July 8, 1969 H. RIESCHEL 3,453,935

MINE ROOF SUPPORT SYSTEMS

Filed March 18, 1968 Sheet 1 of 2

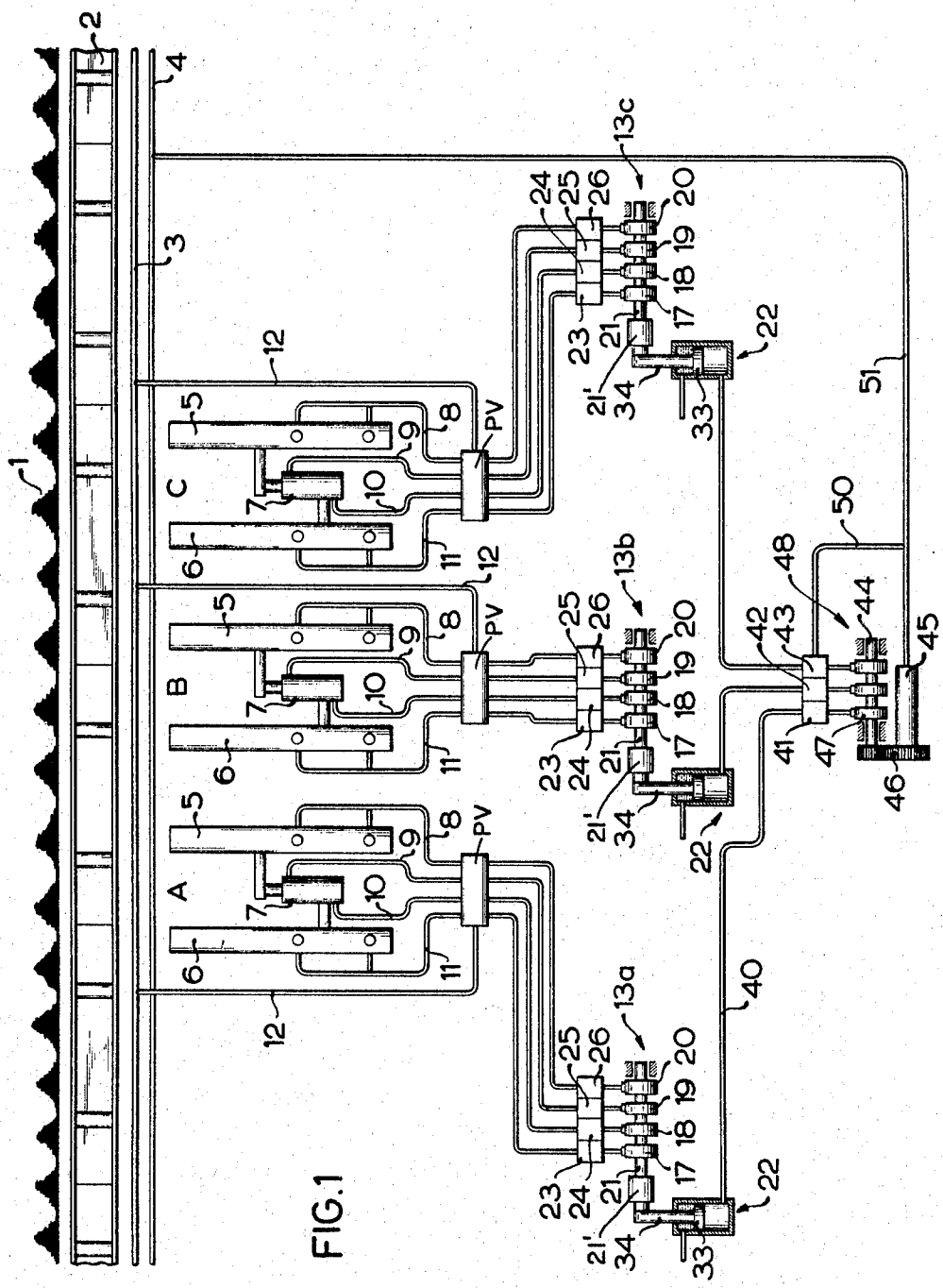


FIG.1

FIG. 2

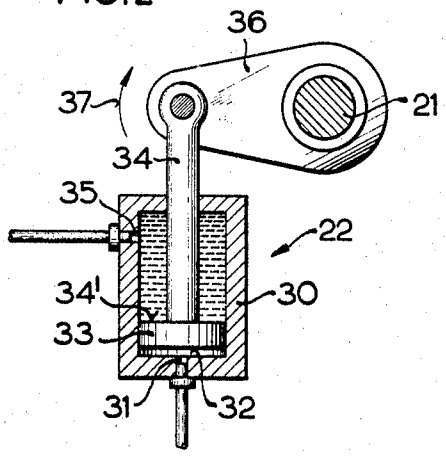


FIG. 3

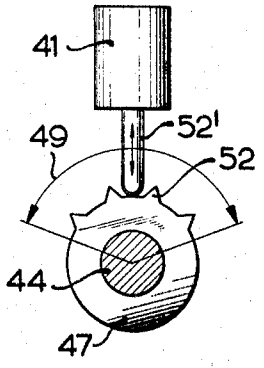


FIG. 4

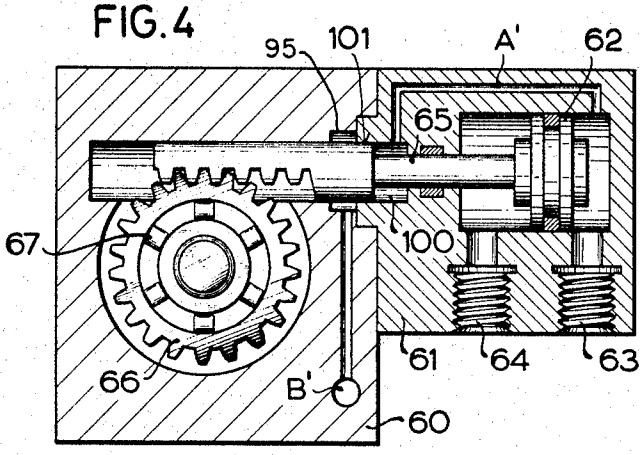


FIG. 5

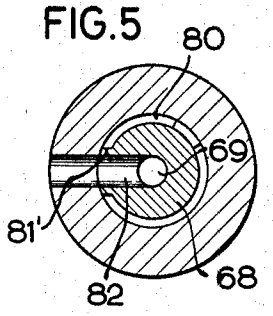
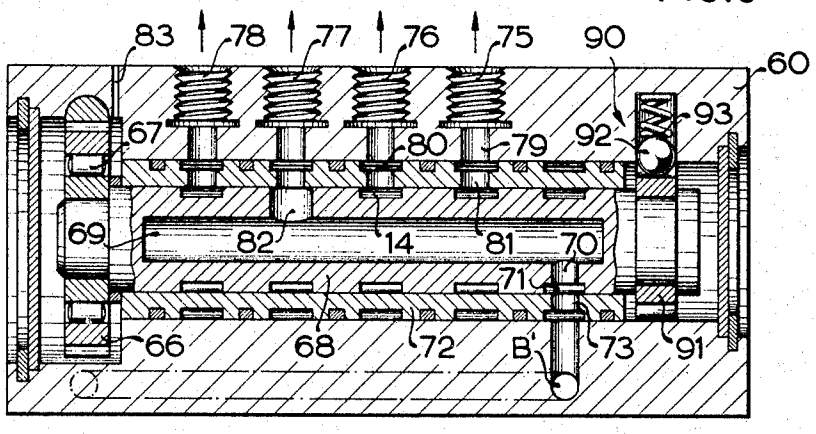


FIG. 6



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MINE ROOF SUPPORT SYSTEMS

Hans Rieschel, Essen-Kray, Germany, assignor to Bergwerksverband GmbH, Essen, Germany, a company of Germany

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Int. Cl. F01b *23/00;* E21d *23/04;* F02b *73/00*
U.S. Cl. 91—36 7 Claims

ABSTRACT OF THE DISCLOSURE

The specification describes a control system for self-advancing mine roof support units. The support units are each controlled by a set of primary valves which in turn are controlled by secondary valves whose operation is controlled by servo-motors. The servo-motors for a group of such roof support units are controlled by tertiary valves driven by a cam shaft or the like.

The present invention relates more particularly to the control of self-advancing mine roof support units and one particular object of the invention is to provide an improved control system in which the operations of the mine roof support units are brought about in accordance with a particular time sequence, as opposed to being interdependent with the advancing of one unit being initiated by a signal given by a neighbouring unit to indicate that the neighbouring unit has finished its advancing operation.

A general discussion of prior art control systems for mine roof support units, in particular in the case of long wall coal mining will be found in the article by Dr. Jacobi in Glückauf No. 101 (1965), vol. 14, pages 860–867.

The present invention consists in a control circuit for at least two self-advancing mine roof support units of which each unit comprises: at least two roof support frames which are provided with hydraulic roof support rams and are connected by an advancing ram, characterized in that the circuit comprises

(a) for each unit, primary fluid-operated valves for operating roof support rams and the advancing ram,
(b) for each of the units, a set of secondary valves arranged to operate the primary valves,
(c) for each set of secondary valves, a primary ganging device for causing sequential operation of the secondary valves,
(d) for each of the primary ganging devices, a fluid-operated servo-motor for operating the respective ganging device,
(e) tertiary valves for operating the servo-motors of the primary ganging devices,
(f) a secondary ganging device for operating the tertiary valves, and
(g) means for driving the secondary ganging device.

Each of the primary ganging devices and their servo-motors can be constituted by a cam shaft arranged to operate the respective set of secondary valves, a free wheel connected with the shaft, a double-acting fluid-operated cylinder and piston unit, one side of the piston being connected with one of the tertiary valves, while the other side of the piston is connected with a source of fluid under constant pressure.

Alternatively, in accordance with a further feature of the invention each of the secondary valves and their primary ganging means can be constituted by a multi-connection valve comprising a rotary plug or core with axially spaced ports in it, a casing with ports arranged to

come sequentially into coincidence with the ports of the core on rotation of the plug, and duct means for leading fluid under pressure into an axially extending cavity in the plug. The casing can comprise a bush and a body surrounding the bush.

The plug can have peripheral grooves which are arranged to serve for the release of fluid under pressure out of the ports in the casing, the ports in the plug being placed in lands forming interruptions in the grooves in the plug. In order to ensure that there is satisfactory mating between the ports in the casing and in the plug, respectively, the plug can be provided with detent means for holding it in different positions of rotation.

For rotating the plug use can be made of a fluid-operated servo-motor in the form of a piston and cylinder unit, the piston being arranged to open and close a port controlling the passage of fluid into the plug as the piston is moved.

The invention will now be described with reference to some embodiments of it as shown in the accompanying drawings.

FIG. 1 is a diagrammatic plan view of self-advancing mine roof support units and their fluid-operated control system.

FIG. 2 is a diagrammatic view of a servo-motor arranged to operate in steps and forming part of the control system.

FIG. 3 shows part of a cam and its associated valve.

FIG. 4 is an end-on view of a valve arrangement used in a second embodiment of the invention.

FIG. 5 is a longitudinal section of the valve shown in FIG. 4.

FIG. 6 is a section of part of the valve shown in FIGS. 4 and 5.

Referring now to the drawings and more specifically to FIG. 1, it can be seen that behind a coal front **1** there is a coal front conveyor **2** for transporting away coal cut by a plough or other implement reciprocated along the coal front so as to remove coal from it. Behind the conveyor **2** there is a main hydraulic power duct **3** and a low pressure air duct as is commonly provided in mines.

The roof support arrangement in the mine consists of hydraulic support units of which each consists of two frames of which two are indicated by reference numerals **5** and **6**. Each unit also comprises an advancing ram of the double-acting type for moving one frame forwards while the other is braced against the roof and then, when the frame just advanced has been braced against the roof and the other frame depressurized, drawing the latter forwards. Each unit comprises five rams, that is to say ram **7** and two roof support rams in each frame.

The five rams in each unit are connected with primary valves, denoted by general reference numeral PV by means of ducts **8**, **9**, **10**, and **11**. Each set of primary valves is supplied with high pressure hydraulic fluid from the hydraulic main duct **3** via a duct **12**. It can thus be seen that the units A, B, and C are connected in parallel and not in series in this respect.

The two ducts **8** and **11** serve for depressurizing and pressurizing the rams in the frames **5** and **6**, and the ducts **9** and **10** for supplying the two sides of the double-acting ram **7**. In operation, for advancing, one of the frames, **5**, is lowered by depressurizing its rams, the rear of the ram **7** is put under pressure so that its plunger is extended and the frame **5** is moved forwards, the frame **5** is raised against the roof again by pressurizing its rams and the front space of the ram **7** is put under pressure so that the cylinder of the ram is moved forwards together with the unit **6** which in the meantime has been depressurized. The performance of these steps in the correct time sequence is ensured by means of cam shaft **21**, with cams **17–20**,

denoted generally by reference numerals **13***a*, **13***b*, and **13***c* and referred to as primary ganging means. These ganging means form part of the respective units and operate secondary valves **23–26** by means of the cams **17–20**. The secondary valves **23–26** control flow to operate the primary valves of the units to which they belong by means of compressed air carried by ducts, the supply of compressed air from the compressed air line **4** to the secondary valves not being especially shown in the figure.

The cams **17**, **18**, **19**, and **20** are suitably off-set about the axis of the shaft **21** so as to bring about the desired timing of the operation of the secondary and primary valves and hence of the rams in the roof support units A, B, and C. For rotating it, each cam shaft **21** is provided with a servo-motor denoted by general reference numeral **22**. The motor consists of a cylinder **30** having at its bottom end a hole **31** for the admission of compressed air supplied by tertiary valve, to be described, from the compressed air duct **40**. This compressed air acts against the lower face **32** of a piston **33** having a piston rod **34** which emerges from the top end of the cylinder **30**. The top face **34'** of the piston is connected via an opening **35** in the cylinder with a source of liquid at constant pressure.

The piston rod **34** connected with the piston **33** moves a crank arm **36** which is connected with the cam shaft **21** via a free-wheel **21'**, as shown diagrammatically in FIG. 1. The shape and timing of the cams **17–20** on the cam shaft **21** is such that for one full stroke of the piston **33** in the cylinder **30** one of the secondary valves **23** to **26** is operated for part of an advancing movement of the associated roof support unit A (or B, or C as the case may be).

At the end of its stroke the piston **33** is caused to return by depressurization of the space below it and the action of the liquid above it entering through the opening **35**.

In order to drive the three servo-motors **22** shown in FIG. 1 there are provided the tertiary valves **41**, **42**, and **43** which are provided with compressed air via a duct **50** connected with the compressed air duct **4** via a duct **51**. The duct **51** also leads to a pneumatic drive motor **45** having a rotating shaft connected with a gear wheel **46** which is in mesh with a further gear wheel, not denoted by a reference numeral, fixed on a further cam shaft **44**. The latter constitutes a secondary ganging means and serves for the operation of the tertiary valves **41–43** by means of cams **47**.

As shown in FIG. 3 the cams **47** have projections **52** over the range denoted by the double arrow **49**. On turning the cam **47** through this range **49** the associated tertiary valve **41** is operated, via a cam follower **52'**, four times and this moves the piston **33** four times through its stroke from the bottom end of the cylinder **30** towards the top. The arrangement is such that when the cam follower **52'** is between two cam projections **52** the piston **33** and consequently the cam shaft **21** are in such positions that one of the primary valves is open and one of the rams in the associated roof support unit is being operated, that is to say liquid is flowing in or out of it.

FIGS. 4 to 6 show a further valve mehanism, constituting the primary ganging means and secondary valves, in accordance with a further embodiment of the invention.

The valve mechanism comprises a casing which is made up of a body **60** with a stationary cylindrical bush **72** mounted in it. The valve mechanism is operated by means of a ram **61**, see FIG. 4, having a piston **62** and connected by duct **63** with one of the tertiary valves **41–43**. The left-hand face of the piston **62** is connected via duct **64** with a braking medium. By means of its piston rod **65**, whose left-hand part is in the form of a rack, the piston **62** rotates a gear wheel **66** connected with a free-wheel mechanism **67**. The free-wheel is arranged to turn a plug or core **68** of the valve mechanism in one direction only, that is to say counter-clockwise in terms of FIG. 4. There is no rotation of the plug **68** on the return movement of the piston **62** to the right.

The plug **68** has a central duct **69** having a right-hand radial opening **70** which is connected with an annular peripheral groove **71** in the plug. The groove **71** is closed by means of the inner surface of stationary bush **72**. The bush **72** has a radial opening **73** which coincides with the opening **70** in the plug **68**. Duct B' is supplied with liquid under pressure and ends opposite opening **73**.

The plug **68** also comprises four ports **82** for making connection with connectors **75–78**. Since the ports **82** are similar and the arrangements connecting them with the respective connectors **75–78** are also, the following description, for the sake of convenience, refers only to the possibility of making one connection with one of the connectors **75–78**, though it must be understood that connection is in fact made with all of them.

The connector **77** is connected with a duct **79** passing through the body **60** and leading to an annular groove **80** in the bush **72**. Extending radially inwards from this groove there is a port **81** which, in the position shown in the drawing, coincides with port **82** leading to the interior of the plug **68**.

As can be seen from FIG. 5 the port **82** opens in the centre of a land **81'** forming an interruption in a groove **14**, which is consequently in the form of a C-shaped groove. A port, not shown, is provided in the bush **72** leading to the groove **14** for draining it. This port in the bush **72** is connected with a suitable waste duct, also not shown in the drawings.

Thus on rotation of the plug **68** the ports **82** are in turn brought into coincidence with the stationary ports **81** and liquid under pressure is forced into the connectors **75–78** to the primary valves PV in a suitable sequence for operation the roof support unit. When each port **82** has passed the corresponding port **81** in the bush **72** the port **81** is connected with the C-shaped groove **14** in the plug **68** so that liquid can be discharged to waste.

In order to hold the plug **68** in particular angular positions in which ports **82** coincide with ports **81**, a spring-loaded detent mechanism is provided generally denoted by reference numeral **90**. It has an indexing disc **91** with notch-like recesses for a ball **92**, which is loaded by means of a spring **93** so as to snap into the recesses as soon as the plug **68** has come into the position which is to be held by means of the detent. The piston **62** can exert sufficient force to turn the plug **68** against the restraining action of the ball **92** acted upon by the spring **93**.

As shown in FIG. 4 the liquid duct B' is connected with a port **95** opening onto a collar-like part at the right-hand end of the rack. When the piston rod **65** is moved to the left by the piston **62** under the action of liquid under pressure from the tertiary valve **41** it moves the collar so far that the right-hand end of the collar **101** uncovers the port **95** and connects it with a space **100** which is connected by a duct A' leading to the space at the right-hand end of the piston **62** and hence to the connector **63**. It will be noted that the body **60** and the block **61** in which the piston **62** is mounted are separate and held together by suitable means, not shown.

It will be seen from the described arrangement that the operation of the valve and hence the performance of the various operations concerned with advancing in each of the units A, B, and C, and also the sequence of operation of the units one after the other is established by the operation of the motor **45**, and there is no interdependence of operation. The connections between the secondary and tertiary valves are pneumatic, at least in the first embodiment of the invention, and this has certain advantages.

What I claim is:

1. In a control circuit for at least two self-advancing mine roof support units of which each unit comprises: at least two roof support frames which are provided with hydraulic roof support rams and are connected by an

advancing ram, the invention which consists in that the circuit further comprises:

(a) for each unit, primary fluid-operated valves for operating roof support rams and the advancing ram,

(b) for each of the units, a set of secondary valves arranged to control flow to operate the primary valves,

(c) for each set of secondary valves, a primary ganging device for causing sequential operation of the secondary valves,

(d) for each of the primary ganging devices, a fluid-operated servo-motor for operating the respective ganging device,

(e) tertiary valves for controlling flow to the servo-motors of the primary ganging devices,

(f) a secondary ganging device for operating the tertiary valves, and

(g) means for driving the secondary ganging device.

2. A control circuit in accordance with claim **1**, in which each of the primary ganging devices and their servo-motors comprise a cam shaft arranged to operate the respective set of secondary valves, a free-wheel connected with the shaft, a double-acting fluid-operated cylinder and piston unit, one side of the piston being connected with one of the tertiary valve means, while the other side of the piston is connected with a source of fluid under constant pressure.

3. A control circuit in accordance with claim **1**, further comprising, as each set of secondary valves and their primary ganging means, a multi-connection valve comprising a rotary plug or core with axially spaced ports, a

casing with ports arranged to come sequentially into coincidence with the ports of the core on rotation of the core, and duct means for leading fluid under pressure into an axially extending cavity in the core.

4. A control circuit in accordance with claim **3**, further comprising, as the casing, a bush and a body surrounding the bush.

5. A control circuit in accordance with claim **3**, in which the core has peripheral grooves which are arranged to serve for release of the fluid under pressure out of the ports in the casing, the ports in the plug being placed in lands forming interruptions in the grooves of the core.

6. A control circuit in accordance with claim **4**, comprising detent means for holding the plug in different positions of rotation.

7. A control circuit in accordance with claim **4**, comprising, as the fluid-operated servo-motor, a piston and cylinder unit, the piston being arranged to open and close a port controlling the passage of liquid into the plug as it is moved.

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EDGAR W. GEOGHEGAN, *Primary Examiner.*

U.S. Cl. X.R.

60—97; 61—45