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(54) Improvements in and relating to long wall hydraulic supply systems

(57) A long wall hydraulic supply system and related controller, method and computer program product are provided. The long wall hydraulic supply system comprises a pump station (10) operatively coupled to a set of remote powered roof supports (22) to supply hydraulic fluid volume thereto via a hydraulic line. The system also comprises a pump station control unit (50). The pump station control unit (50) is operatively coupled to the pump station, and is arranged to control the pump station to supply hydraulic fluid volume to the powered roof supports (22) via the hydraulic line in response to activation signals received from the powered roof support activation controller (24). Using the activation signals in this way enables improvements in pump station control.

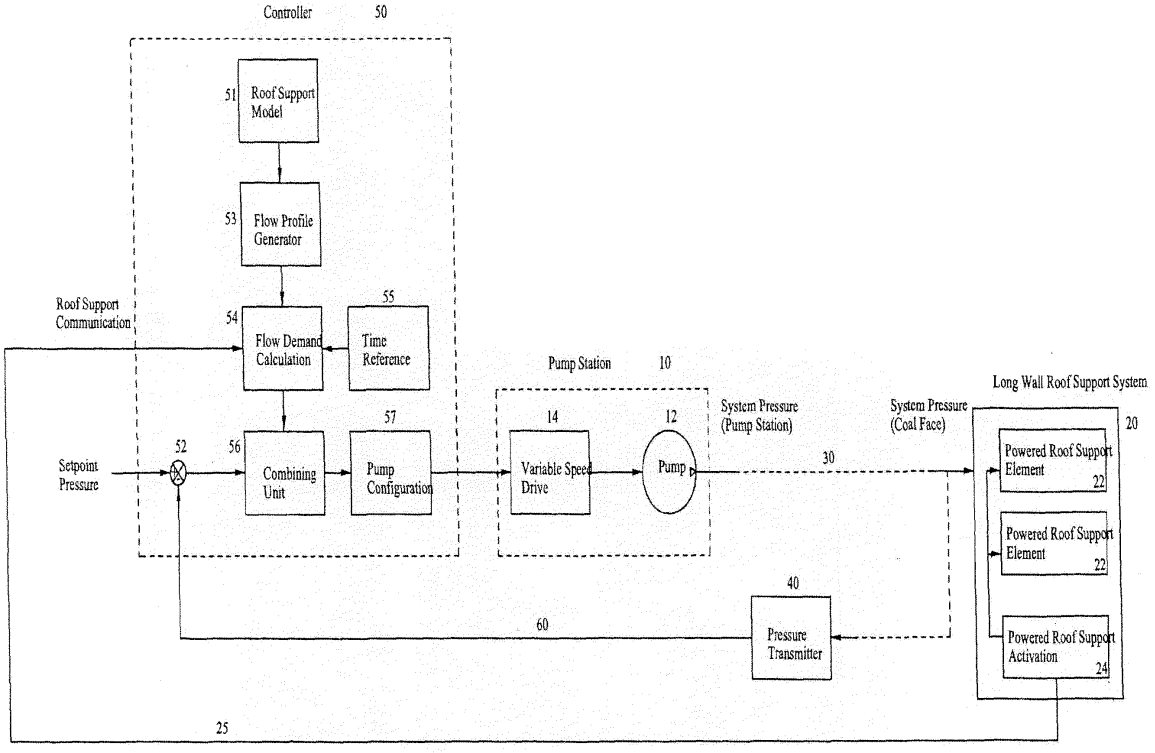

Figure 1 100

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Description

Field of the Invention

[0001] The present invention relates to long wall hydraulic systems, to controllers for use with the same, and to methods of operating the same.

Background to the Invention

[0002] Powered roof supports are electro-hydraulic structures used for supporting the roof of a mine, e.g. a long wall coal mine, in the region above a cutting machine working at the face. As the cutting machine moves across the face the powered roof support is called upon to deal with changes in roof load, and also to advance toward the face after the cutting machine has passed. The roof supporting and advancing operations are driven by hydraulic pressure provided by a remote hydraulic pump station, located away from the face and typically comprising a plurality of pumps. Typically a mine will comprise of a long wall hydraulic system that includes the pump station and a large number of powered roof supports, each powered roof support working as if independent of the others to perform load supporting and advancing operations across the face. The pump station is arranged to supply pressurised hydraulic fluid to all of the powered roof supports.

[0003] It is desirable to maintain a set pressure in the hydraulic system, and the pump station therefore typically comprises a pressure sensor. The pressure sensor at the pump station is used to control the pump station to raise pressure in response to a sensed pressure change at the pump station. However, each pump element at the pump station is constrained to operate at a fixed pumping capacity, and controlling the operation of the pump station to give a desired supply of fluid volume and therefore maintain a set pressure at the powered roof support system according to its varying operational demands is difficult. In particular, there is often a problem in ensuring that powered roof support demands are quickly and effectively met by pump station supply.

[0004] It is an aim of example embodiments of the present invention to address at least one disadvantage of the prior art, whether identified herein or otherwise.

Summary of the Invention

[0005] In a first aspect, the present invention provides a long wall hydraulic supply system comprising: a pump station; a pump station control unit; a hydraulic line; a powered roof support and a powered roof support activation controller, wherein the pump station is operatively coupled the powered roof support to supply hydraulic fluid thereto via the hydraulic line, and wherein the pump station control unit is operatively coupled to the powered roof support activation controller and to the pump station, and is arranged to control the pump station to supply hydraulic fluid to the powered roof supports via the hydraulic line at least in part in response to an activation signal received from the powered rood support activation controller and indicative of a change in activation status of the powered roof support.

[0006] Suitably, the powered roof support activation controller is part of the powered roof support. Suitably, the powered roof support activation controller is operative to change the activation status of the powered roof support. Suitably, the powered roof support activation controller is operative to change the activation status of the powered roof support to initiate a predetermined movement cycle of the powered roof support. Suitably, the long wall hydraulic system comprises a plurality of powered roof supports. Suitably, the pump station control unit is arranged to receive activation signals from a plurality of powered roof supports. Suitably, the activation controller is coupled to a plurality of powered roof supports, and is arranged to provide an activation signal associated with each powered rood support. Suitably, the or each powered roof support is arranged to be activated in a plurality of stages, with the pump station control unit arranged to control the pump station to supply hydraulic fluid to the powered roof support(s) via the hydraulic line at least in part in response to activation signals corresponding to change in activation status of each stage.

[0007] Suitably, the activation controller is operative to activate the powered roof support in stages. Suitably, the pump station control unit is arranged to control the pump station to supply hydraulic fluid to the powered roof support(s) in accordance with the expected demand of the powered roof support(s), with reference to activation signals for each of a plurality of stages of operation of the powered roof support. Suitably, each stage comprises activation of one of a sequence of movement operations of the powered roof support(s) in a predetermined movement cycle. Suitably, each stage comprises activation of one of a sequence of movement operations of a powered roof support within a group of the powered roof supports.

[0008] Suitably, the pump station control unit comprises a timer operative in response to the activation signal. Suitably, the pump station control unit is arranged to control the pump station to supply hydraulic fluid to the powered roof support(s) in accordance with the expected demand of the powered roof support over time, with reference to the timer.

[0009] Suitably, the pump station control unit comprises a powered roof support reference unit. Suitably, the powered roof support reference unit comprises a time-varying profile of the hydraulic fluid requirements of the or each powered roof support according to a predetermined movement cycle of the or each powered roof support.

[0010] Suitably, the pump station control unit comprises a flow profile generator unit. Suitably, the flow profile generator unit is arranged to produce a time-varying expected flow profile for operation of the powered roof support(s). Suitably, the flow profile generating unit is ar-

ranged to operate on information relating to a time-varying profile of the hydraulic fluid requirements of the powered roof support(s) according to a predetermined movement cycle of the powered roof support(s). Suitably, the flow profile generator unit is arranged to operate on information received from the powered roof support reference unit indicative of a time-varying profile of the hydraulic fluid requirements of the powered roof support(s) according to a predetermined movement cycle of the powered roof support(s).

[0011] Suitably, the pump station control unit comprises a fluid volume demand calculation unit. Suitably, the fluid volume demand calculation unit is arranged to operate on information from the flow profile generator unit to determine an instantaneous pump station output requirement according to the expected flow profile and an instantaneous hydraulic status of operation of the powered roof support(s).

[0012] Suitably, the powered roof support(s) each comprise a plurality of powered roof support elements. Suitably, powered roof support elements contribute to the time-varying fluid volume demand profile of the hydraulic operation of the powered roof support. Suitably, the pump station control unit comprises an input unit for entering powered roof support data, arranged to receive and store powered roof support data via a user interface such as a touch screen, control key pad or the like.

[0013] Suitably, the powered roof supports are in use arranged between a main gate end and a tail gate end of a face. Suitably, the long wall hydraulic supply system further comprises a hydraulic fluid pressure sensor. Suitably, the pressure sensor is arranged remote from the pump station. Suitably, the pressure sensor is operatively coupled to the pump station control unit. Suitably, the pump station control unit is arranged to control the pump station to supply hydraulic fluid to the powered roof support via the hydraulic line at least in part in response to a pressure signal received from the pressure sensor.

[0014] Suitably, the pressure sensor is located proximate to the tail gate end of the face. Suitably, the pressure sensor is located centrally between the main gate end of the face and the tail gate end of the face. Suitably, the pressure sensor is located proximate to the main gate end of the face. Suitably, the pressure sensor is located at the powered roof support.

[0015] Suitably, the pump station control unit comprises a set point pressure input unit, arranged to receive and store a set pressure that the pump station is intended to provide. Suitably, the pump station control unit is arranged to cause the pump station to supply a varying volume of hydraulic fluid to the powered roof support(s) at least in part according to variation in the pressure signal, by controlling operation of one or more pumps in the pump station. Suitably, the pump station control unit comprises part of a negative feedback loop. Suitably, the pump station control unit comprises part of a negative feedback loop that aims to maintain the set point pressure at the pressure sensor by controlling operation of the pump station in response to variation in the pressure signal.

[0016] Suitably, the pump station control unit comprises a combining unit arranged to receive information relating to an expected pressure requirement based on the activation signal, and to receive information relating to a current pressure, and to combine these pieces of information for use in driving the pump station. Suitably, the combining unit is arranged to receive information relating to an expected pressure requirement based on the activation signal, and to receive information relating to a current pressure, and to combine these pieces of information to produce a pump control signal.

[0017] Suitably, the pump station comprises one or more pumping elements coupled to variable speed drives. Suitably, the pump station control unit comprises a pump configuration modelling unit. Suitably, the pump configuration modelling unit is arranged to generate a pump control signal according to a fluid volume demand and according to the pumping volume rating and/or status of operation of pump(s) and drive(s) in the pump station. Suitably, the pump station control unit is arranged to output a final pump control signal for supply to the pump station based on a pump control signal received from the combining unit.

[0018] Suitably, the pump station control unit is arranged to control a plurality of pumping elements within the pump station. Suitably, the pump station comprises one or more positive displacement pumping elements. Suitably, one or more of the pumping elements in the pump station are driven by a variable speed drive. Suitably, the pump station control unit is operatively coupled to a variable speed drive to control operation of a positive displacement pumping element to supply a varying volume of hydraulic fluid to the powered roof supports in response to the powered roof support activation signal (s) and/or the variation in the remote pressure signal. Suitably, the pump station control unit is arranged first to cause one or more primary pumping elements to be driven, and then secondly to cause additional pumping elements to be simultaneously driven, in response to the activation signals and/or the variation in the remote pressure signal. Suitably, the primary pumping elements are arranged in a group including a master pump and a secondary pump. Suitably, the primary pumping elements are arranged in a group including a master pump, a secondary pump and a tertiary pump. Suitably, the pumps in the group of primary pumping elements are driven by a variable speed drives. Suitably, the one or more additional pumping elements are driven by a direct on line drive.

[0019] Suitably, the pump station control unit is operatively coupled to the remote pressure sensor and to the pump station by a wired, or wireless connection. Suitably, the pump station control unit is operatively coupled to the powered roof support controller by a wired, or wireless connection.

[0020] In a second aspect, the present invention pro-

vides a pump station control unit for use with a long wall hydraulic supply system comprising: a pump station operatively coupled to a powered roof support to supply hydraulic fluid thereto via a hydraulic line; the pump station control unit arrangeable in use to control the pump station to supply hydraulic fluid to the powered roof support via the hydraulic line at least in part in response to an activation signal indicative of a change in activation status of the powered roof support.

[0021] Suitably, the pump station control unit is arrangeable in use to control the pump station to supply hydraulic fluid to a plurality of the powered roof supports via the hydraulic line at least in part in response to an activation signal indicative of a change in activation status of the powered roof supports. Suitably, the pump station control unit comprises an activation signal input unit arranged to receive an activation signal from a powered roof support(s).

[0022] Suitably, the pump station control unit comprises a timer operative in response to the activation signal. Suitably, the pump station control unit is arranged to control the pump station to supply hydraulic fluid volume to the powered roof support(s) in accordance with the expected hydraulic fluid volume demand of the powered roof support(s) over time, with reference to the timer.

[0023] Suitably, the pump station control unit comprises a powered roof support reference unit. Suitably, the powered roof support reference unit comprises a time-varying profile of the hydraulic fluid volume requirements of the powered roof support(s) according to a predetermined movement cycle of the powered roof support(s).

[0024] Suitably, the pump station control unit comprises a flow profile generator unit. Suitably, the flow profile generator unit is arranged to produce a time-varying expected flow profile for operation of the powered roof support(s). Suitably, the flow profile generating unit is arranged to operate on information relating to a time-varying profile of the hydraulic fluid volume requirements of the powered roof support(s) according to a predetermined movement cycle of the powered roof support(s). Suitably, the flow profile generator unit is arranged to operate on information received from the powered roof support reference unit indicative of a time-varying profile of the hydraulic fluid volume requirements of the powered roof support(s) according to a predetermined movement cycle of the powered roof support(s).

[0025] Suitably, the pump station control unit comprises a fluid volume demand calculation unit. Suitably, the fluid volume demand calculation unit is arranged to operate on information from the flow profile generator unit to determine an instantaneous pump station output requirement according to the expected flow profile and an instantaneous hydraulic status of operation of the powered roof support(s).

[0026] Suitably, the pump station control unit comprises a set point pressure input unit arranged to receive a set point pressure. Suitably, the pump station control unit comprises a pressure input unit arranged to receive a pressure signal.

[0027] Suitably, the pump station control unit comprises a subtraction operator to determine a difference between the set point pressure and a received pressure signal.

[0028] Suitably, the pump station control unit comprises a combining unit arranged to receive information relating to an expected pressure requirement based on the activation signal, and to receive information relating to a current received pressure, and to combine these pieces of information to drive the pump station based on the combination. Suitably, the combining unit is arranged to receive information relating to an expected pressure requirement based on the activation signal, and to receive information relating to a current pressure, and to combine these pieces of information to produce a pump control signal.

[0029] Suitably, the pump station control unit comprises a pump configuration modelling unit. Suitably, the pump configuration modelling unit is arranged to generate a pump control signal according to a fluid volume demand and according to the pump volume rating and/or status of operation of pump(s) and drive(s) in the pump station. Suitably, the pump station control unit is arranged to output a final pump control signal for supply to a pump station based on a pump control signal received from the combining unit.

[0030] Suitably, the pump station control unit comprises an output interface for coupling to the pump station.

[0031] Suitably, the pump station control unit is arranged to operate as the pump station control unit of the first aspect described above.

[0032] In a third aspect, the present invention provides a method of operating a long wall hydraulic supply system comprising: a pump station operatively coupled to a remote powered roof support to supply hydraulic fluid thereto via a hydraulic line; and a pump station control unit, the method comprising: receiving an activation signal indicative of a change in status of the powered roof support; and controlling the pump station at least in part in response to the activation signal received from the powered roof support.

[0033] Suitably, the method further comprises determining an expected time varying fluid volume demand requirement for the powered roof support according to predetermined characteristics of the powered roof support system, and controlling the pump station at least in part in line with the expected time varying fluid volume demand requirement.

[0034] Suitably, the method comprises controlling the pump station according to a combination of a sensed system pressure and an expected time varying pressure requirement.

[0035] Suitably, the powered roof support system further comprises a remote pressure sensor located local to the powered roof supports, and therefore remote from the pump station, and the method further comprise controlling the pump station at least in part in response to a

remote pressure signal generated by the remote pressure sensor.

[0036] Suitably, the method comprises receiving and storing a set point pressure. Suitably, the method comprises determining a difference between the set point pressure and a sensed system pressure. Suitably, the method comprises supplying a control signal to the pump station to cause the pump station to match the sensed system pressure with the set point pressure. Suitably, the method comprises a feedback control method.

[0037] Suitably, the method comprises determining a current pump station operating status, and controlling the pump station to change its operating status consistent with a predetermined model including detail of the pumping capacity and the current pump station operation status.

[0038] Suitably, the method comprises operating a pumping element comprising part of a group of primary pumping elements using a variable speed drive to account for variations in the demand of hydraulic fluid volume. Suitably, the method comprises simultaneously operating an additional pumping element using a direct on line drive to cater for a base demand of hydraulic fluid volume.

[0039] In a fourth aspect, the present invention provides a computer program product, recorded on a machine-readable data carrier, and containing instructions arranged, when loaded on a suitable computing platform to perform a method according to the third aspect of the present invention.

[0040] According to the present invention there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

Brief Introduction to the Figures

[0041] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 shows a schematic illustration of a long wall hydraulic system according to an example embodiment of the present invention;

Figure 2 shows a schematic illustration of a pump station control unit for a long wall hydraulic supply system according to an example embodiment of the present invention;

Figure 3 shows a schematic flow diagram illustrating a method of operating a powered roof support system according to an example embodiment of the present invention; and

Figure 4 shows a group of machine-readable carriers containing instruction thereon, each machine-readable carrier in the group according to an example embodiment of the present invention.

Description of Example Embodiments

[0042] Example embodiments of the present invention will be described in detail with reference to the accompanying drawings. Referring now to Figure 1 there is shown a long wall hydraulic supply system 100 comprising: a pump station 10 operatively coupled to a set of remote powered roof supports 20 to supply hydraulic fluid thereto via a hydraulic line 30.

[0043] The powered roof supports comprises a number of independently actuatable powered roof support elements 22, all coupled to the hydraulic line 30. The powered roof support system also contains an activation controller 24 that is operatively coupled to the powered roof supports and their elements 22. The pump station 10 comprises a pump 12 and a drive 14 to actuate the pump 12. A remote pressure sensor 40 is located in the hydraulic line 30 at a position remote from the pump station 10. A pump station control unit 50 is operatively coupled to the remote pressure sensor 40 over a wired or wired less link 60, to the activation controller 24 over a wired or wired less link 25 and to the pump station 10, and is arranged to control the pump station 10 to supply hydraulic fluid volume to the powered roof supports 20 via the hydraulic line 30. In this document, "remote" means away from the pump station 10, and includes locations at or proximate to the powered roof support 20.

[0044] The long wall hydraulic supply system 100 operates such that the pump station control unit 50 causes the pump station 10 to supply hydraulic fluid to the powered roof support at least in part based on knowledge of a predetermined operation cycle of the powered roof support 20. The activation controller 22 activates one or more of the powered roof support elements 22 and also provides the pump station control unit with the activation signals over the link 25. In response to the activation signals the pump station control unit 50 is arranged to try to match the pump station fluid volume output to the expected fluid volume demand of the powered roof supports 20. Matching of the expected demand may also be combined with feedback control, such that the pump station control unit 50 compares the remote pressure signal with a set point pressure, and controls the pump station 10 to try to maintain the set point pressure at the powered roof support 20 despite changes in pressure caused by changes in loading of and operation of the powered roof supports 20. The feedback control operation of the pump station control unit is illustrated schematically by the subtraction operator 52 shown in the pump station control unit 50. The set point pressure is determined according to the load rating of the powered roof support 20, which itself is a dependent on the characteristics of the installation in which the powered roof support system 100 is

to operate. The set point pressure is received and stored at a set point pressure input unit of the pump station control unit 50, for example in response to user input.

[0045] In this way the pump station control unit 50 is able to accurately match the output of the pump station 10 to variations in requirement for hydraulic fluid volume of the powered roof supports 20. Operation of the pump station can be more smoothly controlled, leading to fewer instances of peak operation. Furthermore, when the powered roof support comprises a number of powered roof support elements and/or operates in a number of stages at variable time intervals the pump station control unit receives and processes the activation signals accordingly, meaning that the pump station control method is adaptive to a required change in cycle time of each powered roof support.- For example, if the linear travelling speed of the shearer across the face increases, it will reduce the cycle time for each powered roof support. However, the pump station control unit responsive to each activation signal derived from the increased linear travelling speed of the shearer is able effectively to match the demand from the powered roof supports.

[0046] Providing a remote sensor at the powered roof support can enable the pump station control unit to provide an improved response over systems that measure the pressure at a point close to the pump station. The feedback from the pressure sensor to the pump station is not distorted by factors such as losses in a long run of hydraulic hose between the pump station and the powered roof support, or a mis-match in the capacity of the hydraulic hose and the capacity of the pump station for fluid delivery. A wired or wireless connection between the remote pressure sensor and the pump station control unit, such as a connection 60 shown in Figure 1, can be made more robust and accurate than operating the pump station control unit solely based on sensed pressure at the pump station in combination with unknown and possibly variable characteristics of the hydraulic coupling between the pump station and the powered roof support.

[0047] Further details of the configuration and operation of the pump station control unit are provided below.

[0048] The pump station control unit 50 comprises a timer 55 operative in response to the activation signal received from the powered roof support. The timer 55 is used by the pump station 50 controller to match the time of operation of the pump station to the expected demand. The expected demand is based on a model stored in the pump station control unit 50. The pump station control unit 50 comprises a powered roof support reference unit 51 including a time-varying profile of the hydraulic fluid volume requirements of the powered roof supports 20. This profile is predetermined according to a predetermined movement cycle of the powered roof supports 20.

[0049] The pump station control unit 50 further comprises a flow profile generator unit 53. The flow profile generator unit 53 is arranged to evaluate and produce a time-varying expected flow profile for operation of the powered roof supports. The flow profile generating unit 53 operates on information derived from the time-varying profile of the hydraulic fluid volume requirements of the powered roof supports according to a predetermined movement cycle of the powered roof support. The flow profile generator unit 53 operates on information received from the powered roof support reference unit that is indicative of a time-varying profile of the hydraulic fluid volume requirements of the powered roof supports according to a predetermined movement cycle of the powered roof support.

[0050] The pump station control unit 50 still further comprises a flow demand calculation unit 54. The flow demand calculation unit 54 is arranged to operate on information from the flow profile generator unit 53, and from activation signals from the roof support controller 24 received via link 25, to determine an instantaneous pump station output requirement according to the expected flow profile and an instantaneous status of operation of the powered roof support.

[0051] The pump station control unit further comprises a pump configuration modelling unit 57. By monitoring the pump station status and by modelling of pump station characteristics further improvements are provided. The pump station control unit 50 is arranged to improve response to the variable demand for hydraulic fluid volume supply from the pump station 10. Typically the pump 12 and drive 14 are provided as multiple pumping and driving elements. The pump station control unit 50 is arranged in such example embodiments individually to control a plurality of pumping elements within the pump station 10 to provide a desired overall output.

[0052] Typically, the pumping elements may include positive displacement pumps driven by a direct on line drive. In some example embodiments of the present invention one or more of the pumping elements in the pump station are suitably driven by variable speed drives. The pump station control unit 50 is arranged first to cause the primary pumping element to be driven, for example by a variable speed drive to respond quickly and efficiently to a change in demand according to the remote pressure signal, and then secondly to cause one or more further pumps to be driven in addition to the primary pump, for example by a direct on line drive to provide a base pumping capacity.

[0053] This principle can be extended so that the pump station control unit 50 is arranged to manage a plurality of pumping elements driven by variable speed drives. This allows greater variability of supply, which in turn can be advantageous in allowing the pumps to operate away from their maximum capacity ratings for more of the time in response to varying demand. The pump station in example embodiments suitably also includes a local pressure sensor (not shown) as a safety feature to prevent over-pressuring the system.

[0054] To coordinate the pump station control unit in generation of the input to the pump configuration modelling unit 57 a combining unit 56 is provided. The combining unit 56 is arranged to receive information relating

to an expected pressure requirement based on the activation signal, and to receive information relating to a current remote pressure, and to combine these pieces of information for use in driving the pump station, through the pump configuration modelling unit 57. The combining unit 56 receives information relating to an expected pressure requirement based on the activation signal from the flow demand calculation unit 54, and to receive information relating to a current remote pressure from the subtraction operator 52, and to combine these pieces of information to produce its output. The combining performed by the combining unit 56 is for example based on a summation. Another way that the combining unit may operate is to act in response to the remote pressure signal only in circumstances when the sensed pressure is outside of a prederemined range.

[0055] Figure 2 shows a schematic illustration of the pump station control unit 50 for a long wall hydraulic supply system according to an example embodiment of the present invention. The pump station control unit 50 comprises a set point pressure input unit 501 arranged to receive a set point pressure and a remote pressure input unit 502 arranged to receive a remote pressure signal. The pump station control unit further comprises an activation signal input unit 505. The set point pressure and remote pressure signal are compared in the controller 50 as schematically represented by the subtraction operator 52, with the results of the comparison passed to the combining unit 56. The combining unit 56 also receives signals via the activation signal input unit 505 and operated on according to the predetermined powered roof support reference model, flow profile and flow demand units 51, 53-55. The output of the combining unit 56 is passed to a pump configuration modelling unit 57.

[0056] As described above, the pump configuration modelling unit 57 stores information relating the pressure difference to characteristics of the pump 12 and drive 14. The pump configuration modelling unit 57 and provides an output interface 503 for controlling a pump station, e.g. by providing a signal to a drive coupled to a pump.

[0057] Figure 3 shows a schematic flow diagram illustrating a method of operating a long wall hydraulic supply system according to an example embodiment of the present invention. At step S101 the pump station control unit is arranged to receive and store activation signals indicative of a current activation status of the powered roof support. At step S102 the expected fluid volume requirements are determined based on the activation signals received at step S101 and knowledge of the expected powered roof support demand. At step S103 a set point pressure is determined, based on information provided at a user interface such as a touch screen, keyboard, control panel or the like. At step S104 remote pressure sensor information is received at the pump station control unit. The pump station control unit then determines the difference between the set point pressure and the remote pressure signal to determine a pressure error at step S105. The pump station control unit then determines the current status of the pump station at step S106 and then transforms the pressure error, pump configuration and expected fluid volume requirements into a control signal for the pump station, before supplying the control signal to the pump station in steps S107.

[0058] The method of Figure 3 may be described as machine readable program instructions provided on a data carrier 200 such as the example data carriers 200 shown in Figure 4. The carriers 200 comprise a machine-readable optical disc, a Universal Serial Bus (USB) memory stick, and an application specific solid state memory device.

[0059] By enabling more accurate control and increasing pump station efficiency as above, it is possible to improve the availability of hydraulic fluid at the a powered roof supports, which in turn enables increased speed of response and therefore operation. Increased speed of operation of powered roof supports is a major advantage in mining operations. Similarly, since the invention as described is responsive to activation of a powered roof support it can be easily turned into an adaptive method that can work well despite changes in timing of demand from multiple powered roof support elements.

[0060] The present invention will be understood readily by reference to the above description of example embodiments and the accompanying drawings. The present invention may, however, be embodied in many different forms and should not be construed as being limited to the example embodiments described above. Rather, these embodiments are provided so that this disclosure will be thorough and complete and will fully convey the concept of the invention to those skilled in the art. The present invention is defined by the statements of aspects of the invention in the summary of invention section above, and with reference to any appended claims.

[0061] The example embodiments are described above with reference to flowchart illustrations, methods, and computer program products. It is to be understood that each block of the flowchart illustrations, and combinations of blocks in the flowchart illustrations, can be implemented by computer program instructions. These computer program instructions can be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions specified in the flowchart block or blocks.

[0062] These computer program instructions may also be stored in a computer usable or computer-readable memory or data carrier that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer usable or computer-readable memory or data carrier produce an article of manufacture including instruction means that implement the function specified in the flowchart block or blocks.

[0063] The computer program instructions may also be loaded into a computer or other programmable data processing apparatus to cause a series of operational steps to be performed in the computer or other programmable apparatus to produce a computer implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

[0064] And each block of the flowchart illustrations may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that in some alternative implementations, the functions noted in the blocks may occur out of the order. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved.

[0065] The term "module" or "unit", as used herein, means, but is not limited to, a software or hardware component, such as a Field Programmable Gate Array (FPGA) or an Application Specific Integrated Circuit (ASIC), which performs certain tasks. A module or unit may advantageously be configured to reside in an addressable storage medium and configured to execute on one or more processors. Thus, a module or unit may include, by way of example, components, such as software components, object-oriented software components, class components and task components, processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables. The functionality provided for in the components, units and modules may be combined into fewer components, units and modules or further separated into additional components, units and modules.

[0066] Although a few preferred embodiments have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

[0067] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0068] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0069] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0070] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A long wall hydraulic supply system comprising: a pump station; a pump station control unit; a hydraulic line; a powered roof support and a powered roof support activation controller, wherein the pump station is operatively coupled the powered roof support to supply hydraulic fluid thereto via the hydraulic line, and wherein the pump station control unit is operatively coupled to the powered roof support activation controller and to the pump station, and is arranged to control the pump station to supply hydraulic fluid to the powered roof supports via the hydraulic line at least in part in response to an activation signal received from the powered rood support activation controller and indicative of a change in activation status of the powered roof support.

2. The long wall hydraulic supply system of claim 1, comprising a plurality of powered roof supports, and wherein the pump station control unit is arranged to receive activation signals from the plurality of powered roof supports, each activation signal associated with initiation of a predetermined movement cycle of a powered roof support.

3. The long wall hydraulic supply system of claim 1 or 2, wherein the pump station control unit comprises a timer operative in response to the or each activation signal, wherein the pump station control unit is arranged to control the pump station to supply hydraulic fluid to the powered roof support(s) in accordance with the expected demand of the powered roof support(s) over time, with reference to the timer.

4. The long wall hydraulic supply system of claim 1, 2 or 3, wherein the pump station control unit comprises a powered roof support reference unit including a time-varying profile of the hydraulic fluid requirements of the or each powered roof support according to a predetermined movement cycle of the or each powered roof support.

5. The long wall hydraulic supply system of any preceding claim, wherein the pump station control unit comprises a flow profile generator unit arranged to

produce a time-varying expected flow profile for operation of the powered roof support(s).

6. The long wall hydraulic supply system of claim 5, wherein the pump station control unit comprises a fluid volume demand calculation unit arranged to operate on information from the flow profile generator unit to determine an instantaneous pump station output requirement according to the expected flow profile and an instantaneous hydraulic status of operation of the powered roof support(s).

7. The long wall hydraulic supply system of any preceding claim, further comprising a hydraulic fluid pressure sensor arranged remote from the pump station and operatively coupled to the pump station control unit.

8. The long wall hydraulic supply system of claim 7, wherein the pump station control unit is arranged to control the pump station to supply hydraulic fluid to the powered roof support via the hydraulic line at least in part in response to a pressure signal received from the pressure sensor, with reference to a set point pressure that the pump station is intended to provide.

9. The long wall hydraulic supply system of claim 7 or 8, wherein the pump station control unit comprises a combining unit arranged to receive information relating to an expected pressure requirement based on the activation signal, and to receive information relating to a current pressure, and to combine these pieces of information for use in driving the pump station.

10. The long wall hydraulic supply system of any preceding claim, wherein the pump station control unit comprises a pump configuration modelling unit arranged to generate a pump control signal according to a fluid volume demand and according to the pumping volume rating and/or status of operation of pump (s) and drive(s) in the pump station.

11. A pump station control unit for use with a long wall hydraulic supply system comprising:

> a pump station operatively coupled to a powered roof support to supply hydraulic fluid thereto via a hydraulic line; the pump station control unit arrangeable in use to control the pump station to supply hydraulic fluid to the powered roof support via the hydraulic line at least in part in response to an activation signal indicative of a change in activation status of the powered roof support.

12. A method of operating a long wall hydraulic supply system comprising: a pump station operatively coupled to a remote powered roof support to supply hydraulic fluid thereto via a hydraulic line; and a pump station control unit, the method comprising: receiving an activation signal indicative of a change in status of the powered roof support; and controlling the pump station at least in part in response to the activation signal received from the powered roof support.

13. The method of claim 12, further comprising determining an expected time varying fluid volume demand requirement for one or more powered roof supports according to predetermined characteristics of the powered roof support system, and controlling the pump station at least in part in line with the expected time varying fluid volume demand requirement.

14. The method of claim 12 or 13, further comprising controlling the pump station according to a combination of a sensed system pressure and an expected time varying pressure requirement.

15. A computer program product, recorded on a machine-readable data carrier, and containing instructions arranged, when loaded on a suitable computing platform to perform a method according to any one of claims 12-14.

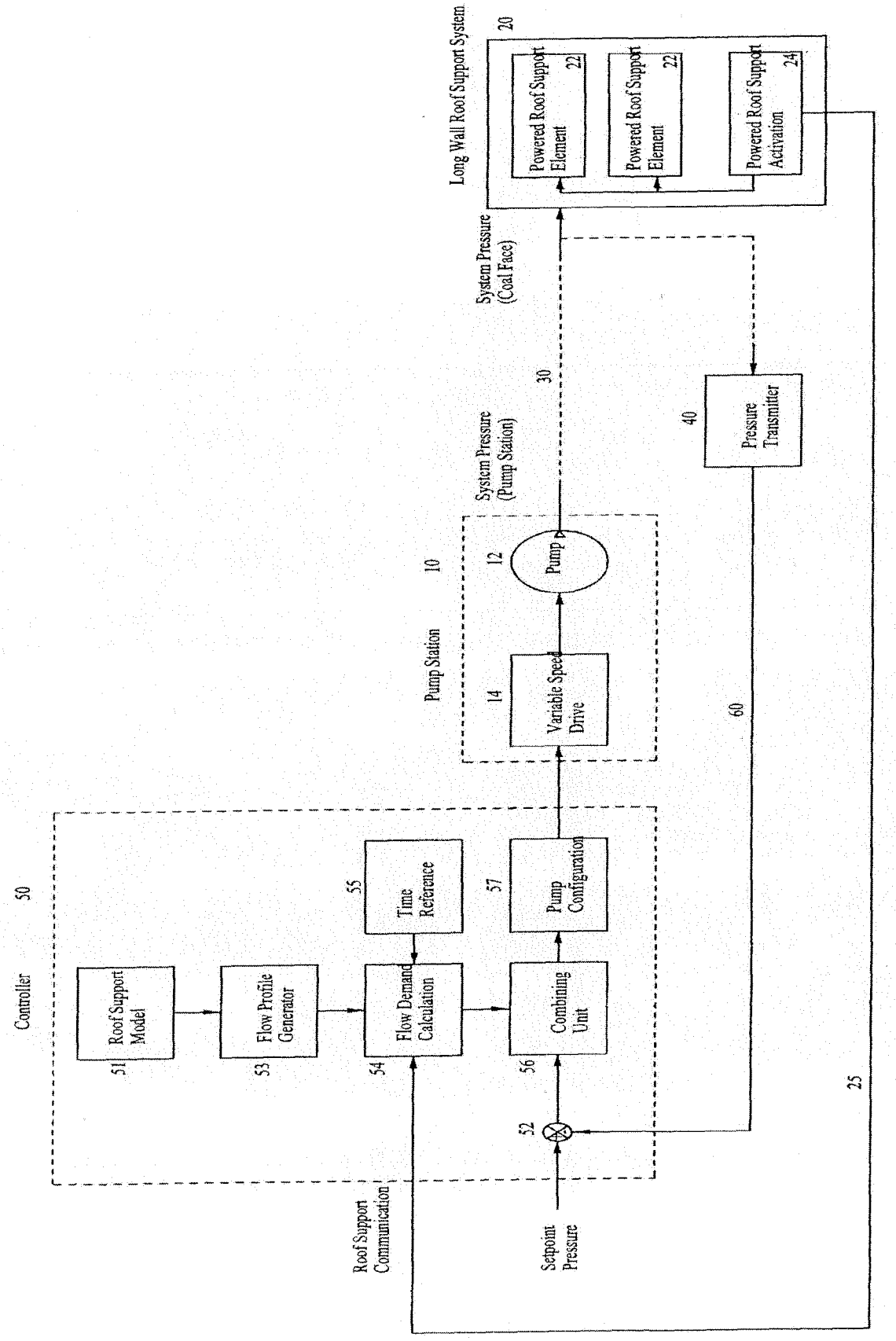

Long Wall Roof Support System
20
Powered Roof Support Element
22
Powered Roof Support Element
22
Powered Roof Support Activation
24
System Pressure (Coal Face)
30
System Pressure (Pump Station)
Pump Station
10
12
Pump
14
Variable Speed Drive
40
Pressure Transmitter
60
100
Controller
50
Roof Support Model
51
Flow Profile Generator
53
Flow Demand Calculation
54
Time Reference
55
Combining Unit
56
Pump Configuration
57
52
25
Roof Support Communication
Setpoint Pressure

Figure 1

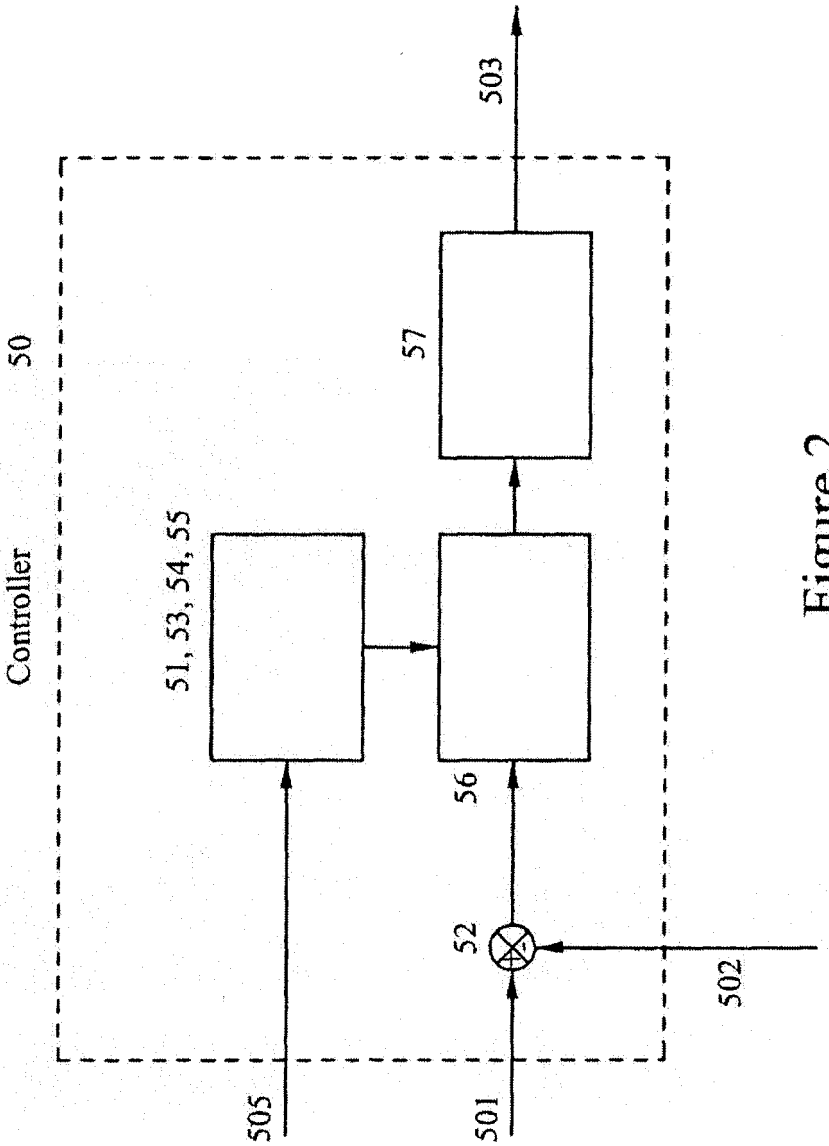


Figure 2

Figure 3

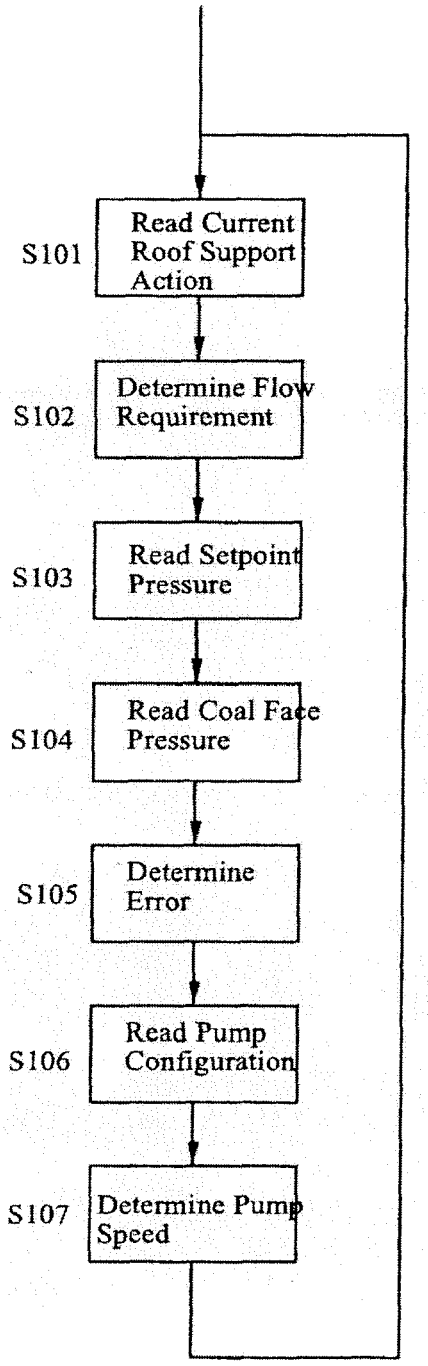
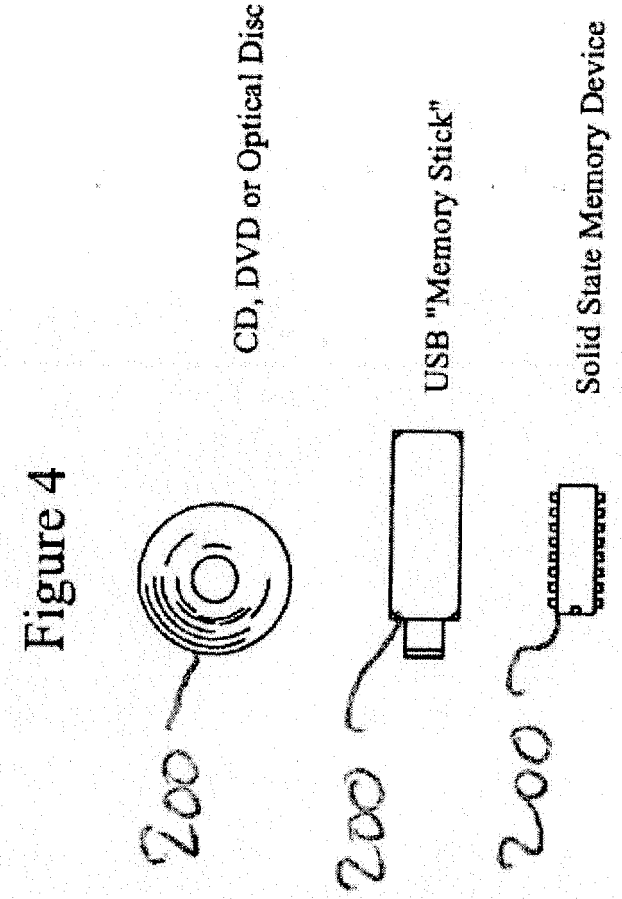

S101
Read Current Roof Support Action
S102
Determine Flow Requirement
S103
Read Setpoint Pressure
S104
Read Coal Face Pressure
S105
Determine Error
S106
Read Pump Configuration
S107
Determine Pump Speed

Figure 4


CD, DVD or Optical Disc
USB "Memory Stick"
Solid State Memory Device
200
200
200

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 0220

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC) E21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 July 2010	Manolache, Iustin

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29-07-2010

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82