June 16, 1953 R. N. KNIGHTS ET AL 2,641,906

MINE ROOF SUPPORT

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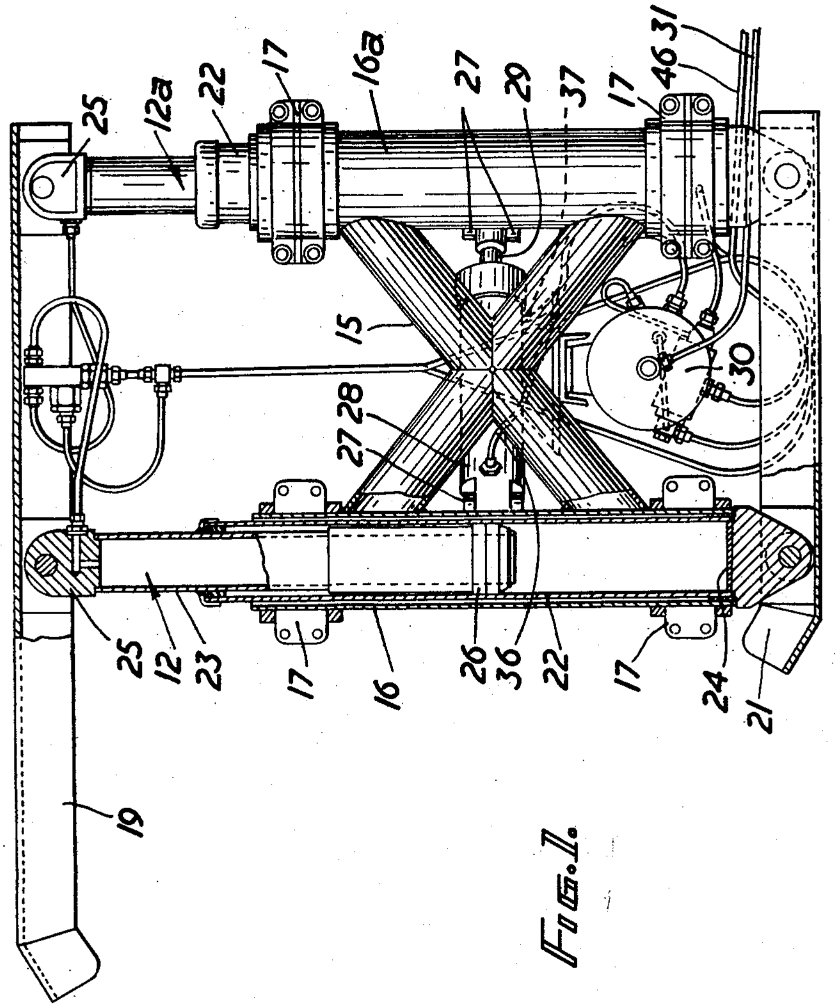

Fig. 1.

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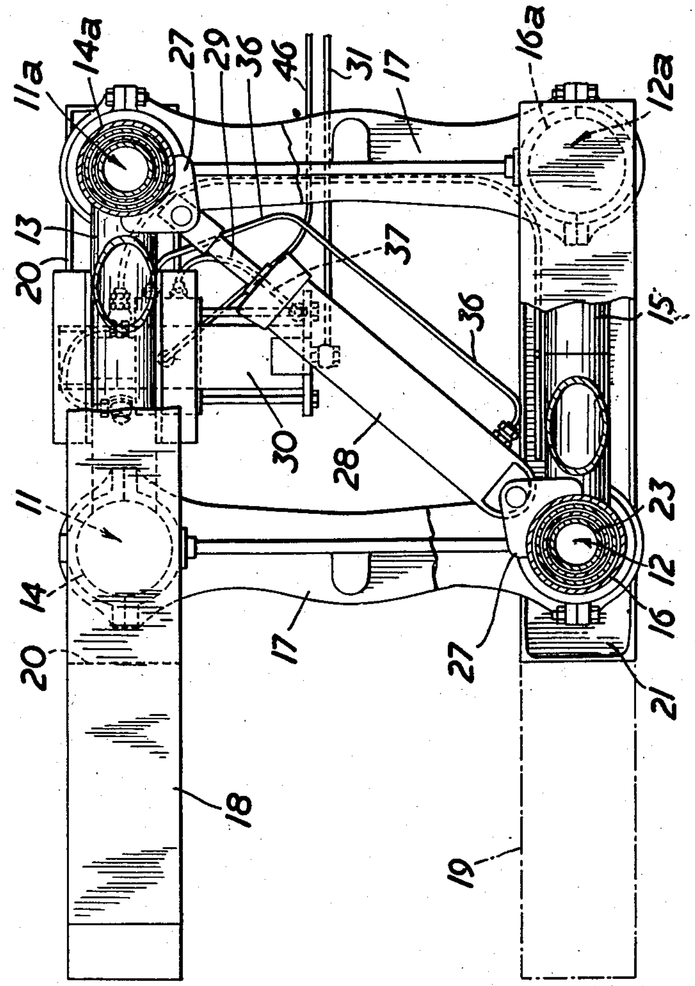

FIG. 2.

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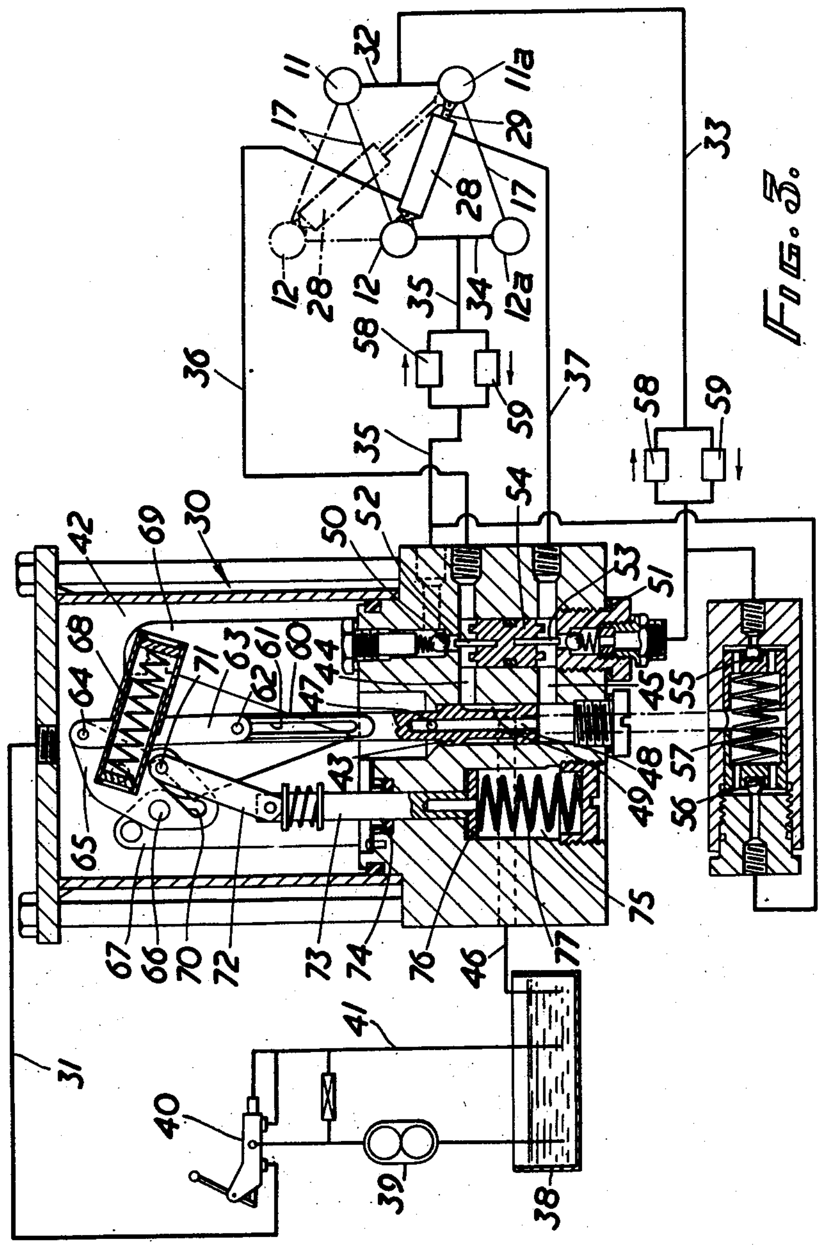

FIG. 3.

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MINE ROOF SUPPORT

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12 Claims. (Cl. 61—85)

The present invention consists in a mine roof support comprising two sets of at least two rigidly interconnected props arranged one behind the other in parallel spaced relationship, and means in the nature of parallel links connecting the two sets together side by side into a parallelogram, whereby when the props of either set are loosened whilst those of the other remain held, the set of loosened props can be advanced by being moved relatively to the other set under the influence of a force acting diagonally of the parallelogram. By thus linking the two sets together advancement can take place by the one held set swinging with the parallel links about the other loosened set, and so on alternately in a "walking" movement.

The support will generally be used with one end of each set being nearer the coal face. When the cutting operation has proceeded sufficiently to require support for the roof exposed between the coal face and the nearest supported section, the props of one set will be loosened and moved forwardly nearer to the coal face. When the loosened set has been advanced, the props of this set will be extended to give the additional support required. In time, the other set of props will be loosened and similarly advanced to a new position of support.

Although the invention is applicable for use with many kinds of prop it is preferred to use hydraulically actuated props which may embody the usual relief valves for permitting the props to shorten under increasing roof pressure. If the props are of the hydraulic type, the pressure spaces of all the props of a set may intercommunicate so that the pressure can be developed from a single pump.

A further feature of the invention consists in providing between the two sets of props power driven mechanism for advancing the support set by set. A double-acting fluid-pressure operated jack may conveniently be used as an extensible and contractible link extending diagonally between linked sets of props. When the jack is extended, the set at one side of the support will be advanced, and when the jack is contracted the other set will advance, provided of course that the stationary set is clamped between the roof and floor.

The invention further consists in a mine roof support comprising at least two hydraulically actuated roof supporting units, means interconnecting the units so that when one is held and the other is loosened, the loosened unit can be advanced by being moved relatively to the held

one, and valve mechanism preventing either unit from being loosened unless the other is taking a predetermined roof loading. Thus the hydraulic system associated with the support may include primary valve mechanism permitting supply flow to the props of one set or unit whilst permitting return flow from the other, and vice versa, and secondary valve mechanism moveable in response to a predetermined pressure in the supply flow to move from a position preventing such return flow to a position permitting such flow. The primary valve mechanism may serve also to permit pressure fluid to reach an appropriate end of an advancement jack while supplying the props of one set and permitting return flow from the other end of the jack, and vice versa, means being provided for reversing the action of the primary valve mechanism upon the attainment of a predetermined pressure in the system being supplied.

If the props are of the hydraulic type, and if the hydraulic system supplying them is controlled by valve mechanism in accordance with the invention, the supply of pressure fluid along a single line will serve to bring about automatically a sequence of operations which causes the mine roof support to be advanced step by step.

If the coal-getting installation includes a conveyer extending along the coal face, the conveyer may, as the working face recedes, be advanced as a whole by means of a number of hydraulic roof supporting units having a single valve mechanism in accordance with the invention, said supports thus being controlled from a single control point.

A mine roof supporting installation incorporating the several features of the present invention will now be described in conjunction with the accompanying drawings, of which Figures 1 and 2 illustrate the roof supporting structure, Figure 1 being a side elevation partly in section and Figure 2 being a plan view partly in section; and Figure 3 is a diagrammatic representation of the hydraulic system associated with the structure of Figures 1 and 2.

The roof supporting structure shown in Figures 1 and 2 incorporates at least four upright hydraulic props, arranged in two sets, one set at the left and the other set at the right. One prop in each set, **11** and **12**, respectively, may be considered the forward prop and the other prop in each set, **11***a* and **12***a*, respectively, will be the rear prop of its set. The props **11**, **11***a* of one set are pin jointed to a roof bar **18** and to a floor bar **20**, and the props **12**, **12***a* of the other set are similarly pin jointed to the roof bar **19** and the floor bar 21. These pin joints allow some slight tilting of the individual roof bars and floor bars to accommodate irregularities in the mine roof and floor. In addition, the props 11 and 11a of the right hand set are supported in and connected by a rigid side frame consisting of cross tubes 13 joining sleeves 14 and 14a that surround and mount the respective props 11 and 11a. In similar manner the props 12 and 12a of the left hand set are connected and mounted in the respective sleeves of a second such side frame made up of sleeves 16 and 16a joined rigidly by cross tubes 15. The right hand side frame and the left hand side frame are linked together by parallel linkage such as the four transverse links 17, two connecting the top and bottom of the sleeves 14 and 16, and the other two connecting the top and bottom of the sleeves 14a and 16a. The links 17 and the two rigid side frames relative to which the ends of the links may swing constitute thus an articulated upright structure which can be deformed by effecting alternately approach of its diagonally opposite sleeves 14a and 16, and their separation, always maintaining their side frames in parallelism. Each prop, it will be observed from Figure 1, is permitted limited axial freedom with respect to the sleeve of the rigid side frame wherein it is mounted, and this is required in order to accommodate irregularities in the level of the mine roof and floor, through the pin joints already mentioned which connect the props to the roof bars 19 and the floor bars 21, while avoiding the imposition of any undesirable stresses on the rigid side frames and the links 17 which connect them.

The four props are structurally substantially identical with one another, and referring to the prop 12 in Figure 1 it will be seen that there is a lower outer tubular member 22 within which there is slidable telescopically an upper inner tubular member 23. The tube 22 is closed at its lower end by a closure piece 24 and the tube 23 is closed at its upper end by a head piece 25. At its lower end, the tube 23 is glanded at 26 to the tube 22. It will therefore be seen that the introduction of pressure fluid into the space within the tubes will cause the prop to extend, and that contraction is permitted when the pressure fluid is allowed to leave the space.

Deformation of the upright articulated structure, such as has already been mentioned, can be accomplished by a double-acting hydraulic advancement jack 28, 29 which is pin jointed at its respective ends to lugs 27 fitted upon diagonally opposite sleeves such as 16 and 14a. If, say, the props 11, 11a mounted in the right hand side frame 14, 14a, 13 are extended between the roof and the floor to hold that side frame fixedly in position, and the props 12, 12a mounted in the left hand side frame 16, 16a 15 are slacked or loosened, extension of the advancement jack 28, 29 will thrust forwardly the sleeve 16 and of course the entire left hand side frame, by reaction from the fixed sleeve 14a and right hand side frame. The floor bar 21 will shuffle forwardly over the floor, and the roof bar 19 also moves forwardly; the links 17 all swing about the sleeves at their ends. If now the props 12, 12a are extended to fix the left hand side frame 16, 16a, 15 in the attained advanced position, and the props 11, 11a are loosened, contraction of the advancement jack 28, 29 will draw the sleeve 14a and the entire right side frame forwardly, reacting from the now fixed sleeve 16, and so the entire mechanism can be "walked" forwardly by successive

opposite deformations of the upright articulated structure.

The support may with advantage be fitted with a valve box indicated generally at 30 by which the sequence of operations necessary to effect a number of advancing movements or steps may occur automatically upon the continued supply of pressure fluid along a single feed pipe 31. This valve mechanism will now be described in detail with reference to Figure 3 of the drawings.

The spaces within the tubes 22, 23 of the props 11 and 11a intercommunicate through a line 32 to which leads a common supply and return line 33, and the spaces of the other two props 12 and 12a intercommunicate through a pipe 34 to which leads a common supply and return line 35. There are also two lines 36 and 37 leading to opposite ends of the jack cylinder 28.

Liquid from a reservoir 38 is fed by a pump 39 to a manually operable control valve 40 from which the liquid flows either through a return line 41 back to the reservoir or through a single supply line 31 leading to the valve box 30. The supply line 31 opens into a chamber 42 from which the liquid reaches the primary valve 43 of the system. The primary valve 43 is a piston valve which opens either one of the passages 44 and 45 to the source of supply while placing the other of the passages 44 and 45 in communication with a return line 46 leading back to the reservoir 38. In the position shown, liquid from the chamber 42 can reach the passage 45 through the port 47 and passage 48, and the passage 44 communicates with the return line 46 by way of the annular space 49 around the valve 43. The passage 44 communicates directly with the pipe line 36 leading to one end of the jack cylinder 28, and leads through a spring loaded non-return valve 50 to the pipe line 35 of the props 12 and 12a. The passage 45 similarly leads directly to the pipe 37 connected with the opposite end of the jack, and through a spring loaded non-return valve 51 to the pipe line 33 of the props 11 and 11a. The non-return valves 50 and 51 are adapted to be unseated by projections 52 and 53 respectively formed on the opposite ends of a piston 54 and thus constitute a coordinated control valve means operatively interposed between the primary control valve and the props of the respective frames. The piston 54 is shown in a mid-position at which neither projection engages its valve, and it may be assumed that the roof support has been standing for a time and that the piston 54 has assumed this mid-position due to leakage in the valve 43. All the props are reacting against the roof, and if necessary could support a maximum roof loading of say 50 tons for each pair of props which is the limit imposed by relief valves 55 and 56 controlling flow from the pipe lines 33 and 35 to the return line 46. By arranging the two relief valves 55 and 56 with a common spring 57 between them, the relief valve of either system, when operating alone, will limit the roof loading for the set of props to 50 tons, whereas if the two relief valves should operate simultaneously, as may happen after the support has been standing in use for a period of time, each set of props will be capable of supporting 50 tons loading so that the support as a whole will withstand a loading of 100 tons.

In the example being described it is desired that when a set of props is "loosened," each prop of the set shall be supporting a roof loading of 1 ton which is overcome by the jack when the latter is effecting an advancing movement. For this purpose the pipe lines 33 and 35 each include in parallel a non-return valve 58 preventing flow away from the props and a relief valve 59 permitting return flow only when pressure in the line is above a pressure at which each prop supports the roof loading of 1 ton.

When the primary valve 43 is in its up position shown, pressure fluid will reach the props 11 and 11a through the non-return valve 51, and will reach the lower end of the jack 28 through the line 37. The piston 54 of the valve box and its projections 52 and 53 act as a differential-area piston, as will later be explained, limiting the setting pressure of the props 11 and 11a to a roof loading of 5 tons, the projections 52 and 53 each being $\frac{1}{10}$ of the cross-sectional area of the piston 54.

During operation of the system it is necessary for the primary valve 43 to reverse its action and change-over from one extreme position to the other as soon as possible after one set of props has reached the setting pressure of 5 tons, and the other set has been relieved down to one ton, and before going on to explain the operation of the system it is necessary to describe the mechanism by which this reversal is achieved.

The valve 43 has a stem 60 extending into the chamber 42, said stem having a longitudinal slot 61 through which extends a pin 62 at one end of a link 63 which latter thereby has lost motion connection with the stem 60. The other end of the link 63 is pivoted at 64 to a rocking plate 65 which rocks about a pivot 66 on a bracket 67. The plate 65 can swing down against the resistance of a pair of snap-over springs one of which is shown at 68 extending between abutments on the rocking plate and on a further fixed bracket 69. As the rocking plate is caused to move down, as will be explained, the abutment of the springs with the plate 65 passes through a dead centre position after which the action of the expanding springs 68 causes the plate 65 to move down with rapid positive movement during which the pin 62 in the slot 61 in the valve stem 60 engages the inner end of the slot and shifts the valve 43 to its other extreme position.

The rocking plate 65 has a slot 70 through which extends a pin 71 on a link 72 connected at the upper end of a plunger 73 which extends through a gland 74 into a chamber 75 where the plunger carries a head 76 which is spring biassed by a spring 77 so that the plunger 73 tends to project a maximum amount into the chamber 42.

The slot 70 in the plate 65 is disposed in relation to the axis of the plunger 73 so that it forms in effect one side of a V with the pin 71 at the upper end of the slot. The fluid pressure in the chamber 42 acts upon the end of the plunger 73 and when the pressure has reached a predetermined pressure, the plunger will be moved against its springs 77 to cause the pin 71 to rock the plate 65 in a clockwise direction thus causing the spring 68 to compress through the dead centre position already mentioned. It will be appreciated that the pressure in the chamber 42 at which the trip mechanism changes over the position of the primary valve 43 in this way, will correspond to a pressure somewhat above that at which the props obtain their setting pressure of 5 tons roof support. As soon as the springs 68 expand after one end thereof passes through the dead centre position, the rapid movement of the rocking plate 65, given by the snap-over springs 68, causes the pin connection with the link 72 to take up a position at the other end of the slot 70, which slot has moved so that it now forms the other side of the V. The pin 71 now engages a notch at said other end, and the rocking plate 65 is held in its new angular position by the expansion of the spring 68 after the latter had passed through the dead centre position. The springs 68 now extend down to the left. The plunger 73 is again projecting the maximum amount into the chamber 42 ready to be depressed when the pressure of the fluid in the chamber 42 again reaches the predetermined value. When the plunger 73 is again depressed, the link 72 will rock the plate 65 in an anticlockwise direction to carry the snap-over spring 68 up through the dead centre position after which the trip mechanism again arrives at the position shown.

The sequence of operations occurring during advancement of the mine roof support will now be described, it being assumed that all the parts are in the positions shown in Figure 3. In these positions all the props are reacting between the roof and floor and when the pressure fluid is supplied into the passage 45 and pipe lines 33 and 37 the jack will meet resistance and the pressure will build up below the piston 54 of the secondary valve mechanism. The piston 54 will therefore rise and open the valve 50 to relieve the props 12 and 12a by placing the pipe line 35 in communication with the return line 46. The supply of pressure fluid to the jack will not result in any movement of the support because the jack is fully contracted. Pressure will therefore build up in the chamber 42 housing the trip mechanism and when this pressure reaches the proper valve the valve 43 will be moved automatically into its lower position at which the passage 44 is in communication with the chamber 42, and the passage 45 is in communication with the return line 46 by way of the annular space 49 around the valve 43. The changeover of the valve will also place the line 37 from the lower end of the jack in communication with the return line 46, and place the line 36 at the upper end of the jack in communication with the pressure fluid supply in the chamber 42. Thus directly the valve 43 has moved to its lower position pressure fluid will be applied to the upper end of the jack which will move the relieved props 12 and 12a into the dotted line position. At the same time pressure fluid will be supplied along the line 35 leading to the newly advanced props 12 and 12a and once the jack has reached the limit of its travel pressure will build up in the props 12 and 12a until the setting pressure of 5 tons roof support is reached, and just above this pressure the piston 54 will be moved down to allow the valve 50 to close and to open the valve 51 to relieve the props 11 and 11a whereafter pressure will build up in the chamber 42 and so that the trip mechanism will return the valve 43 to its upper position. This sequence of operations will continue as long as pressure fluid is supplied to the valve box along the single supply line 31.

The pressure sequence may be summarised as follows: The jack moves relieved props when the relieved props are taking a 1 ton roof loading and while the other props are taking at least 5 tons. The props moved by the jack are then raised to a 5 ton loading and the other props are relieved by the corresponding non-return valve 50 or 51 opening. The trip chamber pressure then reverses the slide valve at a pressure a little above the setting pressure of 5 tons. The hydraulically locked props are relieved by way of relief valve **55**, **56** at 50 tons pressure per side of the structure.

The valve mechanism above described for a single roof supporting unit may serve to control the advancing movements of a number of such units, and these units may be placed at intervals along the length of a conveyor in order to shift the conveyer as a whole as a consequence of shifting the several roof supporting units. Although in the example described the props of one set are said to be loosened while still supporting a roof loading of 1 ton, they may be entirely freed from the roof before the jack causes them to advance. In any event the secondary valve mechanism comprising the piston **54** and the non-return valves **50** and **51** prevent either set of props from being loosened until the other set is taking a predetermined roof loading.

If desired manually operable means may be provided whereby the props of a support may be relieved at will. For example the pipe lines **33** and **35**, between their respective props and non-return and relief valves **58** and **59**, may be fitted with cocks operable separately or together to place said lines in connection with the reservoir.

We claim:

1. A mine roof support comprising at least four constrictable and expansible upright hydraulic props disposed in two sets at right and left, respectively, and one prop ahead and one prop behind in each set, said props being of a length, when extended, to rest upon the floor and to support the roof, a rigid frame connecting and supporting the forward and the rear props, respectively, in the set at the right, and a like rigid frame connecting and supporting the forward and the rear props in the set at the left, parallel linkage means connecting the forward ends and the rear ends of the two frames, to constitute with the frames a deformable parallelogram, extensible and contractable power means extending diagonally of such parallelogram between and connected to the forward end of one frame and the rear end of the other frame, and operable upon contraction to shorten the distance between its two points of connection, and upon extension to length such distance, hydraulic control means shiftable between two limit portions, and operable when in one such position to extend the two props at one side to hold fast these props and their frame between the floor and the roof, and operable when in its other limit position to constrict the other two props at the other side to loosen them and their frame, and vice versa, and further control means to alternately extend and retract said power means, whereby the loosened props and their frame may be advanced relative to the held-fast props by appropriate contraction or extension of such diagonally extending power means in coordination with extension and constriction of the respective sets of props.

2. A mine roof support comprising four constrictable and expansible upright hydraulic props disposed in two sets at right and left, respectively, and one ahead and one behind in each set, said props being of a length, when extended, to rest upon the floor and to support the roof, a rigid frame including two spaced parallel upright sleeves connecting and supporting the two props at the right, and a like rigid frame including two spaced parallel upright sleeves connecting and supporting the two props at the left, each prop being mounted by its sleeve with a limited freedom of independent axial movement therein, a link connecting the forward ends of the two frames, and a similar link connecting the rear ends of the two frames, to constitute with the frames an articulated structure wherein one frame can swing about the other in parallelism, a double-acting hydraulic advancement jack extending diagonally between and pivotally connected to the forward end of one frame and the rear end of the other frame, control means operatively connected to said advancement jack to contract the same and so to shorten the distance between its two points of pivotal connection, and alternately to extend the same to lengthen such distance, and further control means operatively connected to the several props and controllable to extend the two props at one side to hold fast these props and their frame between the floor and the roof as a point of reaction, and at the same time to constrict the other two props at the other side to loosen them and their frame for advancement by reaction therefrom, and vice versa, whereby the loosened props and their frame may be advanced relative to the held-fast props by appropriate contraction or extension of the diagonally extending advancement jack.

3. A mine roof support as in claim 1, wherein the parallel linkage means interconnecting the two frames comprise an upper and a lower transverse links connecting the forward portion of each frame and two like links connecting the rearward portions of each frame in the parallelogram arrangement, to maintain each frame upright by support from the other frame when the props of either frame are loosened whilst those of the other frame are held fast, and the loosened props and their frame is advanced by being swung uprightly about its connections to the held-fast set.

4. A mine roof support as in claim 1, including a single pressure fluid source operatively connected to the props of both frames, and the first-mentioned hydraulic control means is operatively connected between said source and alternatively the props of one frame or the props of the other.

5. A mine roof support as in claim 2, including a single pressure source, conduit means connecting said source, by way of the control means for the advancement jack and thence to the further control means for the props, and for relief from the same, and a selector device incorporated in said further control means to regulate access of pressure fluid to one or the other set of props, and relief from the other set, in accordance with the setting of the first control means for extension or for retraction of the advancement jack.

6. A mine roof support as in claim 2, including a primary control valve governing the direction of supply of pressure fluid to one or the other end of the advancement jack, and a coordinated secondary control valve means operatively interposed between the primary control valve and the props of the respective frames, and automatically shiftable by pressure fluid, according to whichever end of the double-acting jack is supplied with pressure fluid, to deliver the pressure fluid likewise to the forward props for their holding fast, and to relieve the rearward props for their loosening.

7. The combination of claim 2, and means automatically operable by completion of an advance cycle to shift the control means for the advancement jack, and thereby to condition the mechanism for reverse movement of said jack at commencement of the next cycle.

8. A mine roof support as in claim 6, including

means sensitive to back pressure from a held-fast set of props, automatically operable to reverse the primary valve, to reverse thereby the direction of actuation of the double-acting jack, for advance of the loosened set of props.

9. A mine roof support as in claim 1, including a single pressure fluid source operatively connected to the props of both frames, means operable to connect said source alternatively to the props of one frame or the other, and valve means automatically operable to block connection of the fluid supply source to loosen the props of one frame unless those of the other frame are loaded to a predetermined value.

10. A mine roof support as in claim 2, including a single fluid pressure source operatively connected to the props of both frames and to the opposite ends of said advancement jack, a reversible primary valve constituting the first-mentioned control means, and governing delivery of pressure fluid to the respective ends of said jack, and to secondary valve means constituting the further control means, said secondary valve means including two spaced-apart non-return valves in separate conduits to the props of the respective frames, and a double-acting differential area piston interposed between said non-return valves, movable under the influence of predetermined pressure in the conduit not being supplied.

11. A mine roof support as in claim 1, including a single pressure fluid source operatively connected to the props of both frames, the first-mentioned control means being operable to connect said source alternatively to the props of one frame or the other, and a branch relief line off the pressure line to each set of props, and a relief valve in each such pressure line openable at a predetermined maximum roof loading.

12. A mine roof support as in claim 11, including a single loading spring common to the two individual relief valves, urging either or both to closed position.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,473,157	Morgan	Nov. 6, 1923
1,870,088	Beckwith	Aug. 2, 1932
2,152,654	Maxon	Apr. 4, 1939
2,163,959	Nilson	June 27, 1939
2,420,755	Mavor	May 20, 1947
2,452,632	Cameron	Nov. 2, 1948