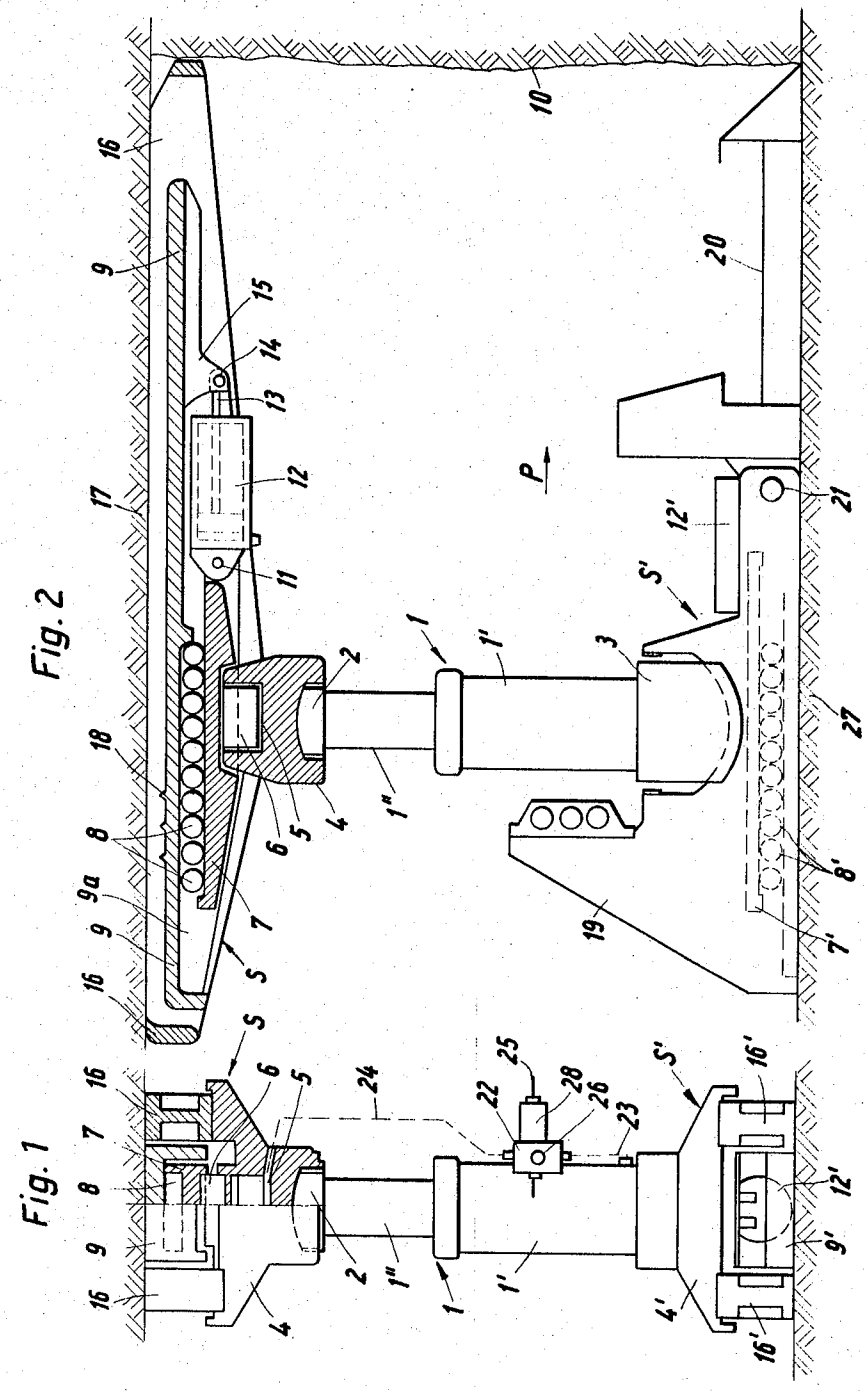
March 12, 1968 HANS-JOACHIM VON HIPPEL 3,372,551

MINE ROOF SUPPORT

Filed Aug. 30, 1966 6 Sheets-Sheet 1



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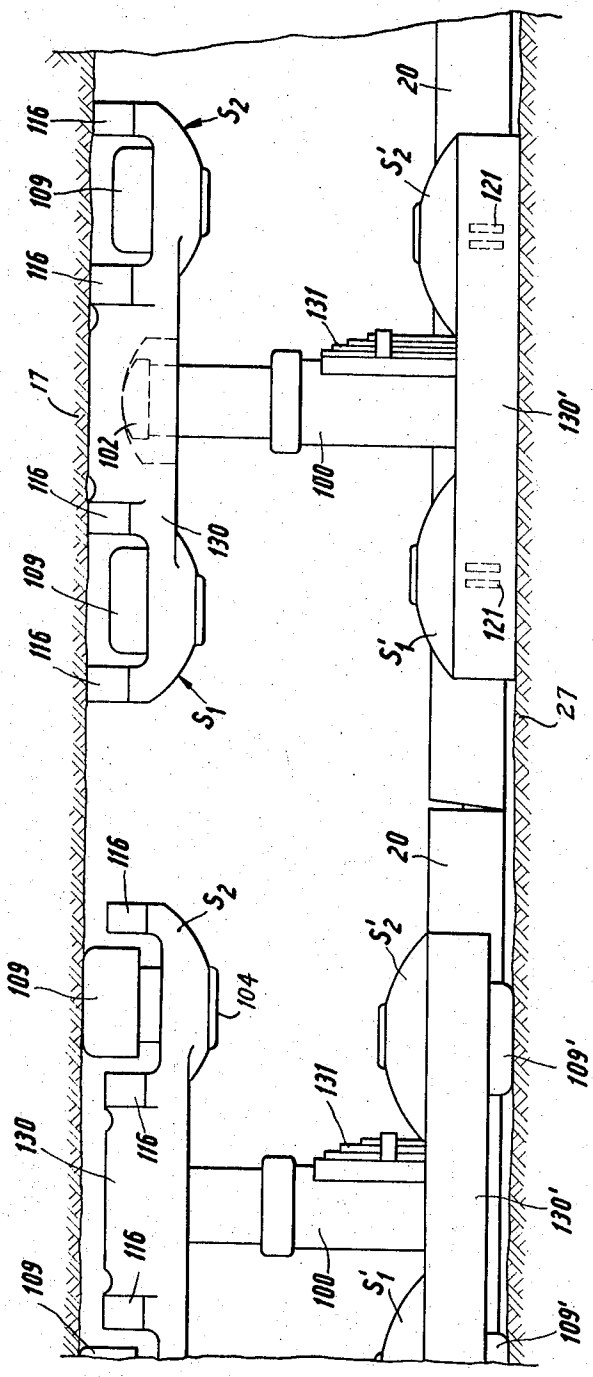


Fig. 3

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MINE ROOF SUPPORT

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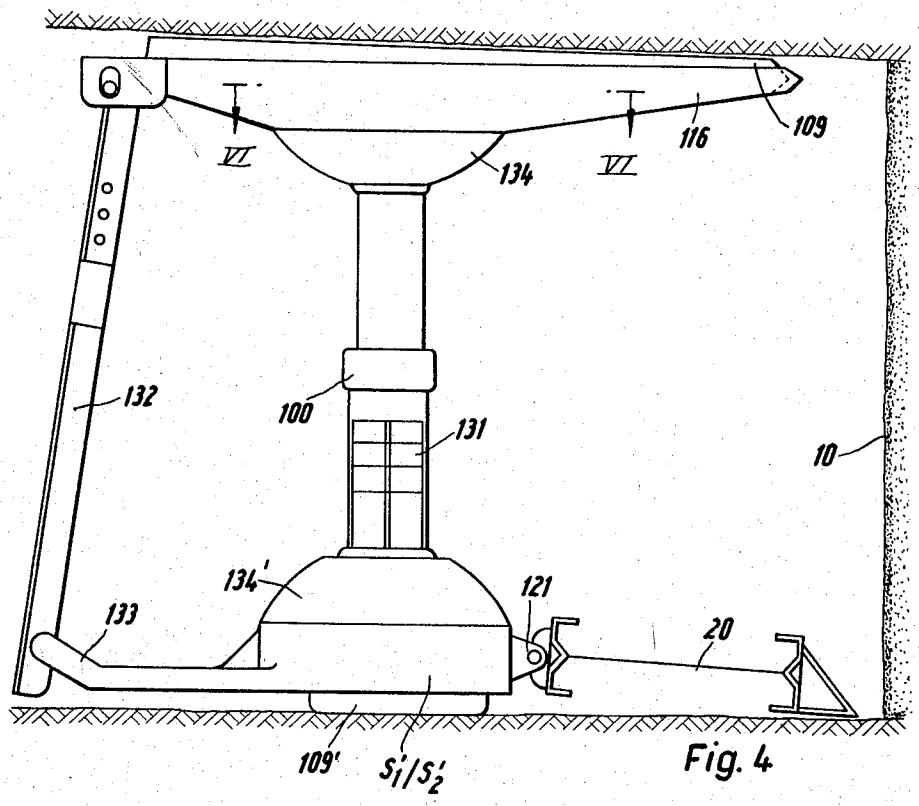


Fig. 4

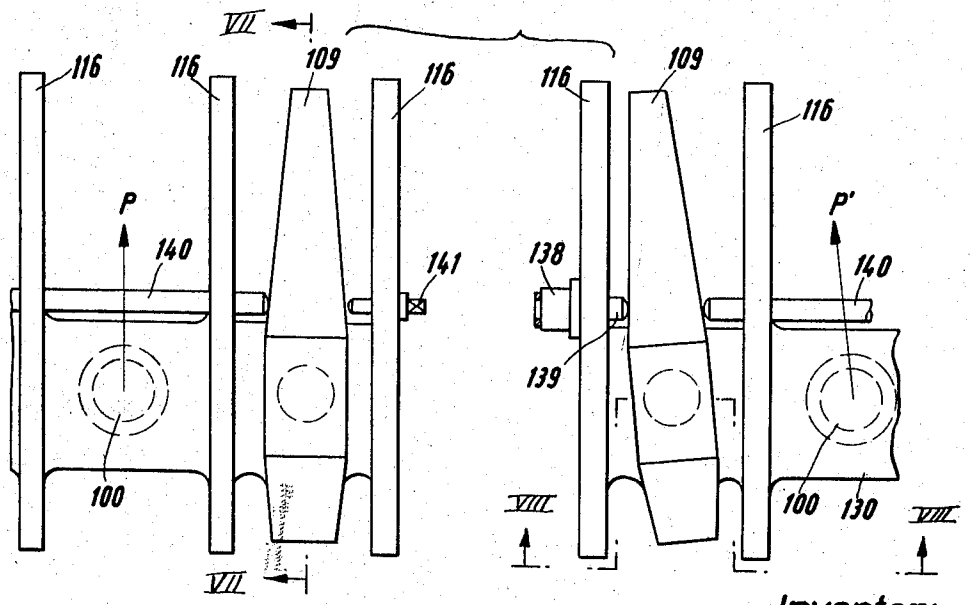


Fig. 5

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Fig. 6

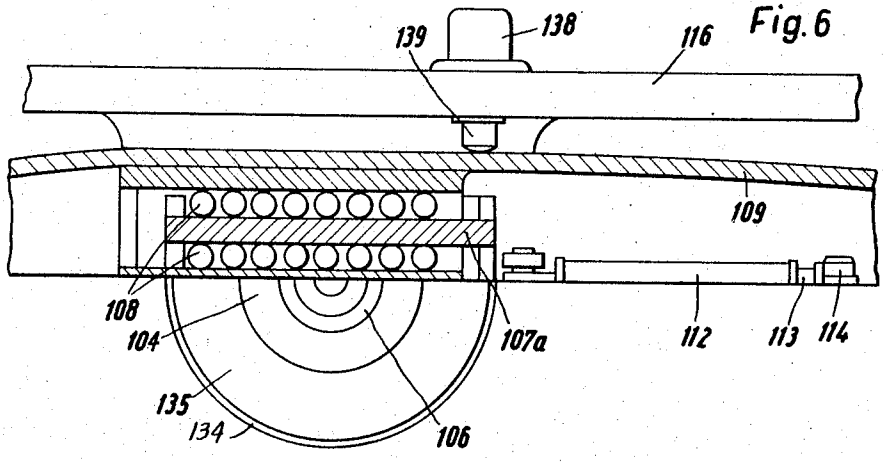


Fig. 7

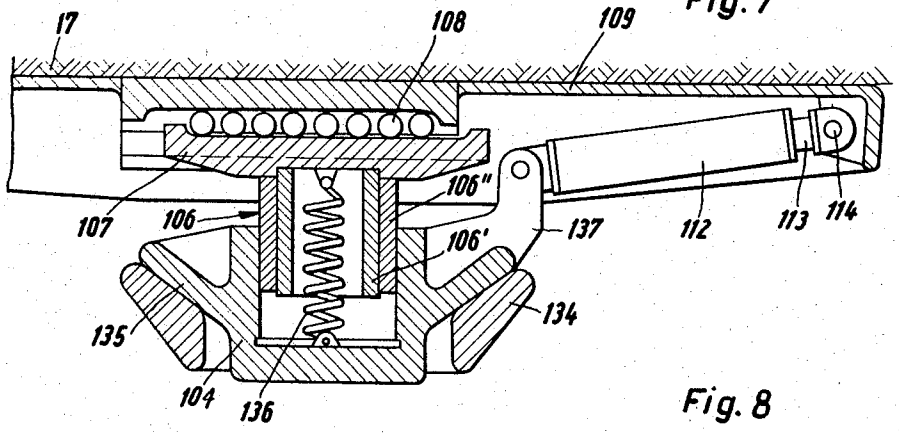
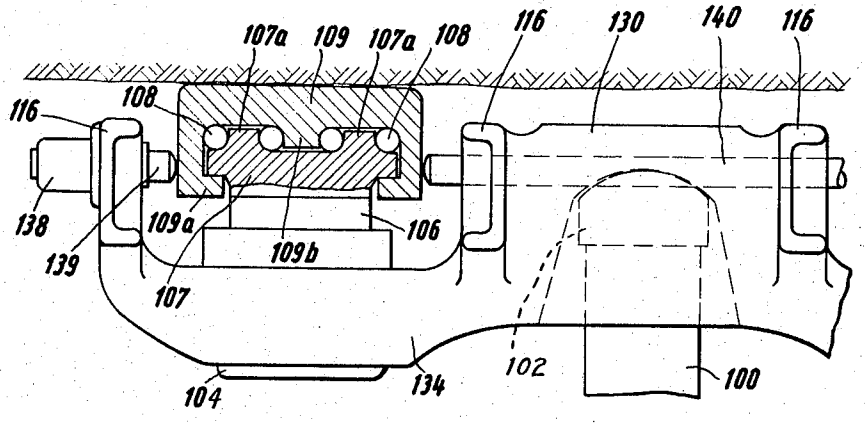


Fig. 8



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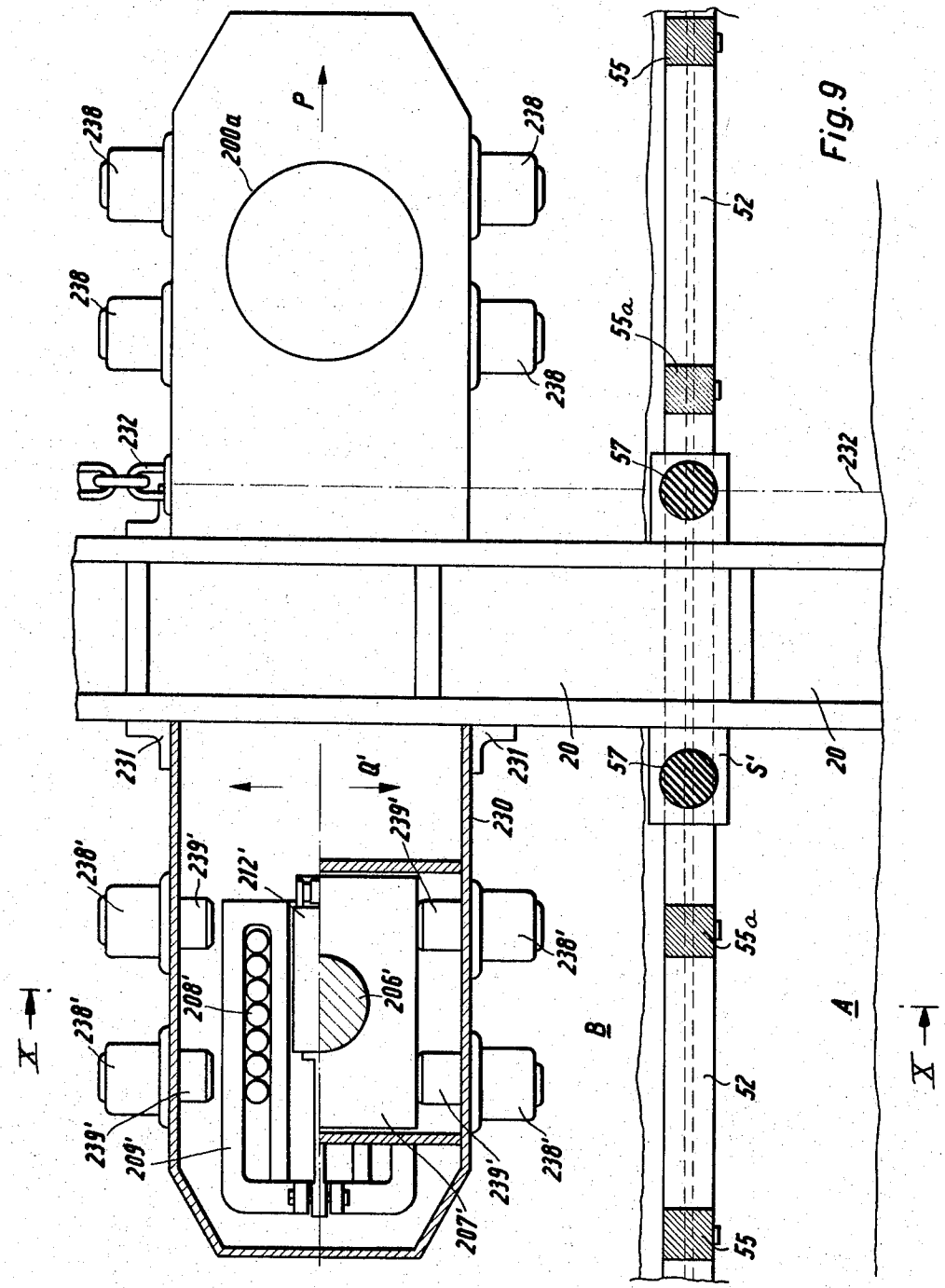
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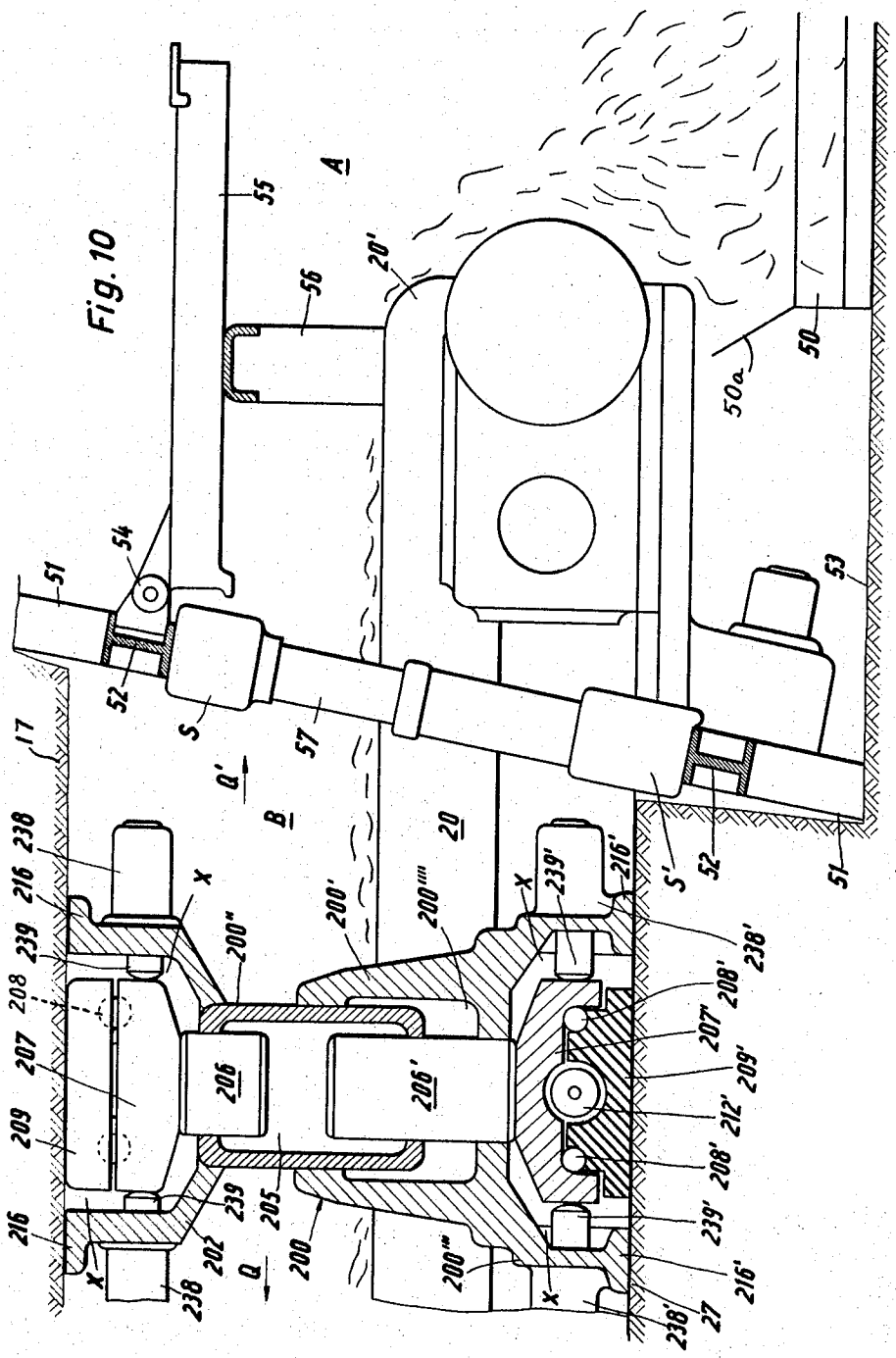
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Fig. 10



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United States Patent Office

3,372,551

Patented Mar. 12, 1968

3,372,551

MINE ROOF SUPPORT

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Filed Aug. 30, 1966, Ser. No. 575,995

Claims priority, application Germany, Sept. 1, 1965, H 57,042; Sept. 7, 1965, H 57,101; Jan. 7, 1966, H 58,168

22 Claims. (Cl. 61—45)

The present invention relates to apparatus for supporting the roofs of mining galleries and other underground excavations. More particularly, the invention relates to improvements in so-called walking mine roof supports which are movable stepwise toward the mine face in an underground excavation and wherein the moving parts are preferably actuated by hydraulic and/or pneumatic systems.

It is an important object of the present invention to provide a walking mine roof support which can be moved along the mine floor without even temporarily ceasing to support the mine roof so that the apparatus and the miners are protected from cave-in.

Another object of the invention is to provide a walking mine roof support which can change the direction of its movement in a mining gallery and can perform a composite movement including a movement toward or away from the mine face and a movement in at least one additional direction, for example, in parallelism with the mine face.

A further object of the invention is to provide a mine roof support which can embody one or more extensible and contractible pit props, which can be operated by remote control, which can be assembled of a relatively small number of rugged and compact parts, which can support a relatively large surface area of the mine roof, which can be assembled with one or more similar apparatus to support the mine roof along the full length of the mine face in a gallery, which can be used to transport the material evacuating conveyor, and which can be operated by a very simple control system, particularly by a hydraulic control system.

An additional object of the invention is to provide a hydraulic walking mine roof support which can be advanced while its components carry the full weight of a mine roof, which can perform steps of desired length, which can transport the driving means of an ore-evacuating conveyor, and which is capable of supporting an uneven mine roof and of being properly supported on an uneven mine floor.

Still another object of the invention is to provide a walking roof support which can be used alone or as a part of a battery of two or more mine roof supports, which can be operated by persons having little technical skill, and which can be used in high, low, wide or narrow underground excavations.

Briefly stated, one feature of my invention resides in the provision of a walking mine roof support which comprises at least one extensible and contractible pit prop or an analogous load carrying member, and upper and lower advancing or motion imparting units each of which comprises first and second caps mounted on the respective end portions of the prop and movable substantially vertically into and from engagement with the adjoining material surrounding the excavation. Thus, the caps of each upper advancing unit can be moved into and away from full supporting engagement with the mine roof and the caps of each lower advancing unit can be moved into full engagement with the mine floor. The caps of each advancing unit are reciprocable with reference to each other in a substantially horizontal direction and one of these caps is coupled with and transmits such horizontal

movement to the prop. Each advancing unit further comprises friction reducing means interposed between the first and second caps, operating means (preferably comprising hydraulic cylinder and ram members) for moving the caps vertically with reference to each other, and shifting means for moving the first cap horizontally when the second cap engages the material surrounding the excavation, or vice versa.

For example, and if the mine roof support comprises a single upper advancing unit and a single lower advancing unit, one cap of each unit will be moved horizontally toward the mine face when the other cap engages the adjoining material whereby such one cap entrains the pit prop while the mine roof remains properly supported. The one cap is then moved into full engagement with the adjoining material and the other cap is retracted so that the shifting means can advance the other cap toward the mine face. The other cap is thereupon preferably returned into engagement with adjoining material so that, when the just described two-stage displacement of the mine roof support is completed, all four caps engage with the adjoining material to insure satisfactory anchorage of the support and reliable propping of the mine roof. One cap of the lower advancing unit can push the aforementioned evacuating conveyor toward the mine face.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved mine roof support itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a schematic end elevational view of a walking mine roof support with two advancing units which embodies one form of the present invention, a portion of the upper advancing unit being shown in transverse vertical section;

FIG. 2 is a schematic side elevational view of the mine roof support, the upper advancing unit being shown in longitudinal vertical section;

FIG. 3 is an end elevational view of a battery of two modified walking mine roof supports each of which comprises two upper and two lower advancing units;

FIG. 4 is a side elevational view of one of the mine roof supports shown in FIG. 3;

FIG. 5 is a fragmentary top plan view of the mine roof supports shown in FIG. 3;

FIG. 6 is an enlarged fragmentary horizontal section as seen in the direction of arrows from the line VI—VI of FIG. 4;

FIG. 7 is an enlarged fragmentary longitudinal vertical section as seen in the direction of arrows from the line VII—VII of FIG. 5;

FIG. 8 is an enlarged fragmentary transverse vertical section as seen in the direction of arrows from the line VIII—VIII of FIG. 5;

FIG. 9 is a top plan view of a third mine roof support with one of the advancing units shown in horizontal section; and

FIG. 10 is a vertical section as seen in the direction of arrows from the line X—X of FIG. 9.

The walking mine roof support of FIGS. 1 and 2 comprises a single hydraulic pit prop **1** including a lower tube **1'** and an upper tube **1''** which latter is reciprocably telescoped into the lower tube **1'** so that the prop can be extended and contracted. The tubes **1'**, **1''** are respectively provided with cooperating cylinder and piston means to extend or contract the prop in response to controlled admission or evacuation of a hydraulic fluid. The upper end

portion 2 of the tube 1'' constitutes a male coupling member which extends into a socket provided in an operating cylinder 4. The lower end portion 3 of the lower tube 1' extends into a socket provided in an operating cylinder 4'.

The operating cylinders 4, 4' respectively form part of two advancing units S, S' which can cause the mine roof support to "walk" along the mine floor 27 toward or away from the mine face 10 and to shift an evacuating conveyor 20 which extends transversely of the mine roof support along the front part of the mine floor 27 and serves to evacuate material which is being removed from the mine face. The two advancing units S, S' are of similar or identical construction.

The upper advancing units S comprises the aforementioned operating cylinder 4 which may be rigidly or tiltably secured to the upper end portion 2 of the tube 1'' and defines a cylinder chamber 5 for a plunger or ram 6 which is rigid with a slide or runner 7. This runner can travel lengthwise along a track constituted by rolls, balls or analogous friction reducing elements 8 installed in a first roof-engaging member or cap 9. In the illustrated embodiment, the elements 8 are rolls which are accommodated in a cage including a first portion constituted by the runner 7 and a second portion constituted by the lower part 9*a* of the cap 9. The latter is preferably of U-profile and extends lengthwise of the mine roof support at right angles to the mine face 10. The downwardly extending flanges of the cap 9 to form the side walls of the cage portion 9*a* and shield the friction reducing elements 8 against debris falling off the mine roof 17.

A shifting device of the upper advancing unit S comprises a double-acting hydraulic cylinder 12 which is articulately connected to the front end portion of the runner 7 by a horizontal pin 11 and accommodates a reciprocable piston whose piston rod 13 is connected with a downwardly extending bracket 15 of the cap 9 by a second horizontal pivot pin 14. The shifting device including the cylinder 12 and piston rod 13 can move the cap 9 with reference to the runner 7, or vice versa. This shifting device is fully protected by the cap 9 in that it is mounted between the downwardly extending flanges bounding the sides of the cage portion 9*a*.

The advancing unit S further comprises a second roof-engaging cap including two elongated I-beams 16 which are fixedly secured to the operating cylinder 4 at the opposite sides of the cap 9.

The upper side of the cap 9 is preferably provided with teeth 18 or similar protuberances which can bite into the material of the mine roof 17 to prevent sliding of the cap 9 when the latter is caused to bear against the mine roof.

The lower advancing unit S' comprises the aforementioned operating cylinder 4' which is fixedly connected with a floor-engaging cap composed of two spaced parallel I-beams 16'. The operating cylinder 4' has a chamber (not shown) for a vertically reciprocable plunger or ram which can displace a U-shaped cap 9' corresponding to the cap 9 and movable into and from firm engagement with the mine floor 27. The cap 9' extends lengthwise between the I-beams 16' and its front end portion is articulately connected with the double-acting cylinder 12' of a hydraulic shifting device serving to move the cap 9' with reference to the beams 16' or vice versa. A horizontal pivot pin 21 connects the front end portions of the beams 16' with the evacuating conveyor 20 which is slidable sideways along the mine floor 27. The friction reducing rollers 8' are disposed between the cap 9' and a runner or slide 7' which is connected with the aforementioned ram in the operating cylinder 4'.

The cap 9' and the beams 16' are respectively shorter than the cap 9 and beams 16 to provide room for the evacuating conveyor 20. A shield 19 on the rear end portions of the beams 16' protects the operating cylinder 4' from filling which is used to fill up the gallery rearwardly of the mine roof support. The evacuating conveyor 20 preferably comprises two endless chains which are driven to travel in a direction at right angles to the plane of FIG. 2.

The hydraulic system of the mine roof support comprises a valve block 22 which is mounted on the lower tube 1' of the prop 1 and is connected with a conduit 23 for admitting hydraulic fluid into the chamber of the lower operating cylinder 4'. A conduit 24 connects the valve block 22 with the chamber 5 of the upper operating cylinder 4 and a supply conduit 25 feeds oil or another suitable hydraulic fluid from the pressure outlet of a hydraulic pump, not shown. The numeral 26 denotes an actuating member which can be manipulated by hand or by remote control to regulate the flow of fluid to and from the operating cylinders 4, 4'. The hydraulic system further includes a differential piston assembly 28 of conventional design and conduits which convey fluid to and from the cylinder chamber in the tube 1' to bring about extension or contraction of the prop 1. The pump which feeds fluid into the supply conduit 25 may be mounted on the mine roof support or the conduit 25 may extend through the gallery to receive pressurized fluid from a remote source. Additional conduits (not shown) connect the valve block 22 with the cylinders 12, 12' of the two shifting devices.

The operation of the apparatus shown in FIGS. 1 and 2 is as follows:

In order to anchor the mine roof support, the actuating member 26 is set to admit pressurized fluid to the conduits 23, 24 and into the cylinder chamber of the tube 1'. The tube 1'' is moved upwardly and presses the I-beams 16 against the mine roof 17. Fluid admitted into the operating cylinders 4, 4' (via conduits 24, 23) moves the caps 9, 9' into engagement with the mine roof 17 and mine floor 27. The lower I-beams 16' bear against the mine floor 27 by gravity and also in response to pressure in the cylinder of the tube 1'. A suitable relief valve (not shown) of the block 22 insures that the prop 1 is not subjected to excessive pressure.

When the material removing instrumentalities remove a certain amount of material from the mine face 10, the apparatus must be shifted in the direction indicated by arrow P. This is achieved by raising the fluid pressure in the operating cylinders 4, 4' and by simultaneously shortening the prop 1 to move the beams 16 away from the mine roof 17 or to cause these beams to bear against the mine roof with a reduced force. The same holds true for the lower beams 16' which bear against the mine floor 27 with a reduced force. The pressure between the caps 9, 9' and the mine roof 17 and floor 27 increases so that the apparatus continues to support the roof against cave-in.

The prop 1 can be shortened or contracted by means of differential piston assembly 28. This assembly can raise the pressure of fluid above the pressure prevailing in the supply conduit 25 so that the operating cylinders 4, 4' receive highly pressurized fluid. The manner in which a differential piston can raise the pressure of a fluid is well known in the art of hydraulics.

Once the beams 16, 16' are properly disengaged from or bear with a reduced pressure against the mine roof 17 and floor 27, the operator admits hydraulic fluid into the cylinders 12, 12' to retract the piston rods 13 whereby the runners 7, 7' travel along the friction reducing elements 8, 8' and entrian the prop 1 and the beams 16, 16' in the direction of the arrow P, namely, toward the mine face 10. The caps 9, 9' cannot follow such movement of the beams 16, 16' because they bear against the mine face 17 and floor 27. Such positions of the prop 1 and beams 16, 16' are shown in FIG. 2. The lower beams 16' push the evacuating conveyor 20 which moves sideways and toward the lower part of the mine face 10. The elements 8, 8' reduce friction sufficiently to allow for relative movement between the runners 7, 7' and caps 9, 9'.

In the next step, the differential piston assembly **28** is reset to reduce the pressure in the operating cylinders **4, 4'** and to bring about extension of the prop **1** whereby the beams **16, 16'** return into strong frictional engagement with the mine roof **17** and floor **27.**

In order to advance the caps **9, 9'**, the operator will set the actuating member **26** in such position that fluid can escape from the operating cylinders **4, 4'** whereby the caps **9, 9'** move toward the respective ends of the prop **1** and are respectively disengaged from the mine roof **17** and floor **27.** By admitting fluid into the cylinders **12, 12'** in a sense to expel the respective piston rods **13**, the operator will cause the caps **9, 9'** to advance toward the mine face **10.** During such displacement of the caps **9, 9'**, the beams **16, 16'** are in firm supporting engagement with the material of the mine roof **17** and floor **27** so that the pivot pins **11** are stationary but the pins **14** move forwardly and away from the runners **7** and **7'.** When the caps **9, 9'** assume their foremost positions, the operator again admits fluid into the operating cylinders **4, 4'** to move the caps into strong supporting engagement with the material of the roof **17** and floor **27.**

It will be seen that walking or stepwise advancement of the apparatus involves two successive movements the first of which includes moving the beams **16, 16'** with the prop **1** while the caps **9, 9'** remain in engagement with the material surrounding the excavation, and the second of which includes anchoring the beams **16, 16'** and moving the caps **9, 9'** with reference to the beams. An important advantage of such operation is that the roof **17** remains supported at all times, regardless of whether the beams move with reference to the caps, or vice versa.

The operating means of the advancing units S, S' serve to move the caps **9, 9'** substantially vertically with reference to the caps including the beams **16** and **16'**, or vice versa. Such operating means comprises the aforementioned cylinders **4, 4'**, their rams, and the cylinder and piston means in the tube **1'.**

The apparatus of FIGS. 1 and 2 may comprise two or more pit props **1** and four, six or more advancing assemblies. Also, the two runners **7, 7'** can be coupled with two or more props so that the apparatus then comprises only two advancing assemblies and two or more props.

FIGS. 3 to 5 illustrate two modified walking mine roof supports each of which comprises an extensible and contractible pit prop **100** having a spherical upper end portion **102** for a transversely extending crosshead or carrier **130.** The crosshead **130** supports two advancing units **S1, S2** which are disposed at the opposite sides of and at the same distance from the prop **100.** Each of the advancing units **S1, S2** is analogous to the advancing unit S of FIGS. 1 and 2 and comprises a first cap **109** and a second cap including two elongated C-beams **116.** The beams **116** are rigid with the crosshead **130** but the caps **109** are movable with reference to the crosshead into and from engagement with the mine roof **17.** The operating means for moving the caps **109** with reference to the crosshead **130** will be described in connection with FIGS. 6 to 8.

The lower end portion of each pit prop **100** carries a second or lower crosshead **130'** which supports two lower advancing units **S1', S2'.** These advancing units are similar to the units **S1, S2.** A package of leaf springs **131** is provided on each lower crosshead **130'** to bias the respective prop **100** to a vertical position.

The rear end portions of the upper beams **116** are connected with shields **132** which prevent filling from entering the space surrounding the respective props **100.** The lower end portions of the shields **132** are connected with arms **133** secured to and extending rearwardly from the respective lower crossheads **130'.** Horizontal pivot pins **121** connect the front end portions of the lower crossheads **130'** with an evacuating conveyor **20.**

Referring to FIGS. 6 to 8, the crosshead **130** is provided with cupped end portions or sockets **134** each of which accommodates an operating cylinder **104** forming part of the advancing unit **S1** or **S2.** The operating cylinders **104** are turnable about vertical axes and can also swivel in the respective sockets **134.** As best shown in FIG. 7, each operating cylinder **104** has an annular flange **135** whose convex external surface abuts against the concave internal surface of the respective socket **134.** These two parts form a universal joint.

Each operating cylinder **104** accommodates a reciprocable plunger or ram **106** including an inner sleeve or guide sleeve **106**, which is rigidly affixed to the respective slide or runner **107**, and an outer sleeve **106''** which is slidable in the respective operating cylinder. The runners **107** have longitudinally extending ribs **107*a*** bounded by rounded flanks clearly shown in FIG. 8. Each such rounded flank is adjacent to a row of spherical friction reducing elements **108.** The caps **109** are of U-shaped cross section and their downwardly extending flanges **109*a*** straddle the respective runners **107.** Each cap **109** further comprises a downwardly extending centrally located rib **109*b*** disposed between the ribs **107*a*** and separating two rows of balls **108.** In the embodiment of FIGS. 3 to 8, each advancing unit comprises four rows of balls **108** which are confined in cages each having a first portion including the flanges **109*a*** and ribs **109*b*** and a second portion constituted by the runner **107.** The flanks of the ribs **109*b*** are rounded in the same way as the ribs **107*a*.** The balls **108** take up vertical stresses as well as horizontal stresses acting at right angles to the ribs **107*a*, 109*b*.**

Each operating cylinder **104** accommodates a helical spring **136** one end of which is anchored in the bottom wall of the respective cylinder and the other end of which is secured to the associated runner **107.** These springs couple the runners with the respective operating cylinders.

Each operating cylinder **104** further comprises a bracket **137** for the cylinder **112** of the corresponding shifting device. The piston rod **113** is secured to a pivot pin **114** connected to the front end portion of the cap **109.** The cylinder **112** is rockable with reference to the bracket **137.**

The construction of the lower advancing units **S1', S2'** is analogous. The drawings merely show their cap **109'** which are shorter than the caps **109.** Each lower crosshead **130'** comprises two sockets **134'** which accommodate the operating cylinders of the lower advancing units.

The mine roof supports of FIGS. 3–8 are advanced substantially in the same way as described in connection with FIGS. 1 and 2. In the support shown in the right-hand half of FIG. 3, the caps **109** are illustrated in their lower end positions disengaged from the mine roof **17.** The lower caps **109'** of this right-hand support are raised above the mine floor **27** so that the apparatus rests on the lower crosshead **130'** (which may be provided with short beams **116**, not shown) and its upper beams **116** bear against the mine roof **17.** The caps **109, 109'** are now ready to be shifted toward the mine face in response to expulsion of piston rods **113** from the respective cylinders **112.**

The left-hand mine roof support of FIG. 3 maintains its caps **109, 109'** in engagement with the mine roof **17** and floor **27** so that the prop **100** and crossheads **130, 130'** are ready to be shifted toward the mine face. Retraction of the crossheads **130, 130'** takes place in response to shortening of the prop **100.**

The crossheads **130, 130'** are turnable on the upper and lower end portions of the respective props **100** so that the apparatus can change the direction of its movement. Such change in direction of movement is facilitated by turnability of operating cylinders **104** in the associated sockets **134.** The turning means for rotating the caps **109, 109'** about the vertical axes of the respective sockets **134** comprises hydraulic turning cylinders **138** whose piston rods **139** can engage the respective caps **109** at points remote from the sockets. Each piston rod **139**

bears against one of the two caps **109**, **109'** on a crosshead **130**, or **130'** and the one cap turns the other cap through the same angle by means of a motion transmitting push rod **140**. The extent of angular movement of caps **109** or **109'** is limited by adjustable stops **141** each meshing with one of the beams **116** or with the lower crosshead **130'**. The push rods **140** and stops **141** insure that the caps **109** or **109'** on a crosshead **130** or **130'** will be turned through the same angle. The stops **141** can be replaced by cylinders corresponding to the cylinders **138**.

When the caps **109** are inclined with reference to the adjoining beams **116** (see the right-hand half of FIG. 5), the apparatus will move in the direction indicated by arrow p' (i.e., not exactly at right angles to the mine face) and will have a component of movement in the longitudinal direction of the evacuating conveyor **20**.

The apparatus shown in the left-hand portion of FIG. 5 will advance in the direction of arrow P and at right angles to the plane of the mine face because the cap **109** is parallel with the beams **116**. Each lower cap **109'** (not shown in FIG. 5) is parallel with the respective upper cap **109**.

It is to be noted that the threaded stops **141** may replace the turning cylinders **138** or vice versa. These stops are preferably provided with non-circular end portions which can be engaged by suitable tools to rotate the stops and to thereby change the inclination of caps **109** or **109'**.

The chambers in the operating cylinders **104** of the mine roof supports shown in FIGS. 3 to 8 are dimensioned in such a way that the props **100** are slightly contracted when the cylinders **104** receive fluids from the hydraulic pump. This can be achieved without resorting to a differential piston or an analogous pressure amplifying assembly.

Referring to FIGS. 9 and 10, there is shown a third walking mine roof support which can be utilized to displace the driving assembly **20'** of the evacuating conveyor **20** in the longitudinal direction of this conveyor. As shown in FIG. 10, the driving assembly **20'** extends sideways from the gallery B and into a shaft A which accommodates a further conveyor **50** serving to transport ore to the surface or to an underground loading station. The coal or other material which is removed from the mine face is first loaded onto the evacuating conveyor **20** which transports such material in a direction to the right, as viewed in FIG. 10, and discharges onto the second conveyor **50**. The latter conveyor may be a conventional belt conveyor with skirts **50***a*.

The supporting structure for the roof of the shaft A comprises rows of upper and lower segments **51** and two rails **52**. The lower segments **51** rest on the floor **53** of the shaft A and the upper segments **51** rest on the upper rails **52** and bear against the roof of the shaft A. The upper rail **52** carries a plurality of longitudinally spaced braces **55** which are attached thereto by horizontal hinges **54** so that each such brace can be pivoted about a horizontal axis into and away from engagement with the lower rail **52**. One or more braces **55** will be raised to the position shown in FIG. 10 to provide room for the driving assembly **20'**. The remaining braces **55** will engage with the lower rail **52** to transmit stresses from the upper segments **51**. The driving assembly **20'** carries a yoke or an analogous retaining member **56** which can maintain the adjoining brace or braces **55** in raised position as shown in FIG. 10.

If the opening exposed by the raised braces **55** is relatively long, the supporting structure for the roof of the shaft A may comprise one or more apparatus of the type shown in FIGS. 1 and 2 and serving to prop the upper rail **52**. This apparatus is shown as comprising two aligned props **57** (see FIG. 9) disposed at the opposite sides of the conveyor **20** and each carrying an upper advancing unit S and a lower advancing unit S'. The advancing units S, S' are mounted to respectively travel along the upper and lower rails **52** but will remain in the positions shown in FIG. 9 when the displacement of the evacuating conveyor **20** is completed. The apparatus including the props **57** and the two pairs of advancing units S, S' will reduce the width of the gap between the braces **55***a* shown in FIG. 9 and the distance between its props **57** is sufficient to provide an opening large enough to accommodate the driving assembly **20'** and not to interfere with the flow of material which is being supplied by the evacuating conveyor **20**.

The walking mine roof support of FIGS. 9 and 10 comprises a leading pit prop **200***a* located in front of the evacuating conveyor **20** and a trailing pit prop **200** located behind the conveyor **20**. Otherwise stated, the leading prop **200***a* is located between the conveyor **20** and the mine face which is located to the right of the prop **200***a*, as viewed in FIG. 9. When the conveyor **20** is to be advanced toward the mine face, it must move in the direction indicated by arrow P.

The prop **200** comprises a lower tube **200'** and an upper tube **200''** which is telescoped into and is reciprocable in the lower tube. These tubes define between themselves an annular cylinder chamber **200''''** which will receive oil from a suitable hydraulic system not shown in FIGS. 9 and 10. The lower end portion or foot **200'''** of the lower tube **200'** resembles a cup and is rigid with two elongated beans **216'** constituting one cap of the lower advancing unit and engaging the floor **27** of the gallery B. The cupped foot **200'''** accommodates a second cap **209'** which can be moved vertically into and out of strong engagement with the floor **27**. The upper part of this cap **209'** constitutes the lower portion of a cage for rows of friction reducing rolling elements **208'**. The upper portion of the cage is constituted by a slide or runner **207'** which can be moved downwardly by a lower plunger or ram **206'**. The cylinder for the ram **206'** is constituted by the upper tube **200''** of the prop **200**. The cylinder **212'** of the shifting device for the lower end portion **200'''** and cap **209'** is accommodated in matching cutouts provided in the cap **209'** and runner **207'**. When the chamber **205** in the tube **200''** receives pressurized hydraulic fluid, the ram **206'** moves downwardly and presses the cap **209'** against the floor **27**.

The advancing unit at the upper end of the prop **200** similar to the just described advancing unit and its parts are identified by similar reference characters. The operating means for moving the upper cap **209** toward and away from the roof **17** of the gallery B comprises a ram **206** which is reciprocable in the upper tube **200''** of the prop **200** simultaneously with the ram **206'**. FIG. 10 further shows the cup-shaped upper end portion **202** of the prop **200** which is rigid with the tube **200''** and carries a cap including two beams **216**. The cap **209** will be lifted through the intermediary of the slide or runner **207** constituting the lower portion of a race for rolling elements **208**. The upper cap **209** will descend by gravity as soon as the fluid is free to escape from the chamber **205**. The pressure between the lower cap **209'** and the floor **27** is then reduced sufficiently to allow for lengthwise movement of the cap **209'** with reference to the beams **216'** which are pressed against the floor **27** by fluid admitted into the chamber **200''''**.

The construction of the two advancing units which are mounted on the upper and lower end portions of the leading prop **200***a* is the same as that of the advancing units on the prop **200**.

FIG. 10 shows that the caps **209**, **209'** are received in the end portions **202**, **200'''** with a considerable lateral clearance which is shown at X. Such clearance is provided on purpose to allow for sidewise movement of the mine roof support. The displacing means for moving the apparatus sideways (namely, in the longitudinal direction of the evacuating conveyor **20**) comprises hydraulic cylinder and piston assemblies **238**, **238'** whose piston rods **239**, **239'** extend through the respective end portions

202, 200''' and can move the caps 209, 209'. The piston rods 239, 239' bear against the runners 207, 207' which latter, however, are arranged to transmit sidewise movement to the associated caps 209, 209' through the intermediary of rolling elements 208, 208'. Thus, the runners 207, 207' can move relative to the caps 209, 209' in the direction indicated by arrow P but they cannot move with reference to such caps in directions indicated by arrows Q and Q'. As shown in FIG. 9, the piston rods 239, 239' can be utilized to place the caps 209, 209' into positions of slight inclination with reference to the beams 216, 216' so that the mine roof support can perform a composite movement substantially as described in connection with FIG. 5. The cylinders 238, 238' are rigidly secured to the end portions 202, 200'''.

Movements of the mine roof support including the props 200, 200*a* in the direction indicated by arrow P are carried out in two stages and in the same way as described in connection with FIGS. 1 and 2. When the chamber 200'''' receives pressurized fluid, the respective prop extends and presses the beams 216, 216' against the mine roof 17 and floor 27. The operator then permits fluid to escape from the chamber 205 so that the caps 209, 209' are disengaged and can be shifted lengthwise in response to actuation of shifting cylinders. On admission of fluid into the chamber 205 and in response to escape of fluid from the chamber 200'''', the beams 216 are disengaged but the caps 209, 209' bear against the mine roof 17 and floor 27 so that the prop and the beams can be shifted toward the mine face. The lower end portions 200''' of the props 200, 200*a* are preferably coupled to each other by a two-piece connector 230 which is fixed to the conveyor 20 by brackets 231 which advance the conveyor toward the mine face.

The numeral 232 denotes in FIG. 8 a chain for a conventional material removing machine, also called planer, which is moved along the mine face and removes coal or other material. This chain is driven by the assembly 20' at the discharge end of the conveyor 20 and its stringer extends through aligned openings provided therefor in the side walls of the connector 230 behind the leading prop 200*a*. It can happen that the pull of the chain 232 and the pull of chains in the conveyor 20 displaces the entire mine roof support in the direction indicated by arrows Q, namely, away from the shaft A and in parallelism with the mine face. In order to subject the chains to requisite tension, the operator will actuate the displacing cylinders 238, 238' in a sense to move the mine roof support in the opposite direction as indicated by the arrows Q'. This is achieved in the following way:

Fluid is admitted into the chambers 200'''' and is permitted to escape from the chambers 205 so that the caps 209, 209' are disengaged from the roof 17. In response to admission of pressurized fluid into the left-hand displacing cylinders 238, 238' of FIG. 10, the piston rods 239, 239' displace the runners 207, 207' in the direction indicated by arrow Q' to the extent determined by the clearances X. The chambers 205 then receive fluid to move the caps 209, 209' apart and into engagement with the mine roof 17 and floor 27. The fluid is admitted into the chambers 205 at such a high pressure that the tubes 200'' move downwardly through small distances and into the respective tubes 200' whereby the length of the props 200, 200*a* decreases and the beams 216, 216' are disengaged. In such position of the beams 216, 216', the tension of chain 232 and of chains forming part of the conveyor 20 (acting in the direction of the arrow Q) is transmitted through the connector 230 and brackets 231, piston rods 239, 239' of the right-hand displacing cylinders 238, 238' (FIG. 10) and runners 207, 207' on to the safely anchored caps 209, 209'. In response to expulsion of the right-hand piston rods 239, 239', the cupped end portions 200''', 202 (and hence the props 200, 200*a*, connector 230 and conveyor 20) are moved in the direction of arrow Q' to complete the tensioning of chains. If necessary, the same steps can be repeated once or more than once, depending on the slack in the chains.

The mine roof support can be moved toward the mine face (arrow P) simultaneously with sidewise movement in the direction of arrow Q'. This is advisable because, when the caps 209, 209' engage the mine roof 17 and floor 27, the beams 216, 216' can be moved forwardly (by shifting cylinders 212') and sideways (by displacing cylinders 238, 238'). Such operation saves much time. However, it is equally within the purview of the present invention to move the mine roof support stepwise in the direction of arrow P and thereupon in the direction of arrow Q', or vice versa. Furthermore, the mine roof support can be moved only lengthwise or only sideways, depending on the slack or tension in the chains and on the distance of the leading prop 200*a* from the mine face. Also, the mine roof support can be provided with displacing cylinders 238, 238' even if it is not connected with the conveyor 20 or if it is connected with this conveyor for the sole purpose of moving it toward the mine face.

In accordance with a further modification of my invention, the mine roof support may comprise a pair of leading and a pair of trailing pit props disposed at the four corners of a rectangle and each supporting one or more advancing units. Alternatively, a single advancing unit can be provided midway between the upper and lower ends of each pair of pit props so that the apparatus will comprise a total of four advancing units. Still further, such four-prop apparatus can comprise two upper advancing units, each located between a leading and a trailing pit prop, and two lower advancing units each of which is located between a leading and a trailing pit prop. The number of upper advancing units need not be the same as the number of lower advancing units. Thus, and referring again to FIGS. 9 and 10, a single upper advancing unit could be mounted at the upper ends of the props 200, 200*a*.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is:

1. Apparatus for supporting roofs in mining galleries and other underground excavations, comprising at least one prop having upper and lower end portions; and upper and lower advancing units each including first and second caps mounted on the respective end portions of the prop and each movable substantially vertically into engagement with the adjoining material surrounding the excavation, said first and second caps being reciprocable with reference to each other in a substantially horizontal direction and said prop being coupled for such horizontal movement with one of said caps, friction reducing means interposed between said first and second caps, operating means for moving said caps vertically with reference to each other, and shifting means for moving said first cap horizontally when the second cap is in engagement with said material, and vice versa.

2. Apparatus as set forth in claim 1, wherein said operating means comprises a hydraulic cylinder member and a ram member for moving the other cap of each advancing unit vertically with reference to the one cap, one of said members being carried by said prop and being coupled with said one cap, said friction reducing means comprising a cage including first and second portions respectively provided on the other member and on said other cap and rolling elements received between said portions of the cage, said shifting means comprising a hydraulic cylin-

der and piston assembly operating between said first portion of the cage and said other cap.

3. Apparatus as set forth in claim 2, wherein each of said ram members is coaxial with said prop.

4. Apparatus as set forth in claim 1, wherein said other cap of each advancing unit forms a protective enclosure around the respective friction reducing means.

5. Apparatus as set forth in claim 1, further comprising turning means for rotating at least one cap of each advancing unit about a vertical axis.

6. Apparatus as set forth in claim 5, wherein said turning means comprises hydraulically operated cylinder and piston means and wherein said vertical axes are defined by said operating means.

7. Apparatus as set forth in claim 1, further comprising displacing means for moving the caps of each advancing unit with reference to each other substantially horizontally and at right angles to said horizontal direction.

8. Apparatus as set forth in claim 1, further comprising an upper and a lower carrier each mounted on the respective end portion of said prop, each of said carriers having two arms extending laterally of said prop and said advancing units including two upper and two lower advancing units each mounted on one arm of the respective carrier.

9. Apparatus as set forth in claim 8, wherein said upper and lower advancing units are respectively equidistant from said prop.

10. Apparatus as set forth in claim 1, further comprising a socket mounted on each end portion of said prop and having a concave internal surface, said operating means comprising hydraulic cylinders having convex external surfaces received in said sockets so that said cylinders can rotate and swivel with reference to such sockets.

11. Apparatus as set forth in claim 1, wherein each of said friction reducing means comprises a cage having a first portion rigid with the other cap of the respective advancing unit, and a second portion connected with said operating means, and rolling elements between said first and second portions, said portions having elongated ribs defining channels for said rolling elements and having rounded flanks providing tracks for such rolling elements.

12. Apparatus as set forth in claim 1, wherein said caps of each advancing unit are movable sideways with reference to each other substantially at right angles to said horizontal direction, and further comprising displacing means for moving said one cap sideways when the other cap engages said material and vice versa.

13. Apparatus as set forth in claim 12, wherein said displacing means comprises hydraulical cylinder and piston assemblies having clyinders secured to said one cap of each advancing unit and reciprocable piston rods engageable with said other cap.

14. Apparatus as set forth in claim 12, wherein each of said friction reducing means is movable sideways with said other cap of the respective advancing unit.

15. Apparatus as set forth in claim 1, wherein said advancing units comprise a plurality of upper advancing units and a plurality of lower advancing units, said other cap of each advancing unit being rotatable about a vertical axis with reference to said one cap and further comprising turning means for simultaneously rotating said other cap of each upper and each lower advancing unit through the same angle to thereby select the direction of forward movement of the apparatus.

16. Apparatus as set forth in claim 15, wherein said turning means comprises turning devices operative to turn said other cap of one of said upper and lower advancing units and motion transmitting means for turning the other caps of remaining upper and lower advancing units in response to operation of the respective turning devices.

17. Apparatus as set forth in claim 1, comprising a second prop aligned with said one prop in said horizontal direction, additional upper and lower advancing units mounted on the respective end portions of said second prop, and connector means securing said props to each other so that such props can be advanced as a unit in said horizontal direction.

18. Apparatus as set forth in claim 17, further comprising material evacuating conveyor means secured to said props for movement therewith in said horizontal direction.

19. Apparatus as set forth in claim 18, wherein the caps of each advancing unit are movable with reference to each other sideways substantially at right angles to said horizontal direction and further comprising displacing means for moving said other cap of each advancing unit sideways when the one cap engages said material and vice versa whereby said conveyor means is moved in response to sidewise movement of said one cap.

20. Apparatus as set forth in claim 18, wherein said conveyor means extends transversely between said props and is secured to said connector means.

21. Apparatus as set forth in claim 1, wherein said prop comprises a plurality of relatively movable portions and said operating means comprises first hydraulic cylinder means for moving said portions with reference to each other to thereby change the length of said props and to move said one cap of each advancing unit with reference to the adjoining material, additional hydraulic cylinder means for moving said other cap of each advancing unit with reference to the one cap, fluid conveying conduit means connected with said cylinders, and regulating means for controlling the admission, evacuation and pressure of fluid in said cylinders.

22. Apparatus as set forth in claim 21, wherein said regulating means comprises means for raising the fluid pressure in said additional cylinder means above the fluid pressure in said first cylinder means.

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