United States Patent

Groetschel et al.

[15] **3,672,176**

[45] **June 27, 1972**

[54] ROOF SUPPORTING SYSTEMS

[72] Inventors: **Karl Maria Groetschel**, Bochum; **Utz Groetschel**, Munich, both of Germany

[73] Assignee: **Karl Maria Groetschel, by said Utz Groetschel**

[22] Filed: **Dec. 18, 1970**

[21] Appl. No.: **99,496**

[30] **Foreign Application Priority Data**

Dec. 18, 1969 Germany ..... P 19 63 558.6

[52] **U.S. Cl.** ..... **61/45 D**, 91/170

[51] **Int. Cl.** **E21d 23/18**

[58] **Field of Search** ..... 61/45 D; 91/170 MP, 170, 36, 91/411, 412, 413, 414

[56] **References Cited**

UNITED STATES PATENTS

3,217,606 11/1965 Bolton et al. ..... 91/170 MP

3,453,935 7/1969 Rieschel ..... 61/45 D X

3,482,407 12/1969 Rieschel ..... 61/45 D

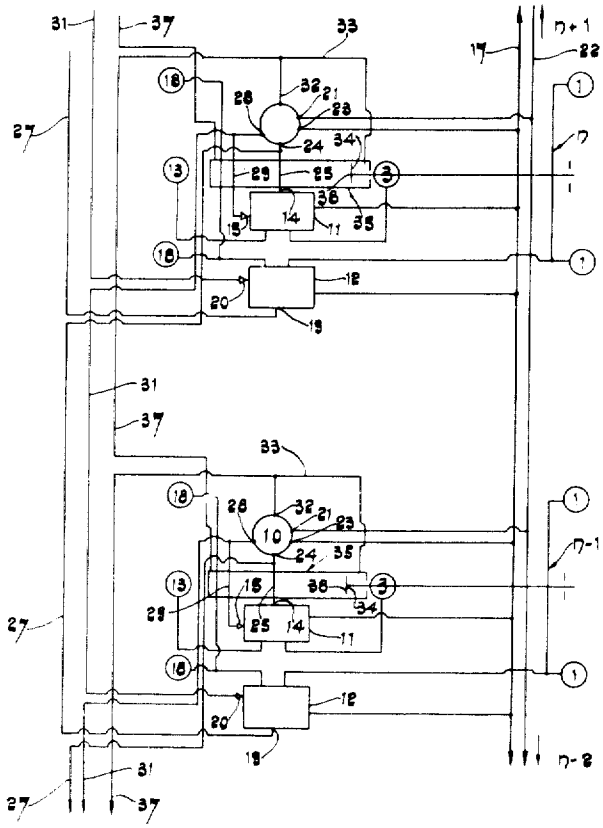
Primary Examiner—Dennis L. Taylor

Attorney—Spencer & Kaye

[57] **ABSTRACT**

The invention comprises a roof supporting system for use in a mine working employing a row of roof supports each having an inner unit and an outer unit incorporating hydraulic props and advanced in turn by hydraulic ram means. A control valve provided on each of the supports can be moved into a position to depressurize the props of the inner unit of that support to pressurize the props of an outer unit on an adjacent one of the supports in the system and advance these two units simultaneously so that each support need be visited only once by an operator to bring about advancement of all the units in the whole supporting system. Each control valve may have selectively usable outlets to enable the outer unit of an adjacent support on one side or the other of that incorporating the control valve to be advanced simultaneously with the inner unit of the latter support.

14 Claims, 16 Drawing Figures



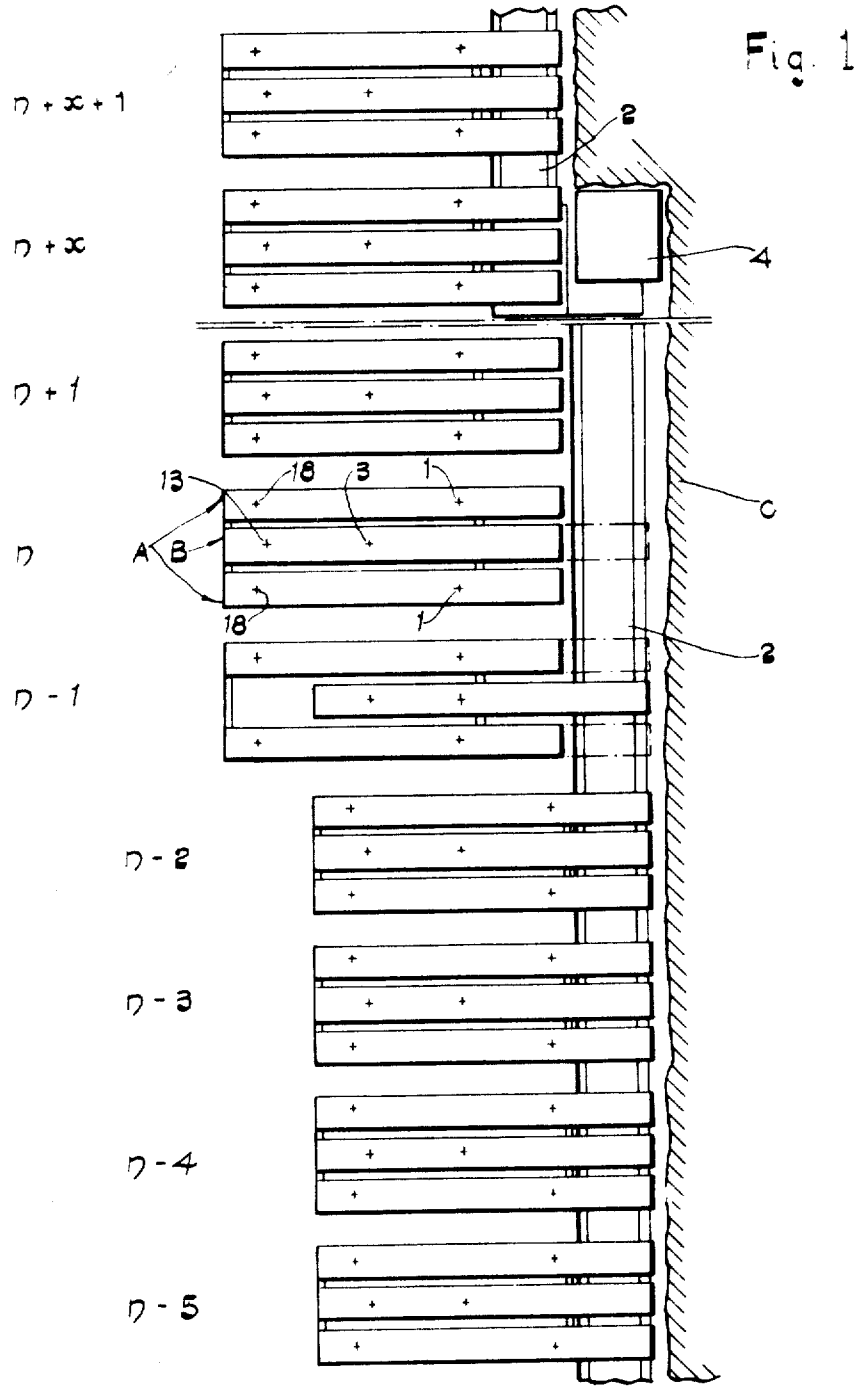
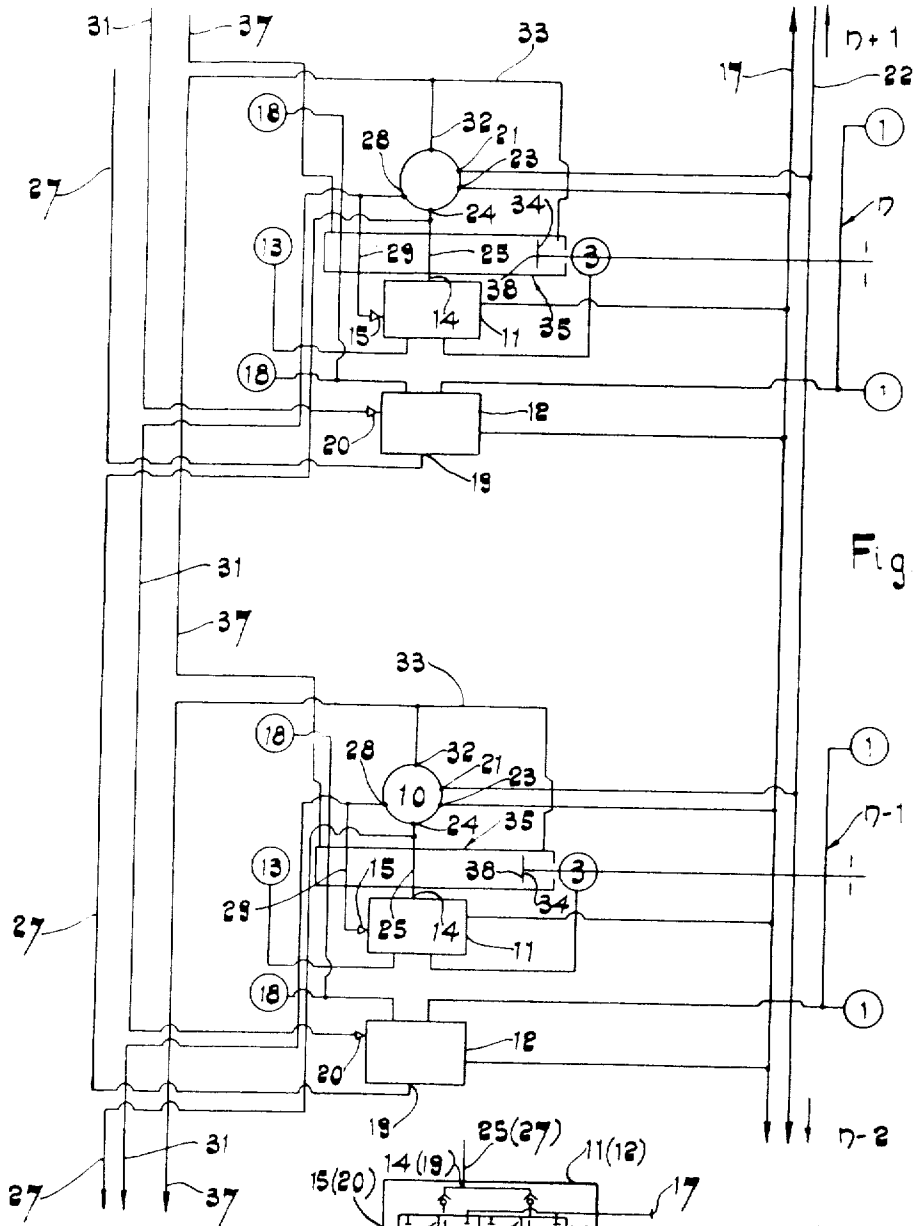
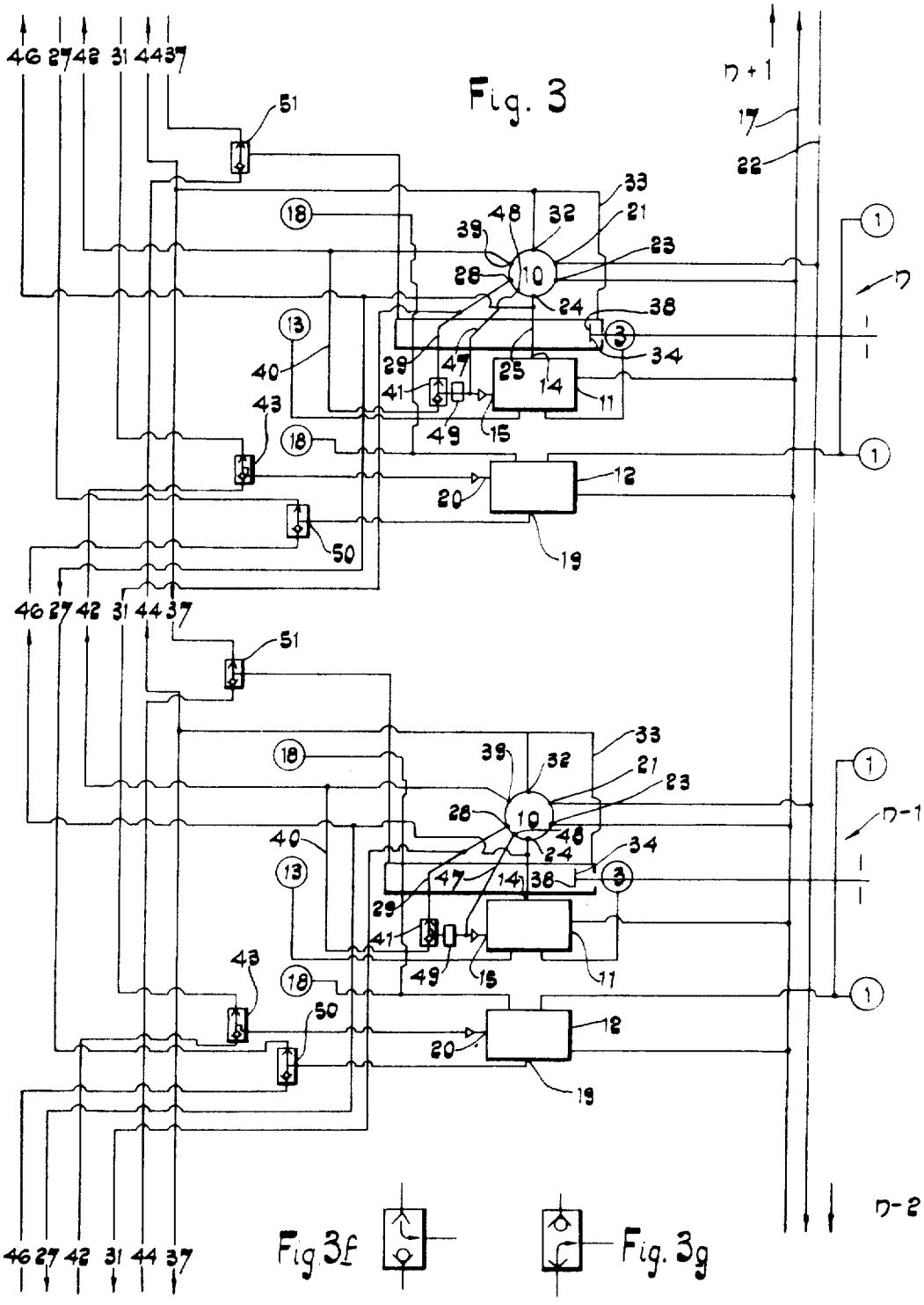
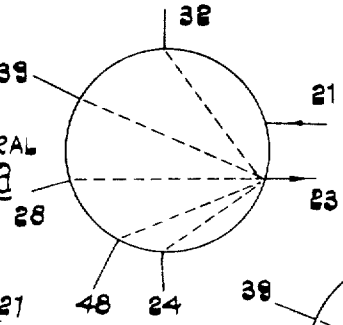


Fig. 1


31
37
33
n+1
17
22
18
28
32
21
23
24
34
27
n
13
29
25
3
38
14
15
11
35
18
20
12
19
Fig 2
31
37
33
18
28
32
21
23
10
24
35
n-1
13
15
38
3
29
34
25
14
11
27
18
20
12
19
n-2
31
27
37
25(27)
14(19)
11(12)
15(20)
17
29(31)
3(1)
13(18)
Fig. 2a
32
21
28
23
24
Fig 2d
SETTING
(UNIT B IN n
UNIT A IN n-1)
Fig. 2b
Fig 2e
ADVANCING
(UNIT B IN n
UNIT A IN n-1)
Fig. 2c (NEUTRAL)


Fig. 3
46 27 42 31 44 37
n+1
n
n-1
n-2
51
18
13
10
14
11
12
15
17
19
20
21
22
23
24
25
26
28
29
32
33
34
38
39
40
41
43
47
48
49
50
Fig. 3f
Fig. 3g



NEUTRAL

Fig. 3a

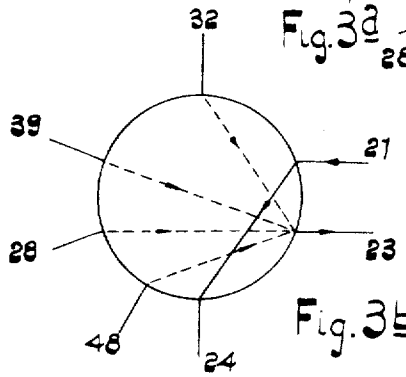


Fig. 3b

SETTING
UNIT B IN n
UNIT A IN (n-1) or (n+1)

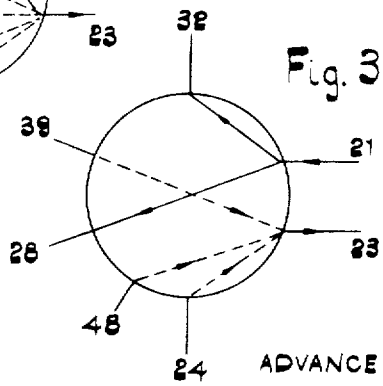


Fig. 3c

ADVANCE
UNIT B IN n
UNIT A IN (n-1)

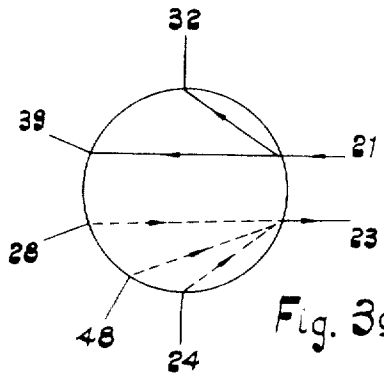


Fig. 3d

ADVANCE
UNIT B IN n
UNIT A IN (n+1)

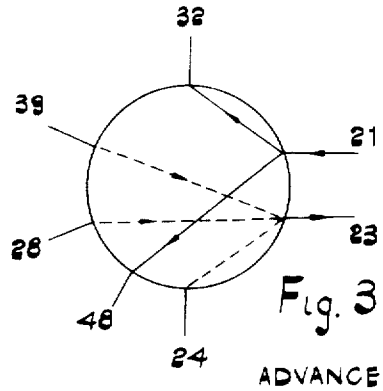


Fig. 3e

ADVANCE
UNIT B IN n (ONLY)

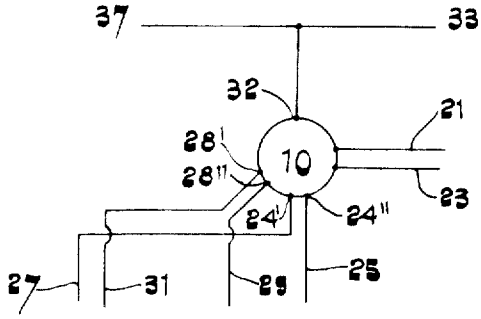


Fig. 4

ROOF SUPPORTING SYSTEMS

CROSS REFERENCES TO RELATED APPLICATIONS

This invention relates to a roof supporting system wherein the supports employed may be of the form disclosed and claimed in U.S. Pat. No. 3,490,243 to Karl Maria Groetschel. The invention may, however, be applied generally to roof supporting systems employing other forms of support provided same incorporate a number of separately advancable units.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

A roof supporting system to which the present invention relates is intended to be used in underground mine workings for supporting the roof of the working and comprises a row of supports each of which includes a plurality of units each incorporating hydraulic props for supporting the roof, and advancing means for advancing each unit in turn in a direction transversely of the row when their respective props are depressurized, while another unit of the support has its props maintained pressurized to enable it to bear roof load. Such roof supporting systems are herein referred to as being of the kind specified.

The invention is applicable primarily, but not exclusively, to roof supporting systems of the kind specified wherein the individual supports are of the two-step type, that is to say they incorporate two units which are advanced successively by the advancing means. Such supports are already known in the form of twin assemblies and triple assemblies, in the latter case the preferred form being one in which an outer support unit is formed by mutually rigidly connecting the two outer assemblies by transverse bars, a gap being afforded between the two outer assemblies in which the inner assembly constituting the second unit is accommodated. Each assembly would typically consist of a base element, a plurality of upstanding hydraulic props carried thereon, and a superstructure element carried by the props. The advancing means would be connected operatively between the two units thus formed to effect sequential advance in a direction generally lengthwise of the base elements and superstructure element, that is to say in the direction in which the props of each assembly are spaced apart longitudinally from each other.

2. Description of the Prior Art.

In roof supporting systems of the kind specified utilizing two-step supports of the kind described in the foregoing paragraph it is the present practice that, when a given support is in its starting position (that is prior to advancement), the foremost prop of each assembly is positioned adjacent to a conveyor means extending lengthwise of the row between the row of supports and a face of the mine working to which the supports are required to be advanced. Alternatively, in some cases, the foremost prop of one of the units, for example the inner unit, may be spaced rearwardly from the conveyor means when the support is in its starting position by approximately the length of one advancement step. In this case the length by which the superstructure element of this unit is required to extend as a cantilever forwardly of its foremost prop requires to be greater than the corresponding dimension applicable to the superstructure element or elements of the other unit by about the same distance as the advancement step.

With triple assemblies formed as two-step supports as last described, it is possible to coordinate advancement of the units with the travel of a cutting machine, for example a coal cutting machine traveling lengthwise of the conveyor means, to provide early support where the roof formation is known to be weak. For this purpose the unit incorporating the longer superstructure element may be advanced relatively to the remaining unit in a direction towards the conveyor means immediately after the machine has passed the support, and before the conveyor means itself has been advanced, thereby bringing the superstructure element of this unit into position beneath the portion of the roof newly exposed by the operation of said machine.

It is also known in a different system of roof support to employ supports of the kind which are known generally as one-step supports. In these all of the hydraulic props are carried by, or associated with, a common base element and support a superstructure, and the advancing means operates to advance the base element, props and superstructure as a whole relatively to the conveyor in a single step which requires all of the props to be depressurized and the superstructure to be brought out of load bearing relation with the roof.

Roof supporting systems employing two-step supports present, inter alia, two fundamental advantages compared with roof supporting systems employing one-step supports. The first of these advantages is that the advancement of each of the two units in each support occurs at all times under the protection afforded by the other unit of the support which remains in load bearing relation to the roof at this stage. Accordingly the roof region associated with any one support is never at any moment entirely without support considering the advancement of the roof supporting system as a whole. The second advantage, which is presented especially by the preferred form of triple assembly two-step support, wherein outer assemblies are connected by transversely extending bars to form an outer unit within which an inner unit is disposed, resides in the ability to control the alignment of one unit relatively to another and the direction of advance of one unit relatively to another, and hence the direction of advance of the supporting system as a whole. This advantage has particular importance wherein the mine working presents an appreciable slope in a direction lengthwise of the row of supports.

In the case where the mine working has comparatively weak roof formations, these advantages pertaining to a supporting system incorporating two-step supports outweigh the possible disadvantage which resides in the fact that the outlay as to attendance and maintainence, depending upon the design of the system, may have to be substantially greater than that applicable to a supporting system using single step supports. It may occur, however, that a roof supporting system incorporating two-step supports, and which was installed initially because of the existence of factors rendering same desirable, for example weakness in the roof formation, may require to be used in another working involving less stringent conditions and where the particular advantages presented by two-step supports are less important. In such an event the relatively smaller outlay in attendance and maintainence involved in the use of a roof supporting system using single step supports, and which has heretofore not been achieved in roof supporting systems using two-step supports, would be more desirable especially in relation to achieving a higher production rate which intrinsically would be possible under the more favorable conditions presented by this working.

The object of the present invention is to provide a new or improved form of roof supporting system of the kind specified which enables the advantages of roof supporting systems using two-step supports to be combined with the advantage of low attendance and maintenance requirements heretofore available only in relation to roof supporting systems using one-step supports.

SUMMARY OF THE INVENTION

According to the present invention there is provided a roof supporting system for an underground mine working comprising a row of roof supports each including a plurality of roof supporting units incorporating hydraulic props, advancing means for advancing each of said units in turn while its props are depressurized and while another unit of support has its props pressurized to establish this unit in load bearing relation with the roof, a control system for controlling pressurization of the props of the units and advancement thereof and including valve means for each support having an inlet for connection to a hydraulic supply source and outlets selectively placed in communication with said inlet in different respective settings of said valve means, pipe means connecting said outlets of each of said valve means to the props of a unit and to

the advancing means on that support on or for which said valve means is provided, and also connecting said outlets to the props of a unit and to the advancing means of an adjacent unit in a group of supports in one region of a row, which group of supports are required to be advanced progressively starting from one end of the group and continuing to the other end, said connection being such that operation of the valve means on or for each support of this group effects advancement of a unit therein and also a unit in said adjacent support of the group.

A single operator operating the valve means on or for any given one of the supports is able to bring about depressurization of the props of a unit in the support on which the valve means is situated, and also in a unit of one or more other supports of the group, and concurrently to effect advancement of all of these units. Thereafter a like operation performed in respect of the valve means on the next one of the supports contained in the group will bring about depressurization of the props of the other or another one of the units in the support first mentioned, and also depressurization of the props of a unit in one or more other supports (one support being subtracted from, and one added to, the group each time the operator changes his position to the next support). The units having the depressurized props are then also concurrently advanced.

Instead, therefore, of an operator having to carry out a minimum of two separate operations (on each of a row of two-step supports) at two separate times on each support in order to effect advancement of the units thereof, each support requires to be visited only once by an operator who can thus carry out a single operation (irrespective of whether this is performed on a single operating member or a plurality of operating members provided on or for the support, although the former arrangement is preferred).

Accordingly the overall time and the number of visits which a given operator has to make to each support or valve means therefor to bring about advancement of the whole system by one advancement step is appreciably reduced.

It will be understood that, although ordinarily the use of supports incorporating only two units and advancable in two steps will be satisfactory, it would be within the scope of the invention for the roof supporting system to incorporate roof supports having three or more individually advanceable units. The group of supports then undergoing advancement at any given time would ordinarily consist of a number of supports equal to the number of units, and operation of the valve means on or for any one support would bring about depressurization of the props of a unit and advancement of such unit in each of the supports of the group. Again, ordinarily, the supports of a group will occupy successive positions in the row but it would be within the scope of the invention to select some other layout. For example, the group of supports may occupy alternate positions in the row should circumstances make this necessary or desirable.

Thus, in the preferred arrangement according to the invention, each support incorporates only two units, one of these being an inner unit which has props spaced apart longitudinally in the direction of advancement, and the other being an outer trestle-like unit which has the props also spaced apart longitudinally as aforesaid on each of the opposite sides of the inner unit, the advancing means comprising hydraulic ram means operatively connecting the inner and outer units.

In some cases the machine which extracts the coal or other material to be mined from the face is designed and operated to execute a cutting traverse only in one direction of travel along the conveyor means, and has an idle return traverse. In other cases, however, the machine is designed and operated to execute a cutting traverse in both directions of travel.

To meet this latter requirement a further feature of the invention is that the valve means on each support may be movable into alternative positions, in one case to bring about advancement of a unit in an adjacent support on one side of the first said support, and in the other case to bring about advancement of a unit in an adjacent support on the other side of the first said support, in both cases simultaneously with advancement of a unit in the first said support. Thus, in the arrangement above described wherein the valve means comprises a control valve on or for each of the supports, such control valve may, instead of being provided with two outlets for controlling pressurization of a unit of the support and a further support at one side of the first support (with a possible third outlet to control the advancing means) be provided with a further outlet (herein referred to as the fourth outlet) and this would be connected to control pressurization of props in a still further support on the side of the first support opposite to that aforesaid.

In the arrangement last referred to it is preferred that pressurization of the props be controlled by the control valve through the intermediary of secondary valves. The connection from two control valves on different supports to a single control inlet of any one of the secondary valves to enable same to be operated from one or the other of said control valves may then be effected through the intermediary of an alternating valve. An alternating valve is defined herein as being a valve having an outlet (connected to the control inlet of the secondary valve) and two inlets (connected to outlets of respective control valves on different supports), the construction and arrangement of the alternating valve being such that only one, or the other, of the inlets is placed at any given time in communication with the outlet of the alternating valve.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example, with reference to the accompanying drawings wherein:

FIG. 1 is a diagrammatic plan view of a roof supporting system having a control system in accordance with the present invention and showing different advancement stages in respective two successively positioned supports;

FIG. 2 is a hydraulic circuit diagram illustrating a portion of one embodiment of control system applicable to the support system of FIG. 1 in accordance with the present invention and wherein the machine for extracting the material to be mined has a working traverse in only one direction;

FIGS. 2*a* and 2*b* illustrate diagrammatically different positions of the secondary valves incorporated in FIG. 2;

FIGS. 2*c* to 2*d* illustrate diagrammatically different positions of the control valve unit;

FIG. 3 is a hydraulic circuit diagram generally similar to FIG. 2 but incorporating facilities enabling the control system to be applied to a roof supporting system as shown in FIG. 1 when the machine for extracting the material to be mined has working traverses in each of two opposite directions;

FIGS. 3*a* to 3*e* show different positions of the control valves incorporated in FIG. 3;

FIGS. 3*f* and 3*g* show different positions of the alternating valves incorporated in FIG. 3; and

FIG. 4 is a fragmentary view illustrating the modification which may be made in either the circuit of the control system illustrated in FIG. 2 or FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The roof supporting system shown in FIG. 1 comprises a plurality of roof supports arranged in a row which extends lengthwise of the face C of a long wall working such as that found in coal mines.

The material to be mined is extracted from the face by a machine 4. The machine 4 may extract coal on each of its traverses in opposite directions or on only one working traverse, the other traverse being idle.

For convenient reference in the following description individual supports are identified by the references $n-5$ to $n+x+1$. These supports are of the two-step type and may be constructed as disclosed in my U.S. Pat. No. 3,490,243.

Generally each support comprises an outer unit A as identified in respect of the support n, and an inner unit B. The

outer unit includes two laterally spaced assemblies each having a pair of longitudinally spaced hydraulic props 1 and 18 carried by side members of an outer base element, such side members being connected to each other at opposite ends by transversely extending connecting members and affording a longitudinally extending gap or slot between them.

The props 1 and 18 each carry a longitudinally extending girder which is connected to that carried by the other pair of props by transversely extending connecting members which are depressed or cranked downwardly in between the girders to form a longitudinally extending channel. The inner element B includes an elongated base element arranged in the slot or gap afforded by the base element of the outer unit and a pair of longitudinally spaced props 3 and 13 carried by the inner base element and serving to support a further longitudinally extending girder arranged in the channel afforded between the girders of the outer unit.

In front of each support is disposed a conveyor 2 which extends longitudinally of, and adjacent to, the face C. In the known manner such conveyor is constructed of articulately connected sections to be capable of being advanced towards the face C as material is cut away therefrom, such advancement taking place section by section. An advanced portion of the conveyor is shown in the lower part of FIG. 1 and an unadvanced portion in the upper part of FIG. 1 opposite that part of the face C which has not yet been cut away by a working traverse of the machine 4. In practice the two portions will be connected by a portion of the conveyor occupying the omitted or cut-away part of the drawing in which the conveyor section or sections are oblique to the advanced and unadvanced portions.

When the supports occupy their initial positions in which the props of both units A and B are pressurized so that the girders are in load bearing relation with the roof, as shown particularly in respect of supports $n+x+1$ to $n+1$ and $n-2$ to $n-5$, the props 1 of the outer base unit and the forward boundary of the outer base element will lie adjacent to the conveyor 2, but the foremost prop 3 and the adjacent boundary of the inner base element (not visible in the drawings) will be spaced from the forward end of the slot or gap afforded by the base element by a distance equal to, or slightly greater than, the length of the advancement step required to be performed and which will be equal to that afforded by the face C. The girder of the inner unit B projects as a cantilever for a distance forwardly from its foremost prop 3 which is greater than the distance by which the girders of the outer unit A project forwardly of their foremost props 1, the difference being equal to the advancement step, or approximately so.

With a conventional control system, an operator carrying out advancement of the supports as a whole, and taking the support n as the first one which is ready to be advanced, must firstly depressurize the props 3 and 13 to relieve the associated girder from load bearing relation with the roof, and must then operate the advancing means of the support, namely a hydraulic ram means connecting the inner and outer units and consisting either of a double acting ram or two single acting rams, thereafter the props 3 and 13 being repressurized to re-establish load bearing relation between the girder of the inner unit B and the roof. This operation can, in fact, and ordinarily is, performed immediately after the machine 4 has passed the support, and, although not shown in FIG. 1, the section of the conveyor 2 which is immediately in front of the support will not usually be capable of advancement at this stage since the machine 4 will not have traveled far enough along the conveyor to render the particular section of the conveyor free for advancement. Due to the close relation between the forward boundary of the outer base unit and the conveyor, it is not, therefore, possible for the outer unit A to be advanced by the operator by the like procedure of depressurizing the props 1 and 18, pressurizing the ram means in an appropriate mode to draw up the outer unit, and then re-pressurizing the props 1 and 18.

Consequently the operator must proceed to the next support, for example $n+1$, which is ready to have its inner unit advanced, and at a later time must return the support n when the section of the conveyor immediately in front of this support has itself been advanced to provide sufficient clearance for advancement of the outer unit A of the support n.

It will be evident, therefore, that each support must be visited at least twice by the operator. This is not only time consuming but also requires different operations to be performed on each support according to whether the inner unit or the outer unit is to be advanced, so that intrinsically an error is possible, particularly under difficult working conditions such as are frequently encountered in underground mine workings.

The present invention provides a control system which enables an operator visiting the support n to effect advancement of the inner unit B thereof to the position indicated in chain lines, while simultaneously bringing about advancement of the outer unit A of the preceding support $n-1$ into the position indicated by chain lines in respect of that support. With such a control system each support requires to be visited only once by the operator in effecting overall cycle of advancement of the supporting system as a whole, thereby effecting considerable economy of time and possibly numbers of operating personnel involved. Furthermore, so far as the portion of roof newly exposed by a working traverse of the machine 4 is concerned more effective early support is furnished. The stage at which the inner unit B of, say, the support n can be advanced is not earlier than in a conventional system, but the stage at which the unsupported span between the inner unit B of the support n and the inner unit B of the support $n-1$ receives additional support by way of the outer unit A of the support $n-1$ is appreciably earlier, by virtue of the fact that this outer unit is advanced to the broken line position shown earlier than would be the case with conventional operation. In poor roof conditions it is of the utmost importance to provide the most effective early support to newly exposed roof to prevent deterioration.

In comparison with a roof supporting system wherein the supports are of the one-step type, the overall operating time and number of personnel required does not need to be increased when using the new control system, but the duration for which newly exposed portions of the roof are left unsupported is reduced, since, with one-step supports, these cannot be advanced until the section of the conveyor in front of the particular support concerned has first been fully advanced.

Furthermore, the advantages derived from the particular type of support wherein the inner unit has a base element movable in a longitudinally extending slot or gap between side members of the outer base element is attained, namely the ability to guide and control the direction of advancement of each unit, inner or outer, with respect to the associated unit, outer or inner, whereof the props are at that time pressurized so that such unit forms a stable reference with respect to which guiding and directional control may be effected.

Reference is now made to FIG. 2 which illustrates a portion of a hydraulic control system in accordance with the invention applicable to FIG. 1 in cases where the machine 10 has a working traverse in only one direction.

In the system illustrated in FIG. 2 only two supports n and $n-1$ are illustrated. Components of the control system provided on each are identical.

The control system comprises a valve means preferably mounted in some convenient position on each support, for example on the forward or rearward end portion of the outer base element. However, the valve means could be mounted on some separate mounting member. For example on a member extending lengthwise of the conveyor to enable each valve means to be operated (if desired) automatically by the machine 4 as it moves along the face. Each valve means comprises a primary valve 10 in the form of a control valve block or unit having a manually operable control means, preferably in the form of a single operating member.

Each valve means further comprises secondary valves **11** and **12** on each support. The secondary valve **11** controls pressurization of the props **3** and **13** of the inner unit B, and the secondary valve **12** controls pressurization of the props **1** and **18** of the outer unit A.

Each secondary valve is movable between an unoperated position, as shown diagrammatically in FIG. **2***a*, to an operated position, as shown diagrammatically in FIG. **2***b*.

The first references applied to the parts in FIGS. **2***a* and **2***b* are those applicable to secondary valve **11** but the corresponding references for secondary valve **12** are shown in brackets.

In the unoperated position of each secondary valve communication exists between the feed inlet **14** (**19**) to outlets connected by pipes to props **3** (**1**) and **13** (**18**). This allows the props to be set, i.e. pressurized, by fluid from a pressure supply pipe **22**. When the props have been set non-return valves incorporated in the secondary valves maintain the pressurization of the props, the value of which is controlled as roof load increases due to descent of the roof by relief valves (not shown).

When each secondary valve is in its unoperated position as shown in FIG. **2***b*, the feed inlet **14** (**19**) is connected to an exhaust pipe **17**. The pressure supply pipe **22** and exhaust pipe **17** extend for the whole length of the row of supports and are connected respectively to the output of a suitable source of pressure such as a motor-driven pump and to a reservoir tank from which respectively the pump draws its supply.

Movement of each secondary valve from its operated to its unoperated position is brought about by incidence of pressure at a control inlet **15** (**20**) derived from one of the outlets of the control valve unit as hereinafter described.

The secondary valves are preferably also manually operable independently of the pressure conditions at the control inlet **15** (**20**) to allow the props of the inner unit B and outer unit A to be set or relieved independently if required.

Each control valve unit has a number of outlets, the first of which **28** is connected by way of pipe **29** to control inlet **15** of the secondary valve **11** of the same support on which the control valve block is situated, e.g. support *n*. Also outlet **28** is connected by way of pipe **31** to the control inlet **20** of secondary valve **12** on an adjacent one of the supports *n*−1.

The second outlet **24** of the control valve unit is connected by way of pipe **25** to the feed inlet of secondary valve **11** on the same support, i.e. support *n*. Outlet **24** is also connected by way of pipe **27** to feed inlet **19** of secondary valve **12** on the adjacent support *n*−1.

The control valve unit has inlets designated by **21**, **23** connected to the pressure supply pipe **22** and exhaust pipe **17**.

By manual operation of a single operating member on the valve in each of the three outlets **28**, **24** and **32** can be selectively placed in communication with the pressure inlet **21** or the exhaust inlet **23** as required.

Various settings of the control valve unit are illustrated in FIGS. **2***c*, **2***d*, **2***e*. In FIGS. **2***c* to **2***e* and also in FIGS. **3***a* to **3***e* hereinafter described, connections established through the control valve unit in each setting to the pressure inlet **21** are shown by full lines and to the exhaust inlet **23** by broken lines.

Setting **2***c* which is a neutral position in which all of the outlets are in communication with exhaust inlet **23** the secondary valve **11** on the support concerned, for example support *n*, and the secondary valve **12** on the support *n*−1 are maintained in their unoperated positions. Props which have previously been set by pressurization are maintained in the set condition by the non-return valves in the secondary valves. Setting **2***d* illustrates setting or pressurization of the props of the inner unit B of support n and the props of the outer unit A of support *n*−1. FIG. 2e illustrates depressurization of the props of the inner unit B of support *n*, depressurization of the props of outer unit A of support *n*−1, and advancement of both these units. It is to be understood that, depending upon the construction of the control valve unit **10**, communication from the pressure inlet **21** to outlets **28** and **32** may require the operating member of a valve to be placed sequentially in positions to supply fluid to outlet **28** and then to outlet **32**, or alternatively both of these outlets may be supplied with fluid concurrently from pressure inlet **21**.

The operating member of the valve may be maintained frictionally or otherwise in the position in which it is set or may be biased by spring or pressure fluid to return to a predetermined position, such as the setting position.

The control system illustrated in FIG. **2** operates as follows.

Assuming that the machine **4** has just passed the support *n* so that the latter is ready to have its inner unit advanced, the operator moves the operating member of the control valve unit **10** from the setting position shown in FIG. **2***d* to the position shown in FIG. **2***e*.

The props **3** and **13** of the inner unit B of support *n* and props **3** and **13** of the outer unit A of support *n* are thus depressurized. Simultaneously, or thereafter, fluid under pressure is delivered from the outlet **32** to pressurize piston face **34**. The piston rod is connected to the base element of the outer unit and the cylinder of the ram **35** connected to the inner unit. Accordingly the latter moves to the right, as seen in FIG. **2**, in a direction towards the face C.

Fluid under pressure is also delivered from the outlet **32** along pipe **37** to the left-hand side of the piston to pressurize piston face **38** in the double acting ram **35** of support *n*−1, thereby causing the outer unit of this support (connected to the piston rod) to be moved to the right, i.e. towards the face C.

Reversion of the control member of the control valve **10** of support *n* to its setting position **2***d* either manually or by biasing means, causes the fluid paths illustrated in FIGS. **2***d* and **2***a* to be re-established, thereby ensuring that all props will be pressurized with units of both supports *n* and *n*−1 established in load bearing relation to the roof.

It will be evident that after leaving the support *n* the operator will perform a like operation in respect of the control valve block or unit **10** on the support *n*+1 to effect advancement of the inner unit B thereof, and concurrently will thereby bring about advancement of the outer unit A of the support *n* in a like manner to that already described relative to the support *n*−1.

The control system of FIG. **2** is appropriate to the case where the machine **4** is designed to have a working traverse only in one direction of travel.

It will, of course, be understood that advancement of the individual supports can be effected independently of the coordinated system of control provided by the system of FIG. **2**, inasmuch as the secondary valves **11** and **12** are capable of being set manually to their operated positions. Although not shown separate manually operable valves may be provided to pressurize the double acting ram **35** in the desired direction to advance the inner unit and outer unit as required when independent operation of each support is to be effected.

Referring now to the control system illustrated in FIG. **3**, this is suitable for use in roof supporting systems such as that shown in FIG. **1** in which the machine **4** executes a working traverse in both directions of travel. It is accordingly necessary that the control system shall provide the facility of being able to select on each support, such as *n*, a manner of operation of the control system which concurrently with the advancement of the inner unit B on the support *n* will produce advancement of the outer unit of either the support *n*−1, as already described, or the support *N*+1 (in the latter case the support *n*−1 being in the condition illustrated diagrammatically in FIG. 1 in respect of the support *n*+1).

Parts corresponding functionally to those already described with reference to FIG. **2** are designated by like numerals of reference in FIG. **3**. The following description is confined, therefore, to the modifications effected to provide the additional facility already referred to. These modifications will be most clearly understood by describing the manner of operation of the system illustrated in FIG. **3**.

It is assumed that the control valve unit of each support will have been operated to move it from the neutral position shown in FIG. 3*a* to the setting position of FIG. 3*b*. In this latter position the props of support *n*, which are supplied through the secondary valve 11 of this support, receive their supply of fluid from outlet 24, and the props supplied through a secondary valve 12 of an adjacent support receive their supply of fluid through outlet 24 of the valve 10 on either the support *n*−1 through pipe 46, or support *n*+1 through pipe 27. The fluid paths through secondary valves 11 and 12 are as already described with reference to FIGS. 2*a* and 2*b*. Pipes 27 and 46 are connected to the pressure inlets 19 of the secondary valve 12 through the intermediary of an alternating valve 50. The manner of operation of the alternating valve 50 and other alternating valves in the circuit as hereinafter mentioned disclosed diagrammatically in FIGS. 3*f* and 3*g*.

In FIG. 3*f* the pressure in the upper inlet is higher than that in the lower inlet and causes a stop or one-way valve element to be operative in relation to the lower inlet, so that communication is established only between the upper inlet and the outlet. In FIG. 3*g* the reverse condition is established by a higher pressure at the lower inlet, communication then existing only between this inlet and the outlet. Communication between the two inlets is impossible by virtue of the stop or one-way valve element incorporated in the alternating valve.

When it is desired to operate the circuit of FIG. 3 in the same manner as FIG. 2, that is to produce advancement of the supporting system as a whole when the machine 4 is undergoing a working traverse upwardly as seen in FIG. 1, the control valve block or unit 10 is set by means of its operating member to establish the channels of communication through the valve 10, as illustrated in FIG. 3*b*. It will be understood that the channels of communication from 21 to 18 and 21 to 32 can be established simultaneously, or the former can precede the latter depending on the construction of the valve. If the sequential manner of operation is used the valve 11 will revert to its former setting (appropriate to pressurize the props) but the props will not be repressurized at this stage since, in the advance setting of FIG. 3*c*, outlet 24 is connected to exhaust through outlet 23.

The pressure applied to the control inlet of the secondary valve 11 is in this case communicated through the intermediary of pipe 29 and alternating valve 41 and the pressure inlets 14 are connected to exhaust through outlet 24 of the valve 10. The props 3 and 13 are exhausted through the exhaust outlets of secondary valve 11. Concurrently the double acting ram 35 is pressurized through outlet 32 and pipe 33 to effect advancement of the inner unit of support *n*.

The props 1 and 18 of the outer unit of support *n*−1 are depressurized through operation of secondary valve 12. The control inlet 20 thereof receives pressure through outlet 28, pipe 31, and alternating valve 43. Concurrently the double acting ram 35 of support *n*−1 is pressurized from outlet 32 of valve 10 in support n through the intermediary of pipe 37 and alternating valve 51.

On completion of advancement of the inner unit of support *n* and the outer unit of support *n*−1, the control member of the valve 10 of support *n* is caused or permitted to return to its setting position, FIG. 3*b*, thereby again pressurizing the props of both inner and outer units of the support respectively.

When it is desired to advance the support system as a whole during a working traverse of the machine 4 in a downward direction, as seen in FIG. 1, movement of the control member of the valve 10 in support *n* from its initial position is effected to bring about the channels of communication through the valve 10 as represented in FIG. 3*d*. As previously referred to with reference to FIG. 3*b*, the full line channel of communication 21 – 39, 21 – 32 can be established either simultaneously or in sequence depending upon valve construction.

It will be noted that the control valve unit 10 is furnished with an additional outlet 39 which is functionally equivalent to the outlet 28 but is provided for the purpose of advancing the outer unit in support *n*+1 instead of *n*−1. The outlet 39 is the "fourth" outlet previously mentioned.

Accordingly fluid under pressure is supplied as before to the control inlet 15 of relay valve 11 in support *n* through the intermediary of pipe 40 and alternating valve 41. Concurrently fluid under pressure is supplied from outlet 39 through pipe 42 and alternating valve 43 to the control inlet 20, secondary valve 12 in support *n*+1. The circuit diagram of the control system of support *n*+1 is not visible in FIG. 3 but it will be seen that the same relation exists between supports *n*−1 and *n* as will exist between support *n* and *n*+1.

Depressurization of the props 3 and 13 of the inner unit of support *n* and of the props 1 and 18 of the outer unit of support *n*+1 will thus occur. Concurrently the double acting ram 35 in support *n* is pressurized from outlet 32 through pipe 33 and a double acting ram in support *n*+1 is pressurized from outlet 32 through pipe 44 and alternating valve 51 to effect advancement of the inner unit of support *n* and the outer unit of support *n*+1. Again, the routing of the pipe connections as between support *n* and *n*+1 will be identical to those between support *n*−1 and n and the manner of operation above described can, therefore, readily be ascertained from FIG. 3.

The control valve unit 10 on each support is further provided with a fifth outlet 48. By moving the operating member of the valve 10 into a fourth position the channels of communication through the valve 10 are as illustrated in FIG. 3*d*. Fluid under pressure supplied from the outlet 48 is fed through pipe 47 to control inlet 15 of secondary valve 11 to place same in a condition to depressurize the associated props 3 and 13 of the inner unit. However, a one-way or shut-off valve 49 prevents transmission of pressure to the alternating valve 41, thereby isolating outlets 28 and 39 on the valve 10 from outlet 48. Alternatively one-way or shut-off valves may be fitted in pipe 29 (between valve 41 and the connection to pipe 31) and in pipe 40 (between valve 41 and pipe 42).

Accordingly the control valve unit as in FIG. 3*e* produces independent depressurization of the props of the inner unit on the particular support on which the valve 10 is so operated without producing any related depressurization of the outer units in either of the supports *n*+1 or *n*−1. The channels of communication would require to be operated in the following sequence: 21 – 48, followed by, or accompanied by, 21 – 32, and finally 21–24.

If the valve 49 (or each of the alternatively provided valves in pipes 29 and 40) is a manually operable shut-off valve, this (or these) would be operated preparatory to movement of the operating member of control valve into the setting of FIGS. 3*c* or 3*d* to advance the outer unit A of supports *n*−1 or *n*+1.

Advancement of the inner unit of support *n*, and advancement of the outer units of either the supports *n*−1 or *n*+1 thus achieved independently will be effected by virtue of the establishment of fluid under pressure at outlet 32. Such fluid cannot prematurely move either of the outer units of supports *n*−1 and *n*+1 before depressurization of their respective props, since the outer unit concerned will be held fast in load bearing relation between the floor and roof of the mine working.

Referring now to FIG. 4, this illustrates a modified form of control valve block or unit which may be employed in either of the circuits of FIGS. 2 and 3.

In this modification, instead of providing a single outlet 28, a pair of functionally equivalent outlets 28′ and 28″ are provided which are connected respectively to pipes 29 and 27 feeding the control inlet of secondary valve 11 of support *n* and secondary valve 12 of support *n*−1. Each outlet 28′, 28″ can be placed in communication with the pressure line 21 or exhaust line 23 by placing the control member of the valve 10 in respective positions. By setting the control member in an intermediate position both outlets 28′ and 28″ can be pressurized concurrently. In a like manner two outlets 24′ and 24″ are provided instead of a single outlet 24. Again by suitable positioning of the control member the outlets 24′ and 24″ can be pressurized one at a time or by an intermediate setting of the control member can be pressurized concurrently. As will be noted, the outlets 24′ and 24″ are connected respectively to pipes 25 and 27 feeding the pressure inlets of secondary valves 11 in support *n* and 12 in support *n*−1.

These arrangements enable the props of the inner unit of support n to be depressurized independently, e.g. in advance of, the props of the outer unit of support $n-1$.

Likewise cutting off of the pressure supply to the feed inlets of secondary valve **11** for support n and secondary valve **12** for support $n-1$ may be effected independently, although preferably in coordination with the setting of the control member to pressurize outlet **28'** and **28''** respectively.

Although not illustrated, it will be evident that separate outlets may be provided in place of the single outlet **32** for respective connection to pipes **33** and **37**. However, this is less advantageous, in that only when the props of a selected unit are depressurized is it possible for such unit to be advanced by the advancing means, so that pressurization of the advancing means in a mode tending to effect advancement of the outer unit of support $n-1$ prior to depressurization of the props will not cause any improper operation of the system as a whole.

It will be evident that the modification illustrated in FIG. **4** may be applied to the circuit of FIG. **3** as it is applied to the circuit of FIG. **2**.

The control valve unit **10** may be constituted by a single valve body and a single movable valve element therein having ways or channels cooperating with ports in the valve body represented diagrammatically as the various outlets already described. Alternatively, the valve **10** may be constituted by a plurality of valve units coupled together or operated by a common operating mechanism.

Where a valve unit **10** provides for pressurization of outlets **28** or **39** and **32** concurrently, it will evidently be convenient that a single operating member be provided for the valve. However, it will be understood that it is within the scope of the invention for separate control valves to be provided on each support, one of these controlling the supply of fluid to the props, and another controlling the supply of fluid to the advancing means, the requisite pipe connections being provided to enable an operator situated at a support n to effect advancement of the appropriate unit of the support $n-1$ or $n+1$ as the case may be.

Further, although in most cases it will be convenient and advantageous for the control system to provide for concurrent depressurization and advancement of a unit in a support **10** and a unit in an adjacent support $n-1$ or $n+1$, the group of supports which undergo concurrent operation in part need not necessarily be adjacent supports in the row. Further, the group need not necessarily be confined to two supports but could include three supports, especially where the construction of the support was such that it incorporated three separately advancable units.

Further, it will be understood that advancement of a unit need not in all cases entail advancement of a base element, props and a girder or other part of the superstructure. Constructions of self-advancing roof support are known wherein the superstructure is provided with advancing means for effecting advancement of the superstructure relatively to its supporting props, and a control system in accordance with the present invention may be applied to a roof supporting system utilizing supports of this kind.

Thus, for example, the first support provided to newly exposed roof may be effected by advancement of a part of the superstructure alone and the props and base element of this part of the superstructure may be drawn up in a second stage of advancement involving another unit of the support.

We claim:

1. A roof supporting system for an underground mine working comprising

a. a row of roof supports each including:

i. a plurality of roof supporting units incorporating hydraulic props,

ii. advancing means for advancing each of said units in turn while its props are depressurized and while another unit of support has its props pressurized to establish this unit in load bearing relation with the roof,

b. a control system for controlling pressurization of the props of the units and advancement thereof and including:

i. valve means for each support having an inlet for connection to a hydraulic supply source and outlets selectively placed in communication with said inlet in different respective settings of said valve means,

ii. pipe means connecting said outlets of each of said valve means to the props of a unit and to the advancing means on that support on or for which said valve means is provided, and also connecting said outlets to the props of a unit and to the advancing means of an adjacent unit in a group of supports in one region of a row, which group of supports are required to be advanced progressively starting from one end of the group and continuing to the other end, said connection being such that operation of the valve means on or for each support of this group effects advancement of a unit therein and also a unit in said adjacent support of the group.

2. A roof supporting system according to claim **1** wherein:

a. each of said supports includes only two of said support units,

b. one of said support units in each support is an inner unit having props spaced apart longitudinally in the direction of advancement,

c. the other of said support units in said support is an outer trestle-like unit having props also spaced apart longitudinally of the direction of advancement on each of the opposite sides of said inner unit,

d. said advancing means comprises hydraulic ram means operatively connecting said inner and outer support units.

3. A roof supporting system according to claim **1** wherein:

a. the valve means on or for each of said supports is movable from a setting position for pressurizing the props of a unit of the support on or for which the valve means is provided, and for pressurizing the props of a unit of an adjacent support to a position for depressurizing these props of said supports respectively,

b. energization of said advancement means in said support and in said adjacent support being established in response to movement of said valve means into said depressurizing position.

4. A roof supporting system according to claim **1** wherein:

a. the valve means on or for each of said supports is movable from a setting position for pressurizing the props of a unit of the support on or for which the valve means is provided and for pressurizing the props of a unit of an adjacent support to a position for depressurizing these props of said supports respectively,

b. said valve means being movable into a still further position for establishing energization of said advancement means of said support and said adjacent support respectively to effect advancement of the units therein whereof the props have been depressurized.

5. A roof support according to claim **3** wherein each of the valve means is movable also to a still further position for depressurizing the props of said unit of said support on or for which the valve means is provided without depressurizing those of said unit of said adjacent support.

6. A roof support according to claim **4** wherein each of the valve means is movable also to a still further position for depressurizing the props of said unit of said support on or for which the valve means is provided without depressurizing those of said unit of said adjacent support.

7. A roof supporting system according to claim **1** wherein said valve means comprises:

a. a control valve,

b. operating means movable to change the setting of said control valve,

c. secondary valves operatively connected to said control valve by said pipe means and movable between unoperated and operated positions in response to hydraulic pressure, said secondary valves controlling pressurization of the props of respective units.

8. A roof supporting system according to claim **7** wherein:

a. each of said supports incorporates only two of said roof supporting units,

b. each of said control valves has a plurality of outlets which in respective settings of said control valve are selectively in communication with said inlet,

c. a first one of said outlets being connected to control inlets of said secondary valves, one in the support on or for which the control valve is provided, and another on or for an adjacent one of said supports of said group to effect depressurization of the props of respective units in these two supports controlled by said secondary valves,

d. a second one of said outlets being connected by said pipe means to feed inlets of these secondary valves in said support and in said adjacent support to effect pressurization of the props of said units of these supports.

9. A roof supporting system according to claim 8 wherein each of said control valves has a third outlet connected by said pipe means to said advancing means of the support on or for which said control valve is provided, and also by said pipe means to the advancing means of said adjacent support of the group to energize said advancing means in a mode to effect advancement of that unit in each of said supports whereof said props have been depressurized to relieve said unit from load bearing relation with respect to the roof.

10. A roof supporting system according to claim 1 wherein:

a. said valve means is provided on or for each of said supports is movable into alternative settings, in one case to bring about advancement of a unit in an adjacent support of said group on one side of the first said support, and in the other case to bring about advancement of a unit in an adjacent support of said group on the other side of the first said support, in both cases simultaneously with advancement of a unit in the first said support.

11. A roof supporting system according to claim 9 wherein:

a. each of said control valves has a fourth outlet,

b. said fourth outlet is connected by said pipe means to the control inlet of the secondary valve of the support on or for which said control valve is provided and to which said first outlet of said control valve is also connected,

c. said fourth outlet is connected by said pipe means to a control inlet of a secondary valve in an adjacent one of said supports of said group on the side of said first support opposite to that which includes the secondary valve, to the control inlet of which said first outlet is connected,

d. all of said secondary valves have their feed inlets connected by said pipe means to said second outlet of said control valve.

12. A roof supporting system according to claim 11 wherein:

a. said secondary valve of each of said supports which has its control inlet connected to an outlet of a control valve of an adjacent support of the group is connected to both of the control valves provided on or for supports of the group situated adjacent to and on opposite sides of the support containing said secondary valve,

b. connection between said control inlet of said secondary valve and said outlets of control valves respectively is effected through the intermediary of an alternating valve.

13. A roof supporting system according to claim 12 wherein:

a. the advancing means of each support is adapted to be energized in a first mode to effect advancement of a unit in the support on which the advancing means is provided upon depressurization of the props of this unit by operation of the control valve on this support,

b. said advancing means is adapted to be energized in a second mode to effect advancement of another unit of said support when the props thereof are depressurized in response to operation of a control valve in one or the other of the adjacent supports of the group situated respectively on opposite sides of the first said support,

c. said advancing means is connected to outlets of the control valves of said adjacent supports through the intermediary of an alternating valve.

14. In a roof supporting system of the kind comprising roof supports each including roof support units incorporating hydraulic props for bearing the roof load and advanceable in separate steps by a piston and cylinder advancement device, a control system including:

a. a plurality of control valves on respective supports, said control valves having inlets for connection to a source of hydraulic pressure and to an exhaust and having a plurality of outlets which can selectively be placed, by operation of said control valve, in communication with one or the other of said inlets,

b. secondary valves on each support for effecting pressurization and depressurization of the props of respective units of the support in response to pressure conditions at a control inlet of the secondary valve,

c. pipe means

i. connecting an outlet of each of said control valves to a control inlet of a secondary valve on the same support as that on which the control valve is provided, and also upon a support occupying a position spaced laterally from the first said support in a row deployed along a face to be traversed by a mining machine,

ii. connecting an outlet of said control valve to the advancing means of said support on which said control valve is provided, and also the advancing means of said laterally spaced support to enable units whereof the props are depressurized concurrently by said secondary valve to be advanced concurrently,

iii. connecting an outlet on said control valve on the support on which said control valve is provided to said secondary valve thereon for pressurizing said props of said unit, and also to said secondary valve on said laterally spaced support for simultaneously pressurizing the props of the unit controlled by said secondary valve.

* * * * *