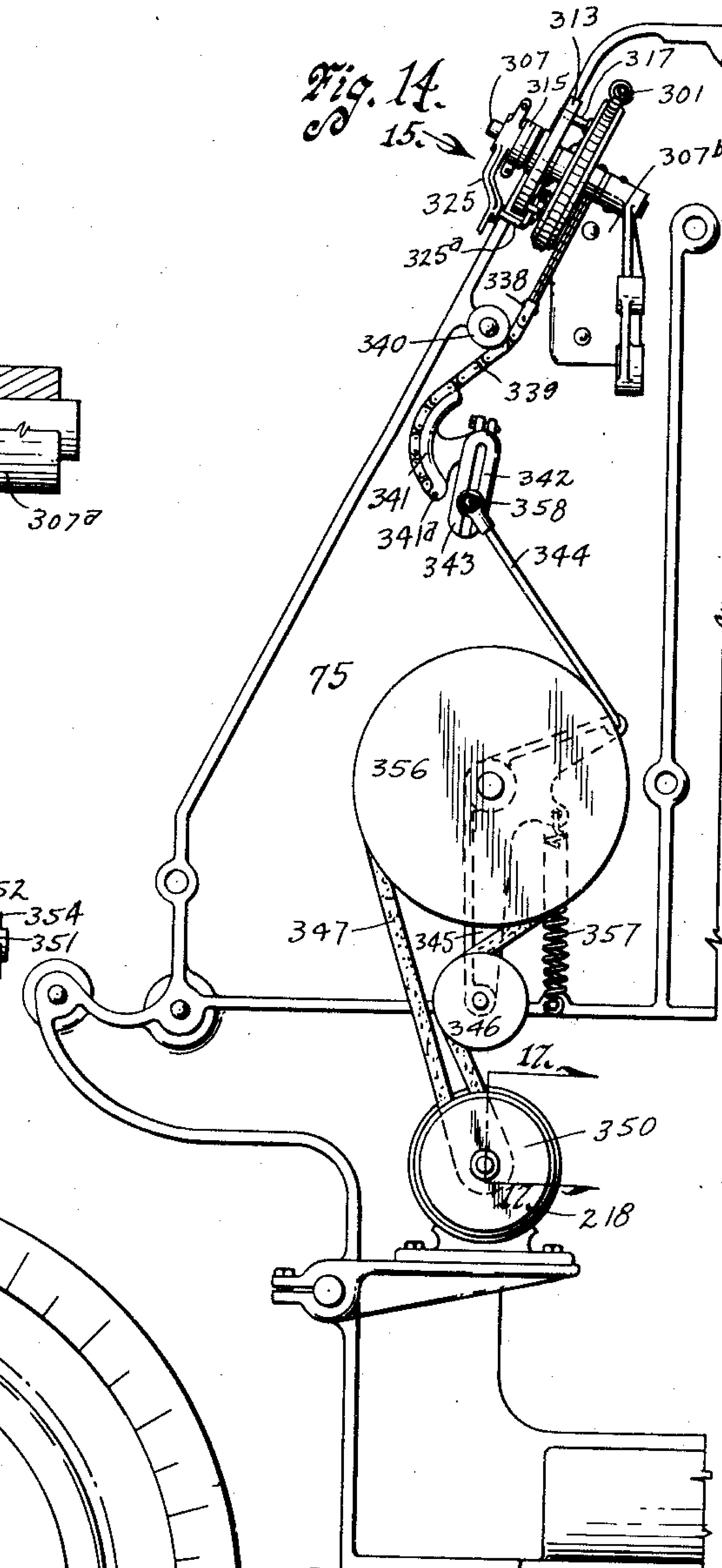


Fig. 17.

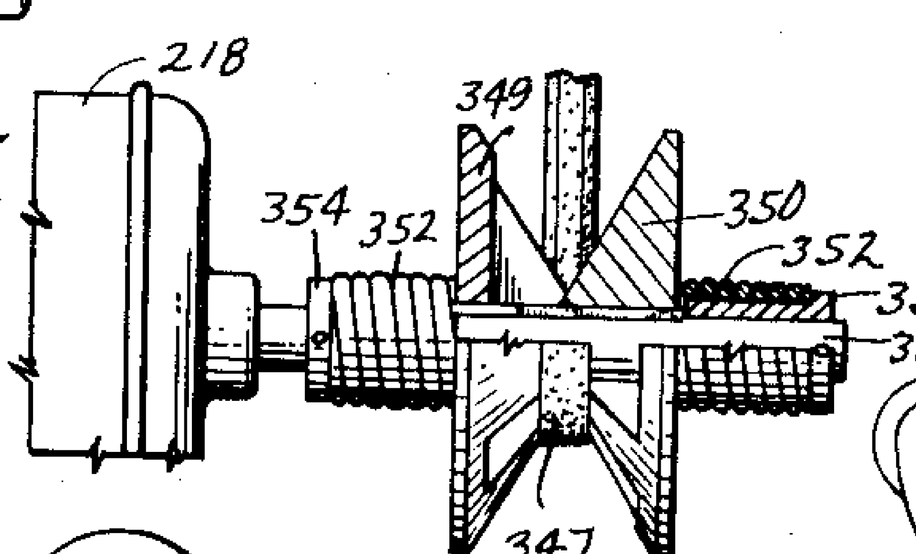
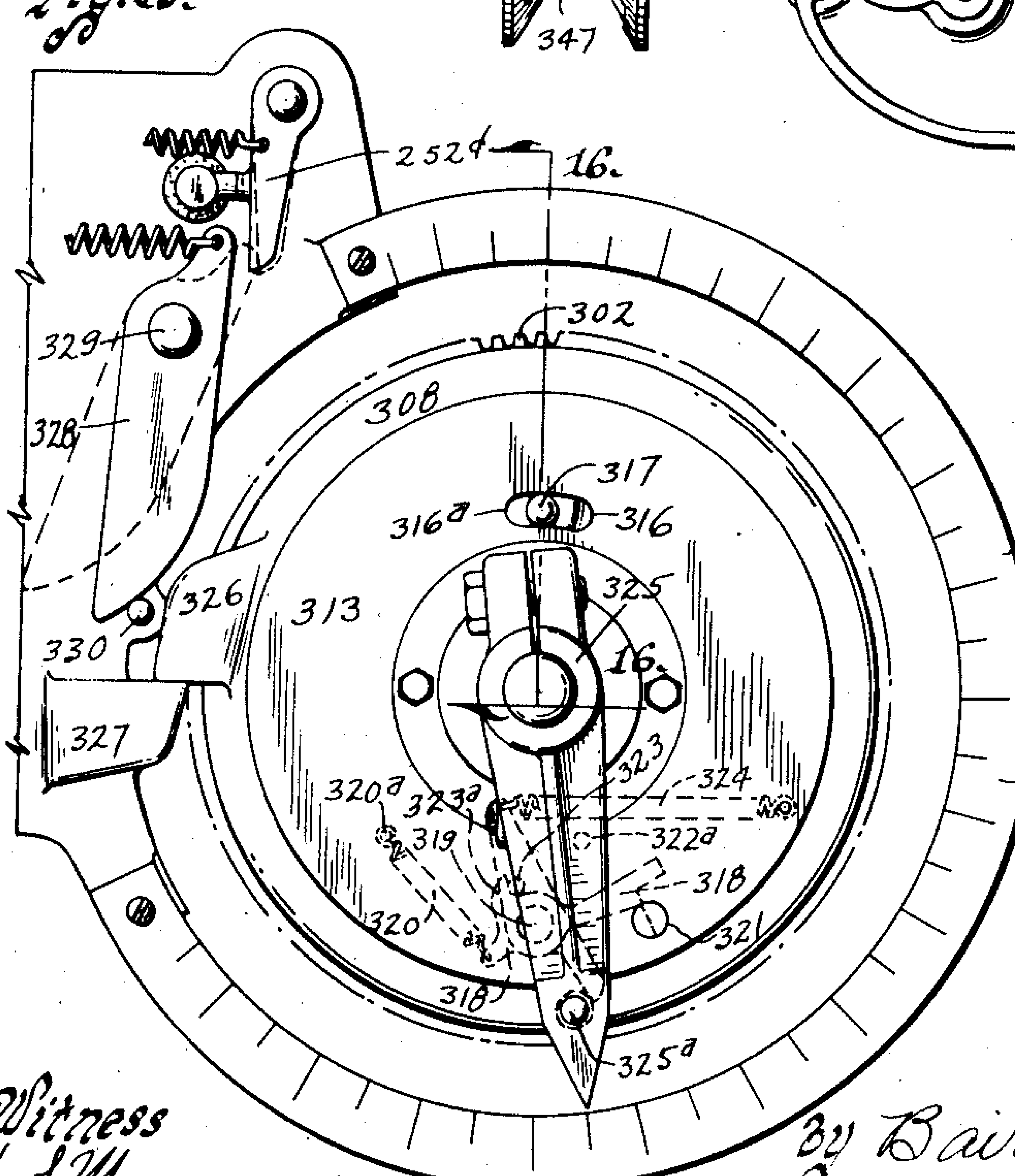


Fig. 15.



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UNITED STATES PATENT OFFICE

2,022,225

WIRE WEAVING MACHINE AND METHOD OF WEAVING WIRE CLOTH

Herbert L. Thompson, Elgin, Ill., assignor to Reynolds Wire Co., Dixon, Ill., a corporation

Application April 3, 1933, Serial No. 664,192

8 Claims. (Cl. 139—18)

The object of my present machine is first to provide a machine and a method, whereby wire cloth may be woven at a higher rate of speed and at less expense than has been possible by means and methods heretofore available.

The machine has numerous novel features, some of which will be mentioned here and others of which will be referred to in the course of the description.

My improvement consists in a series of features, some of which I here mention.

It is my purpose to provide an improvement in warp wire feeding and tension control means.

Also it is the object of my present invention to provide an improved beater and comb structure.

Likewise it is my purpose to provide novel and rapid shuttle operating mechanism, whereby the shuttle may be rolled on its periphery for distributing the weft wire.

Still another purpose of the present invention is to provide an improved feed mechanism for controlling the advance of the product through the machine, one form of the mechanism compensating for decreased weight of the shuttle as the wire is dispensed therefrom so that the machine can always operate at maximum speed.

I have also provided an improved take-up for the finished wire cloth.

In the foregoing statement, I have not attempted to fully enumerate all the parts, which embody improvements in structure and other improvements will appear as the description proceeds.

It is my purpose to provide a mechanism and a method whereby a number of advantages in wire weaving may be attained.

The operation of this mechanism is rapid and may be practically continuous except for infrequent shuttle changing. The shuttle does not need to be changed as often as with mechanisms heretofore used. The warp and selvage wires are fed in the same lengths, which I believe to be new and this contributes to the result of a perfectly flat cloth.

The mechanism is such that the cloth is tightly crimped with a sharp bend at the wire junctions, the bend tending to be uniform in all warp and weft wires but capable of adjustment to provide more or less crimp in either the warp or the weft wires, if desired.

The spacing of the weft wires is accurate and uniform.

The arrangement is such that the reeds may be removed for purposes of repair or replacement without the necessity for unthreading the machine.

I have eliminated variations in weft wire tension.

I provide means for welding the ends of the cloth to keep them square and to avoid raveling and provide suitable means for attaching other lengths of cloth for subsequent successive processing, such as galvanizing.

With the mechanism here provided, great lengths of cloth can be woven without danger of wind-up, roll-slip or strain.

By the means provided, the finished cloth may be removed from the machine and mandrel without unwinding and without stopping production.

My mechanism has an intermittent feed and a stationary weaving point. Owing to this period during which the cloth is stationary, I find it possible to pass the cloth over an inspection apron, which may support the welding and cutting apparatus, and which may be used, if desired, to align special mechanism to perform any unusual operations as for marking the cloth for identification and so forth.

With these and other objects in view, my invention consists in the construction, arrangement and combination of the various parts of my wire weaving machine and in the practice of my method, whereby the objects contemplated are attained, as hereinafter more fully set forth, pointed out in my claims, and illustrated in the accompanying drawings, in which:

Figure 1 illustrates my wire weaving machine in side elevation, the wire tensioning mechanism which takes the warp wire from the rolls and tensions it for its progress through the machine being broken away.

Figure 2 is a side elevation of a wire tensioning and control mechanism, which receives the warp wires from the source of supply and supplies them in equal lengths to the weaving mechanism.

Figure 3 is a rear elevation of this warp wire supplying mechanism.

Figure 4 is a detail sectional view taken on the line 4—4 of Figure 3.

Figure 5 is a vertical sectional view of the warp wire supplying mechanism taken on the line 5—5 of Figure 3.

Figure 5A is an enlarged sectional view on the line 5A—5A of Figure 5.

Figure 6 is an elevation of the left end of the machine viewed from the front,—to-wit from the end having the warp supplying mechanism mentioned.

Figure 7 is a similar view of the right side of the machine.

Figure 8 shows a rear elevation of one side of the machine.

Figures 8A and 8B show respectively a side elevation and a front elevation of a hand welding tool.

Figure 9 is a fragmentary side elevation of the side opposite that shown in Figure 1.

Figure 9A is a sectional view on the line 9A—9A of Figure 9, parts being omitted.

Figure 9A' is a similar view showing a modified construction, parts being omitted.

Figure 9A'' is a sectional view on the line 9A''—9A'' of Figure 9A'.

Figure 9B is a plan view of the lower part of Figure 9A.

Figure 9C is an end elevation of a clip shown in Figure 9B as viewed in the direction of the arrow 9C adjacent Figure 9B.

Figure 10 is a vertical sectional view taken on the line 10—10 of Figure 6, illustrating the parts at one stage of the operation, some parts being omitted.

Figure 10A is a detailed sectional view of a part of the heddle structure taken on the line 10A—10A of Figure 10.

Figure 10B is a sectional view of part of the pick operating mechanism taken on the line 10B—10B of Figure 10.

Figure 10C is a sectional view taken on the line 10C—10C of Figure 10B.

Figure 10C' is aview similar to the left hand portion of Figure 10 slightly below the top thereof, showing a modified holding mechanism.

Figure 10D is a vertical sectional view taken on the line 10D—10D of Figure 7.

Figure 11 is a view similar to that of Figure 10, illustrating the parts at a different stage of the weaving operation.

Figure 11A is a diagrammatic view of a section of wire cloth, illustrating a stage of the weaving operation.

Figure 11B is a view similar to the central portion of Figure 11 adjacent the upper end thereof showing a modified comb holder construction.

Figure 11C is an enlarged plan view of a portion of one end of the comb shown in Figure 11B.

Figure 12 is an elevation, partly in section taken on the line 12—12 of Figure 1, of the driving and automatic declutching and braking mechanism.

Figure 12A is a vertical sectional view taken on the line 12A—12A of Figure 12.

Figure 12B is a vertical sectional view of portions of the pawl and pin shown in Figure 12A.

Figure 12C is a vertical sectional view taken on the line 12C—12C of Figure 12, illustrating the control handle.

Figure 12D is a horizontal sectional view taken on the line 12D—12D of Figure 12C.

Figure 12E is a vertical sectional view taken on the section 12E—12E of Figure 12C.

Figure 12F is a horizontal sectional view taken on the line 12F—12F of Figure 12A.

Figure 12G is a diagrammatic view of the stop circuit system.

Figure 13 is a perspective view of the rolling shuttle.

Figure 13A is a detailed sectional view taken on the line 13A—13A of Figure 13.

Figure 13B is a detailed sectional view taken on the line 13B—13B of Figure 13A looking in the direction indicated by the arrows on the section line.

Figure 14 is a side elevation somewhat like Figure 1 except omitting much of the mechanism and showing a modified type of driving mechanism for the loom to compensate for varying shuttle weight.

Figure 15 is an enlarged rear elevation of part of the modified driving mechanism as viewed in the direction of the arrow 15 adjacent Figure 14.

Figure 16 is a partial sectional view taken on the line 16—16 of Figure 15; and

Figure 17 is a partial sectional view taken on the line 17—17 of Figure 14.

In order to simplify the explanation of the construction and operation of my improved weaving machine and the steps of my method, I shall endeavor to describe the units of the machine separately.

The warp wires are fed from suitable sources of supply as for instance from spools rotatably supported on racks adjacent to the front of the machine. These spools and racks are not here shown. From them the warp wires, as indicated at 10 in Figure 5, are fed to the warp wire tensioning and control mechanism, which is best illustrated in Figures 2 to 5 inclusive. It might be said at this point that the warp wires travel through the tensioning mechanism shown for instance in Figures 2 and 5. From thence the warp wires are carried forwardly to the weaving mechanism proper, in which they travel upwardly during the weaving process, as perhaps best shown in Figures 10 and 11. Then the finished cloth moves over the breast roll hereafter to be described to the take-up mechanism.

Tensioning device and warp length control

It is well known that it is very difficult in weaving machines heretofore used to produce wire cloth which will lie flat and straight as it comes from the loom. This is due in part to difficulties which have been encountered in supplying the warp wires in exactly equal lengths. Whenever there is variation in the tension on the incoming warp wires, the result is that the wires of the less tension are crimped more easily than the wires under tension, resulting in an uneven cloth. The ideal wire cloth is that in which the crimp is equal in warp and weft wires, so that the cloth will at all times have just the thickness of two wires. If one wire crimps so easily that it does not deflect the wire against which it is crimped, the cloth will have spots where it will be more than two wires thick. High wire crimps are easily seen and ruin the appearance of wire cloth, and in addition to this, if the subsequent handling of the wire involves passing the woven cloth with the uneven crimps over rolls under tension or even on to a tightly rolled roll of cloth, the high crimps will be pressed down and this will cause a loose spot in the finished wire cloth. It is obvious that where tensile strain is imposed on cloth, a loose wire does not receive its share of the pull. This explains the "pulled" or distorted cloth frequently seen. This problem will be again referred to in connection with the explanation of the operation of my machine and I will now proceed to explain the construction for tensioning and feeding the warp wires to the machine in equal lengths.

Integral with the base elements 11 and 11a are laterally spaced upright frame members 12 and 12a. Mounted in the frame members 12 and 12a are three vertically spaced shafts 13, 14 and 15 shown in Figures 2 and 5. Spaced rearwardly from the shafts 14 and 15 and staggered vertically between them is a similarly mounted shaft 16. On the shafts 13 to 16 inclusive are rotatably mounted metal rolls 13a, 14a, 15a and 16a. These rolls 13a to 16a inclusive are of the same diameters and are caused to rotate in unison by meshing gears 17. A shaft 18 has its ends journaled to rotate freely in the frame members 12 and 12a. On the shaft 18 is keyed a roll 19 of the same exterior diameter as and parallel with the rolls 13a to 16a. The roll 19 is geared to the other rolls as at 20, so that all of these rolls rotate together at the same surface speed.

A spacer rod or shaft 21 is detachably clamped to the upper ends of the frame members 12 and 12a by means of the clamps 22 and the screw bolts 23, which extend through the clamp members and are threaded into the frame members 12 and 12a. The spacer rod or shaft 21 is provided with equally spaced circumferential grooves 21a as shown in Figure 3.

A closing bar 24 is supported by the clamp members 22 adjacent to the spacer rod 21 and functions to keep the warp wires 10 in the grooves 21a. These spacer rods and closing bars are easily changeable so that rods with differently spaced grooves may be used for making cloth with different spaces between the successive warp wires.

Substantially below the spacer rod 21 and rearwardly in the machine from the roll 13a is a second spacer 25 in the form of a freely rotatable shaft. It is grooved similarly to the rod 21 and has the lower part of its periphery below the upper part of the periphery of the roll 13a. It is located quite close to the roll 13a. The ends of the spacer shaft 25 are recessed, as indicated in Figure 5A, to receive bearings 25a. Adjustable studs 25b are supported in the frame members 12 and 12a to in turn support the bearings 25a and the spacer shaft 25.

By locating the shaft 25 nearly in contact with the roll 13a, even very hard wire which has a marked tendency to retain its original crookedness can be fed onto the surface of the roll 13a in perfectly straight circumferential lines, which is essential to the successful performance of the tension device as a means for feeding exactly equal lengths of warp wire.

The spacer shaft 25 is readily removable to facilitate threading up the tension device. By merely loosening the studs 25b, the bearings 25a can be retracted out of their sockets so that the shaft 25 can be removed. This also facilitates changing shafts for weaving wire of different mesh.

The warp wires 10 come from the source of supply usually located above and forwardly with relation to the machine and are threaded around the rear face of the spacer rod 21 and then threaded with a rather sharp bend around the spacer shaft 25 and then successively around the smooth rolls 13a, 19, 14a, 16a and 15a.

It will be noted that the wires are threaded so that they embrace the larger part of the circumference of each of the rolls 13a, 19, 14a, 16a and 15a. This provides for frictional contact between the wire and the surface of the roll, which effectually prevents slippage of the wire upon the roll surface at any pull within the tensile strength of the wire.

As the warp wire is always under tension, which is necessary in weaving wire cloth, the friction between the surfaces of the geared rolls and the warp wire constitutes an efficient means for insuring precise duplication of the lengths of the respective warp wires admitted to the machine.

In order to further assure even initial tension on the warp wires as they start their travel through the rolls of the tension device, I provide means for producing slack in the warp wires.

Rocker arms 31 are fixed to a rock shaft 32 journaled in the frame members 12 and 12a. The rocker arms 31 extend upwardly and their upper ends are connected by a rocker bar 33. On the shaft 32 is fixed an arm 34 carrying a weight 35 as shown in Figure 5, for normally holding the rocker bar 33 against the warp wires 10 between the spacer bar 21 and spacer shaft 25. Pivoted to one of the rocker arms 31 is a link 36 extending forwardly in the machine and having an elongated slot 37.

At the front of the machine, a substantially upright lever 38 is pivoted at 39 substantially midway between its ends. Projecting from the upper end of the lever 38 through the slot 37 is a headed pin 40. Pivoted to the lower end of the lever 38 is a link 41 extending rearwardly in the machine.

Referring for the moment to Figure 10, it will be observed that the rearward end of the link 41 has a pivotal connection with a bell crank lever 42 pivoted on the main frame of the machine hereinafter to be described, and that the other end of the bell crank is pivoted to a link 43 which extends upwardly and has on its upper end the collar 44 carried on the eccentric cam 45 on the operating shaft 46 hereafter to be referred to.

It will be seen that the rotation of the shaft 46 imparts an oscillating movement to the rocker bar 33 through a short arc for intermittently putting slack in the incoming warp wires 10.

It will be seen from the description of the operation of the other parts of the machine to be hereinafter set forth that this operation of the rocker bar 16 is properly synchronized with the other operations of the weaving mechanism.

The operation of the rocker bars insures an even initial tension on the warp wires by drawing slack from the supply spools for each warp feed movement.

It might be mentioned here that the actual feed in drawing the wire from the spools is accomplished only when the wires approach a straight line between the two spacer bars and have thus lifted the rocker bar to the point where the pin 40 engaging in the forward end of the slot 37 serves to pull a short length of wire from the spools just before the wire is fed through the machine. The feeding action which immediately follows this slack producing action takes up the loose slack in the wire and the process is then repeated for furnishing slack warp wires for the next succeeding machine feeding motion.

It is sometimes necessary to momentarily reverse the direction of motion of the incoming warp wires to correct a bad piece of weaving or to make a "set" in starting a new shuttle of weft wire.

For this purpose, there is provided on one end of the shaft 18 a hand wheel 47 shown in Figures 2, 3 and 5. When it is desired to reverse the movement of the incoming warp wire, the feed pawl hereinafter referred to is moved out of feed position and the hand wheel is operated for reversing the normal movement of the rolls of the tension device. The slack which would then otherwise occur in the incoming warp wires between the roll **13***a* and spacer shaft **25** is taken care of by the rocker bar **33**. The link **36** serves for transmitting the motion of the cam **45** to the rocker bar **33** only when that motion is necessary to strip wire from the supply spools for the next succeeding feed motion of the machine.

In case of reversal of the movement of the warp wires, the weight **35** of the rocker bar mechanism presses the rocker bar **33** against the nearly vertical warp wires between the spacer rod **21** and the spacer shaft **25** and as the wire is released from the top of the roll **13***a*, this weight causes the rocker bar **33** to draw the loose wire around the spacer rod **25** and to maintain tension in the slack wire,—though not enough tension to strip wire from the supply spools. This arrangement affords a reliable automatic control for the slack wire, which would otherwise accumulate above the rolls in case of a reverse movement of the warp wires on the rolls. It is, however, a safeguard only within the limits of travel of the rocker bar, which is designed to have sufficient movement to care for any normal requirements.

Result of operation of warp length control

The warp length control herein described in connection with the means hereafter mentioned for pulling the cloth through the machine results in automatically causing all wires to be uniformly crimped.

I shall now proceed to explain how this desirable result occurs.

It will be obvious that even when the wires are under equal tension, there will be some wires softer than others,—to-wit of different temper and there may be some little difference in size. The weaver determines by experiment what the tension to be maintained should be and keeps this beneath the elastic limit of the warp wires.

A certain amount of cloth is first woven and this will not be good flat wire, but after a short period of operation, the even crimp of all wires becomes automatic. The action is about as follows:

After the first weft wire is laid, the first heddle reversal will crimp all of the warp wires upon this first weft wire. The harder and stiffer warp wires will crimp less than those that are soft and flexible. Consequently these harder warp wires will deflect the weft wire more than will the soft warp wires. After each weft wire is laid in succession, the same action will follow, but it is plain that the hard wires crimping less than their neighbors will not use up as much of their length in crimp as do the softer wires. As the weaving progresses, the hard low crimping warp wires will tend to become less taut and the softer crimping warp wires by using up their length faster on the higher crimps will tend to become more taut until a balance is established where the excess tension on the softer wires will lower the crimp thereof, and the reduced tension on the harder wires will result in increasing the amount of crimp in them to the cloth average. After the loom has operated long enough for this condition to appear, its continued operation will automatically maintain uniform crimping, so long as the warp wires are fed in exactly equal lengths.

Tension adjustment

The structure heretofore described, including the warp wire rolls, not only serves to provide for supplying warp wires in identical lengths but also functions in connection with certain additional parts now to be described to provide a certain general tension upon the warp wires during the weaving operations.

Assuming that the warp feed through the feeding mechanism is definite and for all purposes practically irresistible, it follows that the load applied against the rotation of the rolls of the mechanism shown in Figure 5 will increase the tension of the warp wire between those rolls, and the machine feed mechanism. I have provided means for automatically establishing a certain controlled degree of this tension producing friction load. The amount of friction to be applied must be regulated by the actual tension of the warp itself, so that increasing tension produces a decreasing friction and a decreasing tension produces an increase in friction.

In this way, the tension will be self-regulated and automatically constant.

On the shaft **18** between it and the frame member **12***a* is fixed a brake drum **48**. On the brake drum is a brake band **48***a* (Figures 3 and 4). One end of the brake band **48***a* is anchored to the frame **12***a* by means of a pin **48***b* and ordinary parts including a short arm **48***c*, a post **48***d*, and a lock nut **48***e*. The other end of the brake band is pivoted between ears of a lever **48***f* mounted to rock on the frame by means of a pin **48***g*. The lever **48***f* has an arm **48***h* acting against a spring **48***i*, which serves to normally hold the brake band out of contact with the drum.

When the brake band is thus inoperative, the tension on the warp wires required to pull them rearwardly through the machine is only that tension, which is necessary to revolve the warp wire rolls and to overcome the friction of the wires on the spacer shaft **25** and on the rocker bar **33**.

There is provided mechanism for regulating the brake friction. (See Figures 2, 4, 5, 6 and 10.) After the warp wires leave the roll **15***a*, shown in Figure 5, they travel rearwardly in the machine toward the weaving mechanism supported upon the main side frame members **75** and **75***a*. It might be mentioned here that the main frame members **75** and **75***a* are rigidly connected with the frame members **12** and **12***a* by means of heavy connecting frame members **75***b*.

The warp wires pass under and then upwardly from a whip roll **48***j* rotatably supported on a shaft **48***k*. The shaft **48***k* is supported between the rearward ends of the arms **48***l* and **48***m*. The arms **48***l* and **48***m* extend forwardly in the machine and are rigidly connected with a transverse shaft **48***n*, journaled in bearings **48***o* supported by the frame members **75***b*. (See Figure 5.)

The arm **48***m* has a forward projection **48***p* (Figure 5) which stands just below a rearwardly extending arm **48***q* on the lever **48***f*. Adjustably threaded in the arm **48***q* is an adjustment screw **48***r* on which is a lock nut **48***s*. This adjustment screw **48***r* serves to vary the effective distance between the arm **48***q* on the lever **48***f* and the projection **48***h* on the arm **48***m*. It is obvious that upward movement of the projection **48***p* bearing against the screw **48***r* (Figures 4 and 5) serves to tilt the lever **48***f* and tighten the brake band **48***a* against the drum **48** for thus resisting rotation of all of the rolls and consequently resisting the forward feed of the warp wires.

As the warp wires are drawn around the whip roll **48***j* and upwardly through the weaving mechanism by the means hereinafter to be described, the wires exert an upward pull upon the whip roll, which merely lies upon them. If the warp wires were given slack, the whip roll would have no support and would thereafter drop to the floor, if it were not for the engagement of the projection 48p with the adjustment screw 48r. This engagement is, of course, with sufficient pressure to support the whip roll 48j and its supporting arms. The weight thus imposed on the lever 48f causes the brake band 48a to engage the brake drum with considerable friction and to thus resist the rotation of the warp wire rolls.

It is thus seen that there is provided a means for establishing tension on the warp. The warp can not pass through the warp rolls until there is sufficient tension upon it to lift the whip roll a certain distance or amount. This distance or amount can be regulated by means of the adjustment of the screw 48r. This screw adjustment, however, only establishes the height at which the whip roll causes the brake to be released. It does not adjust tension. In order to change the tension on the warp, it is necessary to change the downward pressure exerted upon the warp by the whip roll. I will now describe the mechanism for regulating this downward tension of the whip roll on the warp.

The arms 48l and 48m have short rearward extensions beyond their hubs which embrace the shaft 48k, indicated at 48t (Figure 10). These extensions have what might be called anvil faces 48u machined in a plane radial with relation to the axis of the shaft 48k. Just rearwardly of the whip roll 48j, a transverse shaft 48v is rigidly supported between the machine side frames 75a and 75. Upon this shaft 48v is rotatably supported a sleeve or tube 48w by anti-friction bearings of any suitable type, not here shown. At each end of the sleeve 48w are fixed rigid forwardly extending arms 48x, which bear upon the anvil faces 48u. At approximately the center of the sleeve 48w is fixed a rearwardly extending arm 48y. Secured to the rearward end of this arm is one end of a coil spring 48z. The other end of the spring 48z is connected to a chain 49, which can be wound more or less tightly around a sleeve 49a on a shaft 49b for controlling the pull on the arm 48y.

For winding the chain 49 on the sleeve 49a, which is fixed on the shaft 49b, a lever 49c is fixed to the shaft 49b (Figure 1). The lever 49c may be locked in various positions of adjustment by means of a movable pin 49d having slidable mounting in the lever 49c and adapted to be projected into any one of a series of holes 49e in a rigid quadrant 49f.

As the warp weaving tension is dependent upon the pull required to lift the whip roll 48j high enough to release the brake on the tension rolls, it follows that any downward pressure applied to the whip roll will increase the warp tension just that much, because the brake will not release the rolls until this downward pull has been overcome by the upward pull of the warp itself, and once the proper adjustment is established, it is permanent except for slight variations due to wear and so forth, although the adjustment is easily altered by varying the tension on the spring 48z. The sleeve 48w really functions somewhat like the beam of a scale in that it serves to balance the warp tension against the spring 48z.

In addition to its function as a means for altering the warp tension, the tube 48w and its arms 48x serve to keep the whip roll perfectly horizontal and thus prevent either side of the warp from straining or pulling the whip roll frame out of alignment.

In action, the whip roll and attendant mechanism are constantly rising and falling through a short travel in unison with the heddle movement and the feed of the warp hereafter to be described. However, this does not necessarily involve the warp rolls in a perfectly synchronized feed movement, since the elasticity of the train of members conveying the action as well as that of the wire itself blends this motion into a brake release that is somewhat more constant but which accurately averages the feed at the particular tension at which it is set.

It is thus possible to take up the warp slack, due to heddle movement and at the same time automatically adjust the tension brake with the same mechanism. This is feasible since the heddle movement is compensated within the range of the elasticity of the parts, while the warp feed causes an actual permanent rise to the vibrating parts until the lift of the whip roll results in sufficient brake release to allow additional warp wire to pass through the warp rolls.

Heddles

From the whip roll 48j, the warp wires 10 extend upwardly through the heddles 49g, which function to successively move alternate wires rearwardly and forwardly in the machine for forming the shed for the passage of the shuttle carrying the weft wire (Figure 10). These heddles or trestles have a number of features, which distinguish them from heddles used in standard wire cloth weaving machines.

Instead of being frail needle-like members strung upon a wooden harness frame, my heddles 49g have substantial metal frames set in horizontal planes, one above the other. The side members of the heddle frames travel upon rollers 49h.

Adjacent the inner faces of the transverse members of the heddle frames are mounted removable spacer bars 50. These spacer bars have regularly spaced inward projections 51, which serve as supports for properly locating and spacing the heddle dents 52. These spacer bars may be held by screws, not shown. The spacer bars are removable so that they may be replaced by others having differently spaced projections 51. It is thus possible to select spacer bars for properly spacing the warp wires according to the number of warp wires per inch in the desired finished wire cloth.

The heddle dents 52 are rigid metal members having transverse sections in the shape of a downwardly opening U. Each has a slot 53 in its center at its top for the free passage of a warp wire and between its walls below the slot has metal sheaves 54 for receiving the warp wire between them and serving as anti-friction means. The U-shaped heddle dents at their ends straddle the projections 51. A locking strip 55 is placed above the ends of the heddle dents and is secured to the transverse frame member of the heddle by means of screws 55a. This prevents the heddle dents from being lifted off the supporting projections 51.

This assembly makes a substantial sufficiently light weight but very durable heddle member, and permits its use for the extraordinary purpose of supporting the rolling shuttle, which carries the weft wire through the warp shed in the manner described below.

Reciprocating movement is transmitted to the heddles 49g by mechanism which will now be described.

Journaled on the frame of the machine is a shaft 56 to which levers 57 are fixed between their ends. Links 58 are pivoted to the upper ends of the levers 57 and to the upper heddle frame 49g. Similar links 58a are pivoted to the lower ends of the levers 57 and to the lower heddle frame 49g.

Rocking motion is transmitted to the shaft 56 from the shaft 59 journaled on the main frame. On the end of the shaft 59 as shown in Figure 10D and in Figure 7 is a cam disc 60, having a cam groove 60a in its face. A lever 61 has one end pivoted on the frame as at 61a and carries a roller 62 which travels in the cam groove 60a. The lever 61 is pivoted to one end of a link 62a which is in turn pivoted at its far end to an arm 63 fixed on the shaft 56.

As the shaft 59 rotates, the lever 61, the link 62a and the arm 63 are reciprocated for rocking the shaft 56. The rocking of the shaft 56 serves to reciprocate the heddle frames 49g through the media of the links 58—58a.

Beater and comb or reed

The line where the weft wire is laid as the warp is fed through the machine is just above the heddles.

I use a novel swinging beater 66, shown for instance in Figures 10 and 11, extending transversely in the machine. The beater 66 carries a toothed comb 67 clamped to it by means of a member 68 and screw bolts 68a, so that the comb can be readily removed and replaced with another for differently spaced warp wire.

This beater and comb swing on a short radius and only during a portion of their travel is the comb within the warp shed. This permits a greater portion of the operative cycle to be used in passing the shuttle back and forth for laying the weft wire while the beater and comb are out of the shed area and will not interfere with the shuttle.

The beater is operated from spaced cams 69 on the cam shaft 59 already referred to. The cams 69 contact rollers 71 on levers 72 pivoted at 72a (Figures 7, 10 and 11). The levers 72 are pivoted at their upper ends to links or connecting rods 73, which are in turn pivoted to the beater 66. The beater 66 is journaled on a transverse shaft 74 (see Figures 6, 7, 10 and 11). The rotation of the shaft 59 through the mechanism just described serves to rock the beater 66 from the position shown in Figure 10 to the position shown in Figure 11 and back.

The operation of the beater and comb will again be referred to in connection with the description of the weft wire laying mechanism.

In Figures 11B and 11C, I have shown a modified comb construction comprising parts built up to form the comb. The comb is indicated generally by the reference numeral 67a and comprises a plurality of teeth elements 67b arranged on edge and threaded on tie rods 67c. Interposed between the teeth 67b and surrounding the tie rods 67c are spacer washers 67d.

The comb 67a is clamped in a modified beater arm 66a between the arm and a transversely extending clamping bar 66b. Clamping bolts 66c extend through the arm 66a and the bar 66b to clamp the comb between them.

Wire cloth feed mechanism

The feed mechanism for the wire cloth is located at the top of the machine. A breast roll 76 (Figures 10 and 11) is carried by suitable anti-friction bearings not here shown on a transverse shaft 77 rigidly supported on the main frame members of the machine.

Upon one end of the breast roll 76 is fixed a gear 78, preferably having a pitch diameter approximately equal to the diameter of the breast roll.

A shaft 79 (Figures 7, 8, 9 and 10) is journalled in the main frame 75a and in a bracket bearing 80 and has fixed thereto a pinion 79a (Figure 8) which meshes with the gear 78 on the breast roll.

Intermittent fractional rotation is imparted to the shaft 79 and pinion 79a at each machine cycle by means of a ratchet 81, fixed on the shaft 79 (Figures 8 and 9). The ratchet 81 is actuated by a pawl 82 which is pivoted by a pin 83 on the oscillating arm 84 and spring loaded by the spring 82a. The arm 84 is rotatably mounted on the shaft 79 and rocks through an arc around the shaft 79. The rearward end of the arm 84 is pivoted to a link 85, which extends downwardly and has its lower end pivoted on a crank pin 86. The crank pin 86 is adjustably mounted on the pinion 87 by means of an ordinary screw fed and friction lock variable feed indicated generally at 86a in Figure 9.

The pinion 87 is fixed on the main drive shaft 46. A spring loaded pawl 83a is pivoted on the bearing 80 at 83b to coact with the ratchet 81.

Directly above the breast roll and parallel therewith is a transverse shaft 88 supported in slots 90 in brackets 91 on the main frame. Above the ends of the shaft 88 are plates 88a upon which are helical compression springs 89 above which are plates 88b. The plates and springs are contained in seats, machined in the upper portion of the walls of the slots 90. The upper ends of the slots are covered by plates 92 bolted to the brackets 91. Adjusting screws 93 are threaded through the plates 92 and bear adjustably against the plates 88b, and thus provide means for controlling the tension of the springs and the pressure imposed on the shaft 88.

At the opposite ends of the shaft 88, rearwardly and downwardly extending arms 94 are pivoted. They support a shaft 97 upon which is journaled a roller 99 by anti-friction bearings not shown. Likewise on each end of the shaft 88 is pivoted an arm 95. The arms 95 support a shaft 98 upon which is journaled a roller 99a by means of anti-friction bearings not shown. An endless band 100 of rubberized fabric is extended around the rolls 99 and 99a in such a way as to embrace the top of the breast roll 76 for a considerable portion of its circumference, so that any rotation of the breast roll will tend to drive the belt and the rolls 99 and 99a by frictional contact. The frictional pressure of the belt on the breast roll may be regulated by means of the screws 93 and the springs 89 affording a suitable cushioning means for the shaft 88.

Pressure brought to bear by adjustment of the screws will tend not only to cause the belt 100 to bear more strongly against the breast roll, but it will also tend to separate the rolls 99—99a, without forcing any of the members out of their proper relations.

On account of the anti-friction bearings, variations in this pressure do not substantially change the frictional resistance to rotation.

The weaving point where the weft wires are moved to their ultimate position in the completed wire cloth is located just a few inches below the point at which the belt 100 makes contact with the surface of the breast roll on the front side of the machine. The finished wire cloth passes between the belt 100 and the surface of the breast roll 76 and is held by a firm grip for its entire width and for a length along the warp equal to that portion of the breast roll circumference embraced by the belt.

Intermittent rotation of the breast roll by means already described functions to feed the finished wire cloth through the machine.

Since the pressure applied by means of the belt may be varied as desired, it is evident that the feeding means is positive over any range of tensions that may be imposed. This is particularly true because the gripping surfaces of the roll and belt press equally upon both the woven warp and woven weft and tend to grip them firmly at each crimp junction.

The feed mechanism serves another function in addition to feeding the cloth. After the cloth enters the vice-like grip of the feed, pressure is applied at each wire junction sufficient to reduce any high crimp. If under unusual conditions, high crimps are encountered, due to the fact that there is a soft wire in the warp, the crimp will be rolled down to a two wire thickness in the cloth, and the loose wire obtained from the flattened crimp will be steadily rolled back out of cloth, until it appears as loose warp below the weaving point, and this will give notice to the weaver that a new supply spool of harder wire should be inserted.

As wire cloth is ordinarily woven, the outside or selvage warp wires are never crimped in the loom. The weft wire in looping around these selvage wires does not cause them to crimp, because in ordinary looms, it is not possible to support the weft loop with sufficient rigidity to cause the warp wire to bend around it. As a consequence, the weft loop ordinarily merely twists a trifle to permit the passage of the selvage wire through it. In ordinary looms, a similar effect is noticeable also upon the warp wires immediately adjacent to the selvage wires, but in a considerably modified degree.

Ordinarily the subsequent rolling of the cloth upon the take-off mandrel forces some crimp into the selvage in the effort to press all of the cloth into a two wire thickness. However, in the weaving the lack of the crimp results in loose selvage wires and it is common practice to use weights or other expedients applied to the outside warp wires to maintain their weaving tension.

In the present machine, although the weaving does not actually crimp the outer wires, the direct pressure applied by the belt just above the weaving point serves to force a very fair crimp into the wires near the edges of the cloth. Experience shows that this action is sufficient to eliminate the usual tendency of wire cloth to roll into a roll of hour glass shape. In this machine, the surfaces of the belt and breast roll form the crimp in the selvage wire without stretching and hence the weft loops leave the selvage wire free to pull through them from the distance between the final weaving point and the point at which the belt and breast roll engage. The completion of the crimp formed by the belt pressure results in part from the lack of tension in the warp wire involved. Since the warp wire is somewhat loose, it requires less pressure to crimp it snugly about the weft wire. The more complete the crimp is, the more warp length will be absorbed, and as a consequence, this tension is in a measure self-regulating.

In looms in ordinary use, the finished wire is usually wound upon a wind-up member and tension is provided by means of a transverse weighted roller bearing upon a bight in the cloth. The action of the weighted roller is made perpetual regardless of the mechanism which rotates the take-up mandrel and winds up a certain amount of cloth, thus raising the weighted roller each time that it drops low enough to trip a wind-up clutch.

The warp is generally fed by a gear controlled rotation of a warp drum or beam and is constant so far as the angular velocity of the drum is concerned. This, however, does not result in precise accuracy in the length of the cloth, because as the warp wire is paid off the drum, the roll of wire is constantly decreased in radius, and consequently there is a constant reduction of the spaces between the weft wires.

Furthermore in such looms, a considerable length of cloth and of unwoven warp is constantly subjected to full weaving strain.

As the beater drives the reed through the warp for forcing the weft wire into place, a considerable forward impulse is given. Since wire is elastic, this additional forward impulse puts a strain upon the warp wires and results in the temporary forward displacement of the weaving point, due to such elasticity, and as a consequence there is a recoil as the beater recedes and relieves the strain. This is known among weavers as jumping or dancing of the weaving point, and is very annoying and a source of inaccuracy in the spacing of the weft wires. Furthermore the forward impulse of the beater in ordinary looms being conveyed to the elastic cloth and from there to the weighted tension roll, it causes the roll to take sudden drops and results in a periodic oscillation thereof, which limits the speed of the loom on account of the inertia of the weight roll. In ordinary looms now in use the wind-up mandrel is the final warp tension support, since the wire is stretched between it and the drum. Warp tension is established and maintained by the rotation of this member. At the beginning of a run, the cloth is wound tangent to perhaps a two inch radius. As each convolution of cloth is added to the intermittently rotating member, the radius at which it is received is greater by the thickness of one cloth layer.

Since the weight roll imposes an average uniform tension on the cloth, it is obvious that each successive convolution of cloth on the mandrel imposes a greater tortional stress upon the mandrel. The cloth being attached at one end to the mandrel must carry the same tortional load as the mandrel on the inside convolution and if the roll becomes twice the size of the mandrel, the cloth next the mandrel is subject to stress nearly twice the weaving tension. As this tension reaches the elastic limit of the wire, permanent elongation of the wire results. Since the warp wires vary in the elastic limit, some stretch more than others, and this sometimes results in what is known as "pulled cloth". When the "pull" is bad enough, the cloth can not be marketed. My present machine is free from the evils mentioned above.

The final weaving point is immediately adjacent to the feed means and variable stretching of the warp is prevented by the fact that the feeding means is positive, and the tension created thereby is uniform in amount.

As the beater and comb raise a weft wire into place, there is no jump of the weaving point, since any force expended in this operation must overcome the entire warp tension and actually lift the whip roll 48j in order to move the cloth in the machine.

The cloth, not being weight fed, remains stationary above the weaving point under the thrust from the comb, since the feed means is then stationary, and while sustaining the tension exerts no pull, and if the comb should exert sufficient lift, it would merely bend the cloth between the comb and the feed mechanism, because the comb would take the entire load and enough more to lift the whip roll 48j.

The force exerted in picking up a weft wire does not add to the weaving tension between the warp rolls and the feed unit, but merely momentarily supports a portion of the total warp strain, which is normally supported by the feed unit during the remainder of the machine cycle.

In this way, the warp is not subjected to various periodical strains, but is constantly strained by the downward pressure of the whip roll only, which allows merely such tension variations as are represented by its action in controlling the tension brake.

From the foregoing, it is plain that the friction feed gives precise control to the movements of the cloth instead of the variable control resulting from the old weight roll feed. The friction feed permits perfect spacing of the weft because it eliminates the dancing of the weaving point and does not variably stretch the warp wires. Likewise it provides a means for crimping the selvage and adjacent wires to a considerable extent and delivers the cloth free of tension or strain of any kind to the wind-up device or to the open floor for subsequent processing.

I shall hereafter describe the operation of laying the weft wires, but will first refer to certain operations performed upon the wire after it passes through the feed mechanism, which are largely made practical by the advantages resulting from my friction feed of the wire cloth.

Welder and cutter

Supported on the main frame to receive the finished wire cloth after it leaves the breast roll is an inclined apron 103 (Figures 10 and 11). Journaled in the side walls of the apron is a transverse shaft 103a. The shaft carries parallel arms 103b, which support a transverse clamp bar 101. On the shaft is a manual control handle 101a. The arms 103b have lugs 103c to which are secured springs 102. The springs 102 are also fastened to the main frame, so as to function to hold the clamping bar on either side of a certain position of movement (Figure 1). This is accomplished by mounting the spring, so that it moves over center with relation to the shaft 103a during the swing of the arms 103b and the clamp bar 101. The clamp bar is designed to engage the wire cloth as it passes over the apron 103 and for that purpose is provided with a resilient member or members 104 at its engaging edge.

In Figure 10C' I show a modified clamp which can be used instead of the clamp bar 101 and its associated mechanism. The clamp in Figure 10C' comprises a clamp roller 101b eccentrically mounted and covered with rubber or other yieldable surface material. A handle 101c extends from the clamp roller 101b for swinging it from the dotted unlocked position to the full line locked position or vice versa. The clamp roller 101b binds the woven cloth in a normal feed direction. The clamp roller holds the wire, while additional wire being fed toward the clamp merely buckles above the roller.

A little below the clamp bar, the apron 103 supports two transverse copper bars 105 and 106 parallel with each other. These copper bars have flat faces parallel with the cloth and in part support the cloth. Current supply wires 251 and 252 are provided for feeding a welding transformer W. The output of the transformer W is a low voltage high amperage electric current, one wire of which is connected with the frame of the machine, as indicated at 75, to include the copper plates 105 and 106 in the circuit (Figures 1 and 12G). The other wire of the secondary circuit is connected with a manual welding tool (Figure 8A).

The welding tool has a non-conducting handle 107a provided with a yoke 107b in which is supported a flat-faced copper roller 108. One side of the yoke of the roller is provided with a thin flat copper plate 109. The yoke, which is insulated from the handle, is connected by a wire 106a with the secondary circuit and the transformer W.

There is thus provided means whereby a circuit may be closed through the roller 108 or blade 109 and the copper bars 105 or 106 by permitting contact between the bars and the roller or the plate.

Ordinarily, as the cloth passes down the back of the machine, over the apron 103 and under the clamp plate 101, it is cut transversely to unload the machine of the finished product, which has been suitably rolled in the desired quantity. It may be said that for determining the quantity delivered from the machine, a revolution counter, not here shown, is applied to the breast roll.

When the desired length of cloth has been woven, the clamp 101 is manually thrown to down position against the moving cloth. This prevents further movement of the cloth below the clamp, but permits the cloth to feed and belly out above the clamp, so that it is not necessary to stop the machine.

The clamp holds the cloth in rigid engagement with the apron 103 and the machine operator now lightly rolls the welding tool across the cloth and successively along the copper bars 105—106. Proper amperage is provided to insure the welding of the wire at each junction, due to the heat generated by the resistance of the crossed wires to the current.

The welding tool is turned in the hand of the operator and the cloth is burned apart or cut by pushing the blade 109 transversely across the warp wires between the two copper bars 105 and 106.

Cloth may be cut by other means, but this method permits cutting without straining the cloth and without any apparatus except the copper blade.

It will be noted that two welds are made, one along each copper bar.

The cutting may even cause further welding at the exact cut edge of the cloth. The cutting in this manner leaves ordinarily a rounded smooth edge on the protruding stub of warp, which is more comfortably handled than the sharp edge of shear cut wire.

The welding of the wire at the ends of the sections of cloth eliminates waste due to unraveling, facilitates the attachment of various lengths to each other, stiffens the cloth at the ends, and simplifies the starting of the free end of the cut cloth still attached to the machine on the wind-up mandrel below.

Wind-up apparatus

At the lower rear end of the machine is the wind-up mandrel 110, a hollow metal roll, having in its periphery a longitudinal slot 110a to receive the edge of the woven cloth (Figure 1).

It has at its ends projecting hollow gudgeons 111. Each gudgeon has an annular circumferential groove 111a, shown by dotted lines in Figure 1 and in full lines in Figure 8.

Hardened steel rollers 112 are journaled in the frame at each end of the mandrel, with their edges received in the grooves 111a, to support the mandrel.

The cloth is drawn over the apron 103 and thence down to the mandrel, and the edge is inserted into the slot 110a.

The mandrel is then turned by hand until the entire slack in the cloth is taken up. Above the wind-up mandrel is a pressure roll 113, having a shaft 113a (Figure 1) journaled in slidable bearing blocks 113b. These blocks slide in inclined guide slots 114 in the frame elements 114a.

Attached to the ends of the bearing blocks are the ends of chains 115 (Figure 1). The upper stretches of these chains travel over sprockets 116 (Figure 8) on a shaft 117 journaled in the frame members 114a. The lower stretches of the chains travel over idler rollers or sprockets 118.

On the shaft 117 is a hand wheel 117a, which may be used for manually raising or lowering the pressure roll, which is always kept parallel with the cloth and with the wind-up mandrel (Figure 1).

On the shaft 117 is a ratchet 119 and a coacting pawl 120 is pivoted on one of the frame members 114a. The pawl may be manipulated for holding the pressure roll 113 after it has been manually raised, for instance to permit the removal of a wind-up mandrel with the roll of cloth thereon.

Motion is imparted to the pressure roll by means of a chain 121, which travels over a sprocket 122 on the breast roll and over part only of the periphery of a sprocket 123 on one of the shafts 113a of the pressure roll 113 and around suitable idler guide rolls 123a, 123b and 123c as shown in Figure 1. The idler roll 123c is mounted on a bracket arm 123d extending from a slide block 113b as shown by dotted lines in Figure 1, so that the guide roll may travel with the pressure roll as it moves upward. When the diameter of the rolled wire on the wind-up mandrel is increased. There is enough play in the chain 121 to permit this operation without the use of any special take-up means.

Pivotally supported on the shaft 113a of the pressure roll are forwardly extending arms 124. These arms have suitable anti-friction bearings (not shown) at their ends for the pressure roll shaft and for a shaft 125a of a weight roll 125.

The weight roll 125 is driven from the pressure roll 113 by a chain 126 traveling on sprockets 127 on the pressure roll and weight roll (Figure 8).

When the cloth is in place on the wind-up mandrel and the pressure roll and weight roll are bearing on the cloth, the mandrel is rotated only by the friction imparted from the pressure and weight rolls. The parts are so proportioned that the rotation imparted to the pressure roll from the breast roll is such as to give the pressure roll and weight roll a surface speed which slightly exceeds that of the breast roll and hence slightly exceeds the speed of the feed of the cloth.

This results in a continuous slight slip between the pressure and weight rolls and the cloth on the wind-up mandrel. The purpose of giving this slip is to impart to the cloth that tension derived from its friction with the pressure and weight roll surfaces.

I find this a very satisfactory means of producing a slight tension, since the frictional contact is constant within close limits, and is not altered by the amount of cloth on the mandrel.

While the pressure roll alone would make a fair roll of cloth upon the wind-up mandrel, the addition of the driven weight roll, urging the cloth forward at about the point where it passes under the pressure roll for the second time serves to give the cloth tension clear around the outside convolution of the cloth roll and results in a snug but not unduly tense strained roll of wire cloth, which does not bind the mandrel, and can be removed from the mandrel by the simple expedient of pushing the mandrel out of the roll of cloth after the removal of the mandrel from the machine.

After considerable cloth is upon the mandrel, the cloth is cut, the pressure and weight rolls are lifted away from contact with the roll of cloth on the mandrel by manipulation of the hand wheel 117a.

The roll of wire cloth may be tied by means of a wire fastened around it. Bars are placed in the openings of the gudgeons 111 and by means of the bars, the mandrel can be lifted out of the machine. It can then be removed from the roll of cloth and replaced on the machine.

I have provided an additional precautionary means for preventing any telescoping of the inner convolutions of cloth on the mandrel by axial crawl. I provide near each end of the wind-up mandrel a flat metal guide 133, the left-hand one being shown in Figure 8. Each guide 133 is supported upon a rod 134, which is horizontally slidable in a bearing 135 on the main frame member. The guides 133 are merely flat plates, which can be locked in position by means of the set screws 136 having threaded connection with the bearing 135 and having their ends attached to engage the rods 134. The guides 133 act as retaining walls at the ends of the wire roll to confine the cloth to a roll of a maximum length corresponding to the width of the fabric being woven.

I have now described a considerable portion of the mechanism of my improved machine and have outlined the progress of the warp wires through the machine, but have not yet described the laying of the weft wires and the actual weaving process.

WEFT LAYING MEANS

Shuttle

Practical wire weaving machines heretofore in use have used a bobbin for carrying the weft wire and a shuttle for carrying the bobbin. The shuttle has been actuated in various ways, usually by transversely reciprocating arms.

In the present machine, I have provided a shuttle which performs the functions of both the old shuttle and the old bobbin. The old shuttle and bobbin mechanism while in wide use has many disadvantages. The weight of the shuttle, bobbin and shuttle arms limits the amount of wire that can be placed on the bobbin and consequently the bobbins must be frequently changed and during the change the weaving machine must be stopped.

Furthermore what has been considered high loom speed has been consistently obtainable only with small shuttles and bobbins. Inertia changes between full and nearly empty bobbins have seriously affected the tension of the weft wires being laid, and this has resulted in variations in the cloth which were annoying and difficult to overcome. These difficulties I have in fact largely overcome in the present machine.

In Figures 13, 13A, and 13B, I have illustrated my improved shuttle.

It is in general appearance a hollow disc-shaped vessel, comprised of two parts, **137** and **138**. The part **138** has the peripheral annular wall **138***a* and the part **137** has the peripheral annular wall **137***a*. In use, the wall **137***a* fits snugly within the wall **138***a* to form a closed annular chamber.

For locking the embracing halves together, the wall **137***a* may be provided with tongues **137***b* between slits **137***c*, each carrying a button **139** adapted to fit in a hole **139***a* of the wall **138***a*.

It will, of course, be understood that the walls **137***a* and **138***a* are resilient.

The member **137** is formed with the central inwardly projecting truncated cone-shaped portion or barrier **140**, the inner edge of which is out-turned as at **140***a* to leave a central opening **140***b*.

I preferably provide the wall **137***a* of the member **137** with a rubber lining **141**, the purpose of which is to prevent undue relative movement between the coil of wire contained within the shuttle and the shuttle itself.

Rotation applied to the shuttle when it is discharged, as hereinafter explained, tends to cause inertia slip between the case and its wire contents, and when the shuttle is received on the other side, a counter-tendency is developed due to momentum. The rubber lining furnishes a resilient and efficient brake upon the coil of wire.

The member **138** carries an inwardly extending cylindrical hollow cone **142**, which projects into the opening **140***b* as illustrated in Figure 13A. The opening **142***a* through the cone **142** permits the passage of the wire and the ends of the opening or passage **142***a* are bell-mouthed to facilitate the travel of the wire.

The inner end of the cone may be provided with a hardened tubular bushing **143** around the hole **142***a*. This may be drilled with a hole so small that only one diameter of wire can pass through it. This is to prevent the possibility of a snarl or knot in the wire passing from the shuttle and into the fabric. These little bushings **143** may be replaced as rapidly as the hole in them wears to a size which would pass a knot in the wire and to fit different sizes of wire.

A further explanation of the shuttle of the general kind under consideration may be found in my Patent No. 1,890,008 issued December 6, 1932.

The shuttle is loaded with a simple layer wound coil of wire. I have indicated this coil of weft wire at **10***a*. The coil of weft wire fills the entire annular space between the two halves of the shuttle, outside the base of the conical projection **140**. I find that I can utilize sixty-five percent of the entire volume of the shuttle in solid wire and eighty percent of the total weight of shuttle load is wire.

The present shuttle overcomes the disadvantage of the old style bobbin in having to rotate to discharge its load of wire within the shuttle. In the present shuttle, the wire is simply pulled from the inside of the enclosed coil around the inner end of the cone-shaped member or barrier **140** and then through the hole **142***a*, as indicated in Figure 13A. In this way, the feed of the wire when pulled from the stationary shuttle involves no inertia except that developed by the mass of the small portion of the wire actually being uncoiled and set in motion. This largely eliminates the inertia loss and inaccuracies which develop from rotating a shuttle bar carried bobbin to deliver the weft. For instance in old style machines now in use, it is common practice to limit the amount of wire carried on the bobbin to a portion of its full capacity, when it is desired to get particularly well woven cloth. With my new shuttle, neither the amount of wire carried in the shuttle nor the speed at which it is delivered are harmful factors in producing differences in its tension.

My shuttle is passed through the warp shed in what I believe to be a wholly novel manner. Instead of being shunted from side to side by shuttle bars or carried in a wheeled or sliding shuttle propelled across the shed by its momentum, this shuttle is complete in itself and merely rolls through the warp shed upon its own periphery supported by the heddles **49***g* and held upright by its own gyroscopic impulse.

This plan has many advantages which will become more obvious as the description proceeds. It involves a minimum of power for its operation, since the laying of the weft wire is almost a matter of rolling a coil of wire back and forth.

I shall now proceed with the description of the mechanism for rolling the shuttle back and forth.

Shuttle operating mechanism (catapult)

Rolling motion of the shuttle through the warp shed along the upper surface of the upper heddle **49***g* (Figure 10) is imparted by duplicate mechanisms at the opposite sides of the machine, illustrated for instance in Figures 6, 7, 8 and 9.

In passing the shuttle to and fro, a primary object is high speed, so that the shuttle passage time may be limited to as small a fraction of the complete machine cycle period as may be.

It is, of course, also desirable to accomplish this high speed movement with a minimum of power and of shock.

The motion to the shuttle must be applied with a graduated acceleration and the retarding of the shuttle at the end of its stroke must be gradual, and it is highly desirable that the potential energy in the form of momentum remaining in the moving shuttle at the end of its travel should be saved and applied to the succeeding shuttle propulsion.

It is also desirable that in starting the shuttle on its journey across the heddles, it should be given a preliminary spin in the direction of its travel, so that it will not have to develop its spin from friction between its periphery and the heddle dents. This is desirable to avoid friction, loss of power and speed, and prohibitive wear upon shuttle and heddle dents, and is also desirable to give the shuttle gyroscopic motion to keep it upright and true in its course.

I have for convenience marked the shuttle S. In Figure 6, it is shown received in a channel-shaped guide box **145**. The floor of this guide box is just flush with the top of the upper heddle **49**g and forms in effect a continuous support with the top of the upper heddle for the travel of the shuttle.

The shuttle appears held in the loop or bight of the strap **146**. It is observed that a roller **147** projecting against the strap and into the path of the shuttle effectually blocks the path of the shuttle toward the right side of the machine. The shuttle is held in this position just after it is received from the other side and its position is attained entirely by its own momentum.

I shall now describe the shuttle propelling mechanism or catapult. The principal member or frame of the catapult mechanism is indicated at **148**.

The strap **146** is anchored above the box **145** to the side frame of the machine at **149**. The strap is then threaded over the roller **150** carried by the upper end of the catapult frame member **148**, thence downwardly through the catapult frame and around the roller **147**, also carried by the catapult frame member **148**, and through a slot **145**a in the bottom of the shuttle guide box **145**, and then is attached at **146**a to one end of the threaded adjustment rod **151**, which has a threaded mounting in the bearing **152**, and is provided with a hand wheel **151**a for convenient adjustment for taking up slack which may appear in the strap.

The catapult member **148** is mounted to oscillate freely upon the shaft **153**.

Referring now to Figure 7, it will be observed that when the catapult is swung to one position of its movement with the roller **150** at its greatest distance from the anchor point **149**, the strap **146** is taut and the roller **147** is substantially directly above the slot **145**a in the bottom of the box **145**. The catapult is then in position to receive the shuttle as it travels from the other side of the machine. The vertical part of the strap then forms a barrier in the path of the rolling shuttle. As the rolling shuttle moves to the right against the vertical part of the strap (Figure 7) its impact presses the strap back until the strap partly embraces the shuttle as shown in Figure 6. The exact distance the shuttle will travel after meeting the resistance of the strap depends upon the speed of the shuttle, the amount of wire it contains, and the adjustment of the mechanism which gives tension to the strap. When the shuttle strikes the strap, the strap gives. Since the lower end of the strap is rigidly anchored, the movement of the shuttle and the consequent movement of the strap from the position shown in Figure 7 to the position shown in Figure 6 serves to rock the catapult member **148** and bring the roller **147** from its position shown in Figure 7 to its position shown in Figure 6 where it stands in the path of return movement of the shuttle.

It is of importance that when the shuttle travels into the bight of the strap and the catapult frame is swung to position where the roller **147** is in the path of return movement of the shuttle, as illustrated for instance in Figure 6, means be provided to prevent the shuttle from bounding back into the warp shed where it might stay during a heddle reversal and possibly result in the breakage of some of the warp wires.

To insure the holding of the catapult frame **148** in the position shown in Figure 6, where the roller **147** will prevent return movement of the shuttle, there is provided on each catapult frame member **148** the pivoted twin pawls **156** held in engagement at the proper times by springs **157** with the rack **158**. The pawl engages the rack and when the shuttle has moved the catapult to its greatest recoil point, the rack and pawl prevent any reverse movement temporarily.

Resilient resistance to the travel of the shuttle into the bight of the strap is provided by a spring **154**, which has a pivotal connection at its upper end at **155** to the projecting sleeve **148**a forming part of the catapult frame **148**.

It is desirable that the spring **154** should exert a minimum resistance to the flexing of the strap **146** during the time the strap is receiving the shuttle, and it is likewise desirable that during the last part of the movement of the shuttle into the bight of the strap, the tension of the spring should build up rapidly to absorb the remaining momentum of the shuttle before the catapult reaches the limit of its movement. This is also desirable so that the movement of the shuttle into the bight of the strap should tense and store up power in the spring to the greatest possible extent.

After the shuttle has been received and locked in the bight of the strap, it is necessary to increase the tension on the spring, so that it may subsequently shoot the shuttle toward the other side of the machine, or in other words to increase the tension of the spring for cocking the catapult.

It is also necessary to drop the rack **158** out of engagement with the pawls and to release the catapult for giving impulsion to the shuttle for laying the next weft wire.

In the operation of discharging or firing the shuttle from the catapult, certain problems are involved, due to the fact that the weight of the shuttle and its load of wire gradually decreases as the roll of wire is laid in the weaving cloth.

Shuttle velocity tends to be governed inversely by its weight. I have provided a construction in the main spring and latch structure of the catapult, which provides a compensating action, whereby the propelling effort imposed upon the shuttle is greater when the shuttle is filled with wire and is less when the shuttle is nearly emptied of wire.

The lower end of the catapult spring **154** is attached to a threaded stem **159**, which projects through a sleeve **160** and has the adjustable lock nuts **159**a. The sleeve **160** is pivoted to oscillate freely between the forked arms **161**a of a bell crank lever **161** pivoted between its ends at **161**b on a bracket **145**b projecting from the shuttle box **145**.

Pivoted to the other end of the bell crank lever **161** is a rod **162**. The rod **162** is pivoted at its other end to a lever **166**, which in turn is pivoted between its ends at **166**a on the main frame and projects inwardly transversely of the machine and is pivoted at its inner end to the lower end of an upwardly extending rod **165** (Figure 6).

Referring now to Figure 10, it will be seen that the upper end of the rod **165** has a pivotal connection by a ball and socket joint **165**a with an arm **164**, which is pivotally supported at its opposite end on the shaft **46**. The arm **164** carries a roller **164**a which travels on a cam **163** on the cam shaft **58**. Thus the operation of the cam **163** (Figure 10) serves to impart reciprocating motion to the rod **165** and to periodically increase and decrease the tension of the spring **154** (Figure 6) for contributing to the functioning of the catapult mechanism according to the operation hereafter to be more fully explained.

Catapult latch

Mounted to rock with the shaft 153 is the two-armed latch bracket 167 shown best in Figure 8. One arm of the bracket 167 has a universal joint connection with a rod 167*a* extending downwardly in the machine. The rod 167*a* at its lower end has a universal joint connection with a crank pin 168 on the face of a disc 169 fixed on the main cam shaft 59.

Pivoted between its ends to the other arm of the latch bracket 167 is the latch 171. One end of the latch 171 carries a roller 174, which travels on a stationary cam 175. The other end of the latch is connected with a spring 171*a*, which is suitably anchored for holding the roller 174 in engagement with the cam. The pivot pin 171*c* has a projecting end 171*d* (Figures 1 and 9).

The member 148 has an extension 172 having a projection 172*a* shown in Figure 8.

When the latch swings from its position shown in Figure 8 toward the right, the projection 171*d* slides under the projection 172*a* and in swinging toward the left the projection 171*d* engages the projection 172*a* and moves it and the whole catapult frame for further tensioning the main spring 154 until the roller 174 reaches the rise on the stationary cam 175 and trips the latch out of contact with the projection 172*a*. This releases the catapult spring and allows it to actuate the catapult for rolling the shuttle across the heddles for laying a weft wire.

Returning now to the swinging rack 158 and the twin pawls 156 shown in Figure 6, it will be noted that the pawls are elongated beyond their pivot stud 176 and a pin 177 above their tails limits the possible motion of the pawls toward the rack to positions where they will rest at the bottoms of the teeth when the rack is raised.

As the latch in completing the cocking of the catapult approaches the trip-off point, the rack 158 drops downward away from the pawls, so that they can not engage the rack during the discharge of the shuttle. This movement is accomplished as follows:—

The rack 158 is pivoted upon a cross rod 178 supported on bracket 178*a* extending from the main frame and preferably integral with the shuttle box 145. The rack 158 has a downwardly projecting arm 179 connected to a spring 180, which is in turn anchored on the box 145 for tending to pull the rack down.

The lower part of the rack rides on a cam 181 on the shaft 153.

The parts are so arranged that the rack will engage or escape the pawls according to the position of the cam 181.

This structure insures the engagement of the pawls for preventing any appreciably retrograde movement of the catapult during the reception of the shuttle but places the rack out of reach of the pawls during the discharge of the shuttle. The so-called twin pawls 156 are not exactly twins, since one is half of a rack tooth space longer than the other.

It is simply an expedient to hold the catapult within close limits of its highest position without cutting the rack teeth too fine for safe engagement with the pawls.

When the latch pivot 171*d* engages the projection 172*a* and starts to cock the catapult to full position, it consequently increases the tension upon the spring 154.

However, the timing of the complete tensioning of the spring is controlled by the cam 163 (Figure 10 and Figure 11) which oscillates the lever 161 through the media of the members 164, 165, 166 and 162 to relieve or to stress the spring 154.

To obtain the best results from this spring, accurate timing is essential. The main spring should be relieved while the shuttle is being received, but it must be under some tension to provide a cushion to absorb the shuttle impact. If the main spring were immediately stretched to its greatest working tension for the catapult position directly after the shuttle were received, the entire load of the tension would then be borne by the twin pawls and the latch would be obliged to engage the projection 172*a* and complete the cocking of the catapult under this extreme load. This would be wearing on the latch edges and the entire mechanism for the driving of the shuttle and would involve severe shock to the mechanism at the instant of discharge. Furthermore such an arrangement would not be of the highest efficiency because the spring would immediately lose tension after the tripping of the latch and would not follow through as it should do to apply maximum impetus to the rapidly accelerating movement of the shuttle.

Therefore the cam 163 is so arranged that its action does not tense the spring to its utmost at the moment of the trip, but rather immediately after the trip, at which time it quickly tenses the spring while the catapult is in motion, thus prolonging its drive while relieving all the parts of the initial shock.

This arrangement has another advantage in that to some extent it tends to evenly regulate the speed of a full and a partially emptied shuttle. Thus in case of a full shuttle, its inertia is high and after the catapult trip its motion will be more deliberate and as the cam 163 tenses the spring 154, the slowly moving shuttle will furnish a load against which the spring will be tensed to the utmost, thus resulting in applying maximum effort toward the expulsion of the shuttle. That is to say, the cam 163 may pull the bell crank 161 faster than the upper end of the spring can follow and accelerate the heavy shuttle, which would, of course, cause additional tension on the spring and a decidedly greater effort toward ejecting the shuttle.

On the other hand in the case of a very light nearly empty shuttle, its slight inertia would permit the spring, with the same initial tension to set it in such sudden motion that the spring might collapse against its lower end, having expended itself against the shuttle before the cam 163 produced the maximum drop in the bell crank 161.

However, with my structure, since the spring has never been extended, it has not delivered a maximum impetus to the shuttle, and since the partially spent shuttle tends to over-run the maximum timing and the full shuttle lags behind the maximum timing, the result attained is highly important toward the efficiency of the machine.

Shuttle operation

I will now describe the action of the shuttle in laying the weft wire.

Assume that the shuttle is to be started from the left side of the machine, as shown in Figure 6, and that the shuttle has reached its just received position there illustrated. Wire is pulled from the shuttle by hand and threaded through the opening 75c in the machine side frame, illustrated for instance in Figures 10 and 11, which is the opening through which the shuttle travels. Wire is then tied to the frame member beyond the warp and above the pick 193 hereafter described on the side from which the shuttle is about to leave. After the machine is then started the operation of the cam shaft 59 and the cam 163 will serve to complete the cocking of the catapult and the release of the catapult and discharge of the shuttle. When the shuttle is received in the strap on the right side of the machine, the weft wire will have been stretched between the point at which it is tied and the shuttle from which it has emerged and the shuttle will be held in receiving position.

Weft wire lifting fingers

On the outer face of each of the main frame members 75—75a is a rather long weft wire lifting finger 190 pivoted at 210 near its rear end. When the weft wire is being laid, one end of this finger rests just below the line where the weft wire is laid and adjacent the discharge end of the shuttle box 145. (See Figures 1 and 6.) A spring 190a holds the forward end of the finger 190 down.

On the finger 190 is a roller 190b which contacts with the cam 211 fixed on the shaft 212. The shaft 212 has at its left-hand end as shown in Figure 8 a sprocket 215. A chain 213 travels over the sprocket 215 and over a sprocket 214 on the main drive shaft 46, which carries the pinion 87.

The parts are arranged to drive the cam shaft 212 and the cam 211 at a speed of one revolution to two machine cycles, so that the respective fingers 190 lift on their respective sides of the machine alternately and only once for each alternate weft wire laid. These fingers are important because of the necessity for allowing room in the warp shed for so large a shuttle.

In order to allow the room in the warp shed, a certain distance of heddle motion is essential and to keep this distance at the desired minimum, it is necessary to allow considerable distance above the top of the heddles and between the heddles and the weaving point to prevent the converging wires of the warp shed from interfering with the shuttle.

A beater and comb long enough to lift the weft in the warp feed from the place where the weft wire is laid would be too long and heavy to move with sufficient speed and would also block the shuttle path during the operation of the beater and comb.

I therefore provide the lighter fingers 190, which can be moved rapidly and serve the purpose since it is only necessary to raise the lower portion of the wire, which is near the shuttle, the other end having already been raised during the ordinary operation of the machine. The operation of the weft wire lifting finger 190 changes its angle from a substantial inclination to almost horizontal. (See Figure 11A.)

Weft engaging clip

When the finger 190 lifts the weft wire, it brings it into engagement with a clip 191 mounted on the side of the catapult. This clip is shown in detail in Figures 9A, 9B and 9C. The clip 191 consists of two longitudinally fluted resilient plates 191a and 191b fastened to the catapult frame 148 by means of screws 191c and held apart by a somewhat resilient spaced block 191d. This block is such that it may be replaced by another or may be squeezed by means of the screws to permit the two plates of the clip 191 to be adjusted toward or away from each other. The free ends of the plates 191a and 191b are curved away from each other as indicated at 191e and 191f. The clip 191 is so shaped and located that when the finger 190 raises the weft wire, it passes close to the clip 191 and pulls the wire into the clip.

The movement of the finger 190 lifts the left hand end of the lower weft wire shown in Figure 11A from its full line to its dotted line position.

The wire will then be high enough so that it may be subsequently engaged by the comb 67 when the latter moves from the position shown in Figure 10 to the position shown in Figure 11 for bringing the weft wire to position properly spaced from the last preceding weft wire. The clip grips and frictionally holds the wire close to the shuttle as illustrated diagrammatically in Figure 11A. The clip has enough resiliency to grip the wire and to hold it from slipping out. The fluted members of the clip tend to hold the wire against any longitudinal pull on it and the gripping action of the clip may be regulated as explained. The clip 191 contributes to the proper tensioning of the weft wire.

On account of the variation in the physical characteristics of the wire, it is not always possible to secure perfect tensioning from the shuttle barriers alone over a considerable weaving period.

As the wire from the shuttle is drawn between the corrugated or fluted plates of the clip by the action of the lifting finger 190, the reluctance of the wire to pass lengthwise between the plates causes it to tense across the warp shed as it is beaten into place by the comb in the manner hereafter described, whereas if it were simply drawn from the shuttle alone, its tension would be only that caused by the shuttle barriers, which tension should be kept very low in order to impose minimum load against the momentum of the rolling shuttle as it pays out the weft.

In addition to its function in tensioning the weft wire, the clip grips the wire lightly to prevent its premature entrance between the warp wires. When the shuttle is discharged, it approaches and passes the selvage loop retainer (which for brevity and convenience I call the pick) hereinafter described, over which the weft wire is lodged. As the shuttle moves across the machine it leaves a loose loop in the wire. This loop, unless restrained, is likely to pass through before the shuttle. In that case, the loose loop is thrust aside by the rolling shuttle becomes entangled by the warp wires and spoils the weave. The clip 191 holds this loose loop. The motion of the discharging catapult causes the loop to pull out of its clip lengthwise of the flutes with very slight impedence, and to engage over the pick which stands in its way.

Following the shuttle upon its course across the warp, its travel soon absorbs the following loop of loose wire and the wire becomes stressed to the limit of the shuttle imposed tension, so that when the shuttle is received upon the opposite side of the machine, the wire is again taut between the shuttle eye and the more distant pick 193 hereinafter mentioned.

From this position, the former operation is repeated.

In Figures 9A' and 9A'', I have shown a modified clip **191***g*. It is secured to the side of the guide box **145** and is slightly resilient, engaging the side of the shuttle S as it enters the guide box. During entry, as shown by solid lines in Figure 9A', the weft wire **10***a* is pulled along to a position above the clip **191g** and after the shuttle is started on its return trip by the catapult, a loop **10***b* occurs in the weft wire and this loop catches under the upper end of the clip **191***g*, as shown by dotted lines, the upper end of the clip being curved slightly toward the shuttle.

The clip engages the wire so as to insure that it does not re-enter the side of the machine before the shuttle does and this form of clip is even more efficient than the form shown in Figure 9B. To insure the weft wire following the proper path, a guide clip **10***c* is mounted on the catapult frame member **148**. The lower end of the guide clip is curved toward the shuttle, as clearly shown in Figure 9A''.

Picks

Looms of this kind are equipped with picks to hold the loop or weft wire on one side of the machine while the shuttle is laying another weft wire, so as to eliminate undue strain upon the selvage warp wire around which the loop is formed.

I have provided an improved structure for the picks and their mountings.

Heretofore picks have usually been mounted upon independent adjustable stands and operated directly from the beater.

In the present machine, the motion of the beater is so rapid that it is not satisfactory to drive the picks by impact from them. Furthermore, it is desired in the present structure to so mount the pick lever members that they may support and operate special forming dies and punches for the precise crimping of the selvage wire, where this is wanted.

My picks are cam operated and do not operate directly from impact with the beater.

The pick levers **193** are clamped by split hubs on the shaft **194**, which is supported to oscillate in two brackets **195**, a bracket **196** and a bracket **196***a*. (Figures 6, 7, 10 and 11.)

These brackets are keyed and clamped by split hubs to the fixed shaft **197** mounted in the main frame members **75—75***a*.

The pick levers **193** may be adjusted axially or rotatably on the shaft **194**, by releasing their split hubs. Any suitable means may be used for adjustably locking the pick levers on the shaft **194**. At the free end of each pick lever **193**, it has a split hub **193***a*, in which is frictionally gripped a tubular bushing **199**, which projects beyond the hub in both directions (Figure 10B).

Received in each bushing **199** is a short spindle **199***a* having in one end a diametrical slot **199***b* to receive the pick point **199***c*. A plate **199***d* is secured to one end of the spindle **199***a* and serves as a clamp for the pick point **199***c*.

The plate can be loosened when it is desired to adjust the pick to compensate for wear or causes of misadjustment.

The bushing **199** has opposite slots **199***e* to permit free passage of the pick point **199***c*. These slots are elongated circumferentially of the bushing sufficiently to allow limited rocking movement of the spindle **199***a*. A spring **199***f* has one end secured to the spindle **199***a* and the other end secured to the pick lever **193** and functions to hold the parts in position where the pick point is at the downward limit of the rocking movement of the spindle **199***a*, while providing for the circumferential yielding of the pick in the slot **199***e* as it is forced up by the intermittent feed of the cloth.

As the pick remains in the cloth during the feed period, means must be provided to permit the point to follow the cloth as it is fed. During the stationary portion of the feed, the pick is lifted out of the cloth and the spring **199***f*, acting torsionally, returns the pick to its normal position in front of and below the last weft wire.

The brackets **195** are preferably mounted for lengthwise adjustment on the shaft **197**, but are keyed against rotary adjustment thereon by ordinary structure not here shown in detail. This permits transverse adjustment of the picks without interfering with the normal height of the shaft **194**. The shaft **194** once installed is held at the same height by the brackets **195**, **196** and **196***a*, but may rock in those brackets.

Oscillation of the shaft **194** for operating the picks is provided for in the following manner: The hub of the beater **66** has a projecting arm **202** which carries a roller **204**. On the shaft **197** adjacent to the bracket **196***a* is mounted rotatably between its ends a cam lever **203**. On the shaft **194** is fixed an arm **206**. A link **207** is pivoted to the lever **203** by a pin **207***a* and is also pivoted to the arm **206** as shown in Figure 10. The pin **207***a* projects far enough as indicated in Figure 7 to engage the bracket **196***a* to limit the rocking movement of the lever **203** in one direction. (See also Figure 10.) I provide means to normally tend to rotate the shaft **194** clockwise as shown in Figure 10 and to hold the left-hand end of the cam lever **203** down. As shown in Figure 6, an arm **203***a* projects downwardly from the rockable shaft **194** and another arm **203***b* projects downwardly from the fixed shaft **197**. These arms are connected by a spring **203***c* for the purpose mentioned.

The sequence of operations during the weaving operation may now be referred to for further clearness of description.

Weaving operation

Let us assume that a few strands of weft wire have been woven into the cloth. Figure 11A shows in full lines the position of the weft wire after the shuttle has traveled from right to left as the piece of cloth is viewed in this figure.

After the shuttle is received in the bight of a strap on the left side of the machine, the weft wire lifting finger **190** on that side of the machine lifts the weft wire from its inclined full line position shown in Figure 11A to its inclined dotted line position shown in that figure.

During this movement, the picks are in down position where the pick finger is in the lower loop of the weft wire at the right hand side of Figure 11A. When the finger **190** thus raises the weft wire, it delivers it to the grip of the clip **191** on the left-hand catapult frame **148**.

The beater and comb then move from the position shown in Figure 10 upwardly and forwardly to cause the comb teeth to engage beneath the weft wire shown in dotted lines in Figure 11A and to lift that strip of weft wire upwardly, pushing it between the wires of the warp shed, until it is exactly properly spaced from the next weft wire above and where it will be held by the friction, as has already been explained. The fact that the weft wire is gripped by the clip 191 helps to give it the proper tension as it is beaten into the place by the comb.

As the comb approaches the upward limit of its movement in beating the weft wire into place, the rollers 204 engage the cam faces of the cam levers 203 (see Figure 11) for lifting the picks away from operative position. In the instance under consideration, this releases the pick at the right-hand side of the cloth (Figure 11A) from the weft wire loop. The comb dwells momentarily in position for holding the weft wire in its final resting place and the reversing movement of the heddles takes place for changing the warp shed. Then the comb moves back away from its position shown in Figure 11 toward its position shown in Figure 10, and the picks drop to position shown in Figure 10, where the left-hand pick will then rest below the lowermost weft wire, so that when the shuttle then shoots across from left to right, pulling the strand of weft wire from the left-hand clip 191; the left-hand pick will retain the weft wire loop instead of allowing the pull to come against the left-hand selvage wire.

Attention might be called to the importance of the dwell of the comb. In machines heretofore used for weaving wire cloth, the heddles swing the warp wires across the shed while the comb is in movement. Consequently instead of providing a sharp crimp in the warp wires and also in the weft wire, a fairly sharp crimp may be produced in the weft wire, but the crimp in the warp wire is elongated, due to the movement of the weft wire caused by the comb during the heddle movement which causes the crimp.

With a mechanism of the kind herein described, the warp wire is stationary during this crimping movement and hence a sharper crimping of the warp wires is possible. The machine thus gives sharp crimps around the weft wire instead of gradual bends. This is important in securing cloth of uniform structure throughout its length and in forming a firmer frictional bond between the warp and weft wires as they are interwoven, as the weft will lie in a sharper bend in the warp.

It may also be said that the method here employed imposes less strain upon the comb and beater because they do not have to force the weft between the closing warp wires. It is therefore possible to use a lighter beater and comb and this contributes to higher weaving speed, since the machine speed is always limited by the mass inertia of reciprocating members.

The structure here described also eliminates sudden strain on the warp, which has resulted from the machines mentioned heretofore in use.

Driving mechanism—Automatic stop

Even in a machine having large shuttle capacity, it is necessary to stop and change the shuttle at regular intervals. Sometimes the wires break or there may be other reasons for instant stopping of the machine. It is highly desirable that this function should be handled automatically, especially since one operator usually attends to several machines.

I have provided such a stop in connection with the driving mechanism of the present machine.

Power is applied in this machine to the gearing device 217a on a cone clutch member 217, which is rotatably mounted on the drive shaft 46 carried in bearings in the main frame member 75—75a and in a suitable bearing in a bracket 218 (Figure 12).

Power may be transmitted to the cone clutch member 217 for example from a motor 218a (Figure 1) and a chain 218b traveling on the gear member 217a, which in this case is a sprocket, and on a sprocket 218c on the motor shaft.

A coacting cone clutch member 219 is splined on the shaft 46 as indicated at 219a to rotate with the shaft and for axial sliding movement on the shaft. Projecting from the clutch member 219 and away from the clutch member 217 is a sleeve 219c of considerable length. On this sleeve is an annular flange 219d, which has a face 220 similar to the curved surface of a truncated segment of a sphere. The end of the sleeve 219c beyond the flange 219d is threaded to receive a hub 222 having a flange 222a on which is mounted an internal cone clutch 222b, which is spring-cushioned by an ordinary structure on the flange. The clutch member 222b is adapted to coact with an external cone clutch member 223 rigidly fixed with relation to the frame member 75. The end of the sleeve 219c is counterbored at 224 and contains a helical compression spring 226 surrounding the shaft 46 and bearing against the shoulder at the inner end of the bore and against a shoulder 225 on the shaft and serving to exert a constant pressure toward engaging the clutch members 219 and 217.

Embracing the hub 222 is a two-part housing 228 bolted to the frame 75 and fixed to the clutch member 223. The outer member of the housing 228 has an opening 228a in its wall and supports an electro-magnet 229 projected into the interior of the housing, as shown in Figure 12.

A pawl 230 is pivoted on the interior of the housing 228 by a pin 231, and has a part 231a serving as an armature for the magnet (Figure 12A). The pawl is slightly spring-loaded away from the magnet by means of a spring 232. A pin 233 is slidably supported in the wall of the housing 228 and has a flattened inner wedge-shaped end 233a adapted to engage an angular face machined into the pawl 230 (Figure 12B). The pin is spring-loaded away from the pawl by the spring 234.

Bolted to the housing 228 is the central part of a yoke 236 between the arms of which extends a pin 237 (Figs. 12C and 12D). A pair of semi-circular members 238 and 239 are provided with projecting flanges 238a and 239a having elongated slots 238b and 239b embracing the pin 237 between the arms of the yoke 236. The members 238a and 239 partially embrace the face 220 of the flange 219 and fit that face.

At their ends opposite the flanges 238a and 239a the members 238 and 239 have the spaced flanges 238c and 239c gripping between them and bolted to a clutch control handle 240.

This handle 240 with the members 238 and 239 forms a means for engaging the member 219d and thus disengaging the clutch member 219 from the clutch member 217 against the pressure of the spring 226. The handle 240 has some resiliency and coacts with a bar 241 suitably supported and provided with a notch 241a.

When the handle 240 is moved to position to be received in the notch 241a, it not only disengages the clutch members 219 and 217, but causes engagement of the clutch 222b with the fixed member 223 to provide a braking action for instantly stopping the machine.

By means of the handle 240, I have provided a manually controlled declutching mechanism. It is desirable, however, that there be provided means for automatic declutching of the mechanism, whereby the machine will be automatically stopped in case of certain emergencies. I have provided such means.

I have also provided means whereby after automatic declutching and braking, the mechanism may be restored to operative condition as soon as the fault that caused the stop has been corrected.

The inner face of a portion of the housing **228a** is machined at **242** to coact with a thrust ball bearing **243** (Fig. 12). A steel ring **244** contacts with the thrust ball bearing and has ratchet teeth **244a** on its periphery to coact with the pawl **230** when the latter is released by the magnet **229**. The ring has a free running mounting on the sleeve **219c** and is restrained from longitudinal movement toward the hub **222** by the lengthwise extension of the hub.

Six toggles **245** have ball and socket connections with the ring **244** and with the flange **222a** respectively. The flange **222a** and the ring **244** are also connected by a plurality of springs **246**, which normally tend to pull the ring and the flange toward each other and to retain the toggles in their angular positions. The parts are so proportioned that the toggles can never quite reach axial alignment with the shaft **46** and normally the springs **246** pull the toggles toward such angular positions, as illustrated in Figure 12A, as to drive the ring **244** ahead of the flange **222a**. The ring **244** normally rotates freely with the sleeve **219c**, so long as the magnet **229** holds the pawl **230** raised. However, if any break is caused in the circuit supplying the magnet, the pawl **230** immediately drops into engagement with the ratchet teeth **244a** for stopping the ring **244** whereupon the further rotation of the shaft **46** and the sleeve **219c** will tend to bring the toggle members toward axial alignment with the shaft and this causes the declutching of the members **217** and **219** and a powerful thrust of the clutch member **222b** into engagement with the clutch member **223** for braking and stopping the machine.

It should be noted that all of the action that takes place after the pawl drops is due to momentum of the machine alone. In this way, its motion is being retarded by the effort that declutches it and applies the brake. As a consequence, the stop is efficient for protecting the machine and the weave from serious injury. The arrangement of the electric stops by which the circuit through the magnet **229** is broken is referred to below.

The machine now stands with the pawl **230** engaging the teeth of the ring **244**. A movement of the lever **240** farther toward clutch disengaging position will cause the lever to engage the pin **233** to force it under the pawl and lift the pawl out of the teeth of the ratchet ring.

If the fault that stopped the machine has been repaired, the magnet will again retain the pawl, so that the machine can operate and the automatic stop mechanism will have been reset to position for protecting the mechanism. The toothed ring when released from engagement with the pawl will be snapped back to normal position by the action of the springs **246**.

If the fault has not been corrected, it is true that the ring will be temporarily released, but movement of the lever **240** toward clutch engaging position for starting the machine will permit the pin **233** actuated by the spring **234** to move to position for dropping the pawl **230** before the clutch members **217**, **219** engage and as a consequence any motion of the shaft **46** will simply cause it to declutch again immediately.

The power control here described provides a very rapidly acting safety stop which operates suddenly but does it with a minimum amount of shock and uses the momentum of the machine itself to kill its momentum. Restoration to running condition is extremely simple. The machine can not be started without releasing the pawl **230** and after that is released, parts are immediately in condition to function again as an automatic stop.

The circuit, which includes the magnet **229** is illustrated in Figure 12G.

It will be understood that stops (circuit breaking means) may be installed at any suitable point on the machine where it is considered the trouble is likely to occur.

Current is supplied by a transformer T, one side of which is grounded on the machine frame. I preferably use a current of twenty volts, as a small current of such low voltage, when employed, will not cause any dangerous shocks to the operator.

Any accidental short circuit would simply cause the machine to stop.

The secondary circuit of the transformer T has in it a relay **253** spring-loaded in the ordinary way to be normally closed. From the relay, the circuit is carried by a wire **252b** through the declutching magnet **229** to the junction at **254**, one lead from which connects with the grounding brush **255** while the other connects the brush **256** with the contact **257**, **258** and a brush **259**. A short line **260** connects the second grounding brush **261** to the contact brushes **262** and **263**.

In action, it is of course necessary to keep the magnet coil **229** energized in order to prevent the dropping of the pawl **230** and the consequent declutching and braking of the machine. The wire **252b** containing the coil **229**, also contains four or more contact points, such as **256**, **257**, **258** and **259**. These contacts have mating members, which under certain conditions serve to connect the line **252** with the grounded machine frame and complete the circuit through the magnet **229**.

The brush **255** is also connected to the line **252b** and serves to complete the magnet circuit through the grounded interrupted slip ring **268** at such times as it is normally not maintained by one or the other of the contacts **256—263** or **259—262** or **257—265** or **258—265**.

One of the chief things to guard against is the snarled weft wire or accident to the shuttle which might destroy its momentum to such an extent that it might not be properly held by the receiving catapult. In such case it might roll back into the warp shed or the heddles might close upon it, if the machine were not stopped soon enough. To prevent this sort of occurrence, each catapult is equipped with a flat copper plate **269** insulated from the catapult frame and so disposed that just at the time of the reception of the shuttle, the plate bridges the gap between an attendant pair of brushes such as **262—259** or **263—256**. (See Figures 1, 12 and 6.)

When the left-hand catapult (Figure 6) receives the shuttle and the roller **147** moves to locking position, the plate **269** on the left-hand catapult will bridge the brushes or contacts **256—263** and so maintain the circuit closed through the magnet **229**. The location and size of the copper plate is such as to close the circuit only if and when the shuttle is safely received.

This is determined by the catapult position at that time. This affords protection, because at that time nothing but the shuttle tends to move the catapult, and if it is moved far enough, it is sure to embrace and hold the shuttle. The bridged gap between the brushes 256—263 then furnishes the only path for the current, which is energizing the magnet 229 and the line is grounded through the wire 260 by the brush 261, which bears against the raised segment of the timing ring 268, which is mounted on the cam 60 and rotates with the cam shaft 59. (See Figures 7 and 8.) For instance as shown in Figure 12G when the contacts 263—256 are bridged by the plate 269 (see also Figure 6), the contact 161 will be grounded on the slip ring 268 but the contact 255 will then engage a piece of insulation inset in the slip ring 268.

After the shuttle has been safely received on the left side of the machine (Figure 6), there is no further use for a continued contact between the brushes 256 and 263 since the shuttle is not subject to accident after once being firmly held by the catapult until it is again discharged. However, the brushes must keep the circuit closed until after some other contact for that purpose is made. At this time, it is essential that the shuttle should be feeding wire and that the wire be properly lifted to the comb by the finger 190 and from there carried to the weaving point by the comb. Adjacent to the comb on the inner side of each machine-side frame and electrically grounded on the frame is a contact bearing, pivoted lever 265, lightly spring-loaded to keep it normally out of contact with the contact point 257 or 258 as the case may be. Projecting from the lever 265 is a pin 265*a* located within the line of travel of weft wire as it is lifted and placed by the comb.

As the wire is thus lifted, it engages the pin 265*a* and forces it upward and brings the lever 265 into contact with the point 257. This action now provides two connections from 252 to the ground and each one kills the selectivity of the other, so the timing ring 268 must break the circuit by passing out of contact with the brushes 255 and 261. (See Figures 12G and 10.)

When the lever 265 is directly grounded to the machine frame, it still maintains the magnet in the live circuit, but as the wire only holds the lever 265 in contact for an instant, the brush 255 is furnished to ground the circuit through the projection on the periphery of the timing ring, which now is presented and carries the contact while the shuttle is being passed.

The action on both sides of the machine is identical.

The four contact stages shown should prove to be adequate safeguard for the machine, since the time of action for each one is sufficiently in advance of the following heddle reversal to be sure to stop the machine before that reversal takes place. The particular object of the stops is to insure the stopping of the machine when the shuttle wire is broken or has paid out of the shuttle entirely.

A secondary object is the prevention of heddle reversal when the shuttle is within the warp shed.

There are other accidents which may occur during the operation of the machine and which can be prevented from doing damage by connecting certain parts of the machine with the stop system. For instance, breaking of the warp wires sometimes occurs. Contact members may be placed in a variety of positions for taking care of this difficulty and I will illustrate the location of contacts for taking care of the breaks that might occur in the warp between the whip roll and the weaving point.

Connected to the wire 252*b* is a wire 252*c* which forms a lead to a coil of the relay 275, which is normally closed in the line 252*b*. The line 252*c* passes through the coil of the relay and then is connected to an open loop 276 closely formed about the warp wires just above the whip roll. (See Figure 10.) If one end of the vertical warp wires should break, its weight would cause the portion below the break to fall or sag, due to the rather violent motion of the whip roll and the vibrating heddles. That portion of the wire below the break would be sure to leave its normal position enough to make contact with the loop 276 and in so doing would close the circuit between the grounded machine frame and the loop. Current in the wire 252*c* would energize the solenoid of the relay 275 and result in the immediate opening of the closed circuit through the magnet 229 which supports the pawl 230 when energized. This would, of course, stop the machine just as effectually as any other opening of the closed circuit system.

By using both circuits, it is possible to take advantage of both systems. The closed circuit is important since it eliminates the danger of operating the machine when the service current is interrupted. The open circuit is ideal for operating the stop by a single contact and can be readily applied to various parts of the operative mechanism for stopping the machine in case of any accident. The stops as explained here are simply illustrative.

In the wire 252*b* I also show a circuit breaker 252*d* interposed. This is entirely omitted in using the foregoing driving and automatic stop mechanism, but is used in a timing device which I will now describe.

Timing device

The timing device is shown in Figures 14 to 17 inclusive and is substituted for the driven sprocket 217*a*, the chain 218*b* and the driving sprocket 218*c*. In place of these, a V-belt driven pulley 356, a V-belt 347 and an adjustable diameter V-belt pulley composed of two cone shaped members 349 and 350 are used. Various other associated mechanism is also used which will be presently described.

Much of the trouble experienced in weaving with my type of machine has been occasioned by allowing the shuttle to feed itself entirely out of wire. The last few turns, having no support from neighboring turns, tend to mix and tangle and if they do feed out smoothly, it is never possible to tell just where the end of the weft wire will come in realtion to the weave. If the shuttle does feed itself entirely out of wire, the loose end of the wire may drop so that it is not lifted by the lifting finger 190 and the heddle dents 52, in reversing, crimp this wire in and break the warp several inches below the weaving point.

As it is impossible to tell where the shuttle or weft wire end will come in realtion to the weave, it is necessary for the operator to cut out any fractional weft course laid at the end and frequently the machine will thereby lose a course of weft in the weave unless it is backed up and started again with a new shuttle of wire over the old course.

This is a slow process and one requiring some skill and attention on the part of the operator and as several feet of wire could be woven on the machine, designed as it is for high speed, during the time consumed in doing so, it is highly desirable to stop the machine just before the shuttle pays out its last few feet of wire. By so doing, a full shuttle is merely placed where the spent one was taken out and the old wire is cut at the weave selvedge and twisted to the wire from the new shuttle. This insures a perfect start without any chance of missing a course and it is almost impossible to make a mistake.

On the other hand, if the shuttle pays out entirely, it is difficult to tell which side of the machine should receive the newly filled shuttle and if a mistake is made and the machine started, several courses of weft will be laid before the machine can be stopped and then this will have to be cut out, the machine reversed to accurate position and the place rewoven, causing a loss of time representing many feet of woven cloth.

The average time lost in shuttle changing because of the shuttle paying entirely out of weft wire would more than pay for the few feet of wire left in a shuttle that was timed to stop just before running out. In any event, the shuttle coils must be wound automatically and it is a very simple matter to provide means for giving each coil a definite number of turns at a certain feed which should eliminate any difference in coil length other than that occasioned by a change in the wire diameter which should be negligible.

Assuming then that the shuttle coils are of nearly equal length, it is only necessary to establish a means for stopping the machine after it has run a certain number of beats which would represent all but a few remaining turns of the wire in the shuttle. However, the means employed must be independent of the services of the operator after once being set for a certain number of machine beats and it must be capable of automatically resetting itself every time the machine stops for a shuttle change. It must also be capable of being changed in setting to accommodate all the kinds and sizes of wire and cloth that the machine is capable of weaving. Furthermore, it must be possible for the operator to trip the timing mechanism manually in cases where on account of accident or mistake, it is necessary to run a fraction of a shuttle coil.

Another peculiar condition is present: The shuttle is spring driven on its passage across the warp and is entirely out of control during that period, thereby making it essential that the timig of the machine be in synchronism with the shuttle passage to avoid undesired interference.

If the shuttle always made its passage at the same speed, this would, of course, be a simple matter. However, due to the diminishing mass of the wire coil enclosed in the shuttle and the fact that there is no entirely adequate means of compensating for this by automatically progressively reducing the impulse of the catapult spring 154, there is a necessity of allowing a considerable waste of time by providing a safety time period at each end of the shuttle stroke or of manually changing the machine speed to accommodate that of the shuttle stroke, as the coil of wire pays out in laying the weft. Either of these expedients would be wasteful and a detriment to the efficiency of the machine.

Accordingly, it is desirable to provide means for automatically progressively increasing the machine speed as it weaves a coil of weft wire into the warp. This permits the closest timing between the machine and the shuttle and takes advantage of the possibility of increasing the production from the machine by eliminating unnecessary unproductive time periods in the operation cycle, especially those occurring after some of the weft wire has been fed out of the shuttle, resulting in lightening its weight and increasing its speed from catapult to catapult.

As the machine is repeatedly loaded with filled shuttles which immediately begin reducing their mass by paying out their contents, it is not only necessary to provide means for increasing the machine speed, but the apparatus used for this purpose must automatically restore the original slow speed each time a new shuttle is applied to the machine. It is essential that each of the functions mentioned should be automatically accomplished without any attention upon the part of the operator, as the value of the machine as a producer of woven cloth is greatly augmented by the fact that it requires but little attendance on the part of the operator.

With the foregoing requirements in view, I have devised the mechanism illustrated in Figures 14 to 17 inclusive. A worm 301 is mounted upon the end of the feed pinion shaft 79 outside of the frame member 75. Meshed with the worm 301 is a worm gear 302. When the worm gear is driven by the worm, it will rotate upon the hub of a disk 303 which is shrunk fast or otherwise secured to a sleeve 304. The sleeve and disk are rotatable as a unit upon a stationary stub shaft 307 mounted in a stationary hub 307*a* of a bracket 307*b*. The bracket 307*b* is secured to the side frame 75.

Slidably mounted on the sleeve 304 is a second disk 308. The disk 308 is non-rotatable on the sleeve 304 by reason of pins 309 extending from the hub of the disk 303. Pinned to a hub of the disk 308 is a ball cam ring 310 in the exposed face of which are three shallow cone-shaped depressions 310*a* which serve as seats for three balls 311. A thrust member 312 has three similar cone-shaped seats 312*a* for the balls 311 located so as to exactly oppose the seats in the ring 310 under normal conditions.

To the thrust member 312 a washer-like plate 313 is attached by means of cap screws or the like. The left face of the thrust member 312 acts as a thrust ball race coacting with a stationary race plate 314 between which and the thrust member 312, thrust balls 314*a* are interposed. A binding nut 315 provides axial adjustment for the thrust bearing 312—314—314*a*.

It is obvious that if relative rotation occurs between the disk 308 and the thrust member 312, the balls 311 would tend to roll out of the depressions 310*a* and 312*a* in which they normally rest and that in doing so they would tend to separate the disk 308 and the plate 313. As the disk and the plate are confined between the worm gear 302 and the nut 315, it is obvious that their separation must cause the disks 303 and 308 to exert a squeezing action upon the worm gear and thereby act as two driven disks of a disk clutch with the gear being a third and driving disk.

The plate 313 has a slot 316 which loosely receives a pin 317 extending from the disk 308. The slot permits limited rotation of the disk 308 relative to the plate 313 to allow the balls 311 to act as described in the preceding paragraph, but when the pin 317 is at the end 316*a* of the slot, the depression 310a and 312a are in axial alinement and the worm gear is free to rotate between the disks 303 and 308. However, rotation of the plate 313 counterclockwise, as viewed in Figure 15, brings the depressions 312a out of alinement with the depressions 310a to engage the clutch.

I provide a latch 318 pivoted on a stud 319 protruding from the face of the disk 308. The latch is biased by a spring 320 toward engagement with a coacting stud 321 extending from the plate 313. A lever 322 is also pivoted on the stud 319 and has a pin 323 to engage a lug 323a on the latch 318. The lever 322 is lightly biased in a clockwise direction by a spring 324. The free ends of the springs 320 and 324 are connected with pins 320a and 324a, respectively. The pin 320a extends from the disk 308, while the pin 324a extends from the plate 313.

Clamped upon the end of the stationary stub shaft 307 and therefore stationary is a radial arm 325. It carries adjacent its outer end a stop pin 325a so placed that it will always be in the orbit of the projecting end of the lever 322. The stop pin is designed to trip the latch 318 upon engagement of the outer end of the lever 322 therewith.

The disk 303 has a hub 335 to which one end of a chain 336 is attached. This chain functions through a series of levers and linkage to adjust the position of a belt idler pulley 346 to alter the speed of the weaving machine. At the time of starting a new shuttle coil in the machine, a projection 326 on the disk 308 is always resting against a fixed stop 327 and the clutch is engaged. Therefore, any running of the machine will rotate the timer unit in a clockwise direction, the projection 326 thereupon leaving the stop 327. This will wind the chain 336 upon the hub 335.

The lower end of the chain is attached by a connector 338 to another chain 339 which is capable of flexure at right angles from the flexure of the chain 336 so that it can pass over an idler roller 340 and over a segment arm 341. The lower end of the chain 339 is pinned at 341a to the arm 341.

The arm 341 is pivoted at 342 and an adjustable radius arm 343 is integral with the arm 341. A link 344 transmits motion to a bell crank 345 which is spring loaded by a spring 357 against the pull of the chains 336 and 339.

The bell crank 345 carries on the outer end of its downwardly extending arm, the idler pulley 346 which engages the main driving belt 347.

The adjustable diameter belt pulley shown in Figure 17 comprised of the cone-shaped members 349 and 350 provides a variable diameter seat for the belt 347 by being slidable axially upon the motor shaft 351. They are keyed to the shaft so that they may be rotated thereby and have in their opposing conical faces, radially extending alternately arranged segments for mutual interengagement. The cones 349 and 350 are biased toward each other by helical springs 352 interposed between the cone-shaped members and collars 354 mounted on the shaft 351.

The springs 352 tend to force the members 349 and 350 to engage to the maximum depth of their respective segmental slots and in so doing, expand the diameter of the effective belt groove between them to the maximum. However, sufficient pull upon the belt while the pulley is turning will cause them to separate against the thrust of the springs 352 and decrease the effective diameter of the groove.

In Figure 14 of the drawings, the belt 347 is shown displaced by the idler pulley 346 and it is riding on the smaller diameter of the interlocking cone faces which are well separated. In this position it is obvious that the halves of the adjustable pulley cannot approach each other without stretching or breaking the belt and further, that the belt can be used to govern the relative axial positions of the cone members if some means is provided to lengthen the belt.

The idler pulley 346 and its attendant bell crank lever 341 furnish this means and any reasonable position of the belt race upon the adjustable pulley can be attained by deflecting the belt more or less by the idler pulley, depending upon the diameter ratio required between the driving and driven pulleys to attain the desired machine speed.

To make this action automatic and entirely under the control of the timing device, the chain connection 336 with the hub 335 of the disk 303 furnishes a competent means for moving the idler lever 345. The worm gear 302 acting through the clutch plates 303 and 308 is capable of exerting a powerful effort and as the chain 336 is attached to the hub 335, it will tend to wind about the hub and travel upward, tensioning the spring 357 and at the same time swinging the idler pulley in a direction to loosen the belt and permit the springs 352 to force the halves of the driving pulley toward each other, thus increasing the effective diameter of the pulley and augmenting the speed of the weaving machine.

The spring 357 not only functions to position the idler 346, but it also acts as a constant yieldable load toward backward rotation of the whole timing unit. While the timing unit is being driven by the machine through the worm 301 and the worm gear 302, a potential force is being built up by tensioning the spring 357 to be used in restoring the timing unit to normal operating condition after the stop pin 325a has tripped the latch 318.

Situated near the stop 327 and partly in the path of movement of the projection 326 is a pendulum 328 freely pivoted on a pin 329. It is spring biased to normally engage a stop pin 330. Arranged within the path of the upper end of the pendulum 328 is the circuit breaker 252d, spring loaded to normally keep the contacts in engagement. This circuit breaker is shown in the electric diagram of Figure 12G so that if the circuit breaker 252d is opened, the magnet 229 will be deenergized to drop the pawl 230, thus stopping the machine.

It is obvious that if the projection 326 slowly passes the pendulum 328, it will move it but a slight distance so that its upper end would not open the circuit breaker 252d. On the other hand, if the projection 326 is caused to move swiftly past the pendulum 328, the pendulum would receive a blow and the momentum thus received would cause it to swing to the dotted line position of Figure 15 to open the circuit breaker.

As the worm 301 is fixed to the feed pinion shaft 79, it will rotate only when the machine is actually weaving. Therefore, when the machine is weaving, the worm gear 302 will slowly rotate and its angular motion is a true index to the number of machine beats made at any time. The speed ratio between the worm gear 302 and the machine is such that the longest weft wire ever carried in a shuttle coil will not furnish enough machine beats to cause the gear 302 to make one complete rotation even when the weft is applied upon the narrowest cloth. Therefore, something less than one rotation of the worm gear is sufficient to represent the number of machine beats that can be obtained from any shuttle coil that could be applied to the machine.

Operation of timing device

Assuming that the clutch plates 303 and 308 are forced against the worm gear 302 by displacement of the balls 311 due to a slight relative rotation of the disk 313, which on starting, may be manually given, and that the latch 318 has engaged the stop 321 to maintain this condition, as the machine operates, there will be a slow clockwise rotation of the gear 302 and as the clutch is engaged, it will carry all of the rotatable mechanism with it and wind the chain 336 upon the hub 335.

The arm 325 will be located at a position where the stop pin 325*a* will trip the latch 318 after the gear has traveled that portion of a circle represented by the machine beats contained in the coil of weft wire being used at the time. The arm 325 is in the shape of a pointer and adjustable relative to the stub shaft 307 so that it can be set according to the size of shuttle coil and length of weft wire, or in other words, according to the machine beats. Associated with the pointer-like arm 325 is a scale 325*b* to facilitate setting the pointer.

When the latch 318 approaches the stop pin 325*a*, the lever 322 will be engaged by the stop pin and as its normal position due to the spring 324 is nearly radial, it will have considerable movement about the stud 319 before the pin 323 engages the projection 323*a* of the latch 318 and causes the latch to disengage the latch pin 321, as shown by dotted lines in Figure 15. During the preliminary movement of the lever 322, the spring 324 is being extended and is building up a load on the disk 313 toward returning to axial ball depression alinement with the disk 308. At the instant of tripping of the latch 318, the disk 313 releases the clutch plates by rotating until the stop pin 317 reaches the end 316*a* of the slot 316.

This is vigorously brought about by the pull induced by the spring 324, which at this instant is greatly tensioned by the idle motion of the lever 322.

As soon as the rotating timing unit is declutched from the worm gear 302, the spring 357 acting through the various parts and finally the chain 336, causes an immediate reversal in the rotation of the timer parts and forcibly and rapidly continues this movement until the stop projection 326 on the edge of the disk 308 engages the fixed stop 327 on the machine frame and comes to rest. At this instant, the plate 313 is rapidly rotating with the other timer parts and the sudden stopping of the disk 308 upon the impact of the stops 326 and 327 will cause the plate 313 to overrun due to its momentum and reclutch the parts to the worm gear 302. The plate 313 being in effect a fly-wheel will at the moment of coming to rest overrun its own latch 318 by springing the disks 308 and 303 to some extent.

This latter expedient is provided in this otherwise rigid train of mechanism to permit the use of the fixed position latch 318. The rather thin disks 303 and 308 bulging slightly under the axial thrust of the balls 311 and thus furnishing an elastic cushion permit the pin 321 to travel slightly past the shoulder of the latch 318 at the instant of impact, thus eliminating the necessity for a particularly close adjustment of the nut 315. At the same time, a firm pressure between the clutch plates and the gear 302 is assured over a considerable angular motion of the plate 313.

As the timing unit counter-rotates to the clutching position with the projections 326 and 327 in contact, the projection 326 forcibly strikes the pendulum 328, causes it to swing to the dotted line position for opening the circuit 250*d* and thereby stops the machine. As it would be impossible to start the machine with the stop circuit interrupted, the spring of the circuit breaker immediately returns the breaker to closed position and as the timing device rotates very slowly, in a forward direction, the projection 326 will not displace the pendulum far enough to reach the circuit breaker so that the breaker will remain closed until the next tripping of the latch 318 after which the same train of events will be repeated.

From the foregoing, it will be seen that the timing device is entirely automatic and that it will vary the speed of the machine through the chain 336, causing a gradual increase in speed as the shuttle pays out and then restoring the original slower speed after the timer, which has been set for the particular number of turns of wire and length of weft, has tripped, leaving only a small quantity of weft wire in the shuttle. The amount of speed change can be regulated by moving the pin 358 of the adjustable radius arm 343 along the slot in the arm to any position required. This determines the amount of travel of the bell crank 345 and consequently the diameter of the driving pulley 349—350 in relation to the machine beats.

Slight variations of the pointer arm 325 can readily be made by the operator to correct a tendency of the timer to stop the machine either too soon or too late.

The timing mechanism leaves nothing to the machine operator after the machine is once set up for a given run. It is necessary to adjust the amount of speed change desired and to set the stop arm for the number of machine beats, but once set the apparatus will continue to function without attention.

Recapitulation of operation and advantages

Assuming that the warp wires are threaded through the machine and that the machine is ready to operate and is started, it will be seen that the warp rolls shown in Figure 5 feed the warp wires in equal lengths. The member 33 puts a little slack in the warp wires just before they reach the warp rolls, so that the predetermined friction on the warp rolls will remain exactly as desired.

The breast roll pulls the wire through the machine and the whip roll automatically regulates the tension to retain it at the desired point. The operation of the shuttle lays the weft wires and the fingers 190 and the comb 67 raise the weft wires to proper position between the walls of the warp shed. When enough wire is woven, the end is welded and finally connected with the take-up mandrel.

Many of the advantages of a machine of this kind have already been referred to and others will be obvious from the foregoing description of of its construction and operation.

This machine occupies much less room on the factory floor than old type wire weaving machines.

There are no reciprocating shuttle arms swinging out laterally from the machine. The machine is relatively short because the warp wires are in substantially upright position during the weaving operation.

On account of the method of operating the shuttle herein explained, the machine can be made to operate at great speed. It is automatically stopped on occurrence of accidents, which might cause breakage.

My machine practically eliminates all of the difficulties due to inertia in the laying of the weft. The rolling shuttle feeds its wire without continually starting and stopping the rotation of a bobbin containing variable amounts of wire. The wire in issuing from the shuttle merely becomes stationary in relation to the machine without setting up motion in any other part. For this reason, the distribution of the weft can occur with great speed without effecting the woven product.

The rolling shuttle contributes to this speed by requiring no carrier nor container and by constituting in itself little to add to the huge coil of wire that it carries. Consequently, its vibration period can be as much faster as it has less mass than other mechanisms used in passing a bobbin of weft wire. Rotating wire traveling at a circumferential velocity exactly equal to its lineal speed imposes practically no wear upon its path. The impact of the shuttle at either end of its stroke is absorbed and used as potential energy toward its following expulsion from the catapult. It carries a simple cylindrical coil of wire which is easily wound and so large that stops for replenishing the weft supply are infrequent.

The machine feeds warp under such control that all of the wires are of equal length. The tension on the warp is manually variable and automatically constant by means included within the machine design and not due to the application of outside weight. The warp is definitely fed and produces cloth of uniform weft spacing in unlimited length.

The accurate feed means applied directly adjacent to the weaving point permits crimping of the warp and weft while stationary and supported by a stationary comb, thus producing an accurate and sharp crimp not modified by the "crawl" of the wire due to continuous feed, reed movement, nor elasticity in the wire.

Warp feed on my machine is not applied through the entire length of the cloth within the machine. It is not applied by the wind-up mandrel. The friction feed unit delivers the cloth free to the floor or to a wind-up mechanism supplied which will store a very large roll of wire at perfectly uniform slight tension, thus eliminating all tendency to distort the cloth after weaving.

The same wind-up means permits the ready handling of the cloth in units of large size and the welding facilities supplied allow the perfect sealing of all cut ends for further processing.

The operation of my machine is entirely automatic with the exception of the changing of the shuttles when spent and the occasional welding of new warp supply to the wires whose spools are becoming empty.

The machine automatically stops just before a shuttle coil is entirely used and also upon the happening of any abnormal event such as a breaking wire or any other accident to which the stop system is applied.

It is obvious also from the foregoing that numerous changes might be made in the construction, arrangement and operation of the parts, and it is my purpose to cover by my claims any modifications in structure or use of mechanical equivalents, which may reasonably come within the scope of my invention and of the claims.

I claim as my invention:

1. In a weaving machine of the kind described, means for supplying warp wires to the machine, means for applying braking action to said first means, feeding means for drawing the woven fabric upwardly through part of the machine, horizontally operating heddles for forming a warp shed and means for rolling a shuttle across the heddles within the warp shed for supplying the weft wire for the weaving within the warp shed.

2. In a weaving machine of the kind described, means for supplying warp wires to the machine, means for applying braking action to said first means, feeding means for drawing the woven fabric upwardly through part of the machine, horizontally operating heddles for forming a warp shed, a shuttle comprising an annular casing for containing a coil of weft wire, and means for imparting rolling motion to the shuttle on its periphery across the heddles within the warp shed for supplying the weft wire for the weaving operation.

3. In a weaving machine of the kind described, means for supplying warp wires to the machine, means for applying braking action to said first means, feeding means for drawing the woven fabric upwardly through part of the machine, horizontally operating heddles for forming a warp shed, a shuttle comprising an annular casing for containing a coil of weft wire, means for imparting rolling motion to the shuttle on its periphery across the heddles within the warp shed for supplying the weft wire for the weaving operation, means for lifting the weft wire on the side of the machine which receives the arriving shuttle after each weft laying operation, and means for thereafter beating such weft wire into place at the upper end of the warp shed.

4. In a wire cloth weaving machine, means for drawing the warp wires and woven cloth upwardly through the machine under tension, horizontally moving heddles arranged one above the other for forming a warp shed, means for placing weft wire in the shed, means for moving the weft wire when placed in the warp shed to final woven position, a shuttle comprising an annular casing for containing a coil of weft wire, and shuttle operating mechanism comprising means on each side of the machine for imparting rolling motion to the shuttle and causing it to travel on its own periphery across the upper heddle for placing the weft wire, said means in each case including a shuttle receiving box, a flexible strap, a pivoted catapult and a spring.

5. In a wire cloth weaving machine, wire cloth weaving mechanism including a shuttle and means for increasing the speed of the wire cloth through the machine as the weight of the shuttle decreases comprising a progressively adjustable speed changing mechanism between the source of power and the machine and automatic means responsive to the machine beats to cause progressive adjustment of said speed changing mechanism.

6. In a weaving machine of the kind described,

means for supplying warp wires to the machine, means for applying braking action to said first means, depending on the pull of the warp wires, feeding means for drawing the woven fabric upwardly through part of the machine, horizontally operating heddles for forming a warp shed, and means for rolling a shuttle across the heddles within the warp shed for supplying the weft wire for the weaving within the warp shed.

7. In a weaving machine of the kind described, means for supplying warp wires to the machine, means for applying braking action to said first means, depending on the pull of the warp wires, feeding means for drawing the woven fabric upwardly through part of the machine, horizontally operating heddles for forming a warp shed, means for rolling a shuttle across the heddles within the warp shed for supplying the weft wire for the weaving with the warp shed, means for providing slack in the warp wires as they approach the rolls, means for reversing the movement of the rolls for emergencies, and means associated with said slack providing means for taking up slack in the warp wires due to such reversal.

8. In a weaving machine of the class described, means for supplying warp wires to the machine, feeding means for drawing the woven fabric upwardly through part of the machine, horizontally operating heddles for forming a warp shed, in the upward moving warp wires, means for rolling a shuttle across the heddles within the warp shed for supplying the weft wire for the weaving within the warp shed, means for beating the weft wires successively into place, and means for rendering said feeding means inoperative during the movement of the weft wires by the beater means.

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