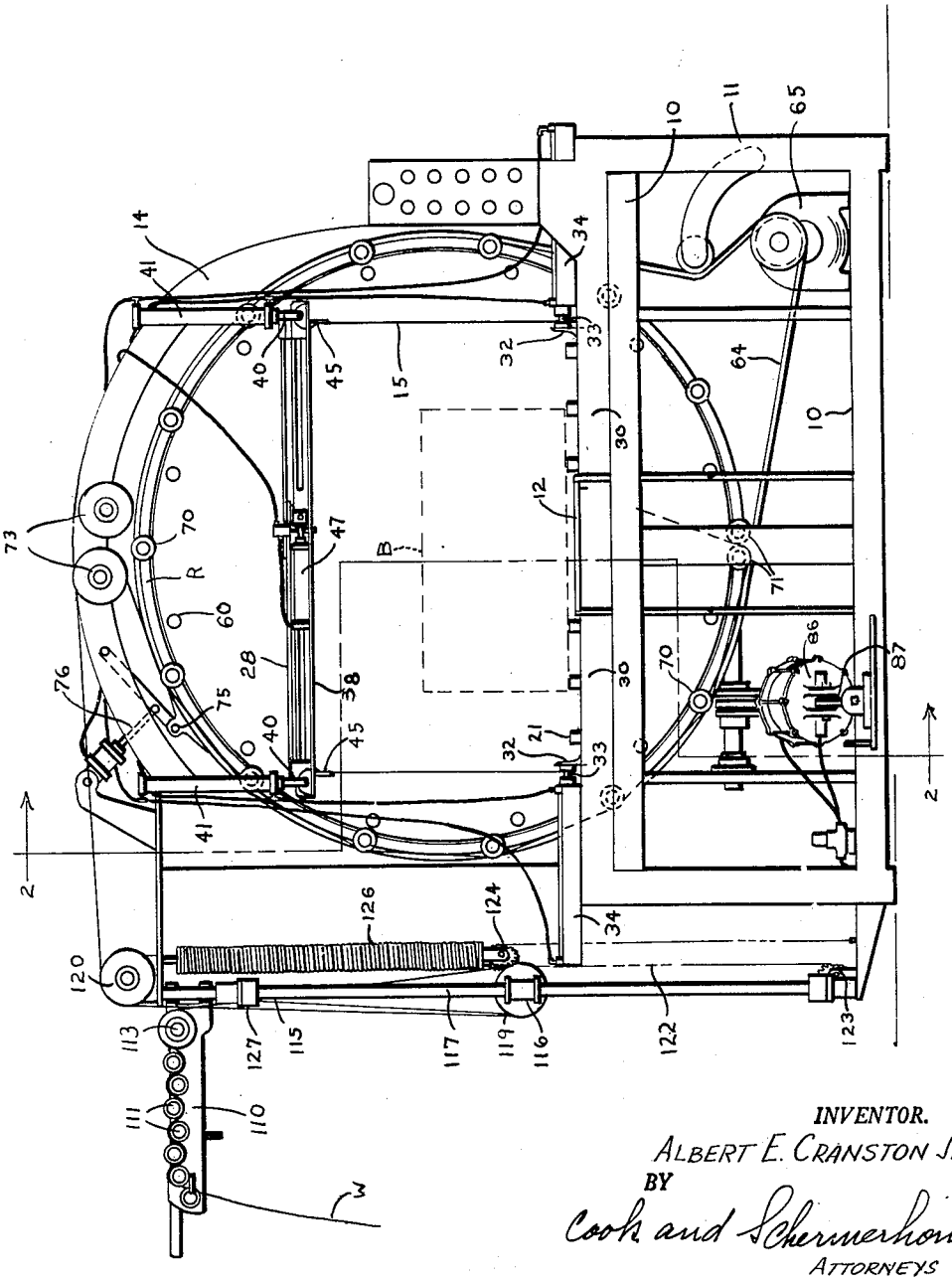
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REVERSIBLE WIRE BINDING MACHINE

Filed July 3, 1956 10 Sheets-Sheet 1

Fig. 1



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REVERSIBLE WIRE BINDING MACHINE

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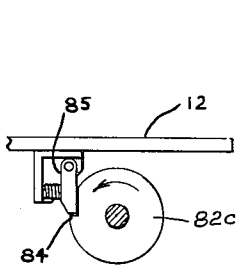


FIG. 2A

FIG. 2

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REVERSIBLE WIRE BINDING MACHINE

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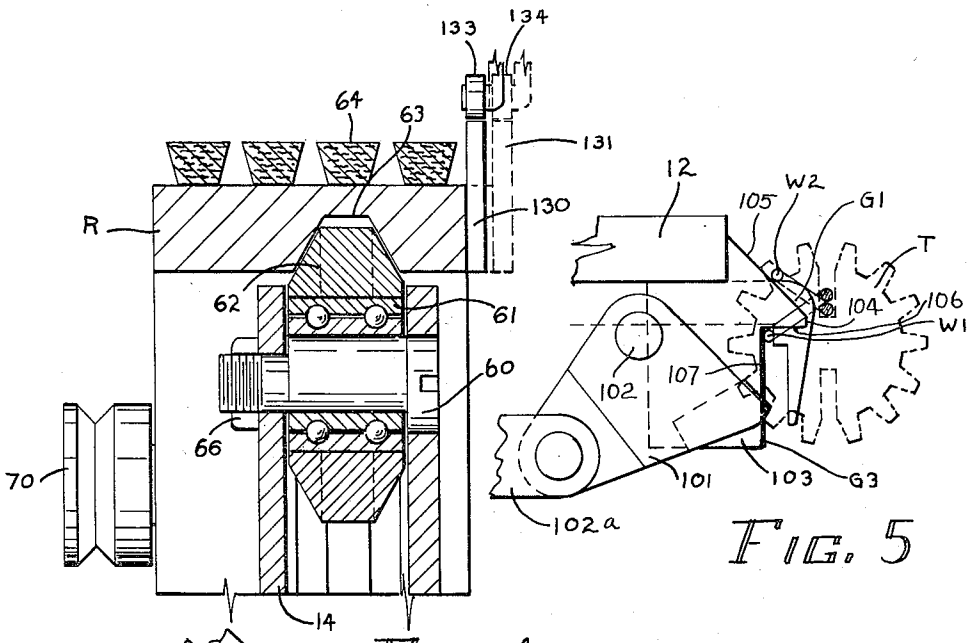


FIG. 5

FIG. 4

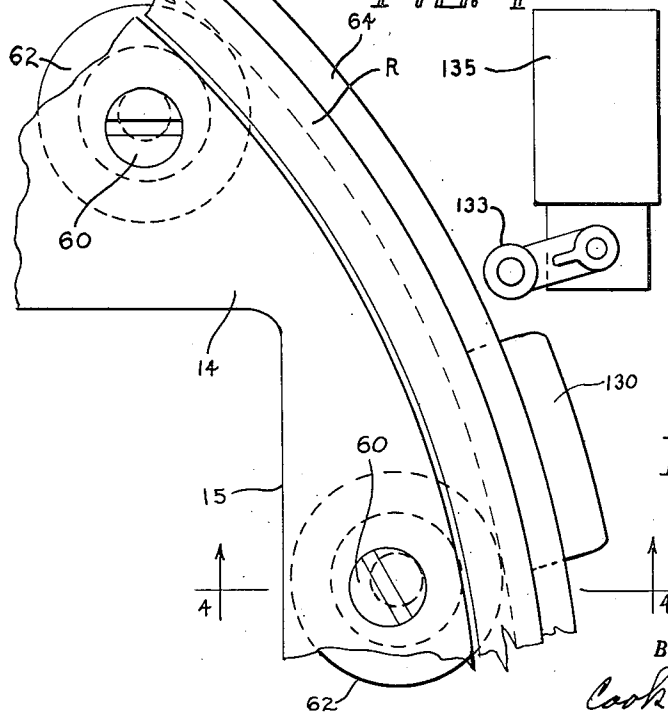


FIG. 3

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REVERSIBLE WIRE BINDING MACHINE

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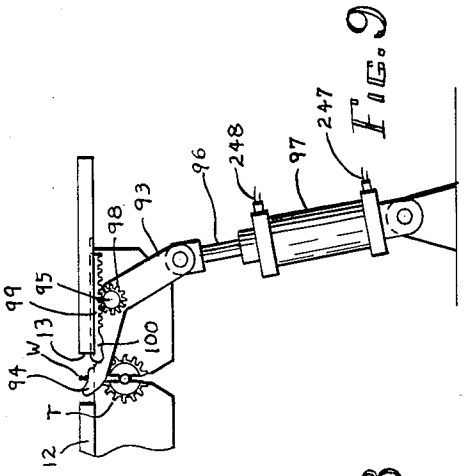


FIG. 9

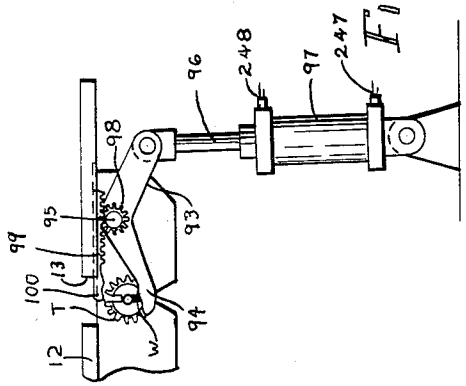


FIG. 8

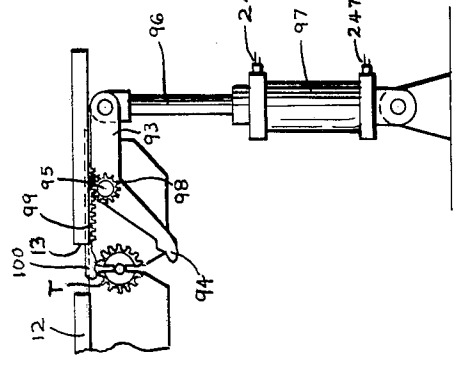


FIG. 7

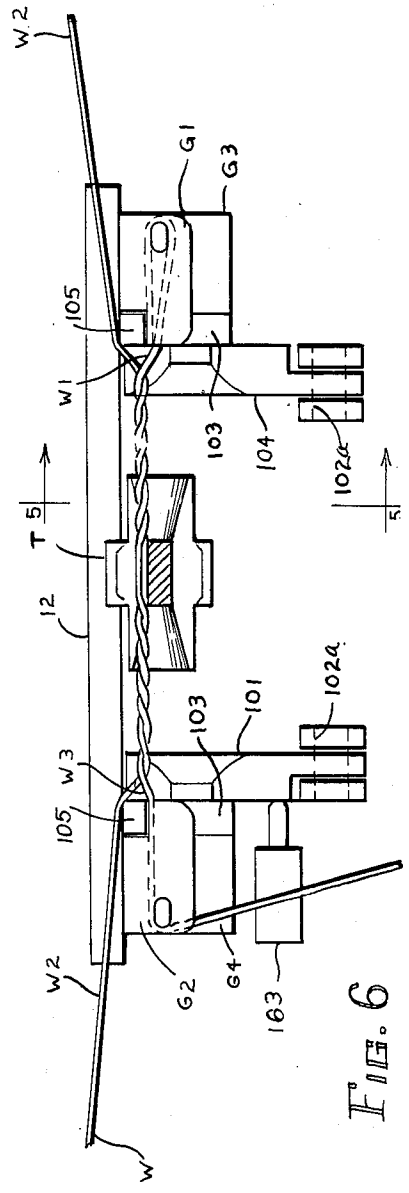


FIG. 6

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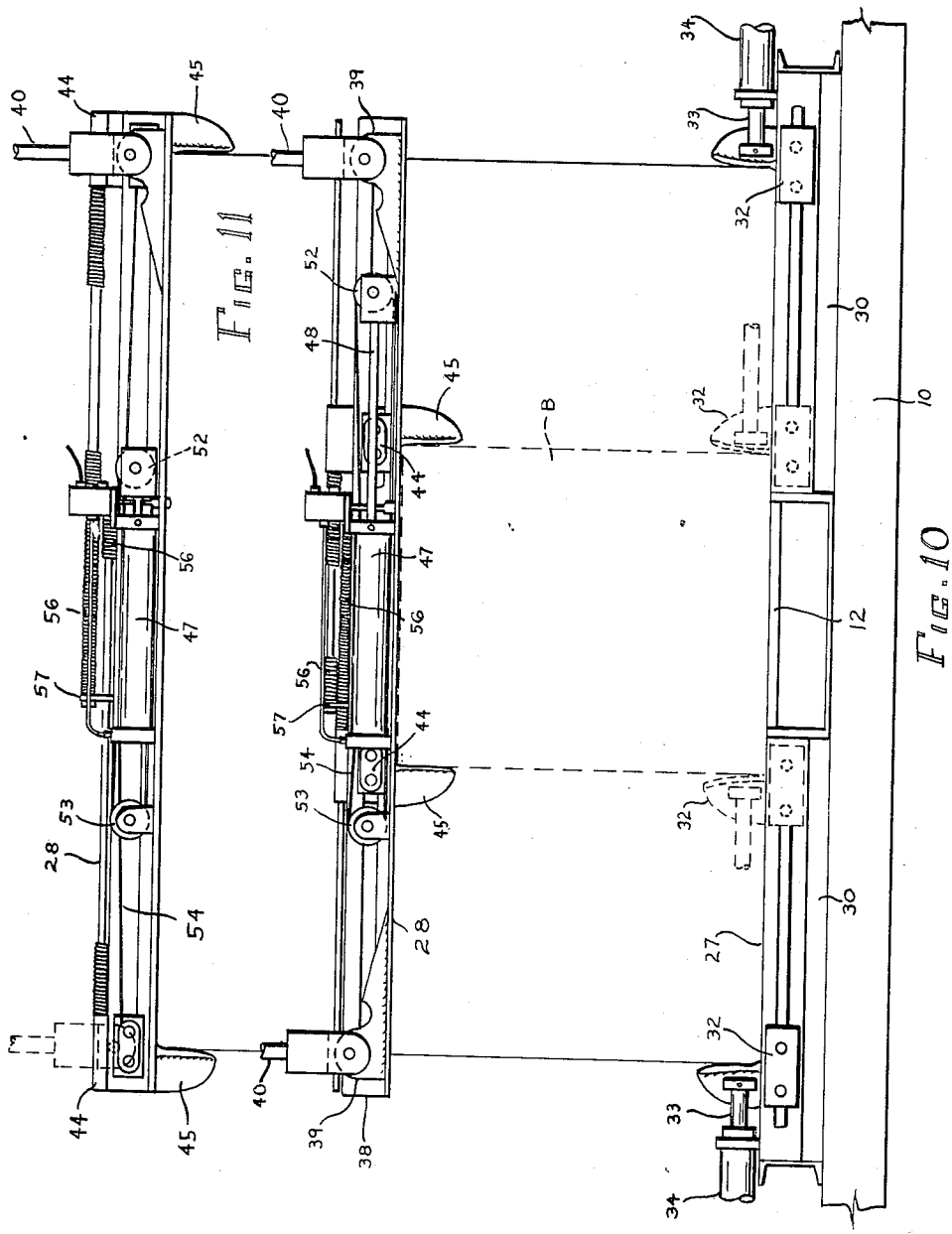


Fig. 11

Fig. 10

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REVERSIBLE WIRE BINDING MACHINE

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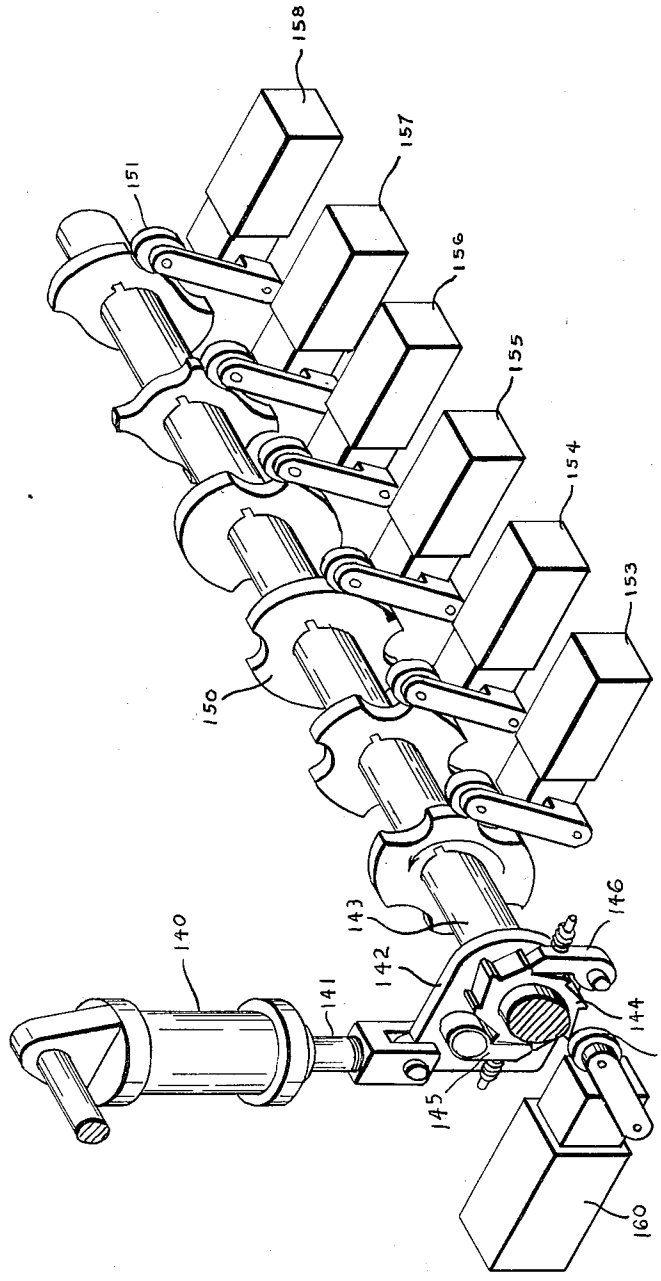


Fig. 12

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REVERSIBLE WIRE BINDING MACHINE

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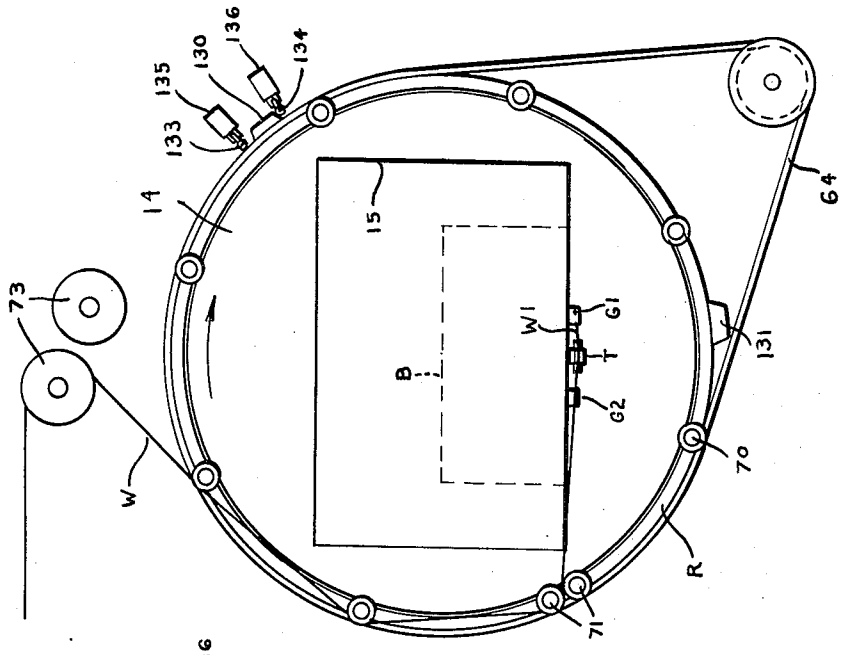


Fig. 14

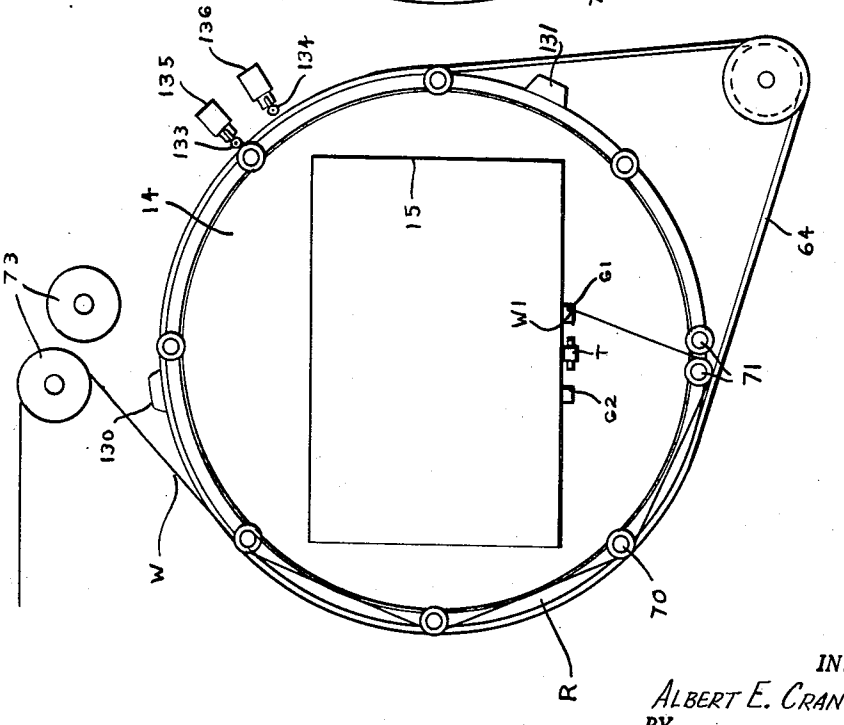


Fig. 13

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REVERSIBLE WIRE BINDING MACHINE

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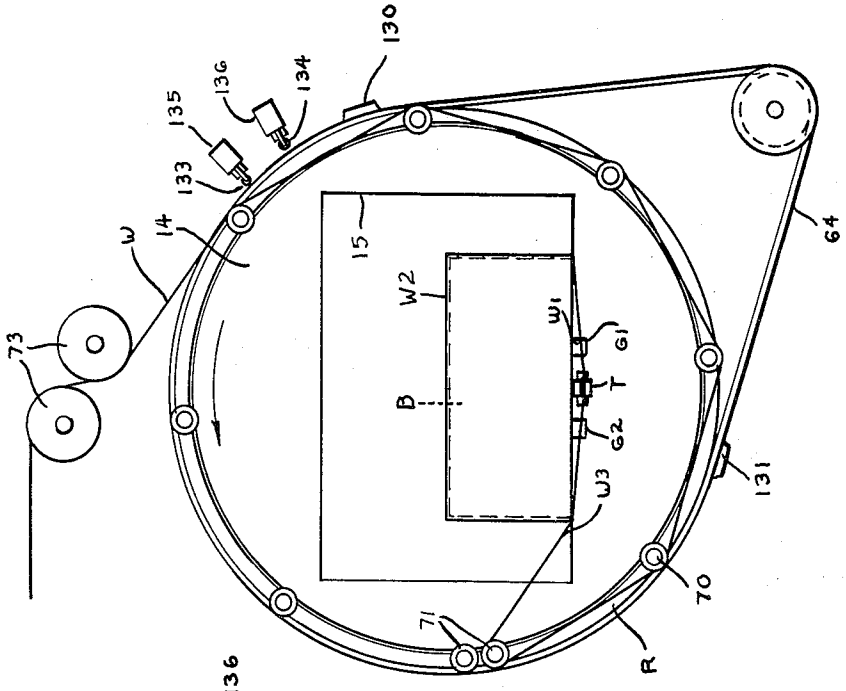


Fig. 16

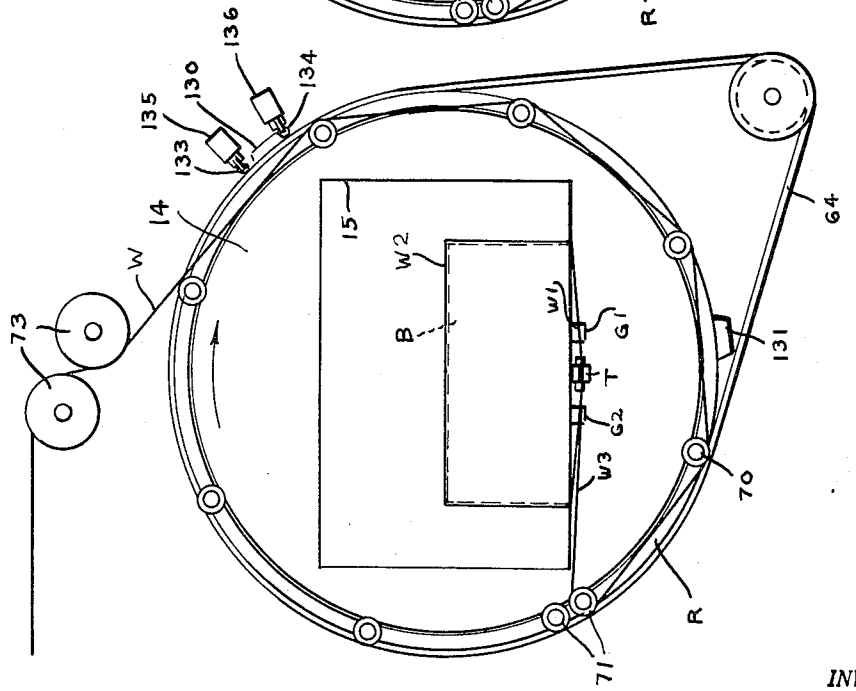


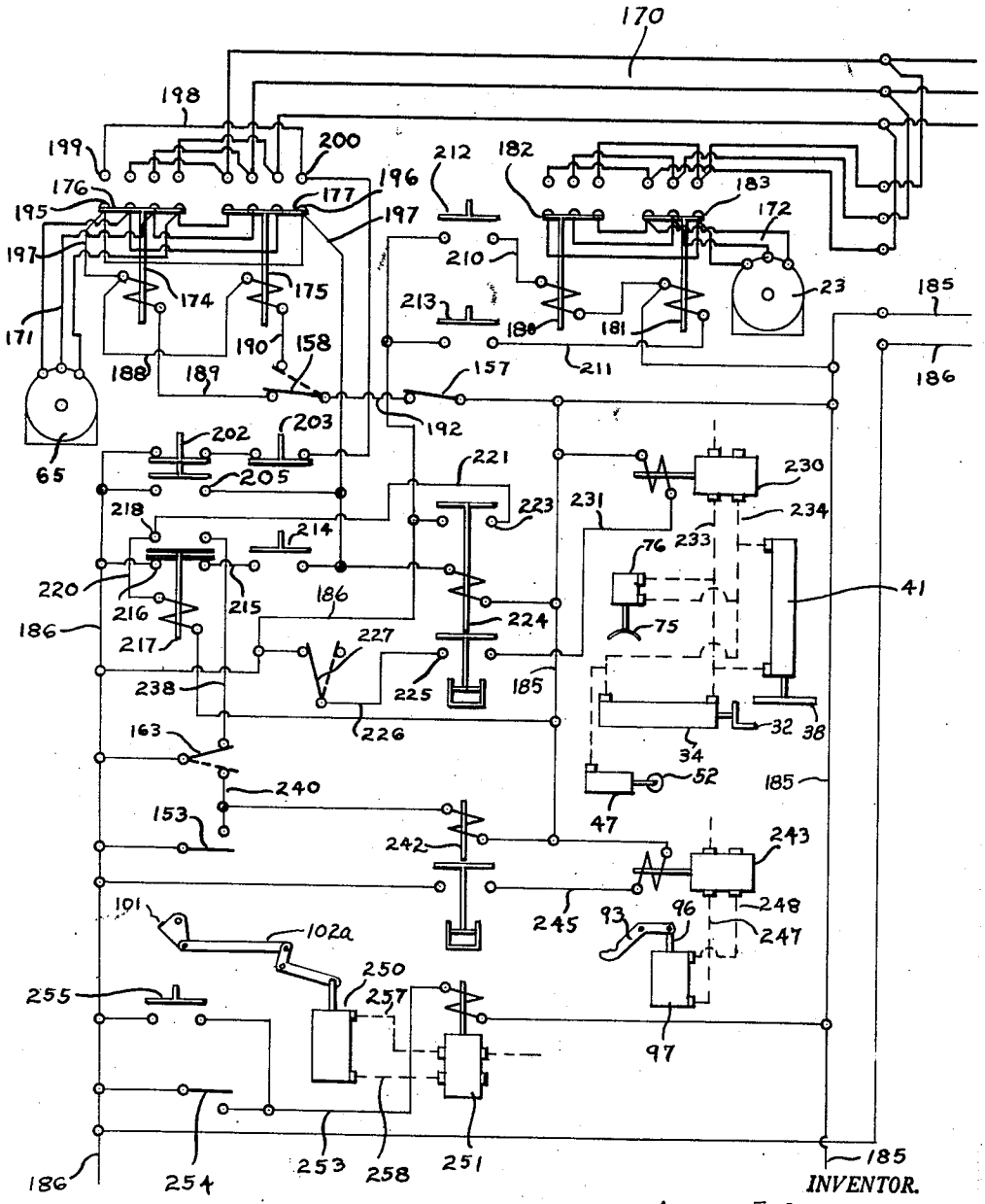
Fig. 15

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REVERSIBLE WIRE BINDING MACHINE

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FIG. 17

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REVERSIBLE WIRE BINDING MACHINE

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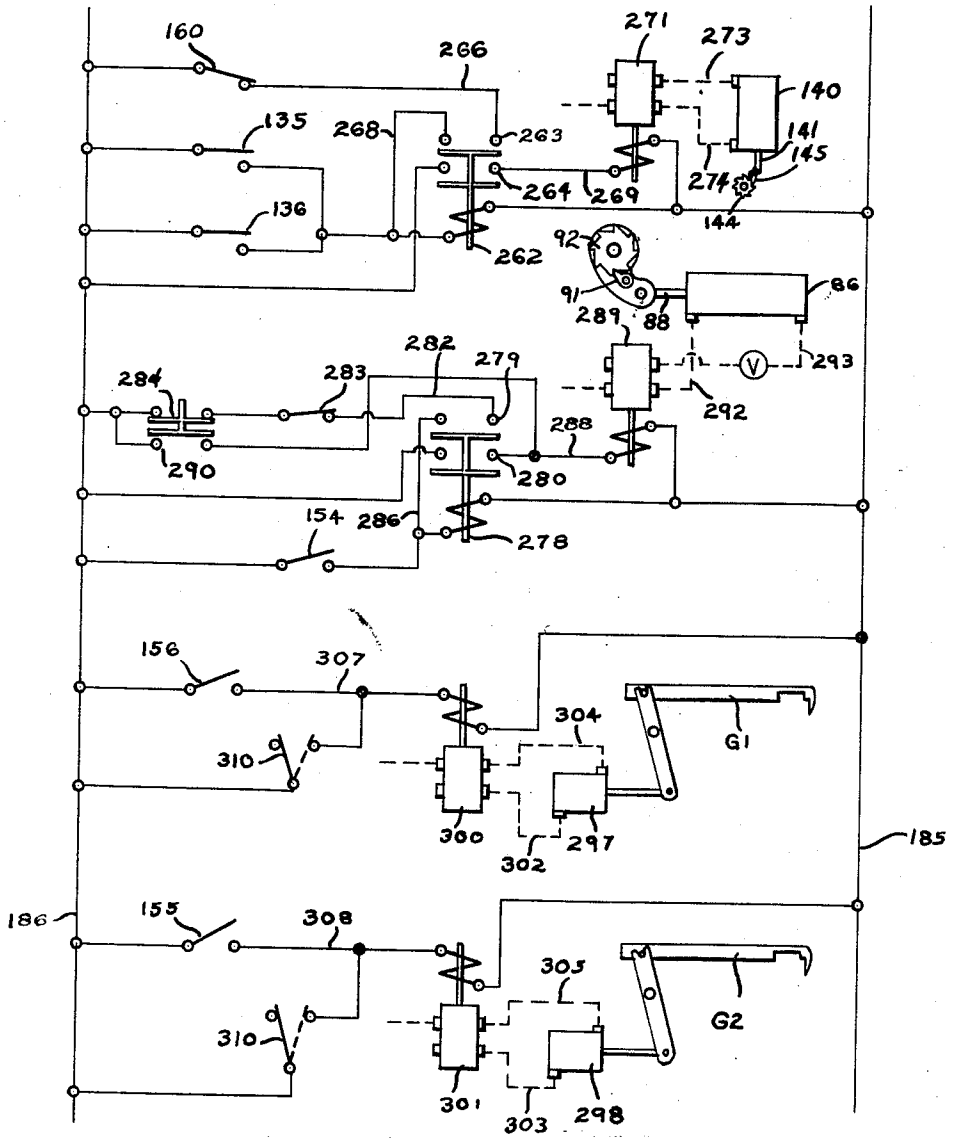


FIG. 17A

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United States Patent Office

2,941,464
Patented June 21, 1960

2,941,464

REVERSIBLE WIRE BINDING MACHINE

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Filed July 3, 1956, Ser. No. 595,771

14 Claims. (Cl. 100—28)

This invention relates to improvements in a binding machine of the type utilized to secure a wire band about a bundle or other object supported in the machine.

More specifically, the machine disclosed herein is of the type known as a reversible binding machine, having a wire laying ring which rotates in opposite directions about a bundle in successive binding operations. The general object of the invention is to provide an improved machine of the type described which functions smoothly and efficiently in tightly securing wire bands around a bundle, particularly where the bundle is relatively large and requires unusually heavy wire.

When the size of the machine is increased, certain difficulties are experienced which have tended heretofore to limit the size and weight of bundle which could be bound. The heavier wire is stiffer, imposing greater binding resistance over each guide sheave, greater resistance to twisting and greater resistance to injection and ejection from the slot in the twister gear. A large bundle passage requires a large wire laying ring having higher peripheral speed if it is to complete a revolution in the same time. Control switches heretofore actuated mechanically by cams on the ring are then operated too fast for solenoid relays and valves, and air cylinders, to complete their functions in the time available. Such difficulties are not overcome by mere increase in physical dimensions. In many instances they are aggravated because larger relays, valves and air cylinders tend to be slower acting. The present invention, therefore, provides new mechanical components and new control devices to meet the foregoing and other problems which have developed in the growth of the binding machine art.

More specific objects are to provide a binding machine having improved control means for efficiently governing the performance of a series of operations in rapid sequence in a binding operation, and to provide an improved electrical and pneumatic system for initiating and performing the various functions at the proper times in each cycle of operation.

An additional object is to provide improved bundle clamping means operative to hold the bundle in a stationary position during a binding operation and to release the bundle at the completion of a binding operation.

Another object is to provide improved drive means for a twister gear which drives said gear forwardly a number of revolutions to accomplish a wire knotting operation and which drives said gear in reverse a partial revolution after the tensioned ends of the wire have been cut, to embed the projecting ends of the cut wire in the bundle and eliminate the possibility of injury to workmen or loosening of the knot in handling or shipping of the bundle.

Another object is to provide an improved arrangement of twister gear, wire cutters, and gripper mechanisms which operate to form an improved knot.

Another object is to provide means associated with the twister gear for retaining the wire in the gear when a knot is being formed and kicker means operative to strike

a first wire in the twister gear for insuring the entry of the wire in the gear and operative subsequently to eject a completed knot from the gear.

Still another object is to provide novel sheave means operative in connection with resistance and slack pulling means for imparting the same retarding force to the wire laying ring in opposite directions of rotation whereby the momentum of the ring will carry it approximately the same rotative distance in each operation after the power circuit for the driving motor therefor has been deenergized.

In the present machine, a large and heavy bundle is carried into a wrapping plane by a power driven conveyor, and, when properly positioned in the wrapping plane, wire is wrapped therearound by a rotary carrier comprising a wire laying ring driven by a reversible electric motor. Power-operated bundle clamping means, which engage the bundle throughout the binding operation, comprise opposed lower gripping members slidable on a stationary guide and opposed upper gripping members slidable on a vertically movable pressure bar. The wire laying ring engages switch means which actuate fluid pressure operated drive structure for a control assembly, and this assembly causes the functioning of various operating parts in a binding operation, including fluid pressure operated drive means for a twister gear. Associated with the twister gear are grippers and wire cutters, as well as a kicker arm and wire retaining means, which function at the proper time in a binding operation. The drive means for the twister gear is operative to rotate said gear several times in one direction in a knot forming step and to rotate said gear through a partial revolution in the other direction for embedding projecting cut ends of the wire into the bundle being wrapped. Wire resistance apparatus and sheave means are provided which apply the same retarding force to the wire laying ring in opposite directions of rotation whereby the wire laying ring rotates an equal amount in each binding operation after its driving motor has been shut off. The foregoing features are especially adapted for application to large machines having a wire laying ring travelling at relatively high peripheral speeds and handling relatively heavy wire beyond the capacity of the conventional machines known in the art and heretofore used.

The invention will be better understood and additional objects and advantages will become apparent from the following description taken in connection with the accompanying drawings which illustrate a preferred form of the invention. It is to be understood, however, that the invention may take other forms, and that all such modifications and variations within the scope of the appended claims which will occur to persons skilled in the art are included in the invention. The improvements herein disclosed and claimed are not limited to abnormally large machines but may also be employed to advantage in machines of conventional size.

In the drawings:

Figure 1 is a front elevational view of a wire binding machine of the present invention;

Figure 2 is a cross sectional view taken on the line 2—2 of Figure 1 and showing, in particular, driving mechanism for the twister gear;

Figure 2A is a fragmentary sectional view showing a detail of construction of the driving mechanism for the twister gear;

Figure 3 is a fragmentary elevational view of a portion of the wire laying ring and mounting means therefor;

Figure 4 is a sectional view taken on the line 4—4 of Figure 3 showing in particular the mounting means for the wire laying ring;

Figure 5 is a sectional view showing in particular the twister gear and associated structure, taken on the line

5—5 of Figure 6, the twister gear being shown in phantom lines;

Figure 6 is a sectional view taken on the line 6—6 of Figure 2 and also showing the twister gear and associated structure;

Figures 7, 8 and 9 are fragmentary elevational views taken at one end of the twister gear showing in combination therewith the wire kicker and wire retaining means in different operative positions;

Figure 10 is a fragmentary elevational view of the bundle clamping means showing both upper and lower clamping members disposed, respectively, in closed and open positions;

Figure 11 is a fragmentary elevational view of the upper bundle clamping member in open position;

Figure 12 is an enlarged perspective view of the central assembly for controlling automatically most of the functions of the machine;

Figures 13, 14, 15 and 16 are fragmentary elevational views showing in sequence different positions assumed by the wire laying ring in performing a binding operation in one direction of rotation; and

Figures 17 and 17A show a wiring diagram for the present machine.

Referring first to Figures 1 and 2, the operating parts of the present machine are carried on a frame structure having upper and lower horizontal fame members 10 supported by legs 11. Supported on the frame structure in horizontal position is a base plate 12, also shown in Figures 6 through 9, having a slot 13 in the plane in which the wire is laid about the bundle, this plane being referred to hereinafter as the wrapping plane. An upstanding frame 14, having a rectangular opening 15 comprising a passage through which bundles are moved and operated upon in a binding function, comprises an integral part of the frame structure. A bundle is shown in dotted lines in Figure 1 and is designated by the character B.

Bundles B are movable through the bundle passage 15 on a conveyor 20 comprising a plurality of endless chains 21 trained over end sprockets 22. Sprockets 22 are driven by a reversible drive motor, designated by the numeral 23 in Figure 17 and adapted to be energized for either forward or reverse movement by manually operated switch means to be described in connection with the electrical system of the machine. By energizing the conveyor drive motor 23 in the desired direction, bundles supported on the conveyor are movable into and out of the wrapping plane or suitably adjusted in the wrapping plane when it is desired to secure more than one binding around the bundle. As seen in Figure 2, the bundle supporting runs of the conveyor chains 21 are disposed in a plane slightly above the upper surface of the base plate 12 so that the bundles will be carried above said plate. Also, as seen in Figure 2, the conveyor 20 comprises individual sections disposed on each side of the slot 13 in plate 12 so that no part of the conveyor is in the wrapping plane.

Bundle clamping means

Referring specifically to Figures 1, 2, 10 and 11, means are provided to clamp the bundle firmly while the wire is being tied therearound. This clamping comprises a lower clamp 27 and an upper clamp 28. Lower clamp 27 comprises a pair of tracks 30 projecting inwardly from the sides of the bundle passage 15, and slidably mounted on each of the tracks is a jaw member 32 on the end of a piston rod 33 having forward and reverse movement in a double acting fluid pressure operated cylinder 34. Operation of the piston rods 33 in forward and reverse directions is controlled by solenoid valves in a manner well understood in the art. Upon the application of fluid pressure to the rear end of the cylinders 34, the piston rods 33 are extended to move the jaw members 32 to the dotted line position shown in Figure 1 for firmly engaging the bundle, and, upon application of fluid pressure to the front end of the cylinders, the jaw members are retracted to their full line position.

The upper clamp 28 comprises a horizontal pressure bar 38 having a flat bottom surface and a pair of upstanding ears 39 disposed at opposite ends thereof. Pivotally attached to the ears 39 are piston rods 40 from double acting fluid pressure operated cylinders 41 secured to the upright frame 14. If fluid pressure is introduced to the upper end of the cylinders, the pressure bar 38 is moved downwardly into firm engagement with the top of the bundle, as shown in Figure 10, and the introduction of fluid to the lower end of the cylinders move the bar 38 upwardly to retracted position, as shown in Figure 1. Slidably mounted for horizontal movement on the bar 38 are two slides 44 having integral downwardly projecting jaws 45. Secured to the bar 38 intermediate the ends thereof is a single acting fluid pressure operated cylinder 47 operative to move a piston rod 48 outwardly in a bundle clamping operation.

Mounted on the end of piston rod 48 is a sheave 52, and mounted adjacent the other end of the bar 38 in a stationary position is a sheave 53. A cable 54 is reeved around the sheaves 52 and 53 and, more specifically, one end of the cable is attached to the slide 44 carrying the left-hand jaw 45 from whence it is reeved around sheave 52 and then around sheave 53 with its opposite end attached to the slide 44 carrying the other jaw 45. This cable and sheave arrangement may take other forms in that more than one sheave 52 or 53 may be utilized to increase the clamping effort of the jaws 45. A pair of springs 56 connected between each slide 44 and stationary abutments 57 on the pressure bar are adapted to return the jaws to their open position when fluid pressure does not exist in the cylinder.

In a binding operation, fluid pressure is admitted to one end of the cylinders 34, 41 and 47, whereupon jaws 32 are moved inwardly to engage the lower portion of the bundle, the pressure bar 38 is moved downwardly into firm engagement with the top of the bundle, and the jaws 45 are moved inwardly into engagement with the sides of the bundle adjacent the top. The bundle is thus held firmly in a set position while a wire binding operation is taking place. Each of the fluid cylinders 34, 41 and 47 is supplied by a common inlet pipe and is preferably controlled by the same solenoid valve so that these parts will operate in unison, the illustration of such arrangement being shown in Figure 17 and being explained more fully in connection with the electrical system. For retracting the piston rods in cylinders 34 and 41, fluid under pressure is admitted to the opposite end of the cylinders from that mentioned above. The piston rod 48 in cylinder 47 is retracted by the springs 56 acting on the slides 44.

Although Figure 10 shows the upper jaw members in bundle clamping position and the lower jaw members in retracted position, it is to be understood that these jaw members close and open together and their relative positions shown are for illustration only. As each of the cylinders 34, 41 and 47, when actuated in a bundle clamping operation, is supplied by a common inlet pipe, each is subjected to an equal fluid pressure. The bundle engaging members comprising the jaws 32 and 45 and the pressure bar 38 simultaneously advance toward bundle clamping position, and, when either of these members engages the bundle before the others, it will stop and the other members will move up against the bundle. Therefore, equal pressure will be applied by these members against the bundle even though the bundle is not centered. As the jaws 45 are driven by a common cable, it is necessary that the cable be capable of slipping on the sheaves 52 and 53 when one jaw engages a bundle before the other. The purpose of jaws 45 is to hold the upper side portions of the bundle in their original straight form and thereby prevent the downward thrust of the pressure bar from turning over the top edges which would

be cut by the wire when the ring laid the wire thereabout.

Rotary carrier

The wire is laid about the bundle by a rotary carrier comprising a ring R adapted to lay the wire W into a splicing or knotter mechanism comprising a double slotted twister gear T disposed just beneath the upper surface of the plate **12**, this twister gear being more fully described hereinafter. Twister gear T has disposed at opposite ends thereof a movable right gripper jaw G1 and a movable left gripper jaw G2, shown in Figures 6 and 13–16. Associated with the gripper jaws G1 and G2 are stationary jaws G3 and G4, respectively, and, as well understood in the art, the movable gripper jaws are coordinated with movement of the ring R whereby certain portions of the wire are clamped in the grippers to hold the wire under tension while other portions of the wire between the grippers are laid in the twister gear slot.

To illustrate further, Figures 13–16 show various positions of the ring in a wire laying operation with the ring rotating in a clockwise direction. In Figure 13, a primary end W1 of the wire is gripped in the gripper G1, and, as the ring R approaches its Figure 14 position, it lays this end of the wire in the twister gear and outside of the other gripper G2. In moving to its Figure 15 position, the ring lays wire portion W2 about the bundle, and, in being brought across the bottom of the bundle, wire portion W3 is laid outside the first mentioned gripper from whence it is laid in the twister gear and into the second mentioned gripper. In the next binding operation, wherein the direction of rotation of the ring is reversed, the primary end of the wire is gripped in the gripper G2 and this end is laid in the twister gear and outside of the gripper G1. Upon completing its wrap around the bundle, the wire is laid outside the gripper G2, into the twister gear and into gripper G1. Operation of the two grippers in a binding cycle is controlled by solenoid valves discussed hereinafter in connection with the electrical system of the machine.

Mounted in the frame member **14** in circular relationship is a plurality of eccentric pins **60** which support suitable bearings **61** for tapered rollers **62**. Rollers **62** support the wire laying ring R for rotary movement, and, as seen in Figure 4, the inner surface of the ring has an annular groove **63** for receiving the rollers. The outer peripheral surface of ring R directly over the rollers is engageable by a plurality of belts **64** from a reversible drive motor **65**. Pins **60** are threaded at one end for receiving nuts **66** for locking the pins in a desired set position, and, by rotative adjustment of the pins, the rollers **62** are movable radially for proper engagement with the ring R. This structure facilitates installation of the ring in the manufacture of the machine and provides a take-up for the wearing of bearing parts.

On the front side of the ring R are a plurality of wire guiding sheaves **70** disposed at regular intervals around the ring and a pair of sheaves **71** disposed in close relationship for leading the wire W from the ring inwardly toward the bundle in different positions of the ring. The wire is trained between the two guide sheaves **71** and over a number of the other guide sheaves **70** to a pair of sheaves **73** on the upper end of frame structure **14**, and, in binding operations, the guide sheaves **71** carry the wire about the bundle into engagement with the grippers and the twister gear. Sheaves **73** are disposed in a predetermined position relative to the ring and relative to each other to apply an equal resistance to the wire in opposite directions of rotation, as will be more fully explained hereinafter.

The ring R is adapted to be stopped by a brake shoe **75**, Figure 1, engageable on the back sides of the belts **64**. The brake shoe **75** is operated by means of a fluid cylinder **76** controlled by a solenoid valve.

Twister mechanism and associated structure

The knotter or twister gear T is shown in Figures 2 and 5 through 9, and this gear is operated by a gear train comprising a large gear **80** secured to a drive shaft **81**, a gear assembly **82**, and a gear **83** which meshes with the twister gear T. Gear assembly **82** has a first gear **82***a* which meshes with the large gear **80**, a gear **82***b* which meshes with the gear **83**, and a cam **82***c*, these three members forming an integral structure. In a preferred embodiment, the gear **82***a* is disposed between the gear **82***b* and the cam **82***c*. In Figure 2, the cam is not shown, and in Figure 2A, the cam is shown but the two gears are not illustrated. Cam **82***c* has a notch **84** adapted to be engaged by a spring-pressed pawl **85** pivoted on the machine frame and adapted to stop the reverse rotation of the cam **82***c*, as well as the entire gear train and twister gear. The gear **80** is rotated in the direction of the arrow **79** in a knot-tying step by fluid operated drive means comprising a cylinder **86** controlled by a solenoid operated valve described hereinafter.

Fluid cylinder **86** is pivotally mounted on a bracket **87**, which is in turn mounted on the machine frame in different longitudinal positions. Adjustment of the bracket **87** is accomplished by a screw **87***a* and such adjustment is utilized to obtain the proper stroke of the piston rod in the assembly of the machine and for subsequently varying the stroke if desired. Cylinder **86** has a piston rod **88** carrying at its outer end a pair of plates **90** journaled on shaft **81**, only one of said plates being shown. Pivotally mounted on a pin **77** carried between the plates **90** is a spring-pressed pawl **91**, and also pivoted on the pin **77** on each side of the pawl **91** is a link **78**. The two links are connected at their end opposite from the pin **77** by a pin **77***a* which forms a drive pawl. Secured to the shaft **81** in the plane of pawl **91** is a ratchet wheel **92** having teeth **92***a* adapted to be engaged by the pawl **91** and notches **92***b* adapted to be engaged by the pawl **77***a*. A tension spring **89** connected between pawl **77***a* and one of the plates **90** biases the links **78** in a counterclockwise direction to urge the pawl **77***a* into seating engagement with a notch **92***b*. The purpose of the links **78** and their connecting pawl **77***a* is to drive the ratchet wheel and gear train in a partial reverse rotation counter to the arrow **79**, as will now be explained.

In the knot-tying step, the control mechanism hereinafter to be described causes the actuation of cylinder **86** which then drives its piston rod **88** outwardly. The pawl **91** is engageable behind a tooth **92***a* in the ratchet wheel **92**, and, in a knotting operation, the ratchet wheel and shaft rotate through slightly more than a quarter revolution. The gear ratio of the gear train is such that this amount of rotation causes the gear assembly **82** to rotate slightly more than one revolution and the twister gear to rotate four and three-quarters revolutions, whereupon at this time the twister gear slots will not be vertically aligned but rather will be approximately horizontally aligned. In addition to the relationship established by the predetermined gear ratio, the notch **84** in the cam **81***c* is located in a position such that, when the gear **80** rotates slightly beyond a quarter turn, this notch rides by the pawl **85** a predetermined amount. The arrangement is such that, when the gear train rotates in the reverse direction an amount to bring the notch **84** into engagement with the pawl **85**, the twister gear will have rotated backwards a quarter turn, wherein its slots will be vertically aligned, as is desired at the completion of a knotting step. This partial reverse movement of the twister gear is to rotate the knot backwards and cause cut end portions thereof to embed themselves into the bundle. With these cut ends embedded in the bundle, there is no possibility of injury to the workmen handling the bundles and also there will be no cut ends to snag on other structure which may damage the knot.

The partial reverse drive of the gear train is accomplished by return movement of the piston rod 88. In this return movement, the pawl 77*a* is engaged in one of the notches 92*b* and will serve as a drive connection between the plates 90 and the ratchet wheel. When the partial revolution of the gear train is stopped by engagement of pawl 85 in the notch 84, the piston rod 88 nevertheless continues to retract, and, when such retracting force overcomes the exertion of spring 89, pawl 77*a* disengages from its notch 92*b*. As the piston rod 88 reaches its fully retracted position, the pawl 91 falls behind a tooth 92*a*, and pawl 77*a* engages in a notch 92*b* in readiness for the next knot-tying step.

Also associated with the twister gear is a wire kicker arm 93, shown in Figures 7, 8 and 9, in the form of a bell crank lever and having a dished wire-engaging head 94. The kicker arm 93 is pivotally mounted on a shaft 95 mounted on the opposite side of the twister gear from the grippers and is connected at the end opposite from the head 94 with a piston rod 96 of a fluid pressure operated cylinder 97 pivotally connected at its bottom end to the machine frame. Suitable control means associated with the cylinder 97 cause it to operate the kicker arm 93 which strikes the single wire portion W1 which has been laid in the twister gear prior to a knotting operation of said gear and which ejects a knot from the gear at the termination of a knotting operation.

To explain the operation of the kicker arm 93 more thoroughly, it is first to be noted, as is well known in the art, that, as the wire is being wrapped about a bundle, the two diametrically opposed slots in the twister gear are disposed in vertical relation. As the ring R starts its revolution, a single wire is laid in the bottom slot of the gear. At this time the piston rod 96 is in extended position wherein the head 94 of arm 93 is clear of the wrapping plane, Figure 7, so that the wire can be laid in the twister gear. After the wire has been laid in the twister gear, Figure 8, the arm 93 is pivoted clockwise and the head 94 strikes the single wire portion W1 and injects the wire against the inner wall of the slot.

The arm 93 then retracts into its Figure 7 position as soon as it has struck the single wire as described. The ring R continues its rotation and lays a second wire in the downwardly disposed slot of the twister gear. The twister gear then operates to form the knot, and, in the ultimate position of the gear, the slot containing the completed knot is directed upwardly. The kicker arm 93 is then operated by the cylinder 97 to its knot ejecting position shown in Figure 9. Arm 93 will return immediately to its retracted position in readiness for the next binding operation.

Secured to the arm 93 is a gear 98 which meshes with rack teeth on a slide 99 having guided movement in the under surface of plate 12. Slide 99 has a dished end portion 100, and, as seen in Figures 7, 8 and 9, when the arm 93 is in retracted position, the slide 99 is driven forward so that the dished end is vertically disposed over the wire. When the arm 93 is engageable with the single wire portion W1, as shown in Figure 8, the slide is partially retracted, and, in the knot-ejecting position, as shown in Figure 9, it is wholly retracted to be out of the way of the knot being ejected. The primary purpose of the slide 99 is to insure the retention of the wires in the twister gear as the twister gear is rotating to form a knot. More specifically, the wire around the bundle is inclined downwardly into the bottom slot of the twister gear, and when said gear rotates in a knotting operation to a position wherein the slot containing the wires is on top, the wire may tend to lift out of the gear. The slide 99 forms a retaining means and insures against displacement of the wires from the twister gear at a critical time. Although the wire will normally be laid properly in the twister gear slot and the knot formed without accidental displacement of the wire from the gear, the kicker arm 93 and slide 99 insure a positive knotting operation at all times.

Referring particularly to Figures 5 and 6, cutter blades 101 pivoted on pins 102 and movable by suitable power operated arms 102*a* are disposed on opposite ends of the twister gear T. These movable cutter blades are pivoted in counterclockwise rotation, Figure 5, in a wire cutting operation and cooperate with stationary cutter blades 103 for shearing the wire portions W1 and W3, Figure 6, disposed in the grippers G1 and G2 after a knotting operation. Stationary cutters 103 assume the shape shown in Figure 5 having a projection 104 with a beveled upper edge 105 and a straight lower edge 106 which meets a vertical wall 107 of the cutter body portion. The twister gear rotates in a counterclockwise direction, as viewed in Figure 5, for forming the knot, and, in this particular direction of rotation, the wire, when it is being twisted, cannot engage on edge portions of the grippers or the cutting mechanism. In this direction of rotation, the wire may engage the beveled portion 105 of the cutters 103 but no damage results to the wire as might be the case if the wire were twisted in the opposite direction. Furthermore, the wire portion W2, which passes around the bundle, is held up on the beveled portion 105 of the stationary cutters after the knot has been formed so that the movable cutters will sever only the wire portions desired, i.e., the wire potrions W1 and W3 which are held in the grippers.

Variable resistance and slack pulling device

Referring to Figure 1, the wire W from a suitable supply is first reeved through a variable resistance device 110 comprising a plurality of small top and bottom sheaves 111 and a sheave 113. Intermediate the variable resistance device and the sheaves 73 is a slack pulling mechanism 115 comprising a slide 116 mounted for vertical movement on upright guides 117. Mounted at the lower end of slide 116 is a pair of sheaves 119, and mounted in a stationary position at the upper end of the slack pulley mechanism is a pair of sheaves 120. Only one of each pair of sheaves 119 and 120 is shown but such arrangement is well understood in the art. From the sheave 113 the wire is trained around one of the sheaves 119 at the bottom of the slide 116, then around one of the upper sheaves 120, then around the other sheave 119 and up to the other sheave 120, from whence the wire leads to the guide sheaves 73 on the frame.

A chain 122 has one end thereof secured to the lower end of slide 116 and is trained around a first sprocket 123 mounted in a stationary position on the machine frame and around a second sprocket 124 carried on the lower end of a tension spring 126 connected at its upper end to the machine frame. The other end of chain 122 is anchored at the lower end of the machine frame. The upward movement of slide 116 is limited by an upper stop 127. Upon rotation of the ring R in a binding cycle, the resistance on the wire W imparted by the resistance device 110 causes the wire to move the slide 116 upwardly, and, as this slide is chain-connected to the spring 126, the spring will be flexed to store potential energy for imparting an initial movement to the ring in the reverse direction in the next binding cycle.

Carrier operated controls

The wire laying ring R carries a pair of cams 130 and 131, Figures 3, 4, and 13 through 17, and these cams are engageable with respective cam followers 133 and 134 operatively connected to switch mechanisms 135 and 136 mounted in a stationary position on the machine frame. As seen in Figure 4, the cam followers 133 and 134 are disposed in different planes so that each is engaged only by its respective cam 130 or 131. The cams and their followers are arranged so that the switch 135 is momentarily closed by its cam in clockwise rotation of the ring, and the switch 136 is momentarily closed by its cam in

counterclockwise rotation of the ring. The switches 135 and 136 are not closed by their cams in the direction of rotation of the ring opposite from that mentioned. In each binding operation, the switch which is being rendered operative in that particular direction of rotation is closed twice.

Switches 135 and 136 control the operation of a fluid pressure operated cylinder 140, Figure 12, which drives a control assembly C. The cylinder 140 has a piston rod 141 pivotally connected to an arm 142 journaled on a shaft 143. Secured on the shaft 143 is a ratchet wheel 144 engageable by a spring-pressed pawl 145 pivotally mounted on the arm 142 and a spring-pressed pawl 146 pivotally mounted on the machine frame, the former pawl serving as a drive pawl for the ratchet to impart rotation to the shaft 143, and the later pawl serving to prevent reverse rotation of the shaft. Rotation of shaft 143 is restrained sufficiently by suitable brake means, not shown, to prevent overrunning beyond the drive limits of the cylinder 140.

As viewed in Figure 12, the drive cylinder 140 rotates the shaft 143 in a counterclockwise direction, and secured on the shaft 143 are six cam wheels 150, each engaged by a cam follower 151 which operate switches 153–158, inclusive. The cylinder 140 and ratchet mechanism operated thereby cause the shaft 143 to rotate one-eighth turn two times in each binding cycle. The switch 153 comprises a wire injector switch, and the cam associated therewith has four raised portions, or projections, separated by narrow notches, or depressions. The raised portions of this cam exceed 45° so that the follower can begin and end on one of the raised portions without crossing one of the notches. Switch 153 is normally open and is momentarily closed as its follower rides through one of the notches. This switch controls one of the operations of the kicker arm 93 in that when closed, it causes the arm to engage the single wire W1 and inject it into the bottom slot of the twister gear. Switch 154 is a knotter start switch, and the cam wheel therefor has a contour similar to the cam wheel for switch 153 but is shifted around slightly. This switch is normally open, but, when momentarily closed, as when its cam follower rides through a notch, it causes the actuation of the knotter drive mechanism.

The cam wheel for switch 155, which controls the gripper G2, has a pair of diametrically opposite notches. This switch is normally open and is closed when its follower engages one of the notches in the cam wheel, resulting in actuation of drive means for opening the gripper G2. The cam wheel for switch 156, which controls the gripper G1, has a similar contour but is shifted on the shaft relative to the wheel for the switch 155. Switch 157, referred to as a ring motor stop switch, has four projections spaced more than 45° apart so that the follower can begin and end in the same depression between two projections without moving over a projection upon 45° rotation of shaft 143. This switch is closed when its follower rides in a depression and is momentarily opened as said follower rides over a projection. Switch 157, when momentarily opened, stops the ring motor 65. The cam wheel for switch 158 has two raised portions and two depressions each of which exceeds 45°. The follower thereby can begin and end in the same depression or on the same projection upon 45° rotation of the shaft 143. This switch is a selector switch which causes the next rotation of the ring motor to start in one direction when its cam follower rests in a depression in the cam wheel and which causes the next rotation to start in reverse direction when its cam follower rests on a projection.

Also associated with the control assembly is a limit switch 160 having an arm 161 engageable with plate 143 in the lowered position of this plate for opening the switch 160 at the completion of each drive operation of the cylinder 140. Switch 160 is normally closed and is in a holding circuit for the solenoid which controls cylinder 140. When this switch is opened, the fluid pressure to cylinder 140 is reversed and it draws its piston rod inwardly to a retracted position in readiness for driving the shaft 143 in the next control movement.

As described hereinbefore, the switch 153 in the control assembly C controls the operation of the kicker arm 93 in its wire injecting function comprising engaging the single wire at the initiation of a binding operation and pushing it into the bottom of the twister gear slot. The ejecting step of the arm 93, however, is controlled by a switch 163, Figure 6, which is mounted adjacent one of the cutter blades 101. This switch is engageable by one of the cutter blades when said cutter blades reach their retracted position to cause the arm 93 to perform its ejecting step at this time.

Electrical system

Referring first to Figure 17, a three-wire supply 170 energizes a power circuit 171 for the ring motor 65 and a power circuit 172 for the conveyor motor 23. Ring motor 65 is a reversible motor and is controlled by a pair of relays 174 and 175 having movable armatures 176 and 177, respectively. The three wires of ring motor power circuit 171 are connected in parallel to the first three contacts of each relay armature 176 and 177, and the three wires of the supply circuit 170 are connected to the first three stationary contacts of each of these armatures for energization of the power circuit 171. Two of the circuit wires 171 are transposed between the two relays so that two of the power circuit connections established by the closing of relay armature 177 will be reversed with respect to the connections established by the closing of armature 176 for reversing the ring motor 65, the two relays never being closed at the same time. Relay armature 176 is connected to produce clockwise rotation of the ring R and the relay armature 177 is connected to produce counterclockwise rotation of the ring. Each relay armature 176 and 177 also has a fourth movable contact for a holding circuit to be described.

Conveyor motor 23 also is a reversible motor and is controlled by a pair of relays 180 and 181 having movable armatures 182 and 183, respectively. The three circuit wires 172 are connected in parallel to the contacts of the armatures 182 and 183, and, similar to the ring motor circuit, two of the wires 172 are transposed between the two relays to produce reverse rotation of conveyor motor 23. Relay armature 182 is connected to produce forward rotation of the motor 23, and armature 183 is connected to produce reverse rotation of the motor.

The coils of relays 174 and 175 and the coils of relays 180 and 181 are in a low voltage control circuit having supply wires 185 and 186. The relays 174 and 175 for the ring motor 65 are controlled by a plurality of switches including the ring motor stop switch 157 and the ring motor direction or selector switch 158, these two switches being operative by the control assembly C, previously mentioned. The coils of relays 174 and 175 are connected at one end to a common wire 188, and the other ends of these coils are connected, respectively, through wires 189 and 190 to the two contacts of the ring direction control switch 158. The arm of switch 158 is adapted to make a circuit connection between a wire 192 and either of the wires 189 or 190 to permit one of the relays 174 and 175 to be closed at a time. Ring motor stop switch 157 is adapted to make a circuit connection between wire 192 and supply wire 185 and this switch is opened by its cam 150 in the control assembly C near the termination of a knotting operation to stop the ring motor. Wire 188 is in circuit with the fourth contacts 195 and 196 on the armatures 176 and 177 by means of a wire 197 also connected to the one end of the coil of relay 174. A wire 198 is connected between the fourth stationary contacts 199 and 200 for the relay armatures 176 and 177, respectively, and this wire leads to supply wire 186 through a manually operated ring jog switch 202 and a manually operated emergency stop switch 203.

Jog switch 202 is normally spring held in closed position on a pair of contacts 204 and also has a second pair of contacts 205, one of which is connected to supply wire 186 and the other of which is connected to wire 197. Emergency stop switch 203 is a push button switch normally spring held in closed position. When it is desired to jog the ring R slightly without running the machine through a complete cycle, the switch 202 is closed on its second pair of contacts to establish a circuit through wires 186 and 197, one of coils of relays 174 or 175 to the wire 185 through switches 158 and 157 and the wire 192. Switch 203 is in a holding circuit with wire 198 and contacts 195, 199 or 196, 200, as the case may be, and when this switch is opened the particular relay which is at that time closed will be opened to stop rotation of the ring motor.

Coils of relays 180 and 181 are connected at one end to the supply wire 185, and the other ends of these coils are connected to wires 210 and 211, respectively, leading to supply wire 186 through manually operated push button switches 212 and 213. By closing switch 212, the coil of relay 180 is energized to close the power circuit to conveyor motor 23 for causing forward movement of the conveyor, and, in the same manner, switch 213 causes reverse movement of the conveyor. Each of these switches is spring urged into open position and is held closed manually for moving the conveyor.

Wire 197 connects with one of the stationary contacts of a push button switch 214 comprising a cycle or run switch. This switch is normally spring held in open position. The other contact of this switch is connected to a wire 215 having its other end connected to one of a pair of switch contacts 216 of a relay 217. Relay 217 has a second set of switch contacts 218. With the system in rest position, the armature of relay 217 is spring held in engagement with contacts 216, and, when the cycle switch 214 is closed momentarily, a circuit through wire 197, one of the coils of relays 174 or 175 and switches 158 and 157 is established for energizing one of said coils and moving one of the armatures 176 or 177 into engagement with its stationary contacts to start the ring motor. Such closing of one of the armatures 176 or 177 establishes the holding circuit through wire 198.

One of the contacts 218 of relay 217 is connected to one end of the coil of this relay by a wire 220. The other end of this relay coil is connected to supply wire 185. The contact 218 mentioned is connected to a wire 221 leading to one of a pair of contacts 223 of a time delay relay 224, the other contact 223 being connected to supply wire 186. One end of the coil of relay 224 is connected to wire 197 and the other end is connected to supply wire 185. Relay 224 has a second pair of contacts 225, one of which is circuit connected to supply wire 186 through a wire 226 and a manually operated normally closed switch 227, and the other of which is connected to one end of a coil of a solenoid valve 230 by means of a wire 231. The other end of the coil of solenoid valve 230 is connected to supply wire 185.

Solenoid valve 230 is normally spring held in open position to connected a pipe 233 with a source of fluid pressure, and a pipe 234 to fluid discharge. When the solenoid winding is energized, these connections are reversed, making pipe 234 a pressure pipe and pipe 233 a discharge pipe. Pipe 233 is connected directly to the upper end of ring brake cylinder 76, the lower end of cylinders 41, the forward end of cylinders 30, and the rear end of cylinder 47, and pipe 234 is connected directly to the lower end of the ring brake cylinder 76, the upper end of cylinders 41 and the rear end of cylinders 30. When the coil of solenoid valve 230 is not energized, fluid pressure in pipe 233 causes the brake 75 to be applied, causes the pressure bar 38 to be retracted by the cylinders 41 and causes the bottom jaws 32 of the lower clamp 27 to be retracted. When the solenoid winding of this valve is energized, the brake 75 is released, the pressure bar 38 is lowered into engagement with the bundle, and the jaws 45 and 32 are closed on the bundle.

It is thereby apparent that when the cycle switch 214 is momentarily closed, the coil of delay relay 224 is energized to cause the solenoid valve 230 to be energized to accomplish the functions mentioned above. With the energization of the coil of either relay 174 or 175, a holding circuit is also established for the coil of relay 224, this circuit including wires 197 and 198 and one of the sets of contacts 195, 199 or 196, 200. As will be explained hereinafter, the time delay relay 224 remains closed for a time sufficient after the ring motor has been deenergized such that the ring rotatably adjusts itself by its momentum and by force applied by the wire tensioning and slack pulling mechanisms to a position for starting in the next cycle.

The other contact 218 of relay 217 is connected to a wire 238 in turn connected to one of the contacts of knot ejector limit switch 163. Switch 163 is operable by the cutter mechanism, but is shown disassociated therefrom in Figure 17 for conveniently showing the hookup therefor. The other contact of switch 163 is connected to the contact of the wire injector switch 153 by means of a wire 240. Wire 240 is also connected to one end of a coil of a time delay 242. The other end of the coil of relay 242 is connected to supply wire 185, and this supply wire is connected directly to one end of a coil of a solenoid valve 243. The other end of the coil of relay 243 is connected to one of the switch contacts or the relay 242, and, upon closing of this latter relay, the wire 245 is moved into circuit with the supply wire 186, which is connected to the other switch contact of relay 242. When either of the switches 153 or 163 is moved into circuit with the wire 240, the coil of relay 242 is energized to move the armature thereof into a closing circuit for the solenoid valve 243. When both of the switches 153 and 163 are open, as shown, wherein the solenoid valve 243 is deenergized, fluid under pressure is adapted to enter the lower end of the cylinder 97 through a pipe 247, and fluid can discharge from the other end of the cylinder through pipe 248, to extend the piston rod 96 and hold the kicker arm 93 in retracted position. If either of the two switches 153 or 163 is closed, fluid flow through the pipes 247 and 248 is reversed and the kicker arm is rotated for either injecting wire into the twister gear or ejecting a knot therefrom, depending upon the position of the ring R in its cycle. The arm 93 is operated twice in a cycle, the first time being just subsequent to the laying of a single wire in the twister gear and the second time being after the splice is formed for ejecting the splice from the twister gear.

In the rest position of the machine, the coil of relay 217 is deenergized and the armature is spring held in engagement with its contacts 216. However, when the cycle button 214 is momentarily closed and the coil of relay 224 is energized, the coil of relay 217 is also energized and its armature moves into engagement with contacts 218 and is held in such position throughout a binding operation by a holding circuit now moving through said contacts and said armature and through the wire 238 and switch 163. Thereby the starting circuit, which existed through the cycle button 214 and contacts 216, is now open and another cycle cannot be started when the machine is operating through a binding cycle. As the holding circuit for the coil of relay 217 includes the wire ejector switch 163, the coil of relay 217 will remain energized until the switch 163 is opened. In other words, the system will not be returned to a position for recycling until the kicker arm 93 has ejected the knot from the twister gear. Although another holding circuit exists for the coil of relay 217, comprising wire 221 and contacts 223, the coil of relay 224 always deenergizes before the coil of relay 217 so that the opening of switch 163 always deenergizes the coil of the latter relay.

The cutter blades 101 are operated by air cylinders 250

under the control of a solenoid valve 251. One end of the coil of solenoid valve 251 is connected to the supply wire 185, and the other end of said coil is connected to a wire 253 which leads through a switch 254 to the supply wire 186. Wire 253 has a branch line around the switch 254 which leads through a manually operated switch 255 to supply wire 186. In the deenergized condition of the solenoid valve 251, fluid is admitted under pressure to one end of the cylinder 250 by means of a pipe 257. Fluid is discharged from the opposite end of said cylinder by means of a pipe 258. When the solenoid valve is energized, such as when either switch 254 or 255 is closed, the pipe 258 becomes the supply pipe and the pipe 257 becomes the exhaust pipe, and the cutter 101 is caused to sever the wire. The switch 254, which is normally open, is located adjacent the twister gear and is closed momentarily by the quarter turn retracting movement of said gear which embeds the end of the cut wire into the bundle. Switch 255 is normally open and is closed manually when it is desired to operate the cutters at times other than in a bundle binding cycle.

In the circuit for the operation of the cylinder 140, which drives the control assembly shown in Figure 12, there is disposed a relay 262 having two sets of switch contacts 263 and 264. When the coil of this relay is deenergized, the armature of the relay engages neither set of contacts. One of the contacts 263 is connected to a wire 266 leading to control wire 186 through switch 160. Switch 160, it will be remembered, is a limit switch engageable by the drive means for the control assembly. The other contact 263 is connected to a wire 268 which is in turn connected to switches 135 and 136 and one end of the coil of relay 262. Switches 135 and 136 are normally open, and, when these switches are closed, they establish electrical connection between supply wire 186 and the wire 268. The other end of the relay coil is connected to supply wire 185. One of the contacts 264 of the relay 262 is connected to the supply wire 186 and the other contact is connected to a wire 269 connected to one end of a coil of a solenoid valve 271, the other end of the coil of this solenoid valve being connected to supply wire 185.

The fluid cylinder 140 is controlled by the solenoid valve 271 by means of a pair of pipes 273 and 274. With the solenoid valve 271 deenergized, fluid under pressure is admitted through pipe 274 to the lower end of the cylinder 140 to retract the piston rod 141 to cause the pawl 145 to override the teeth on ratchet wheel 144, and, when the solenoid valve 271 is energized, pipe 273 becomes the supply pipe to cause downward movement of the piston rod 141 for driving the ratchet wheel 144 sufficiently to cause one-eighth turn of the shaft 143. It is thereby seen that if either of the switches 135 or 136 is closed, the coil of relay 262 is energized to move the armature of this relay into engagement with the contacts 263 and 264 to cause energization of the solenoid valve 271 and to cause the closing of a holding circuit through the wire 266. When switch 160 is engaged and opened by the arm 142 in the drive means after the shaft 143 has made a 45° rotation, it opens the holding circuit to relay 262 to deenergize the coil of this relay which in turn deenergizes the coil of solenoid valve 271.

In the circuit for controlling the operation of knotter drive cylinder 86 is a relay 278 having two pairs of contacts 279 and 280. One of the contacts 279 is connected to a wire 282 and this wire leads through a switch 283 and a switch 284 to the supply wire 186. The other contact 279 is connected to a wire 286 which leads through the switch 154 to the supply wire 186. Wire 286 is also connected to one end of the coil of relay 278, the other end of coil 278 being connected to the supply wire 185. One of the contacts 280 is connected to the supply wire 286, and the other contact is connected to a wire 288 in turn connected to one end of the coil of a solenoid valve 289. Switch 284 has a second pair of contacts 290, one of which is connected to the supply wire 186, and the other of which is connected to the wire 288, and, by closing the switch 284 on its contacts 290, a circuit bypasses the switch 283 and the relay 278 to energize the solenoid valve 289. Switch 284 is a manually operated switch and may be closed to rotate the twister gear to a desired position.

Solenoid valve 289 is normally deenergized, and, in this condition, a pipe 292 leading into the front of cylinder 86 is connected with a source of fluid pressure, and a pipe 293 leading from the other end of cylinder 86 is connected to fluid discharge. Thereby, when the valve is deenergized, fluid pressure at the front of cylinder 86 urges the piston rod 88 into retracted position, and, when the valve 289 is energized as when either switch 154 is closed or switch 284 moved into engagement with contacts 290, pipe 293 becomes a fluid supply pipe and pipe 292 becomes the fluid discharge pipe for causing the piston rod 88 to be driven outwardly for rotating the ratchet wheel 92 to drive the gear train to the twister gear. In the operation of the knotter in a binding cycle, the circuit through switch 283 and contacts 279 of the relay 278 is a holding circuit for the relay, the switch 283 being a limit switch associated with the knotter drive cylinder so as to be opened upon the completion of a knotting operation.

The grippers G1 and G2 are operated by air cylinders 297 and 298 under the control of solenoid valves 300 and 301, respectively. The solenoid valves are spring biased and admit fluid pressure by means of pipes 302 and 303 to one end of the gripper cylinders 297 and 298, respectively, to hold the grippers closed when the solenoid valves are deenergized. Pipes 304 and 305 are connected to the opposite end of the cylinders 297 and 298, respectively, for exhausting fluid from the cylinders. When the solenoid valves 300 and 301 are energized, fluid under pressure is reversed and is admitted to the front portion of cylinders 297 and 298, respectively, for retracting the piston rods and causing the grippers to open, the pipes 304 and 305 then being supply pipes, and the pipes 302 and 303 being fluid discharge pipes.

One end of the coil of relays 300 and 301 is connected to wires 307 and 308, respectively, and the other end of these coils is connected to supply wire 185. Wire 307 leads to supply wire 186 through the switch 156, and the wire 308 leads to the supply wire 186 through the switch 155. Each of the two gripper circuits has a manually operated switch 310 connected between supply wire 186 and the wires 307 and 308, and this switch circuit bypasses the switches 155 and 156 so that by manually closing the switches 310, the grippers can be operated when the machine is at rest.

Operation

Figure 13 represents the approximate rest position of the ring R after a binding operation has been accomplished in a counterclockwise direction. The cam follower of the switch 158 is disposed in a depression on its cam 150 so that, upon the next binding cycle, the solenoid 174 will be energized to cause clockwise rotation of the ring motor. The wire kicker switch 153 is open because its cam follower is engageable with a projection on its cam whereby fluid is present in the bottom of the cylinder 97 to pivot the kicker 93 to a lowered and retracted position. The knotter switch 154 is open. Gripper control switches 155 and 156 are both open to cause the grippers to be held in closed position, the gripper G1 being closed on wire portion W1, and the gripper G2 being closed empty. The ring motor stop switch 157 is closed, and the ring direction switch 158 is disposed to cause energization of the coil of relay 174, as described above. The coil of solenoid valve 230 is deenergized whereupon fluid is admitted to the top of ring brake cylinder 76 and the brake shoes 75 engage the belts on the ring R. Fluid is admitted to the cylinders 34 and 41 in

the gripping mechanism for retracting the pressure bar 38 and the lower jaws 32. Upper jaws 45 are held in retracted position by the springs 56. The switch 254, controlling the operation of the cutters 101, is open wherein the solenoid valve 251 is deenergized to cause the cylinder 250 to hold the cutters in retracted position. Switches 135 and 136, which initiate the operation of the control assembly C, are open and the switch 160, which stops the control assembly C, is closed. Piston rod 141 in the control assembly cylinder 140 is thereby held in retracted position. The switch 154 in the knotter drive cylinder circuit is open wherein the piston rod 88 is also held in retracted position. Wire injector switch 153 is open and wire ejector switch 163 is closed into circuit with wire 238 wherein a holding circuit for relay 217 is adapted to be established therein once the coil of this relay is energized.

The wire is under tension by the force of spring 126 which is moved to partially stretched position in the prior binding operation and such spring force tends to rotate the ring in the opposite direction, but such reverse rotation is prevented by the frictional engagement of brake shoes 75 with the belts 64. Prior to initiating a binding cycle, the bundle is moved into a desired position in the bundle passage by means of the conveyor 20. If forward movement of the conveyor is desired, the push button switch 212 is held closed manually until the bundle is moved to the desired place in the wrapping plane. Reverse rotation of the conveyor is accomplished by manually closing push button switch 213.

A binding operation is initiated by momentarily closing cycle switch 214 which closes the circuit to the solenoid coil 174 to cause clockwise rotation of the ring R. With the closing of switch 214 the holding circuit through wire 198 holds the solenoid coil 174 in energized condition even though the switch 214 is released. With the momentary closing of switch 214, the relay 224 is energized to close the circuit to the coil of solenoid valve 230, whereby the cylinders 41 cause the pressure bar 38 to move down into engagement with the bundles, the cylinder 47 to move the jaws 45 into engagement with the bundle, and the cylinder 34 to move the jaws 32 into engagement with the bundle. At the same time the brake shoe 75 is retracted from engagement with the ring belts 64. Movement of the armature of relay 224 into engagement with the contacts 223 establishes a circuit through the wires 221 and 220 which energizes the coil of relay 217. Relay 224 remains energized throughout the time the coil of relay 174 is energized and, in addition, its opening will be delayed somewhat to prevent the immediate application of the brake ring and the retracting of the bundle gripping means.

As the ring rotates to its Figure 14 position, the wire is laid in the slot of the twister gear and outside the closed gripper G2. In this position, the cam 130 has engaged and moved past the cam follower 133 of the switch 135 whereupon the coil of relay 262 is energized to move the relay armature into engagement with both pairs of contacts 263 and 264 for energizing the coil of solenoid valve 271 which then admits fluid pressure to the upper end of cylinder 140 to drive the control assembly shaft 143. Operation of the cylinder 140 causes a 45° rotation of the shaft 143, and, at the desired limit of movement, the arm 161 of switch 160 is engaged by the arm 142 and the switch is opened. As switch 160 is in a holding circuit for the relay 262, this relay and solenoid valve 271 will be deenergized with the opening of said switch.

In this 45° rotation of the shaft 143, the cam follower 151, associated with the switch 153, has moved through a notch in its cam and comes to rest on a raised portion. Movement of the cam follower through the notch momentarily closes the wire injector 53 to energize the coil of relay 242. The coil of solenoid valve 243 is in turn energized to admit fluid to the top of cylinder 97 for pivoting the kicker arm into engagement with the wire strand which is laid in the twister gear. The relay 242 remains energized momentarily by its delay mechanism but is deenergized prior to the time that the ring lays the wire a second time in the twister gear. The kicker arm thus pushes the single wire into the twister gear and then moves downwardly out of the way prior to the time the wire is wrapped completely around the bundle. The cam follower, associated with the knotter start switch 154 remains on the same raised portion of the cam 150 throughout this first rotation of the shaft 143 and does not engage a depression at this time, whereby the knotter mechanism remains idle.

In the stopped position of the control shaft 143 after the first 45° rotation thereof, the cam follower associated with the switch 155 controlling the operation of gripper G2 seats in one of the notches in the cam, whereupon switch 155 is held closed to cause gripper G2 to open. This opening of gripper G2 occurs immediately after the wire portion has been laid outside this gripper. The cam follower associated with the switch 156 remains on the same raised portion of its cam throughout the partial rotation of said cam without engaging a notch and the switch 154 thereby remains open with the result that the gripper G1 is held closed. The cam followers for each of the switches 157 and 158 remain in the depressions of their cams in which they started and no switch operation takes place. Thereby, the ring motor 65 remains in operation and the selector switch 158 is not as yet shifted to its other position.

Referring now to Figure 15, it will be observed that the ring R has made one revolution from the position shown in Figure 14, whereupon the cam 130 has engaged the follower 133 on switch 135 for momentarily closing this switch. Closing of the switch 135 will cause the cylinder 140 to be actuated the second time for moving the control shaft 143 through another 45°. Prior to the functioning of various parts caused by the actuation of the control assembly C this second time, the ring has laid another wire portion outside of the closed gripper G1, in the twister gear, and in the gripper G2. The cam follower for switch 153 remains on a raised portion of its cam, and it does not cause actuation of the kicker arm 93 at this time. The cam follower for the switch 154 moves through a notch in the cam to momentarily close the switch 154 for energizing the coil of relay 278. The engagement of the armature of relay 278 with the auxiliary contacts 279 closes the holding circuit through the wire 282 and the wire 286, whereby the solenoid valve 289 is energized for admitting fluid under pressure to the rear portion of the cylinder 86 for driving the piston rod 88 outwardly. The knotter cylinder continues to operate until the piston rod thereof has engaged limit switch 283 which is in the holding circuit for the relay 278, the twister gear being rotated four and three-quarter revolutions.

Upon deenergization of the coil of relay 278, the fluid to the cylinder 86 will be reversed and the knotter drive mechanism will return, driving the gear train in this reverse direction until pawl 85 engages notch 84 in the gear 82 for rotating the twister gear backwards a quarter revolution. In this return movement, the knotter drive mechanism engages and closes the switch 254. Closing of switch 254 closes the circuit to the coil of solenoid valve 251 which permits fluid under pressure to flow to the rear portion of the cylinder 250 for driving the piston rod outwardly for operating the cutters 101. Retracting movement of the cutters closes the wire ejector switch 163 for causing operation of the kicker arm to eject the knot from the twister gear.

In moving to the second position of the control shaft 143, the cam follower of switch 157 has moved over one of the projections on its cam, and, in moving over this projection, the switch 157 is momentarily opened to cause the deenergization of the coil of relay 174 and stop the ring motor 65. The armature 176 is moved away from its stationary contacts and the current to the coil of relay

224 is cut off. After the ring motor 65 is deenergized, the ring continues to rotate by momentum to its point of reversal, as illustrated in Figure 16. By the time the ring reaches its point of reversal, or shortly thereafter, the splice is completed and the cutters have severed the wire portions which are clamped in the grippers, and the wire kicker has ejected the splice from the twister gear to free the bundle from the twister gear and grippers. As described above, the relay 224 has a delayed opening so that the ring brake will not be applied and the bundle gripping means will not be retracted until the wire tension has pulled the ring back through a partial revolution, the brake being applied to stop the return movement of the ring after the wire clears the bundle passage, preferably when the guide sheaves 71 are in their lowermost position which comprises the starting position for the next cycle.

As stated before, sheaves 73 are located in such position relative to the ring R and relative to each other that there is an equal amount of resistance applied to the wire in opposite directions of rotation of the ring. More specifically, it will be apparent that when the ring is performing a binding operation in a clockwise direction, Figures 13–16, and the sheaves 71 have moved past their uppermost position, the wire is engageable with both sheaves 73. In the next binding operation wherein the ring rotates in a counterclockwise direction and the sheaves 71 have moved past said uppermost position, the wire is engageable with only one of the sheaves. However, the location of the sheaves 73 is such that in either direction of rotation, the wire is subjected to an equal wrapping arc whether it engages the one sheave or both of them, these wrapping arcs being equal, of course, only in the positions of the ring wherein the sheaves 71 have moved substantially past their uppermost position. Thereby, as the ring approaches the point of reversal, the bending friction on the wire is the same in either direction of rotation. With this equal resistance being imparted to the ring, the momentum thereof will carry it substantially the same degree of rotation in each direction of rotation after the motor 65 has been deenergized.

In the second position of the control shaft 143, the cam follower of switch 153 is moved into engagement with the raised portion of its cam to move the selector switch 158 into circuit with the coil of relay 175 which is operative to cause rotation of the ring motor in the opposite direction when the cycle switch 214 is again closed.

The potential energy stored in the spring 126 assists in accelerating the ring in its next cycle to remove a starting load from the ring motor 65. Although the slide 116 moves downwardly somewhat as the ring rotates from its point of reversal to its stopped position between cycles, the potential energy stored in the spring will, nevertheless, be sufficient to impart a rotative force to the ring.

After the completion of a cycle, the bundle is adjusted relative to the wrapping plane of the wire if a second binding is desired by means of the conveyor switches 212 or 213. To start the next cycle, the cycle switch 214 is closed momentarily, and, as the switch 158 has been shifted at the completion of the last binding cycle, the ring motor will be reversed to rotate the ring in a counterclockwise direction. In this cycle, the cam 131 is operative with the switch 136 for actuating the control assembly C for the shaft 143. In this direction of rotation, the gripper G2 holds the primary end of the wire for the next cycle, and the gripper G1 operates in the same manner as the gripper G2 did in the clockwise cycle.

The electrical system for the present machine embodies switches mentioned hereinbefore which may be manually manipulated for causing the functioning or non-functioning of parts in a binding operation or when the machine is at rest. The ring jog switch 202 may be closed on its contacts 205 when the machine is at rest for energizing the coil of either the relay 174 or 175, depending upon the position of ring direction switch 158, to cause the energization of ring motor 65 for adjusting the ring around to a wire re-thread position. Switch 203 may be opened when the machine is operating in a binding cycle for stopping the machine in an emergency. Switch 227 is in the circuit to the coil of solenoid valve 230, and, by turning the switch to its off position, the bundle clamping means is rendered inoperative and the ring brake remains on. The principal purpose of this switch is to prevent the clamping means from operating and the ring brake from retracting when the ring is jogged by means of switch 202. With the brake on, the ring may be jogged but will not coast after the jog switch is released and an accurate positioning for re-thread is obtainable.

The switch 255 may be closed to operate the cutters 100 when desired. Knotter jog switch 284 may be closed on its contacts 290 for manually actuating the knotter drive. Finally, the two manually operated switches 310 may be utilized for opening the grippers in a re-threading operation.

Although the present machine may assume relatively large sizes, the control features thereof will operate it smoothly at a fast rate. The switches 135 and 136, when only momentarily engaged by their respective cams 130 and 131 on the ring R, close a holding circuit to the relay 262 which then permits the control assembly C to properly operate through its cycle. Therefore, even though the wire laying ring R has a fast peripheral speed, the control assembly C will operate properly. Furthermore, the present machine is especially applicable for using heavier wire than heretofore used, in that means are provided to inject the wire into the twister gear and to eject a knot therefrom.

Having now described my invention and in what manner the same may be used, what I claim as new and desire to protect by Letters Patent is:

1. A binding machine comprising a reversible rotatable wire laying member, switch actuating means on said member, a pair of switches engageable by said actuating means upon rotation of said wire laying member in a binding operation, fluid pressure operated drive means controlled by said switches, a control assembly movable by said drive means, and switches actuated by said control assembly to automatically operate said machine in a binding operation.

2. A binding machine comprising a reversible rotatable wire laying member, switch actuating means on said member, a pair of switches engageable by said actuating means upon rotation of said wire laying member in a binding operation, fluid pressure operated drive means controlled by said switches, a control assembly movable by said drive means to automatically operate said machine in a binding operation, and limit switch means actuated by said drive means for stopping the operation thereof to place said control assembly in predetermined control positions.

3. A binding machine comprising a reversible rotatably mounted wire laying ring, actuating means on said ring, a pair of switches engageable by said actuating means upon rotation of said wire laying ring in a binding operation, a rotatable control assembly for automatically controlling the operation of said machine in a binding operation, and fluid pressure operated drive means having a ratchet connection with said control assembly for rotating said control assembly in one direction, the operation of said drive means being controlled by said switches.

4. A binding machine comprising a movable band laying member, a band splicing mechanism and band grippers all controlled by a plurality of switches, a cam shaft arranged to actuate said switches, means operated by a source of power independent of said member to rotate said shaft through a predetermined angle, and a

switch actuated by said member for energizing said means from said independent source of power.

5. A binding machine comprising a band laying member, a band splicing mechanism and band grippers all controlled by a plurality of switches, a cam shaft arranged to actuate said switches, a cylinder containing a piston having a ratchet connection with said cam shaft to rotate the shaft through a predetermined angle in each stroke, a fluid pressure supply for said cylinder controlled by a solenoid operated valve, and a switch in circuit with said solenoid arranged for actuation by said band laying member.

6. A binding machine comprising a band laying member having reversible movement, a band splicing mechanism and band grippers all controlled by a plurality of switches, a multiple cam operator for said switches, incremental moving means for said operator actuated by a power source independent of said member, a control circuit for initiating operation of said moving means, a switch for energizing said control circuit actuated by said member in one direction of band laying movement, and a switch for energizing said control circuit actuated by said member in the opposite direction of band laying movement.

7. A binding machine comprising a band laying member having reversible movement, a band splicing mechanism and band grippers all controlled by a plurality of switches, a single operator for all of said switches having a source of power independent of said member, and switch means operable by said member in opposite directions of band laying movement for energizing said operator from said independent source of power for incremental movement.

8. A binding machine comprising a slotted twister gear, a wire laying member for laying wire in said twister gear and about a bundle adjacent said twister gear, means for driving said twister gear for forming a knot in said wire, a wire kicker adjacent said twister gear movable between an upper wire engaging position and a lower retracted position, means for retaining said wire in said twister gear movable between a position to engage wire in said twister gear and a retracted position, and a reciprocating fluid pressure motor connected with said kicker and retaining means for movements thereof in unison in opposite directions of movement of said motor.

9. A binding machine comprising a slotted twister gear, a wire laying member for laying wire in said twister gear and about a bundle adjacent said twister gear, means for driving said twister gear for forming a knot in said wire, a wire kicker adjacent said twister gear, means for driving said kicker between a wire engaging position and a retracted position, a sliding wire retainer for retaining said wire in said twister gear, rack teeth on said retainer, and a gear on said kicker meshed with said rack teeth.

10. A binding machine comprising a twister gear, a rotary wire laying ring for laying a wire around a bundle and twice in said twister gear, means for driving said twister gear to form a knot in said wire, a movable cutter operable to sever wire portions extending out of said twister gear after a knot has been formed, a wire kicker adjacent said twister gear, means actuated by said wire laying ring after the wire has been laid once in the twister gear for causing operation of said kicker to push said one wire in said gear, and means actuated by said cutter after the wire has been laid twice in said twister gear and a knot formed therein to operate said kicker to remove said knot from said twister gear.

11. A binding machine comprising an upright frame member, a reversible wire laying ring rotatably mounted on said frame member, a plurality of wire sheaves on said ring for supporting wire therearound, wire supply means, and a pair of spaced guide sheaves on said frame member for receiving said wire and disposed between said supply means and said ring, one of said guide sheaves being offset closer to said ring than the other so that said guide sheaves present substantially equal total lengths of guide surfaces thereof to the wire in extreme positions of the ring to apply approximately the same bending stress to said wire in opposite directions of rotation of the ring.

12. In a wire binding machine having a slotted twister gear, a gear train for driving said twister gear, a cylinder having a piston rod for driving said gear train, a ratchet connection between said piston rod and one of said gears arranged to produce a partial rotation of said one gear in a driving stroke of said piston and a lesser reverse rotation on the return stroke, the gear ratios in said train being such that a particular intermediate gear rotates through a small angle in excess of one revolution in each driving stroke of said piston, and a pawl engaging said intermediate gear to limit said reverse rotation thereof to the amount of said angle.

13. In a binding machine having a reversible rotatable wire laying ring, wire splicing mechanism, wire gripping mechanism and wire cutting mechanism; a control assembly driven by means independent of said ring, a plurality of switches actuated by said control assembly controlling the operations of said mechanisms, and a pair of switches actuated by said ring in opposite directions of rotation for energizing said drive means for said control assembly.

14. In a binding machine having a reversible rotatable wire laying ring, wire splicing mechanism, wire gripping mechanism and wire cutting mechanism; individual motor means for operating each of said mechanisms, a control assembly driven by individual motor means, a plurality of switches actuated by said control assembly for energizing said motor means for said mechanisms, and a pair of switches actuated by said ring in opposite directions of rotation for energizing said motor means for said control assembly.

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