June 26, 1934. E. E. NEWTON ET AL 1,964,529

STRAND WORKING APPARATUS

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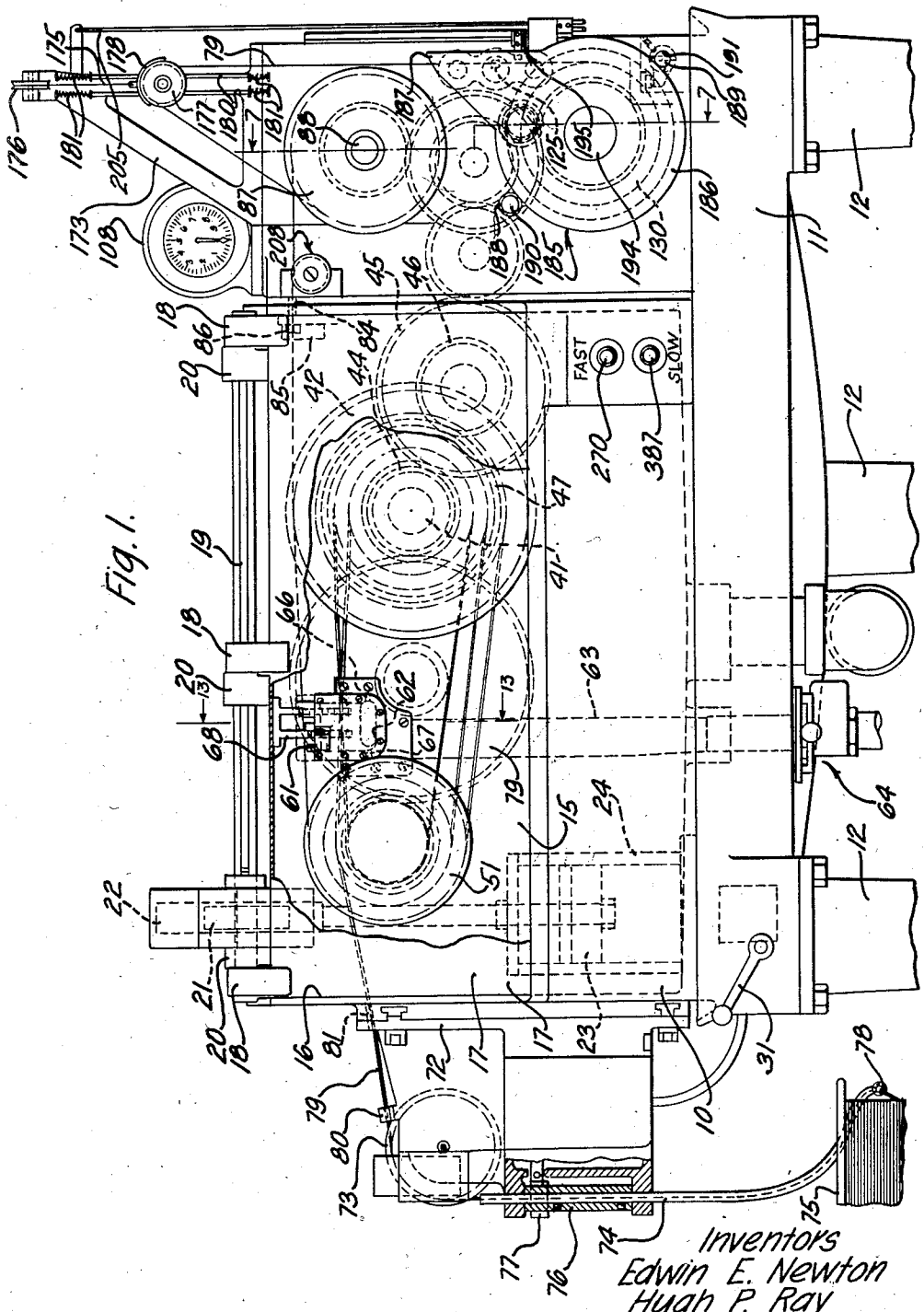


Fig. 1.

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STRAND WORKING APPARATUS

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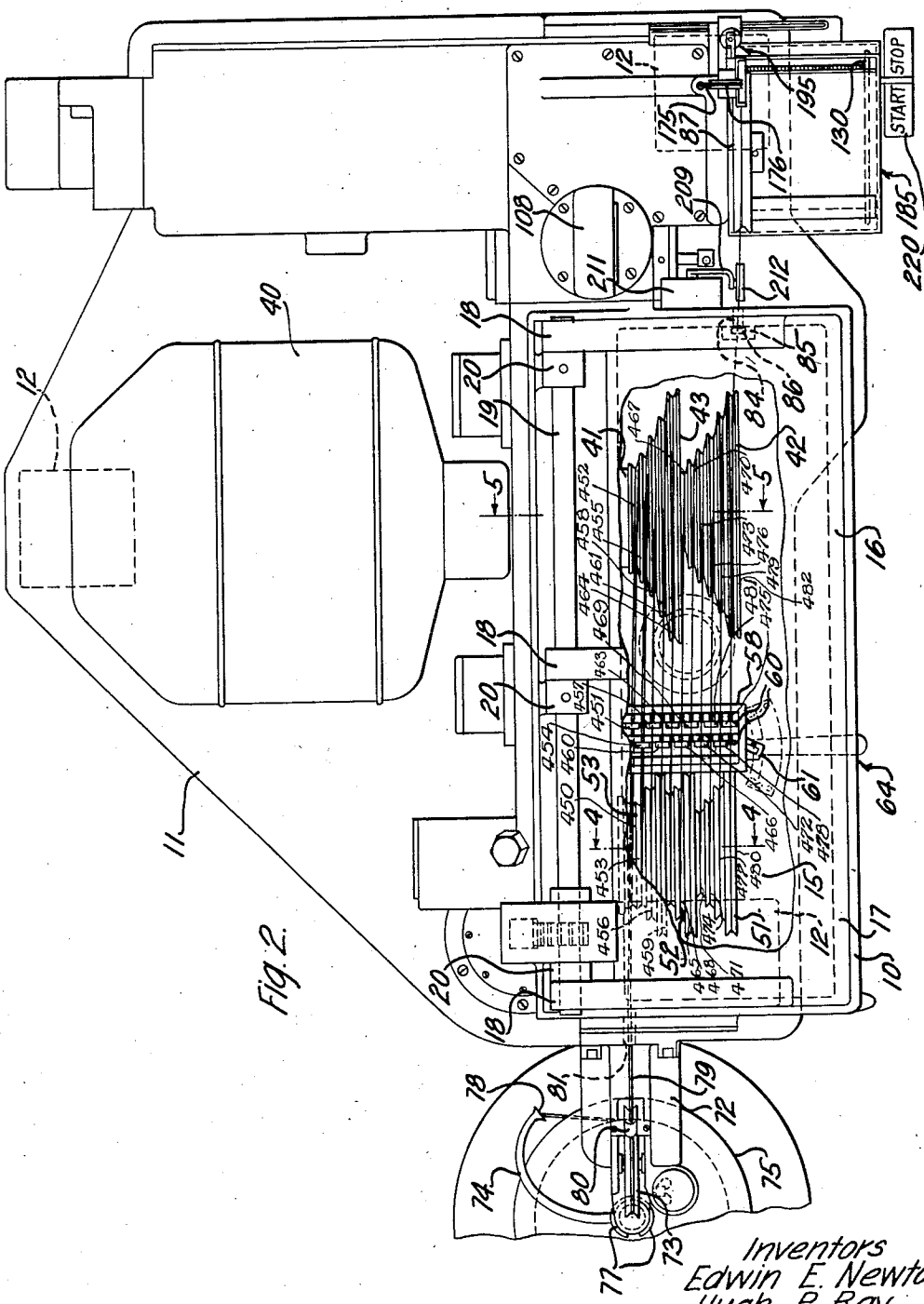


Fig. 2.

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STRAND WORKING APPARATUS

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Fig. 3.

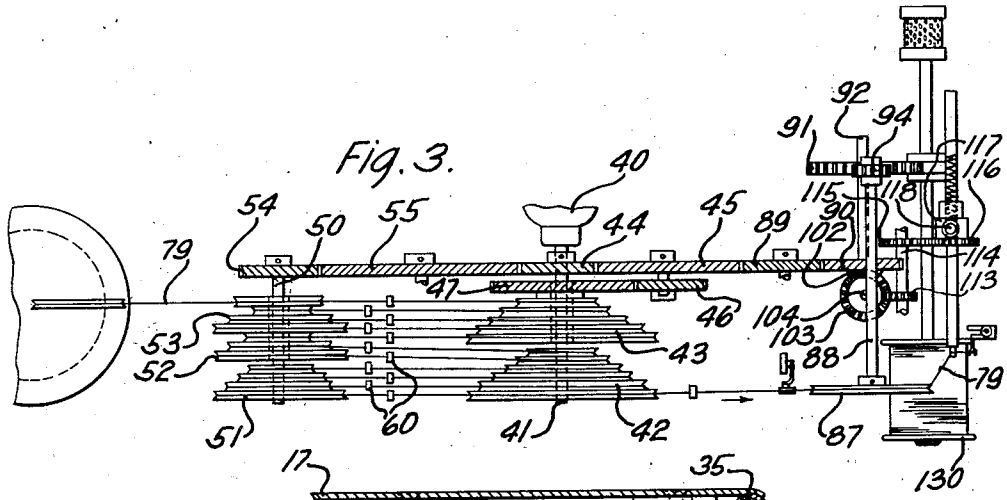


Fig. 13.

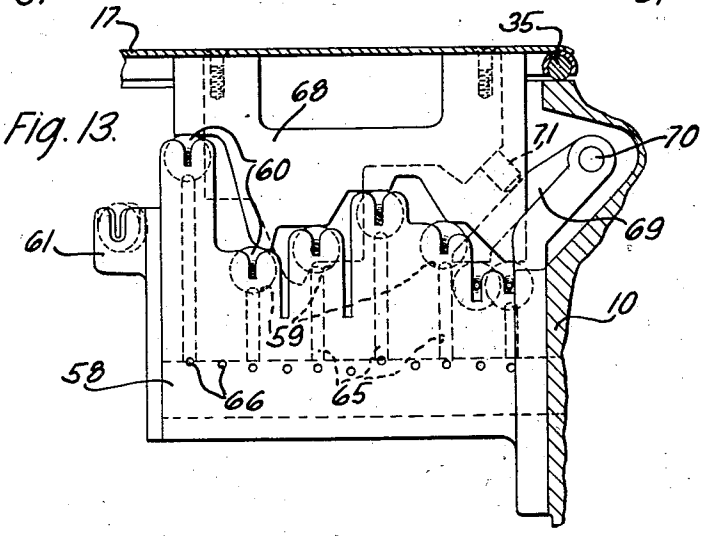
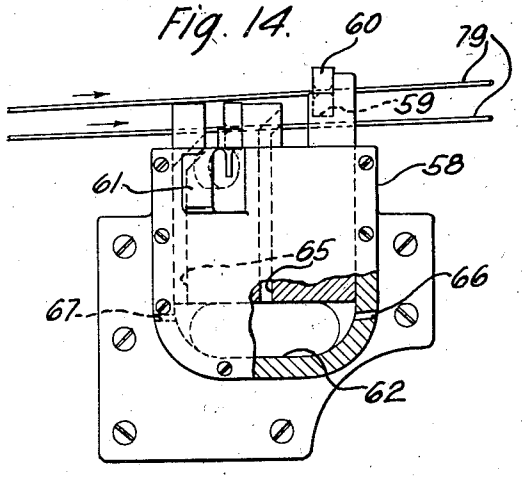


Fig. 14.



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Fig. 4.

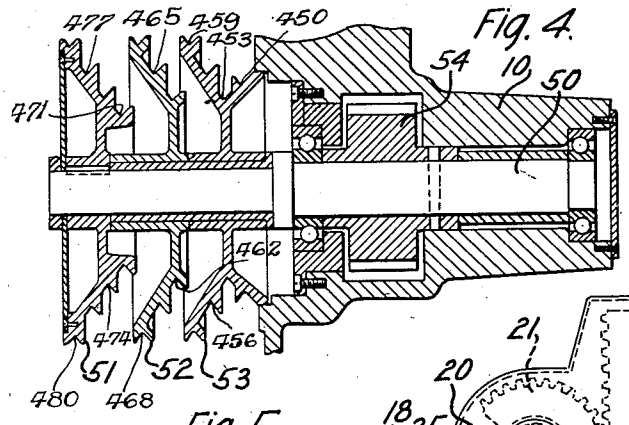


Fig. 9.

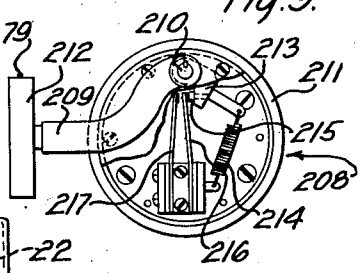


Fig. 5.

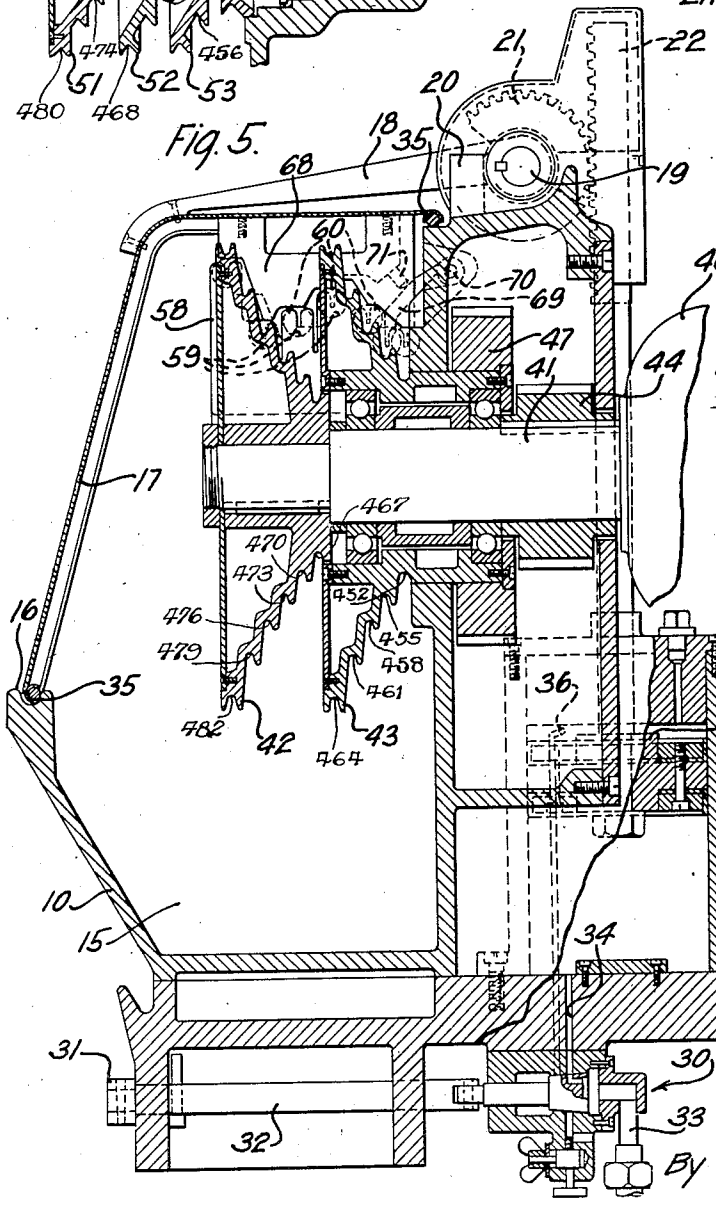


Fig. 10.

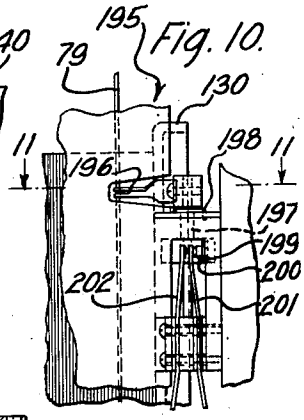
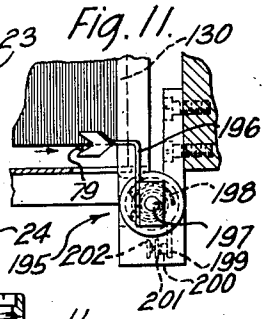


Fig. 11.

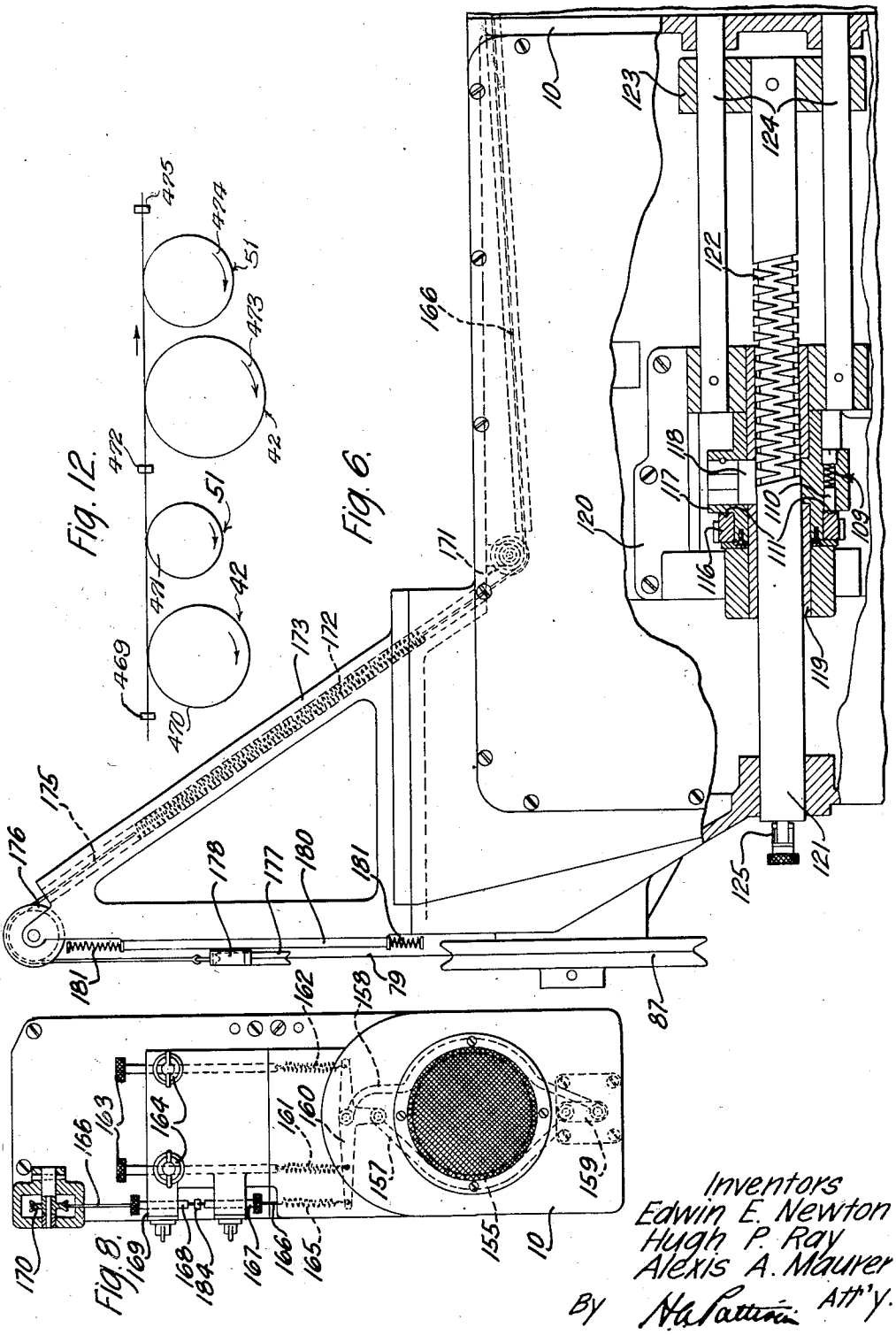


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STRAND WORKING APPARATUS

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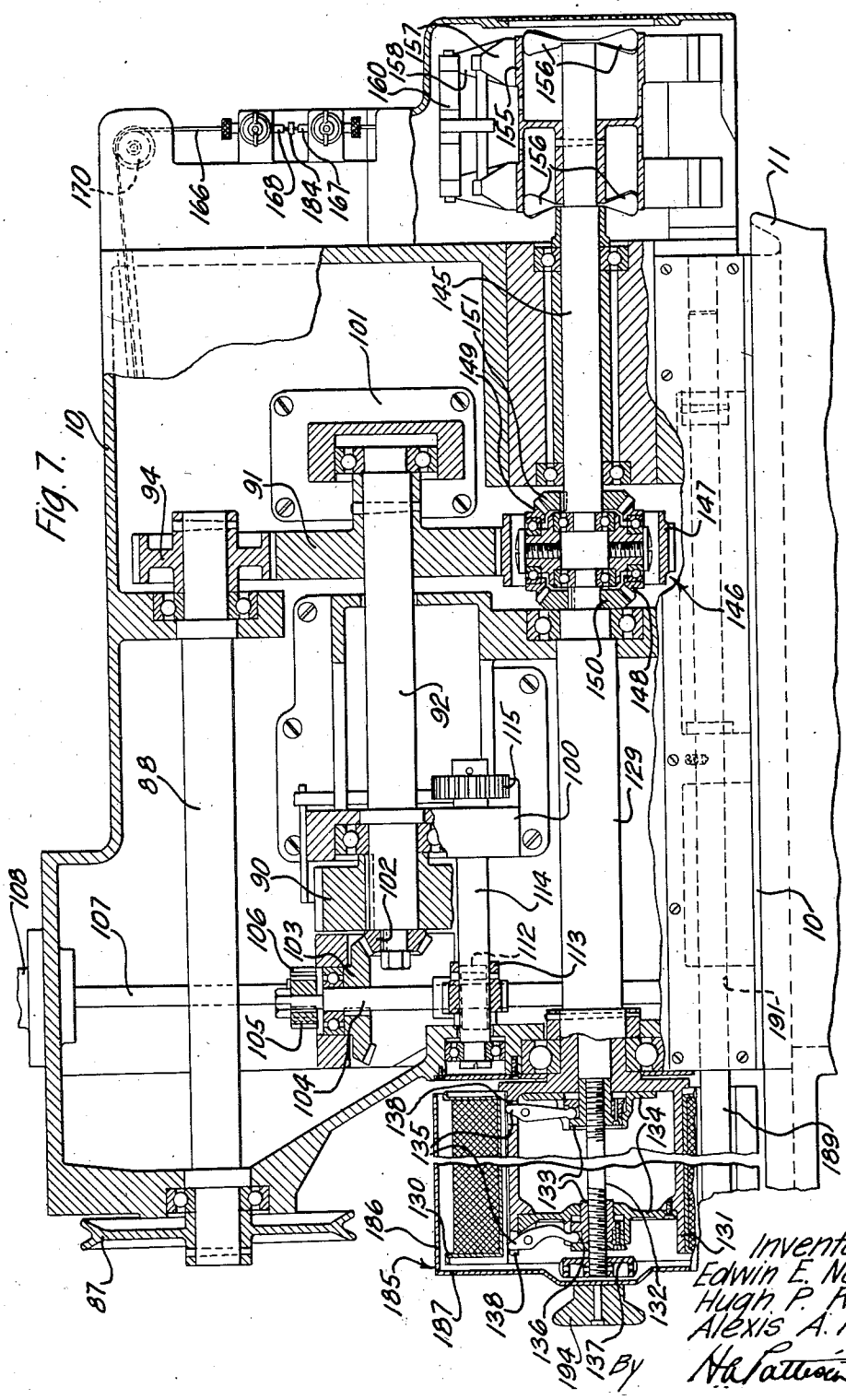
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STRAND WORKING APPARATUS

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Fig. 7.



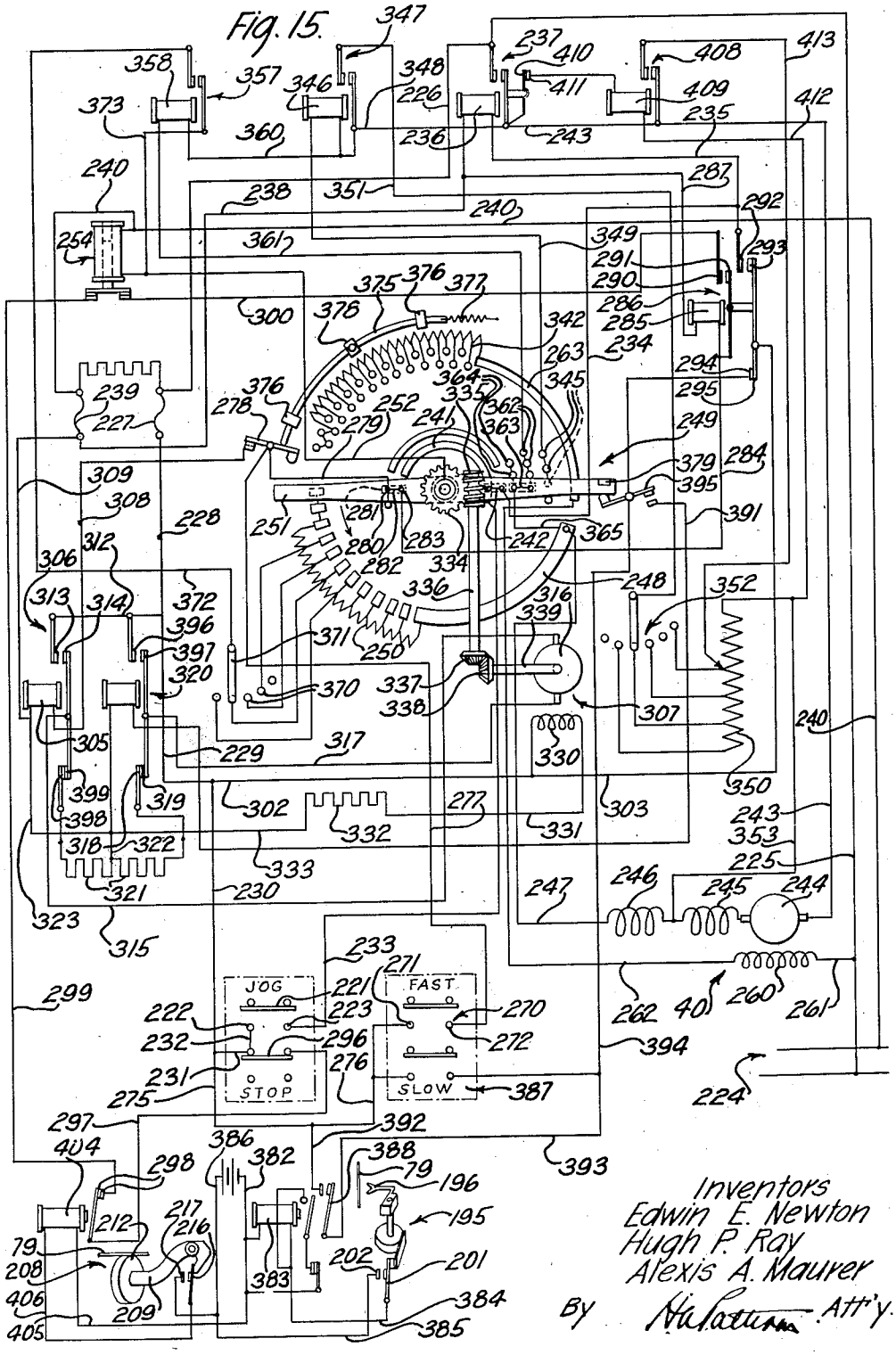
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Fig. 15.



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Patented June 26, 1934 1,964,529

UNITED STATES PATENT OFFICE

1,964,529

STRAND WORKING APPARATUS

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Application June 3, 1929, Serial No. 367,855

8 Claims. (Cl. 205—16)

This invention relates to strand working apparatus, and more particularly to wire drawing apparatus.

The principal object of the invention is to provide a compact and durable apparatus for efficiently working a strand at high speeds.

In accordance with one embodiment, the invention contemplates a high speed wire drawing machine comprising a housing supported at three points and having a pneumatically operated cover on the under side of which is a device for locking a plurality of drawing dies upon a die shelf when the cover is closed. To the right of the die shelf within the housing are positioned a stepped capstan secured to a motor shaft and driven directly thereby, and another stepped capstan rotatably mounted on, but driven at a speed slower than that of the motor shaft so as to reduce the slippage between the wire and the capstan. For guiding the wire into position for successive passage through the dies, three stepped sheaves are mounted to the left of the die shelf on a shaft driven from the motor shaft through a train of gears, two of the sheaves being idlers and the third being keyed to a driven shaft to impart to the steps of the sheaves surface speeds equal to the linear speed of the wire. The wire being reduced in diameter is drawn by the capstans from a vertical stationary supply spool into the wire drawing machine through a curved tube rotated in a circular path about the spool by the tensioned wire reacting against the interior wall thereof. As the finished wire leaves the last die it passes around a capstan and over a slidable pully operatively associated with a differential mechanism for driving and controlling the speed of a take-up spool to allow for any irregularities in the winding and for automatically tensioning the wire while it is being wound thereon. To prevent breakage of the wire in starting and stopping the machine, an electrical control system is provided for gradually increasing the speed of the machine when starting, and for gradually decreasing the speed when stopping. This system also decreases the speed of the machine when a predetermined amount of wire is wound on the take-up spool, and stops the machine when there is a break in the continuity of the wire being drawn.

Other features and advantages of the invention will be apparent from the following description when taken in conjunction with the accompanying drawings, in which

Fig. 1 is a fragmentary front elevational view of a wire drawing machine embodying the features of the invention;

Fig. 2 is a fragmentary plan view thereof with certain portions of the casing broken away to more clearly show interior portions;

Fig. 3 is a schematic view of the gear trains for driving the various parts of the wire drawing machine from the motor shaft;

Fig. 4 is an enlarged fragmentary sectional view taken on the line 4—4 of Fig. 2;

Fig. 5 is an enlarged transverse sectional view taken on line 5—5 of Fig. 2.

Fig. 6 is an enlarged fragmentary end view, partly in section, looking toward the left of Fig. 1;

Fig. 7 is an enlarged fragmentary sectional view of the differential driving mechanism for the take-up spool taken on line 7—7 of Fig. 1;

Fig. 8 is an end view of the braking mechanism forming a part of the differential driving mechanism for the take-up spool;

Fig. 9 is an enlarged elevational view of the contacting device for automatically stopping the motor when there is a break in the continuity of the wire;

Figs. 10 and 11 are enlarged fragmentary front elevation and plan views, respectively, of another contacting device for automatically decreasing the speed of the wire drawing machine when the take-up spool becomes filled;

Fig. 12 is a theoretical diagram showing the wire passing through the dies and over the capstans and sheaves to better explain the function of the sheaves in maintaining the proper tension on the wire;

Fig. 13 is an enlarged fragmentary transverse sectional view taken on line 13—13 of Fig. 1 and showing the die shelf and the block for locking the dies in operative position when the cover is lowered;

Fig. 14 is an enlarged end view of the die shelf, and

Fig. 15 diagrammatically discloses the electrical control circuits for the wire drawing machine.

Referring now to the drawings in which like reference numerals designate similar parts through the various views, the numeral 10 designates a housing secured to a triangular shaped bed plate 11 which is supported at three points by legs 12—12 to effectively reduce vibration. The housing 10 has a wire drawing compartment 15 provided with an opening 16 which is adapted to be closed by a sloping cover 17, as shown in Figs. 1 and 5. This cover is secured to outwardly extending arms 18—18 keyed to a horizontally disposed rod 19 which is suitably journaled in

upwardly extending portions 20—20 of the housing 10. At the left hand end of the rod 19 a segmental pinion 21 keyed thereto engages a rack 22, the lower end of which is fastened to a piston 23 within a cylinder 24 secured to the top of the bed plate 11 to the rear of the left hand front leg 12.

The operation of the cylinder 24 is controlled by a valve 30 whereby upon the turning of a handle 31 positioned at the front of the bed plate 11 to rotate a pin 32 connected to the valve 30, air under pressure is admitted to one side or the other of the piston to reciprocate the rack 22. Hence, to close the cover 17 compressed air from any suitable source of supply (not shown) is admitted through a tube 33, valve 30, and aperture 34 in the bed plate 11, into the lower end of the cylinder 24 whereby the piston 23 is forced upwardly, actuating the rack 22 and pinion 21 and forcing the cover 17 downwardly to compress a gasket 35 (Fig. 5) preferably of round soft rubber between the under edge of the cover 17 and the top edge of the front wall of the wire drawing compartment 15 to form a liquid tight enclosure so long as the air pressure is maintained on the under side of the piston. By operating the valve 30 in a reverse direction, the air pressure on the under side of the piston 23 is disconnected and released to the atmosphere, while compressed air is admitted to the upper end of the cylinder 24 through a bore 36 in the wall thereof, forcing the piston 23 downwardly, rotating the segmental pinion 21, and thereby raising the cover which remains open so long as the air pressure is maintained on the upper side of the piston.

Positioned medially of the bed plate 11 and secured thereon at the rear of the housing 10 is an electrical motor 40 mounted above and in front of the rear leg 12 the driving shaft 41 of which extends within the wire drawing compartment 15 of the housing 10. Stepped capstans 42—43 are mounted on the driving shaft 41, the outer capstan 42 being keyed thereto and the inner capstan 43 being rotatably mounted thereon but driven by gears 44 to 47 inclusive (Fig. 3) from the driving shaft 41. To the left of the capstans in the wire drawing compartment and suitably journaled within the housing 10 is a shaft 50 on which are mounted three stepped sheaves 51—53 (Fig. 4), the outer sheave 51 being keyed to the shaft 50 and the intermediate sheave 52 and inner sheave 53 being rotatably mounted thereon. Secured to the shaft 50 is a gear 54 which is driven through an idler gear 55 meshing with the gear 44 secured to the driving shaft 41.

A die shelf 58 secured to the housing 10 intermediate the capstans 42—43 and sheaves 51—53 is provided with seats 59—59 (Figs. 5, 13 and 14) at various levels for supporting wire drawing dies 60—60; and the faces of the die seats are formed at such angles that the axes of the dies 60 produced are substantially tangential to the respective companion steps of the capstans and sheaves. At the upper, outer end of the die shelf is a die seat 61 positioned at an angle convenient for the purpose of manually stringing the drawing dies on the wire. The die shelf has a cavity 62 (Figs. 1 and 14) which is connected by a pipe 63 to a source of wire drawing compound or lubricant under pressure (not shown) and the flow thereof is controlled by a hand operated valve 64. Connecting with the cavity 62 are passageways 65, 66 and 67; passageway 65 provided for directing a stream of lubricant into the mouth of each die to lubricate, cool, and wash away any deleterious matter which may tend to collect in the dies, passageway 66 for directing a stream of lubricant onto each step of the capstans to lubricate and cool them and passageway 67 for directing a stream of lubricant into each groove or step of the sheaves to lubricate and cool them, respectively.

Directly above the die shelf 58, a block 68 (Figs. 1, 5 and 13) is rigidly fastened to the underside of the cover 17 and has depending portions at various levels corresponding to the elevations to the tops of the seated dies 60—60 so that when the cover is closed the block 68 will engage the dies and hold them in operative positions. One of the dies is maintained in position by a lever 69, pivoted at 70, which is engaged by a pin 71 projecting at an angle from the block 68.

On the left hand end of the housing 10 is fastened a bracket 72 (Figs. 1 and 2) carrying a pulley 73 and a light weight tube 74, the upper straight portion of which is in axial alignment with a stationary supply spool 75 suitably supported in a vertical position. The tube 74 is freely rotatable in the bracket 72 but is provided with a brake drum 76 having a pair of adjustably tensioned brake shoes 77—77 bearing on its periphery. Below the brake drum 76, the tube 74 curves outwardly in a vertical plane, then in an inclined plane, and terminates in a bell mouth 78 immediately beneath the level of the upper head of the supply spool 75 and somewhat further from the axis than the largest radius of the spool head and opening normally to the diameter thereof. The wire 79 from the supply spool is threaded through the bell mouth 78, upwardly through the tube 74, over the pulley 73, through a guide 80 secured to the bracket 72, and thence through an aperture 81 in the left hand wall of the housing 10 into the wire drawing compartment 15. A small tension on the wire supplied by the capstan 43 will cause the wire to react upon the inside wall of the curved tube 74 and rotate the bell mouth 78 in a circular path about the upper end of the supply spool 75 to unwind the wire without danger of snarling or kinking. Moreover, since the tube 74 is constructed of light weight material, its inertia is so small that a small tension will rapidly accelerate it and light braking force supplied by the brake 76—77 will rapidly decelerate it. Thus, it is very sensitive to the changes in tension applied to the wire. Also, as the supply spool is stationary, the required tension does not change from a full spool to one that is nearly empty as would be true if the supply spool were rotated.

Fastened to the housing 10 at the right end of the wire drawing compartment 15 and in horizontal alignment with the top of the largest step in the outer capstan 42 is an individual die holder 85 (Figs. 1 and 2) for properly positioning a final drawing die 86. To the right of this die holder is an outside capstan 87 for pulling the wire through the final drawing die 86. The capstan 87 is secured to a shaft 88 which is suitably journaled in the housing 10 and is driven from the driving shaft 41 through a train of gears 44, 45, 89, 90, a gear 91 fastened to a shaft 92 carrying the gear 90, and a gear 94 secured to the rear end of the shaft 88 (Figs. 3 and 7).

The shaft 92 is suitably journaled in brackets 100—101 (Fig. 7) fastened to the housing 10 and carries at its forward end in front of the gear 90 a bevel gear 102 which meshes with another bevel gear 103 secured to a vertical shaft 104 jour-

naled in the housing 10. At the upper end of the vertical shaft 104 is keyed a gear 105 meshing with a gear 106 secured to a vertical shaft 107 which drives a tachometer 108 of any suitable character mounted on the top of the housing 10 for indicating the speed in feet per minute at which the wire 79 is being drawn.

Medially of the vertical shaft 104 is secured a helical gear 112 for driving a helical gear 113 keyed to a horizontal shaft 114 which carries a spur gear 115. The gear 115 meshes with a gear 116 (Fig. 6) which is connected through a safety device 109 to a collar 117 carrying a plunger 118 and rotatably mounted on a bushing 119 supported within a bracket 120 secured to the housing 10. The safety device 109 comprises an adjustable spring pressed pin 110 housed within a bore in the collar 117 and having a rounded end which is adapted to engage a series of depressions 111 on the right hand side of the gear 116 so as to permit slippage between the gear 116 and the collar 117 if, for any reason, the plunger 118 is subjected to an overload. Reciprocally mounted in the bushing 119 is a distributing rod 121 having a right and left hand threaded portion 122 engaged by the rotatable plunger 118. When the gear 116 and plunger 118 are rotated, the distributing rod 121 is reciprocated and guided by a block 123 secured thereto and slidably mounted on a pair of parallel guide pins 124—124 supported by the bracket 120 and the housing 10. The forward end of the distributing rod has an adjustable bushing 125 for guiding and distributing the finished wire 79 on a take-up spool or reel 130.

The take-up spool 130 is supported on a drum 131 positioned over the right hand front leg 12 and secured to a shaft 129 (Fig. 7) which is suitably journaled in the housing 10. Extending centrally through the drum 131 is a threaded rod 132 supported within threaded sleeves 133—133 slidably mounted in spiders 134—134 secured to the inner wall of the drum 131. On each of the spiders 134 are pivoted three levers 135—135 spaced one hundred and twenty degrees apart and having their inner ends positioned in slots 136 in the sleeves 133—133 threaded on the rod 132. By turning a hand wheel 137 secured to the outer end of the rod 132, in one direction the sleeves 133—133 are moved away from each other due to the right and left hand threading of the rod 132. This movement of the sleeves 133—133 rocks the levers 135—135 about their pivots, whereby the upper ends of the levers protruding through slots 138 in the drum 131 are caused to engage and hold the interior wall of the drum of the take-up spool 130 to obtain a three point front and back centering thereof.

When the outside capstan 87 drawing the wire through the final die 86 is delivering wire at constant linear speed, it is essential that the speed of rotation of the take-up spool 130 be gradually decreased owing to the increasing diameter of the spooled wire upon the spool. This is accomplished as illustrated in Fig. 7 by journaling a brake drum shaft 145 in the housing 10 in alignment with the axis of the take-up spool shaft 129 and mounting between them and on their common axis a differential 146. Within a crown gear 147 of the differential are housed differential gears 148—149 which mesh with gears 150—151 keyed to the shaft 129 and 145, respectively, in such a manner that the crown gear 147 will tend to drive both of the shafts 129 and 145 with equal tractive forces, but not necessarily at the same speed. Actuation of the take-up spool shaft 129 is obtained through the crown gear 147 of the differential 146 meshing with the gear 91 which, as has been previously described, is driven from the driving shaft 41.

The brake drum shaft 145 has mounted on its outer end a brake drum 155 (Figs. 7 and 8) in which are positioned a plurality of fan blades 156—156 for air cooling the perforated brake drum. Brake shoes 157—158 engaging diametrically opposite surfaces of the brake drum 155 are pivoted at their lower ends to a plate 159 fastened to the housing 10 and at their upper ends to a T-shaped lever 160 which is held in suspension by coil springs 161—162 tensioned by screws 163—163. The springs 161—162 are adjusted to a desired value of tension and the screws 163—163 are then locked in position by means of wing nuts 164—164. Thus, the upward pull of the spring 162 will increase the pressure of the brake shoes 157—158 on the drum 155 and an upward pull on the spring 161 will decrease the pressure. At the outer end of the left arm of the T lever 160 is fastened a coil spring 165 connected to a cable 166 which passes up through a pair of opposed hollow adjusting screws 167—168 threaded vertically in protruding portions 169 of the housing 10, over and under pulleys 170 (Fig. 8) and 171 (Fig. 6) rotatably positioned in the housing 10, and is then connected to the lower end of a very resilient coil spring 172. The other end of this spring which is housed within a hollow arm of a bracket 173 bolted to the top of the housing 10, is fastened to another cable 175 which passes over a pulley 176 in the top of the bracket 173 and is then connected to a slidably mounted pulley 177 over which the wire travels on its way to the take-up spool (Fig. 1). The pulley 177 is made of light weight material and is mounted on a slide 178 of similar material which is movable up and down on a pair of suitable guides 180—180 provided with buffer springs 181—181 at each end and secured to the bracket 173.

From the foregoing description it will be clear that if the tension on the wire traveling to the take-up spool 130 should increase sufficiently to pull the slide 178 and the pulley 177 downwardly, the resultant increased tension on the spring 165 (Fig. 8) will pull up the left arm of the T lever 160 to spread the brake shoes 157—158 farther apart and thereby reduce the braking force of the drum 155. The reduction of the braking force on the shaft 145 permits it to rotate faster whereby the speed of rotation of the differential gears 148—149 and the gear 150 meshing therewith is decreased to decrease the speed of rotation of the shaft 129 and take-up spool 130. Conversely, a decreased tension in the wire traveling over the pulley 177 increases the braking force on the shaft 145 to decrease the speed of the gear 151 keyed thereto, whereby the speed of rotation of the differential gears 148—149 and the gear 150 is increased to increase the rotative speed of the take-up spool 130. Hence, when the tension on the wire varies, due to the increasing diameter of the spooled wire, or if the diameter thereof between the spool heads is not uniform so as to necessitate a rapid acceleration or deceleration of the take-up spool, the pulley slide in cooperation with the brake and differential will vary the speed of the take-up spool as the particular condition requires.

The normal tension on the wire between the capstan 87 and the take-up spool 130 is adjusted

by means of one or both of the adjustable tension springs 161—162 which are attached to the T-shaped lever 160, and the tension imparted to the spring 165 can be controlled by clamping a block 184 on the cable 166 between the opposed ends of the hollow adjusting screws 167—168. If these hollow screws are adjusted towards one another in such a manner that should the slide 178 move from one extreme end of the guides 180—180 to the other, the block 184 abuts one or the other, or both, of the screws 167—168, the range of tension in the spring 165 will not be as great as the range of tension in the spring 172, and hence the variation in the braking force can he held within desirable limits to control the speed of the take-up spool 130. If the hollow screws are adjusted to clamp the block between them, the slide may be moved from one extreme to the other on the guides 180—180 without effecting a change in the speed of the take-up spool. Thus, if any irregularities in the spooling of the wire causes the pulley slide to surge excessively up and down and thereby cause a surging of the braking force to effect a surging of the speed of the take-up spool, the surging can be eliminated by adjusting the hollow screws 167—168 so that the block 184 clamped on the cable 166 will have its movement restricted to limit the braking force and the variations in speed of the take-up spool.

In the winding of wire on the take-up spool at high speeds, the wire may break due to some abnormal condition and unless the free end of the rotating wire is drawn within a guard for the take-up spool 130, the wire end may be whipped or portions broken therefrom and thrown at high velocity, thus constituting a source of danger to the operator. To obviate this danger, a guard 185 (Figs. 1 and 7) is provided, comprising a substantially cylindrical member 186 having an upwardly extending spout-like portion 187 terminating in a narrow opening for admitting the wire, which portion encloses the reciprocating, distributing rod 121 and guide bushing 125 used in distributing the finished wire on the take-up spool 130. The substantially cylindrical member 186 has secured to its periphery a sleeve 188 and a pin 189 positioned diametrically opposite each other and adapted to be slidably supported on a rod 190 extending from the face of the housing 10 adjacent the take-up spool and in a bore 191 in the housing 10, respectively. The pin 189 is much longer than the length of the substantially cylindrical member 186 and slides in the bore 191 in the housing 10 so that when the guard 185 is pulled outwardly by means of a knob 194 on the outer enclosed end thereof to clear the take-up spool, the guard can be rotated through approximately one hundred and eighty degrees and suspended by means of the pin 189 to permit the easy removal of the take-up spool.

However, the more effective the guard is, the more it hides the take-up spool and renders it difficult for the operator to determine when the spool 130 is filled with wire and to be replaced by an empty one. By means of an automatic device 195 (Figs. 1, 10 and 11) secured to the housing 10 beneath and to the right of the distributing rod 121, the speed of the wire drawing machine will be gradually decreased when the take-up spool 130 is filled with a predetermined amount of wire. Near the inner head of the take-up spool 130 and adjacent to the inclined wire passing from the guide bushing 125 to the take-up spool, a two prong fork 196 (Figs. 10 and 11) is fastened to a shaft 197 free to rotate through a limited arc. A light torsion spring 198 holds the shaft and fork in their normal positions, which is such that the prongs are pointing outward and the point of the prong which is nearer the take-up spool 130 is near the plane in which the inclined wire 79 lies when the spool is filled with the desired amount of wire, the root of the slot between the prongs being a short distance outward from the plane of the inner spool head in the take-up spool 130. When the spool is filled with the desired amount of wire, the wire 79 will have reached such an inclination that when the guide bushing 125 is guiding the wire toward the inner spool head, the wire will enter the slot in the fork 196. When the wire has engaged the root of the slot, further movement of the guide bushing 125 causes an increasing pressure of the wire on the root of the slot, thus causing the fork and the shaft 197 to rotate clockwise through a limited arc. Mounted on the fork shaft 197 is a lug 199 carrying a dielectric stud 200, when the shaft 197 is rotated from its normal position one contact spring 201 is pressed against another contact spring 202 to operate an electrical control system disclosed in Fig. 15 and to be fully explained in the description of the operation of the wire drawing machine to follow.

As a further safeguard, a guard panel 205 is secured to the right hand end of the housing 10 so that it extends above the slide 178 and below the spout-like portion 187 of the guard 185 for the take-up spool 130, as illustrated in Fig. 1. This panel protects the operator from injury when a free end of the moving wire passes over the pulley 177 on the slide 178.

An automatic device 208 (Fig. 9) positioned intermediate the die holder 85 and the outside capstan 87 stops the wire drawing machine when the wire 79 breaks or the supply thereof is exhausted. The device 208 includes a lever 209, which is keyed to a shaft 210 suitably journaled in a casing 211 fastened to the outside wall forming the wire drawing compartment 15, projects out of the casing and carries a pulley 212 which is adapted to engage the wire as it passes from the final reducing die 86 to the outside capstan 87. The shaft 210 also has keyed to it another lever 213 which is fastened to one end of a coil spring 214 under tension, whereby the lever 209 is rotated in a clockwise direction until the rim of the pulley 212 presses up against the taut wire between the final die 86 and the outside capstan 87. When there is a break in the continuity of the wire, the pressure thereof on the pulley 212 is removed and the lever 209 is rotated clockwise through a small arc by the energy stored in the spring 214, until an insulating pin 215 carried by the lever 213 engages and moves a contact spring 216 into engagement with another contact spring 217. This closure operates a circuit in the electrical control system hereinbefore referred to, to effect the stopping of the wire drawing machine.

As illustrated schematically in Fig. 15, the control system for the main driving motor of the wire drawing machine comprises, in general, a master switch having a controller arm which is actuated through suitable gearing by a pilot motor under control of electro-responsive means and manually operated switches located at convenient stations on the wire drawing machine. Thus, by maintaining a "fast" switch depressed for a predetermined interval of time, the main

motor is started at slow speed and the energizing of an electromagnet establishes an operating circuit for the pilot motor, whereby the controller arm is rotated to increase the speed of the main motor by gradually shunting out the armature resistance and introducing additional field resistance. When the desired wire drawing speed is obtained, the pilot motor circuit is automatically interrupted by the controller arm engaging and opening a limit switch. Upon manually closing a "slow" switch to decrease the wire drawing speed, certain electromagnetic switches are energized to effect the operation of the pilot motor and controller arm in a reverse direction to decrease the speed of the main motor as long as the "slow" switch is manually held down. Means are also provided in the control system for automatically stopping the operation of the wire drawing machine when the wire breaks or the supply thereof becomes exhausted, and for automatically decreasing the speed when a predetermined amount of finished wire is wound on the take-up spool. These and other features, it is believed, will be readily understood from the detailed description of the operation of the wire drawing machine to follow.

In the operation of the wire drawing machine, the supply of wire to be reduced in diameter, taken from the stationary supply spool 75, is threaded through the bell mouth 78, up through the tube 74, over the pulley 73, through the guide 80, and thence through the aperture 81 in the left hand wall of the housing 10 into the wire drawing compartment 15. The wire is then guided over the rear step of the sheave 53 and through the first reducing die 60 in the die shelf 58. After leaving the first die, the wire is wound around the smallest step of the inner capstan 43, after which it is passed under and over the next step in the sheave 53, and through the next reducing die and around the next step in the capstan 43, etc., until it is passed over the steps in the sheaves 51—52 and the outer capstan 42 and through all of the die 60. From the step of largest diameter on the outer capstan 42 the wire is threaded through the final die 86, through an aperture 84 in the right hand wall of the wire drawing compartment 15, and then over the pulley 212 of the automatic stopping device 208. From the pulley 212 the wire is wound around the outside capstan 87, after which it is passed upwardly over the pulley 177 on the slide 178 and then downwardly through the guide bushing 125 on the end of the distributing rod 121, through the opening in the spout-like portion 187 of the guard 186 onto the take-up spool 130.

It is to be particularly noted that the actuation of the two stepped capstans 42—43 at different speeds and the driving of the sheave 51 makes possible the commercial drawing of wire at high speeds without undue breakage thereof, because the sheaves are rotated at circumferential speeds equal to the linear speeds of the traveling wire to thereby impart only the minimum required tensions necessary to effect gripping of the wire on the capstans. The wire is threaded through the aperture 81 (Fig. 1) in the left hand wall of the housing 10, over the rear step 450 (Figs. 2 and 4) of the sheave 53, through the first reducing die 451 of the group of dies 60 in the die shelf 58, one or more times completely around step 452 of the inner capstan 43, under and over step 453 of sheave 53, the second reducing die 454, around step 455 of capstan 43, under and over step 456 of sheave 53, reducing die 457, around step 458 of capstan 43, under and over step 459 of sheave 53, reducing die 460, around step 461 of capstan 43, under and over step 462 of sheave 52, reducing die 463, around step 464 of capstan 43, under and over step 465 of sheave 52, reducing die 466, around step 467 of capstan 42, under and over step 468 of sheave 52, reducing die 469, around step 470 of capstan 42, under and over step 471 of sheave 51, reducing die 472, around step 473 of capstan 42, under and over step 474 of sheave 51, reducing die 475, around step 476 of capstan 42, under and over step 477 of sheave 51, reducing die 478, around step 479 of capstan 42, under and over step 480 of sheave 51, reducing die 481, around step 482 of capstan 42, and through the final die 86. The size of the steps of the capstans and sheaves is such as to compensate for the increase in the length of the wire as the diameter decreases due to the action of the reducing dies.

As each of the steps 452, 455, 458, 461 and 464 of the capstan 43 must exert sufficient tension on the wire to draw it through the associated dies 451, 454, 457, 460 and 463, respectively, and as the wire is merely wrapped around the steps of the capstans and not secured to them, it is necessary to rotate the capstan 42 so that the linear speeds at the bottoms of the grooves in the individual steps are slightly greater than the linear speeds of the different portions of the wire passing thereover. This provides a certain amount of slippage which allows for the wire passing through any die being elongated less than the standard amount owing to that die or the entering wire being off size. The tension is imparted to the wire by the friction between the surface of the capstan and the wire.

The wire portion between the reducing die 451 and the step 452 of the capstan 43 is therefore under some tension. If the sheave 53 is to be rotated by the wire portion travelling over the step 450 thereof, the tension on the wire portion between the reducing die 451 and the step 452 must be increased sufficiently to provide for this rotation of the sheave 53. As the wire leaves the second reducing die 454, it is decreased in cross-section, but it is under a greater tension in proportion to its cross-sectional area as it is pulled through the third reducing die 457 of the step 458 of the capstan 43. As the tension on the various portions of the wire as it is passed through the dies increases per unit of cross-section of the wire, the greatest tension per unit cross-section of wire is exerted on the smallest diameter portion of the wire.

In prior art practice the speed of drawing is partially limited by the maximum tension that can be placed on the smallest diameter portions of the wire without undue breakage.

In accordance with the present invention the sheave 51 is positively driven and the steps in the sheave 51 are proportioned so that the circumferential speed at the bottoms of the grooves 471, 474, 477 and 480 is substantially the same as the speed of the wire portions travelling thereover. This removes from that portion of the wire between the die 472 (Figs. 2 and 12) and the step 473 of the capstan 42, the tension required to rotate the sheave 51 and also enables the use of less tension on that portion of the wire between the step 473 of the capstan 42, and the step 474 of the sheave 51, since the positive rotation of the sheave 51 at the required speed supplies added tension to enable the wire to properly grip the step 473 of the capstan 42. In the same man-

ner the necessary tensions on the portions of the wire between the dies 475, 478 and 481, and the steps 476, 479 and 482 of the capstan 42, are reduced.

On the larger diameter portions of the wire which pass over the sheaves 52 and 53 it is not as essential that the tensions be reduced as with the smaller diameter portions of the wire. The diameters of the steps in the sheaves 52 and 51 are proportioned so that the diameter of a smaller step is to the diameter of the next larger step as the length of a given volume of wire passing over the smaller step is to the length of the same volume of wire passing over the larger step after the wire has been increased in length by being drawn through the intervening reducing die. The sheaves 51 and 52 tend to rotate at the speed of the shaft 50 which is the same speed as the sheaves 51 attached to the shaft 50. However, as the wire has increased in length from the point where it passes over the step 450 in the sheave 53 to the point where it passes over the step 480 in the sheave 51, the sheave 51 will rotate faster than the sheave 52 and the sheave 52 will rotate faster than the sheave 53. The portions of the wire passing over the sheaves 52 and 53 will retard the speed of the sheaves 52 and 53 and will place the portions of the wire between the sheaves 52 and 53 and capstans 42 and 43 under a certain amount of tension. The action of the sheaves 52 and 53 and the rotating shaft 50 is similar to that of a slipping clutch which would maintain a certain amount of tension on the wire and also rotate the sheaves at the approximate speed of the wire passing over them, the slippage taking place between the shaft 50 and the sheaves 52 and 53.

In the stringing of the wire through the dies 60 and around the sheaves 51—53 and the capstans 42—43, the operator causes the machine to operate for short periods of time by depressing a foot pedal 220 (Fig. 2) mounted on the right hand front leg 12 and connected by any suitable mechanism, (not shown) to operate a jog switch 221 (Fig. 15) to interconnect contacts 222—223. The connecting of these contacts through the switch 221 establishes a circuit from the positive terminal of the power line 224, through conductors 225—226, fuse 227, conductors 228 to 232 inclusive, contact 222, switch 221, contact 223, conductor 233, contact segment 241, interlocking conductor 242, conductor 234, conductor 235, the winding of an electromagnet 236 of a line switch 237, conductor 238, fuse 239, conductor 240 to the negative terminal of the power line 224. The energization of the electromagnet 236 operates the line switch 237 which completes a circuit through the compound motor 40 from the positive terminal of the power line 224 through conductor 225, contactors of switch 237, conductor 243, armature 244, commutating field 245 and series field 246 of the compound motor 40, conductor 247, contact segment 248 of a master switch 249, armature resistor 250, controller arm 251, conductor 252, the winding of an overload relay 254, conductor 240 to the negative terminal of the power line 224. Since an energizing shunt field 260 of the motor 40 is connected across the power line 224 by a circuit traced from the positive terminal of the power line 224 through conductor 261, shunt field 260, conductor 262, contact segment 263 of the master switch 249, controller arm 251, conductor 252, the winding of the overload relay 254, conductor 240 to the negative terminal of the power line; the motor 40 is thereby operated to drive the wire drawing machine. When it is desired to stop the machine, the operator removes the pressure from the pedal 220, whereby the jog switch 221 is moved upwardly by a spring (not shown), disconnecting the contacts 222—223 to deenergize the electromagnet 236 and open the line switch 237 to disconnect the motor 40 from the power line 224.

With the wire properly strung through the wire drawing machine as hereinbefore described, the machine is automatically brought up to speed by pressing a "fast" button 270 positioned in the front of the housing 10 (Fig. 1) to interconnect contacts 271—272 (Fig. 15). This interconnection establishes a circuit from the positive terminal of the power line 224 through conductors 225—226, fuse 227, conductors 228 to 230 inclusive, conductors 275—276, contactor 271, the switch of the button 270, contactor 272, conductor 277, limit switch 278, conductor 279, stationary contact 280 mounted in an insulator 281, interlocking conductor 282 carried by the switch arm 251 and effective only on speed point one of the 56 speed points into which the master switch 249 is divided, stationary contact 283 also mounted in the insulator 281, conductor 284, the winding of an electromagnet 285 of switch 286, conductor 287, conductor 238, fuse 239, conductor 240 to the negative terminal of the power line 224. The energization of the winding of the electromagnet 285 operates the switch 286 to close contacts 290—291, 292—293, and to open contacts 294—295. The closure of contacts 290—291 established a locking circuit for the electromagnet 285 from the positive terminal of the power line 224 through conductors 225—226, fuse 227, conductors 228 to 231 inclusive, a normally closed stop switch 296, conductor 297, contacts 298—298 opened when the wire breaks, conductor 299, the switch of overload relay 254, conductor 300, contacts 290—291, the winding of the electromagnet 285, conductor 287, conductor 238, fuse 239, conductor 240 to the negative terminal of the power line. At the same time the closure of the contacts 292—293 completes a circuit for energizing the electromagnet 236 of line switch 237, from the positive terminal of the power line 224 through conductors 225—226, fuse 227, conductors 228, 229, 302, and 303, contactors 293—292, conductor 235, the winding of electromagnet 236, conductor 238, fuse 239, conductor 240 to the negative terminal of the power line 224. As has been previously described, the energizing of electromagnet 236 operates line switch 237 and establishes an operating circuit for the motor 40 to actuate the wire drawing machine.

Simultaneously with the closure of the above mentioned circuits an energizing circuit for an electromagnet 305 of a switch 306 for effecting the operation of a pilot motor 307 is established from the positive terminal of the power line 224 through conductors 225—226, fuse 227, conductors 228 to 230 inclusive, conductors 275 and 276, contactor 271, the switch of the "fast" button 270, contactor 272, conductors 277, limit switch 278, conductor 308, the winding of the electromagnet 305 for the switch 306, conductor 309, fuse 239, and conductor 240 to the negative terminal of the power line. The energization of electromagnet 305 operates the switch 306 and establishes an operating circuit for the pilot motor 307 from the positive terminal of power line 224 through conductors 225—226, fuse 227, conductor 228, conductor 312, contactors 313—314 of switch 306, conductor 315, armature 316 of the

pilot motor 307, conductor 317, normally closed contactors 318—319 of a switch 320, a portion of resistance 321, conductors 322—323, conductor 309, fuse 239, and conductor 240 to the negative terminal of the power line. Inasmuch as a shunt field 330 of the pilot motor 307 is energized by a circuit traced from the positive terminal of the power line 224 through conductors 225—226, fuse 227, conductors 228—229, conductor 302, shunt field 330, conductor 331, non-inductive resistance 332, conductors 333, 323, and 309, fuse 239, conductor 240 to the negative terminal of the power line, the pilot motor 307 is operated. The pilot motor rotates the controller arm 251 of the master switch 249 counter-clockwise through a gear 334 secured to the arm, helical gear 335, vertical shaft 336, bevel gears 337—338 and pilot motor shaft 339, whereby the armature resistance 250 of the main motor 40 is gradually reduced and a shunt field resistance 342 is gradually introduced in the shunt field circuit to increase the speed of the motor 40.

As the controller arm 251 rotates in a counter-clockwise direction, it moves off contactors 345—345 of the master switch 249 to open an energizing circuit for an electromagnet 346 of an armature shunting switch 347. This circuit established when the line switch 237 is closed to complete a power circuit for the electric motor 40, is traced from the positive terminal of the power line 224 through conductor 225, the closed contactors of line switch 237, conductor 348, the winding of the electromagnet 346, conductor 349, interconnected contactors 345—345, controller arm 251, conductor 252, the winding of the overload relay 254, and conductor 240 to the negative terminal of the power line 224.

The deenergization of the electromagnet 346 opens the contactors of the armature shunting switch 347 to disconnect a paralleling armature shunt and brake resistor 350 normally connected through a circuit from the positive terminal of the power line 224 through conductor 225, contactors of the line switch 237, conductor 348, the contactors of armature shunting switch 347, conductor 351, a brake adjusting switch 352, resistor 350, conductor 353, series field 246, conductor 247, contact segment 248, armature resistor 250, controller arm 251, conductor 252, the winding of the overload relay 254, and conductor 240 to the negative terminal of the power line.

Further movement of the controller arm 251 removes the armature resistor 250 and since the paralleling resistor 350 is disconnected, full voltage is placed on the armature 244 of the motor 40. At the same time the resistance 342 is introduced into the circuit of the shunt field 260 to gradually increase the speed of the motor 40 and hence the speed of the wire drawing machine.

In order to increase the torque of the motor 40 at starting for a short period of time, a switch 357 is provided for momentarily shunting some of the armature resistance 250 to thus increase the voltage across the armature 244 until the motor gets started. A circuit for energizing the winding of an electromagnet 358 to operate the switch 357 is traced from the positive terminal of the power line 224 through conductor 225, the closed contactors of line switch 237, conductor 348, conductor 360, the winding of the electromagnet 358, conductor 361, interconnected contactors 362—362 of the master switch 249, interlocking conductor 363 carried by the controller arm 251, contactors 364—364 of the switch 249, conductor 365, contact segment 248, armature resistor 250, controller arm 251, conductor 252, the winding of the overload relay 254, and conductor 240 to the negative terminal of the power line 224. This energizing circuit operates the switch 357 to establish a shunting circuit from the positive terminal of the power line 224, conductor 225, the contactors of the operated line switch 237, conductor 243, armature 244 of the motor 40, the commutating field 245, the series field 246, conductor 247, contact segment 248, a portion of the armature resistance 250, one of a number of conductors 370—370, a dial switch 371, conductor 372, the contactors of switch 357, conductor 373, the winding of the overload relay 254, and conductor 240 to the negative terminal of the power line 224.

When the motor 40 has reached the desired speed for the wire drawing operation as indicated by the tachometer 108 (Fig. 1), pressure on the "fast" button 270 is released and the operating circuit for the pilot motor 307 is opened by operating a slidable trip 375 so that the motor 40 will operate at that speed. Mounted on a controller panel (not shown) are brackets 376—376 for slidably supporting the trip 375 which is normally held in a retracted position by a spring 377. Secured to the trip 375 is an adjustable stop 378 adapted to be engaged by a depending projection 379 on the right hand end of the controller arm 251 to thus move the slidable trip 375 to operate the limit switch 278 and open the energizing circuit for the electromagnet 305 of the switch 306. The deenergization of the electromagnet 305 permits the contactors 313—314 of the switch 306 to open and thus disconnect the operating circuit for the pilot motor 307 hereinbefore described, whereby the motor 40 operates at the speed as set by the stop 378 on the trip 375.

When the take-up spool 130 is filled with finished wire, the wire traveling from the guide bushing 125 of the distributing rod 121 to the take-up spool 130 enters the slot in the fork 196 of the automatic device 195, causing the dielectric stud 200 to move the contact spring 201 into engagement with contact spring 202. This closure of the contact springs 201—202 completes a circuit from battery through conductor 382, the winding of an electromagnet 383, conductor 384, contact springs 201—202, and conductors 385—386 to the other terminal of the battery. The energization of the electromagnet 383 closes a switch 388 to short circuit a "slow" switch 387, this having the same effect as if the "slow" switch were manually operated to decrease the speed of the motor 40 to jog speed obtained by operating the foot pedal 221. The closure of switch 388 establishes an energizing circuit for the electromagnet of the switch 320 from the positive terminal of the power line 224 through conductor 225—226, fuse 227, conductors 228 to 230 inclusive, conductor 275, conductor 392, switch 388, conductors 393—394, contactors of a limit switch 395, conductor 391 the winding of the electromagnet for the switch 320, conductor 323, conductor 309, fuse 239, conductor 240, to the negative terminal of the power line 224. The operation of switch 320 completes a circuit for operating the pilot motor 307 in a reverse direction to return the controller arm 251 to its normal position. This circuit is traced from the positive terminal of the power line 224 through conductors 225—226, fuse 227, conductor 228, the contactors 396—397 of the switch 320, conductor 317, armature 316 of the pilot motor 307, con-

ductor 315, normally closed contactors 398—399 of the switch 306, a portion of resistance 321, conductors 322—323, conductor 309, fuse 239, and conductor 240 to the negative terminal of the power line 224. As the controller arm 251 is thus driven clockwise and returns to its normal position, the right hand end thereof engages and operates the limit switch 395 to open the pilot motor operating circuit, previously described, and thus to stop the operation of the pilot motor 307.

If, during the drawing operation, the wire breaks or the supply thereof becomes exhausted, the pressure of the wire on the automatic stop device 208 (Fig. 9) is removed and the lever 209 thereof is rotated through a small arc until the contact spring 216 is moved into engagement with the contact spring 217 as hereinbefore described. This closure establishes an energizing circuit for an electromagnet 404 for opening the contacts 298—298, which is traced from battery through conductor 382, conductor 405, the winding of the electromagnet 404, conductor 406, spring contacts 216—217, conductor 386 to battery. The energization of electromagnet 404 causes the attraction of the switch 298 to open the locking circuit for the electromagnet 285 of the switch 286 and has the same effect as if the stop switch 296 were manually opened. The deenergization of the electromagnet 285 and subsequent opening of the contactors 292—293 of the switch 286 disconnects the energizing circuit for the electromagnet 236, whereby the contactors of the line switch 237 are opened and the operating circuit for the motor 40 is disconnected to stop automatically the operation of the wire drawing machine.

Bringing the machine to a quick stop is expedited by the operation of an electromagnetic switch 408 to establish a dynamic braking circuit when the electromagnet 236 of the line switch 237 is deenergized. The circuit for energizing an electromagnet 409 for operating the switch 408 is established from the right hand brush of the armature 244 of the motor 40 through conductor 243, normally closed contactors 410—411 associated with the line switch 237, the winding of the electromagnet 409, conductor 412, conductor 353, and the commutating field 245 to the left hand brush of the armature 244. Since the shunt field 260 of the motor 40 is always energized, as previously described, and the momentum of the armature 244 continues its rotation, the motor 40 then acts as a generator to send current through the above circuit to energize the electromagnet 409 and operate the relay 408 to connect it to a resistor circuit and thus quickly stop the rotation of the armature 244. The resistor circuit is traced from the right hand brush of the armature 244 through conductor 243, the closed contactors of switch 408, conductor 413, resistance 350, conductor 353, and the commutating field 245 to the armature 244 to complete the circuit. The resistance 350 serves as a load and thus the momentum of the armature 244 is rapidly transformed into dissipated electrical energy to quickly bring the armature to a standstill.

Although the invention herein described is particularly well adapted for use in wire drawing, it will be understood that the invention is capable of many other modifications and applications without departing from the scope and the spirit of the invention as defined by the appended claims.

What is claimed is:

1. In a strand working apparatus, a plurality of dies, means for drawing a strand through the dies, a shaft, a sheave secured thereto for guiding the strand to the dies, means for driving the shaft to impart a circumferential speed to the sheave substantially equal to the speed of the traveling strand, and another sheave rotatably mounted on said shaft and being driven by the strand at approximately the same angular speed as that of the shaft.

2. In a strand working apparatus, a housing, a cover therefor, means mounted within the housing for supporting a die, means for drawing the strand through the die, a lever pivoted at one end, the other end of the lever in contact with the die, and means carried by the cover for making contact with the lever and locking the die in operative position when the cover is in its closed position.

3. In a strand working apparatus, a housing, a cover therefor, means mounted within the housing for supporting a plurality of dies, means for drawing the strand through the dies, locking means for the dies, and means for closing the cover to render the locking means effective to lock the dies in operative position, said locking means comprising a block secured to the cover, a lever pivoted at one end, the other end of the lever in contact with one of the dies, and means secured to said block and in contact with said lever.

4. In a strand working apparatus, a plurality of dies, a die shelf for supporting the dies, a pair of shafts, a plurality of stepped sheaves mounted on one of said shafts, a plurality of stepped capstans mounted on the other shaft, and means operatively associated with the shafts for actuating simultaneously each of the separate capstans and one of the sheaves at different speeds to draw a supply of wire through the dies, another of said sheaves rotatably mounted on said one shaft and driven by the strand at approximately the same angular speed and in the same direction as the shaft.

5. In a strand working apparatus, a plurality of dies through which the strand is adapted to be drawn, a rotating shaft, a plurality of sheaves secured to said shaft driven at circumferential speeds equal to the linear speeds of the portions of the wire passing thereover, and other sheaves rotatably mounted on said shaft and having diameters such that the portions of the wire passing thereover rotate the sheaves at approximately the same angular speeds as that of the shaft.

6. In a strand working apparatus, a pair of shafts, means for rotating said shafts, a plurality of dies located between said shafts, a plurality of capstans on one of said shafts, one of said capstans rigidly secured to said one shaft and another of said capstans rotatable on said one shaft, means for driving said other capstan, a plurality of sheaves on said other shaft, one of said sheaves rigidly secured to said shaft, another of said sheaves rotatable on said shaft independent of the means for rotating said shaft and said other capstan.

7. The method of drawing a strand of wire through two groups of dies which comprises drawing the strand through the first group of dies and over a plurality of sheaves loosely mounted on a shaft, then drawing the strand through the last group of dies and over a plurality of sheaves secured to the shaft while simultaneously rotating the shaft to positively drive the sheaves secured to the shaft at circumferential speeds equal to the linear speeds of the portions of the wire passing thereover.

8. In a strand working apparatus, a pair of

shafts, means for rotating said shafts, a plurality of dies located between said shafts, a capstan secured to one of said shafts, a plurality of sheaves on said other shaft, one of said sheaves rigidly secured to said shaft and rotating at approximately the same linear speed as the wire passing thereover, and another of said sheaves frictionally mounted on said shaft and having a diameter such that the linear speed of the wire passing thereover is approximately equal to the linear speed of the sheave.

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