

Aug. 3, 1965

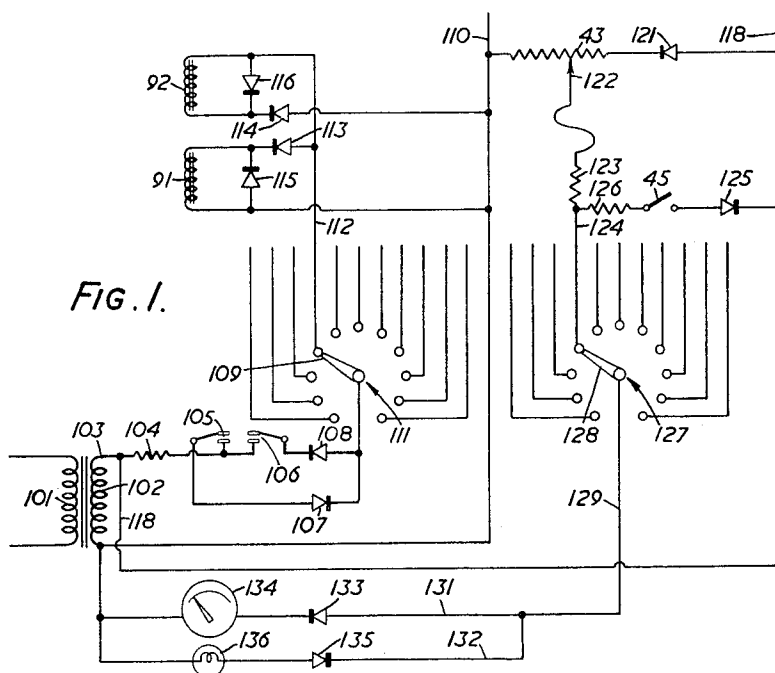
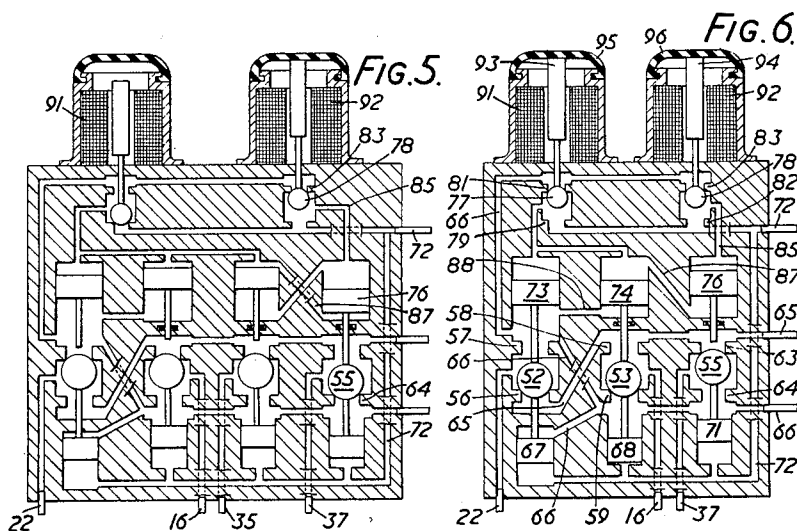
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3,198,083

CONTROL SYSTEM FOR MINE ROOF SUPPORTS

Filed May 13, 1963

5 Sheets-Sheet 1



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CONTROL SYSTEM FOR MINE ROOF SUPPORTS

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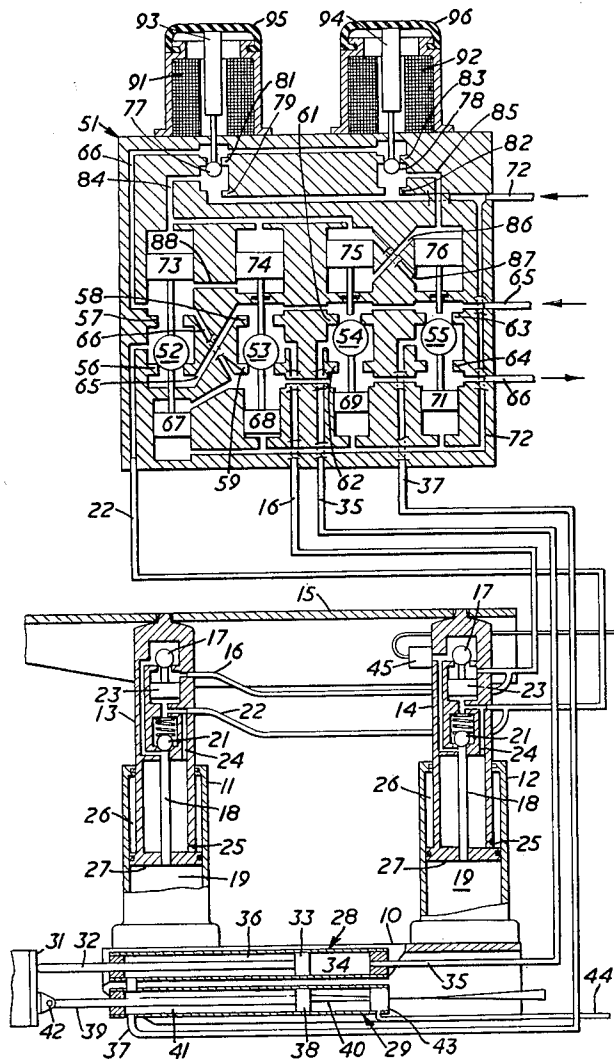


FIG. 2.

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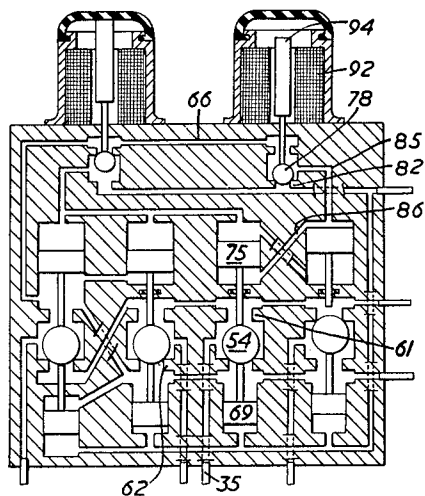


FIG. 3.

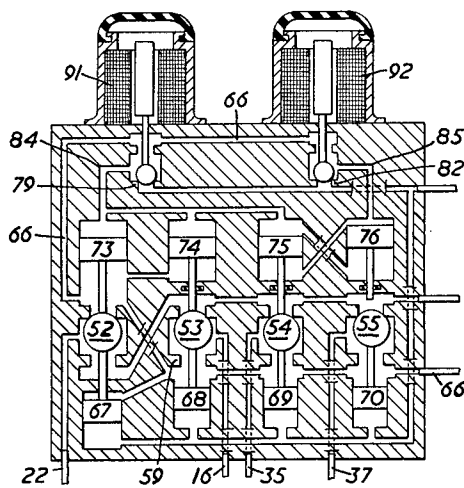


FIG. 4.

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CONTROL SYSTEM FOR MINE ROOF SUPPORTS

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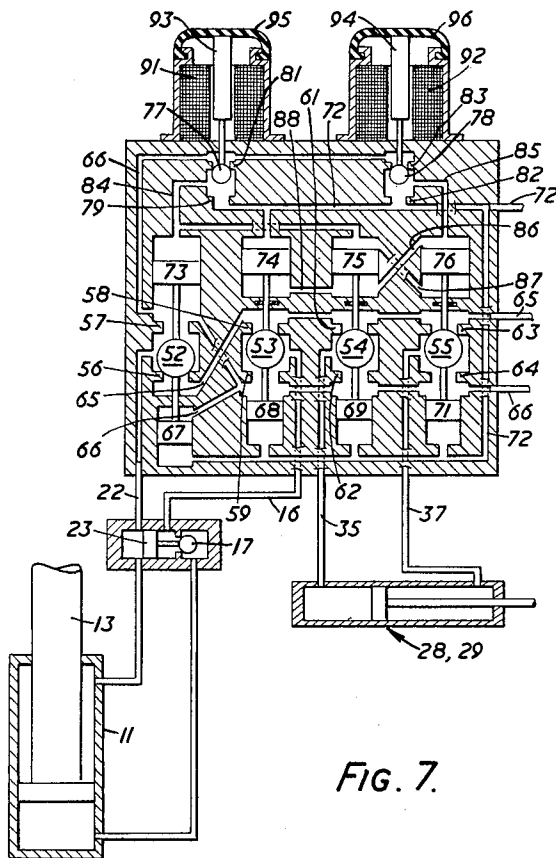


FIG. 7.

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5 Sheets-Sheet 5

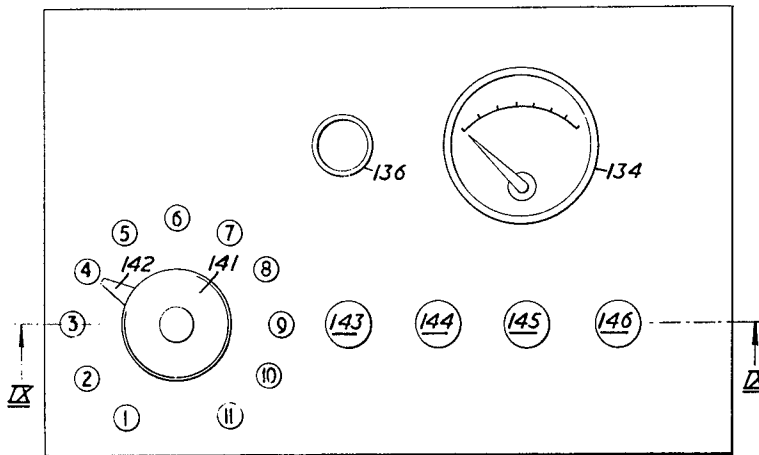


FIG. 8.

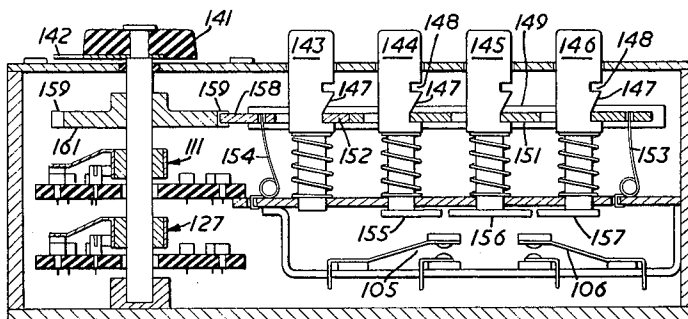


FIG. 9.

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## CONTROL SYSTEM FOR MINE ROOF SUPPORTS

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5 Claims. (Cl. 91-1)

This invention relates to mine roof supports which include at least one fluid-pressure-operated prop operable to support the roof and a fluid-pressure-operated jack operable to advance the support relative to an anchorage.

In such roof supports, it is necessary to be able to actuate the prop in two or more ways. For example, one way is that in which the prop is connected to a source of fluid pressure to set the prop against the roof, a second way is that in which the prop is connected to low pressure to release the prop from the roof, and a third way is that in which the prop is isolated from both high pressure and low pressure. Similarly, it is necessary to be able to actuate the jack in two or more ways. For example, if the jack is single-acting, one way is that in which the jack is connected to a source of fluid pressure and a second way is that in which the jack is connected to low pressure. If the jack is double-acting, the number of necessary ways of actuation is correspondingly increased.

Thus, in such roof supports, there are many possible combinations of operating states of the prop and the jack. Some of these combinations are necessary, but others are unwanted and possibly dangerous.

It is therefore an object of this invention to provide an improved roof support in which the necessary combinations of operating states of the prop and the jack can be included and the unwanted combinations excluded.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, of which:

FIGURE 1 shows electric controlling and signalling circuits for a mine roof support;

FIGURE 2 is a hydraulic diagram of a mine roof support, and a solenoid actuated control valve unit for the props of the support and two oppositely acting shifting jacks;

FIGURES 3, 4 and 5 show the control valve in subsequent stages of its operational sequence;

FIGURE 6 is a diagram of a modified control valve unit for a mine roof support having one single-acting shifting jack;

FIGURE 7 is a diagram of another control valve unit providing a different set of operative combinations of the props and shifting jacks;

FIGURE 8 shows in plan view a simple form of control and signal indicating panel; and

FIGURE 9 is a sectional view on the line IX-IX of FIGURE 8.

The support shown diagrammatically in FIGURE 2 comprises a floor bar 10 having upstanding front and rear prop cylinders 11 and 12 mounted thereon with telescopic ram tubes 13 and 14 respectively carrying at their heads a roof bar 15. Setting of each prop is effected by hydraulic liquid under pressure in a supply conduit 16 which enters the head of the ram tube, and flows through a non-return valve 17 into a central pipe 18. The pipe 18 opens at its lower end through the piston shaped base of the ram tube 13 into the pressure chamber 19 of the prop. The upper end of the central pipe 18 leads to an excess pressure relief valve 21 which discharges into a second conduit 22 connected into the head of the ram tube 13. The conduit 22 leads to the underside of a piston 23 which

is movable upwardly under pressure in the conduit 22 to unseat the non-return valve 17 and release liquid pressure from the pressure chamber 19. The conduit 22 also leads through a branch passage 24 into the interior of the ram tube 13 and thence through one or more apertures 25 in its wall to an annular chamber 26 which lies between the ram tube 13 and the cylinder 11, and above the piston 27 at the base of the ram tube 13. Liquid pressure in the conduit 16 thus extends the prop while liquid pressure in the conduit 22 serves to contract the prop. The front and rear props which are similar have liquid connections in parallel provided by the conduits 16 and 22 which extend from the control valve to be later described.

The base 10 of the prop is provided with hydraulic shifting devices comprising a pusher jack 28 and a puller jack 29, both capable of acting against a face conveyor 31. The jacks 28 and 29 are illustrated one above the other on the side of the base 10 merely for convenience in showing the hydraulic circuit, but it must be understood that these jacks will occupy conventional positions according to the nature of the roof support unit. The pusher jack 28 has a piston rod 32, a piston 33, and a chamber 34 behind the piston connected to a conduit 35 which extends from the control valve. Liquid pressure in the conduit 35 and chamber 34 acts upon the piston 33 to thrust the piston rod 32 forwardly against the conveyor 31. The piston 33 is retractable, though it performs no work in doing so, by liquid pressure supplied through a conduit 37 leading from the control valve into the chamber 36 around the piston rod 32. This conduit 37 also enters the annular chamber 41 around the piston rod 39 of the puller jack 29 so that liquid pressure in the chamber 41 acts on the piston 38 and through the piston rod 39 upon a connection 42 with the conveyor 31 whereby the roof support unit may be pulled forward by the jack 29. An electric potentiometer 43 interposed between the piston and cylinder of the puller jack 29 can transmit through a feed-back cable 44 a signal of the position of the piston 38 in its cylinder. The potentiometer, which is of the rotary type, is indicated generally at 43 fixed to the end of the cylinder of the jack 29. The potentiometer is operated by the known device of a twisted metal strip 40 attached to the piston 38, the strip passing slidably through a slot (not shown) in the movable contact rotor of the potentiometer. The angle of twist in the metal strip 40 provides full range movement of the potentiometer for full range movement of the jack piston 38. A further signalling device is provided by a pressure switch 45 which is mounted on the ram tube 14 of the rear prop in communication with the pressure chamber 19. The pressure switch 45 is provided to indicate when a predetermined roof supporting pressure in the rear prop 12, 14 has been attained, so that an adjacent support unit can be safely released and advanced.

The control valve unit 51 in the upper part of FIGURE 2 comprises a bank of four main valves of which the movable valve elements are steel balls 52, 53, 54 and 55. The balls 53, 54 and 55 lie between upper high pressure seats 58, 61 and 63 which are supplied by a common high pressure passage 65, and low pressure return seats 59, 62 and 64 which are connected in common by a return passage 66. The passages 65 and 66 cross over beyond the ball valve 53 into communication with the lower pressure seat 56 and the upper low pressure return seat 57 for the ball valve element 52. The balls 52, 53, 54 and 55 are movable from below by pistons 67, 68, 69 and 71 respectively which are in common subject to liquid pressure in a high pressure passage 72. The upper ends of the pistons 67, 68, 69 and 70 are all subject to low pressure in the passage 66. The balls are also movable from above by pistons of larger diameter 73, 74, 75 and 76 respectively. These large pistons which dominate the

action of the ball valves are themselves controlled by two pilot valves having movable valve elements 77 and 78 provided by smaller balls. The movable valve elements 77 and 78 are contained between lower high-pressure valve seats 79 and 82 and upper low-pressure seats 81 and 83 respectively, the high pressure seats 79 and 82 being connected in common with the passage 72 and the low pressure seats 81 and 83 being connected in common with the return passage 66. A passage 84 controlled by the valve element 77 leads to the upper sides of the large pistons 73, 74 and 75, while a passage 85 controlled by the valve element 78 leads to the upper side of the large piston 76. Opposite sides of the large pistons 75 and 76 are cross-connected by passages 86 and 87. The undersides of the large pistons 73 and 74 are connected by a passage 88 which stays at the low pressure of the return pipe 66. The conduits 22, 16, 35 and 37 are connected to passages in the valve unit 51 which bear the same numbers and these passages are controlled by the ball valves 52, 53, 54 and 55 respectively. Thus, the ball valves 52 and 53 control contraction and extension of the two props, the ball valve 54 controls the pusher jack 28 and the ball valve 55 controls the puller jack 29.

The high pressure passage 72 is subject to the same pressure as in the main supply passage 65, but it is preferably supplied by an independent pressure source. In this way the valve pistons are not subject to the variation of pressure which can occur in the main supply upon a large flow demand.

The valve elements 77 and 78 are actuated by solenoids 91 and 92 which have armatures 93 and 94 respectively. The solenoids are not energized in FIGURE 2 and the valve elements 77 and 78 are maintained against their low pressure seats 81 and 83 by liquid pressure in the passage 72. The armatures 93 and 94 are raised, but they can be lowered to hold the valve elements 77 and 78 against the high pressure seats 79 and 82, either by energizing the solenoids 91 and 92 or by hand pressure on rubber caps 95 and 96 which enclose the armatures from above. The circuit controlling the solenoids 91 and 92 will be later described.

In FIGURE 2 liquid pressure in the passage 72 is admitted by the valve element 77 and passage 84 to the upper faces of the pistons 73 and 74 whose lower faces are at the low pressure of the passage 66. The pistons 73 and 74 overcome the upward load of the smaller diameter pistons 67 and 68 to hold the ball 52 against its high pressure seat 56 and the ball 53 against its low pressure seat 59. Pressure from the passage 65 is therefore admitted to the conduit 16 to extend the props 11, 15 and 12, 14 or to maintain such extension, while the conduit 22 is connected past the low pressure seat 57 to the low pressure return passage 66 and its therefore provides an escape path for any liquid discharged by the excess pressure relief valves 21 of the props. The pilot valve elements 77 and 78 and the cross-connecting passages 86 and 87 maintain opposite faces of the pistons 75 and 76 at high pressure, and the upwardly acting small diameter pistons 69 and 71 therefore maintain the balls 54 and 55 against their pressure seats 61 and 63. This maintains the supply conduits 35 and 37 for the pusher jack 28 and the puller jack 29 respectively at low pressure.

In the next step of the operating sequence the solenoid 92 is energized, see FIGURE 3, so that the armature 94 hold the pilot valve element 78 against the high pressure seat 82. Low pressure from the passage 66 then has access through the passages 85 and 86 to the under face of the piston 75 so that the latter overcomes the upward load of the piston 69 to push the ball 54 against the low pressure seat 62. Pressure liquid can then flow past the pressure seat 61 into the conduit 35 to extend the pusher jack 28.

At the next step, see FIGURE 4, both solenoids 91 and 92 are energized whereby the high pressure seats 79, 82 of both pilot valves are closed. Both passages 85 and 85 are then open to low pressure of the passage 66 whereby

the upper faces of all the large diameter pistons 73, 74, 75 and 76 are at low pressure. The small diameter pistons 67, 68, 69 and 70 therefore raise all four balls 52, 53, 54 and 55. This places the conduits 16, 35 and 37 at low pressure, but the conduit 22 at high pressure. Both jacks 28 and 29 are thus placed at the low pressure of the return passage 66, while high pressure in the conduit 22 acts as previously described to contract the props 11, 13, and 12, 14. Liquid vented from the prop pressure chambers 19 escapes through the conduit 16 and low pressure seat 59 to the return passage 66. The mine roof support therefore contracts from engagement with the mine roof prior to being advanced by the puller jack 29 at the final step of the operation sequence.

In FIGURE 5, the solenoid 91 remains energized whereby the low pressure connection to the conduits 22, 16 and 35 remain unchanged, but the solenoid 92 is now de-energized. High pressure in the passage 72 pushes the pilot valve element 78 against the low pressure seat 83 and has access through the passage 85 to the upper surface of the large diameter piston 76. The latter, having low pressure on its lower surface from the passage 87, depresses the ball 55 against the low pressure seat 64, allowing high pressure to enter the conduit 37. This contracts the puller jack 29 to draw the mine roof support forwardly to a new position in which it can be re-set by returning the control valve to the condition of FIGURE 2.

In some installations of mine roof supports for use with a face conveyor, a minority of roof supports spaced at regular intervals have pusher jacks 28 in addition to puller jacks 29, while the intervening roof supports have puller jacks only. A simplified control valve may be provided which is similar to that described but in which the main valve 54 and its associated pistons are omitted as in FIGURE 6. The elements corresponding to the valve of FIGURE 2 have the same reference numerals. Each intervening roof support has only three operative conditions, and the energizing of the solenoid 92 alone, FIGURE 3, is ineffective. Control of the solenoids 91 and 92 as in FIGURES 2, 4 and 5 produces the same effect upon the props and the puller jacks.

In another kind of installation for use with a face conveyor and a plough, the pusher jack 28 of each mine roof support is required to maintain a continuous thrust against the conveyor throughout a number of traverses of the plough. Although the apparatus shown in FIGURE 2 can be used for this purpose, it follows that the control valve will remain for an extended period in the condition of FIGURE 3, that is with the solenoid 92 energized. It is readily possible therefore to modify the pilot valve 78, 82, 83 for operation by the solenoid 92 so that high pressure liquid in the passage 65 flows into the pusher jack supply conduit 35 when solenoid 92 is not energized.

In the arrangement of FIGURE 7 the control valve unit is modified from that of FIGURE 2 in that the passage 84 communicates with the upper ends of the pistons 73 and 75 only, while the upper end of the piston 74 communicates with the passage 72. Also the passage 88 connects the underside of piston 74 with the underside of piston 75 instead of with the underside of piston 73. With both solenoids 91, 92 not energized as shown, the pilot valve elements 77 and 78 close the low pressure seats 81 and 83, and high pressure in the passage 72 acts on opposite ends of the pistons 74, 75 and 76 by way of the passages 72, 84, 88, 86 and 87. The pressure loaded pistons 68, 69, 71 therefore close the main ball valves 53, 54 and 55 against their pressure seats 58, 61 and 63. Pressure in the passage 72 acts on the upper end only of the piston 73 to hold the main valve 52 on its high pressure seat 56. High pressure has no access by way of the conduit 16 and non-return valve 17 to the pressure chamber 19. Neither have the annular chamber 26 and piston 23 access by way of the conduit 22 to high pressure for causing prop contraction. The prop is therefore hydraulically locked against extension or contraction.

The remaining three possible combinations of valve operation will not be described in detail as the valve positions can be arrived at readily by a similar reasoning process to that used in describing the sequences of FIGURES 2, 3, 4 and 5. In the present instance, the arrangement provides that when both solenoids 91 and 92 are energized, the prop 11, 13 extends, while the double-acting jack 28, 29 is free. When solenoid 92 is energized and solenoid 91 is not, there is pressure in the prop setting conduit 16 and in the conduit 35, causing the jack 28, 29 to push. When solenoid 91 is energized and solenoid 92 is not, it will be seen that the prop 11, 13 is caused to contract and the jack 28, 29 is caused to pull. The arrangement described provides greater safety when manually operating the pilot valves in that prop extension can be immediately halted by releasing hand pressure on both rubber caps 95, 96.

The remote control circuit for the solenoids 91 and 92 in FIGURE 1 operates from an alternating current supply which is fed into a transformer primary winding 101. The secondary winding 102 has a live lead 103 connected by a current limiting resistor 104 to two parallel connected switches 105 and 106. The other end of the winding 102 is connected to a conductor 110 which provides a common earth for a number of pairs of solenoids. The switches 105, 106 are respectively connected through oppositely arranged half wave rectifiers 107, 108 to the movable contact 109 of a multi-position selector switch 111. The switch 111 can select the solenoid pairs of each mine roof support, and one conductor 112 is shown extending from a fixed contact of the selector switch to the solenoids 91, 92. The live conductor 112 is connected in series through a half wave rectifier 113 and the solenoid 91 to the earthed conductor 107, while the latter is connected in series through a half wave rectifier 114 and the solenoid 92 to the live conductor 112.

The arrangement of half wave rectifiers at the transmitting and receiving ends of the conductors 110, 112 is such that upon closure of the switch 105, current flows in one direction through the rectifier 107, the conductor 112 and the rectifier 113 to energize the solenoid 91. Closure of the switch 106 enables current to flow in one direction from the earthed conductor 110 through the rectifier 114, the solenoid 92 and the rectifier 108. Upon closure of both switches 105, 106 alternating current flows in the conductors 110, 112 and both solenoids 91, 92 are energized.

Half wave rectifiers 115 and 116 connected across the solenoids 91 and 92 in opposition to the half wave rectifiers 113 and 114, serve to dissipate electrical energy induced by a break in the circuit.

FIGURE 1 includes a circuit for signalling the condition of the mine roof support. A live conductor 118 connected to the live lead 103 extends to all the mine roof supports. A potentiometer 43 associated with the puller jack 29 of each support as previously described is interposed in series with a half wave rectifier 121 between the conductors 118 and 110, and the movable contacts 122 of the potentiometer is connected through a current limiting resistor 123 to a conductor 124. Also the pressure switch 45 associated with the prop 12, 14 is interposed in series with a half wave rectifier 125 and a current limiting resistor 126 between the live conductor 118 and the conductor 124. The conductor 124 is one of many connected back to the fixed contacts of a multi-position switch 127. The movable contact 128 of the switch 127 is joined by a conductor 129 and two parallel branch loops 131, 132 to the earthed side of the secondary winding 102. The branch loop 131 has a half wave rectifier 133 and voltmeter 134 therein, the rectifiers 127 and 133 being arranged to permit current flow in one direction from the potentiometer 43 and through the voltmeter 134. The branch loop 132 has a half wave rectifier 135 and an indicator lamp 136 therein, the rectifiers 135 and 125 being arranged to permit current flow in one di-

rection through the switch 45 when closed and the indicator lamp 136. The current flow through the voltmeter 134 and the lamp 136 takes place in opposite directions through the conductors 124 and 129, and a simultaneous indication can be given by the voltmeter 134 of the degree of extension of the puller jack 29, and by the lamp 136 as to the existence or otherwise of a predetermined setting pressure in the prop 12, 14.

Referring to FIGURES 8 and 9, the switches 111 and 127 are shown ganged together for operation by a single knob 141 having a pointer 142 to indicate the particular mine roof support under simultaneous control and indication. The switches 105, 106 are operable by four spring-loaded plungers, 143, 144, 145 and 146. The plungers 144, 145 and 146 each have on one side a cam surface 147 and a locking recess 148. The plunger 143 has a cam surface 147 only. Horizontal guides 149 are provided for two locking plates 151, 152 which are loaded towards the cam surfaces 147 by springs 153 and 154. Depression of any raised plunger 144, 145 or 146 results in release of any previously locked plunger and locking of the newly depressed plunger. Depression of the plunger 143 shifts both plates 152 and 151 to release any of the plungers 144, 145 or 146.

In FIGURE 9 all plungers are raised and both switches 105, 106 are open corresponding to the first step of the operating sequence. In the second step, plunger 144 has a foot 155 which closes the switch 105. The plunger 145 has a foot 156 which closes both switches 105 and 106, and the plunger 146 has a foot 157 which closes the switch 106 only.

The locking plate 152 has a toothed end 158 engageable with one of a number of detents 159 in a disc 161 which turns with the knob 141. There is one detent 159 corresponding to each position of the pointer 142. Since the locking plate 152 is separate from the locking plate 151, it can only unlock the disc 161 when the plunger 143 is depressed. The locking plate 152 and disc 161 provide a safety measure to prevent selection of another mine roof support by turning the knob 141 until the support previously operated upon is in a safe condition.

We claim as our invention:

1. In a mine roof support unit for a multiple roof support system, a plurality of hydraulic propping and shifting devices, a control system comprising valve means interposed between a hydraulic power source and the propping and shifting devices, said valve means including a number of electromagnetically actuated valves together providing several operative combinations of valve positions, in each of which combinations said valve means is operative to effect one of several required combinations of operations of the propping and shifting devices, switch means operative to control said electromagnetically actuated valves, a selector device arranged to actuate said switch means in each one of a number of operation selecting positions to cause corresponding actuation of said valves, a multi-position switch arranged to connect said switch means with the electromagnetically actuated valves of any desired roof support unit of the multiple roof support system, and an interlock device arranged to lock the multi-position switch in each position, said interlock device being operable by said selector device to release the multi-position switch when the selector device is in a position corresponding to a predetermined condition of the mine roof support unit controlled thereby.

2. In a mine roof support unit having hydraulic propping and shifting devices, a control system comprising: valve means interposed between a hydraulic power source and the propping and shifting devices, said valve means including two electromagnetically actuated two-position valves together providing a maximum of four operative combinations of valve positions, in each of which operative combinations said valve means is arranged to effect one of a corresponding number of different combined operations of the propping devices and shifting devices;

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first and second solenoids coupled with said valves and adapted for both to be deenergized, one or the other energized singly, or both energized, to provide the said different operative combinations of valve positions; a control circuit including two conductors across which said solenoids are connected, current rectifying means associated with said solenoids to cause energization of one or other of said solenoids for opposite directions of current flow respectively through the two conductors, an alternating current source, switch means arranged to connect the alternating current source across said two conductors, and additional rectifying means associated with said switch means whereby said switch means is operable to isolate said alternating current source from said two conductors, or to direct electric current through the two conductors in one direction, another direction, or in both directions.

3. A control system according to claim 2 having in combination therewith an additional circuit comprising two additional conductors connected to an alternating current source, two signalling devices responsive to different conditions of the mine roof support, said signalling devices being interposed in said additional circuit, two indicating devices also interposed in said additional circuit, and rectifying means arranged to direct electric current from the source through one or the other of the signalling devices and one or the other of the indicating devices respectively in accordance with the direction of current flow in the two conductors.

4. A mine roof support including at least one fluid-pressure-operated prop operable to support the roof; a fluid-pressure-operated jack operable to advance the support relative to an anchorage, a prop fluid-flow control valve assembly operable to control the prop, a jack fluid-flow control valve assembly operable to control the jack, and two pilot fluid-flow control valves operable to control by fluid pressure the prop control valve assembly and the jack control valve assembly, at least one of said pilot

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valves effecting a control on both the prop control valve assembly and the jack control valve assembly, and each pilot valve having a first operating position and a second operating position providing four combinations of operating positions of said valves.

5. A mine roof support according to claim 4 wherein said pilot valves are each electrical solenoid-operated valves, and means for actuating the pilot valves includes two electrical conductors across which the solenoids are connected, current rectifying means associated with said solenoids to cause energization of one only of said solenoids when current flows in one direction through the two conductors and to cause energization of the other solenoid only when current flows in the opposite direction through the two conductors, an alternating current source, switch means operable to connect the alternating current source to the two conductors, and additional rectifying means associated with said switch means to enable the switch means to be operated in four ways, said four ways respectively resulting in isolation of said alternating current source from the two conductors, passage of electric current through the two conductors in one direction only, passage of electric current through the two conductors in the opposite direction only, and passage of alternating electric current through the two conductors.

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