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Nov. 19, 1968 R. WARD 3,412,391

PRESSURE-FLUID-OPERATED DEVICES AND MEANS FOR INDICATING THE CONDITION THEREOF

Filed Oct. 15, 1965 6 Sheets-Sheet 1

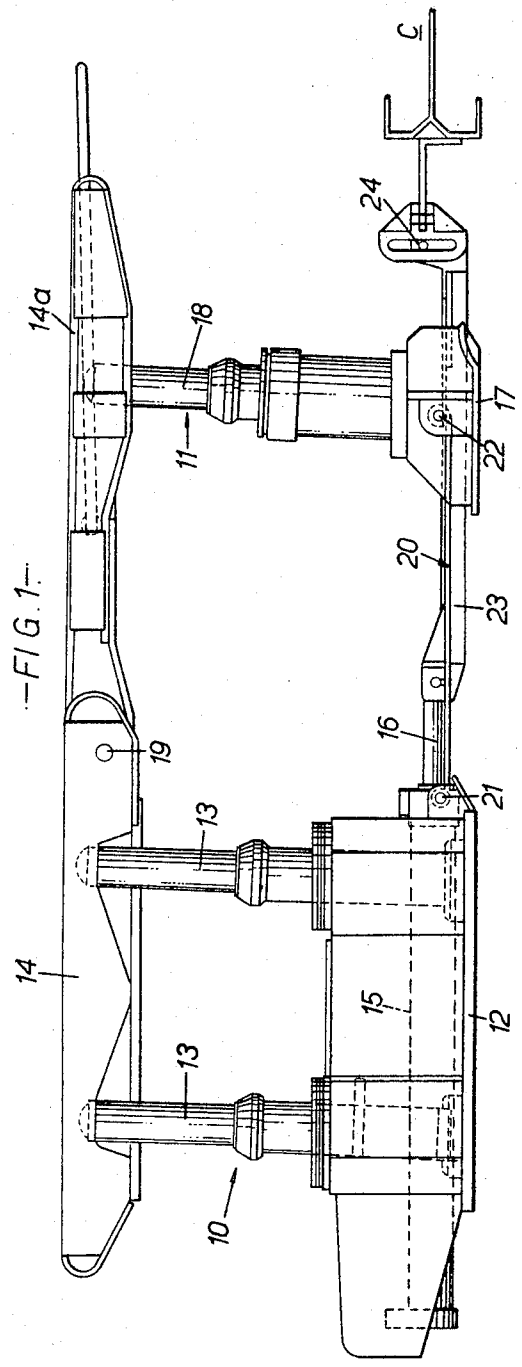


FIG. 1

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PRESSURE-FLUID-OPERATED DEVICES AND MEANS FOR INDICATING THE CONDITION THEREOF

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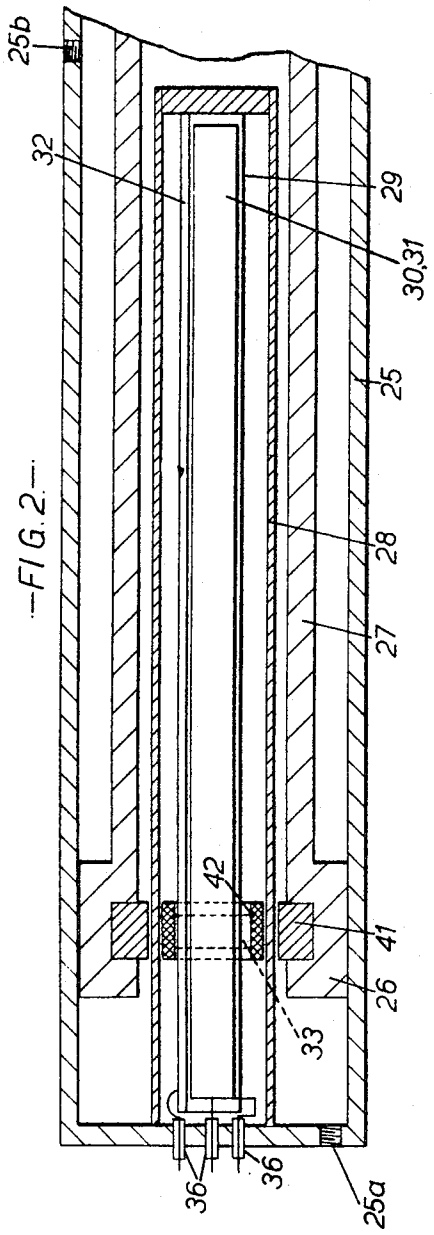


FIG. 2

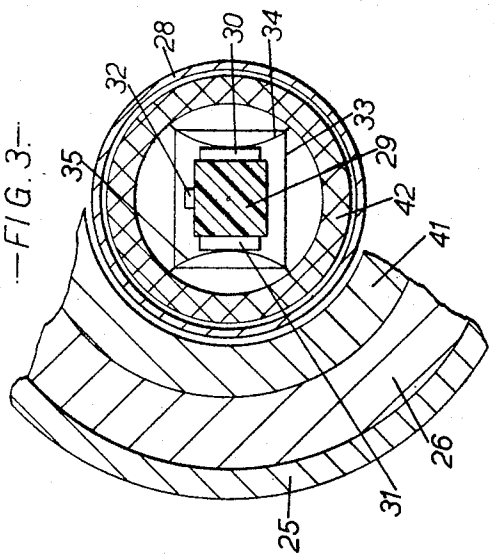


FIG. 3

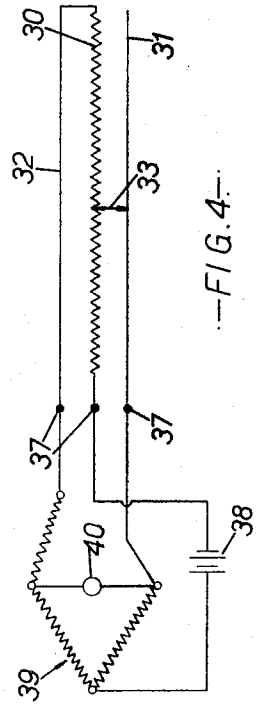


FIG. 4

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PRESSURE-FLUID-OPERATED DEVICES AND MEANS FOR INDICATING THE CONDITION THEREOF

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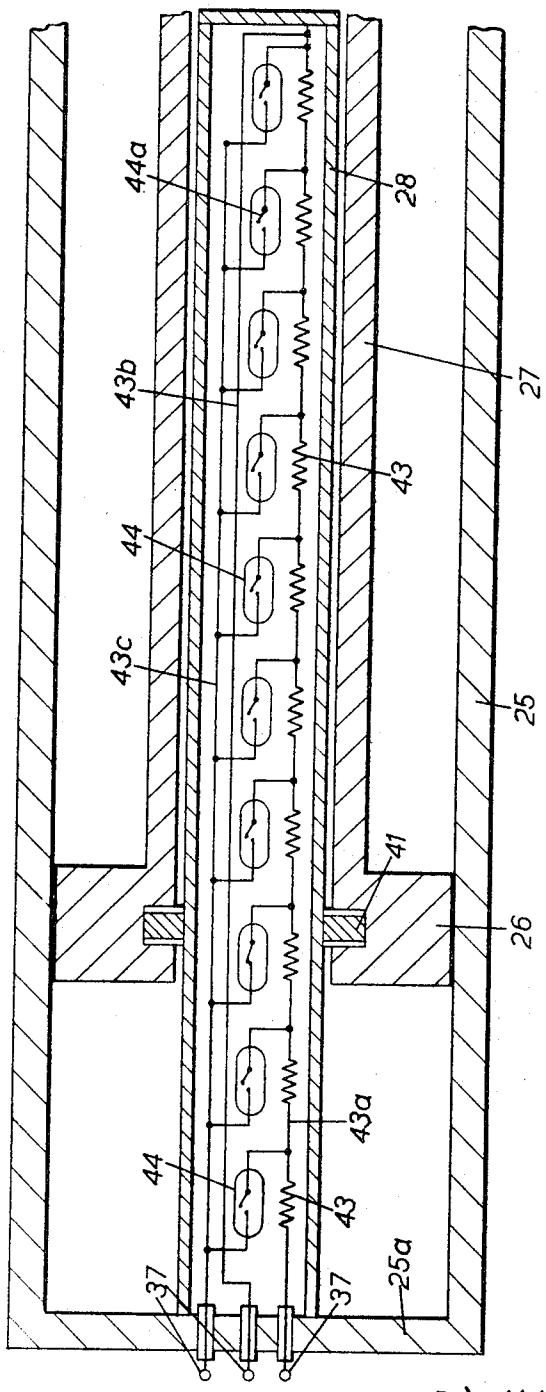


FIG. 5.

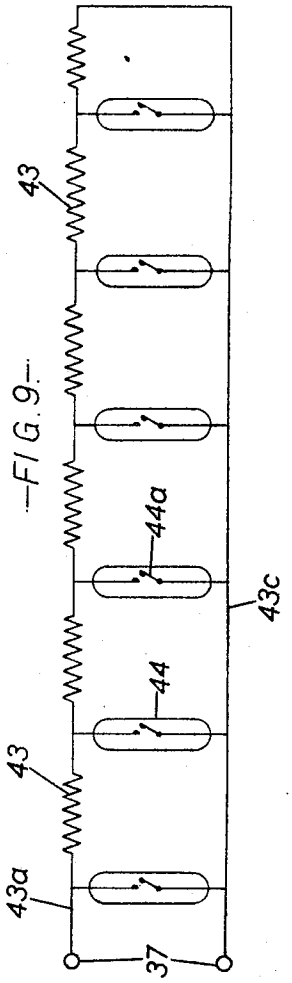


FIG. 9.

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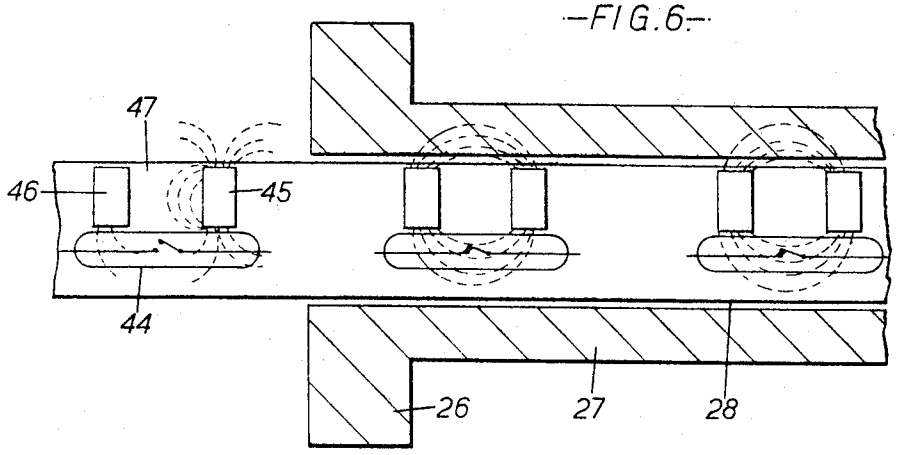
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Nov. 19, 1968 R. WARD 3,412,391

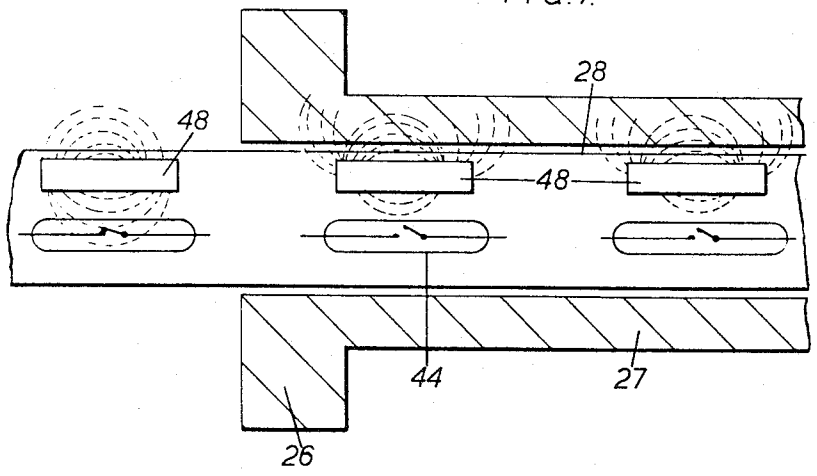
PRESSURE-FLUID-OPERATED DEVICES AND MEANS FOR INDICATING THE CONDITION THEREOF

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—FIG. 6—



—FIG. 7—



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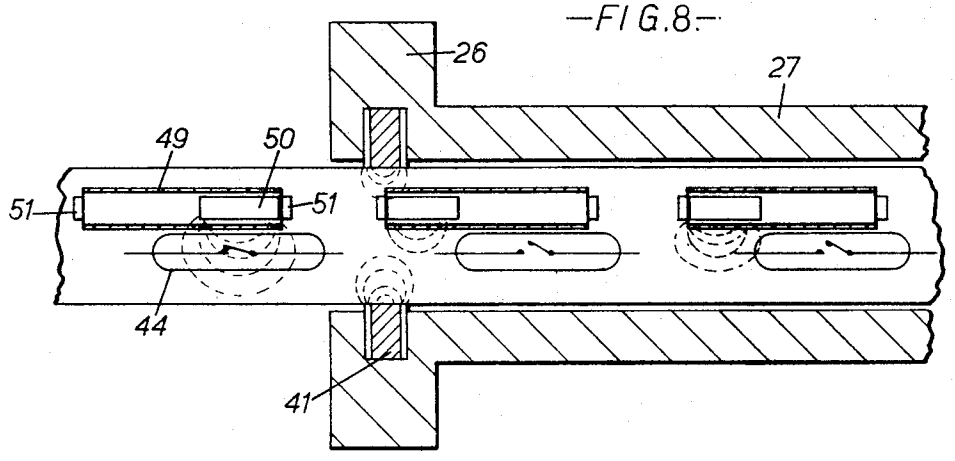
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—FIG.8—



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PRESSURE-FLUID-OPERATED DEVICES AND MEANS FOR INDICATING THE CONDITION THEREOF

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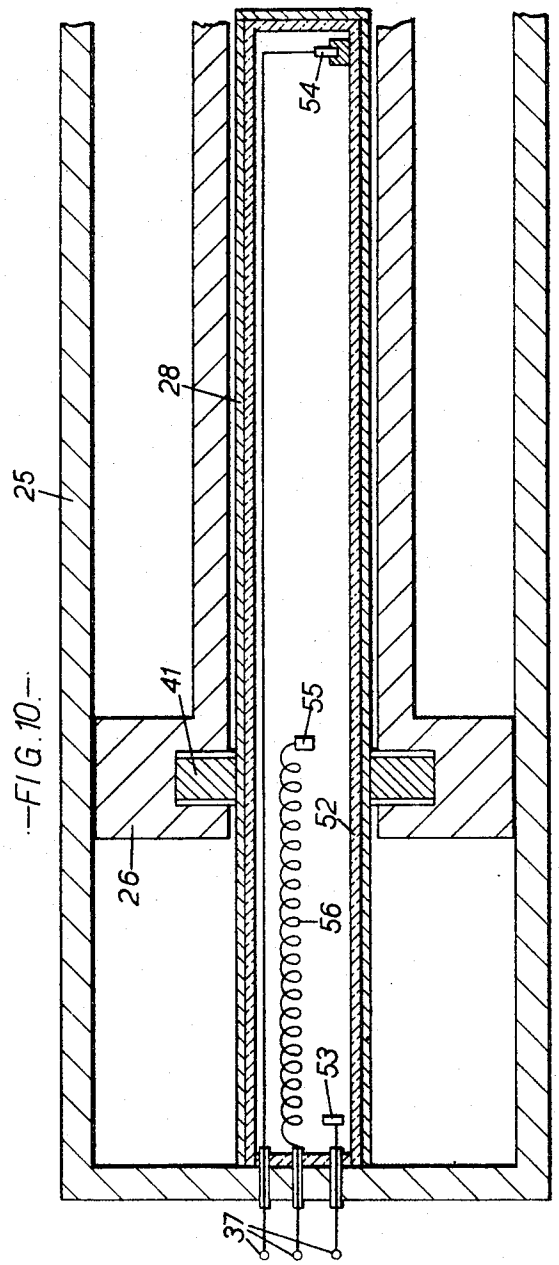


FIG. 10

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United States Patent Office

3,412,391

Patented Nov. 19, 1968

3,412,391

PRESSURE-FLUID-OPERATED DEVICES AND MEANS FOR INDICATING THE CONDITION THEREOF

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Filed Oct. 15, 1965, Ser. No. 496,264

Claims priority, application Great Britain, Oct. 31, 1964, 44,499/64; Jan. 29, 1965, 3,990/65

7 Claims. (Cl. 340—282)

ABSTRACT OF THE DISCLOSURE

A self-advancing mine roof support having a hydraulic ram member for advancing it and at least one hydraulically extensive prop member for securing it between floor and roof. The ram member or the prop member or both have means for indicating, at a remote station, their extent of extension and retraction.

This invention is for improvements in or relating to self-advancing mine roof supports of the kind having a hydraulic ram member for advancing the support and at least one hydraulically extensible prop. One object of the invention is to provide a system for indicating at a remote station the amount of extension of the hydraulic ram and/or hydraulic prop of the support.

According to the present invention there is provided a self-advancing mine roof support having a hydraulic ram member for advancing it and at least one hydraulically extensible prop member for securing it between floor and roof, at least one of said members being combined with means for indicating its extension and retraction comprising a cylinder, a piston within said cylinder, means for entry and exit of a pressure-fluid to and from the cylinder, at least one electric current conduction control element within said cylinder, means isolating said control element from pressure-fluid within the cylinder, means for varying the current conduction of said control element, and magnetic means responsive to relative movement of said piston and cylinder to adjust said control element varying means.

Some particular embodiments of the invention will now be described, by way of example, with reference to the accompanying semi-diagrammatic drawings in which:

FIGURE 1 is a side elevation of a form of self-advancing mine roof support to which the present invention is particularly, although not exclusively applicable,

FIGURE 2 is a fragmentary longitudinal sectional view of a hydraulic ram incorporated in the support shown in FIGURE 1 and adapted to push over the conveyor towards the coal face and then advance the support up to the conveyor,

FIGURE 3 is a fragmentary cross-section, to a larger scale, through the ram piston shown in FIGURE 1,

FIGURE 4 is a diagram showing the electrical connections of the potentiometer incorporated in the ram shown in FIGURES 2 and 3, for the purpose of the invention, and the manner in which this potentiometer may be connected in a remote indicating system,

FIGURES 5, 6, 7 and 8 are fragmentary longitudinal sectional views of four further embodiments of the invention as applied to a hydraulic ram or the like,

FIGURE 9 shows the electrical circuit for the embodiments of the invention shown in FIGURES 6, 7 and 8, and

FIGURE 10 shows a still further embodiment of the invention as applied to a hydraulic ram or the like.

Referring first to FIGURE 1 of the drawings, briefly, the mine roof support comprises a rear unit **10** and a forward unit **11**.

The rear unit **10** comprises a base **12** on which are mounted four telescopic hydraulically extensible props **13**, these props being arranged in side-by-side pairs at the front and rear of the base **12**.

At their upper parts the hydraulic props or legs **13** support a roof-bar structure or canopy **14**.

Mounted and secured in the base **12** of the rear support **10** is the cylinder of a hydraulic double-acting ram **15** having a forwardly extending piston rod **16**.

The forward support unit **11** comprises a base **17** on which is mounted a single telescopic hydraulically extensible prop or leg **18** which, at its upper part, supports a cantilever roof-bar member **14***a* pivotally attached to the rear roof-bar structure or canopy **14** at **19**.

The rear unit **10** and the front unit **11** are articulated together at their lower parts by a link **20** pivotally attached to the rear unit at **21** and to the front unit at **22**.

The piston rod **16** of the ram **15** has an extension or relay bar **23** which passes freely through the base **17** of the forward unit and is attached at **24** to the conveyor C. The conveyor C is arranged to carry away the coal as it is mined from the coal face in the usual way of longwall mining.

As winning of the coal from the coal face proceeds the ram **15**, **16**, **23** is extended so as to push the conveyor C towards the newly exposed coal face ready for a further traverse of said face by the coal cutting machine. When the conveyor has been pushed over the legs **13** and **18** of the support are lowered so as to release the roof-bar structure **14**, **14***a* from the roof and the ram **15**, **16** is then retracted so that, using the conveyor as an anchorage, the support is advanced up to the conveyor. The legs **13** and **18** are then extended again so as to secure the support firmly between floor and roof.

The hydraulic ram shown in FIGURES 2 and 3 of the drawing comprises a cylinder **25**, having pressure-fluid entry and exit ports **25***a* and **25***b*, and a ram proper having a piston **26** and a piston rod **27** which may conform structurally and functionally to the cylinder **15** and ram **16** of FIGURE 1 or may differ therefrom when utilized in the same or a different application.

The piston rod **27** is of tubular construction and houses a tube **28** of non-magnetic material. The tube **28** is sealed at both ends so as to isolate its interior from the pressure-fluid in the ram cylinder.

Enclosed within the tube **28** is a rectilinear potentiometer comprising a rod or bar **29** of insulating material which carries a resistance element or track **30**, a slider track **31** of electrical conducting material and a return conductor **32**.

Mounted on the rod **29** for movement therealong is a wiper assembly **33** having a sprung brush or slider **34** adapted to traverse and make contact with the resistance element **30** and a sprung brush or slider **35** adapted to traverse and make electrical contact with the slider track **31**. The brushes or sliders **34** and **35** are electrically connected together.

The three connections of the potentiometer transducer just described are taken through insulating bushes **36** at one end of the ram cylinder and provided with terminals **37** (see FIGURE 4) for connecting the potentiometer transducer in the remote indicating system which, in the arrangement shown in FIGURE 4, comprises an electricity

supply source **38**, a Wheatstone bridge circuit **39** and a current or potential responsive indicating instrument **40**.

Movement of the wiper assembly **33** and thereby adjustment of the potentiometer device is effected in accordance with the movement of the ram member **26, 27** by a magnetic coupling comprising a ring magnet **41**, secured to the piston **26** and slidable over and along the exterior of the tube **28**, and a ring armature **42** of iron or other ferromagnetic material, slidable within the bore of the tube **28** and to which the wiper assembly **33** is attached.

As the piston moves along the cylinder, carrying magnet **41**, the magnetically attracted armature **42** and connected wiper are also moved to adjust the potentiometer and thus the position of the piston in the cylinder is indicated by the remote indicating instrument **40** which is appropriately calibrated.

It will be appreciated that the tubular bore of the piston rod **27** must be of sufficient length to accommodate the length of the tube **28** when the ram is in its fully retracted condition.

The tube **28** may be of copper, brass, stainless steel or some other non-magnetic material and must be capable of withstanding the full pressure applied to the ram. If the tube is not strong enough itself then it may, for example, be filled with a non-conducting liquid such as a transformer oil and sealed.

When sufficient magnetic coupling can be obtained through even a thick walled tube **28**, the tube can be air-filled at atmospheric pressure and no special sealing at the terminal connections will be required where they pass through the end of the ram.

The resistance element **30** may be a molded carbon resistance track. Alternatively, a wire-wound potentiometer may be used having a rigid core or in the form of a "spaghetti" winding on a flexible glass fibre core.

An alternative to the use of a resistance track is to insulate electrically the inside walls of the tube **28** but not the end closures thereof and to substitute a conductive liquid for the potentiometer track, one of the electrical connections being taken to the armature **42** by an insulated wire and the armature serving as a "wiper." In other words, the three electrical connections will be taken one to each of the opposite ends of the tube and the other to the armature. A conductive liquid is selected which is non-electrolytic and has the right resistance characteristics and is not subject to polarisation. This conductive liquid may be any suitable ionic solution, e.g., an aqueous solution of an acid or salt such as sulphuric acid or sodium chloride.

Referring now to FIGURE 5 of the drawings, the hydraulic ram comprises a cylinder **25** and a ram proper having a piston **26** and a piston rod **27**.

The piston rod **27** is of tubular construction and receives a tube **28** of non-magnetic material. The tube **28** is sealed at both ends so as to isolate its interior from the pressure-fluid in the ram cylinder, the tube being attached at one end to the cylinder head **25***a*.

Enclosed within the tube **28** are a plurality of resistance elements or resistors **43** connected in series in a circuit comprising the resistance lead **43***a* and return leads **43***b* and **43***c*.

Also enclosed within the tube **28** are a plurality of capsulated reed switches **44** one such switch being associated with each resistance element **43** to connect a terminal, between each successive pair of resistors **43**, to the return lead **43***c*. The spring-reed movable contacts **44***a* of the reed switches **43** have a bias such that the switches are normally in the open condition. The arrangement is such that the combination of resistance elements **43** and reed switches **44** provide a form of step-by-step potentiometer.

Operation of the switches **44** and thereby adjustment of the "potentiometer" device is effected, in accordance with the movement of the rams **26, 27**, by means of a magnetic coupling comprising a ring magnet **41** secured to the piston **26** and slidable over and along the exterior of the tube **28**. Each reed **44***a* is adapted to act as an armature or second element of the magnetic coupling so that the switch is closed by the ring magnet **41** as it passes over the switch or comes into its vicinity.

The three "potentiometer" connections **37** may be connected in a remote indicating system after the manner described with reference to FIGURE 4.

As mentioned above, the chain of resistance elements **43** forms a potentiometer and the switches **44** select tapping points in the chain, thus in effect acting as a potentiometer slider which steps from point to point of the potentiometer instead of sliding therealong in the usual way. The switch or switches **44** which is or are closed will, of course, depend on the position of the piston **26** so that said piston, in effect, controls the flow of current or potential in the indicator system and the indicating instrument in that system is caused to take up a position which will indicate the movement of the piston **26** along the cylinder **25**.

The switches **44** will spring open, due to the natural resilience of the reeds **44***a*, or otherwise be caused to open (under the influence of light springs, not shown, or gravity) as the piston and magnet **41** move out of their vicinity.

The number of different positions of the piston **26** which the indicating instrument can indicate will, of course, depend on the number of switches **44**.

The chain of resistances could be replaced with suitable circuit modifications, by a chain of inductors or capacitors, which like resistors control electric current flow or conduction. Hence resistors, inductors and capacitors are hereinafter termed electric current conduction control elements.

A disadvantage, in some circumstances, of the reed switch operated potentiometer system described with reference to FIGURE 5 is that after the magnet **41** has passed the reed switches will open and a reading of ram position will only be given when the ram head **26** is actually close enough to a reed switch to operate it.

FIGURES 6, 7 and 8 show alternative arrangements by which this disadvantage may be overcome. In certain respects the arrangements shown in FIGURES 6, 7 and 8 are similar to that shown in FIGURE 5 where applicable like reference numerals have been used to designate like parts. The resistances associated with the switches **44** are not shown in FIGURES 6, 7 and 8.

In the embodiment shown in FIGURE 6 each magnetic reed switch **44** has a short bar magnet **45** at one end and either another magnet or an iron pole piece **46** at the other, so arranged that there is a large gap **47** between the ends furthest from the switch, said ends being close to the stainless steel tube **28**. There is no magnet in the ram head **26**.

The switches **44** are operated by the steel ram proper **26, 27** of the ram decreasing the reluctance of the magnet path round the magnetic circuit formed by the bar magnet **45**, the pole piece **46** and the magnetic reed switch **44**. The ram proper **26, 27** closes the magnetic circuits to passage of sufficient magnetic flux to close and maintain closed all the switches **44** which happen to be within its tubular bore.

In the embodiment shown in FIGURE 7 a bar magnet **48** is fixed parallel with each magnetic reed switch **44** and just close enough to operate it. Here again, there is no magnet in the ram head **26**.

When the ram proper **26, 27** comes near to a magnet **48** which is fixed as close as possible to the wall of the stainless steel tube **28**, a large proportion of its total flux is shunted by steel ram proper leaving insufficient flux to keep the reed switch **44** closed. When the ram proper moves away from the magnet the reed switch re-closes as the flux returns to its path through the reed switch. Thus, all the switches within the tubular bore of the ram proper are maintained open and all those outside said bore are closed.

In the embodiment shown in FIGURE 8 a magnet **41**

is housed in the ram head **26**. Each reed switch **44** has a short tube **49** of non-magnetic material alongside it as shown. In the tube is a short bar magnet **50** about half the length of the tube and free to slide axially. At each end of the tube **49** a small iron stud **51** is fixed so that the magnet tends to stay at whichever end of the tube it is put.

The position of each tube **49** is such that when its magnet **50** is at one end of the tube the reed switch **44**, associated with that tube, is closed by passage of flux through the switching element and when it is at the other end the reed switch is opened by its natural resiliency or by means not shown.

The magnet **41** in the ram head **26** is sufficiently powerful to overcome the "latching" effect between a magnet **50** and the iron studs **51** at the ends of its tube **49** so that as the ram head passes each tube magnet reed switch assembly **49**, **50**, **44**, from left to right in FIGURE 8, the magnet **50** is moved to the right-hand end of the tube and operates the reed switch keeping it closed after the ram head has passed. When the ram head passes in the other direction the magnet **50** is moved to the left-hand end of its tube where it no longer affects the reed switch, and the switch opens.

The power of the magnet **41** in the ram head need not be closely controlled as it need only be powerful enough to pick up each bar magnet **51** as it passes.

None of the embodiments described with reference to FIGURES 6, 7 and 8 gives a potentiometer output so that the ram position must be read as a change in resistance of the circuit, each reed switch being arranged (see FIGURE 9) to short out a section of a chain of resistors **43** connected in series. This change in resistance is utilized in a system similar to that shown in FIGURE 4 to operate the remote indicating instrument.

FIGURE 10 shows an embodiment similar, in some respects, to that described with reference to FIGURES 2, 3 and 4, but having an alternative to the slider and moulded track or wire-wound rectilinear potentiometer **30–34**. In this embodiment there is still a magnet **41** in the ram head **26** embracing a stainless steel tube **28** attached to the cylinder **25**.

Instead of the tube **28** housing a rigid rectilinear potentiometer, the inside walls of the tube are insulated by a non-conducting lining **52** and the tube is filled with a conducting liquid, such as an aqueous solution of sulphuric acid or sodium chloride. Connections are made to the conducting liquid at the ends of the tube through electrodes **53** and **54** immersed in the liquid, and a further electrode **55** situated within the tube **52** is electrically connected to a terminal extending outside of the tube via an insulated flexible wire **56**.

The third electrode **55**, which forms the potentiometer "wiper," is of magnetic material or is attached to a piece of magnetic material, and the insulated wire **56**, to the end of which it is connected, is sufficiently long and flexible to allow the "wiper" to travel along the length of the tube. The wire **56** may be coiled into a spring.

The magnet **41**, in passing along the outside of the tube **28** will draw the "wiper" electrode **55** through the liquid and the device will operate as a potentiometer. The fact that the tube **28** is filled with liquid makes it possible to use light gauge material for the tube **28** without danger of collapse through external pressure.

It will be understood that a hydraulic prop (e.g. such as is shown in FIGURE 1) incorporating the present invention may be similar in construction to the rams above described and shown in the drawings, a main difference being that a prop will be arranged to stand on its end.

Transducers as above described are very suitable as roof support hydraulic prop or ram extension transducers as they can be made thin enough to fit inside a prop or ram without introducing serious mechanical problems.

It may be possible to make a transducer assembly no greater than ⅜ inch diameter particularly when using the arrangement described with reference to FIGURES 8 and 10.

I claim:

1. A self-advancing mine roof support having a hydraulic ram member for advancing it and at least one hydraulically extensible prop member for securing it between floor and roof, at least one of said members being combined with means for indicating its extension and retraction comprising a cylinder, a piston within said cylinder, means for entry and exit of a pressure-fluid to and from the cylinder, at least one electric current conduction control element within said cylinder, means isolating said control element from pressure-fluid within the cylinder, means for varying the current conduction of said control element, and magnetic means responsive to relative movement of said piston and cylinder to adjust said control element varying means.

2. A self-advancing mine roof support as claimed in claim **1** wherein the electric current conduction control element comprises a plurality of resistors connected in series between terminals adapted to be connected to a power source, the means for varying the conduction of the control element being a plurality of switches one connected between each adjacent pair of resistors so as to alter the number of resistors connected to said terminals when a switch is operated, the means responsive to relative movement of the piston and cylinder so as to actuate said switches comprising at least one magnet carried by the piston and operative to close said switches in turn as the piston moves relative to the cylinder.

3. A self-advancing mine roof support as claimed in claim **1** wherein the electric current conduction control element comprises a plurality of resistors connected in series between terminals adapted to be connected to a power source, said means for varying the conduction of the control element being a plurality of switches one connected between each adjacent pair of resistors so as to alter the number of resistors connected to said terminals when a switch is operated, the means responsive to relative movement of said piston and cylinder so as to actuate said switches comprising at least one magnet disposed adjacent each switch and operative to close the associated switch until magnetic flux is diverted from the switch by approach of said piston.

4. A self-advancing mine roof support as claimed in claim **1** wherein the electric current conduction control element comprises a plurality of resistors connected in series between terminals adapted to be connected to a power source, said meas for varying the conduction of the control element being a plurality of switches one connected between each adjacent pair of resistors so as to alter the number of resistors connected to said terminals when a switch is operated, the means responsive to relative movement of said piston and cylinder so as to actuate said switches comprising at least one magnet disposed adjacent each switch and operative to close the associated switch when magnetic flux is diverted thereto by approach of the piston.

5. A self-advancing mine roof support as claimed in claim **1** wherein the electric current conduction control element comprises a plurality of resistors connected in series between terminals adapted to be connected to a power source, the means for varying the conduction of the control element being a plurality of switches one connected between each adjacent pair of resistors so as to alter the number of resistors connected to said terminals when a switch is operated, the means responsive to relative movement of the piston and cylinder so as to actuate said switches comprising at least one magnet slidably disposed adjacent each switch for movement to positions which respectively open and close the associated switch and an additional magnet secured to the piston for moving said slidable magnet upon approach of said piston.

6. A self-advancing mine roof support as claimed in claim **1** wherein the electric current conduction control element comprises a body of conducting liquid enclosed

in an elongated casing of insulating material, a pair of fixed electrodes within said casing near opposite ends thereof, a movable electrode of magnetic material within the casing and a magnet mounted in said piston and movable along said casing with the piston to cause movement of said movable electrode.

7. A self-advancing mine roof support as claimed in claim 5 wherein magnetic latching means is provided to retain said slidable magnets in their switch open and closed positions after having been actuated thereto by movement of the piston in one direction until positively moved to their other position by movement of the piston in the other direction.

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