April 12, 1955 A. E. CRANSTON, SR 2,705,914

QUICK REVERSIBLE WIRE BINDING MACHINE

Filed March 26, 1951 9 Sheets-Sheet 1

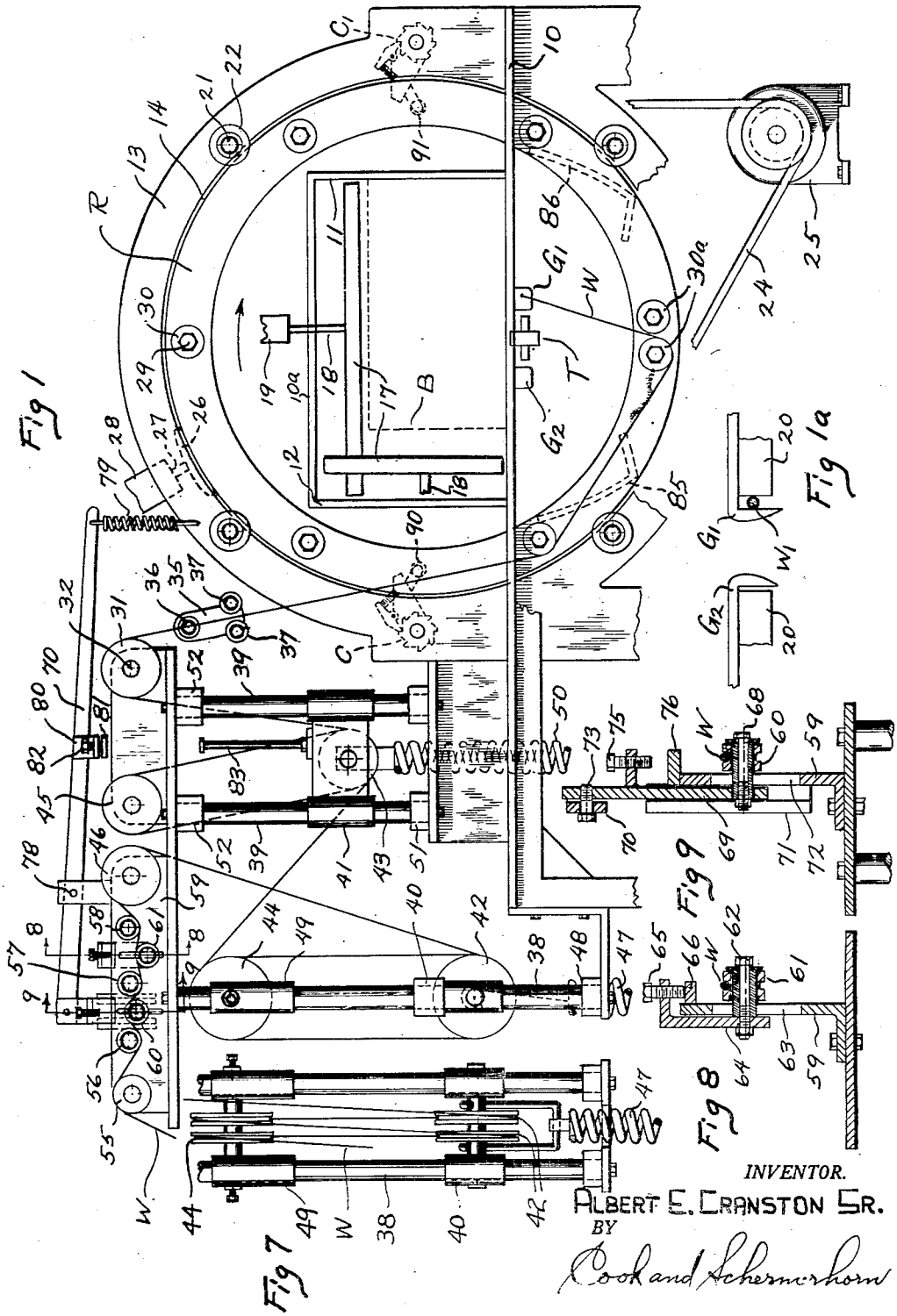


Fig 1

Fig 1a

Fig 9

Fig 8

Fig 7

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QUICK REVERSIBLE WIRE BINDING MACHINE

Filed March 26, 1951 9 Sheets-Sheet 2

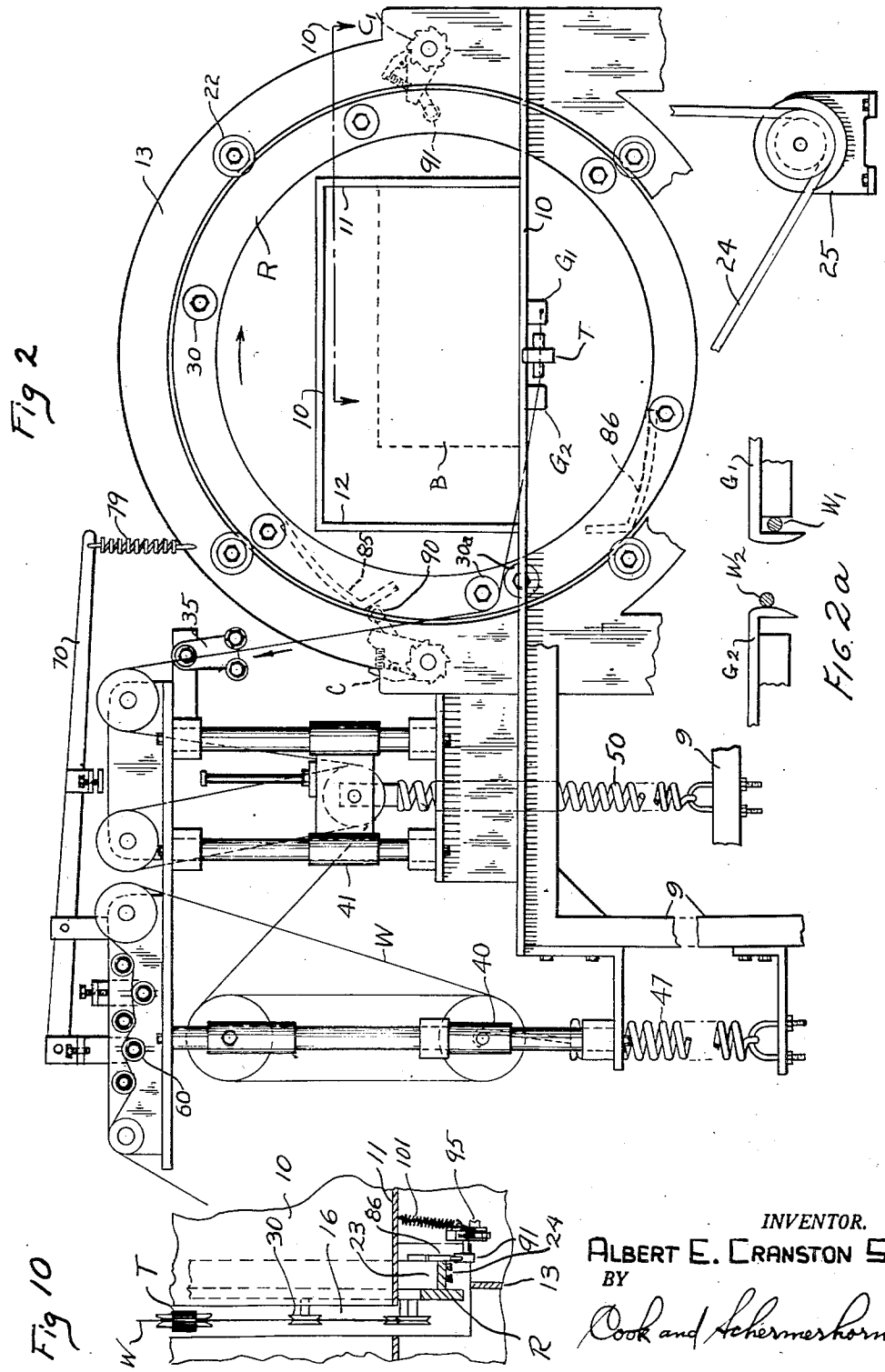


FIG. 2a

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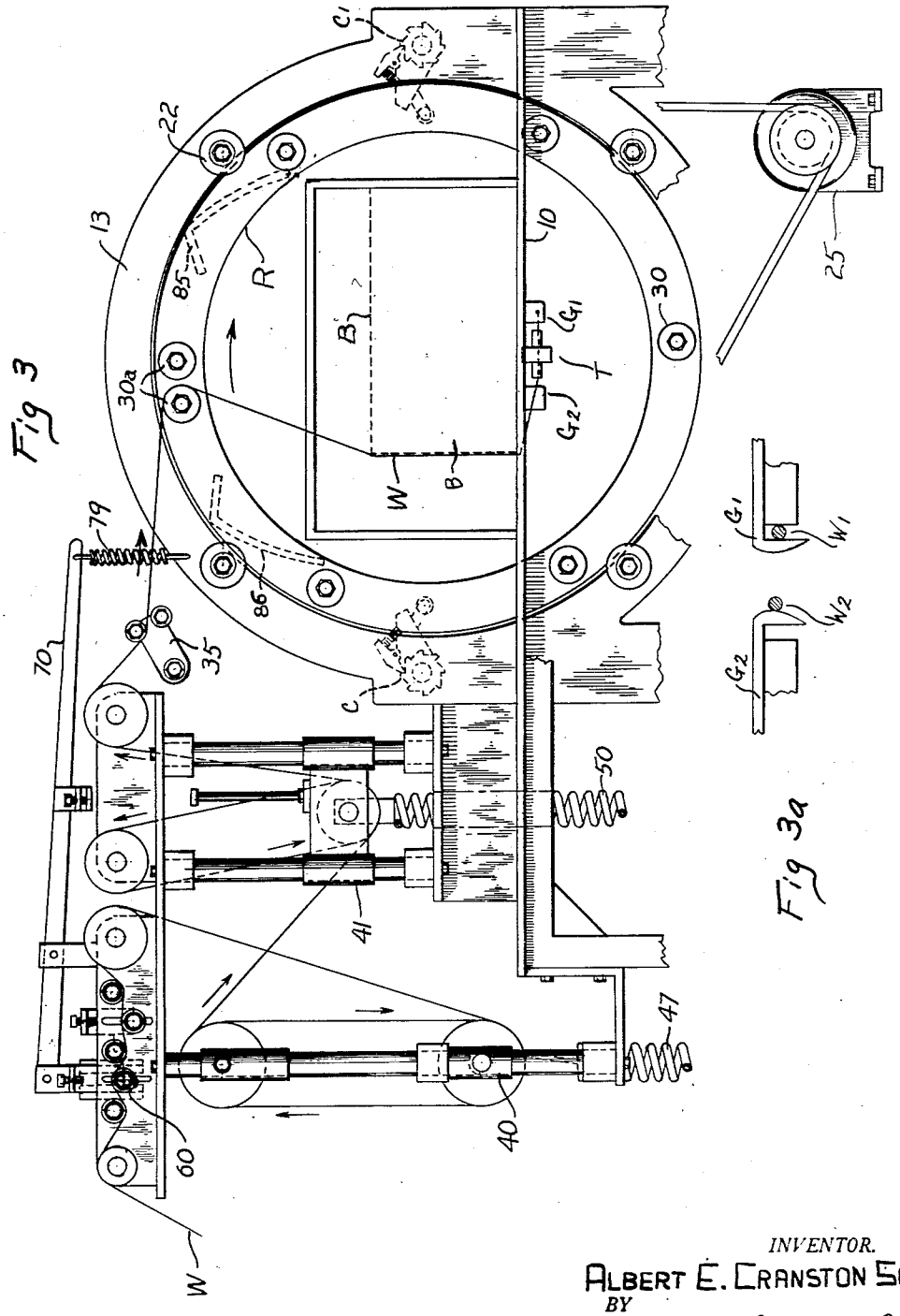


Fig 3

Fig 3a

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QUICK REVERSIBLE WIRE BINDING MACHINE

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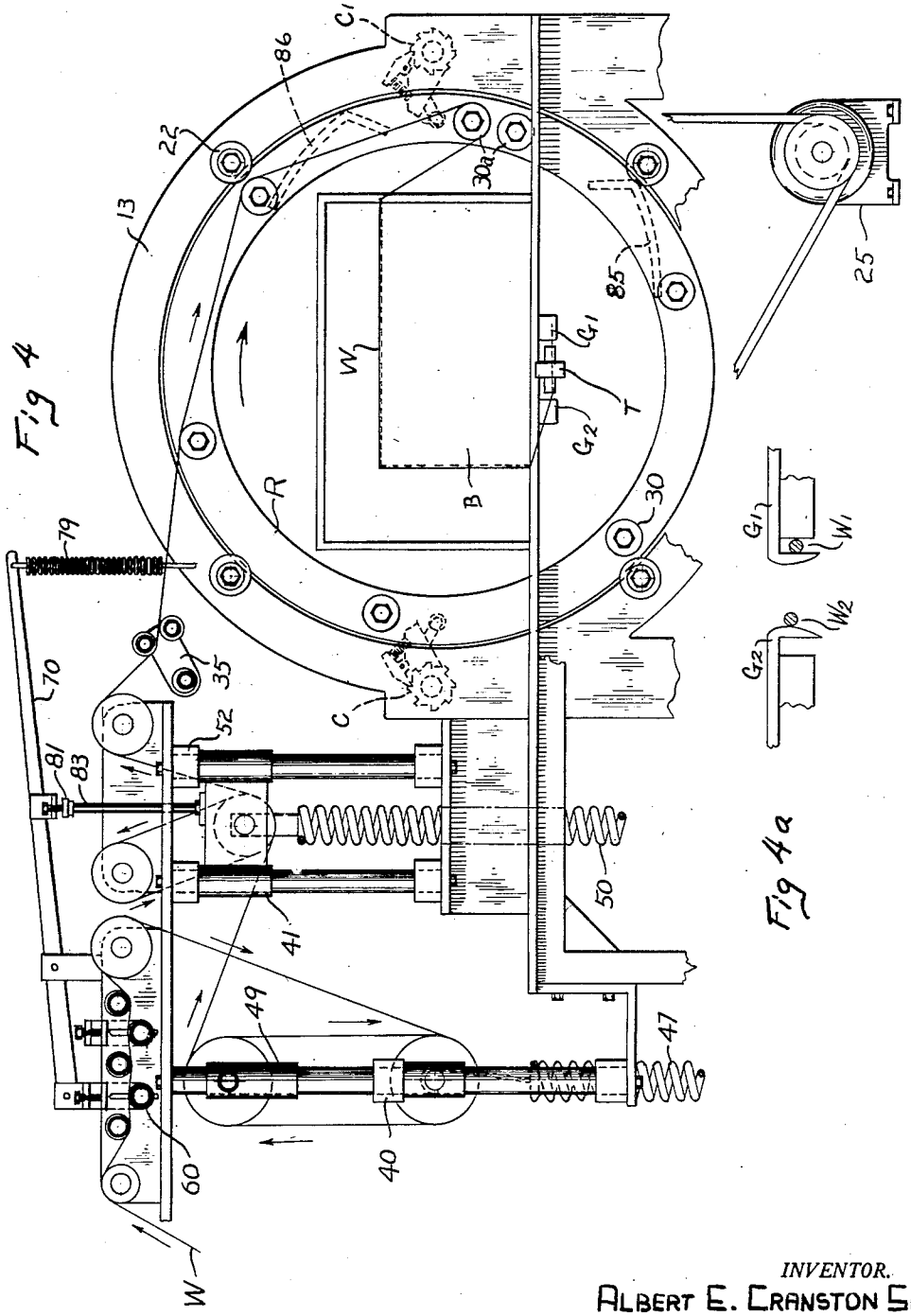


Fig 4

Fig 4a

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QUICK REVERSIBLE WIRE BINDING MACHINE

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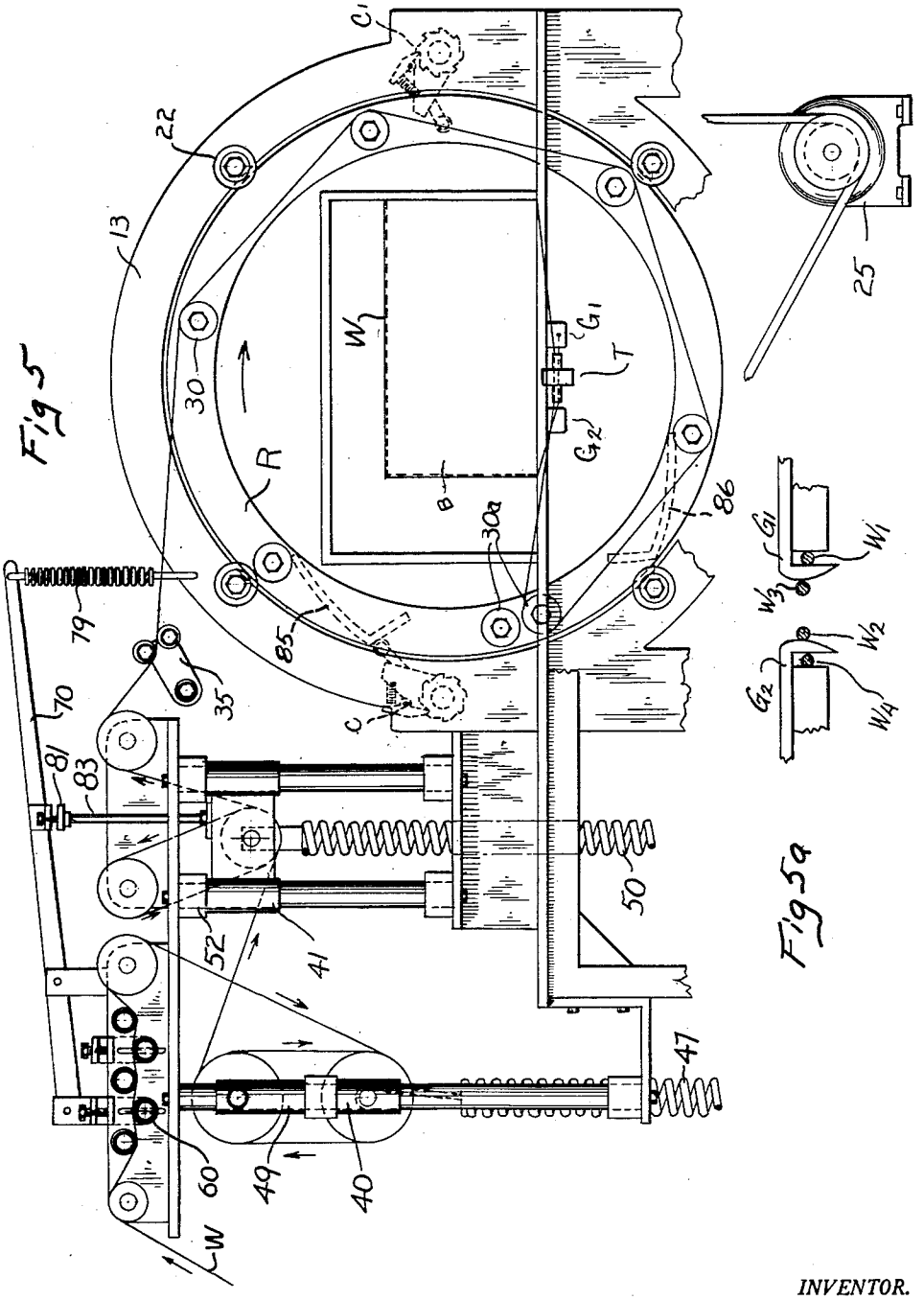


Fig 5

Fig 5a

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QUICK REVERSIBLE WIRE BINDING MACHINE

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Fig 6

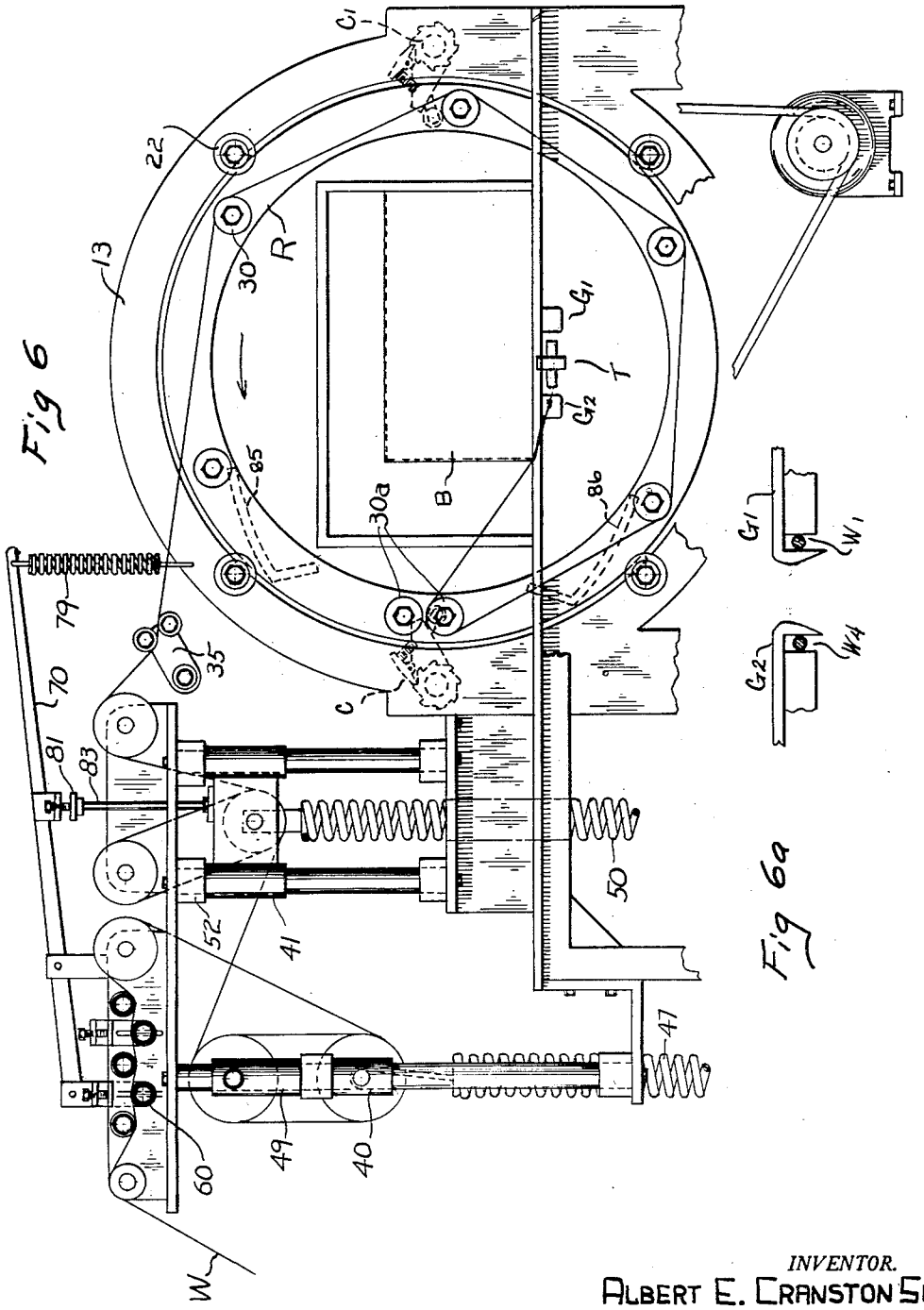


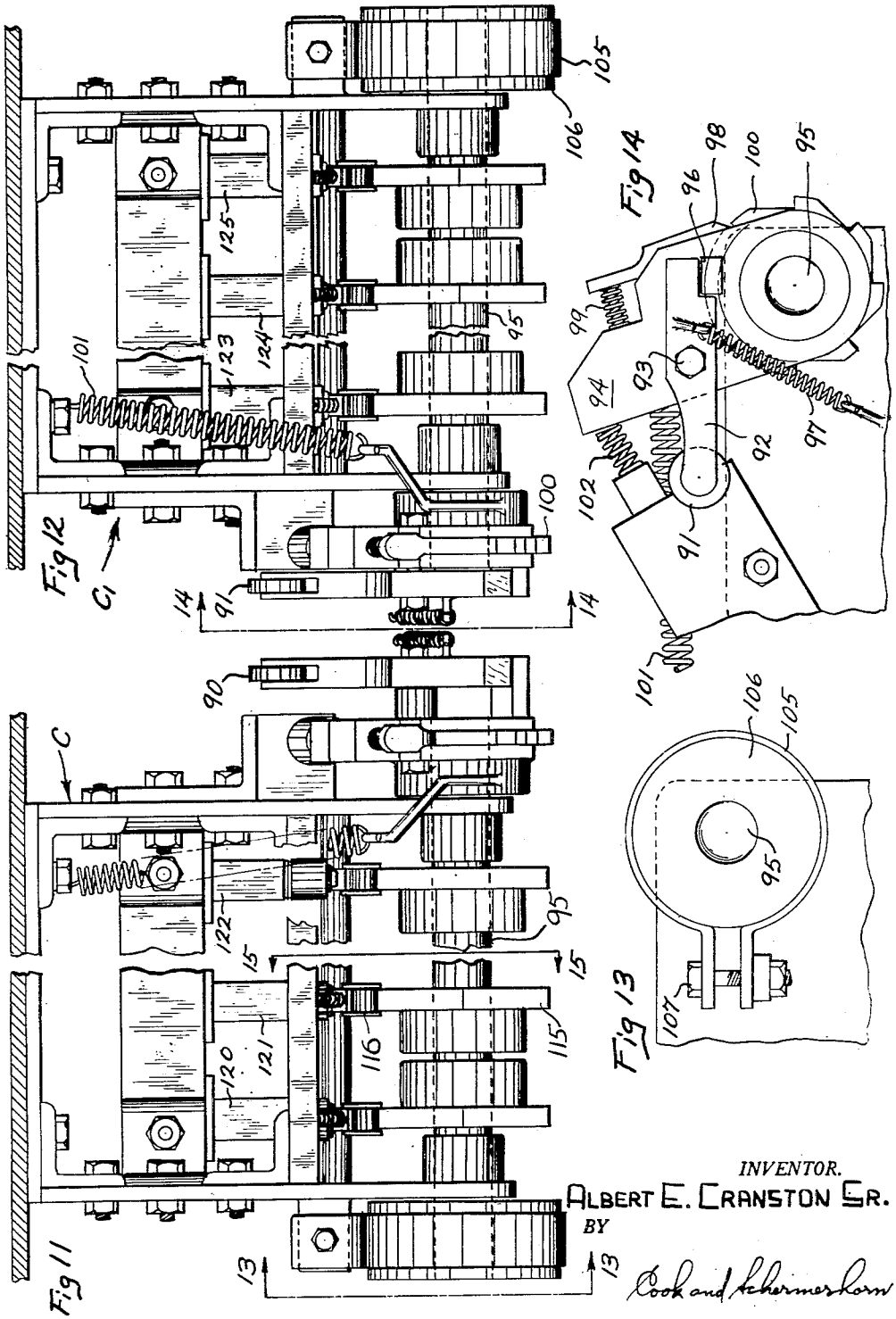
Fig 6a

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QUICK REVERSIBLE WIRE BINDING MACHINE

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QUICK REVERSIBLE WIRE BINDING MACHINE

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Fig 17a

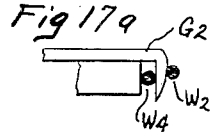


Fig 17b

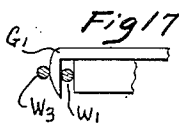


Fig 17

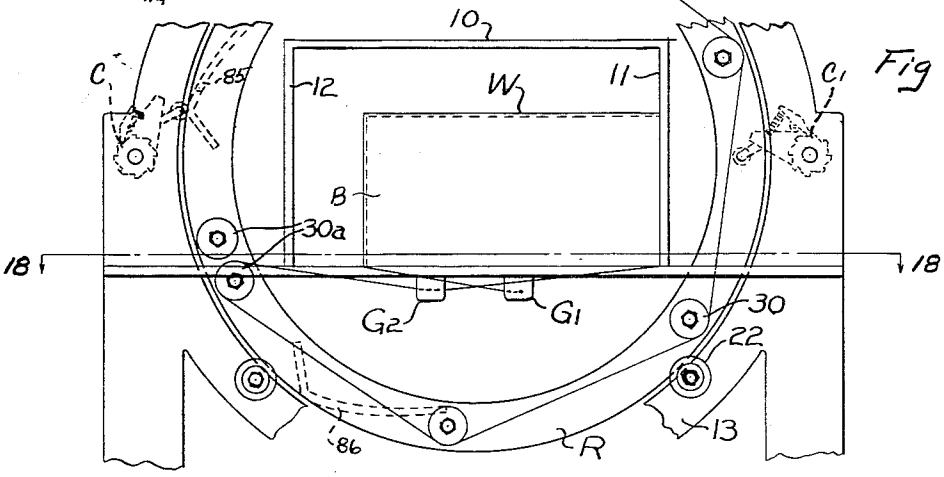


Fig 18

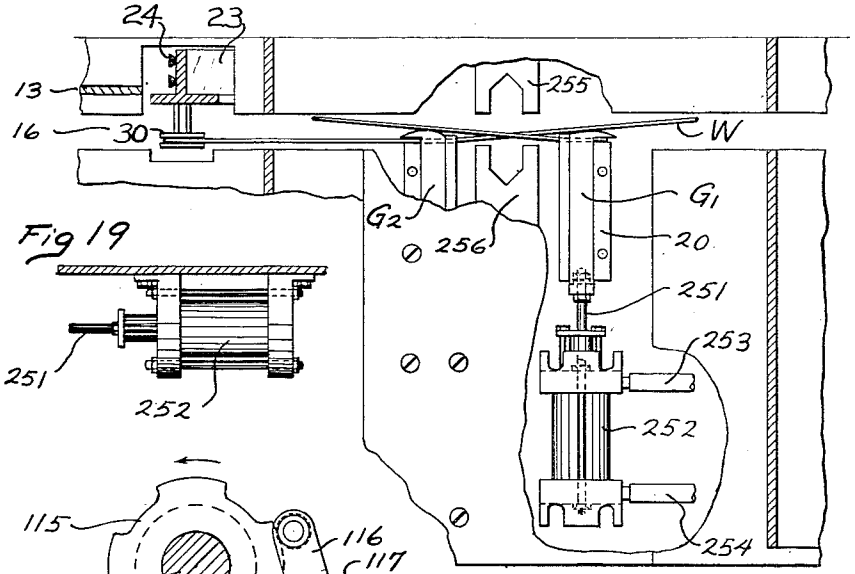


Fig 19

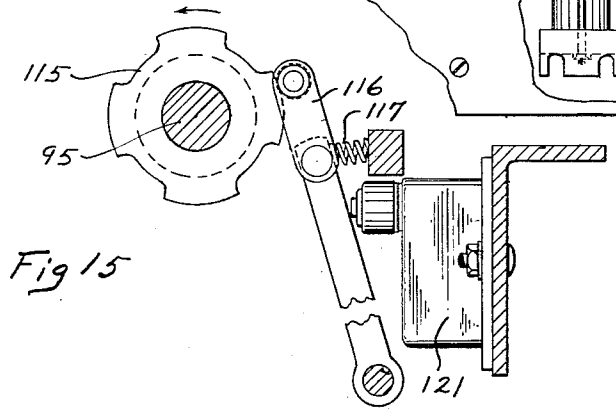


Fig 15

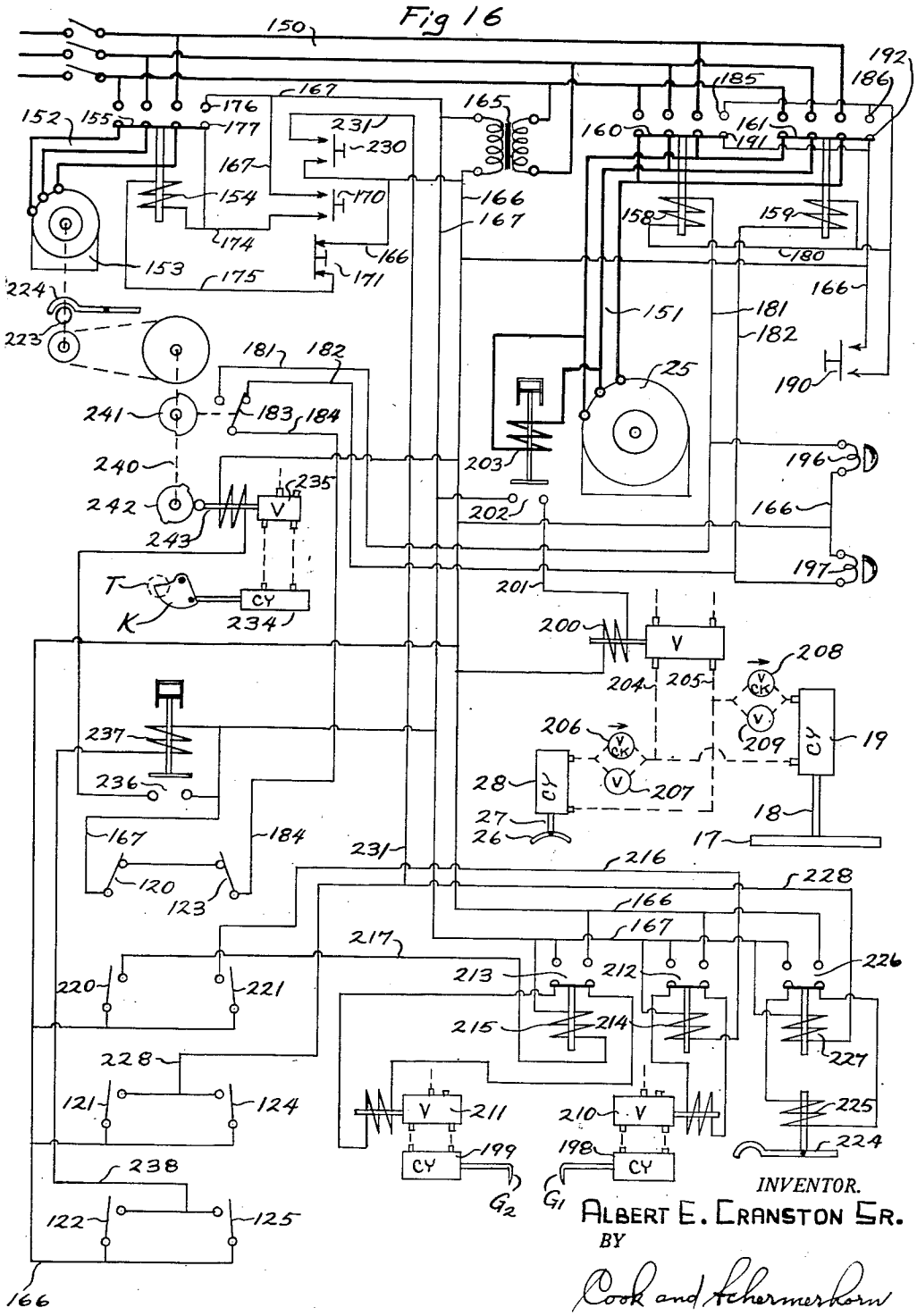
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April 12, 1955 A. E. CRANSTON, SR 2,705,914

QUICK REVERSIBLE WIRE BINDING MACHINE

Filed March 26, 1951 9 Sheets-Sheet 9

Fig 16



United States Patent Office 2,705,914 Patented Apr. 12, 1955

2,705,914

QUICK REVERSIBLE WIRE BINDING MACHINE

Albert E. Cranston, Sr., Oak Grove, Oreg., assignor to Cranston Steel Strapping Co., Oak Grove, Oreg., a corporation of Oregon

Application March 26, 1951, Serial No. 217,622

41 Claims. (Cl. 100—28)

This invention relates to a binding machine for securing a wire band about a bundle or other object.

The invention pertains to the type of binding machine having a rotary carrier, usually in the form of a band laying ring, encircling a bundle passage extending through the machine. The carrier is motor driven to lay the band under tension about the bundle, and rotates in opposite directions in successive binding operations. This type of machine is known as a reversible binding machine to distinguish from unidirectional machines in which the band is always laid about the bundle in the same direction in successive binding operations. Wire binding machines are further equipped with some form of securing means, such as a knotter mechanism, for forming a twisted wire splice to unite overlapped portions of the wire after it has been laid about the bundle. Gripping devices are provided to hold the wire while it is being laid about the bundle and during the formation of the splice, and suitable cutters are actuated at the completion of the splicing operation to cut the wires between the ends of the splice and the grippers to free the bundle from the machine.

In most prior machines of this type, the band laying ring is stopped immediately in the position where it completes each band laying operation, and locked rigidly in that position. In some conventional machines, the friction of the machinery stops the band laying ring and holds it in a fixed terminal position immediately at the completion of a binding operation as soon as the application of prime mover is interrupted, and in other machines brake means are applied quickly for the same specific purpose. In conventional reversible machines the band laying ring cannot be started into motion for a subsequent binding operation except by the application of reverse torque by the prime mover which drives the ring. The prime mover then has to start the band laying ring from standstill at a disadvantageous position at the beginning of each new binding operation, requiring high starting torque. The output of the conventional machine is necessarily limited by reason of the time lost between the completion of one operation and the starting of the next operation, and the prime mover is subjected to excessive power demands. In an electric motor drive, the motor consequently is required to operate for a considerable part of its total running time under high torque starting conditions, drawing a heavy current from the line. Hence, in continuous fast operation of the binding machine, the motor will overheat from the excessive starting current if it is of a capacity merely to carry the normal running load. To avoid such overheating, it has become the practice to use larger motors which then operate less efficiently in the rest of the binding cycle, and consume more kilowatt hours of electricity for a given number of binding operations.

The general object of the present invention is, therefore, to provide an improved reversible binding machine which will perform a greater number of binding operations in a given time, and to provide an electric motor driven binding machine which is more economical to manufacture and operate than conventional machines.

An important object is to provide a binding machine which may be kept in continuous oscillation for capacity operation when maximum output is desired, and to provide energy storing means instead of energy dissipating means for stopping the motion of the band laying ring. A further object is to utilize such stored energy for reversing the ring prior to reenergization of the prime mover for applying reverse torque, so that the prime mover is not called upon to apply starting torque to the band laying ring at the beginning of each cycle.

More specific objects are to provide means for utilizing the wire tension for stopping and reversing the band laying ring, to provide means to vary the resistance applied to the wire in each binding cycle, and to provide means for utilizing the slack take-up device of the binding machine for storing mechanical energy to reverse the band laying ring before power is reapplied to the ring driving motor.

Additional objects are to provide improved ring operated controls, and to provide an improved electrical system for initiating the various functions of the machine at the proper times in each cycle of operation.

These and other objects of the invention, as well as the form and construction of certain features of the machine, will be better understood with reference to the description in the following specification of preferred embodiments of the invention illustrated in the accompanying drawings. Various changes may be made, however, in the construction and arrangement of parts, without departing from the spirit of the invention.

In the present machine, the rotary carrier comprises a band laying ring which is belt driven from a reversible electric motor. Both the band laying ring and the motor are freely reversible by the wire tension exerted by a slack pulling mechanism after the motor is deenergized at the end of a cycle of operation. The motor is deenergized in each cycle as soon as the wire has been laid the second time in the twister gear of the knotter mechanism and secured by the second gripper to receive the wire. Then, while the knotter mechanism or other splice forming device is securing overlapped portions of the wire together, the momentum of the band laying ring is arrested by the wire tension imposed by the resistance device through which the wire is drawn to tension it as it is laid about the bundle. The slack pulling mechanism, which is interposed between the resistance device and the band laying ring, includes strong springs which are stretched to the limit of their movement by the time the band laying ring comes to rest. There being nothing to hold the band laying ring and driving motor in its position of reversal, the springs of the slack pulling mechanism then pull back a considerable length of wire from the band laying ring, causing it to reverse quickly before the motor is reenergized for reverse rotation. The manual starting switch need not be closed until the ring has been accelerated in the reverse direction by the action of the slack pulling springs. Thus, in fast operation, the motor is never required to start under load, from rest, after the first cycle. This novel mode of operation is facilitated and enhanced by novel variable resistance means in the resistance device to vary the degree of restraint imposed upon the wire at different times in the cycle. The restraint imposed on the wire may thereby be increased to prevent slippage through the resistance device while the slack pulling mechanism is pulling back wire to reverse the ring, without maintaining excessive wire tension while the band is being laid about the bundle, which would overload the motor and might break the wire.

While the present machine is intended to be supplied with round wire, it will be appreciated that certain features of the invention are applicable to machines using other types of banding material.

Figures 1, 2, 3, 4, 5 and 6 are fragmentary front elevation views of a preferred embodiment of the present machine, showing in sequence the different positions assumed by the parts in the course of a single binding operation;

Figures 1*a*, 2*a*, 3*a*, 4*a*, 5*a* and 6*a* are fragmentary views showing the open and closed positions of the two wire grippers at the different stages of a binding operation illustrated in Figures 1 to 6, respectively;

Figure 7 is a side elevation view of a portion of the slack pulling mechanism;

Figure 8 is a sectional view taken on the line 8—8 of Figure 1, showing the manual resistance adjustment;

Figure 9 is a sectional view taken on the line 9—9

of Figure 1, showing the variable resistance device which is controlled by the machine;

Figure 10 is a view taken on line **10—10** of Figure 2 but showing the position of the wire in the next cycle of operation;

Figure 11 is an enlarged top plan view of the cam operated switching mechanism on the left side of the machine;

Figure 12 is an enlarged top plan view of the cam operated switching mechanism on the right side of the machine;

Figure 13 is a view taken on the line **13—13** of Figure 11, showing the brake on the switch cam shaft;

Figure 14 is a view taken on the line **14—14** of Figure **12**, showing the cam follower on the switch cam shaft which is actuated by the ring cam;

Figure 15 is a view taken on the line **15—15** of Figure **11**, showing one of the switches and its operating cam;

Figure 16 is a wiring diagram for the machine illustrated in Figures 1 to 15;

Figure 17 is a fragmentary front elevation view of a binding machine with the wire splicing mechanism omitted;

Figures 17*a* and 17*b* are fragmentary views of the two wire grippers in the machine illustrated in Figure 17;

Figure 18 is a view taken on the line **18—18** of Figure 17, showing the use of welding electrodes in the wire joining mechanism; and

Figure 19 is a view showing the fluid pressure cylinder for one of the grippers illustrated in Figure 18.

Figures 1, 2, 3, 4, 5 and 6 are a sequence of fragmentary front elevation views showing the band laying ring, slack pulling mechanism and resistance device in different positions during one cycle of operation of the machine. Parts which are not necessary to an understanding of the principal features of the invention are omitted, such as the knotter drive mechanism, wire cutters, gripper operating mechanism, etc. Also, certain parts appearing in these figures are not shown in detail, such as the grippers and twister gear, because their functions are understood in the art, and the specific forms of these parts are not material to the principal features of the invention.

Rotary carrier

A bundle passage is defined in the machine by a horizontal bottom plate **10**, top plate **10***a* and a pair of spaced parallel vertical guide plates **11** and **12** mounted on the frame **9** as shown in Figures 1 and 2. Perpendicular to these three plates is a front vertical plate **13** having a large circular opening **14** for the band laying ring or carrier R which encircles the bundle passage. The bottom plate **10** and vertical guide plates **11** and **12** are slotted at **16** a short distance in front of and behind the wrapping plane, which is the vertical plane in which the band is laid about the bundle in a binding operation. The band is laid about the bundle by a rotary carrier comprising the ring R.

The arrangement is such that when a bundle B is placed on the bottom plate **10** in the bundle passageway between the vertical guide plates **11** and **12**, and the machine put into operation, the carrier R rotates about the bundle to lay a band, such as the wire strand W, under tension about the bundle in the wrapping plane. With some types of bundles, it is necessary to place only one such binding on each bundle, while on other bundles it may be desirable to secure a number of bindings. The bundle passageway comprising the plates **10**, **11** and **12** is designed to receive such bundles one after another from a conveyor not shown to have one or more bindings placed on each bundle in rapid succession as the bundles are pushed through the bundle passageway in a direction perpendicular to the plane of the view in Figure 1. In accordance with the general objects of the invention, the present machine is designed to perform successive binding operations more rapidly than conventional machines, so that more binding operations can be completed, and, hence, more bundles bound, in a given time.

During each binding operation, the bundle is held against bottom plate **10** and side plate **11** by a pair of pressure bars **17**. The pressure bars are extended and retracted by piston rods **18** in air cylinders **19** which are controlled by a solenoid valve in a manner well understood in the art. This solenoid valve will be identified and its operation described in connection with the electrical system of the machine.

The splicing, or knotter, mechanism is represented by a slotted twister gear T which is journaled in suitable bearings just beneath the level of the top surface of the bottom plate **10** to place the axis of the gear in the opening **16** precisely in the wrapping plane, as shown in Figure **10**. At opposite ends of the twister gear T are a pair of movable gripper jaws G_1 and G_2, shown in Figures 1 to 6, but omitted in Figure 10. Associated with the movable jaws are stationary jaws **20** disposed in the opening **16** closely adjacent the wrapping plane. The movable jaws may be extended through the wrapping plane by piston rods in air cylinders to intercept and engage the wire strand W as it is being laid around the underside of the bundle B. The arrangement is such that when the movable jaw of a gripper is extended before the wire is laid around the underside of the bundle and then retracted after the wire is laid, it will engage a portion of the wire and clamp it against its associated stationary gripper element to anchor that part of the wire. On the other hand, when the movable gripper jaw is retracted at the time the wire strand is laid around the bottom of the bundle, the wire is not intercepted and not engaged by that gripper.

Thus, by coordinating the action of the two grippers with movements of the carrier R, only 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 form a twisted wire splice in a manner well understood in the art. After the splice is formed by the twister gear T, it is to be understood that the wire is cut between the ends of the twister gear and the grippers to release the bundle, but the cutters are not shown as they do not necessarily affect the operation of the parts involved in the present invention.

Adjacent the circular opening **14** the plate **13** is provided with a series of studs **21** equipped with grooved rollers **22** to support the carrier R for rotation concentric with the opening. As shown in Figure 10, the carrier ring R has a rear flange **23** to receive belts **24** from a reversible driving motor **25**. On the front side of the carrier are a series of studs **29** for mounting wire guiding sheaves **30** at regular intervals around the carrier. Two guide sheaves **30***a* are placed quite close together to lead the wire from the carrier R inwardly toward the bundle in the different positions of the carrier.

The guide sheaves **30***a* thereby determine the exact position of the wrapping plane in the opening **16**. In the rest position of the parts shown in Figure 1, one end of the wire W is anchored in the gripper G_1 and the wire is trained between the guide sheaves **30***a* and over a number of the sheaves **30** to a sheave **31** on a stationary supporting stud **32**. The numeral **35** designates a wire guide pivotally mounted on a stud **36** on the main frame of the machine. The wire is trained between a pair of closely spaced rollers **37** mounted on the free end of the arm **35**.

A brake shoe **26** is mounted on a piston rod **27** in an air cylinder **28** to engage the back sides of belts **24**. This brake shoe is controlled in a novel manner, as will presently be described, so as not to interfere with the quick reversal of the ring in fast operation.

Slack pulling mechanism

A plurality of slack pulling sheaves are mounted for movement on pairs of vertical guides **38** and **39** on the frame of the machine. Slides **40** and **41** are mounted for vertical sliding movement on the respective pairs of guides, the slide **40** carrying a pair of pulley sheaves **42**, and slide **41** carrying a similar pair of pulley sheaves **43**. A pair of sheaves **44** are mounted on a stationary horizontal shaft at the top of the guides **38**, and additional sheaves **45** and **46** are mounted in stationary positions at the top of the frame, as shown.

The incoming wire from sheave **46** is trained first around one of the lower sheaves **42**, then around one of the upper sheaves **44**, back to the second lower sheave **42**, and thence to the second upper sheave **44**. From there the wire is trained around the first bottom sheave **43**, thence to sheave **45**, and back to the second bottom sheave **43**, from whence it is delivered to the guide sheave **31**.

A tension spring **47** having its lower end anchored to the frame is connected at its upper end to the carrier **40**, tending to pull the carrier down against the stops **48**.

The upward movement of carrier **40** is limited by the upper stops **49**. A similar spring **50**, having its lower end connected to the frame of the machine, is connected at its upper end to the carrier **41** and tends to draw this carrier down against the bottom stops **51**. The upward movement of carrier **41** is limited by the upper stops **52**.

Variable resistance device

The wire is drawn into the machine over sheave **55** from its source of supply where it is loosely disposed in a coil, which, preferably, lies flat upon the floor so that it may be freely uncoiled at different rates of speed without kinking or overrunning. Between the two sheaves **55** and **46** the wire is trained in reverse bends through a series of small rollers which provide pulling resistance for laying the wire under tension about the bundle. The resistance device comprises three top rollers **56**, **57** and **58**, mounted on stationary studs in a plate **59** on the frame of the machine, and two bottom rollers **60** and **61** mounted on movable studs.

As shown in Figure 8, the roller **61** is mounted on a stud **62** which extends loosely through a vertical slot **63** in the plate **59**, and is connected with a sliding bracket **64**. Bracket **64** is threaded to receive an adjusting screw **65** which bears at its lower end against an abutment **66** on the plate **59**. By turning the screw **65**, the roller **61** may be raised or lowered relative to the adjacent stationary rollers **57** and **58** to increase or decrease the bending of the wire at this point. This is in the nature of a permanent adjustment which need not be altered after the machine is set up to operate with a particular kind and size of wire.

The other bottom roller **60** is mounted on a stud **68** in a vertical slide **69** for up and down movement in each binding cycle by a long lever arm **70**. Plate **69** slides in a vertical guide **71** with the stud **68** projecting through vertical slot **72** in the plate **59**. Screw **73** provides pivotal connection between the arm **70** and the upper end of plate **69**. The screw **73** is fixedly secured in plate **69** and extends through a horizontally elongated opening in the arm **70** so that the arcuate movement of the arm will not bind the pivotal connection. The downward movement of roller **60** is limited by an adjusting screw **75** on the plate **69** which is arranged to bear against a stop **76** on the plate **59**. The arm **70** is pivoted on the machine at **78** and its free end is tensioned in a downward direction by spring **79**.

Between the pivot **78** and spring **79** the lever **70** carries a bracket **80** having a movable striker plate **81** mounted on the end of an adjusting screw **82** which is threadedly engaged in the bracket. Striker plate **81** is positioned directly above a push rod **83** on the slide **41** of the slack pulling mechanism. The spring **79** has sufficient tension to raise the movable roller **60** to its upper position, as shown in Figure 1, to impose a rather great resistance on the movement of the wire between the three rollers **56**, **60** and **57**, in addition to the further resistance imposed by the remaining rollers **61** and **58**. However, after sufficient wire has been pulled out of the slack pulling mechanism to raise the slide **41** to its upper position, push rod **83** engages striker plate **81** to lift the arm **70** and depress the roller **60** to reduce the resistance on the wire temporarily. This occurs only when the lifting effort on slide **41** exerted by the wire tension exceeds the downward pulls of the two springs **47** and **50**. Thus, by suitable adjustment of a striker plate **81**, the resistance on the wire is automatically reduced before excessive tension can develop which might break the wire.

Carrier operated controls

The various functions of the machine which must be performed in timed sequence are initiated by a pair of control mechanisms which are actuated directly by the band laying ring R. The controls are thereby independent of the unavoidable creep of the belt, permitting the use of a reversible belt drive, wherein the motor **25** drives the ring R during certain phases of a binding operation, while in other phases in which the motor is deenergized the ring drives the motor. The ring and motor together are freely rotatable and reversible for reverse movement in response to wire tension for an interval after the motor is deenergized, and before the brake is applied, as will be presently explained.

There are two substantially identical control switch mechanisms C and C′ for performing the necessary operations in different operating cycles distinguished by the two directions of rotation of the ring R. Mounted on the rear side of the ring R are a pair of cam members **85** and **86**, as indicated in Figure 1, to engage the respective cam followers **90** and **91** on the two control mechanisms. The cam **85** and follower **90** are positioned in one plane for engagement in clockwise rotation of the ring, and the cam **86** and follower **91** are positioned in a different plane for operative engagement in counterclockwise rotation of the ring. No control function is produced by engagement of cam **85** with follower **90** in counterclockwise rotation, and, likewise, no control function is produced by engagement of cam **86** with follower **91** in clockwise rotation. The structure to provide this mode of operation will presently be explained. Also, by reason of the arrangement of the cams and cam followers in different vertical planes, cam **85** passes the follower **91** in both directions of rotation without engaging this follower, and cam **86** passes follower **90** in both directions of rotation without engagement. In summary, the control mechanism C is actuated exclusively by cam **85** in clockwise rotation, and control mechanism C′ is actuated exclusively by cam **86** in counterclockwise rotation.

The details of the control mechanisms C and C′ are illustrated in Figures 11 to 15. In view of the substantially identical construction of the two control mechanisms, a description of one will serve for both, and the same reference numerals are applied to corresponding parts on the two mechanisms. The cam followers **90** and **91** comprise identical rollers but are given different reference numerals to distinguish between them in view of their positions in different planes for actuation by the respective cams **85** and **86**.

Referring now more particularly to Figure 14, the roller **91** is carried by the end of an arm **92** which is pivotally mounted on a screw **93** in another arm **94** which is mounted rotatively on a shaft **95**. The end of arm **92** remote from roller **91** is pulled down against a stop **96** on the arm **94** by a spring **97**. Arm **94** carries a pawl **98** which is urged by a compression spring **99** into engagement with an eight tooth ratchet wheel **100** fixed on shaft **95**. Spring **101** normally pulls arm **94** in a counterclockwise direction against a spring bumper **102**, causing the parts to assume the rest position illustrated in Figure 14.

When cam **86** engages the roller **91** in counterclockwise rotation, the arm **92** is restrained against rotation on its pivot **93** by the abutment **96**, and so the arm **94** is swung in a clockwise direction against the tension of spring **101** to allow the cam **86** to pass the roller **91**. This motion causes pawl **98** to rotate ratchet wheel **100** and shaft **95** 45° in a clockwise direction. Overrunning of shaft **95** is prevented by a brake band **105** acting continuously on a drum **106** on the other end of shaft **95**, as best shown in Figure 13. The brake is adjustable by means of the bolt or screw **107**.

As cam **86** leaves the roller **91** in counterclockwise rotation, spring **101** returns the arm **94** to its Figure 14 position, and in this return movement the brake band **105** holds the shaft **95** and ratchet wheel **100** stationary while the pawl **98** rides over one tooth. In clockwise rotation of the cam **86**, the roller end of arm **92** is merely depressed on its pivot **93** without moving the arm **94** or changing the position of the ratchet wheel **100**.

In a similar manner cam **85**, in clockwise rotation, engages roller **90** of control mechanism C to rotate the shaft **95** thereof, while in counterclockwise rotation the cam **85** merely depresses the roller **90** without moving the said shaft of the control mechanism.

Secured on shaft **95** are four cam wheels **115**, each engaged by a cam follower **116** which is held against the cam by an individual spring **117**, as shown in Figure 15. The eight cam wheels **115** and cam followers **116** on the two control mechanisms C and C′ are arranged to actuate eight switches, six of these being indicated at **120** to **125**, inclusive, in Figures 11 and 12. It will be understood that the cams **115** are not necessarily all identical, but are shaped and secured on the shafts **95** in positions to close and open their respective switches at the proper times, it being remembered that the shaft **95** of control mechanism C is advanced one-eighth turn two different times in a binding cycle with the ring R rotating clockwise, and that the shaft **95** of the control mechanism C′ is advanced one-eighth turn two different times in a binding cycle with the ring R rotating counterclockwise. Thus, by the design of cams **115**, certain of

the switches may be operated on two occasions in each binding cycle while others are operated on only one occasion in the cycle. The opening and closing movements of the switches are described in detail in connection with the operation of the machine.

Electrical system

Referring now to Figure 16, a three-wire supply **150** energizes a power circuit **151** for ring motor **25** and a power circuit **152** for knotter motor **153**. The knotter motor always rotates in the same direction and is controlled by a relay having a solenoid winding **154** and an armature **155** carrying a plurality of insulated movable contacts, three of which are connected with the three wires of circuit **152**.

The ring motor **25** rotates in opposite directions in successive binding operations, and is controlled by a pair of relays having solenoid windings **158** and **159** and movable armatures **160** and **161**, respectively. The three wires of circuit **151** are connected in parallel to the first three contacts of each relay armature **160** and **161**. The three wires of the supply circuit **150** are connected to the first three stationary contacts of each of the three relays just described for energization of the power circuits **151** and **152** when the relays are closed. Two of the circuit wires **151** are transposed between the two ring motor relays so that two of the power circuit connections established by the closing of relay armature **161** will be reversed with respect to the connections established by the closing of armature **160** for reversing the motor **25**, the two relays never being closed at the same time. The relay armature **160** is connected to produce clockwise rotation of the ring R while the relay armature **161** is connected to produce counterclockwise rotation of the ring R.

Each relay armature **155**, **160** and **161** also carries a fourth movable contact for a holding circuit which will presently be described. In the following description these relays will be designated generally by the numerals applied to their armatures unless specific reference is made to their solenoid coils.

A transformer **165** provides a low voltage supply for numerous control circuits in the machine, as distinguished from the two power circuits **151** and **152**. The control voltage supply circuit provided by this transformer comprises two wires **166** and **167**, and, for convenience in tracing the various branch circuits, the branch connections to these supply wires are designated by the same reference numerals throughout the diagram.

The knotter motor **153** runs continuously while the machine is in use and does not start and stop in each operating cycle of the machine. Switch **170** is a push button switch designated as a knotter motor start button, and switch **171** is a push button switch designated as a knotter motor stop button. Switch **170** is normally spring held in open position to interrupt a circuit between a pair of stationary contacts connected with a branch of control voltage supply wire **167** and a wire **174**. Switch **171** is normally spring held in closed position to connect a branch of control voltage supply wire **166** with a wire **175**. Solenoid winding **154** of the knotter motor relay is connected to wires **174** and **175**. This relay has a fourth pair of contacts **176**, **177**, connected with the wires **167** and **174**, respectively. Thus, when switch **170** is closed momentarily, solenoid coil **154** is connected through switch **170**, wire **174** and the normally closed switch **171** for energization across the control voltage potential of wires **166**, **167**, to lift the armature **155** and close the relay. Contacts **176** and **177** in parallel with the stationary contacts of switch **170** hold the relay closed after switch **170** is released to open position. A momentary actuation of push button switch **171** interrupts the circuit through solenoid **154**, allowing its armature to drop to open position to deenergize the knotter motor. The separation of contacts **176** and **177** then interrupts the holding circuit so that relay coil **154** is not reenergized by the release of switch **171** to closed position.

The twister gear is operated at the proper time in each binding cycle by a knotter mechanism which is set in motion by an electrically controlled one revolution clutch. The clutch control will presently be described, and it is sufficient to say at this point that the knotter mechanism is driven by motor **153** when the clutch is engaged.

The power relays for ring motor **25** are controlled by a plurality of switches including the switches **120** and **123** previously mentioned in connection with Figures 11 and **12**. Relay solenoid coils **158** and **159** are connected at one end to a common wire **180**. The other ends of these solenoid coils are connected through wires **181** and **182** to the two stationary contacts of a single pole, double throw ring direction control switch **183**. The movable contact member of switch **183** makes a circuit from a wire **184** to the wires **181** and **182** alternately in successive knotting operations. This switch is actuated at the conclusion of a knotting operation and always rests in one or the other of its two closed circuit positions. Wire **184** connects with switch **123** which is normally closed and in series circuit with normally closed switch **120** to establish connection with supply wire **167**. Wire **180** connects with the fourth stationary contacts **185** and **186** above the two relay armatures **160** and **161**, respectively. Wire **180** also connects with one of the stationary contacts of a normally open push button switch **190**. The other terminal of this switch is connected with control voltage supply wire **166** as are also the fourth relay armature contacts **191** and **192**.

Thus, it will be apparent that ring direction control switch **183** determines which one of relay solenoids **158** or **159** may be energized and prevents both of them from being energized at the same time. The particular relay solenoid selected by switch **183** is energized by the momentary closing of push button switch **190** to start the rotation of ring motor **25** in the proper direction. After push button switch **190** is released, the actuated relay is held closed by the holding circuit through contacts **185**, **191**, or **186**, **192**, as the case may be. The closed relay is opened to deenergize ring motor **25** at the end of each band laying operation by the opening of one or the other of switches **120**, **123** in a manner presently to be described. Switches **120** and **123**, which may be designated as ring motor stop switches, re-close immediately to condition the control circuit for the next ring motor operation to be initiated by push button switch **190**. The re-closing of switches **120** and **123** does not re-start the ring motor because the relay circuit through wire **180** is then broken by the separation of both pairs of holding circuit contacts **185**, **191**, and **186**, **192**.

A pair of signal lights **196** and **197** indicate whether the control circuits are in condition for clockwise or counterclockwise rotation of the ring motor **25**. One terminal of each of these lights is connected to supply wire **166** and the other terminals are connected to wires **181** and **182**. Except for the momentary opening of switches **120** and **123**, one or the other of these lights is always energized, depending upon the position of switch **183**.

The compressed air supply for the air cylinders **19** which operate the horizontal and vertical pressure bars **17**, and brake cylinder **28**, is controlled by a solenoid valve **200**, which numeral is also employed to designate the solenoid winding. Only one of the cylinders **19** is shown in Figure 16. One terminal of this solenoid winding is connected directly to the control voltage supply wire **166**, and the other terminal is connected to a wire **201** leading through a switch **202** to the other control voltage supply wire **167**. Switch **202** is closed by a delayed opening relay having a solenoid winding **203**. Relay winding **203** is connected to the ring motor power circuit **151** so that switch **202** will close when ring motor **25** is energized in each cycle of operation.

Solenoid valve **200** is normally spring held in one position to connect a pipe **204** with a source of fluid pressure and a pipe **205** to fluid discharge. When the solenoid winding is energized, these connections are reversed, making pipe **205** a pressure pipe and pipe **204** a discharge pipe. Pipe **204** is connected directly to the lower end of pressure bar cylinder **19**, and to the upper end of brake cylinder **28** through a check valve **206** and a restricted needle valve **207**, in parallel. Pipe **205** is connected directly to the lower end of brake cylinder **28**, and to the upper end of pressure bar cylinder **19** through a check valve **208** and a restricted needle valve **209**, in parallel. Thus, when solenoid winding **200** is not energized, fluid pressure in pipe **204** normally communicates with the upper end of brake cylinder **28** through needle valve **207** to hold the brake applied, and communicates with the lower end of pressure bar cylinder **19** to hold the pressure bar retracted. Then, when solenoid winding **200** is energized and pipe **205** becomes the fluid pressure supply pipe, the brake is released and the pressure bar is

extended to engage with the bundle. The arrangement of check valve 206 and needle valve 207 provides for slow application and quick release of the brake, while the arrangement of check valve 208 and needle valve 209 provides for quick application and slow release of the pressure bars. It will be remembered, too, that solenoid valve 200 has delayed response to the energization of ring motor 25 by reason of the time delay relay 203. Needle valves 207 and 209, and the delayed opening action of relay 203, are adjustable to obtain the desired interval of delay.

The grippers G_1 and G_2 are operated by air cylinders 198 and 199 under the control of solenoid valves 210 and 211, respectively. These valves are spring biased to admit air pressure to one end of the gripper cylinders to hold the grippers closed when the solenoid valves are deenergized. Solenoid valve 210 is energized to admit air pressure to the other end of cylinder 198 for opening gripper G_1 by the closing of relay switch 212 which connects the solenoid winding directly with control voltage supply wires 166, 167, and solenoid valve 211 is similarly energized by the closing of relay switch 213. Switch 212 is operated by relay solenoid 214, and switch 213 is operated by relay solenoid 215. One terminal of each of these solenoids is connected with control voltage supply wire 167, and the other terminals are connected, respectively, to the wires 216 and 217 leading to gripper control switches 221 and 220. Switch 220 is included in the assembly with switches 120, 121 and 122 in Figure 11, and switch 221 is included in the assembly with switches 123, 124 and 125 in Figure 12 for operation by the ring R. Switches 220 and 221 have individual operating cams 115 on the respective shaft 95 but are not shown, however, in Figures 11 and 12. Both of these switches 220 and 221 are also connected with the other control voltage supply wire 166. The timing of the opening and closing movements of these switches will be described in connection with the operation of the machine, it being apparent that the closing of switch 220 energizes relay solenoid 215 to actuate solenoid valve 211 and open the left gripper G_2 and that the closing of gripper control switch 221 energizes solenoid 214 to actuate solenoid control valve 210 to open the right gripper G_1. The air cylinders for the grippers are double acting and their solenoid valves are spring returned, as previously mentioned, to admit compressed air to the proper ends of the cylinders for holding both grippers closed when the solenoid valves are deenergized by both switches 220 and 221 being open as shown in Figure 16.

The numeral 225 designates the knotter clutch solenoid which, when energized, actuate a clutch engaging member 224 to engage a one revolution clutch 223 in the knotter mechanism for rotating the twister gear T by motor 153 the amount required for a wire twisting or knotting operation. The illustration of engaging member 224 is repeated in Figure 16 for convenience in laying out the schematic diagram, it being understood that there is only one of these members in the machine. The terminals of solenoid 225 are connected directly to a pair of contacts on a relay switch 226 which, when closed, connects solenoid 225 directly to the control voltage supply wires 166, 167. This relay is closed by means of a solenoid 227 having one terminal connected directly to control voltage supply wire 167 and the other terminal connected with a wire 228 leading to the switches 121, 124. The other terminals of these switches are connected with control voltage supply wire 166. Switches 121 and 124 are normally open, as shown. In order to operate the knotter mechanism manually when desired, the switches 121 and 124 are shunted by a knotter tripper push button switch 230. This switch is normally open and has one terminal connected with control voltage supply wire 166 and its other terminal connected with a wire 231 which is connected with the wire 228.

The control system also makes provision for the operation of a wire kicker K to push the overlapped wires into the bottom of the twister gear slot just before the knotting operation, and to eject the knot from the twister gear after the knotting operation. The kicker is operated by a double acting air cylinder 234 under the control of a solenoid valve 235, which numeral also designates the solenoid winding of said valve. One terminal of this solenoid winding is connected to control voltage supply wire 166 and the other terminal is connected through a switch 236 to the other supply wire 167. Switch 236 is a delayed opening switch having a solenoid winding 237 to close the switch when the solenoid is energized. One terminal of solenoid 237 is connected with supply wire 167, and the other terminal is connected with a wire 238 leading to previously mentioned switches 122 and 125, which are normally open switches. When either one of switches 122 or 125 is closed, relay 237 and solenoid valve 235 are energized to operate the wire kicker a first time, just prior to the twisting of the splice. The delayed opening action of switch 236 allows time for valve 235 and the kicker to function properly since the switches 122 and 125 are re-opened very quickly.

When the one revolution clutch, symbolized by its engaging member 224, is engaged, a shaft 240 is rotated a half revolution by said clutch and then stops. During this half revolution the twister gear T is rotated as required to form the splice, the kicker K is actuated a second time, to eject the splice from the twister gear, and the ring direction control switch 183 is shifted to its other position to prepare the ring motor circuit for reverse operation of the ring motor in the next binding operation.

Shaft 240 carries a cam 241 having half its periphery raised and thalf its periphery relieved to shift switch arm 183 from one position to another at the end of each knotting operation. Shaft 240 also carries a two-lobed cam 242 engageable with a cam follower 243 connected with the movable valve member in solenoid valve 235. This valve is normally spring held in a position to retract the kicker K, but may be shifted into position to operate the kicker by means of cam 242, as well as the solenoid. As will be explained in greater detail in connection with the operation of the machine, this valve is operated by the solenoid once prior to each knotting operation to cause the kicker to seat the wires in the slot of the twister gear, and then the valve is operated again by the cam 242 after the knotting operation, to eject the knot from the twister gear.

Operation

It has previously been explained that the present binding machine is of the type known as a reversible machine wherein the rotary carrier or ring R rotates in one direction in one binding operation and in the reverse direction in the next binding operation. Thus, Figures 1 to 6 comprise a sequence illustrating successive positions of the band laying ring and associated parts in the course of one binding operation when the ring is rotating clockwise. From this sequence and the following description of the operation, a person skilled in the art will understand how the same functions are performed in the next binding operation when the ring R is rotating counterclockwise. The following description of the operation accordingly makes particular reference to Figures 1 to 6 and the schematic diagram of the electrical system in Figure 16.

Figure 1 represents the approximate rest position of the parts after a binding operation in a counterclockwise direction. Brake shoe 26 engages the belts on ring R to stop clockwise return when the rollers 30*a* are in a lower position beneath the table 10, the gripper G_1 being closed on the primary end W1 of the wire and the gripper G_2 being closed empty, as shown also in Figure 1*a*. The wire is under tension by the partially stretched springs 47 and 50. Spring 79 holds roller 60 in its raised position to impose a resistance on the wire superior to the tensioning effort of springs 47 and 50 so that the wire does not move through the resistance device. Solenoid valve 200 is deenergized and spring biased to connect pipe 204 with the source of air pressure.

The knotter motor 153 is first started by depressing the knotter motor starter button 170 in Figure 16. This results in the closing of relay 155 and the continuous operation of motor 153. Switches 120 and 123 are both resting in closed position and switch 183 is in the proper position to produce and indicate clockwise rotation of motor 25 and ring R. This motor remains at rest until started by switch 190. Knotter clutch control switches 121 and 124 are both open as are also the wire kicker control switches 122 and 125.

Gripper control switches **220** and **221** are both open, to hold the grippers closed.

A binding operation is initiated by momentarily closing push button switch **190**. The first result of closing switch **190** is the closing of one of the relay armatures **160** or **161**, depending upon the position of ring directional control switch **183**. Since switch **183** is illustrated in the position of making contact with wire **182**, the relay coil **159** will be energized at this time, closing relay **161** to energize power circuit **151** for clockwise rotation of ring motor **25** and ring R. Relay **203** is energized at the same time, closing switch **202** to energize solenoid valve **200**, admitting air pressure to pipe **205** to remove the ring brake and apply the pressure bars **17** to the bundle to hold it securely against table **10** and side plate **11** of the bundle guide frame.

As the ring rotates to its Figure 2 position, the wire is laid in the slot of the twister gear and outside the closed gripper G_2, and the pressure bars have moved up against the bundle before the wire engages the bottom corner of the bundle which would otherwise tend to lift the bundle off the table. It will be observed in Figure 2 that ring cam **85** has just engaged and released the switch operator **90** to rotate the shaft **95** in Figure 11 through an angle of 45 degrees. In order to maintain the switches **120** and **123** in normally closed positions, the four raised portions of their cams **115** exceed 45 degrees and the four low portions of the cams are shorter than 45 degrees. The cams for these switches are so positioned on their respective shafts **95** that each 45 degree rotation of the shafts begins and ends with the cam follower on one of the raised surfaces, the switch being momentarily opened and then reclosed on alternate movements of the cam shaft. Also, these cams are so positioned that the first movement of shaft **95** in each binding cycle, illustrated in Figure 2, merely moves the cam follower **116** from one position to another on the same high portion of the cam without crossing a low portion, whereby the switch **120** is not opened at this time. It will be appreciated, of course, that instead of using switches which are closed by the high parts of cams **115** and opened by the low portions, the switches may be closed by the low portions and held open by the high parts and the cams **115** redesigned accordingly.

The knotter clutch control switch **121** remains in its normally open position at this time, its cam having the same shape and position as the cam for switch **120**. Switch **121** is reversed, however, so that it always returns to open position. Figure 15 shows this cam **115** in its starting position corresponding to the Figure 1 position of ring R.

Gripper switch **220** is closed at this time to open gripper G_2 immediately after the wire portion W2 has been laid outside the gripper, as illustrated in Figure 2*a*. The cam for this switch may have the shape of cam **115** but it is keyed on shaft **95** in a position 22½° in advance of the other cams to change the position of switch **220** every time the shaft **95** is actuated.

Wire kicker control switch **122** remains open by reason of the shape of its cam **115** as explained in connection with switch **121**.

In Figure 2 it will be observed that the slack pulling springs **47** and **50** are contracted and that slides **40** and **41** are either at or near their bottom stops **48** and **51**. The spring **79** remains contracted to hold the roller **60** in its uppermost position applying maximum resistance to the movement of the wire through the resistance rollers.

As the ring rotates from its Figure 2 to its Figure 3 position, no change occurs in any part of the mechanism except that the ring starts to pull wire through the slack pulling mechanism as indicated by the arrows, causing springs **47** and **50** to start to stretch. Cam **86** has passed the position of cam follower **90**, but it will be remembered that this cam is offset from the plane of cam follower **90** and does not engage it in either direction of rotation. Thus, the switching connections are not altered in progressing from Figure 2 to Figure 3.

Referring now to Figure 4, it will be observed that nearly all the slack wire has been pulled out of the slack pulling mechanism, stretching spring **50** to the limit of its movement and stretching spring **47** nearly to the limit of its movement. The anchors for the lower ends of these springs are adjusted up or down so that slide **41** will be pulled against its upper stops **52** before slide **40** reaches its upper stops **49**. Before slide **41** reaches its upper stops **52**, push rod **83** engages striker plate **81** and lifts the arm **70** against the tension of spring **79**, lowering the roller **60** and reducing the resistance to movement of the wire through the resistance device.

Cam **85** has passed the position of cam follower **91** but it is not in the plane of this cam follower and so has produced no switch movements. Thus, the grippers shown in Figure 4*a* remain in their Figure 3*a* position.

Turning now to Figure 5, it will be seen that arm **70** is still held in its raised position by slide **41** and that slide **40** has been pulled up against its upper stops **49** to accumulate the full capacity of wire just prior to reversal of the ring.

The wire portion W3 has been laid outside of closed gripper G_1, again in the slot of the twister gear, and portion W4 has been laid in the open gripper G_2. Ring cam **85** has again engaged cam follower **90** to produce a second 45 degree rotation of the switch cams **115** for the switches **120**, **121**, **122** and **220** in control mechanism C1. This movement of the switch cams **115** has opened gripper switch **220** causing the gripper G_2 to close on the wire portion W4 as illustrated in Figure 5*a*. It will be noted that the gripper G_1 has not moved in this binding cycle. Thus, as illustrated in Figures 5 and 5*a*, the wire portion between W1 and W2 lies against the wire portion between W3 and W4 in the slot of the twister gear in readiness for a knotting operation.

This second engagement of ring cam **85** with cam follower **90** has rotated the other switch cams **115** to open and reclose ring stop switch **120**, to close and reopen knotter clutch control switch **121** and to close and reopen wire kicker control switch **122**.

The momentary opening of ring stop switch **120** deenergizes solenoid **159**, allowing relay armature **161** to drop and break its holding circuit through contacts **186**, **192**, thereby deenergizing ring motor **25**. The immediate reclosing of switch **120** does not restart the motor.

The momentary closing of knotter clutch control switch **121** energizes relay solenoid **227** to close switch **226** and energize knotter clutch solenoid **225**. Momentary energization of the solenoid **225** is all that is necessary to operate member **224** and engage the clutch **223** for one revolution to perform a knotting operation. In this operation, the twister gear T is rotated by motor **153** the required amount to produce a twisted wire splice or knot, and shaft **240** is rotated one-half turn.

The momentary closing of wire kicker control switch **122** energizes relay solenoid **237** to close switch **236** and energize the wire kicker control solenoid valve **235** to actuate the kicker K. This occurs before the twister gear starts to rotate and insures that the wires are properly seated in the slot of the twister gear. When the knot, or splice, is fully twisted, cam **242** operates valve **235** a second time, and now the twister gear slot is turned upward and the action of kicker K ejects the knot from the gear. The kicker is immediately retracted after each operation.

After the ring motor **25** is deenergized, the ring continues to rotate by momentum to its point of reversal, as illustrated in Figure 6, or farther, while the knotter mechanism and wire kicker are operating. The knotter mechanism includes the usual cutters (not shown) as is well understood in the art, and 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 W1 and W4 on opposite sides of the twister gear and the wire kicker has ejected the splice from the twister gear to free the bundle from the twister gear and grippers. Relay switch **202** has a delayed opening action so that pressure bars **17** will continue to hold a compressible bundle while the knotter mechanism is operating, and so that application of the brake **26** will be delayed while the ring is starting to reverse under the wire tension exerted by the fully stretched springs **47** and **50**. The brake is adjusted to stop the return movement of the ring R after the wire clears the bundle passage, preferably when the two rollers **30***a* are in their lowermost position.

An important feature of the invention is the automatic self-reversal of the ring to start the next cycle of operation by the action of the potential energy stored in springs **47** and **50** before the ring motor **25** is reenergized for reverse rotation. The rotational friction of

the ring and motor **25** and of the belt drive **24** is relatively small, and the position of rollers **30***a* at the reversal position of the ring in Figure 6 is such that the maximum mechanical advantage of the wire tension is exerted upon the ring at this time to arrest its motion and reverse its rotation quickly. The wire tension for arresting the ring results from the bending friction of the wire in passing over rollers **56, 57, 58, 60** and **61**, and the other sheaves and pulleys. The wire tension for reversely accelerating the ring is developed by springs **47** and **50**. As soon as the ring has started its reverse movement in counterclockwise rotation, the first small amount of slack pulled between the slack pulling sheaves **31, 43, 45** allows slide **41** to drop sufficiently to disengage push rod **83** from the striker plate **81** on arm **70** and raise the roller **60** back to its Figure 1 position to increase the resistance on the wire and prevent movement of the wire through the resistance device. The resistance device then acts as an anchor for the wire at that point so that there is no slippage through the resistance device and the full effort of springs **47** and **50** is exerted on the ring to accelerate it quickly for its next cycle of operation.

The added resistance applied to the wire at this time thus permits the use of stronger spring tension in slack pulling springs **47** and **50** to reverse the ring quickly without pulling additional wire from the wire supply. On the other hand, when the ring has drawn out all the wire available from the slack pulling mechanism and starts to draw more wire from the supply in a band laying operation, the added resistance is automatically removed to avoid excessive wire tension which might break the wire. This permits the use of an inexpensive grade and size of wire having a relatively low tensile strength.

As soon as the wire clears the bundle passage in the counterclockwise return movement from the Figure 6 position, the operator can move the bundle to receive the next binding, and press the starting switch **190** to reenergize the ring motor for the next binding operation before the brake **26** takes effect to stop the ring. Switch 183 having been shifted by the operation of the knotter mechanism, relay solenoid **158** is now energized instead of solenoid **159** to energize the ring motor **25** for counterclockwise torque. Since all the moving parts are already in motion, the motor is now not required to apply the usual starting torque, and the usual heavy surge of starting current to the ring motor at the beginning of each binding operation in a conventional machine is eliminated. The starting torque heretofore supplied by prime mover energy in conventional machines is supplied in the present machine by the potential energy stored in the stretched springs **47** and **50**. This available energy has heretofore been dissipated wastefully in previous conventional binding machines. The new mode of operation also eliminates the usual loss of time between successive binding operations, which, although it may be small with a good operator, nevertheless is multiplied by the number of binding operations accomplished in each working day. Thus, in the present machine, the ring R may be kept in continuous oscillation like the balance wheel of a watch with the springs **47** and **50** storing potential energy at the end of each swing of the ring R and then returning that energy to the ring to reverse its rotation without unnecessary loss of time or energy between successive binding operations. Motor **25** is called upon to supply only the energy required for the useful work of pulling the wire through the machine and laying it under tension about the bundle.

Even when the brake is allowed to stop or partially stop the ring, the springs **47** and **50** remain partially stretched as in Figure 1 to assist the motor in starting for the next operation.

The wire portion W4 in gripper G_2 becomes the new primary end for the next operating cycle in counterclockwise rotation of the ring, the gripper G_2 remaining closed throughout the counterclockwise cycle just as the gripper G_1 remained closed on the primary end W1 in the clockwise cycle described above. In the counterclockwise cycle, the gripper G_1 remains closed on the cut end W1 until the wire has been laid once through the twister gear and outside the gripper G_1, and then the gripper G_1 opens as explained in the case of gripper G_2 in Figure 2*a*. When gripper G_1 opens, it drops the cut end W1, leaving the gripper open and empty to receive another portion of the wire when the wire is laid in the twister gear the second time in the same manner as previously explained in connection with wire portion W4 in Figure 5*a*. In the counterclockwise cycle, control mechanism C1 controls the functions of the machine and control mechanism C is inactive. At the end of the knotting operation in the counterclockwise cycle, switches **183** and **195** are returned to the positions shown in Figure 16 to prepare the control system for another clockwise cycle.

It will be appreciated that the position of the ring R at reversal in Figure 6 is controlled by the wire tension, which in turn depends upon the size and flexibility of the wire and the adjustment of the resistance device. Other adjustments, such as needle valves **207** and **209**, and time delay relays **203** and **237**, are coordinated with the wire tension and reversal position of the ring in order to time the various functions of the machine in proper sequence in fast operation. The machine is thereby adaptable to different kinds of binding strand and the binding tension may be varied for different types of bundles.

When the machine is standing idle, as represented in Figures 1 and 16, but assuming the main switch in power supply **150** to be closed, all the relays and other solenoids are deenergized and the only current consuming unit in the system at such time is one of the two indicating lights **196** or **197**.

Modification to form welded splice

Figure 17 is a fragmentary illustration of a binding machine similar to that described in connection with the preceding views in the drawings, except that the twister gear is omitted. The parts illustrated are the same as shown in Figure 1 and are identified by the same reference numerals. Also, the parts are in the same relative positions as shown in Figure 5, and the two views correspond except for the elimination of the twister gear T. The bundle has been bound and the wire secured in both grippers with the strands overlapped between the grippers and with one strand inside and one strand outside of each gripper as shown in Figures 17*a* and 17*b* corresponding to Figure 5*a*.

Figure 18 illustrates details of the gripper structure which are common to the Figure 1 machine, in addition to the new feature of welding electrodes to form a welded splice. As illustrated in the case of gripper G_1, the gripper is reciprocated relative to a stationary gripper **20** by a piston rod **251** extending from an air cylinder **252**. Air pressure is admitted selectively to opposite ends of the cylinder through pipe or hose connections **253, 254** under the control of a valve such as solenoid valve **211** in Figure 16. The valve **211** is a conventional type of valve which is spring held in one position to connect pipe **253** with pressure and pipe **254** with an exhaust port to hold the gripper normally closed. Then, when solenoid **211** is energized, the valve is moved to a position connecting pipe **254** with pressure and pipe **253** with exhaust to hold the gripper open.

With the wire portions held securely in crossing relationship as shown in Figures 17 and 18, a pair of welding electrodes **255** and **256** may be moved into engagement with opposite sides of the crossed wires in the space between the grippers. When a sufficient welding current is passed between two electrodes, the wire portions become fused together and integrally united to serve the purpose of the usual twisted splice. It is understood that the electrodes **255, 256** are part of conventional welding equipment, not shown, having movable electrode holders.

Reference is made to prior copending applications which show in greater detail certain features referred to in the foregoing description. The present machine is of the general type disclosed in my application Serial No. 39,568, for Bundle Binding Machine, filed July 19, 1948. That application also discloses the construction of the solenoid operated one revolution clutch for the knotter mechanism. My application Serial No. 70,088, for Wire Binding Machine, filed January 10, 1949, discloses an improved arrangement of the knotter mechanism having a switch device actuated by the one revolution drive shaft of that mechanism. The last mentioned application also discloses a pneumatically operated knot ejector or kicker controlled by a solenoid valve. The present application is a continuation-in-part of application Serial No. 86,168, for Quick Reversible Wire Binding Machine, filed April 8, 1949 (now abandoned).

Having now described my invention and in what man-

ner 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 rotary carrier for laying a band in opposite directions about a bundle in successive operations, driving means for said carrier, said carrier being rotatable when said driving means is inactive, and a resilient member arranged to initiate rotation of the carrier while said driving means is inactive.

2. A binding machine comprising a rotary band laying carrier, means for driving said carrier in opposite directions in successive band laying operations, said carrier being rotatable while said driving means is inactive, means to store mechanical energy during each band laying operation, and means employing said stored energy to reverse the carrier after each band laying operation while said driving means is inactive.

3. A binding machine comprising a rotary band laying carrier, means for driving said carrier in opposite directions in successive band laying operations, said carrier being rotatable while said driving means is inactive, means to store mechanical energy during each band laying operation, means on the carrier to interrupt the driving of the carrier when a band laying operation is completed, and means employing said stored energy to reverse the carrier for the next band laying operation.

4. A binding machine comprising a rotary carrier for laying a band about a bundle, a motor for driving said carrier in opposite directions in successive band laying operations, said carrier being rotatable when said motor is deenergized, and a spring operable on said carrier to reverse the carrier at the completion of each band laying operation.

5. A binding machine comprising a rotary carrier for laying a band about a bundle, resilient means to impart an impulse to the carrier at the end of each band laying operation for oscillating said carrier in opposite directions of rotation in successive band laying operations, and means for driving said carrier in each direction of oscillation, said driving means when inactive being freely drivable by said resilient means.

6. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving the carrier in opposite directions of rotation in successive band laying operations, means to interrupt the driving of the carrier at the completion of a band laying operation, allowing the carrier to continue to rotate, and resilient means operable to reverse the carrier after the operation of said interrupting means while said driving means is inactive.

7. A binding machine comprising a freely reversible rotary carrier for laying a band about a bundle, means for driving the carrier in opposite directions of rotation in successive band laying operations, means to interrupt the driving of the carrier in each direction of rotation at the completion of a band laying operation, allowing the carrier to continue its rotation, and resilient means for reversing the carrier and driving means after each operation of said interrupting means to keep said carrier in continuous oscillation as long as said driving means is operated in each cycle of oscillation.

8. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving the carrier in opposite directions of rotation in successive band laying operations, said carrier being rotatable while said driving means is inactive, means on the carrier operable to interrupt the driving of the carrier in each direction of rotation at the completion of a band laying operation, means to arrest the movement of the carrier, and resilient means to reverse the carrier as soon as said movement is arrested.

9. A binding machine comprising a rotary carrier for laying a band about a bundle, resilient means operable upon said band for reversing said carrier after each band laying operation, and a reversible motor for driving the carrier in each direction of rotation, said motor when deenergized being freely drivable by said resilient means.

10. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving said carrier in opposite directions in successive band laying operations, restraining means acting on said band to arrest the motion of said carrier after each band laying operation, and means acting on said band to reverse the carrier for the next binding operation, said carrier being rotatable by said last means when said driving means is inactive.

11. A binding machine comprising a freely reversible rotary carrier for laying a band about a bundle, resilient means operable upon said band for oscillating said carrier in opposite directions of rotation in successive band laying operations, and a reversible motor for driving said carrier in each direction of oscillation, said motor when deenergized being freely drivable by said resilient means.

12. A binding machine comprising a rotary carrier for laying a band about a bundle, a reversible motor for driving said carrier in opposite directions in successive band laying operations, means to store mechanical energy during each band laying operation, and means to apply said stored energy to said band to reverse the carrier after each band laying operation, said carrier being rotatable by said last means when said motor is deenergized.

13. A binding machine comprising a freely reversible rotary carrier for laying a band about a bundle, means for driving said carrier in opposite directions in successive band laying operations, means to store mechanical energy during each band laying operation, means to interrupt the driving of said carrier when a band laying operation is completed, and means acting on said band to apply said stored energy to the carrier to reverse the carrier for the next band laying operation while said driving means is inactive.

14. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving said carrier in opposite directions in successive band laying operations, means to store mechanical energy during each band laying operation, restraining means acting on the band to arrest the motion of the carrier after the completion of each band laying operation, and means to apply said stored energy to the band to reverse the carrier for the next band laying operation, said carrier being rotatable by said last means when said driving means is inactive.

15. A binding machine comprising a rotary carrier for laying a band about a bundle, a reversible motor for driving the carrier in opposite directions of rotation in successive band laying operations, switch means for deenergizing said motor, means on the carrier to operate said switch means at the completion of a band laying operation in each direction of rotation, restraining means acting on said band to arrest the motion of said carrier after the operation of said switch means, and resilient means acting on said band to reverse the carrier, said carrier being rotatable by said resilient means when said motor is deenergized.

16. A binding machine comprising a freely reversible rotary carrier for laying a band about a bundle, a reversible motor for driving the carrier in opposite directions of rotation in successive band laying operations, means to deenergize the motor at the completion of the band laying operation in each direction of rotation allowing the carrier to continue its rotation, and resilient means operable upon the band for reversing the carrier and motor after each operation of said deenergizing means to keep said carrier in continuous oscillation as long as said motor is operated in each cycle of oscillation.

17. A binding machine comprising a freely reversible rotary carrier for laying a band about a bundle, tensioning mechanism for said band, a resilient member in said mechanism, and means comprising said member acting on said band to reverse said carrier after each band laying operation, said carrier being rotatable by said means.

18. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving said carrier in opposite directions in successive band laying operations, a band tensioning mechanism, means in said mechanism to store mechanical energy during each band laying operation, and means to apply said stored energy to the band to reverse said carrier after each band laying operation, said carrier being rotatable by said last means when said driving means is inactive.

19. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving said carrier in opposite directions in successive band laying operations, a band tensioning mechanism, resistance means in said mechanism operable upon said band to arrest the motion of said carrier after each band laying operation, and spring means in said mechanism operable upon the band to reverse the carrier, said carrier being rotatable by said spring means when said driving means is inactive.

20. A binding machine comprising a rotary carrier for laying a band about a bundle, tensioning mechanism for said band, a resilient member in said mechanism acting

on the band to impart an impulse to the carrier after each band laying operation to oscillate said carrier in opposite directions of rotation for successive band laying operations, and a reversible motor for driving said carrier in each direction of oscillation, said motor when inactive being freely drivable by said resilient member.

21. A binding machine comprising a rotary carrier for laying a band about a bundle, means for driving said carrier in opposite directions in successive band laying operations, a tensioning mechanism for the band comprising a resistance device and a slack pulling device, means in said resistance device acting on the band to arrest the motion of said carrier after each binding operation, and means in said slack pulling device operable upon the band to reverse the carrier, said carrier being rotatable by said last means when said driving means is inactive.

22. A binding machine comprising a freely reversible rotary carrier for laying a band about a bundle, means for driving the carrier in opposite directions of rotation in successive band laying operations, tensioning means for said band comprising a resistance device and a slack pulling device, means to interrupt the driving of the carrier at the completion of a band laying operation allowing the carrier to continue its rotation, means in said resistance device acting on said band to arrest the motion of the carrier after operation of said interrupting means, and means in said slack pulling device acting on said band to reverse the carrier and driving means.

23. A binding machine comprising a rotary carrier for laying a band about a bundle, a reversible motor for driving the carrier in opposite directions of rotation in successive band laying operations, switch means for deenergizing said motor, means on said carrier for actuating said switch means at the completion of a band laying operation in each direction of rotation, a tensioning mechanism for the band, resistance means in said tensioning mechanism acting on the band to arrest the movement of said carrier after deenergization of said motor, and spring means in said tensioning mechanism acting on said band to reverse the rotation of said carrier and motor.

24. A binding machine comprising a rotary band laying carrier, a reversible motor connected with said carrier to drive the carrier when the motor is energized and adapted to be driven by the carrier when deenergized, means to deenergize said motor at the completion of a band laying operation allowing the carrier and motor to continue to rotate, and resilient means for reversing the carrier and motor before the motor is reenergized for reverse rotation.

25. A binding machine comprising a freely rotatable band laying carrier, a reversible motor connected with said carrier to drive the carrier when the motor is energized and yielding to the carrier to be driven by the carrier when deenergized, energy storing means energized by the rotation of said carrier in each band laying operation, and means to apply stored energy from said means to said carrier to impart a reverse starting impulse to the carrier for oscillating the carrier in opposite directions in successive band laying operations.

26. In a quick reversible binding machine, a rotary carrier for laying a band in opposite directions about a bundle in successive operations, and means for oscillating said carrier for said band laying operations comprising spring means to impart a reverse starting impulse to the carrier to start a new cycle of operation as soon as the carrier completes each band laying movement, and a motor to continue driving the carrier in the direction of said impulse to complete each cycle of operation.

27. In a wire binding machine, a reversible wire carrier for laying a wire band under tension about a bundle, means for clamping a portion of the wire against movement at a distance from said carrier, and wire pulling means acting on the wire between the carrier and clamping means, said pulling means exerting a pulling effort superior to the frictional restraint of the carrier to reverse the carrier after a band laying operation.

28. In a wire binding machine, a rotary wire carrier for laying a wire band around a bundle under tension, resistance means restraining the movement of the wire to create said tension in wire pulled therethrough by said rotary carrier, means for pulling slack in the wire between said resistance means and said rotary carrier, means for reducing the resistance of said resistance means, and a member engaged and actuated by said slack pulling means to operate said resistance reducing means.

29. In a wire binding machine, a rotary wire carrier for laying a wire band around a bundle under tension, resistance means restraining the movement of the wire to create said tension in wire pulled therethrough by said rotary carrier, means movable in opposite directions for pulling in and paying out slack in the wire between said resistance means and said rotary carrier, means for reducing the resistance of said resistance means, and a member positioned to be engaged and actuated by the final slack paying out movement of said slack pulling means to actuate said resistance reducing means.

30. In a wire binding machine, a reversible wire carrier for laying a wire band around a bundle under tension, variable resistance means for creating said tension in wire pulled therethrough by said band laying carrier, means for pulling slack in the wire between said resistance means and said carrier to reverse the carrier after a band laying operation, means for reducing the resistance of said resistance device when said carrier is laying the band about a bundle to limit the wire tension, and means for increasing said resistance when said carrier reverses its direction of rotation.

31. In a wire binding machine, a rotary wire carrier for laying a wire band around a bundle under tension, resistance means restraining the movement of the wire to create said tension in wire pulled therethrough by said rotary carrier, means for pulling slack in the wire between said resistance means and said rotary carrier, spring actuated means to increase the resistance of said resistance means, and means on said slack pulling means to engage said spring actuated means and remove said increased resistance.

32. In a wire binding machine having a reversible band laying carrier, means for arresting the motion of said carrier at the end of each cycle of operation comprising a resistance device to restrain the movement of the wire, means for reversing said carrier for each new cycle of operation comprising a slack pulling mechanism, and means actuated by said mechanism to vary the resistance of said resistance device.

33. In a wire binding machine, a reversible wire carrier for laying a wire band around a bundle under tension, resistance means for creating said tension in wire pulled therethrough by said band laying carrier, means for pulling slack in the wire between said resistance means and said carrier to reverse the carrier after a band laying operation, and means for increasing the resistance of said resistance means actuated by incipient slack pulling movement of said slack pulling means.

34. In a reversible wire binding machine, a rotary band laying carrier, a first switch mechanism mounted adjacent said carrier for controlling the functions of the machine in clockwise rotation, a first actuating means on said carrier engaging and actuating said first switch mechanism only in clockwise rotation, a second switch mechanism mounted adjacent said carrier for controlling the functions of the machine in counterclockwise rotation, and a second actuating means on said carrier engaging and actuating said second switch mechanism only in counterclockwise rotation, said actuating means being disposed in axially spaced planes relative to said rotary carrier so that each actuating means engages only one of said two switch mechanisms.

35. In a reversible wire binding machine, a rotary band laying carrier, a reversible motor for driving said carrier, a wire splicing mechanism, switch means actuated by said carrier for deenergizing said motor and initiating operation of said splicing mechanism, and a switch actuated by said splicing mechanism for effecting reversal of the power supply connections for said motor.

36. In a reversible wire binding machine having a wire splicing mechanism, a reversible driving motor having a power circuit, a pair of relays for energizing said circuit for clockwise and counterclockwise motor rotation, respectively, a manual switch for energizing one of said relays, and a switch actuated by said splicing mechanism for selecting the one of said relays to be energized by said manual switch.

37. In a wire binding machine, a slotted twister gear, a rotary carrier for laying a wire band about a bundle and twice in said twister gear slot, a wire kicker adjacent said twister gear, means actuated by said carrier for operating said kicker to push portions of said band in said slot toward the bottom of the slot, means initiated in operation by said carrier for driving said twister gear to splice

said portions together, and means actuated by said twister gear driving means for operating said kicker to eject the completed splice from said twister gear.

38. In a wire binding machine, a slotted twister gear, a rotary carrier for laying a wire band about a bundle and twice in said twister gear slot, a fluid pressure operated wire kicker adjacent said twister gear, a solenoid valve for controlling the operation of said kicker, switch means actuated by said carrier for energizing said solenoid valve to operate said kicker to push portions of said band in said slot toward the bottom of the slot prior to operation of the twister gear, means for driving said twister gear to splice said portions together, and mechanical means operated by said twister gear driving means for actuating said solenoid valve to operate said kicker upon completion of the splice to eject the completed splice from said twister gear.

39. In a wire binding machine, a rotary band laying carrier, an electric motor for driving said carrier, a brake operable on said carrier, a wire splicing mechanism, switch means actuated by said carrier for deenergizing said motor, initiating operation of said splicing mechanism, and applying said brake, and means for delaying engagement of said brake with said carrier until said splicing mechanism has functioned.

40. In a wire binding machine, a rotary band laying carrier, a motor for driving said carrier, a brake operable on said carrier, a wire splicing mechanism, a pressure bar for engaging a bundle in said machine, switch means actuated by said carrier for deenergizing said

motor, initiating the operation of said splicing mechanism, initiating the operation of said brake, and initiating release of said pressure bar, and means for delaying the operation of said brake and release of said pressure bar until said splicing mechanism has functioned.

41. In a reversible wire binding machine, a rotary band laying carrier, a reversible motor for driving said carrier, a brake operable on said carrier, a wire splicing mechanism, switch means actuated by said carrier at the completion of a band laying operation for deenergizing said motor and initiating the operation of said splicing mechanism and brake, slack pulling mechanism operable on said wire to reverse said carrier after said motor is deenergized, and means for delaying the engagement of said brake with said carrier until said splicing mechanism has functioned and said carrier has been reversed a predetermined distance by said slack pulling mechanism.

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