United States Patent

Schmidt

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[54] HYDRAULIC CASING SYSTEMS IN MINE WORKINGS

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[51] **Int. Cl.** **E21c 35/24**, F15b 11/16, F15b 13/06

[58] **Field of Search** ..... 91/35, 170 MP, 189, 412; 1/36; 61/45.2

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[57] **ABSTRACT**

This invention provides a hydraulic casing system comprising automatically advancing casing structures which are connected together in groups in such fashion that in each group only one casing structure can move at once, although several casing structures in different groups can move at the same time, the casing structures being allocated individual control systems which are prepared for the advancing movement, or are locked, by elements which sense a freedom to advance, in particular by sensing elements which cooperate with the roof or sill of the seam or working, and is characterized by the fact that the individual control systems are incorporated in a logic system governing the selective advance of the different groups.

6 Claims, 4 Drawing Figures

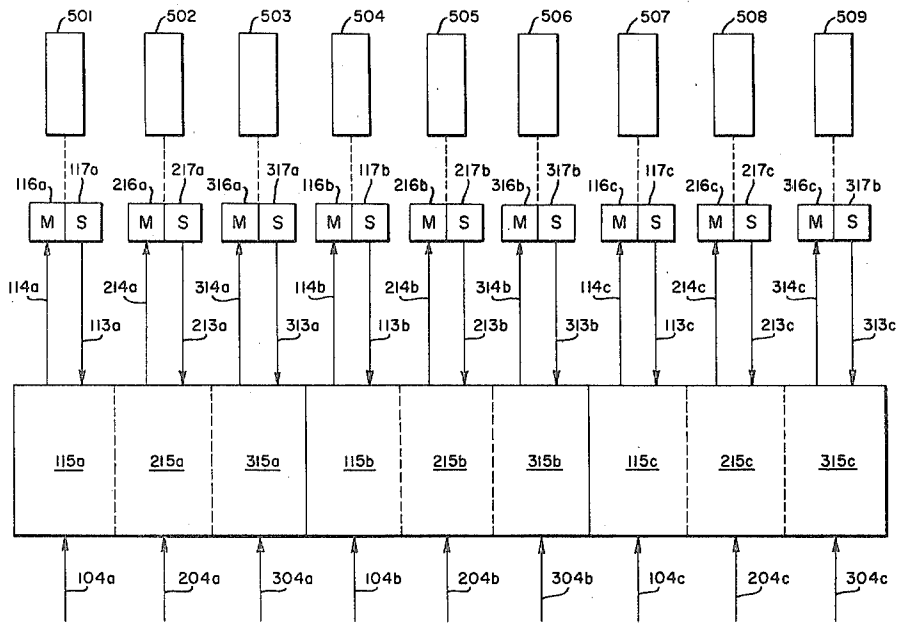
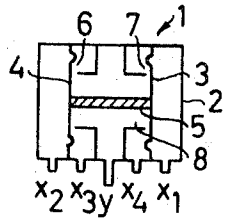
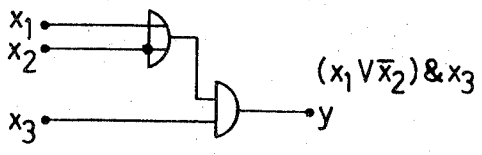
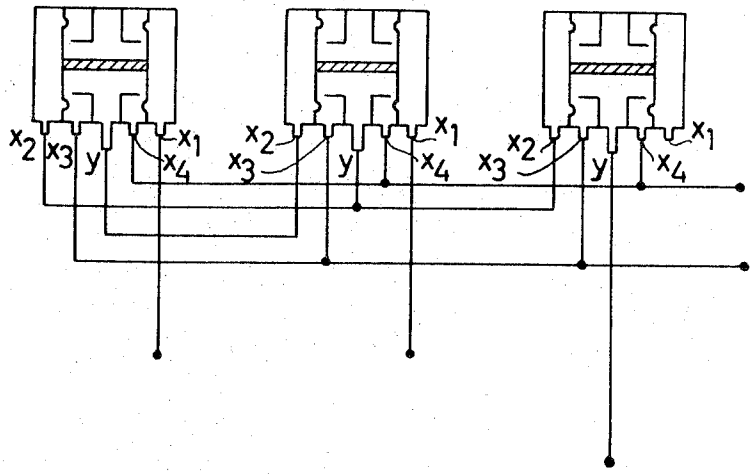
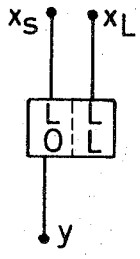


FIG. 1









$y = (x_S V y) \,\&\, \bar{x}_L$

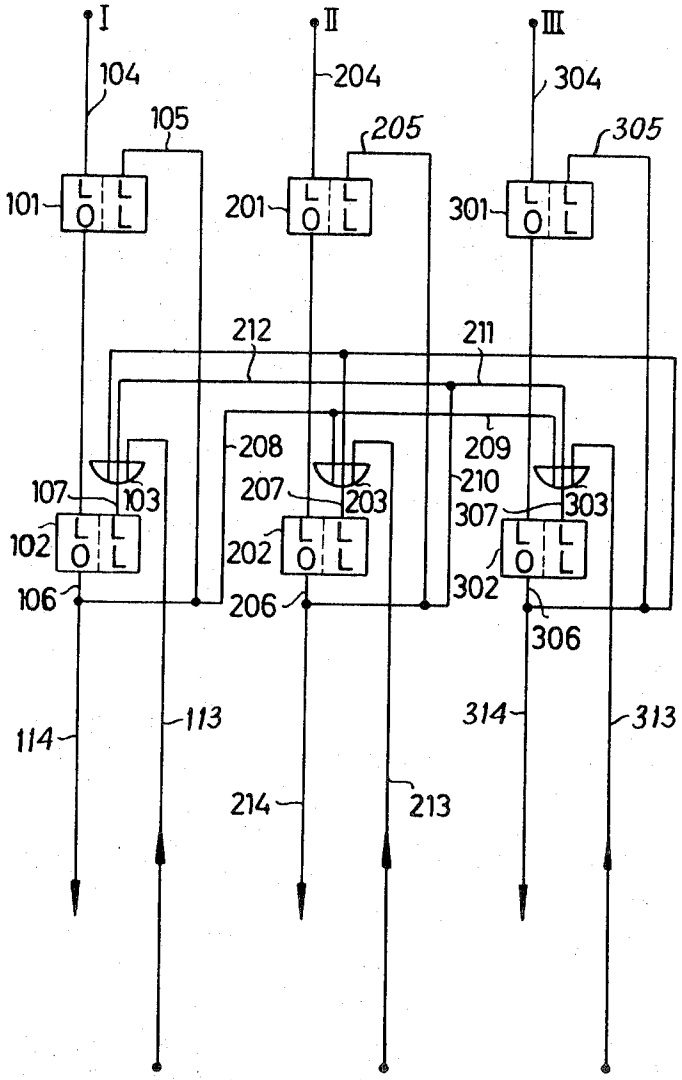
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FIG. 2



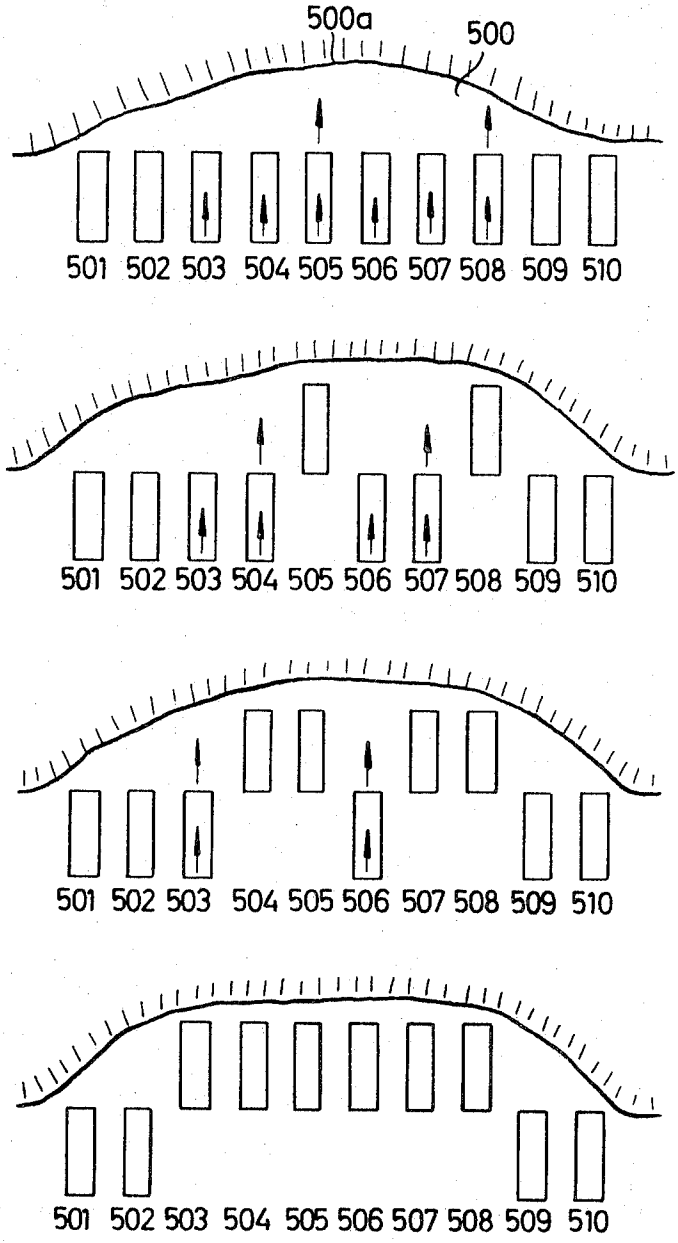
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FIG. 3



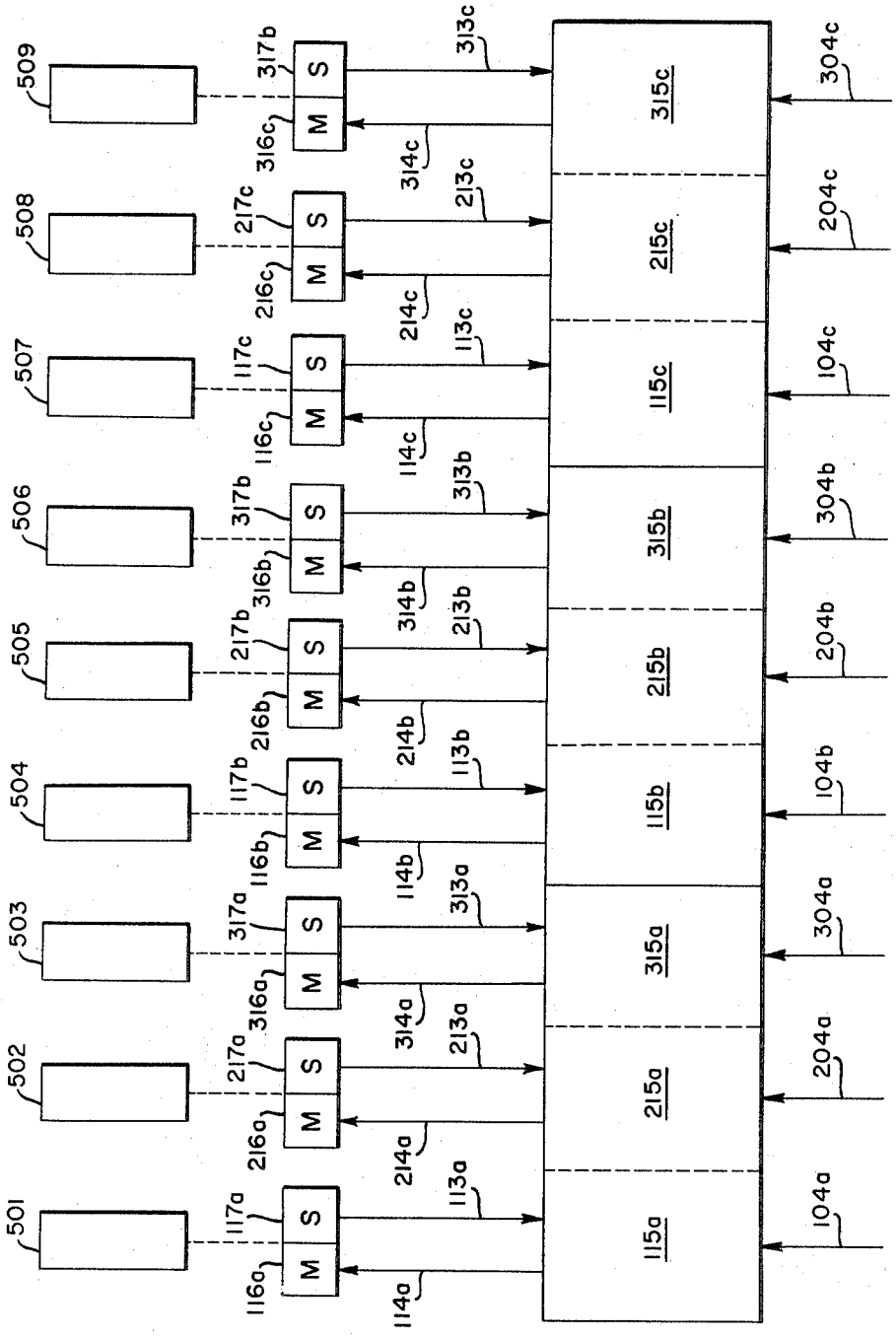
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FIG. 4



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HYDRAULIC CASING SYSTEMS IN MINE WORKINGS

BACKGROUND OF THE INVENTION

I. Field of the Invention

The control of a hydraulic casing system is intended on the one hand to ensure that support is not removed from the roof of the seam simultaneously by two or more neighboring casing structures, and on the other hand that the roof exposed by any advance, equivalent to the length of a full step or fraction thereof on the part of a casing structure, is immediately underpinned by the casing structure in question. It is only in this way that maximum safety of working can be achieved.

2. Prior Art

The group arrangement, within control systems of this kind, is a well known one. It has the advantage that several casing structures can feed forward simultaneously at the seam so that the rate of advance of the structures is increased and the roof of the working more rapidly underpinned than when using other control systems in which only one structure can advance at a time. In addition, it is also known to improve the operation of the casing systems by arranging for the structures to advance automatically, the group-associated control systems being for example independent units, so that as a result all the casing structures advance until the whole of the exposed roof zones of the working are cased. Then the casing is effective even when the seam is not being worked.

In the known automatic control systems, it has to be arranged that a casing structure which is not advancing prevents the transmission of an advancing or feed signal to a neighboring casing frame. To this end, in accordance with another of the known control systems, a stepping switch mechanism is employed as the group-associated control system, this mechanism applying a feed signal of specific duration and in a specific sequence to the control systems associated with each casing structure, and thus in effect sampling these structures so that a given casing structure either advances or remains stationary without impeding the advancing movement of neighboring casing structures. This stepping switch mechanism however, cannot for practical reasons be synchronized to prevent simultaneous feeding forward of neighboring casing structures respectively belonging to separate groups (i.e., at the junctions between groups). However, this kind of possibility must be excluded for safety reasons.

Another disadvantage of these control systems resides in the fact that the groups, of necessity, and not least in respect of the problems occurring at the junctions between them, have to be relatively extensive, i.e., have to cover more than three casing frames. Accordingly, the casing of roof areas which have suddenly been exposed (for example as a consequence of the collapse of extensive lengths of coal seam where there are no pit-props at the working face) takes too long.

OBJECT OF THE INVENTION

The problem with which the present invention is concerned is that of avoiding these drawbacks.

BRIEF SUMMARY OF THE INVENTION

The invention sets about resolving this problem by arranging for all the control systems associated with the various casing structures to be grouped into a logic system, and by locking each casing structure with at least two of the neighboring casing structures to form alternating groups.

By means of the invention, the earlier division of the casing system into fixed groups, i.e., permanently fixed, or fixed for protracted periods, in terms of their location in the seam, is obviated. Instead, due to the logic system, alternating groups (as far as their location in the seam is concerned and in terms of their readiness for advancing) are created and the number of casing structures within these alternating groups becomes an arbitrary matter and is determined in accordance with particular mining requirements, i.e., the stability of the earth through which the working is being driven, the advance on the face and so on, although in the most difficult circumstances likely to be encountered it is nevertheless possible to create groups of three since this minimum constitutes a particularly economical arrangement.

Rigid groups of three structures are indeed known; however in these known control systems there is no facility for preventing the simultaneous advancing of the casing structures located at the junction positions between such groups when it is desired to arrange for one structure in each of the groups to move or where the facility for this is provided. The logic system in accordance with the invention, however, excludes this possibility. Consequently, as many groups as desired can be provided in the seam and the requisite security against double movement at the junctions between groups is provided.

FURTHER FEATURES OF THE INVENTION

It is known, in relation to the prior art control systems mentioned at the beginning, to employ hydro-pneumatic control elements, so that consequently control systems of pneumatic kind can be regarded as known. Although the logic system in accordance with the invention could basically be operated either electrically or for that matter pneumatically and hydraulically, it is nevertheless the preferred course to use certain kinds of pneumatic systems, i.e., systems of the kind which are insensitive to pressure pulses of the kind occurring underground.

A system of this kind is known. Considering control of the hydraulic casing system, the advantage is then obtained of a very long operational life in the elements of which the system is formed, this operational life being measured in the order of 10^9 switching operations. Also, limitations on the component modules and switching operations which can be resorted to, are avoided, i.e., limitations of the kind which are inherent in electrical control systems because of the safety requirement.

Pneumatic logic systems are available whose basic modules can carry out the following logic function:

$$y=(\overline{x_1} \vee \overline{x_2})+\overline{x_3}$$

Using three such modules, a store can be built up which has a dominant inhibit function. The property of this store is that a signal applied temporarily to its information input is maintained at its output until the stored signal is inhibited (erased) by the application of another signal to the inhibit input, although in the case that both signals are applied simultaneously to the information input and the inhibit input, no output signal appears, i.e., the store does not switch through.

In accordance with a further feature of the invention, the switching operations required are carried out using storage elements of this kind in that, at the input of each control system associated with its respective casing structure, two series-connected dominant inhibit function stores are arranged, of which the input store is supplied at its information input with the signal preparing the advance of the casing structure and has its inhibit input taken to the output of the succeeding output store, the output store having its inhibit input supplied with locking signals from the neighboring casing structures via an OR-element, and its output supplying locking signals for the particular neighboring casing structures and a starting signal for the control system belonging to its own casing structure.

It is also convenient to arrange the circuit in such a fashion that the locking signal produced by the control system associated with the particular casing structure is applied to the inhibit side of the output store. The locking signal appears when the advancing phase has terminated, or when it cannot be executed.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be carried into practice in various ways but a practical example thereof will now be described with reference to the accompanying drawings, in which:

FIG. 1 is a sequence of schematic diagrams, the left-hand diagram in the top row indicating a pneumatic module and the right-hand diagram its logic function; in the row below is shown an assembly of the dominant inhibit function store from three of the modules illustrated in the topmost row; and in the bottom row is shown an abbreviated symbol designating the dominant inhibit function store and its logic function;

FIG. 2 schematically illustrates the locking circuit for three casing structures locked together in accordance with the present example, whose independent, associated control systems have however for the greater part been omitted; and

FIG. 3 illustrates, in four diagrams succeeding one another from the top downwards, an example of the advancing process taking place in the seam in the neighborhood of a largish exposed roof zone of irregular form.

FIG. 4 is an overall block diagram of a system according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the topmost illustration of FIG. 1, at the right-hand side is shown the logic function of a basic pneumatic module shown on the left-hand side. This basic module is in the form of a pneumatically operated double-diaphragm valve **1**. Two diaphragms **3** and **4** are accommodated in a housing **2** and these diaphragms are rigidly connected together at **5**. Each diaphragm is associated with an annular gap **6** or **7** as the case may be, created by the provision of an insert, and the annular gaps control the entry of air into the insert **8** or the discharge of air therefrom across x_4. The result is a total of four signal connections marked x_1 to x_3, and y. The number of inputs of the double-diaphragm valve **1** is indicated in the right-hand illustration, representing the logic combination.

Using three double-diaphragm valves of this kind, what is known as a dominant inhibit function store can be constructed. This is illustrated in the central row of FIG. 1. Since the combining lines to the five connections of each diaphragm valve **1** have been indicated and marked at their ends, it can be seen that the logic circuit of the store contains a signal input, an inhibit signal input and a signal output, and two additional lines have to be provided one of which serves an air-bleed function and the other to apply a pneumatic auxiliary medium.

In the bottommost row of FIG. 1, this dominant inhibit function store has been schematically illustrated on the left, the designations of the connections having been simplified, i.e.,

x_s = signal input

x_L = inhibit input

y = signal output.

The logic combination of the inputs and the output is indicated at the right-hand side in the bottommost row of FIG. 1. It can be seen from this that the dominant inhibit function store has the following property:

If a signal is applied to x_s for a short time only, a signal is maintained at the output y until an inhibit signal appears at x_L. On the other hand, if signals x_s and x_L are applied simultaneously, then no y signal appears, i.e., the store does not switch through.

The illustration of FIG. 2 must be imagined as continuing to both sides. The result is a logic circuit for covering all the casing structures at the seam in a mine working. In the circuit shown in FIG. 2 as an exemplary embodiment, in each case one casing structure, e.g., II, is locked to the other two, e.g., I and III. The casing structures can take the form of trusses, i.e., frameworks, which are linked together by feed cylinders, but may equally well be in the form of in-line frames, pit-props or individual frames, which are connected to the conveyor.

Each of the casing structures or frames is equipped with its own control system including at least one element which measures the distance advanced, in particular a sensing device cooperating with the roof and/or sill of the seam. Sensing devices of this kind are well known and therefore require no particular explanation here. Using these sensing devices, the control system can be set into readiness for the advancing movement, or can be locked.

In accordance with FIG. 2, at the input of the control systems (not shown in any detail) there are in each case two series-connected dominant inhibit function stores **101** and **102**, or **201**, **202**, or **301**, **302**. The input stores are those marked **101**, **201**, and **301**, whilst the succeeding output stores are those marked **102**, **202** and **302**.

Since, at this stage, the logic system in question has now been described in relation to each casing frame, we will now confine ourselves to a discussion of the system associated with casing frame II. The corresponding systems of casing frames I and III are given corresponding references.

The input store **201** is provided at its information side (signal input) with a line **204** which carries the signal preparing the frame for an advancing movement. The preparing signal is produced by the sensing device hereinbefore referred to. The inhibit side (inhibit input) is connected to a line **205** which leads to the output (signal output) **206** of the succeeding output store **202**. The output store **202** has its inhibit side **207** connected through an OR-element **203** to lines **208**, **209** in which locking signals appear, and emanating from the neighboring casing frames. The output **206** is also connected to a line **210** which, through lines **211**, **212**, supplies locking signals to the casing frames I and III. Finally, a line **213** supplies a signal coming from the control system of the casing frame itself and appearing at the end of the advance movement (or in the event that a prescribed advance is impeded). This line **213** also leads to the OR-element **203** and thus to the inhibit side of the output store **202**.

From the line **206**, i.e., the output **206** of the dominant inhibit function store **202**, a line **214** leads to the control system of the relevant casing frame, in which line the advance command triggering the control system appears.

Any signal indicative of "permission to advance", which comes from the sensing device and appears on say the line **204** at the signal input of the store **201**, is stored in the store **201** until the locking signals, applied by the OR-element **203** to the inhibit input **207** by the neighboring casing frames I and III, are suppressed. Then, the dominant inhibit function store **202** switches through and carries out the following operations:

First of all, through the line **214**, the command "advance" is passed through the line **204** to the control system of casing frame II. At the same time, the signal on the line **204** is erased through the line **205** leading to the dominant inhibit function input store **201**. Also, through the lines **212** and **211**, locking signals are applied to the inhibit side of the dominant inhibit function stores **103** and **303** of the neighboring casing frames I and III.

As soon as the casing frame II has ceased its advancing movement, there appears on the line **213** a signal which inhibits the signal on the line **214**. This cancels all the locks hitherto produced by the casing frame II.

By departure from the logic circuit illustrated and described hereinbefore in detail, it is also possible to determine the sequence in which the locks on the neighboring casing frames I and III are cancelled. This can be effected by signal-delay elements (throttles and volumes) incorporated into the locking lines **211**, **212**, or by additional dominant inhibit function stores, inserted between **201** and **202** and having corresponding locking lines. Furthermore, it is possible in this way to provide facility for modifying (during operation), the group length which is determined by the locking lines, this for example by switching from an "interlock of three" arrangement to an "interlock of five" arrangement.

This means that, when a casing frame has finished its advancing movement, one or other of the casing frames I and III, or casing frames which are not immediately adjacent but which are interlocked, will advance.

The casing process which is produced, in the presence of an irregularly exposed zone **500** of the roof of the working at a face **500***a*, is schematically illustrated in FIG. 3. Here, four phases can be detected and these have been illustrated consecutively from top to bottom in FIG. 3.

In order to simplify understanding, arrows are used in relation to the casing frames to indicate which of the frames have been prepared for advance, by their sensing devices, as explained hereinbefore. Arrows, above the rectangles depicting the casing frames, indicate that the particular frame is advancing and that the neighboring casing frames are locked.

In the example of FIG. 3, a total of ten casing frames **501** to **510** have been shown. The frames are grouped together in the manner indicated by the circuit of FIG. 2, to form a logic system.

As soon as the casing frames **503** to **508** have been prepared for advance, the question of which of the frames then actually advances and locks the neighboring frames, is a matter determined by the switching rate. In the first phase, the casing frames involved are those marked **505** and **508**. As soon as the frames **505** and **508** advance, they lock their neighbors in the aforedescribed fashion so that the frames **503**, **504** and **506**, **507**, which are also in the "prepared" condition, are prevented from advancing. The condition is then reached which is shown in the second illustration of FIG. 3. The frames **505** and **508** have completed their advancing movement and, by unlocking the frames **507** and **509**, as well as **506** and **504**, have left the latter free to advance themselves. This facility is detected by the frames **504** and **507**. Accordingly, they have locked the frames **506** and **508**, as well as the frames **503** and **505**.

In the third phase, therefore, the frames **504**, **505**, and **507** and **508**, have advanced, so that the frames **503** and **506** can now feed forward and in so doing lock the frames **502**, **504**, **505**, **507**, whilst the frames **501** and **508**, **509** and **510** are unlocked.

In a fourth phase, we have the condition shown in the bottommost illustration of FIG. 3, in which the roof exposed by the irregular working of the face is completely cased.

FIG. 4 illustrates a control system in which the logic circuitry is continuing to both sides for operating a plurality of automatically advancing casing structures **501** through **509**. A plurality of control systems **115***a*, **215***a*, **315***a*, **115***b*, **215***b*, **315***b*, **115***c*, **215***c*, and **315***c* are arranged respectively to control casing structures **501** through **509**. The control systems are arranged into a first group **115***a*, **215***a*, **315***a*, a second group **115***b*, **215***b*, and **315***b*, and a third group **115***c*, **215***c* and **315***c*, each group comprising a circuit as described and illustrated in connection with FIG. 2.

Associated with the respective control systems are sensing means **117***a*, **217***a*, **317***a*, **117***b*, **217***b*, **317***b*, **117***c*, **217***c*, and **317***c* for determining when its associated casing structure is nominally free to advance. Transmission lines **113***a*, **213***a*, **313***a*, **113***b*, **213***b*, **313***b*, **113***c*, **213***c*, and **313***c* are connected to provide input signals to the control systems from the sensing means. Transmission lines **114***a*, **214***a*, **314***a*, **114***b*, **214***b*, **314***b*, **114***c*, **214***c*, and **314***c* provide output signals from the control systems respectively to motive means **116***a*, **216***a*, **316***a*, **116***b*, **216***b*, **316***b*, **116***c*, **216***c* and **316***c* which operate to release and advance the associated casing structures.

It will be seen that the logic circuit which groups together the various control systems associated with the casing frames gives rise to groups of changing control which incorporate as many casing frames as is determined by the number of locking lines.

Finally, the prime advantage of the invention resides in the fact that small groups can be produced and accordingly any exposed roof region which may develop can be underpinned as soon as it occurs. This is a point of extreme significance where the necessary supporting of the roofs of all mine workings is concerned. Since, moreover, the logic system is continually operative, corrections to roof support are effected even when the extraction machinery is not working.

A substantial achievement of the invention resides in the fact that, at the junctions between the groups, it is ensured that two neighboring casing frames are inhibited from simultaneous advance. Consequently, at all times a selectable roof zone is exposed which is formed within the groups by one casing frame only. It is possible in this way to prevent the seam from collapsing in the neighborhood of the cased roof of the working.

A further advantage is the high advance frequency. If a casing frame is unable to advance because it is not receiving a signal from its sensing device, then it cannot lock and therefore another frame can immediately move, whereas with a fixed group system the next frame has to wait for the particular signal intended for it.

I claim:

1. In a hydraulic casing system for working a mine seam comprising: a plurality of automatically advanceable casing structures, a corresponding plurality of motive means for advancing respective casing structures, a corresponding plurality of sensing means for determining when respective casing structures are nominally free to advance, a corresponding plurality of control systems for the respective casing structures, and a plurality of transmission lines interconnecting said sensing means and said motive means with said control means for preparing said control systems when respective casing structures are nominally free to advance and for transmitting selective signals from said control systems to respective casing structures to release and advance the respective casing structures,

the improvement comprising; means interconnecting the casing structures and their associated control systems in groups for allowing only one casing structure in any one group to be released and advanced at one time, while several casing structures in different groups can be released and advanced simultaneously, said interconnecting means including a logic system into which all the casing structure control systems are incorporated and which includes, for each such casing structure control system, series-connected input and output dominant inhibit function stores, each of said stores comprising an information input terminal, an inhibit terminal and an output terminal, of which the input store is provided at its information terminal with a signal indicating preparedness for advance, and at its inhibit terminal is connected to the output terminal of the output store, the output terminal of the output store producing locking signals for the neighboring casing structures as well as a starting signal for the control system of its own casing structure, the output store having its inhibit terminal supplied through an OR gate with such locking signals fed from neighboring casing structures.

2. A hydraulic casing system according to claim 1, wherein the locking signal, supplied by the control system associated with the respective casing frame, is applied to the inhibit terminal of the output store.

3. In a hydraulic casing system for working a mine seam comprising: a plurality of automatically advancable casing structures, a corresponding plurality of motive means for advancing respective casing structures, a corresponding plurality of sensing means for determining when respective casing structures have open space into which to advance, a corresponding plurality of control systems for the respective casing structures, and a plurality of transmission lines interconnecting said sensing means and said control means for unlocking said control systems for operation when the corresponding casing structures have said open space and interconnecting said control means and said motive means for transmitting selective signals from said control means to release and advance respective casing structures,

the improvement comprising: means for interconnecting the casing structures and their associated control systems in groups and for allowing only one casing structure in any one group to be released and advanced at one time while allowing several casing structures in respectively different groups to be released and advanced simultaneously,

said interconnecting means including fluid-operated logic means for automatically causing, in any group, any otherwise uninhibited control system to advance its casing structure immediately when that casing structure has said

open space into which to advance, and with no predetermined sequence of allowing release and advancement of the casing structures.

4. A hydraulic casing system according to claim 3 wherein the logic means has the additional function of preventing the simultaneous advance of any two adjacent casing structures.

5. A hydraulic casing system according to claim 4 wherein said logic means comprises pneumatic combinational logic and data storage elements.

6. A hydraulic casing system according to claim 4 wherein said interconnecting means includes, for each casing structure control system, series-connected input and output dominant inhibit function stores, each of said stores comprising an information input terminal, an inhibit terminal, and an output terminal, of which the input store is provided at its information input terminal with a signal indicating preparedness for advance, and at its inhibit terminal is connected to the output terminal of the output store, the output terminal of the output store producing locking signals for the neighboring casing structures as well as a starting signal for the control system of its own casing structure, the output store having its inhibit terminal supplied through an OR gate with such locking signals fed from neighboring casing structures.

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