Jan. 10, 1961 F. J. MARKEY 2,967,675

CONTROL SYSTEM FOR COIL SUPPORT

Filed April 9, 1956 4 Sheets-Sheet 1

FIG. 1

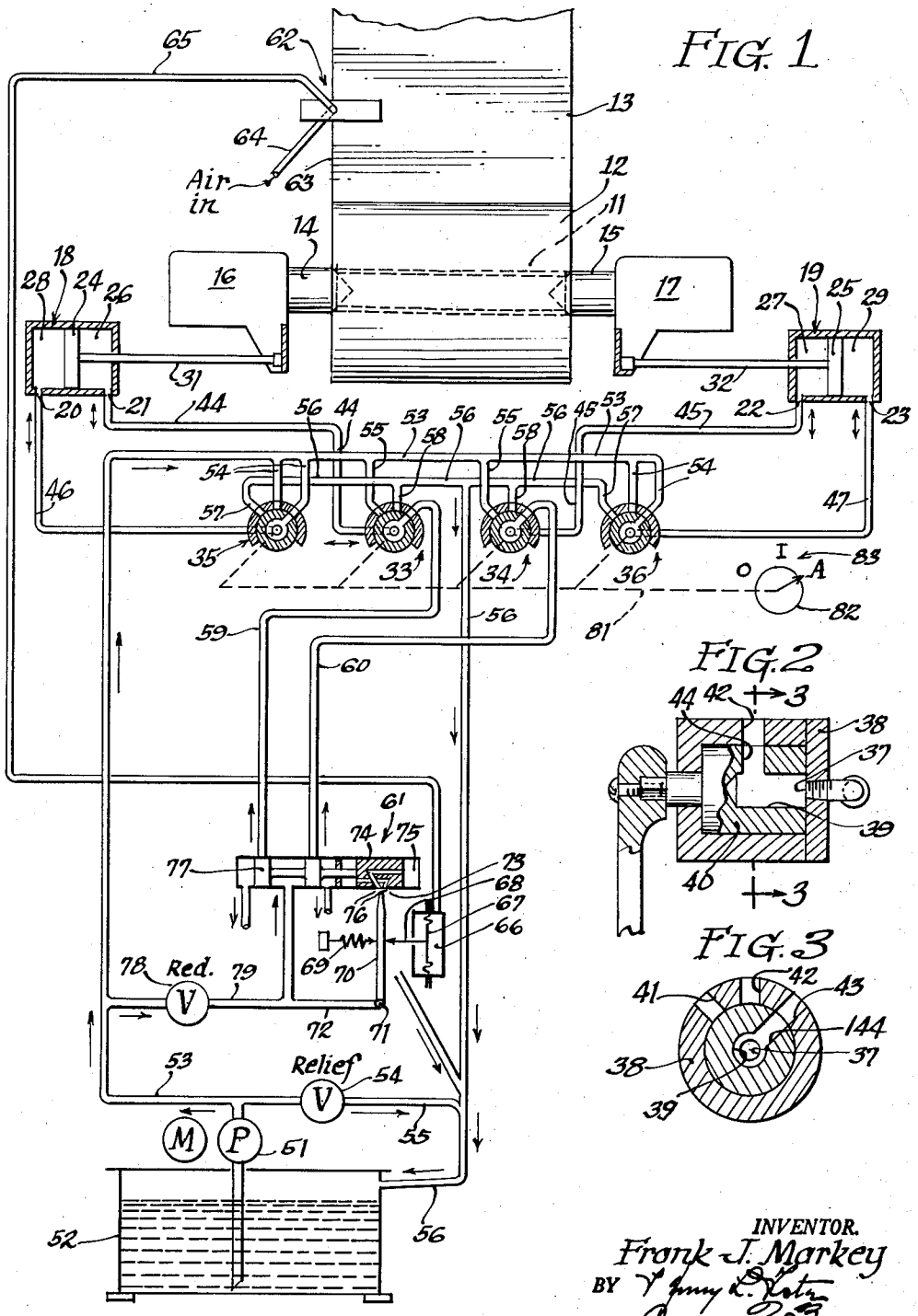


FIG. 2

FIG. 3

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Jan. 10, 1961 F. J. MARKEY 2,967,675

CONTROL SYSTEM FOR COIL SUPPORT

Filed April 9, 1956 4 Sheets-Sheet 2

FIG. 4

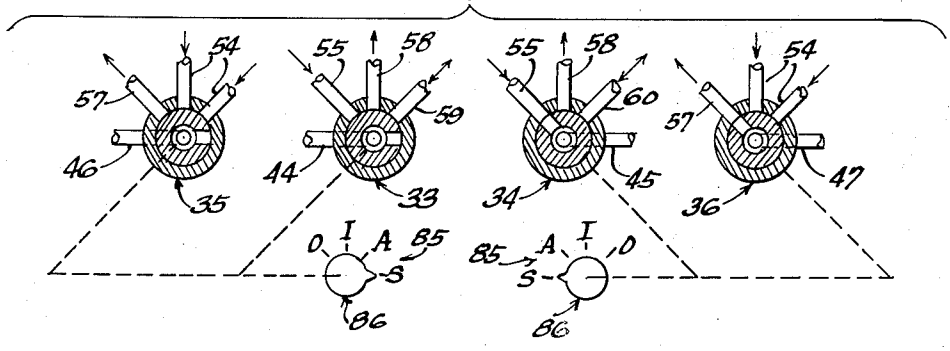


FIG. 5

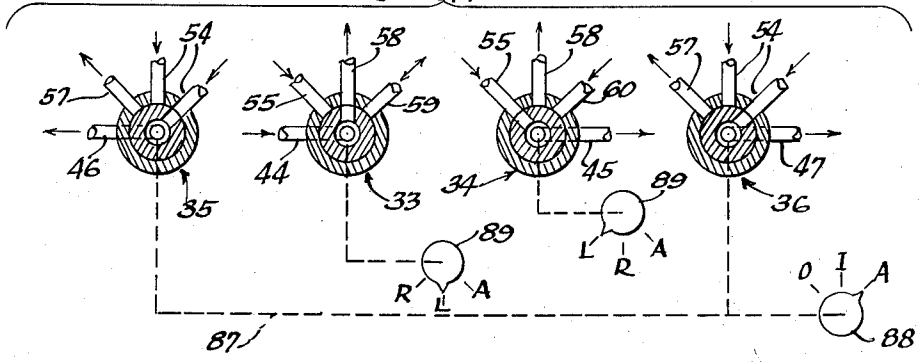
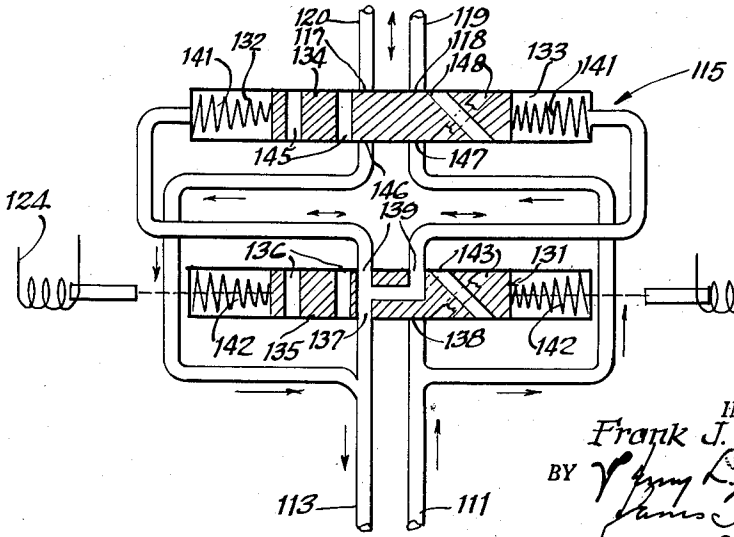


FIG. 7



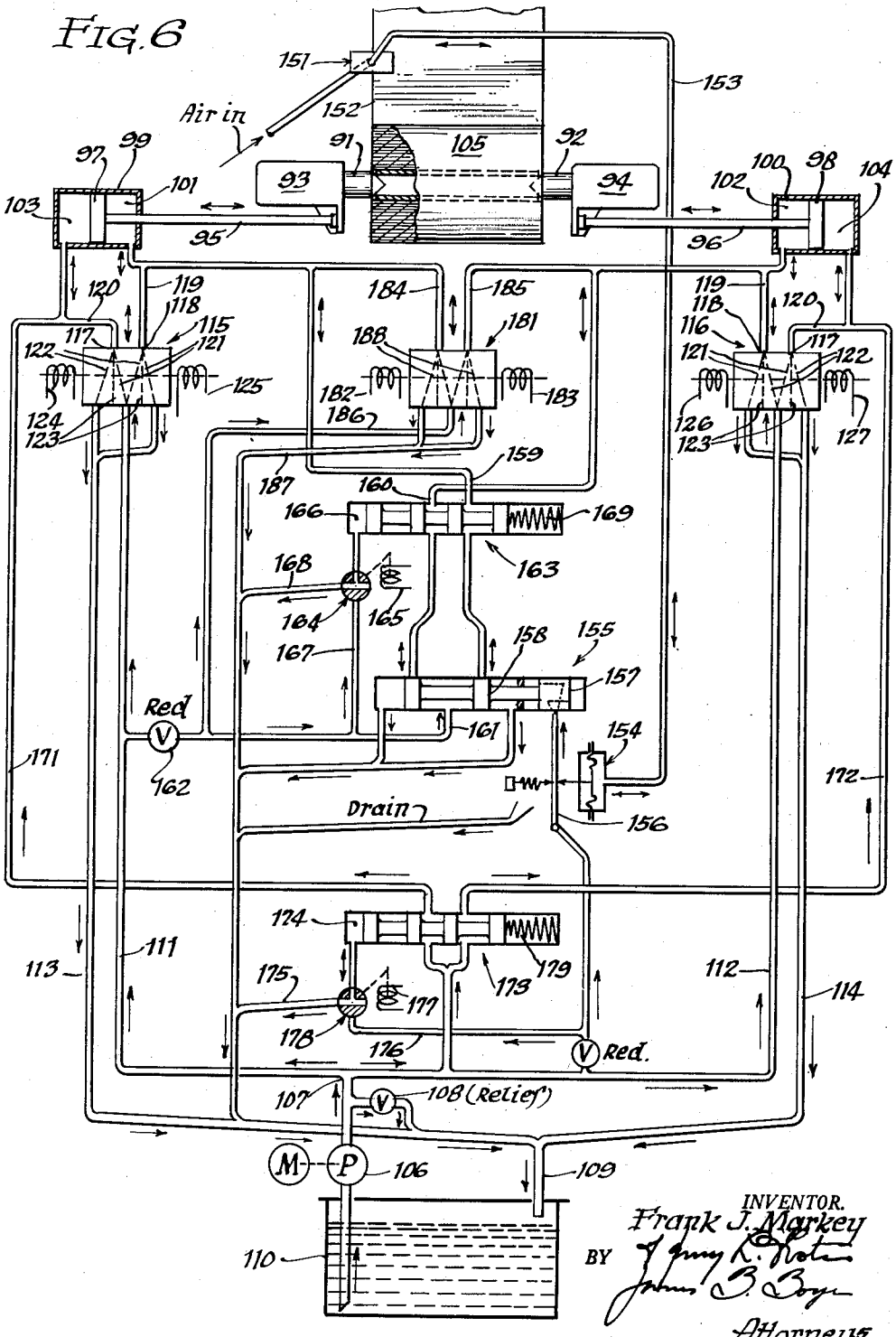
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CONTROL SYSTEM FOR COIL SUPPORT

Filed April 9, 1956 4 Sheets-Sheet 3

FIG. 6

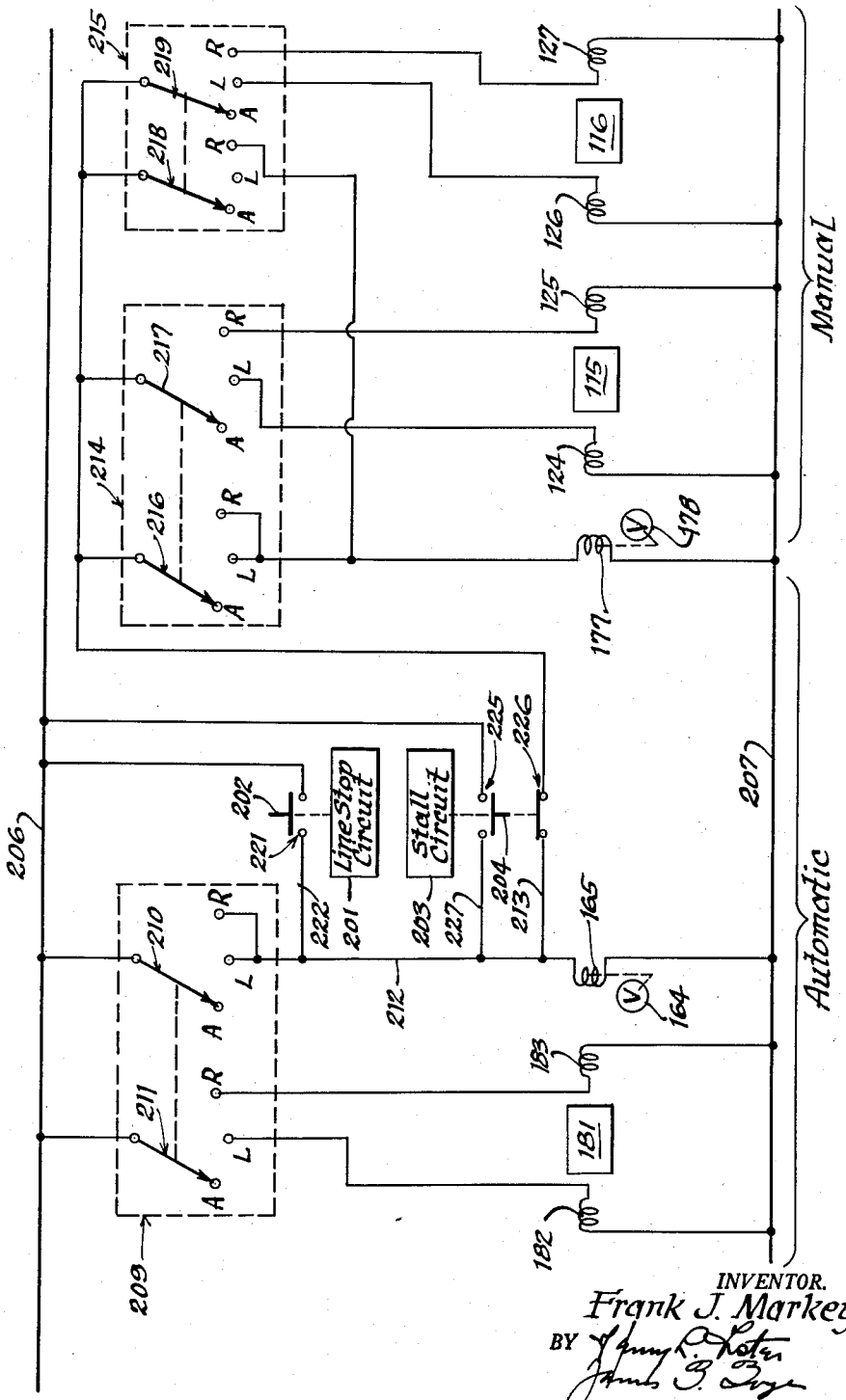


Jan. 10, 1961 F. J. MARKEY 2,967,675

CONTROL SYSTEM FOR COIL SUPPORT

Filed April 9, 1956 4 Sheets-Sheet 4

FIG. 8



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2,967,675

CONTROL SYSTEM FOR COIL SUPPORT

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Filed Apr. 9, 1956, Ser. No. 576,950

13 Claims. (Cl. 242—78.6)

The present invention relates to systems for control of the axial positions of a pair of mandrels or shafts designed to engage opposite ends of, and hold between them the supporting structure of a coil of web or strip material, as a core or reel structure, which shafts are connected operatively to, for axial movement by the output members of a pair of reversible hydraulic power units, typically piston and cylinder assemblies.

More specifically the invention relates to such a control system that is arranged to so control the supporting shafts that selectively, and by very simple manually effected control procedure, those shafts may be moved in accordance with a number of systematically related types of operation that respectively correspond to different procedures that are to be followed in respect to the coil or the coil supporting structure. While such desirable types of operation may vary between different installations, quite universally it is desirable to provide for simultaneous movement of the two mandrel shafts toward each other to bring them into supporting engagement with the coil support, for simultaneous retracting movement of the shafts away from each other to release a coil support, and for simultaneous movement of both shafts in the same direction and at the same speed while maintaining them in secure supporting engagement with an intervening coil support. The last type of operation may be placed under automatic control, as for example, to automatically adjust the axial position of the supported coil during reeling for the purpose of maintaining in a preselected travel path the web or strip being coiled or uncoiled, and/or provision may be made for manual control of that operation for adjusting the axial position of a coil supported between the mandrel shafts. In some situations it may be desirable to provide for independent movement of a single one of the mandrel shafts in either direction. Finally, in certain situations it is desirable to provide for control of the mandrel shaft adjusting system in correlation with control of mechanism that drives or otherwise operates on the material being wound or unwound onto or from the coil supported by the mandrel shafts.

Accordingly, it is a primary object of the invention to provide a novel hydraulic control system arrangement providing for selectively placing the system in different conditions wherein respectively it will perform in accordance with different ones of the described types of operation, by changing the manner of connection of the different inputs of reversible hydraulic units with hydraulic supply lines that are connected to deliver fixed, relatively high pressure, controlled lines that are connected to deliver fluid at variable pressures, and exhaust lines. Such connections are established by variously interrelated settings of multiple selector valve units each of which settings will provide one of a selected group of the above-enumerated types of operation of the two power units and of position adjustment of the mandrel shafts respectively connected with their output members.

Another object is to provide in such a system a novel

combination of control valve members with actuators so interlocked as substantially to preclude misoperation resulting from their actuation in faulty combinations.

Another object is the provision in such a system of a novel arrangement permitting employment of the same system for accomplishing automatic control of the axial position of a mandrel supported coil, while permitting alternative desirable types of manually controlled positioning of the mandrel shafts.

In the accompanying drawings:

Fig. 1 is a view, primarily schematic but showing in cross section certain multiway fluid delivery control elements that are employed to make provision for selection of a required type of operation, and disclosing a relatively simple system embodying the invention and providing the three basic types of operation enumerated, simultaneous inward advance of the mandrel shafts, simultaneous outward retraction thereof, and simultaneous movement of both in the same direction and at the same speed while maintaining secure engagement between the shafts and an intervening coil structure.

Fig. 2 is an axial sectional view of a multiway selector valve of the type used in the Fig. 1 system.

Fig. 3 is a section on line 3—3 of Fig. 2.

Figs. 4 and 5 are fragmentary views showing various alternative interconnections of an array of selector valves as arranged in Fig. 1, that may be employed for providing different types of operation with the valves interconnected for convenient and confusion-free operation.

Fig. 6 is a schematic diagram of a more complex system with refinements designed to provide a high degree of flexibility as to types of operation that may be performed, additional to the three basic ones mentioned and to provide an electrically actuated control system for the selector valves that permits operation selection from any required location.

Fig. 7 is a schematic diagram of one of three solenoid actuated pilot and control valve assemblies that are used as selector valves in the system of Fig. 6.

Fig. 8 is a schematic diagram of an electrical system arranged for control of the system of Fig. 6, also showing manner in which the system can be combined with drive and braking mechanism controls of a pass installation, that is, mechanism for driving and/or operating on material being wound upon or unwound from a coil supported by mandrels that are actuated in accordance with the invention, wherein the mandrel shaft positioning system is used, for automatic correlation of appropriate conditions of the latter system and corresponding types of mandrel shaft control operations, with conditions of the driving or work-performing mechanism that require or make desirable those types of shaft positioning operation.

Describing the drawings, and first referring to Figs. 1 to 3, a reel structure is shown as comprising a cylindrical core **11** on which is a coil **12** of web material **13**, which may be wound or unwound for various purposes, and which is shown without drive means for rotating the coil in either direction. Such reel structure is supported between a pair of mandrels or shafts **14**, **15** which respectively are mounted on carriages **16**, **17** which in turn are mounted for movement in directions parallel to the aligned axes of shafts **14**, **15** for carrying the latter between advanced or reel structure-engaging positions, wherein they are shown, and retracted positions wherein they are withdrawn from their reel structure-engaging positions. In accordance with the control system arrangements embodying the invention, carriages **16**, **17** respectively are connected with the output members of reversible hydraulic motors provided with dual operating fluid input connections, delivery of fluid to the different ones of which serves respectively to operate the motors in oppo-

site directions to move carriages 16, 17 and shafts 14, 15 toward their advanced and retracted positions. Such motors are shown as comprising piston and cylinder assemblies 18, 19 respectively having input connections 20, 21 and 22, 23 by means of which the different cylinder ends of the two assemblies that correspond in respect to their relative positions and the directions of motion of pistons 24, 25, that is, inner cylinder ends 26, 27 and outer cylinder ends 28, 29 may be connected to sources of pressurized operating fluid, exhaust lines, and controlled fluid delivery lines, in such combinations as to produce the types of operation which a given installation is to provide. Herein the input connections of the power unit to which delivery of fluid results in development of forces tending to advance the mandrel shafts toward their reel structure-engaging positions, such as 20, 23 in Fig. 1, are termed "first" input connections, the others, such as 21, 22, being termed "second" input connections. Pistons 24, 25 are connected to carriages 16, 17 by piston rods 31, 32.

It will be appreciated that for the purpose of positioning the mandrels in accordance with the invention, use may be made of various arrangements of piston and other types of hydraulic motors provided with dual fluid input connections and arranged to translate pressures of fluid delivered to the different connections into forces respectively exerted to move the motor output members in opposite directions, and to translate a differential or unbalance between such pressures into a movement of the output member in a direction that is determined by the identities of the different connections to which higher and lower pressures are delivered. Hereinafter an unbalance of pressures in fluid delivered to the input connections of such a motor, or in pressures of lines connected to them, or exhaust of one and delivery of fluid under pressure to the other, that tends to produce inward movement of one or both mandrels toward their reel structure-engaging positions is referred to as being "in a sense" to produce such inward movement, while an unbalance, or an exhausting of one and supply to the other of such connections is termed as being "in a sense" to produce outward or retracting movement of the mandrels.

The fundamental principle of connection of the cylinder ends to supply, exhaust and control lines is to arrange the system for simultaneous connection of outer cylinder ends 28, 29 to the source of operating fluid and inner cylinder ends 26, 27 to exhaust to simultaneously advance shafts 14, 15 toward each other, for establishing supporting engagement with a reel structure such as core 11; to simultaneously connect inner cylinder ends 26, 27 to the pressurized fluid source and outer ends 28, 29 to exhaust for simultaneous retraction or outward movement of shafts 14, 15, and, for simultaneous movement of both shafts 14, 15 in the same direction, and while maintaining them in secure, supporting engagement with a reel structure, to connect the outer cylinder ends 28, 29 with the source of pressurized fluid, through connecting means that maintain relatively high pressure in those outer cylinder ends, and to vary the pressure exerted in the inner cylinder ends to produce unbalance of the total pressure-developed forces exerted in opposite directions by the respective pistons 24, 25, to produce a resultant movement toward that one of the assemblies 18 or 19 of which the piston is exerting the smaller of the opposed forces. In the latter case, the system for varying the inner cylinder end pressures is so arranged that the maximum pressure that it can develop in an inner cylinder end is substantially less than the opposed pressure exerted in the outer end of the same cylinder, thereby assuming that the shafts are maintained in supporting engagement with a reel interposed between them. The system additionally provides for exhausting of fluid from the one of the inner cylinder ends that is at the lower pressure, for escape of fluid from the outer end of the same cylinder, and for continued supply of fluid to the other outer cylinder end, preventing hydraulic lock up in this third condition.

For these purposes a complex valve arrangement is provided comprising four valve sections respectively assigned to and controlling delivery of operating fluid to the four cylinder ends 26, 27, 28, 29. As shown, such valve means may comprise four multiway valves 33, 34, 35, 36, each of which has a controlled port 37 in its housing 38, Fig. 2, which is connected to the cylinder end controlled by that valve section and which is in continuous communication with a passage 39 in the movable body of the valve, as for example, an axial passage in a rotatable cylindrical body 40 as shown, and three individual ports 41, 42, 43, with which passage 39 and port 37 are selectively placeable in communication by appropriate positioning of the valve body. In the arrangement shown, ports 41, 42, 43 are angularly spaced in casing 38 about the periphery of cylindrical body 40, and a radial passage 144 that communicates with passage 39 is arranged to be registered with them by relative positioning of body 40. In the arrangement of Fig. 1 the common or controlled ports of valves 33, 34, 35, 36, corresponding to port 37 of Figs. 2 and 3, respectviely are connected to the cylinder and connections 21, 22, 20 and 23 by service lines 44, 45, 46, 47. Thus, each of the different cylinder ends selectively can be placed in communication with any one of the three ports 41, 42 and 43 of the one of the valves 33, 34, 35 or 36, the port 37 of which is connected to that particular cylinder end.

The source of fluid under pressure provided for operating the hydraulic power units 18, 19 is shown as a pump 51 that withdraws oil from a sump tank 52 and delivers it through a supply line 53 at a constant pressure set by a relief valve 54 in a bypass return line 55. Each of the two outer cylinder end controlling valve units 35, 36 has two of its ports, corresponding to ports 42, 43, Fig. 3, connected to supply line 53 by branch passages 54, while each of the inner cylinder end controlling valve units 33, 34 has a single valve port, corresponding to port 41 of Fig. 3, connected to supply line 53 by a branch passage 55. The fluid system also includes an exhaust main 56 for return of exhausted fluid to tank 52. Each of the outer cylinder end controlling valve units 35, 36 has a port, corresponding to port 41 of Fig. 3, connected to exhaust line 56 by a branch exhaust line 57. Each of the inner cylinder end controlling valve units 33, 34 has a single port, corresponding to port 42 of Fig. 3, connected to exhaust main 56 by a branch exhaust line 58. Finally, the third selector port of each of the inner cylinder end control valve units 33, 34, corresponding to port 43 of Fig. 3, is connected to a different one of a pair of controlled lines 59, 60, delivery of fluid through the different ones of which determines the balance of force, or sense of unbalance of force, exerted oppositely by the two pistons 24, 25, in the third condition, that of simultaneous codirectional movement of shafts 14, 15.

For the moment, assuming that controlled lines 59, 60 are connected to fluid delivery control means so arranged that fluid may be delivered through either at a variable rate and/or supplied under variable pressure, with provision for exhausting fluid from the other, it will be seen that in the conditions in which valve units 33, 34, 35 and 36 are shown, outer cylinder end 28 is connected through service line 46 and valve unit 35 to one of the branch passages 54 of supply line 53, and that outer cylinder end 29 is similarly connected to supply line 53 by service line 47 and valve unit 36. Also inner cylinder end 26 is connected by service line 44 and valve unit 33 to controlled line 59, and inner cylinder end 27 is similarly connected to controlled line 60 by service line 45 and valve unit 34. Further assuming that the maximum pressure at which fluid can be supplied through controlled line 59 or 60 is less than pressure of fluid delivered by supply line 53, it will be seen that a difference in the pressures effective in the different cylinder

ends 26, 27 will serve to unbalance the oppositely directed forces exerted by pistons 24, 25, each of which is a resultant of the difference between pressures exerted in the different ends of each cylinder and oppositely acting on the piston of that assembly. Consequently such an unbalance of piston forces will result in movement of both pistons, shafts 14, 15, and a reel structure, as 11, engaged between the latter. It will also be evident that, because the pressures exerted in the outer cylinder ends always are greater than those exerted in the inner ends, there are always resultant inwardly directed forces exerted by the pistons, which serve to maintain shafts 14, 15 engaged with the reel structure regardless of the existence and sense of unbalance of force components resulting from unequal pressures exerted in the inner cylinder ends. It also will be apparent that connection of both outer cylinder ends to the same supply line 53 establishes an interconnecting path between those cylinder ends, comprising service lines 46, 47, a pair of branch supply lines 54 and valve units 35, 36. This interconnecting path prevents hydraulic lockup between cylinder ends 28, 29, permitting fluid to enter and leave them at corresponding rates as pistons 24, 25 move during unbalance of pressure in the inner cylinder ends 26, 27. Because fluid enters and leaves the outer cylinder ends at the same volume rate, the pistons of the two units effectively are locked together against relative movement in this operating condition.

As shown, controlled lines 59, 60 may be connected to a hydraulic relay regulator for automatic selection of identities of lines 59, 60 through which fluid is delivered for increasing pressure in one inner cylinder end, thereby to produce the indicated axial movement of the assembly. In the specific arrangement shown such a regulator comprises a well known jet pipe, auxiliary piston and booster assembly 61, which is shown as connected to and controlled by a web edge position detector 62 in an arrangement for automatically positioning the reel, coil and support assembly 11, 12, 14, 15 to maintain the edge 63 of web 13 in a preselected travel path.

The web edge position detector is of known jet and receiver type, of which an example is disclosed by United States Patent No. 2,687,885, and wherein a jet of air, supplied by a conduit 64 is discharged across a gap or throat wherein is positioned the marginal portion and edge 63 of web 13, to a receiver port connected to a signal pipe 65, whereby magnitude of pressure developed in the receiver port and present in pipe 65 is a function of the lateral position of web edge 63 and the cross sectional area of the jet intercepted by the web. This pressure is transmitted to an expansible chamber 66 closed at one side by a flexible diaphragm 67 which translates its magnitude to a force in a force balance system that includes transmission link 68 and a settable return spring 69. The opposed forces respectively developed by diaphragm 67 and spring 69 are summarized through opposed exertion on the movable control member of the hydraulic relay regulator, here jet pipe 70.

Jet pipe 70 is pivoted to swing about an axis 71, in response to the resultant of the forces mentioned, effectively to an angular position corresponding to magnitude of signal pressure transmitted to chamber 66, oil being supplied under pressure to jet pipe 70, for discharge through an orifice in the jet pipe tip, through a line 72. Facing the jet pipe discharge orifice is a receiver surface 73 of an auxiliary piston body 74 that is movable in a cylinder 75 in the directions of travel of the jet pipe tip and orifice. A pair of receiver ports 76 face the orifice path, being cross connected through the body of piston 74 to the opposite ends of cylinder 75, and ports 76 being narrowly spaced in the directions of piston and jet pipe orifice travel. The arrangement is such that, due to unbalance of pressures across piston 74 while ports 76 are in unequal degrees of registration with the jet pipe orifice, those pressures being developed by kinetic energy of jet portions impingement on the ports, piston 74 will move in the direction to equalize port-orifice registration. Thereby piston 74 follows movements of jet pipe 70, and its position is a function of signal pressure developed by detector 62 and of the position of web edge 63. A spool type control valve body 77 is connected to piston 74 and by it is positioned in correspondence to positions of the jet pipe 70 and web edge 63, thereby controlling sense of supply and exhaust and rate of supply of operating fluid to controlled lines 59, 60. In order to limit pressure that is effective in the inner cylinder ends 26, 27 to a maximum that is sufficiently less than the supply pressure of fluid delivered to the outer cylinder ends through main supply line 53 to insure maintenance of mandrel shafts 14, 15 in engagement with a reel structure, supply of valve 77 is through a pressure reducing valve 78 connected in a branch line 79 of main line 53.

For convenient, single-operation positioning of the bodies 40 of valve units 33, 34, 35 and 36, those bodies are ganged together, as indicated at 81 in Fig. 1, for simultaneous movement to three different sets of corresponding conditions, in the different ones of which and in combination they are effective to provide the three described types of operation of the mandrel shafts 14, 15. These three types of operation may be selected by movement of a common actuator 82 to appropriate positions as suggested by an indicator scale 83 whereon "I" indicates simultaneous inward movement of shafts 14, 15, "O" indicates their simultaneous outward movement and "A" indicates simultaneous movement of shafts 14, 15 in the same direction while the greater pressures in outer cylinder ends 28, 29 maintain them in supporting engagement with an intervening reel or other coil support structure. In the particular arrangement of Fig. 1, this "A" condition is automatic, operation being under control of the web edge lateral position detector 62 and relay regulator 61.

In some situations it may be desirable to make provision for maintaining one of the mandrel shafts 14, 15 in a fixed position while moving the other in a selected direction. The arrangement shown by Fig. 4 may be used for such purposes. In this arrangement instead of all four operators of the control valve units 33, 34, 35 and 36 being ganged together, the two pairs of such units 33, 35 and 34, 36 which respectively control power unit assemblies 18 and 19 are ganged together, the two pairs so ganged each being operable independently of the other. It will be seen that by providing for the different valve units a fourth position, designated by letters "S" on the two dial scales 85 respectively associated with the operators 86, wherein the cylinder lines 44, 46 and 45, 47 are blocked, either or both power units may be hydraulically locked against movement, or either one may be operated in either direction while the other is maintained locked, by appropriate positioning of the two control members 86.

Another type of connection of the selector valve actuators is shown in Fig. 5, wherein the actuators of the outer cylinder end controlling selector valve units 35, 36 are shown ganged together at 87 for operation by a common actuator 88, and the inner cylinder end controlling selector units 33, 34 are provided with completely independent actuators 89.

The system shown in Fig. 6 is somewhat more complex than that of Fig. 1, refinements having been added in adaptation of the system to electrical control, as by the system of Fig. 8. The system also is arranged to permit alternative control of simultaneous axial movement of reel-supporting mandrel shafts in the same direction while they are maintained in supporting engagement with a reel structure, either by automatic means, again shown as a web edge position detector for web guiding, or manually for inching a reel axially to a required position, provision being made to safeguard against dropping a reel during

the latter operation. The combined electrical and hydraulic systems also provide for placing the mandrel control system in different conditions wherein respectively it will perform different types of operation that are required or highly desirable in certain services, principally in reeling and unreeling metal strip of substantial gauge, such as setting up of a stalled condition wherein the strip is subjected to substantial tensing for set up purposes, emergency stop, and so on, the mandrel control systems chiefly being arranged to lock the mandrels or to condition the hydraulic system for moving them in automatic correlation with conditions of the pass mechanism, that is, drive roll operation, machine operation, and so on, all designed to prevent misoperation by mandrel position control functions that should be effected only during existence of certain conditions of the other mechanism.

In the system of Fig. 6, a pair of coil supporting or reel engaging mandrel shafts **91, 92** are supported by carriages **93, 94** that are movable in directions parallel to the shaft axes, and that are connected by rods **95, 96** to pistons **97, 98** that are movable in cylinders **99, 100**, the latter having corresponding inner ends **101, 102** and corresponding outer ends **103, 104**. As in the system of Fig. 1, the hydraulic system of Fig. 6 is so arranged that three basic operating conditions may be imposed on cylinders **99, 100**, one wherein supply pressure is effective in the outer cylinder ends **103, 104** while the inner cylinder ends are exhausted, for advancing shafts **91, 92** to supporting engagement with the supporting structure of a coil **105**; one wherein supply pressure is made effective in the inner cylinder ends while the outer cylinder ends are exhausted, for retracting shafts **91, 92**; and a third wherein supply pressure is made effective in the outer cylinder ends, with establishment of an effective bypass between them, and variable and reversible unbalance of pressures of the inner cylinder ends may be effected, within a range of maximum pressure materially below the supply pressure, for simultaneous movement of shafts **91, 92** in the same direction while maintaining secure engagement with the coil supporting structure. Basically the system of Fig. 6 is similar to that of Fig. 1, although in the former the various selector valves are shown as more scattered, as permitted by the electrical control system. Additionally, provision of greater flexibility in the Fig. 6 system necessitates a more complex array of control valves.

Operating fluid for the power units **97, 99** and **98, 100**, is supplied under pressure by a pump **106**, that delivers to a main supply connection **107** at a pressure determined by setting of a relief valve **108**. An exhaust main **109** is provided for return of spent or bypassed fluid to a sump tank **110** which supplies pump **106**. Between main supply fitting **107** and the different ends of cylinders **99, 100** are three alternatively operable supply channels that selectively may be established for various types of control of movements of pistons **97, 98** and shafts **91, 92**.

A first such channel is arranged to be established and selectively operated in one of two reversed conditions wherein respectively that channel is effective to simultaneously and oppositely move shafts **91, 92** inward or outward, to engage or disengage a coil support. This channel is arranged to deliver fluid at the full pressure present in main supply fitting **107** to the appropriate corresponding ones of the cylinder ends **101, 102** or **103, 104**, while connecting the other pair of such ends to exhaust main **109**. To these ends a pair of first supply lines **111, 112**, and branch exhaust lines **113, 114** are connected to a pair of control valve assemblies **115, 116** that respectively select, in coordinated relationships to provide the two operations assigned to this channel, the pairs of cylinder ends **101, 102** or **103, 104** that are connected to supply lines **111, 112** and exhaust lines **113, 114**. Valves **115, 116** also have neutral conditions blocking all communication between the cylinder ends and lines **111, 112, 113** and **114**.

The various conditions to which valves **115, 116** are adjustable are indicated schematically in Fig. 6 by the dotted lines that represent the different communication paths that may be selectively set up for pairs of controlled ports **117, 118** that in each of these valve assemblies respectively are connected by first lines **119** to the inner cylinder ends **101, 102** and by second delivery lines **120** to the outer cylinder ends **103, 104**. As shown by dotted lines **121** the controlled ports **117** may be connected to the first supply lines **111, 112** while ports **118** are connected to branch exhaust lines **113, 114**, thereby to move shafts **91, 92** simultaneously inward. As shown by dotted lines **122**, controlled ports **118** may be connected to supply lines **111, 112** while ports **117** are connected to the branch exhaust lines, thereby to move shafts **91, 92** simultaneously outward. Or, as shown by dotted lines **123**, ports **117, 118** may be blocked, setting up a neutral condition which prevails during control of shafts **91, 92** by another channel.

Valve assemblies **115, 116** preferably, and as shown are operable respectively by pairs of solenoids **124, 125** and **126, 127**, in such arrangement that change of the energization conditions of solenoids **124, 126** to an actuating condition, here assumed to be accomplished by their current-energization, places the valves in the conditions represented by dotted lines **122**, for retraction of shafts **91, 92**; change of the energization condition of solenoids **125, 127** to actuating condition, also assumed to be by their current-energization, establishes the conditions represented by dotted lines **121**, advance of shafts **91, 92**; while non-actuating condition of the paired solenoids, assumed here to be non-energization of both, establishes the cutoff conditions represented by lines **123**.

Advantageously valve assemblies **115, 116** are of the arrangement shown in Fig. 7, which is represented in orientation corresponding to that of unit **115** in Fig. 6, and to which the same numerals have been applied, including a pilot valve **131** that is actuated by the solenoids, **124, 125**, and that in turn controls exhausting and delivery of pressure fluid, supplied through line **111**, from and to the different ones of a pair of cylinders **132, 133** to position a main valve body **134** in a selected one of three positions wherein respectively it establishes the three conditions represented by dotted lines **121, 122, 123** in Fig. 6.

Pilot valve **131** includes a body **135**, movable between center left and right positions, as it is seen in Fig. 7, in respective consequence of deenergization of both, and energization and deenergization in reverse senses of solenoids **125, 124**, and having three paired sets of passageways; a pair of straight through passages **136** adapted to connect main valve cylinder **132** to an exhaust port **137** and valve cylinder **133** to supply port **138** when the energization conditions of solenoids **124, 125** are such as to move pilot valve body **135** to the right, a pair of passageways **139** arranged to connect both main valve cylinders **132, 133** to the same one of ports **137, 138**, here shown as being exhaust port **137**, to equalize pressures in cylinders **132, 133** to permit main valve body **134** to be centered in its neutral position wherein it is shown, by centering springs **141** while a force balance exists between solenoids **124, 125**, here assumed to result from deenergization of both, and which permits pilot valve body **135** to be centered by centering springs **142**; and a pair of crossed passages **143** which connect main valve cylinder **132** with supply port **138** and valve cylinder **133** with exhaust port **137** while the relative energization conditions of solenoids **124, 125** are such as to move pilot valve body **135** to the left.

Main control valve body **134** has two pairs of passages; a pair of straight through passages **145**, arranged to connect controlled port **117**, and the outer power unit cylinder end **103** with an exhaust port **146**, and to connect controlled port **118** and inner power unit cylinder end **101** with a supply port **147**, while valve body **134** is in a right position resulting from supply and exhaust of

valve cylinders 132, 133; and a pair of crossed passages 148 adapted to connect controlled port 117 to supply port 147 and controlled port 118 to exhaust port 146, while valve body 134 is in its left position, resulting from supplying valve cylinder 133 and exhausting cylinder 132.

The second of the abovementioned alternative control channels for operating power units 97, 99 and 98, 100 is for simultaneous movement of both shafts 91, 92 in the same direction, and is shown as being arranged for automatic operation for web guiding purposes, under control of a web edge lateral position detector 151 which may be of the arrangement previously described and that develops a signal pressure that is a function of the lateral position of web edge 152 and that is transmitted by a signal pipe 153 to the signal assembly 154 of a relay regulator 155, again shown as comprising a jet pipe 156, auxiliary piston 157 and booster or control valve 158, all arranged as previously described. Valve 158 controls exhaust and supply of a pair of controlled lines 159, 160 with respect to delivery of fluid from a branch supply line 161 wherein is connected a pressure reducing valve 162, corresponding to valve 78 of Fig. 1 and serving the same purpose of limiting maximum internal pressure of lines 159, 160 and the respective power unit inner cylinder ends 101, 102 to which the latter are respectively connected, to less than the full supply pressure of main supply fitting 107, at which the outer cylinder ends are supplied.

It will be noted that controlled lines 159, 160 respectively join the different inner cylinder end lines 119 that serve to connect these cylinder ends with the controlled ports 118 of the "in-out" valve assemblies 115, 116. As previously described, those assemblies have cutoff conditions which serve to block lines 119 and ports 118, so that establishment of those conditions will prevent interference with control of the inner cylinder end pressures by regulator assembly 155. In order to prevent regulator 155 from interfering with control by valve assemblies 115, 116, a cutoff valve 163 is arranged for blocking and unblocking lines 159, 160, and the arrangement is such that those two conditions can be correlated respectively with actuation of valve assemblies 115, 116, to block lines 159, 160 upon actuation of either or both of assemblies 115, 116 to either of its two power unit actuating conditions, and to unblock lines 159, 160 upon establishment of cutoff conditions of both valve assemblies 115, 116. For this purpose, and in correspondence to the solenoid actuation of valve assemblies 115, 116, cutoff valve 163 also is solenoid actuated, preferably through a pilot valve 164 that is arranged in one condition of energization of solenoid 165 to connect a hydraulic actuating cylinder 166 of cutoff valve 163 to a pressure supply line 167 to actuated valve 163 to one of its stated conditions, and in the other condition of solenoid 165, to connect cylinder 166 to an exhaust line 168, permitting return of valve 163 to its first condition by a return spring 169.

The automatic control channel is dual in nature, having lines 171, 172 connected to the different outer power unit cylinder ends 103, 104 and that may be placed in communication with main supply fitting 107 to supply maximum pressure to those cylinder ends and therefore serving as second supply lines for the full pressure of supply fitting 107, or blocked, respectively in correlation with unblocking and blocking of controlled lines 159, 160 by cutoff valve 163. Preferably this control of lines 171, 172 is by a solenoid controlled valve, which is shown as a hydraulically actuable spool valve 173 having at one end an actuating cylinder 174 that may selectively be placed in communication with a drain line 175 or a supply line 176, by appropriate control of energization of a solenoid 177 that actuates a pilot valve 178. A return spring 179 returns the body of valve 173 when cylinder 174 is connected to drain line 175. In the specific arrangement shown, current energization of solenoid 177 actuates pilot valve 178 to deliver fluid to cylinder 174, which actuates valve 173 to its open condition wherein lines 171, 172 are opened for transmission of pressure to the outer power unit cylinder ends 103, 104.

The third of the alternative control channels for power units 97, 99 and 98, 100, is also of dual nature, including lines for maintaining the outer power unit cylinder ends 103, 104 under full pressure of main supply fitting 107 while balance or sense of unbalance of pressures effective in inner cylinder ends 101, 102 are manually controlled. Conveniently the same outer cylinder end high pressure system 177, 178, 173, 171 and 172 is used for this channel as well as for the automatic control channel. A selector valve assembly 181, preferably of the same arrangement as assemblies 115, 116 and shown in detail in Fig. 7 is used, a pair of solenoids 182, 183 being energizable respectively, and each in absence of energization of the other, to connect branch inner power unit cylinder and control lines 184, 185, in reversed senses corresponding to the solenoid 182 or 183 that is energized, with a delivery line 186 supplied at the selected maximum inner cylinder end pressure through reducing valve 162 and with an exhaust line 187, as shown by the dotted lines at 188: As in assemblies 115, 116, simultaneous similar conditions of energization of solenoids 182, 183, here assumed to be deenergization of both, places assembly 181 in a neutral condition blocking lines 184, 185. The channel just described provides for simultaneous movement of shafts 91, 92 in the same directions, selected by energization of solenoid 182, 183, while they are maintained in supporting engagement with an intervening coil support by high pressure delivered through lines 171, 172.

It will be apparent that the employment of solenoid actuators for all valves in the Fig. 6 system provides for extreme flexibility in combinations of their actuation to produce various required types of operations, and additionally permits a control system to be arranged to very largely, or completely, preclude misoperation.

Such a system is shown in Fig. 8, and is arranged to provide for manual selection among the three described channels to condition the system for the corresponding type of operation, and additionally to provide for manual selection of the senses of movement of shafts 91, 92 that are possible in the two non-automatic channels above described as the first and third channels. The system also is shown as including two controls that are actuated automatically and in correlation with two pass mechanism control devices that frequently are used in a reeling assembly, particularly in a metal strip reeling plant for performing some such operation as rolling, trimming or slitting. One such control is shown in Fig. 8 as a line stop circuit 201 that, upon actuation of an operator 202, serves to arrest the web drive mechanism and usually also to brake the web to a stop. The other is shown at 203 as a stalled pass mechanism condition-establishing control, which is effective upon actuation of an operator 204, and after a strip or web has been threaded through the pass mechanism to apply driving force and braking force to the strip or web at spaced locations such as the pass entrance and exit, to properly tension the material in the pass. While this tension-stalled condition exists, the automatic control channel, especially in a plant wherein it is set up for edge guiding, as in Figs. 1 and 6, should be disabled, as should the control channel that provides for relatively opposite or independent movement of the mandrel shafts.

The correlation of operation of these pass mechanism controls with establishment of selected suitable, corresponding mandrel shaft operation conditions will be explained in due course.

The electrical control system is supplied with current for selective energization of solenoids 124, 125, 126, 127, 165, 177, 182 and 183 in appropriate combinations, by a pair of main bus lines 206, 207.

It will be recalled relative to Fig. 6 that the function of solenoids 124 and 125 is to select direction of movement

of mandrel shaft 91 and that of solenoids 126, 127 is to select direction of movement of shaft 92. The function of solenoid 165 is to block and unblock the channel for automatic control by regulator 155 and that of solenoid 177 is to place the outer power unit cylinder ends under high pressure for either automatic or manually controlled simultaneous movement of both mandrel shafts 91, 92 in the same direction. The function of solenoids 182, 183 is to select direction of such manually controlled simultaneous mandrel shaft movement. The system of Fig. 8 is arranged to correlate these functions properly and interlock the various solenoid energization circuits to prevent misoperation that otherwise could result from manipulation of switch controls in faulty combinations. Valves 163 and 173 are shown in the conditions that result from deenergized conditions of their control solenoids 165, 177, and it is assumed that all of valve assemblies 115, 116 and 181 are in their cutoff conditions and that those cutoff conditions are a consequence of deenergized conditions of all of solenoids 124, 125, 126, 127, 182 and 183. It will be seen that in such condition of deenergization of all solenoids, the hydraulic system is conditioned for automatic control by regulator 155, accomplishing simultaneous movement of shafts 91, 92 in the same direction while held in supporting engagement with an intervening reel or other coil support.

Referring to Fig. 8, a master selector switch assembly is designated 209 and includes a pair of single pole triple throw switches 210, 211, the contactors of which are ganged together and connected to current supply bus 206. Switch 210 directly controls energization of solenoid 165, thereby providing for selection between conditions preventing and providing for automatic control by regulator 155, the latter prevailing while switch 210 is in the indicated open condition, interrupting the current supply line 212 to solenoid 165, thereby maintaining the automatic inner cylinder pressure control lines 159, 160 unblocked. Switch 210 also serves to prevent energization of, or conditioning for energization, the circuit that includes solenoid 177. Prevention of energization, and conditioning for energization of that circuit respectively are in consequence of switch 210 being in the illustrated open condition, and in either of its closed conditions. It similarly prevents energization of and conditions for energization of circuits arranged to supply solenoids 124, 125, 126 and 127 according to whether it is in its open or in one of its closed conditions. To these ends solenoid 165 is connected between conductor 212 and the second current bus 207, and a branch supply bus 213 is connected to conductor 212, whereby closing of switch 210 energizes branch bus 213 while simultaneously energizing solenoid 165, the latter resulting in blocking the automatic control lines 159, 160. Connected to branch bus 213 are the movable contactors of two switch assemblies 214, 215 the first of which includes a pair of single pole triple throw switches 216, 217 and the second a pair of similar switches 218, 219. The contactors of each of these paired switches are ganged together as indicated. The function of switch assembly 214 is to control energization of solenoids 124, 125 of the left power unit manual control valve assembly 115, in such correlation with energization of solenoid 165 as enforced by the common energization of the latter and the branch bus 213, that any of solenoids 124, 125, 126 and 127 can be energized only while solenoid 165 is energized, and only with simultaneous energization of solenoid 177. From the hydraulic system point of view this precludes interference with a selected one of the automatic condition and the condition for independent manual control of shafts 91, 92, by partial establishment of the other condition. For these purposes, switches 216, 218 are connected parallel between branch supply bus 213 and solenoid 177, which also is connected to main bus 207, each being arranged to deenergize solenoid 177 while in an open condition, and to energize it in either of two closed conditions which open and closed conditions respectively are correlated with one open and two closed conditions of the switches 217, 219 respectively ganged to switches 216, 218. In its two closed conditions switch 217 respectively energizes solenoid 124 and solenoid 125, while in the corresponding closed conditions switch 219 energizes solenoid 126 and 127. Switch assemblies 214, 215 may be operated together, while switch 210 is closed, to accomplish simultaneous but independent movement of shafts 91, 92, either in the same or opposite directions, or either assembly 214, 215 may be operated alone to move the single corresponding shaft 91 or 92 in either direction.

The second switch 211 of assembly 209 controls energization of solenoids 182, 183, energization of which, it will be recalled, respectively actuates valve assembly 181 for simultaneous movement of both of shafts 91, 92 in the same direction, while they are held in engagement with an intervening structure by high pressure in the outer power unit cylinder ends 103, 104, and in fact, while they are locked together against relative movement by a pressurized bypass, in Fig. 6 comprising lines 171, 172, the chamber of valve 173 and the common connection of lines 171, 172 to branch supply line 112. In one of its two closed conditions switch 211 connects solenoid 182 to bus 206, in the other it connects solenoid 183 to bus 206, both of those solenoids being connected to bus 207. These two conditions unbalance respectively in reversed senses the pressures effective in the inner power unit cylinder ends. Since the contactor of switch 211 is ganged to that of switch 210 this operation necessarily is accompanied by an energized condition of solenoid 165 and the consequent blocking of the automatic inner cylinder and pressure control lines 159, 160.

The stop mechanism actuator 202 has connected with it the movable contactor of a switch 221 that is closed when actuator 202 is moved to effect stopping of the pass mechanism. This closes a bypass supply circuit 222 that connects conductor 212 to bus 206, whereby upon closing of switch 202, solenoid 165 is engaged, regardless of the condition of switch 210, to disable the automatic control channel if conditioned for operation at the time of stopping.

As suggested above, under the tension-stalled condition that is effected by control mechanism 203 upon moving actuator 204, the system should be conditioned to prevent either functioning of the automatic control channel or independent mandrel shaft movement by operation of switch assemblies 214, 215. For accomplishing this condition movable contactors of switches 225, 226 that are operatively connected to actuator 204 and respectively are arranged to close a bypass circuit 227 from supply bus 206 to conductor 212, and to interrupt branch supply bus 213 when control 204 is moved to establish the stalled condition. Thus, solenoid 165 is energized to block automatic cylinder lines 159, 160, and energization of all of solenoids 177, 124, 125, 126 and 127 is precluded while the stalled condition prevails, regardless of setting of switch 210. Maintenance of solenoid 177 deenergized insures application of high pressures to the outer power unit cylinder ends, and, since deenergization of solenoids 124, 125, 126 and 127 results in cutoff conditions of valve assemblies 115, 116, the system is locked against independent or relative movement of mandrel shafts 91, 92. However, simultaneous movement of the shafts in the same direction and effectively in locked together condition can be accomplished by positioning switch 211. The attendant positioning of switch 210 is not then effective to energize branch bus 213 because of the then existing open condition of switch 226.

I claim:

1. A hydraulic control system including a pair of shafts that are axially movable to engage and release a coil structure, each said shaft having operatively connected to it

the output member of a hydraulic power unit provided with first and second fluid input connections delivery to the different ones of which is effective to develop forces that are exerted to move the connected shaft in opposite directions, and the forces that are developed in response to delivery of fluid to corresponding first and second of said input connections of the different said units being exerted to move said shafts oppositely and respectively inward toward advanced positions for engaging a coil structure and outward to retracted positions, a fluid supply means for supplying fluid at a selected pressure, valve means selectively actuable to connect said fluid supply means simultaneously to either both said first or both said second input connections of both power units and simultaneously exhaust the other said corresponding connections respectively to move both said shafts inward or outward, a pair of different controlled lines, additional valve means for connecting the different said controlled lines to said second power unit input connections while said first connections are connected to said fluid supply means, and means for selectively exhausting fluid from either one of the controlled lines, and delivering fluid at a pressure lower than said selected pressure to the other of the different said controlled lines thereby to simultaneously move said shafts in a selected, single direction.

2. A hydraulic control system including a pair of shafts that are axially movable to engage and release a coil structure, each having operatively connected with it a piston that is movable in a cylinder, in opposite directions respectively to advance and retract the shaft connected therewith toward and from coil-engaging position, movement of the said pistons in the different said directions being responsive to unbalance of pressures in the different ends of the cylinders wherein the different pistons are movable, and the two said cylinders having first corresponding ends wherein higher pressure on one side of the piston is effective to advance the shafts toward coil structure-engaging positions and second corresponding ends wherein higher pressure on the other side of the piston is effective to retract said shafts, a first fluid supply means for supplying fluid under pressure of preselected magnitude, means for delivering fluid under a lower pressure, a regulator having an input connected with said fluid delivering means, a pair of output controlled lines and a control member that is movable in opposite directions in response to variations in an applied control signal, respectively to oppositely unbalance pressures of fluid delivered to said pair of output controlled lines from said fluid delivering means, valve means selectively operable to three different conditions wherein respectively said valve means connect said first corresponding cylinder ends to said fluid supply means and the second said ends to exhaust, said second corresponding cylinder ends to said fluid supply means and the first said ends to exhaust, and said first corresponding cylinder ends to said fluid supply means and said second corresponding cylinder ends to different ones of said regulator output controlled lines.

3. Controlled support means for a web coil structure comprising a pair of shafts axially advanceable to engage and retractable to release the coil structure, a pair of pistons respectively connected with the different said shafts and each operable in a cylinder having a first end wherein a higher pressure on one side of the piston is effective to advance toward coil structure-engaging positions the shaft connected with the piston that is therein movable and a second end wherein a higher pressure on the other side of the piston is effective to retract said shaft, a fluid supply line for supplying fluid under pressure of a preselected magnitude, a pair of regulated fluid pressure lines, and an exhaust line, valve means selectively positionable to connect either of said first cylinder ends to said supply line and the second end of the same cylinder to exhaust, to connect both said first cylinder ends to said supply line and both said second cylinder ends to said exhaust line, to connect both said first cylinder ends to said exhaust line and both said second cylinder ends to said supply line, or to connect the said first ends of both said cylinders to said supply line and the different ones of said second cylinder ends respectively to the different said regulated lines, and means for selectively unbalancing fluid pressures in said regulated lines, with respect to the different said regulated lines wherein the pressures are higher and lower for moving said shafts in the same direction while they are in coil engaging positions.

4. A hydraulic control system including a pair of shafts that are axially movable to engage and release a coil structure, each having operatively connected with it the output member of a hydraulic power unit provided with a pair of fluid input connections to the different ones of which delivery of pressurized fluid is effective to develop forces that are exerted respectively to advance and retract the shaft connected therewith toward and from coil-engaging position and that are of magnitudes corresponding to pressures under which fluid is so delivered, and the forces developed in response to delivery of fluid to first ones of said inputs of the two said power units being exerted to move the different said shafts in opposite inward directions toward each other, and the forces developed in response to delivery of fluid to second ones of said power unit input connections being exerted to move the different said shafts away from each other, a fluid supply line for delivering fluid under pressure, a pair of regulated fluid pressure lines, and an exhaust line, valve means selectively operable either to reversibly connect said supply line to either said first power unit input connections and said second power unit input connections to the exhaust line, to connect said first power unit input connections to said fluid supply line and the second said input connections to exhaust, to connect said second input connections to said first supply line and the first said input connections to exhaust, and to connect said first power unit input connections to said first supply line and said second input connections to different ones of said regulator output controlled lines, and means for selectively unbalancing fluid pressure in said controlled lines with respect to the ones of said controlled lines wherein pressures are higher and lower for simultaneously moving said shafts in the same direction by unbalance of pressures of fluid delivered to said second power unit input connection while pressures of fluid delivered to said first power unit input connections are maintained equal.

5. A hydraulic control system according to claim 4, wherein the valve means includes a pair of valve units respectively for connecting different ones of the different said input connections of either power unit to the supply line and to the exhaust line.

6. A hydraulic control system according to claim 4, wherein the valve means includes a pair of valve units connecting the regulated lines to the second power unit input connections for alternatively supplying fluid to one while exhausting the other, and means interconnecting said first input connections, whereby a higher pressure of fluid delivered to one said first input connection is transmitted to the other said first input connection.

7. A control system including a pair of shafts that are axially movable to support a coil structure, a fluid pressure operated power unit for each shaft, pump means for supplying fluid under pressure of preselected magnitude, fluid means for delivering fluid under a lower pressure, and valve means to control flow of fluid from said pump means and said fluid delivering means to said power units, said valve means being settable to a first position to direct flow of fluid to cause movement of said shafts away from each other, said valve means being settable to a second position to direct flow of fluid to cause movement of said shafts toward each other, said valve means being settable to a third position to direct flow of fluid to cause an unbalance of forces acting upon said power units while the

shafts are supporting a coil structure whereby the shafts will be caused to move in the same direction, said valve means providing ports in said second and third positions selectively establishing and maintaining communication between said pump and said fluid delivering means on the one hand and said power units on the other hand and urging said shafts towards one another.

8. A control system according to claim 7, wherein a web edge lateral position detector is adapted to detect the position of the edge of a web that is partly wound on a coil supported between said shafts and to develop a signal of a magnitude corresponding to and varying with changes in lateral position of the web, and a relay means responsive to said signal and arranged to direct pressurized fluid from said pump means to one of said power units when said valve means is in third position.

9. A hydraulic control system including a pair of shafts that are axially movable to support a coil structure, a pair of hydraulic power units each of which is arranged for movement of a shaft, each of said power units comprising a piston and cylinder assembly, pump means for supplying fluid under pressure of preselected magnitude, fluid means for delivering fluid under a lower pressure, and valve means to control flow of fluid from said pump means and said fluid delivering means to said power units, said valve means being settable to a first position to direct flow of fluid to cause movement of said shafts away from each other, said valve means being settable to a second position to direct flow of fluid to cause movement of said shafts toward each other, said valve means being settable to a third position to direct flow of fluid to cause an unbalance of forces acting upon the piston of each power unit while the shafts are supporting a coil structure whereby the shafts will be caused to move in the same direction, said valve means providing ports in said second and third positions selectively establishing and maintaining communication between said pump and said fluid delivering means on the one hand and said power units on the other hand and urging said shafts towards one another, a web edge lateral position detector adapted to detect the position of the edge of a web that is partly wound on a coil supported between said shafts and to develop a signal of a magnitude corresponding to and varying with changes in lateral position of the web, a relay means responsive to said signal, and a pressure reduction valve arranged in a fluid flow line leading from the pump means to the relay means, said relay means being arranged to direct pressurized fluid to either of said power units when said valve means is in third position.

10. A hydraulic control system including a pair of shafts that are axially movable to support a coil structure, a pair of hydraulic power units each of which is arranged for movement of a shaft, each of said power units comprising a piston and cylinder assembly, pump means to supply hydraulic fluid under pressure to said power units to cause movement thereof, and valve means to control flow of fluid from said pump means to said power units, said valve means being settable to a first position to direct flow of fluid to cause movement of said shafts away from each other, said valve means being settable to a second position to direct flow of fluid to cause movement of said shafts toward each other, said valve means being settable to a third position to direct flow of fluid to cause an unbalance of forces acting upon the piston of each power unit while the shafts are supporting a coil structure whereby the shafts will be caused to move in the same direction, said valve means being further arranged to constantly direct pressure fluid from the pump means to the power units to urge movement of the shafts toward each other at all times that a coil is being supported by the shafts, a web edge lateral position detector adapted to detect the position of the edge of a web that is partly wound on a coil supported between said shafts and to develop a signal of a magnitude corresponding to and varying with changes in lateral position of the web, a relay means responsive to said signal, and a pressure reduction valve arranged in a fluid flow line leading from the pump means to the relay means, said relay means being arranged to direct pressurized fluid to either of said power units when said valve means is in third position, said valve means including a plurality of similar valves arranged in pairs, one pair of which is used to direct flow of pressure fluid to one of said power units, and another pair of which is used to direct flow of pressure fluid to the other of said power units.

11. A hydraulic control system according to claim 10, wherein all of said valves are interconnected for simultaneous operation.

12. A hydraulic control system according to claim 10, wherein the valves of each pair of valves are interconnected for simultaneous operation.

13. A hydraulic control system according to claim 10, wherein a valve of one pair of valves is interconnected to a valve of another pair of valves for simultaneous operation.

References Cited in the file of this patent

UNITED STATES PATENTS

2,464,932	Jones	Mar. 22, 1949
2,735,630	Ziebolz	Feb. 21, 1956
2,837,295	Todd et al.	June 3, 1958