

Feb. 1, 1966

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3,232,216

WIRE BINDING MACHINE

Filed April 29, 1963

10 Sheets-Sheet 1

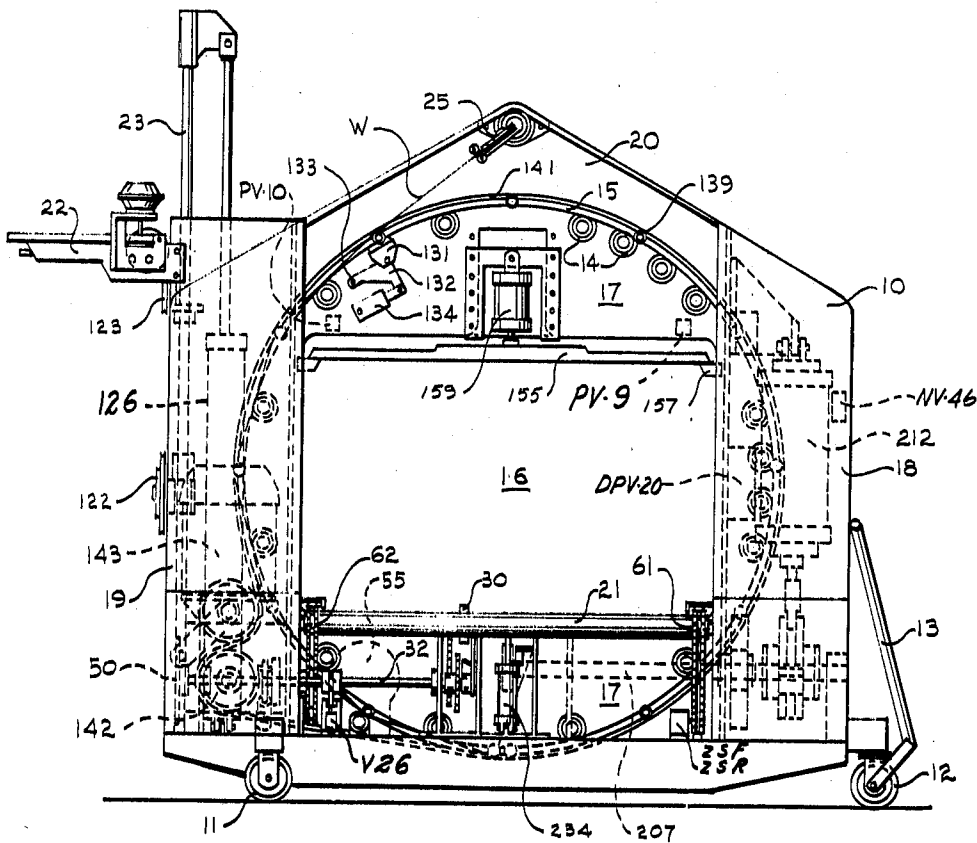


Fig. 1

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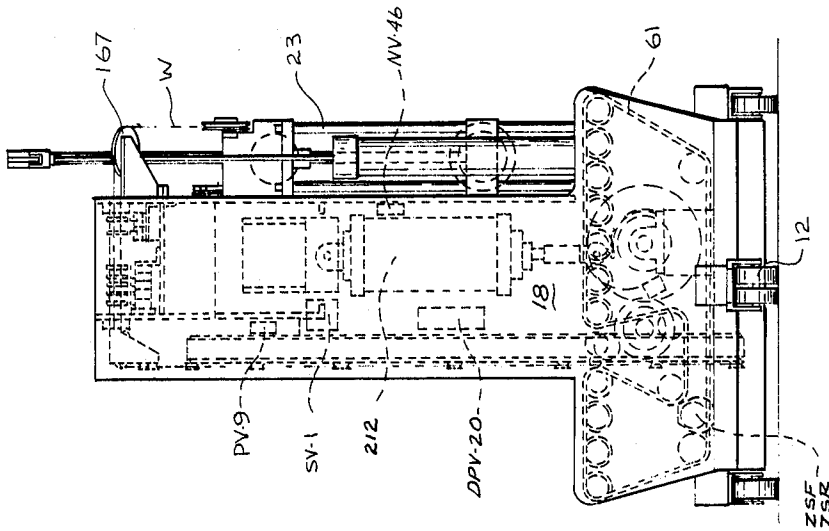


FIG. 3

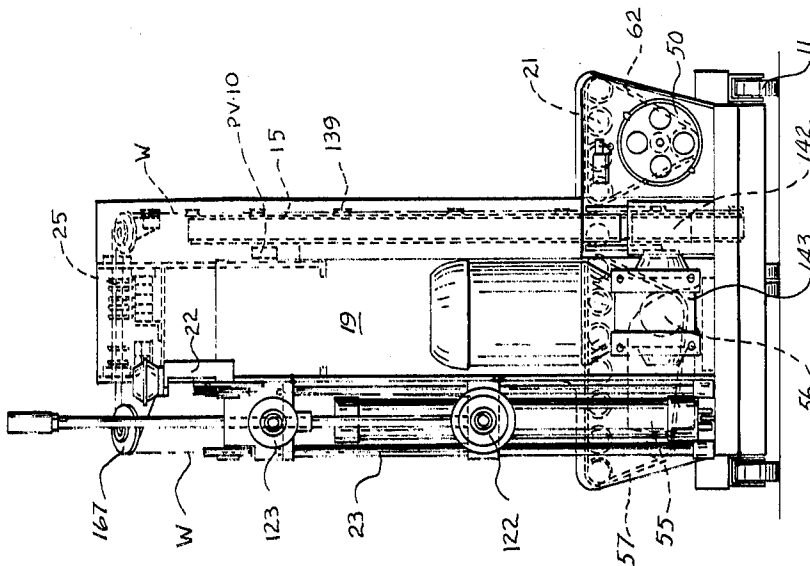


FIG. 2

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FIG. 4

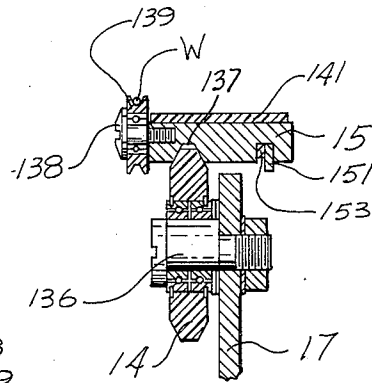
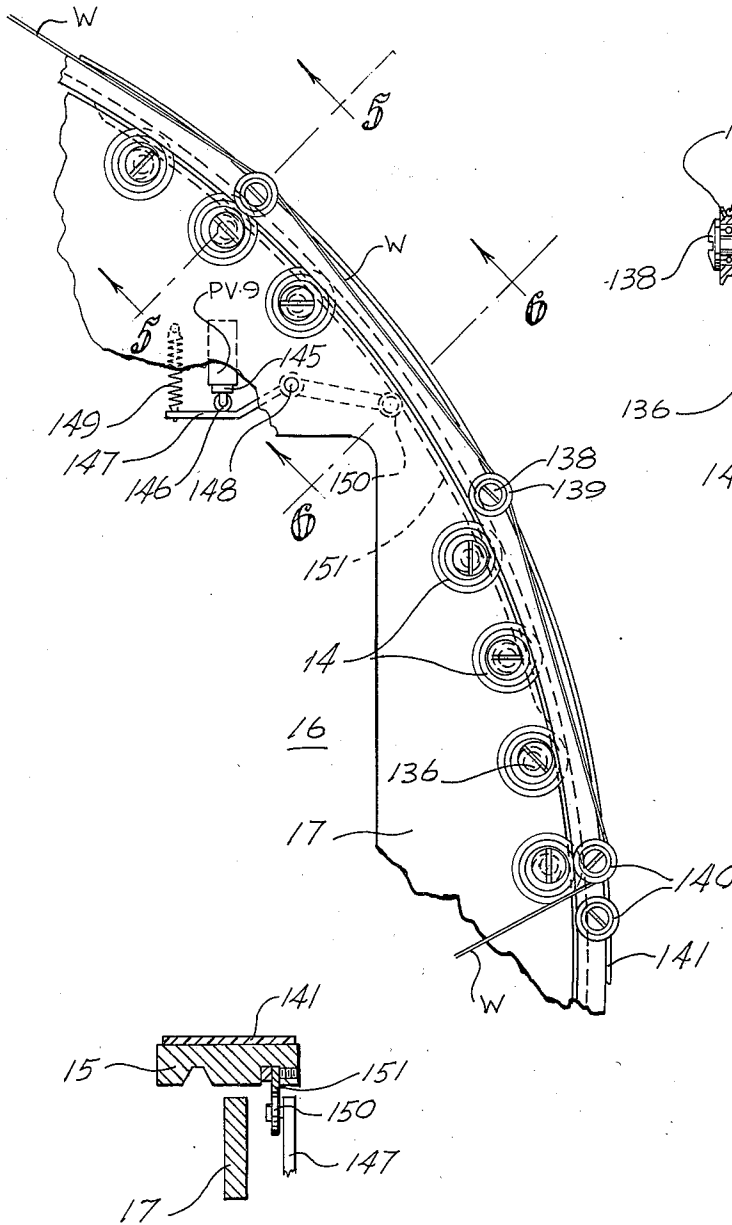
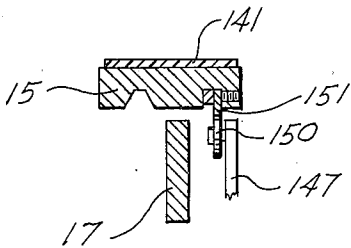


FIG. 5

FIG. 6



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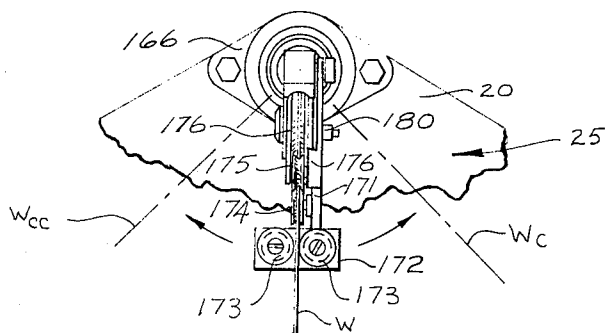


FIG. 7

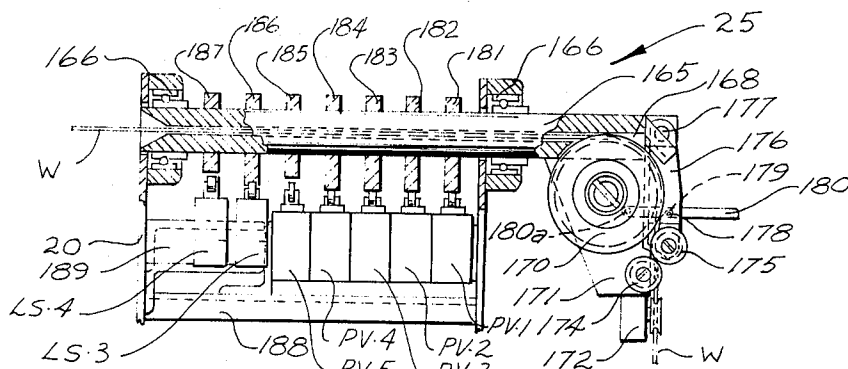


FIG. 7A

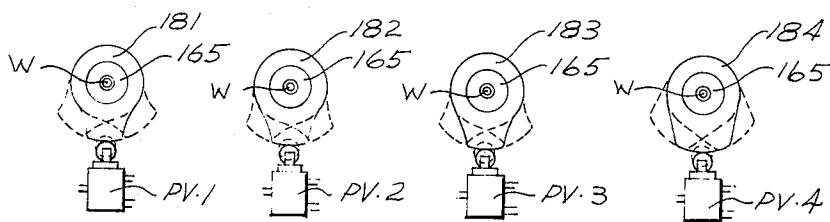


FIG. 7B

FIG. 7C

FIG. 7D

FIG. 7E

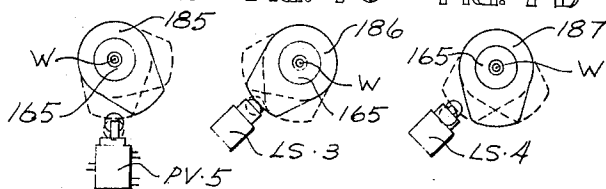


FIG. 7F

FIG. 7G

FIG. 7H

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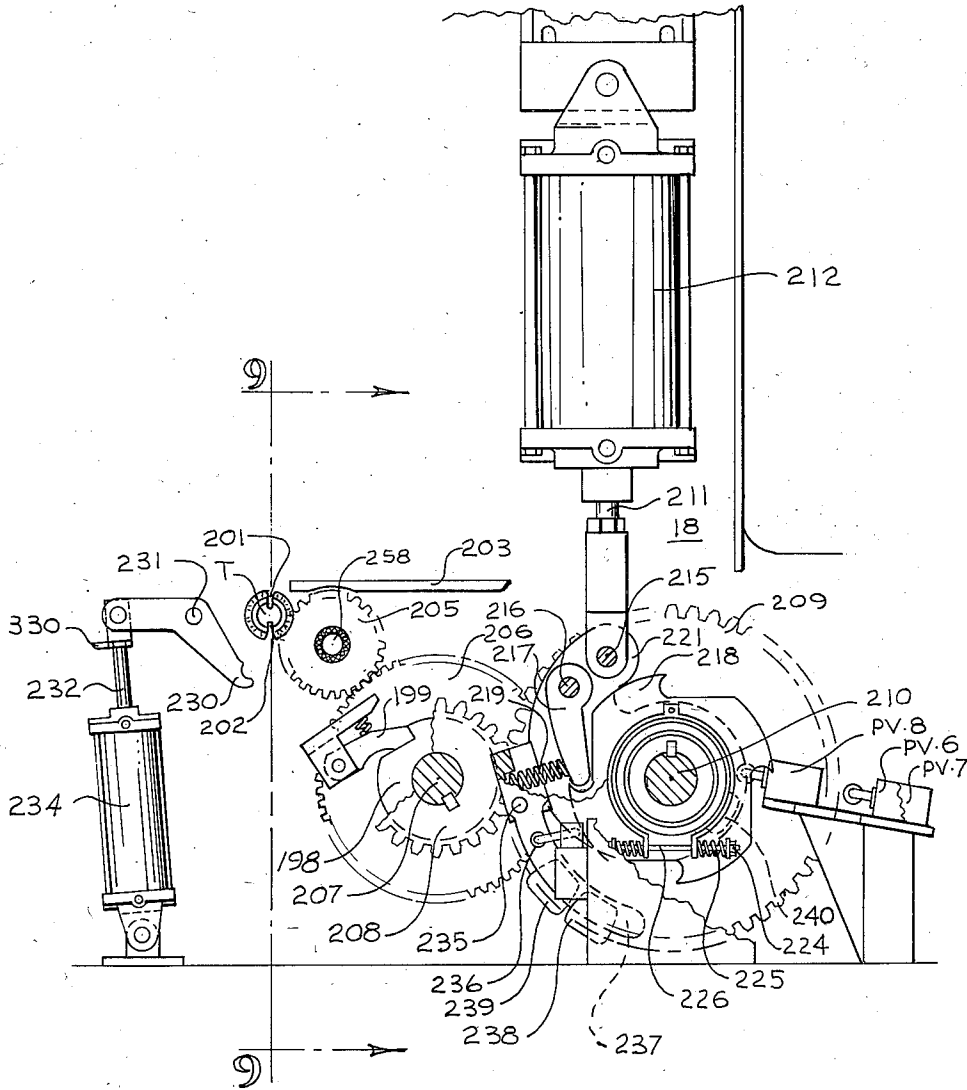


FIG. 8

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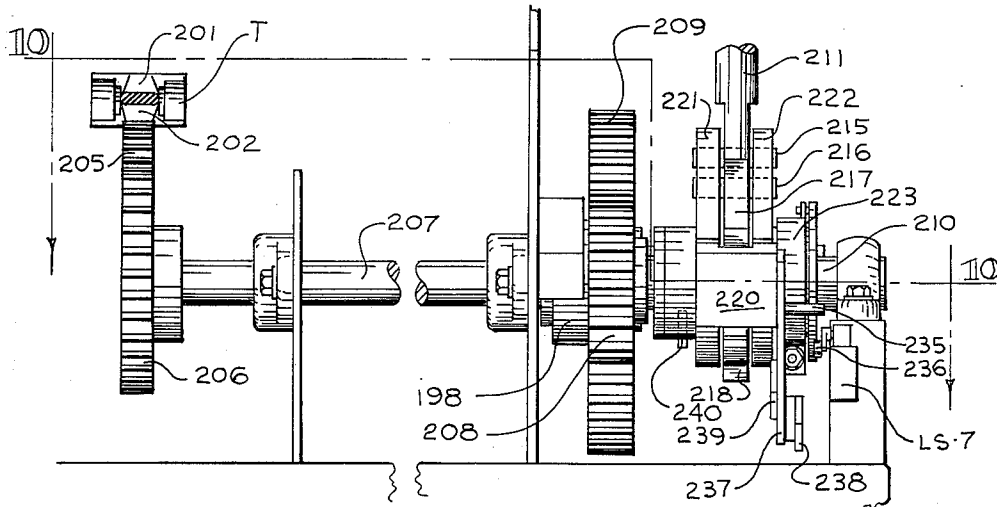


FIG. 9.

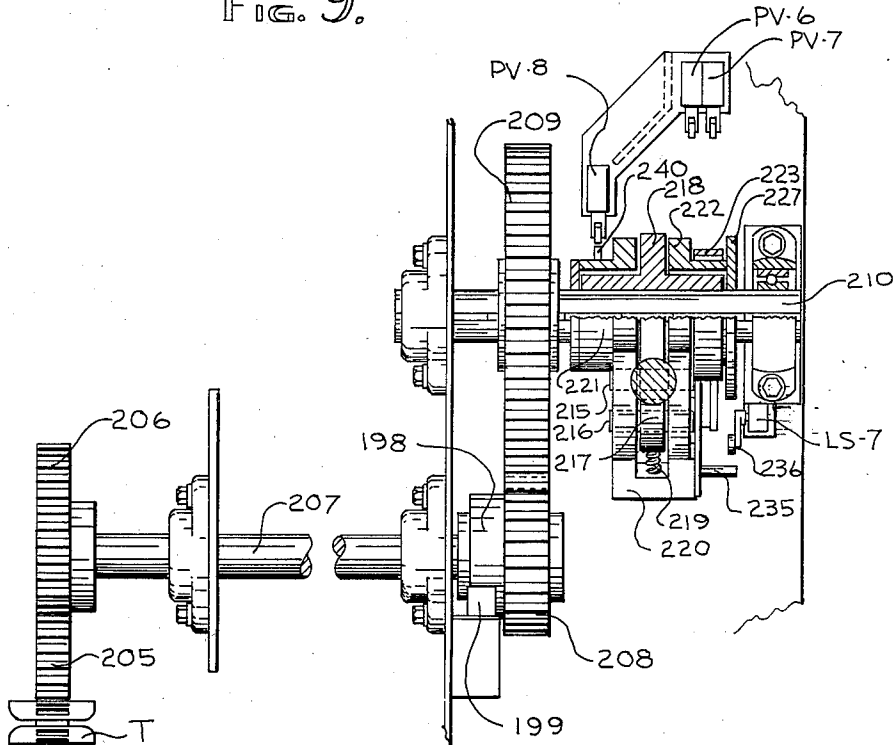


FIG. 10

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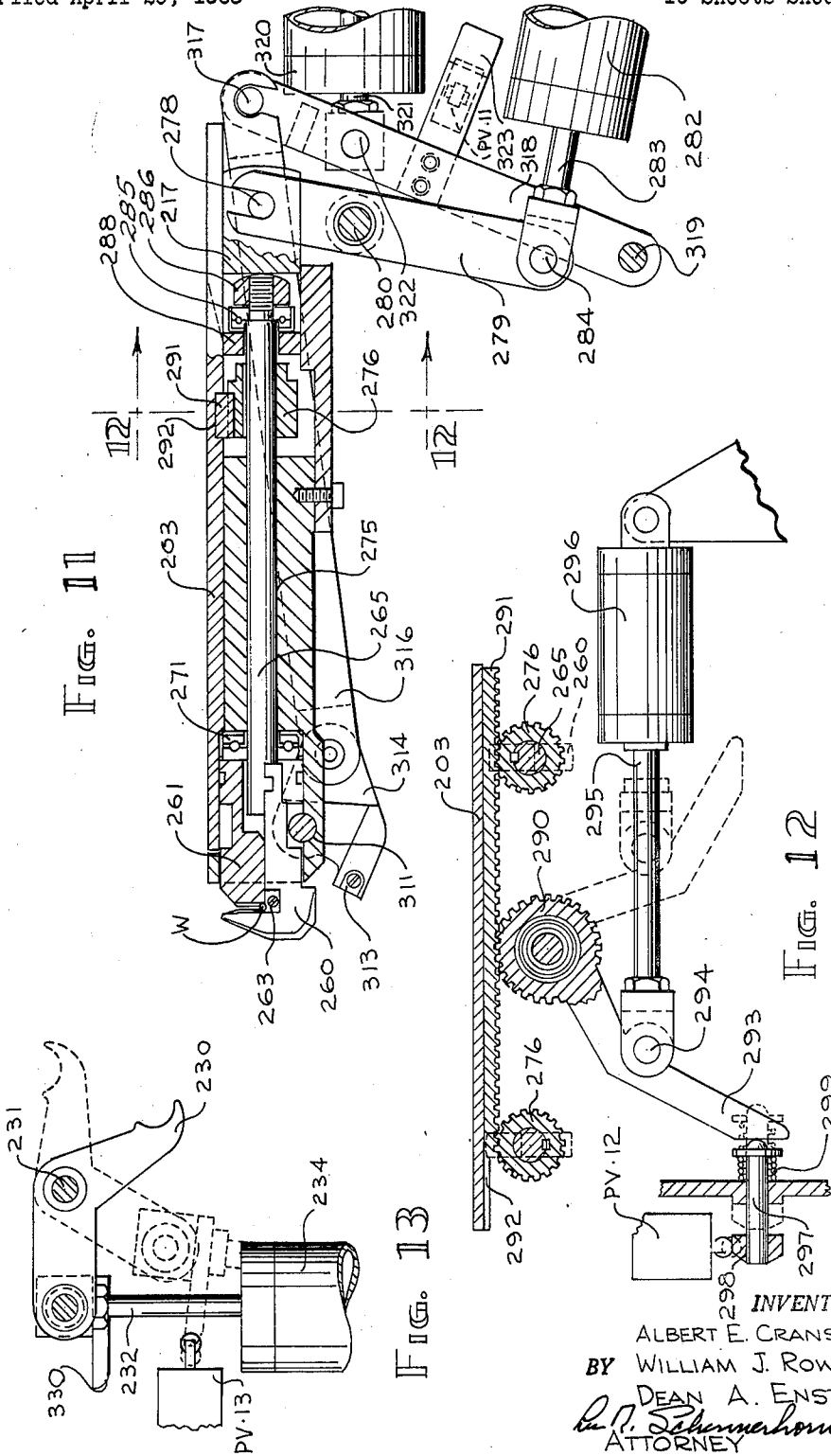
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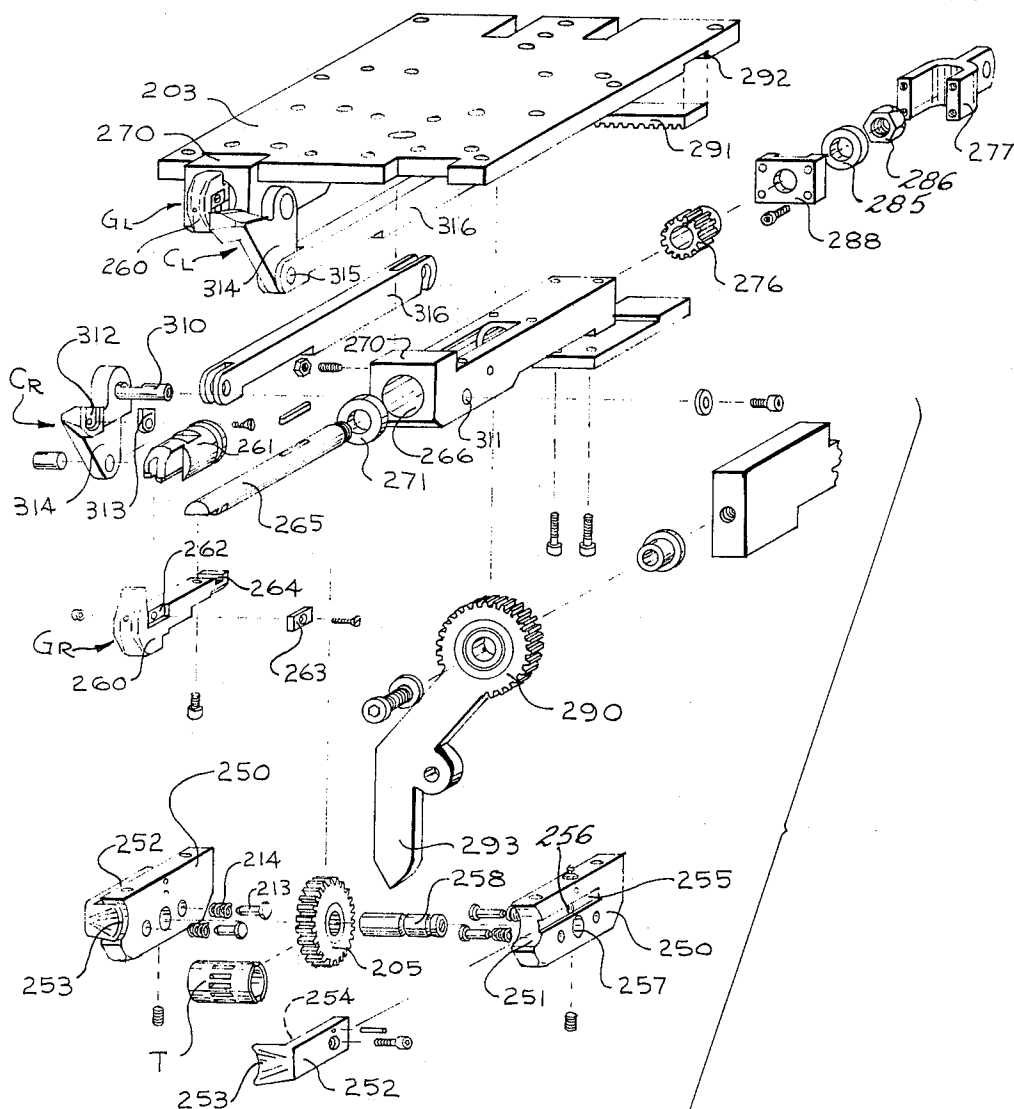


FIG. 14

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WIRE BINDING MACHINE

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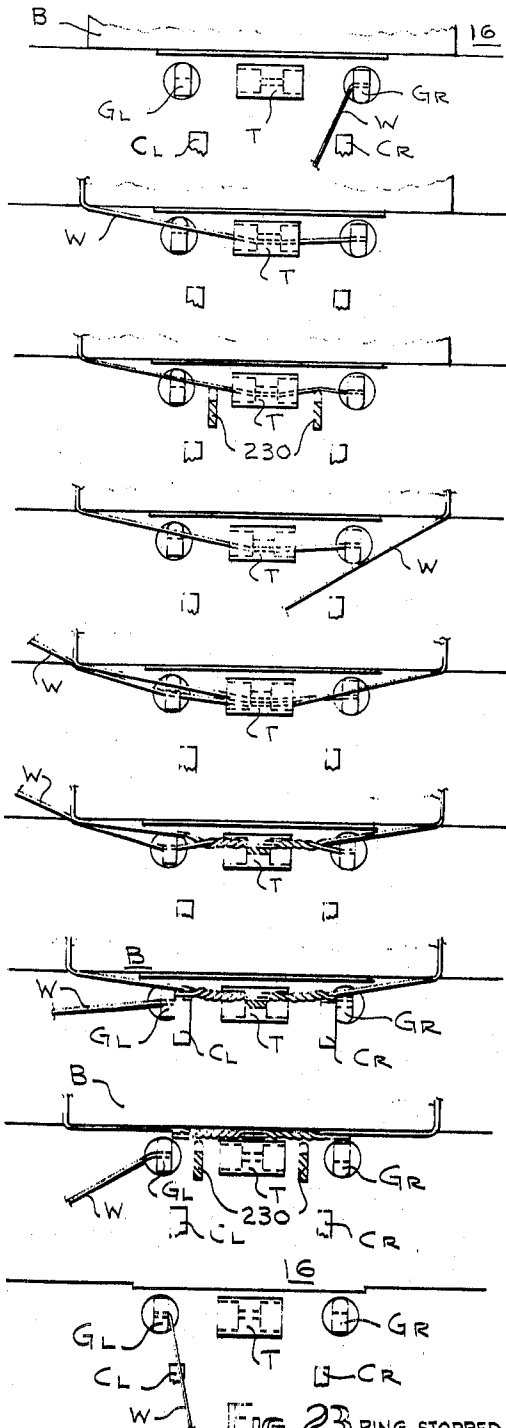


FIG. 15 MACHINE THREADED FOR CLOCKWISE ROTATION. BALE IN AND ACTUATION OF -LS-2.

FIG. 16 RING MOTOR ON. DOUBLE SHEAVES CROSS OVER CENTER WIRE NO 1 IN TWISTER GEAR.

FIG. 17 RING MOTOR ON. DOUBLE SHEAVES PASS CENTER. INJECT AND RETURN. LEFT GRIPPER OPEN.

FIG. 18 RING MOTOR ABOUT TO SHUT-OFF. WIRE NO.2 ENTERS AND PASSES OVER HEAD OF RIGHT GRIPPER.

FIG. 19 RING MOTOR-OFF. RING COASTS TO STOP. WIRE NO.2 INTO LEFT GRIPPER. LEFT GRIPPER CLOSED.

FIG. 20 TWISTER CYCLE STARTS WIRE TWISTING. WIRE TENSION IN TAKE UP. PULLS RING BACK

FIG. 21 RING COASTING BACK. TWIST COMPLETED. RIGHT GRIPPER OPEN. CUTTERS UP AND DOWN

FIG. 22 WIRE RING ABOUT 1/2WAY BACK. EJECTORS UP THEN RETRACT. KNOT IS NOW FREE FROM MACHINE.

FIG. 23 RING STOPPED BY RING BRAKE AND HOLD DOWN RETRACTS. GRIPPERS ROLLOVER. RT GRIPPER CLOSE. READY NEW CYCLE.

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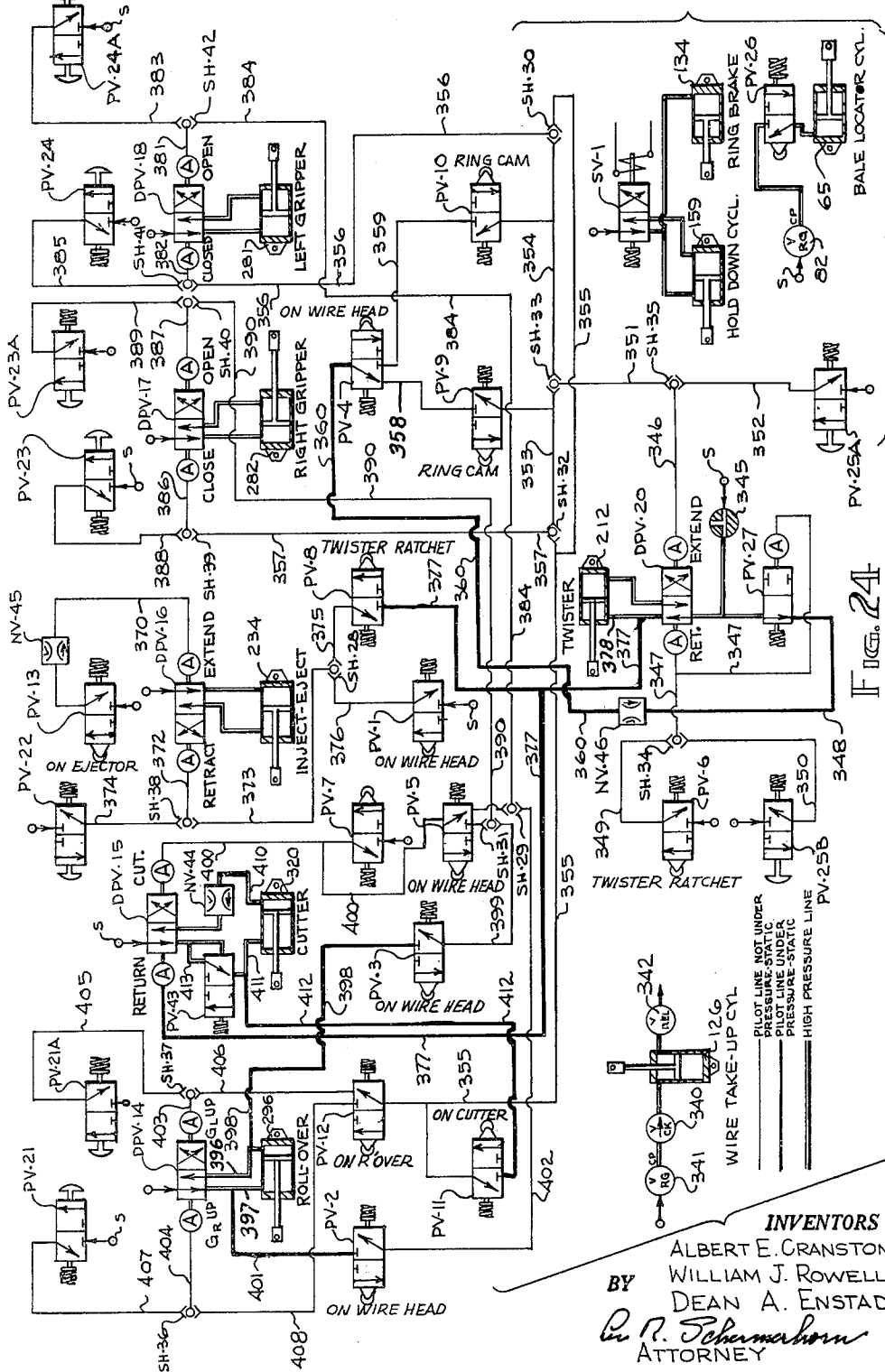
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10 Sheets-Sheet 10



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WIRE BINDING MACHINE

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Filed Apr. 29, 1963, Ser. No. 276,473

22 Claims. (Cl. 100—28)

This invention relates to a wire binding machine and has particular reference to improvements in a reversible rotary ring-type of machine.

The general objects of the invention are to reduce wire waste, obtain a faster operating cycle and provide a machine which is more trouble free and requires less maintenance than conventional machines. Even small improvements in any one of these factors is of considerable economic importance and improvement in all of them is of great importance to the user of the machine. When a binding machine is operating substantially continuously, the elimination of the waste of an inch or two of wire in each binding amounts to a considerable quantity of wire in a short time. Likewise, the saving of a second or two in each binding cycle allows many more cycles and a correspondingly increased work flow through the machine in the course of a day. The elimination of down time at the binding machine keeps production lines moving and eliminates costly interruptions to the work flow in the plant where the machine is used. In the aggregate, improvement of all of these factors may make it possible to handle the output of a plant or factory with a fewer number of binding machines.

Specific objects ancillary to the attainment of the foregoing general objects are to provide an improved arrangement of wire grippers, an improved and faster acting pneumatic and electric control system to control the many functions of the machine and a new and improved type of control mechanism for certain functions of the machine.

Wire waste is largely eliminated through the use of a new arrangement of roll-over grippers which function in such a way that the gripped end of the wire does not have to be cut from the knot or splice. This gripped end is shorter than in conventional practice and is left on the bundle as a part of the splice. This effects not only a saving in wire but also reduces trouble in operation by avoiding the problem of cut wire ends falling into the machine. There is no need for special devices to keep the cut ends out of the mechanism.

The control system is made faster and more trouble free by controlling many of the pneumatically operated functions of the machine directly by pilot valves and utilizing pilot air lines maintained normally under pressure. Conventional solenoid valves have been largely eliminated. In general, pilot valves are more rugged and less sensitive to dust, fumes and moisture in the air than the usual micro-switches. Some of the major functions of the machine are controlled in a new way by the movements of an oscillating wire head which follows the changing direction of lead of the wire to the wire laying ring as the ring revolves.

Still other objects and advantages will become apparent and the invention will be better understood from the following description of the preferred embodiment of machine illustrated in the accompanying drawings. Various changes may be made, however, in the construction and arrangement of parts and certain features may be used without others. Also, some of the improved features of the present machine are not limited to use with wire nor to a reversible ring-type of machine. All such changes

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and modifications within the scope of the appended claims are included in the invention.

In the drawings:

FIGURE 1 is a front elevation view of a binding machine embodying the principles of the invention;

FIGURE 2 is a left side elevation;

FIGURE 3 is a right side elevation;

FIGURE 4 is an enlarged fragmentary view of a portion of the wire laying ring;

FIGURE 5 is a sectional view taken on the line 5—5 of FIGURE 4;

FIGURE 6 is a sectional view taken on the line 6—6 of FIGURE 4;

FIGURE 7 is a front elevation view of the oscillating wire head;

FIGURE 7A is a sectional view of the oscillating wire head;

FIGURES 7B to 7H are views showing the movements of the actuating cams in FIGURE 7A;

FIGURE 8 is a right side elevation view of the twister gear drive mechanism with parts broken away;

FIGURE 9 is a view taken on the line 9—9 of FIGURE 8;

FIGURE 10 is a view taken on the line 10—10 of FIGURE 9;

FIGURE 11 is a vertical sectional view through the twister plate showing a gripper and cutter;

FIGURE 12 is a view taken on the line 12—12 of FIGURE 11;

FIGURE 13 is a fragmentary view of the wire inject-eject device;

FIGURE 14 is an exploded view of the twister plate mechanism including grippers and cutters;

FIGURES 15 to 23 are a sequence of views showing successive steps in the operation of the twister gear, grippers, cutters and wire inject-eject device in a binding cycle;

FIG. 24 is a schematic diagram of the pneumatic control system; and

FIGURE 25 is a schematic diagram of the electrical control system.

Machine in general

With reference to the general views in FIGURES 1-3, the machine has a frame 10 supported on a pair of widely spaced wheels 11 on its left side and a steerable double wheel 12 on its right side provided with a tongue 13 for convenience in moving the machine about. Mounted on rollers 14 around the periphery of a circular plate 17 in the frame 10 is a reversible wire laying ring 15. This ring surrounds an opening in plate 17 which forms a rectangular bundle passage 16. The frame further includes a base portion, right pedestal 18, left pedestal 19 and an interconnecting overhead bridge portion 20. The ring 15 defines a vertical wrapping or binding plane at the front side of the machine.

Power operated conveyor rollers 21 feed bundles into and out of the bundle passage 16 and control means are provided for properly positioning the bundles to receive a single wire binding or a plurality of bindings in predetermined positions on the bundle. This mechanism is designated as a bundle or wire locator. The left pedestal 19 carries a wire resistance device 22 and a slack take-up 23. The wire is fed to the ring through a novel swivel-mounted oscillating wire head 25 which through its swinging movements from side to side controls some of the major functions of the machine. This wire head forms a fairlead which operates a number of pilot valves and limit switches when the lead of the wire changes direction.

After being laid about a bundle, the wire is spliced in a twister unit and cut off. During these operations the wire

is held in a novel arrangement of grippers. Except for the ring and conveyor rollers, the various operating mechanisms are actuated by a pneumatic system which is controlled for the most part by mechanically and pneumatically actuated valves. The electrical system, which controls chiefly the ring and conveyor rollers, includes a portable console equipped with a control panel. The console is preferably mounted on wheels and connected with the machine by a flexible cable so that it may be placed in a convenient position for the operator.

A bundle coming into the bundle passage 16 on conveyor rollers 21 engages and rotates forward the meter wheel 30 in FIGURES 1 and 3. This meter wheel is mounted on a stub shaft on the upper end of the long arm of an L-shaped arm which is pivotally mounted at its lower end on a shaft 32.

The left end of shaft 32 in FIGURE 1 carries an index wheel 50. Index wheel 50 has one or more cams each individually adjustable about the circumference of the wheel 50.

Any one or combination of these cams can be pre-selected and installed in the proper location on wheel 50 to control the quantity and location of the bindings on any single bale. For example, by selection of the cams a bundle can be received, bound by any numbers of wires, then reversed and discharged from the conveyor, then turned by other means and reentered to receive more bindings perpendicular to the first bindings, then discharged in forward direction automatically.

Conveyor drive motor 55 in FIGURE 2 has a drive sprocket 56 which drives the back conveyor rolls on the left side of the machine by a chain 57. The front rolls are driven from the back rolls by a chain 61 on the right side of the machine, as shown in FIGURE 3.

The foremost and rearmost rollers extend across the width of the machine. The adjacent rollers are divided in the middle of the machine and the central rollers are interrupted in the middle by the twister plate. Thus, chain 57 drives all the left hand rollers back of the ring, and chain 61 drives all but one of the right hand rollers from the rearmost roller. A third chain 62 drives the left front rollers from the foremost roller. The left and right rollers in the plane of the ring are not driven.

Wire tension

Binding wire enters the machine through a resistance device and a slack take-up device. This device provides controlled resistance to the movement of the wire so that rotation of the wire ring 15 will tension the wire as it is laid about a bundle. The device is carried by a plate which is mounted in outstanding position on the left pedestal portion 19 of the machine as shown in FIGURE 1.

This deflects the wire into a circuitous path which imposes a resistance on the movement of the wire and also cold works the wire to relieve twisting strains when the wire is drawn from a supply coil in an axial direction.

A crosshead is mounted for sliding movement on a pair of vertical guides which are connected at their lower ends with the machine frame 10. This crosshead carries a pair of sheaves 122. Mounted in stationary position on the upper ends of the guides is a single sheave 123.

The wire enters the take-up from the wire tensioning or resistance device, then makes a double loop around the sheaves 122 and 123 and leaves the wire take-up over a sheave from whence it passes to the wire head 25 in FIGURE 1.

Wire ring and bundle holddown

The details of the wire laying ring are shown in FIGURES 4-6.

The side and top margins of bundle passage 16 in FIGURE 1 are defined by the edges of a transverse vertical frame plate 17 near the front of the machine. FIGURE 4 shows a portion of this plate at the upper right corner of

the bundle passage. The rollers 14, which support wire ring 15, are mounted for adjustment radially of the ring on eccentric studs 136 spaced around the circular margin of plate 17. The circular outer edge of plate 17 is spaced within the ring 15 and the latter is provided with an inner groove 137 which forms a track for the rollers 14, as shown in FIGURE 5.

Studs 138 in the forward edge of the ring carry sheaves 139 for the wire W. At one point on the ring two of these sheaves, here designated 140, are spaced close together to form a guide for laying the wire about a bundle as the ring revolves. The two sheaves 140 are also referred to as double ring sheaves for the purpose of designating this point on the ring, the other sheaves 139 being uniformly spaced around the ring. The ring is rotated by a flat belt 141. This belt is driven by a pulley 142 on an electric motor 143 as shown in FIGURES 1 and 2.

A brake shoe 131 engageable with the inner surface of the ring in groove 137 is provided, as shown in FIGURE 1, to stop the ring after the wire has been wrapped around a bundle and the splice has been completed and ejected from the twister gear. This shoe is mounted on arm 132 which is pivotally mounted at 133 on plate 17 for actuation by a piston in cylinder 134.

The positions of gripper control pilot valves PV9 and PV10 adjacent the ring band above the upper corners of the bundle passage are shown in FIGURE 1. The two valves are similar, the details of PV9 being shown in FIGURES 4-6. The valves are mounted in vertical position on plate 17, each having a downwardly projecting piston or plunger 145 equipped with a roller 146 on its lower end. An actuating arm 147 is pivotally mounted at 148 on plate 17. The portion of the arm on one side of the pivot which engages roller 146 is pulled against the roller by a tension spring 149 but this spring is insufficient to overpower the spring within the valve which normally holds the piston extended. On the other side of pivot 148 the arm has an opposite end equipped with a roller 150 which is engaged by a ring cam 151. When the cam engages the roller the valve plunger 145 is lifted to perform a valve function.

The cam 151 is mounted in one side of a groove 153 in the inside of ring 15. A similar cam, not shown, is mounted in the opposite side of groove 153 at a different position on the ring to actuate the other control valve PV10 in FIGURE 1 in a similar manner. The arrangement is such that valve PV9 is actuated only by the cam 151 while PV10 is actuated only by the other cam, the rollers 150 on the actuating arms of the two valves having the same width as the cams and being disposed in the planes of the respective cams. This is illustrated in FIGURE 6 with respect to the valve PV9.

FIGURE 1 illustrates a holddown bar 155 for clamping a bundle B in stationary position in the bundle passage 16. This bar is equipped at each end with a pair of guide fingers to straddle opposite sides of plate 17 and a roller 157 to roll on the vertical edge of the plate which defines the side of the bundle passage.

The bar 155 may be raised and lowered in the bundle passage by a piston rod in an air pressure cylinder 159. The cylinder is disposed in a notch in plate 17 and its upper end is connected to an inverted U-shaped mounting member. The vertical legs of the U-shaped mounting member are equipped with a series of bolt holes which may be brought into register with holes in plate 17 on opposite sides of the notch. Thus, for low bundles the cylinder may be mounted low in the notch while for higher bundles the cylinder may be mounted higher up in the notch so that the piston will always have about the same distance of travel for low and high bundles and will not have to travel through a long stroke to reach the top of a low bundle. A short stroke clamp movement saves air in the pneumatic system and saves time in each cycle of operation. In most uses of the machine the bundle size does not change frequently.

Oscillating wire head

FIGURES 7-7H show how the oscillating wire head or fairlead 25 in FIGURE 1 swings from side to side to actuate pilot valves and switches controlling some of the major functions of the machine.

The wire head comprises a hollow shaft 165 mounted for oscillation in bearings 166 at the peak of the bridge portion 20 of the machine frame. Referring back to previous views, it will be remembered that the wire leaves the take-up device over a sheave in a transverse direction from the left side of the machine toward the center of the machine. After leaving the take-up sheave the wire changes direction around a guide sheave 167 at the rear of the machine (FIGURE 2) and then proceeds forward through shaft 165, which is left to right in FIGURE 7A.

The wire leaves the forward end of shaft 165 through a bottom slot 168 which contains the upper side of a sheave 170. An ear 171 depending from the forward end of the shaft supports sheave 170 and also a block 172 which carries a pair of closely spaced lateral guide rollers 173. Above the guide rollers 173 is a back roller 174 on the ear 171 and a front roller 175 on the lower end of an arm 176 which hangs from a pivotal connection 177 on the front end of the shaft. From the lateral guide rollers 173 the wire proceeds to the ring sheaves 139, as shown in FIGURE 1.

Roller 175 deflects the wire slightly between sheave 170 and roller 174 for additional cold working. Roller 175 is held against the wire by a pin 178 in arm 176 which engages in a notch 179 in the under side of a handle lever 180. Lever 180 is pivotally mounted on ear 171 at 180A. Thus, arm 180 may be lifted up to move arm 176 and roller 175 out of the way for re-threading.

After the ring 15 reverses direction from clockwise to counterclockwise rotation and vice versa, the shaft 165 will swing from side to side following the direction of the wire in its course from the wire head 25 to the ring sheaves 139 and 140. When the ring is pulling the wire in counterclockwise rotation, as shown in FIGURE 1, the wire will leave the head 25 in the direction of line W_{cc} in FIGURE 7, and when the ring is pulling the wire in clockwise direction it will leave the head in the direction of line W_c . These are the two extreme positions of the head. As the double sheaves 140 in FIGURE 4 pass under the wire head in either direction of rotation, the wire direction will be straight down as shown in full lines in FIGURE 7.

Shaft 165 carries seven identical cams 181-187 between the bearings 166. Cams 181 to 184 and 187 are all set in the same position with the cam lobe in the same direction as sheave 170, as shown in FIGURES 7B to 7E and FIGURE 7H. Cam 185 is offset to the right as shown in FIGURE 7F and cam 186 is offset to the left as shown in FIGURE 7G.

A bracket 188 beneath the cams carries the five pilot valves PV1 to PV5. These are simple plunger or piston valves spring-actuated upward and equipped with roller cam followers for actuation downward by the cams. A bracket 189 carries the two limit switches LS3 and LS4 which are operated in a similar manner. In order to facilitate wiring, the switches are mounted to the left of the bank of valves as shown in FIGURES 7G and 7H.

Cams 181-184 actuate their respective valves only momentarily at the switch-over point of the head as indicated in full lines in FIGURES 7B-7E. The broken line positions of these cams correspond to the right and left wire positions W_c and W_{cc} in FIGURE 7 in which cam positions the valves return to their spring-actuated raised positions. W_c designates the wire position during clockwise rotation of ring 15 and W_{cc} designates the wire position during counterclockwise rotation. PV1 is an inject-eject pilot valve, PV2 is a left gripper open pilot valve, PV3 is a right gripper open pilot valve and PV4 is a selector pilot for gripper close right and left.

PV5 is a right and left gripper open selector pilot valve. This valve is cam actuated only in the wire position W_{cc} in FIGURE 7.

LS3 is a ring stop limit switch which is actuated only momentarily at the cross-over point of head 25. This switch actuation is timed the same as the valves in FIGURES 7B-7E, it being remembered that the switch is mounted in displaced position and that its cam 186 is similarly displaced on shaft 165. LS4 is a ring direction limit switch which is likewise displaced. This switch is timed to operate in synchronism with pilot valve PV5.

Twister unit

The twister unit for splicing the wire is shown in FIGURES 8, 9 and 10. This is often referred to as a knotter. A twister gear T having a pair of diametrically opposite wire receiving slots 201 and 202 is mounted in bearings for rotation just below the level, and adjacent the forward (left in FIGURE 8) edge, of twister plate 203 which also carries the grippers and cutters. The twister gear is driven through intermediate gear 205 from a twister drive gear 206. The latter is fixed on a shaft 207 carrying a driven gear 208. Shaft 207 also carries an index cam 198 having a single notch engaged by a spring pressed index pawl 199. Gear 208 is driven by a ratchet gear 209 on a shaft 210 which also carries a number of other elements.

Rotation of the above gear train is produced by a piston rod 211 in a pneumatic cylinder 212 which appears in the right pedestal 18 of the machine frame in FIGURE 1. The lower end of the piston rod is pivotally connected at pin 215 with a set of side plates 221 and 222 which carries a pivotally mounted pawl 217 on pin 216. The pawl is pressed into engagement with a notched ratchet plate 218 on the shaft 210 by means of a compression spring 219 which is interposed between the pawl 217 and the pawl block 220. Pawl block 220 is mounted to the pair of side plates 221 and 222 which are mounted for rotation on the hub of the ratchet plate 218.

The hub of side plate 22 has a cylindrical braking surface within a brake band 223. The brake band is carried by a stationary brake mounting ring 227. The brake tension is adjustable through nuts 224 and springs 225 on a bolt 226 which passes through apertured ears on the ends of the brake band 223. This brake is operating at all times but is effective only when the cylinder rod 211 is retracted and rotates the side plates 221 and 222 in a clockwise direction. The applied pressure on this brake is set to transmit this rotary movement to the ratchet hub 218 and hence to the gear 209 which in turn transmits movement through the gear train to the twister gear T. The actual movement of gear T at such time is approximately 90° rotation at the end of which the index pawl 199 engages the stop shoulder on cam 198. At this time the cylinder rod will still be returning but the rotation of shaft 210 will be stopped through gear 209. The brake band 223 at this time only slips around side plate hub 222 until rod 211 is fully retracted.

At the start of a twisting cycle the twister gear is on index as described above, the wire receiving slots being straight up and down (202 at bottom will receive wire). During the twisting cycle the twister gear rotates clockwise as seen in FIGURE 8 approximately 3/4 rotations. Then upon return of the cylinder rod 211 the twister gear T is returned approximately 1/4 turn or 90° in the counterclockwise direction until the slot 202 is on center and straight up which will be on index. This then allows ejection of the spliced wire.

When the index pawl 199 contacts its mating stop in hub 198, any bouncing or fractional rotation of the attached shaft 207 is prevented by four brake pins 213 against intermediate gear 205 (FIGURE 14). These pins 213 are always under pressure by springs 214.

Wire injecting and ejecting fingers 230 are pivotally mounted at 231 in front of the twister gear T. These

fingers are actuated by a piston rod 232 in an air cylinder 234. When the wire is in the bottom slot of the twister gear, the fingers move upward on opposite sides of the gear to inject the wire to the top of the slot and, when the wire holding slot later turns upward, the fingers eject the wire from the slot.

The twister unit also includes various control switches and pilot valves for controlling the operation of the machine. Adjacent the ratchet plate 218 are mounted conveyor restart limit switch LS7 and pilot valves PV6, PV7 and PV8. Pilot valve PV6 is a knotted index, pilot valve PV7 is a cutter actuating valve and pilot valve PV8 actuates the wire ejecter. Pawl block 220 carries a pin 235 arranged to engage the actuating arm 236 of switch LS7. Extending downward from the pawl block is an arcuate arm 237 carrying a pair of cams 238 and 239. The former actuates valve PV6 and the latter actuates valve PV7. A cam 240 on side plate 221 actuates the valve PV8.

Grippers and cutters

The twister plate 203 carries twister gear T, left and right grippers G_L and G_R , and left and right cutters C_L and C_R as shown in FIGURES 11, 12 and 14. FIGURE 14 shows the left gripper and left cutter mounted on the twister plate, and the right gripper, right cutter and twister gear removed from the twister plate.

The twister gear is mounted on a pair of twister gear bearing blocks 250 which are attached to the under side of the front end of the twister plate. These bearing blocks have arcuate bearing surfaces 251 on their front ends which fit the end journal portions of the twister gear T at one side of the wrapping plane of the wire. The twister gear is retained in these bearings by a pair of retaining fingers 252 which have angled arcuate forward end portions 253 projecting into the opposite hollow ends of the twister gear without obstructing the wire slots. The back sides of the straight rear portions of the retaining fingers have splines at 254 to fit horizontal grooves 255 in the bearing blocks where they are secured by screws in holes 256. The bearing blocks also have transverse bores 257 to support the ends of a short shaft 258 for the intermediate gear 205 which drives the twister gear. This mounting arrangement permits convenient removal of the twister gear for repair.

Each gripper has a removable jaw 260 which reciprocates to open and close the gripper and a stationary jaw 261 which does not reciprocate. Each movable jaw 260 has a recess 262 on one side to receive a hardened cutter plate 263. These cutter plates are on the sides of the jaws which face the twister gear T when the jaws are turned downward as is the case with the left gripper G_L in FIGURE 14.

The rear end of each movable jaw 260 is transversely notched and fingered at 264 to fit a mating configuration on the front end of a gripper shaft 265. This mating connection is contained within the stationary jaw 261 which has a cylindrical exterior surface for rotation in a cylindrical bore 266 in a gripper shaft guide block 270. The guide blocks 270 for the two grippers are mounted on the under side of twister plate 203 spaced from opposite ends of the twister gear T. The inner end of stationary jaw 261 bears against a thrust bearing unit 271 which is seated against a shoulder in bore 266, as shown in FIGURE 11.

Gripper shaft 265 is supported for rotation in longitudinal sliding movement in a cylindrical bore 275 in guide block 270. Rotary movement is imparted through a roll-over gear 276 which is splined to the shaft. Longitudinal movement is imparted by a yoke 277 which is closed by an end plate 288. A thrust bearing unit 285 is confined between end plate 288 and a nut 286 on the rear end of the shaft. Yoke 277 is connected by a pin 278 on an actuating arm 279. The arm 279 is mounted for pivotal movement on a shaft 280 by means of gripper

cylinder 282 which is the right gripper cylinder. Piston rod 283 is pivotally connected at 284 with the arm 279. The left gripper is similarly constructed and operated by a left gripper cylinder 281 which appears only in the schematic diagram of the pneumatic system, FIGURE 24.

The grippers are rotatable in unison through 180° by a roll-over drive gear 290 which is in mesh with a rack bar 291. Rack bar 291 slides in a groove 292 in the under side of the twister plate 203 and is meshed with the roll-over gears 276 of both grippers.

Integral on the gear 290 is an arm 293 having pivotal connection at 294 with a piston rod 295 in roll-over cylinder 296. When the piston rod is fully extended as shown in FIGURE 12, the lower end of arm 293 depresses a plunger 297 which carries a cam 298 to actuate the valve PV12. When piston rod 295 is retracted, the plunger 297 is extend to the right by spring 299 so that the valve is no longer actuated by cam 298. PV12 is a gripper roll-over selector pilot valve.

Each cutter is mounted on a stub shaft 310 for rotation in a transverse cylindrical bore 311 in one of the gripper shaft guide blocks 270. The cutter has a recess 312 to receive a hardened cutting blade 313 which is arranged for movement in cooperative shearing relation with the cutting blade 263 of the adjacent gripper jaw, as shown in FIGURE 14 in the case of the left gripper and left cutter. The cutter has an actuating arm 314 which is pin connected at 315 with the front end of cutter link 316. The rear ends of both cutter links 316 are pivotally connected at 317 with a double arm 318 which is pivotally mounted at its lower end at 319. Both arms are connected together for movement in unison by the cutter cylinder 320 which has a piston rod 321 pivotally connected with the arms at 322. Mounted on the arms is a bracket 323 carrying an actuating lug for cutter return pilot valve PV11.

FIGURE 13 shows actuating lug 330 for inject-eject return pilot valve PV13. This lug is mounted on piston rod 232 of inject-eject cylinder 234.

FIGURES 15-23 illustrate the different phases of the twister cycle in a clockwise binding operation. This cycle starts in FIGURE 15 with the end of the wire secured in the closed right gripper. The right gripper faces upward and the left gripper, which is also closed, faces downward. For reference, this is the orientation of the grippers illustrated in FIGURE 14. The twister gear is in the position shown in FIGURE 8 with its slots in a vertical plane. As the ring 15 starts to rotate clockwise, the wire is laid in the bottom slot of the twister gear and then slides across the sloping nose of the closed left gripper without entering the gripper and proceeds upward around the left side of the bundle B, as shown in FIGURE 16.

As the double sheaves 140 pass over top center position, the left gripper opens and wire injector fingers 230 are actuated upward to force the wire to the bottom of the twister gear slot as shown in FIGURE 17. The injector fingers are immediately retracted. In FIGURE 18 the wire has passed completely around the bundle and the ring motor is about to shut off. The wire passes over the head of the closed right gripper into the twister gear slot and into the open left gripper which then closes, as shown in FIGURE 19.

Then the twister cycle starts and twists a knot or splice as shown in FIGURE 20. While this is occurring, the wire tension in the take-up device starts to pull the ring back in counterclockwise rotation. In FIGURE 21 the right gripper has opened to free the end of the wire and the cutters have moved upward in unison. Since the right gripper is open and facing upward, the wire is cut only at the left gripper and then the cutters retract downward. While this is occurring, the ring is turning back in counterclockwise rotation and the cut end of the wire from the take-up device is now secured in the left gripper which is facing downward.

In FIGURE 22 the fingers 230 are again actuated, this time functioning as ejector fingers to eject the splice from the top side of the twister gear. In the twisting of the splice, the twister gear has made an odd number of half revolutions so that the slot containing the wires stops in an upward facing direction whereby when the splice is ejected from the twister gear, it is free of the machine. The double sheaves 140 on the ring are now approaching bottom position as indicated by the direction of the wire from the left gripper whereby this part of the wire is also clear of the bundle.

In FIGURE 23 the ring has been stopped by its ring brake with the double sheaves 140 in approximately bottom position. The grippers have rotated 180° counterclockwise so that the open right gripper now faces downward and the left gripper, which is closed on the cut wire end, faces upward. The twister gear presents its opposite slot downward for reception of the wire in the next binding cycle, which will be in a counterclockwise direction of ring 15, and the right gripper closes.

This leaves the grippers and twister gear all in reverse positions relative to FIGURE 15 for the start of a counterclockwise cycle. In the counterclockwise cycle the same events occur with the wire moving in the opposite direction and the gripper functions reversed with respect to the right and left grippers. At the end of the cycle the parts are returned to their FIGURE 15 positions for another clockwise cycle.

Pneumatic system

FIGURE 24 illustrates the pneumatic control system for the machine. This system involves, essentially, cylinder and piston units and various types of valves, all shown diagrammatically by conventional symbols. The numerals identifying these valves are prefixed by letters indicating the type of valve.

The pilot valves, which are the pneumatic equivalent of push button switches and limit switches in an electrical system, comprise the PV series. These valves are three way piston type, spring actuated in one direction and actuated in the opposite direction by moving parts of the machine or push buttons, or in some cases, by air. Slave valves, which function as pneumatic relays, are designated as double pilot valves and comprise the DPV series. These are four way valves actuated in opposite directions by air as indicated by the letter A in a circle. Solenoid valves are designated SV.

The system also includes a considerable number of double check valves which are designated as shuttle valves in the SH series. These are all embodied in T fittings having two opposed inlet connections communicating with a single outlet at right angles. When pressure is applied to either inlet the valve closes the other inlet, the outlet always being in communication with the open inlet. Several flow control valves are included, in the NV series. These valves restrict the flow of air in the direction of the arrow and provide unrestricted flow in the opposite direction as shown, for example, in U.S. Patent 2,841,174.

In order to simplify the diagram, the air supply lines are not shown. Instead, each air supply connection is indicated by a conventional circle and arrow symbol which is identified by the letter S in certain instances. Double lines on the drawing indicate high pressure lines carrying working pressure and volume for the various cylinder and piston units. Heavy single lines indicate pilot or control lines which are under pressure in the static condition of the system, and light single lines indicate pilot or control lines which are not under pressure in static condition. As previously explained, one important feature of the machine is the maintenance of pressure in many of the conduits of the control system so that time and air are not expended in bringing such conduits up to pressure when a machine function is signalled.

The auto (bundle) locator cylinder 65 is controlled by pilot valve PV26, the source of air being obtained through pressure regulating valve 82 from supply S.

Wire take-up cylinder 126 is supplied with air through check valve 340 and pressure regulating valve 341. When the piston is pulled upward in the cylinder by the wire pulling action of the ring 15 in laying the wire about a bundle, the maximum pressure in the upper end of the cylinder is limited to a predetermined value by relief valve 342 which exhausts to atmosphere. This valve is adjusted to open at a higher pressure than the pressure of the incoming air from valve 341. When the ring motor is deenergized the pressure in the upper end of the cylinder forces the piston down to reverse the ring and take up slack. Then, as the cylinder pressure falls with the movement of the piston, more air is admitted through valve 341. When wire tension pulls the piston upward, check valve 340 prevents reverse flow back into the supply pipe, and valve 342 relieves the excess pressure.

Ring brake cylinder 134 and holddown cylinder 159 are supplied through a solenoid valve SV1. The latter cylinder is double acting to retract the pressure bar, and SV1 is a reversing valve for this cylinder.

Twister cylinder 212 is controlled by double pilot valve DPV 20. Air is supplied through this valve under the control of a manual shutoff valve 345. DPV 20 is actuated in a direction to extend the twister piston by pressure in a pilot line 346 and is actuated in the reverse direction to retract the twister piston by pressure in a pilot line 347. One branch of the latter provides actuating pressure for pilot valve PV 27 which is connected to the air supply to apply pressure in a pilot line 348 while another branch is connected to the output side of shuttle valve SH34. PV27 prevents re-cycling of the twister operation.

SH34 is typical of numerous shuttle valves in the system which are double check T's having two inlet connections and one outlet connection. Pressure in either one of the inlet connections closes the other inlet connection. Thus, in this case, the inlet connections are 349 and 350, the former leading from pilot valve PV6 and the latter from push button pilot valve PV25B.

Pilot line 346 is similarly connected to the outlet of shuttle valve SH35 which has inlet connections with pilot lines 351 and 352. The latter is supplied from push button pilot valve PV25A while the former is connected with the outlet connection of shuttle valve SH33. The latter has inlet connections with pilot lines 353 and 354. The latter is connected to pilot valve PV10 and is also connected to one of the inlet connections in shuttle valve SH30. Pilot line 353 is connected to pilot valve PV9 and is also connected to one of the inlet connections of shuttle valve SH32. A branching pilot line 355 is connected with the other inlet connections in shuttle valves SH30 and SH32 and is arranged to be pressurized by other connections to be described presently.

The outlet connection of SH30 is connected with a pilot line 356 while the outlet connection of SH32 is connected with pilot line 357. Pilot valves PV9 and PV10 are connected through pilot lines 358 and 359 with pilot valve PV4. Pressure for the latter valve is obtained through pilot line 360 which is connected through flow control valve NV46 with pilot line 348. NV46 is a typical flow control valve wherein the flow of air is restricted in the direction of the arrow and unrestricted in the opposite direction. The restriction is manually adjustable. The purpose of the restriction here is to delay operation of the twister until the gripper, which has just been actuated to closed position, has time to clamp the wire securely.

Inject-eject cylinder 234 is supplied and controlled by double pilot valve DPV16. This valve is actuated in one direction by pilot line 370 under the control of flow control valve NV15 and pilot valve PV13. The purpose of the restriction here is to control the speed of movement of the wire inject-eject fingers. It is actuated in the other direction by pilot line 372 which is connected to shuttle

valve SH38 to be pressured from either one or the other of pilot lines 373 or 374. The latter is supplied and controlled by push button pilot valve PV22. Pilot line 373 is connected to the outlet of shuttle valve SH28 for supply by one or the other of pilot lines 375 or 376. The latter is supplied and controlled by pilot valve PV1. Pilot line 375 is controlled by pilot valve PV8. The latter is supplied by pilot line 377 from pressure line 378 connected with the lower end of twister cylinder 212.

Left gripper cylinder 281 is supplied and controlled by double pilot valve DPV18. This valve is actuated in one direction by pilot line 381 and in the opposite direction by pilot line 382. The former is connected to the outlet of shuttle valve SH42 which is supplied by one or the other of pilot lines 383 or 384. The former is supplied and controlled by push button pilot valve PV24A. Pilot line 382 is connected to the outlet of shuttle valve SH41 which is supplied by one or the other of pilot lines 385 or 386. The former is supplied and controlled by push button pilot valve PV24.

Similarly, the right gripper cylinder 282 is supplied and controlled by double pilot valve DPV17. This valve is actuated in one direction by pilot line 386 and in the opposite direction by pilot line 387. The former is connected to the outlet of shuttle valve SH39 which is supplied by one or the other of pilot lines 387 or 388. The latter is supplied and controlled by push button pilot valve PV23. Pilot line 387 is connected to the outlet of shuttle valve SH40 which is supplied by one or the other of pilot lines 389 or 390. The former is supplied and controlled by push button pilot valve PV23A. The latter is connected to the outlet of shuttle valve SH31.

Roll-over cylinder 296 has high pressure lines 396 and 397 connecting the inner and outer ends of the cylinders, respectively, with double pilot valve DPV14. Pressure line 396 is connected with pilot line 398 which leads to pilot valve PV3. Another pilot line 399 continues from PV3 to one of the inlets of shuttle valve SH31. The other inlet of this shuttle valve is connected with pilot valve PV5. This pilot valve is supplied from pilot line 400 which has one branch connected with pilot valve PV7 and another branch connected to actuate double pilot valve DPV15 in one direction. Double pilot valve DPV15 is actuated in the opposite direction by pilot line 377.

Pressure line 397 from roll-over cylinder 296 has a branch pilot line 401 to supply pilot valve PV2. Leading from this valve is a pilot line 402 to one of the inlet connections of shuttle valve SH29. The other inlet connection of this shuttle valve is connected with pilot valve PV5.

Double pilot valve DPV14 is actuated in one direction by a pilot line 403 and in the opposite direction by pilot line 404. The former is connected with the outlet of shuttle valve SH37 which is supplied by one or the other of pilot lines 405 or 406. The former is supplied and controlled by push button pilot valve PV21A while the latter is supplied and controlled by pilot valve PV12. Pilot line 404 is connected with the outlet of shuttle valve SH36, the inlets to this valve being supplied by one or the other of pilot lines 407 or 408. Pilot line 407 is supplied and controlled by push button pilot valve PV21. Pilot line 408 is controlled by pilot valve PV12.

Cutter cylinder 320 has pressure lines 410 and 411 connected with its inner and outer ends, respectively. Pressure line 410 is connected through flow control valve NV44 to double pilot valve DPV15 and pressure line 411 is connected to pilot valve PV43. The purpose of the restriction here is to control the speed of operation of the cutters. Pressure line 411 is also connected with a pilot line 412 which supplies pressure to pilot valve PV11. The outlet of this valve is connected with a branch of pilot line 355 which is in turn connected with pilot valve PV12. Outlets for this valve are connected with pilot lines 406 and 408. Pilot valve PV43 has a branched connection

413 which supplies pressure to actuate itself from double pilot valve DPV15.

From the foregoing it will be observed that each of the six double acting cylinders for the twister, injector, grippers, rollover and cutters (212, 234, 281, 282, 296, 320) is controlled by a double pilot valve (DPV20, 16, 17, 18, 14, 15). Further, each of these double pilot or slave valves is connected for pneumatic control by automatic cycle means and also (except the cutters) for individual selective operation by manual push button means (PV25A, 25B, 22, 23, 23A, 24, 24A, 21, 21a). Each of the push button pilot valves is connected into the automatic cycle system through a shuttle valve. Other shuttle valves similarly provide for dual control of such functions by separate means operative in the two directions of rotation of ring 15 as, for example, the pilot valves PV1 through PV5 which are actuated by the swinging movements of oscillating wire head 25.

Electrical system

FIGURE 25 illustrates the electrical control system. This system is energized from power lines 430 through transformer 431. The secondary of the transformer is connected to wires 432 and 433. Wire 433 is connected through three emergency stop switches ES1, ES2 and ES3 with a wire 434 to emergency stop relay solenoid C5. This relay is normally deenergized, causing a line 435 to be energized through the normally closed relay switch C5a. The emergency stop switches are located at convenient points about the binding machine and its control console whereby the closing of any one of these switches energizes relay C5 to open its switch and de-energize line 435. After an emergency stop, relay switch C5b is closed and relay C5 may be deenergized by opening reset switch RS1. The remaining components of the electrical system are energized from lines 432 and 435 whereby all functions of the machine are stopped when line 435 is deenergized.

The machine may be operated in a fully automatic binding cycle or step by step under manual control by a manual selector switch unit comprising the four switches SS1, SS2, SS3 and SS4 which are mechanically connected together for operation in unison. These switches have three positions designated as automatic, off and hand. SS2 and SS4 are connected directly to line 435 while SS1 and SS3 are connected to line 435 through the normally closed contacts C3a and C3b of relay C3. In hand position, switch SS1 energizes wire 436 to operate hand signal light 437 while in automatic position the switch energizes wire 438 to operate automatic signal light 439. Selector switch SS2 performs the sole function of energizing wire 440 when the switch is in automatic position. Selector switch SS3 energizes wire 441 in hand position and wire 442 in automatic position. Selector switch SS4 energizes wire 443 in both hand and automatic positions.

There are four main start relays, CMF, conveyor motor forward, CMR, conveyor motor reverse, RML, ring motor left, and RMR, ring motor right. The functions of these relays are self-explanatory and it is not deemed necessary to illustrate the power circuits to the conveyor motor and ring motor.

The direction of the conveyor motor is further controlled by conveyor direction relay C1 which is also a reversing relay. This relay is energized by a branched wire 445 which connects with limit switch LS1 and thence through the normally closed contacts TD2a of time delay relay TD2 to wire 440. A holding circuit 446 through relay contacts C1a is connected around LS1.

Another branch of wire 445 extends to a switch 447 which is ganged with manual conveyor run switch CM5. Both of these switches are connected with wire 441. Switch 447 connects with wire 445 in the conveyor run reverse position while CM5 connects with wire 442a in both run forward and run reverse positions.

Also connected with wire 441 is a manual conveyor jog switch CM4 having a forward position connecting with

wire 448 and a reverse position connecting with wire 449. Conveyor direction relay C1 is a reversing switch which causes the conveyor motor to run in reverse direction when this relay is energized. When the relay is not energized, the conveyor motor runs in a forward direction.

The conveyor start relays CMF and CMR are controlled by a number of switches. Both of these relays are connected to line 432 through two normally closed switches OL in series. These are protective overload circuit breakers. The other side of CMR relay solenoid is connected through contacts CMF_a to wire 444, and the other side of CMF relay solenoid is connected through relay contacts CMR_a to wire 448. Wire 449 is connected through relay switch C2_a with wire 444 and through relay switch C1_b with a wire 450. Wire 448 also connects through relay switch C1_c with a wire 451. This wire connects through zero speed reverse switch ZSR with wire 443 and also with conveyor re-start limit switch LS7_a which is connected to wire 442a. In a parallel circuit wire 451 connects with wire 442a through the relay switch CMF_b. Wire 444 connects with wire 443 through zero speed forward switch ZSF. Conveyor start jog switch CM2 is connected between wire 442a and wire 450.

The purpose of the zero speed switches is to stop the conveyor motor rapidly by plugging when its energizing circuit is opened in either direction of movement. When the circuit is opened, these switches reverse the electrical field until the speed is reduced to near zero.

A double wire circuit is also provided to prevent movement of the conveyor while a second binding is applied to the bundle in the same position as a previous binding. This circuit involves double wire selector switch CM6 which is connected with wire 440. In the double wire position this switch connects with wire 460 which is connected through double wire limit switch LS8 to a wire 461. The wires 460 and 461 are also connected together in a shunt circuit through time delay relay switches TD3_a and TD3_b. This circuit from wire 460 energizes double wire time delay relay TD3. Wire 442_a is normally energized through the switch TD3_a of this relay. When TD3 is first energized, switches TD3_a and TD3_c are immediately closed by the relay solenoid and switch TD3_b is already closed. Then after an interval TD3_b opens by action of the time delay device. This double wire circuit is an optional or auxiliary circuit and may be omitted when only single wire bindings are desired.

Conveyor time delay relay TD2 is energized from wire 442 through TD3_a normally closed auxiliary contacts, and wire 442_a through a switch CMR_b of the conveyor motor reverse relay CMR.

The pressure bar is actuated downward by solenoid valve SV1 which is in parallel circuit with relay solenoid C3. This circuit is energized through conveyor restart limit switch LS7_b from wire 462. One branch of wire 462 is connected through a switch C3_c in relay C3 to line wire 435, and another branch is connected through a switch C2_a in relay C2 to a wire 464. One branch of the latter energizes cycle protection relay C2. The function of the cycle protection relay is to prevent conveyor movement until the twister cycle has been completed and the pressure bar has been lifted.

Ring motor right relay RMR is energized through relay switch RML_a from a wire 471, and ring motor left relay RML is similarly energized through relay switch RMR_a from a wire 472. Wire 471 connects with ring direction switch LS4_a, the ring jog right contact of ring control switch RC3 and relay switch RMR_b. Wire 472 connects with ring direction control switch LS4_b, the relay switch RML_b and the ring jog left contact of RC3. LS4_a, LS4_b, relay switches RML_b and RMR_b are all connected to wire 473. This wire is connected to wire 464 through relay switch C2_b. RC3 is connected to wire 436.

Right and left ring direction control switches LS4_a and LS4_b in FIGURE 25 are actually combined in a single switch. This is a single pole, double throw switch desig-

nated as LS4 in FIGURE 7A and 7H. When LS4_a is closed for right-hand rotation, LS4_b is open and when LS4_b is closed for left-hand rotation, LS4_a is open.

Manual cycle switch RC2 is connected to wire 436 and has a single contact connected to wire 464. Conveyor stop cycle switch LS2 is connected between wires 438 and 464. Time delay switch TD3_c shunts LS2. Switch TD3_c is a part of the optional double wire circuit and is omitted when only single wire bindings are desired.

Seal relay C4 and ring time delay relay TD1 are energized in parallel from wire 475. TD1 and TD2 are not true time delay relays since they have no auxiliary contacts. They are merely timers and require the use of an added relay for holding circuit contacts. Wire 475 is connected with ring motor stop switch LS3 and a switch C4_a in relay C4. Both of these switches are also connected with wire 473. Relay switches TD1_a and C2_c are connected in series between wires 435 and 464.

Automatic cycle operation

The machine can be operated manually step by step or in a completely automatic binding cycle. In either case, in static condition before the machine is started, the pilot lines in FIGURE 24 shown in light lines are not under pressure and the pilot lines shown in heavy lines are under the control pressure which is used in the system. The pilot lines under pressure at start are 348, 360, 377, 398 or 401; depending upon previous direction of ring rotation, and 412. Certain of the high pressure lines designated by double lines are under working pressure depending upon the positions of the valves controlling these lines.

An automatic cycle operation will be described first, assuming the machine to be threaded for clockwise or right hand rotation. The various switches in FIGURE 25 will be in the positions shown, assuming that the machine has just completed a cycle in left hand or counter-clockwise rotation of the wire laying ring. To start an automatic cycle, the selector switch SS1-4 is placed in "auto" position and the conveyor start switch CM2 is closed. This completes a circuit to normally closed C1_c contacts and CMR_a contacts to energize the conveyor motor forward relay CMF which closes a holding circuit for itself through the normally open CMF_b contacts. CM2 is a push button switch which reopens itself.

As the forward moving conveyor brings the bundle into the machine, it rotates meter wheel 30 and index wheel 50 forward. As the bundle reaches the first wire location, a cam lug actuates limit switch LS2. The closing of this switch produces a momentary pulse of current to C2 relay closing contacts C2_a, C2_b and C2_c. C2_c makes a holding circuit for C2, and C2_a energizes relay C3 and solenoid valve SV1 through closed LS7 to actuate the pressure bar. Relay C3 closes a holding circuit for itself through LS7_b and C3_c.

Operation of relay C3 opens the normally closed contacts C3_b to the conveyor circuit breaking the holding circuit for CMF through CMF_b. While the conveyor is in forward motion there is a secondary circuit from conveyor motor reverse relay CMR through normally closed CMF_a and through the zero speed switch ZSF. When CMF_a recloses, this secondary circuit plus CMF, giving instant conveyor stop.

The closing of relay C2 closes its normally open contacts to the ring starters. Limit switch LS4 on the oscillating wire head determines the direction of rotation of the ring. As shown on the drawing, it calls for clockwise or right hand rotation, LS4_a causing the RMR starter to be closed, which establishes a holding circuit for itself through its own normally open contacts RMR_b, through two sets of other C2 normally open contacts C2_b and C2_c and through time delay relay TD1_a. Relay RMR also opens its normally closed contacts RMR_a to RML relay, providing electrical lockout to the reversing starter.

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As the ring rotates clockwise, the wire head 25 is pulled across center, closing limit switch LS3. This gives a pulse to relay C4 and time delay relay TD1. Relay C4 establishes a holding circuit for itself and TD1 through its own normally open contacts C4_a, wire 473, C2_b, wire 464, C2_c and TD1_a (which remains closed) to a power source at line wire 435 ahead of all switches except the three emergency stop buttons. After a predetermined lapse of time, TD1 opens its normally closed contacts TD1_a, breaking this hold circuit and stopping the ring motor.

During the clockwise rotation of the ring, the following pneumatic operations take place with reference to FIGURE 24. When the double ring sheaves 140 cross over center causing the wire head 25 to swing to the right, pilot valve PV2 is operated thereby allowing air to flow from roll-over cylinder 296 through line 402, SH29, line 384 and SH42 to operate DPV18, which causes the left gripper to open. Also, during this swing of wire head 25, PV3 is momentarily operated but, since there is no air pressure on the side of the roll-over cylinder that is supplying this valve, its operation produces no machine function.

As the wire head 25 swings to the right, PV5 is released thereby selecting the right gripper to be opened when the twister ratchet operates PV7 at a future time during the cycle. Also, PV4 is operated and maintained in operated position, switching the air supply from ring cam pilot valve PV9 to ring cam pilot valve PV10. PV4 determines which of PV9 or PV10 will be connected with the air supply during each rotation of the ring.

Further, during the swing of wire head 25 to the right, PV1 is operated to cause air to flow through line 376, SH28, line 373, and SH38 to operate inject valve DPV16 thereby causing an inject operation of the injector-ejector cylinder 234. As the injector reaches its full stroke, PV13 is operated causing air to flow through flow control valve NV45 to DPV16, retracting the injector-ejector fingers.

As the ring continues in its clockwise direction with the double ring sheaves 140 passing under the bundle to the left and arriving at approximately 15° above the bed line, ring cam valve PV10 is operated. Just prior to this time the time relay TD1, which was energized by the wire head 25 swinging across center, will drop out, deenergizing the ring drive motor. As PV10 is operated by the ring cam, air is supplied in two different directions as follows.

It is supplied through line 354, SH30, line 356 and SH41 to operate valve DPV18, thereby causing the left gripper to grip the second pass of the wire. Also, air is supplied through line 354, SH33 and SH35, causing valve DPV20 to shift, which supplies air to the mount end of twister cylinder 212, starting the twisting operation. At or near the end of the twister outward stroke, valves PV6 and PV7 are operated. PV6 supplies air through line 349 and SH34 to the return side of PV20, cutting off air to PV4 to give more time to roll off valve PV10. PV27 is operated by pilot line 347 from a port inside of DPV20, cutting off air to PV4 until twister cylinder 212 is at the end of its stroke.

PV7 on the twister ratchet supplies air in two directions. In one direction air flows to PV15, shifting it, thereby causing the cutter to begin its outward stroke. Air is also supplied through PV5, which was relieved on the swing of the wire head 25, through SH31, line 390 and SH40 to the "open" side of DPV17, causing the right gripper to open. As the twister starts its return stroke, air is supplied to the "return" side of DPV15, causing it to shift and return the cutter.

During the return stroke of the twister piston in cylinder 212, PV8 is operated, supplying air through SH28, line 373 and SH38, shifting DPV16. This causes the injector-ejector to function, this time in an eject opera-

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tion. Again, as the injector-ejector reaches its full stroke, PV13 is operated causing the air to flow through NV45 to the return side of DPV16, thereby returning the injector-ejector to its normal position. On the return stroke of the cutter, PV11 is operated, which is supplied from the cutter cylinder, causing air to flow in two directions.

In one direction air passes through PV12, which is relieved at this time, causing air to flow through line 406 to SH37, shifting DPV14 and thereby causing the roll-over cylinder 296 to extend its piston and turn the left gripper up. As the roll-over reaches its limit, PV12 is operated and maintained in its operated position so that the next time DPV11 is operated, the air will flow in the opposite direction causing the roll-over piston to move back.

Also, when PV11 is operated, air will flow through line 355 to SH32, line 357 and SH39, shifting the DPV17 and thereby closing the right gripper which at this time is turned down because of the operation of the roll-over cylinder. It will be noted that DPV17 supplies air to the "closed" side of both gripper cylinders during this operation, although the left gripper is already closed.

After the splice has been twisted, limit switch LS7 is tripped by movement of the twister cam. Contacts LS7_b then break the holding circuit to both relay C3 and the pressure bar solenoid SV1. Contacts LS7_a give a pulse to CMF, a holding circuit is established and the conveyor moves forward to discharge the bundle from the machine or locate it in position for another binding operation. The operation of ring direction switch LS4 on wire head 25 shifts contacts LS4_a and LS4_b to reverse the ring motor for each new binding operation.

A double wire operation is accomplished as follows. Double wire switch CM6 is closed, this switch remaining in closed position. This places limit switch LS8 in the circuit energizing time delay relay TD3 which then establishes a holding circuit around LS8 through time delay contact TD3_a and TD3_b. A set of normally open contacts TD3_c are in parallel with LS2, causing a repetition of the wire cycle. The TD3 timing breaks its own holding circuit after the second cycle has started and before the splice is completed.

In order to perform the foregoing functions, normally open switches TD3_a and TD3_c are closed and normally closed switch TD3_b is opened immediately upon energization of the relay solenoid TD3. Normally closed TD3_b is opened later by a pneumatic time delay after the second cycle has started. When TD3_b opens, LS8 has already opened, whereby TD3 is then deenergized. This returns all the TD3 relay switches to their original positions as shown. LS8 is actuated from index wheel 50 by the movement of the bundle. When this auxiliary or optional double wire circuit is not included in the wiring system, wire 442a is connected permanently to wire 442.

After tying a wire, the bundle may be backed out of the machine to turn it through 90°, or for other purposes. In such case, a cam lug is utilized on the index wheel 50 to trip limit switches LS1 and LS2 when the bundle reaches a predetermined wire position. The function of LS1 is to give a pulse through the normally closed contacts TD2_a of time delay relay TD2 to relay C1 which locks itself in around LS1 normally open contacts by its own normally open contacts C1_a. C1 then breaks its normally closed contacts C1_c in the circuit to CMF and makes its normally open contacts C1_b in the circuit CMR so that, following a wire tying sequence as above, the operation of LS7 gives its pulse to CMR.

When CMR is energized, its normally open contacts CMR_b complete a circuit to time delay relay TD2 to start the timing. When the predetermined time has elapsed, the normally closed TD2_a contacts in the C1 circuit break the C1 holding circuit. Then C1 breaks its normally open contacts C1_b in the CMR circuit and makes the normally

closed contacts C1_c in the CMF circuit. At this time the ZSR contacts are still closed, giving a pulse to CMF allowing it to pull in and close its holding circuit. The conveyor is then back in forward run.

Manual operation

For manual operation the selector switch unit SS1, SS2, SS3, SS4 is placed in the "hand" or "manual" position. Now the ring can be jogged either right or left by means of RC3. Also, the conveyor can be jogged either forward or reverse by means of CM4. Plugging will occur in either jogged direction of the conveyor.

Conveyor run is accomplished by actuating CM5 to either forward or reverse position and then closing conveyor start switch CM2. No wire tying cycle will occur unless the manual cycle switch RC2 is closed while in conveyor run. Closing the manual cycle switch will again actuate relay C3, locking out the conveyors from either forward or reverse and plugging to a stop, duplicating an automatic cycle.

The various functions of the twister unit may also be initiated individually by manual means. There are nine manual control valves for this purpose. The grippers may be rotated to the right or left and opened and closed. Operating manual valve PV21 supplies air through SH36 to the piston of the double pilot valve DPV14 causing the grippers to turn to the right. The operation of manual valve PV21A supplies air through SH37 to the opposite piston of valve DPV14, causing the grippers to rotate to the left.

The manual operation of PV22 supplies air through SH38 to a pilot piston of DPV16, causing ejector operation. Return of the ejector fingers is automatically accomplished by mechanical valve PV13.

Manual valve PV23 supplies air through SH39 to a pilot piston of DPV17, causing right gripper to close. Manual valve PV23A allows air flow through SH40 to the opposite pilot piston of DPV17, causing the right gripper to open. Valve PV24 causes air to flow through SH41 to a pilot of valve DPV18, causing the left gripper to close. Valve PV24A supplies air through SH42 to the opposite pilot of DPV18, causing the left gripper to open.

Manual valve PV25A supplies air through SH35 to a pilot of DPV20, causing the twister to cycle. Operation of valve PV25B supplies air through SH34 to the opposite pilot of DPV20, causing the twister to index to start position.

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

1. In a binding machine having a reversible rotary band laying ring, band splicing mechanism and grippers for performing functions of the machine; a fairlead for leading the band to the ring and arranged to swing from side to side to lead the band to opposite sides of the ring when the ring changes its direction of rotation, and means actuated by said swinging movements of said fairlead controlling said functions of the machine.

2. A machine as defined in claim 1, said means controlling the direction of rotation of the ring and the opening and closing of the grippers.

3. A machine as defined in claim 2, said means comprising limit switches controlling said ring, pilot valves controlling said grippers, and cam means on said fairlead for actuating said switches and valves.

4. A machine as defined in claim 1, said band splicing mechanism comprising a wire twister gear.

5. A machine as defined in claim 4, including a wire injector-ejector for said twister gear, a pilot valve controlling said injector-ejector, and cam means on said fairlead for actuating said valve.

6. A machine as defined in claim 4, said fairlead comprising a hollow shaft mounted for rotation adjacent said ring, and a fairlead sheave on said shaft arranged to receive binding wire passing through the shaft.

7. A machine as defined in claim 6, said means comprising cams on said shaft, and switches and valves actuated by said cams.

8. In a reversible ring type wire binding machine, a fairlead sheave mounted on a shaft to swing from side to side to lead the wire to opposite sides of the ring when the ring changes its direction of rotation, an axial passageway for the wire through said shaft to said sheave, cams on said shaft, and means actuated by said cams for controlling certain functions of the machine.

9. In a wire binding machine having a twister gear, a pair of wire grippers, and wire cutters; a double acting fluid pressure operator for each of said devices, a four way double pilot valve controlling each of said operators, fluid pressure actuators for shifting said valves in opposite directions, pilot valves operated by the machine arranged for energizing said actuators in an automatic machine cycle, and push button pilot valves arranged for energizing said actuators to operate any one of said operators in either direction.

10. In a wire binding machine having a twister gear, rotatable wire grippers, wire cutters and a wire injector-ejector for the twister gear; a double acting fluid pressure operator for each of said devices including an operator for gripper rotation, a four way double pilot valve controlling each of said operators, fluid pressure actuators for shifting said valves in opposite directions, pilot valves operated by the machine arranged for energizing said actuators in an automatic machine cycle, and push button pilot valves connected with said actuators to operate any one of said first named devices by itself.

11. In a reversible ring wire binding machine, a twister gear adjacent one side of the ring, rotatable grippers on opposite sides of said gear, and means to rotate said grippers to face toward and away from the ring.

12. A machine as defined in claim 11, said grippers always facing in opposite directions.

13. A machine as defined in claim 11, said rotating means comprising parallel shafts on said grippers, pinion gears on said shafts, a toothed rack meshed with said gears, and means to reciprocate said rack.

14. In a reversible ring binding machine, a band splicing device adjacent one side of the ring, a band gripper on one side of said device facing toward the ring, a band gripper on the opposite side of said device facing away from the ring, and means to reverse the positions of the grippers to face in the opposite directions.

15. A machine as defined in claim 14, including a fairlead for leading the band to the ring and arranged to swing from side to side to lead the band to opposite sides of the ring when the ring changes its direction of rotation, and means actuated by said fairlead controlling the opening and closing of said grippers.

16. In a reversible ring wire binding machine, a twister gear adjacent one side of the ring, a wire gripper on one side of said gear facing toward the ring, a wire gripper on the opposite side of said gear facing away from the ring, means to reverse the positions of the grippers to face in the opposite directions, a fairlead on the opposite side of the ring from said twister gear for leading the wire to the ring and arranged to swing from side to side to lead the wire to opposite sides of the ring when the ring changes its direction of rotation, and means actuated by said fairlead controlling the opening and closing of said grippers.

17. In a reversible ring binding machine, a band splicing mechanism adjacent one side of the ring, band grippers on opposite sides of said splicing mechanism, a fairlead for leading the band to the ring and arranged to swing from side to side to lead the band to opposite sides of the ring when the ring changes its direction of rotation, and means actuated by said fairlead controlling the opening and closing of said grippers.

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18. In a reversible ring wire binding machine, a twister gear adjacent one side of the ring, a wire injector-ejector for said twister gear, wire grippers on opposite sides of said twister gear, a fairlead on the opposite side of said ring from said twister gear for leading the wire to the ring and arranged to swing from side to side to lead the wire to opposite sides of the ring when the ring changes its direction of rotation, and means actuated by said fairlead controlling said injector-ejector and the opening and closing of said grippers.

19. In a machine for binding a bundle with a band, band splicing means, a pair of grippers on opposite sides of said splicing means capable of sustaining the tension of the band about the bundle, means mounting said grippers for rotation on axes perpendicular to the general direction of the band through said splicing means, and means to rotate the grippers through 180°.

20. A machine as defined in claim 19, said grippers have one operative position in which one of said grippers faces toward the bundle and the other gripper faces away from the bundle and another operative position in which said one gripper faces away from the bundle and said other gripper faces toward the bundle.

21. A machine as defined in claim 14 including means operable at the completion of each binding cycle to actuate said gripper reversing means in preparation for a new binding cycle.

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22. In a reversible ring binding machine, a band splicing device adjacent one side of the ring, a band gripper on one side of said device facing toward the ring, a band gripper on the opposite side of said device facing away from the ring, means to open and close said grippers, and means operable on completion of a binding cycle in each direction of ring rotation to reverse the facing directions of the grippers in preparation for a new binding cycle in the opposite direction of ring rotation.

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