US 20080245251A1

(19) **United States**

(12) **Patent Application Publication**

Van Wyk

(10) **Pub. No.: US 2008/0245251 A1**

(43) **Pub. Date: Oct. 9, 2008**

(54) **POWER MANAGEMENT OF BLASTING LEAD-IN SYSTEM**

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(21) Appl. No.: **11/817,579**

(22) PCT Filed: **Apr. 4, 2006**

(86) PCT No.: **PCT/ZA2006/000050**

§ 371 (c)(1), (2), (4) Date: **Aug. 31, 2007**

(30) **Foreign Application Priority Data**

May 9, 2005 (ZA) 2005/03721

Publication Classification

(51) **Int. Cl.**
F42D 1/05 (2006.01)

(52) **U.S. Cl.** **102/200**

(57) **ABSTRACT**

A blasting system (**10**) in which detonators (**12**) are connected to a blast energy source (**30**) by means of a component (**42**) which forms part of the blasting system (**10**) and which is physically movable to a safe position, visually ascertainable by an operator, at which detonator (**12**) firing cannot take place if an unwanted or unsafe condition arises in the blasting system (**10**).

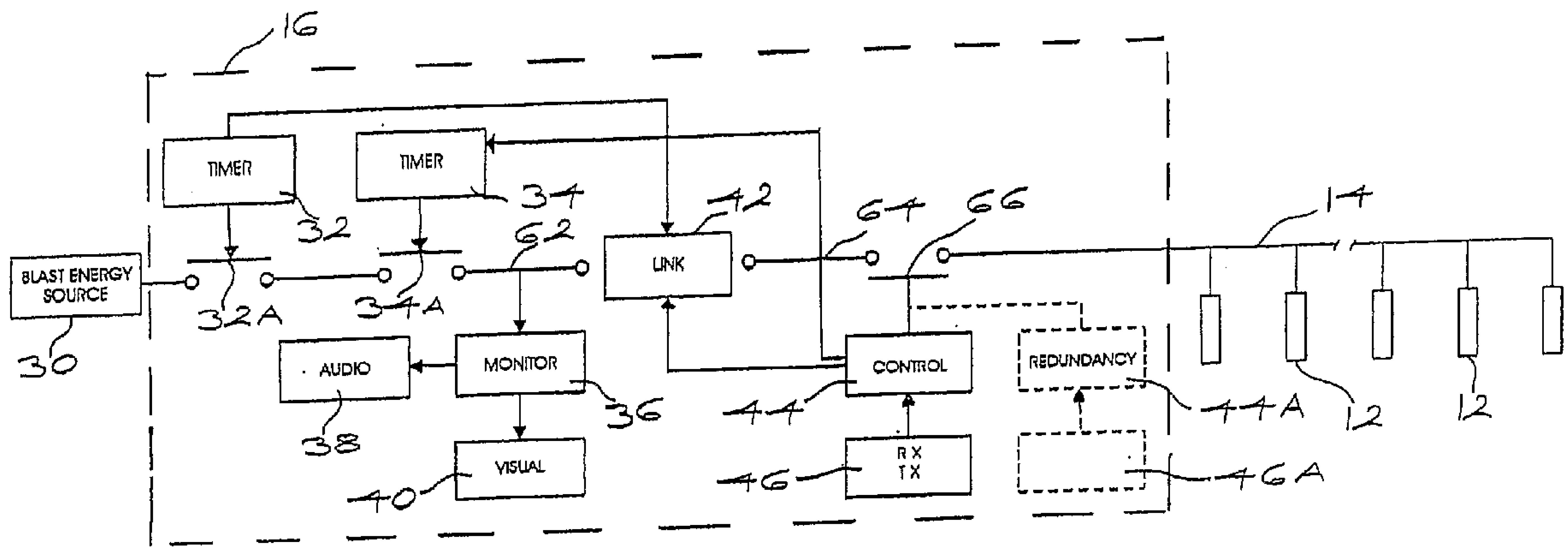


FIG 1

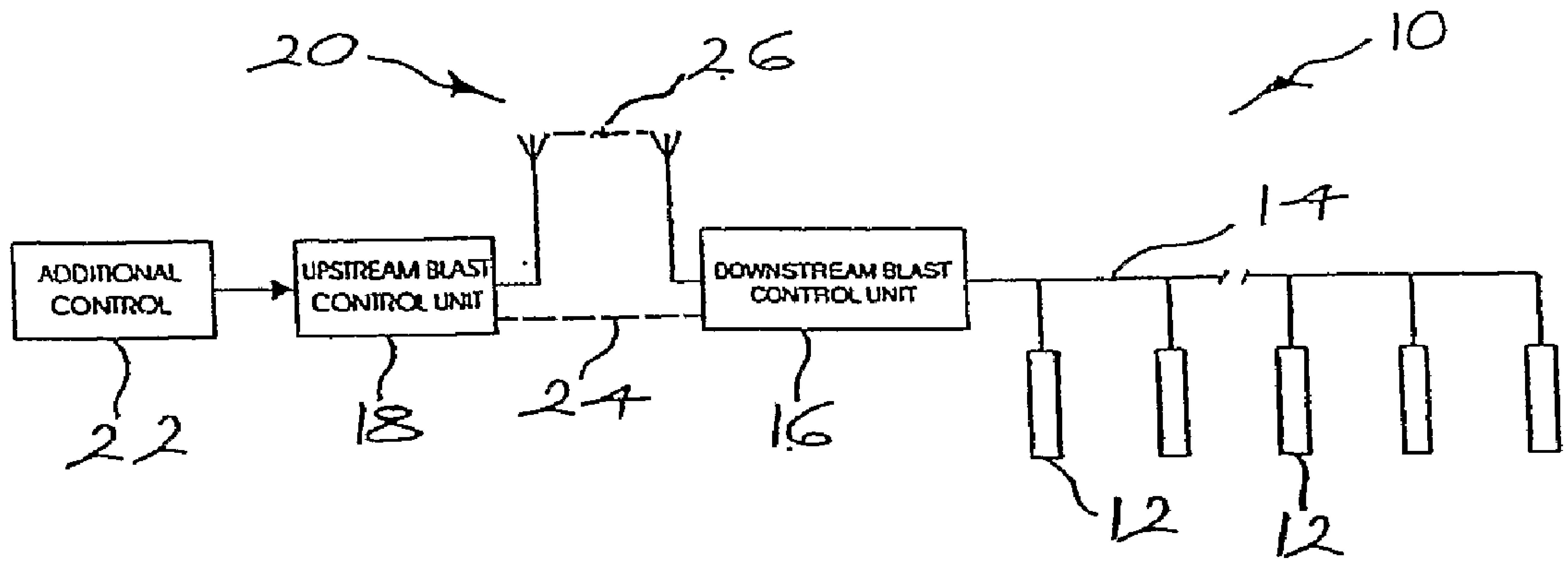
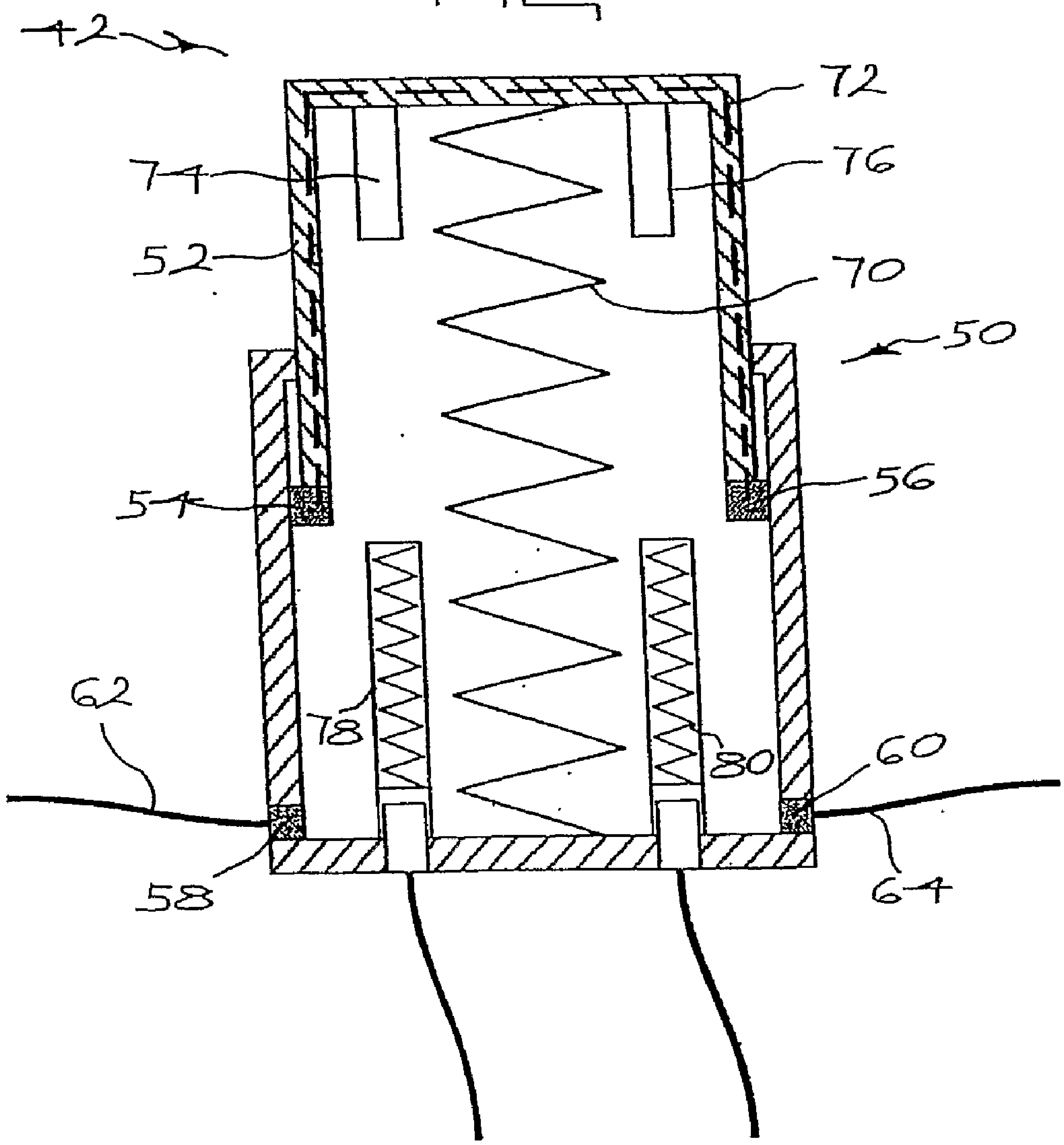

20
26
10
14
ADDITIONAL CONTROL
UPSTREAM BLAST CONTROL UNIT
DOWNSTREAM BLAST CONTROL UNIT
22
18
24
16
12
12

FIG 3


42
72
74
76
52
70
50
54
56
62
78
80
60
58
64

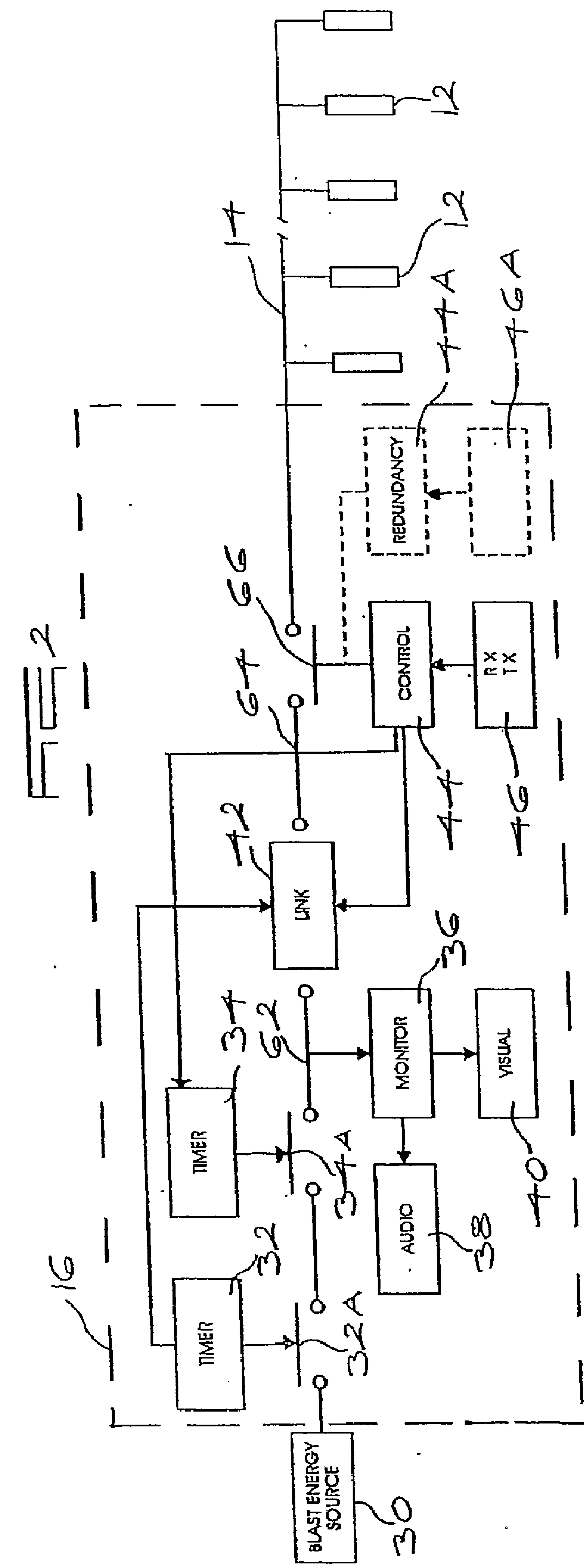

BLAST ENERGY SOURCE
TIMER
TIMER
AUDIO
MONITOR
VISUAL
LINK
CONTROL
RX TX
REDUNDANCY
12
14
16
30
32
32A
34
34A
36
38
40
42
44
44A
46
46A
62
64
66

FIG 2

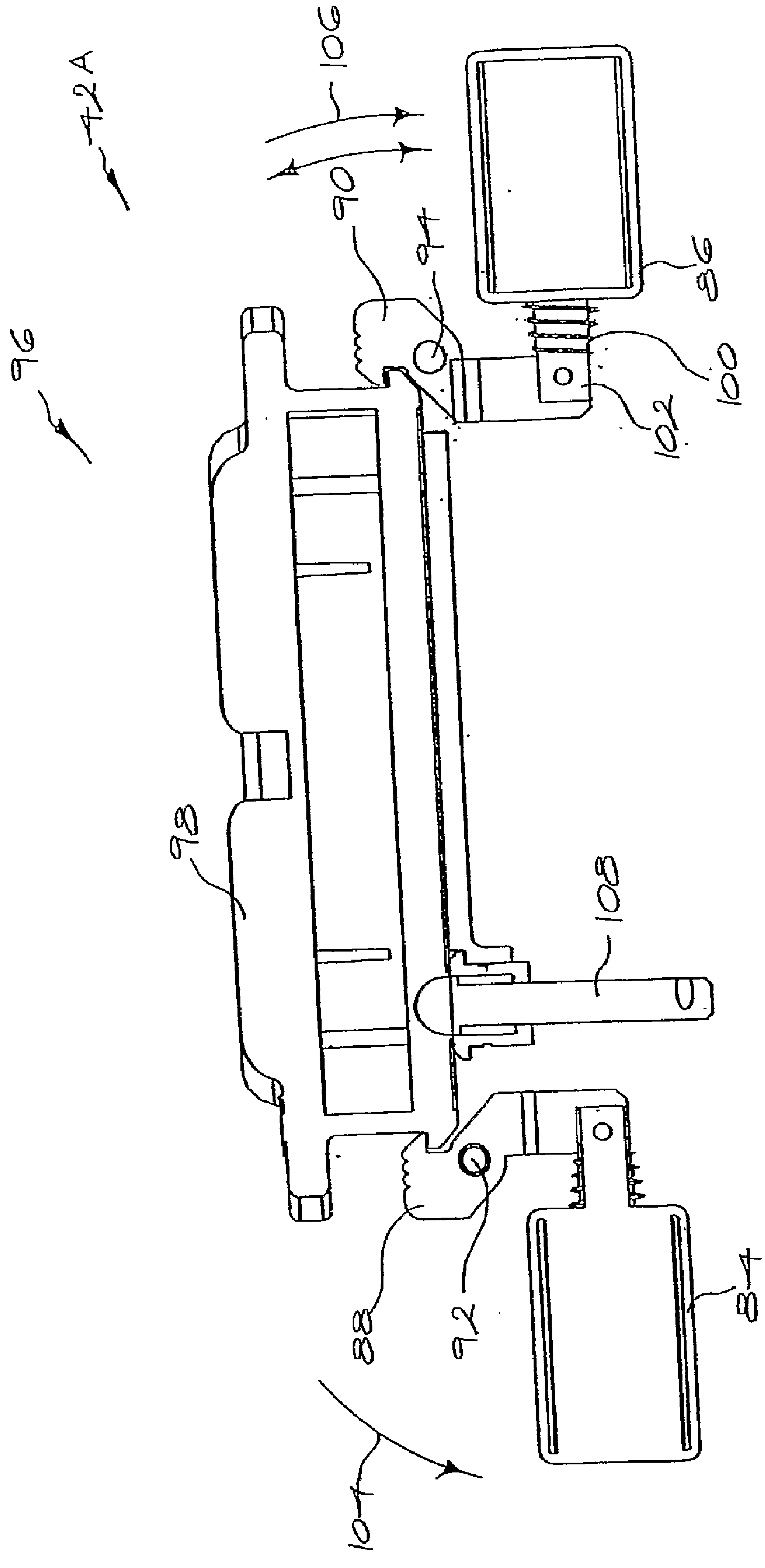


FIG. 4

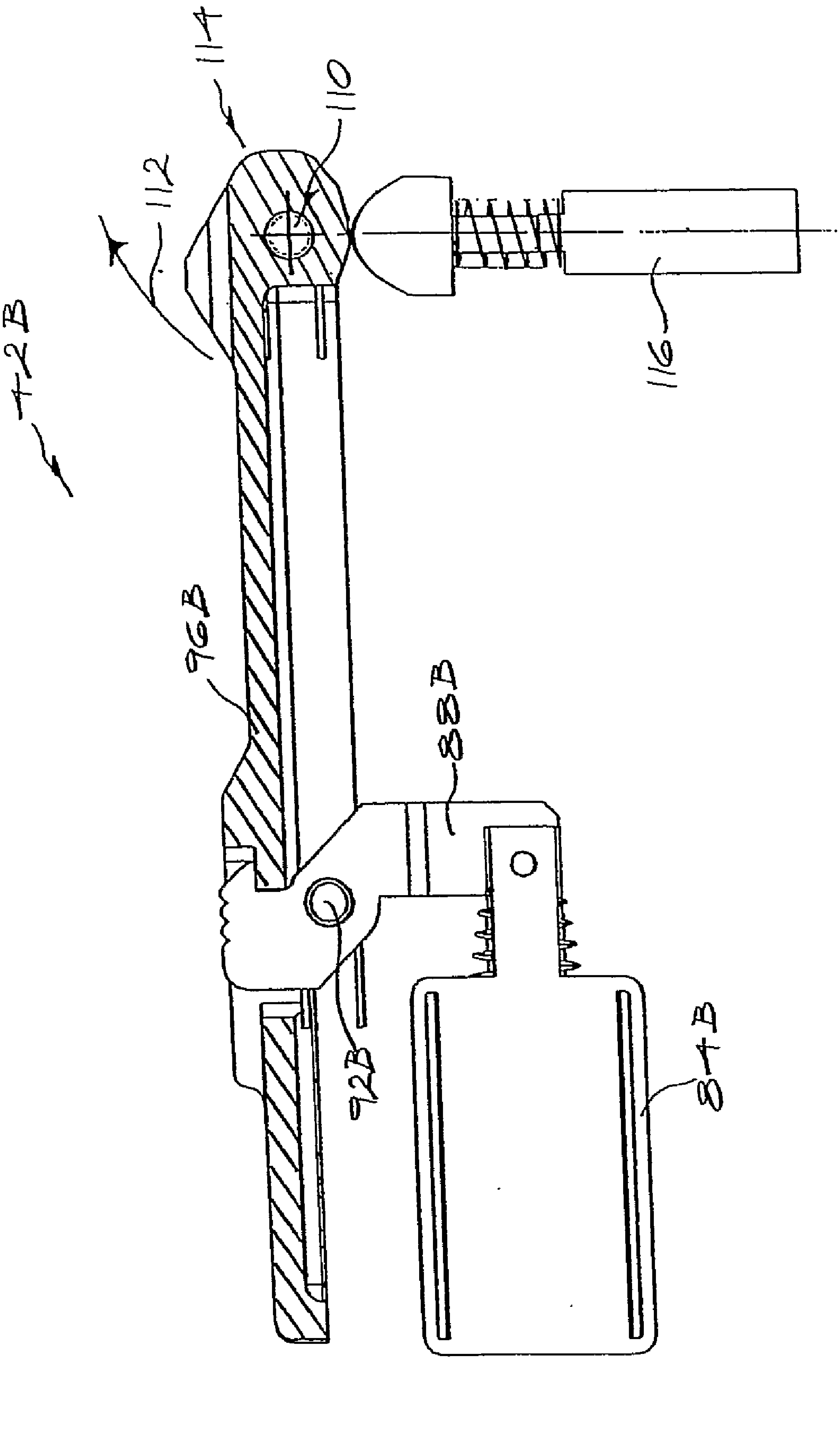


FIG. 5

POWER MANAGEMENT OF BLASTING LEAD-IN SYSTEM

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to a blasting system and more particularly is concerned with the safe management of power delivered to detonators or equipment in a radio frequency or remote wired blasting lead-in system.

[0002] A remote blasting system, for example a system which uses radio frequency to control and initiate a blast, normally employs an electronic or software system, with or without encryption techniques, to fire the blast. A blast energy source, which can be found in a downstream communication unit, is physically connected to detonators in the system which therefore relies only on logic and software security techniques to ensure that the blast is not initiated prematurely nor without upstream control.

[0003] A difficulty with this type of remote blasting system is that if a problem is encountered in the blasting area there is often uncertainty as to whether or not the blast energy source is connected to the detonators. This uncertainty means that the blast system cannot unequivocally be declared to be safe nor can it be said with impunity that personnel are free to enter the blast site.

[0004] A further risk which can exist is that, once a downstream control unit is connected to the detonators, an immediate or premature initiation of the system, during power up or connection of a detonator harness, can only be stopped by an electronic command signal. This carries with it the consequence that firmware, software or specific electronic failures can initiate an unplanned blast.

SUMMARY OF INVENTION

[0005] The invention is concerned with a blasting system which at least partly addressees the aforementioned problems and which provides for the safe management of power to detonators in the blasting system.

[0006] The invention provides a blasting system which includes at least one detonator, a blast energy source, a connection between the blast energy source and the at least one detonator, and control equipment for controlling initiation of the at least one detonator by causing energy from the blast energy source to be supplied to the at least one detonator, and wherein at least one component of the blasting system is physically movable from an operative position to a safe position, which is visible by an operator, at which blast energy from the energy source cannot be supplied to the at least one detonator.

[0007] The component may be selected from the blast energy source and a link in the connection.

[0008] The component may be moved, or be caused to move, in any appropriate way. The component may for example be movable by means of a biasing mechanism which is held in a first state when a first acceptable set of conditions pertains in the blasting system and which is released to a second state when an unacceptable condition arises in the blasting system. In the second state the component is in the aforementioned safe position.

[0009] This movement of the component to the safe position may be caused or initiated by at least one of the following:

[0010] a) after a predetermined period of time has elapsed from a given starting time—the starting time may for example be a time at which the component was moved from the safe position to the operative position;

[0011] b) after communication was established on the connection by means of the control equipment followed by a malfunction; and

[0012] c) if a malfunction of part or all of the control equipment occurs.

[0013] The control equipment may include an upstream control unit and a downstream control unit, the latter unit being closer to the detonators than the former unit and wherein the downstream unit is incapable of generating a blast command signal but can receive a blast command signal from the upstream control unit and transfer the blast command signal to the at least one detonator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention is further described by way of examples with reference to the accompanying drawings in which:

[0015] FIG. **1** is a block diagram representation of a blast system according to the invention;

[0016] FIG. **2** is a schematic representation of a downstream blast control unit included in the blast system of the invention;

[0017] FIG. **3** illustrates the construction of a mechanism for moving a link in the blast system between an operative position and a safe position; and

[0018] FIGS. **4** and **5** show different mechanisms which can interrupt a blasting process for safety reasons.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0019] FIG. **1** of the accompanying drawings illustrates a blast system **10** according to the invention which includes a plurality of detonators **12** which are connected to a harness **14**, a downstream blast control unit **16**, an upstream blast control unit **18**, a connection **20** between the upstream unit and the downstream unit, and additional or optional control equipment **22**.

[0020] The detonators are installed in a defined blast pattern, in blast holes, as desired.

[0021] The connection **20** may be effected via a wired connection i.e. by means of a conductor **24**, or wirelessly through the medium of a radio system **26** which includes two transmitting/receiving antennas respectively connected to the units **16** and **18**.

[0022] FIG. **2** illustrates, enclosed in dotted outline, the construction of the downstream blast control unit **16** which is connected via the harness **14** to the detonators **12**. On an incoming side the unit **16** is connected to a blast energy source **30**. This can be a power source such as a battery, or a voltage step-up circuit with a voltage level which is capable of energising a detonator to set off a blast. As is noted hereinafter this source can be ejectable from an operative to a safe position. Alternatively a similar effect can be achieved by ejecting a connection, not shown, which connects the blast energy source to equipment which controls the application of energy from the blast energy source to the detonators, from an operative position to a safe position, upon the occurrence of an unsafe or potentially unsafe situation.

[0023] The unit **16** includes first and second timers **32** and **34** which control respective switches or links **32**A and **34**A, a voltage monitor **36** which has an audio output **38** and a visual output **40**, a link **42** the physical construction of which is shown in further detail in FIG. **3**, and a control circuit **44** which is responsive to a receiver and transmitter **46**. The control unit and the receiver/transmitter may be duplicated, as is indicated in dotted outline in FIG. **2**, for redundancy purposes.

[0024] The link **32**A is independently operated by the timer **32** which is activated automatically upon start up of the downstream blast control unit **16**. At start up the link **32**A is closed and it is opened automatically after a predetermined period which is measured by the timer **32**. This period is independently fixed and it is not dependent on any component of the system **10**. The function of the timer **32** is to ensure that the system returns to a state of safety after the predetermined time period. The timer **32** may be electronic or mechanical but, preferably, the timer is not microprocessor-based i.e. it is not dependent on software or software routines.

[0025] The link **34**A is also in the blast energy path between the blast energy source **30** and the detonators and, like the link **32**A, it is activated upon start up of the downstream blast control unit **16**. On start up the link is opened and it is closed after the timing period of the timer **34**. The function of this link is to provide a safety or grace period before the system can be armed, during which personnel who armed the blast system are able to leave the blast site under safe conditions.

[0026] The monitor **36** monitors the voltage on the line downstream of the link **34**A. Detection of a voltage on the line is indicative that the link **34**A is closed and then, to ensure safe operation, the link **42** must not be closed. If a voltage is detected on the line then the audio and visual alarms **34** and **40** respectively are energised.

[0027] One embodiment of the link **42** is shown in FIG. **3**. The link can take on a variety of forms (see FIGS. **4** and **5**) but it should provide a visible indication, ascertainable from a safe distance, that it is in an open or closed state, as the case may be. Thus the link should include at least one component which physically moves, and the position of which is indicative of the state of the link.

[0028] The normal state of the link **42** is open and an active action is required to place the link in a closed state. The link is designed to be responsive to any undesired condition in the blast system, for example a power failure or malfunction in the control unit **44** or the timer **32**. These events are given only by way of example for the link, as stated, could be responsive to any other condition or parameter which can be monitored.

[0029] The FIG. **3** embodiment of the link **42** includes a housing **50** with a close fitting cup-shaped plunger **52**. Lower ends of the plunger include contacts **54** and **56** respectively which, when the plunger is inserted to a maximum extent into the housing, are brought into direct electrical contact with corresponding contacts **58** and **60** respectively fixed to an inner surface of the housing at a lower end thereof. Conductors **62** and **64** extend from the contacts **58** and **60** and, as shown in FIG. **2**, go to the link **34**A and a link **66** which is controlled by the control unit **44**.

[0030] A spring or any equivalent biasing mechanism **70** is inside the housing and normally urges the plunger **52** away to extend out of the housing. A conductor **72** is embedded in the plunger and extends between the contacts **54** and **56**. Two metal slugs **74** and **76** are fixed to an inner surface of the plunger and oppose solenoids **78** and **80** mounted to a base **82** of the plunger. If the solenoids are energised and the plunger is pushed inwardly then the solenoids exert sufficient attractive forces which act on the metal slugs **74** and **76**, to keep the plunger in a retracted position. If the power supply to either solenoid is interrupted then the attractive force is at least halved or, if both solenoids are de-energised, the attractive force is reduced to zero. In each case the biasing force of the spring **70** is then such that, automatically, the plunger is pushed out of the housing **50** to a position which is clearly visible and which indicates to an observer that the electric connection between the conductors **62** and **64** is broken.

[0031] The downstream blast control unit is under the control of the control unit **44**. The control unit **44** will only close the link **66** if a valid command is received from the upstream blast control unit **18** which is under operator control. Alternatively or additionally a valid signal can be generated by and transmitted from the additional control unit **22**.

[0032] As is indicated in FIG. **1** communication from the upstream unit to the downstream unit can be established via a physical hard wire connection **24**, or wirelessly over the antenna system **26**. In the latter case the antenna which is shown in FIG. **1** as being connected to the downstream blast control unit **16** is connected to the receiver/transmitter unit **46** of FIG. **2**.

[0033] The control unit can be responsive to a command instruction from the upstream unit **18** to interrupt the power supply to one or both the solenoids **78** and **80** thereby to cause the link **42** to be activated whereupon the plunger **52** is substantially ejected from the housing **54**. A similar process takes place if the control unit establishes that the integrity of any component or module in the blast system has been compromised.

[0034] The redundancy circuits, marked **44**A and **46**A, are essentially duplicates of the modules **44** and **46** respectively and function in the same way to ensure that backup is automatically provided upon failure of either module. One or both of the circuits can be coupled to the link **42** and cause activation of the link, thereby placing the system in a state of safety, if a circuit malfunction occurs.

[0035] The transceiver **46** does not take part in any interlocking or blasting decisions. Its function is to channel the data stream between the upstream and downstream control units.

[0036] When a blast is to be established an operator starts up the blast control unit **16** whereupon the timer **32** commences its timing cycle and closes the link **32**A. Communication is then established between the upstream and downstream control units as required. The link **42** is closed by the operator pushing on the plunger **52** so that it goes into the housing and bridges the contacts **58** and **60**. The monitor **36** constantly monitors the line **62** and if a voltage is detected on the line the operator is alerted and can take appropriate action. If any malfunction should occur the link **42** is automatically opened in the manner described.

[0037] If the timing period of the timer **32** is exceeded, for whatever reason, without the blasting system being fully armed, then the link **32**A automatically opens. When this occurs the link **42** is also opened to provide a visual indication that the system has been returned to a safe state.

[0038] Once the blasting system has been established and the blasting system is to be armed, the link **34**A is opened for a predetermined time period, set by the timer **34**, during which all personnel should leave the blast site. On expiry of the time period the link **34**A is closed and the detonators can be armed and thereafter fired with a blast command signal generated by the control equipment. Thus the timer **34** provides a grace period during which personnel can leave the blast site with safety before the electronic control system takes control of the detonators.

[0039] If a malfunction occurs during the arm and blasting stages then the physical link **42** is automatically opened and is moved to a position, which is visible from a distance, at which the conductor **62** is electrically disconnected from the conductor **64**. Thus personnel know that they can re-enter the blast site with safety.

[0040] FIG. **4** shows a component **42**A which can be used in place of the link **42** shown in FIG. **3**. The component includes opposed solenoids **84** and **86** each of which acts on a respective latch **88** and **90**, mounted for pivotal movement about a respective axis **92** and **94**. Structure **96** which, according to requirement, carries a visible blast energy source (eg. a battery), blast energy converter or a connector, designated **98**, is held in an operative position (as shown) by the latches **88** and **90**. However, if a command instruction is received from the upstream unit **18** or if a malfunction is detected then the power supply to one or both solenoids is interrupted. A spring **100** on a plunger **102** of a de-energised solenoid then rotates the respective latch in the direction of an arrow **104** or **106**, as the case may be. A spring-loaded member **108** then forces the structure **96** upwardly to provide a visible indication of the circuit interruption.

[0041] One or more electrical contacts in the member **108** or associated with the structure **96** are simultaneously broken so that the system is thereby automatically placed in a state of safety.

[0042] FIG. **5** shows another possible form of the link **42**. A component **42**B includes structure **96**B, which can carry a blast energy source or converter, or a connector link, and which is mounted for pivotal movement about an axis **110**. A solenoid **84**B acts on a latch **88**B which moves about a pivot **92**B and which can retain the structure in an operative position, as shown.

[0043] When the structure is moved to the operative position a coil spring, not shown, centred on the axis **110**, is biased. If for any reason, e.g. a malfunction occurring in the blasting circuit, the solenoid is de-energised, the spring causes the structure to pivot upwardly, about the axis **110**, in the direction of an arrow **112**. A cam formation **114** on the structure then acts on a spring-loaded plunger **116** and breaks an electrical connection or connections in the blasting circuit which is thereby rendered safe.

[0044] Again, a visible indication is given to personnel of the change of state, and the blast site can be re-entered with safety.

1-12. (canceled)

13. A blasting system which includes at least one detonator, a blast energy source, a connection between the blast energy source and the at least one detonator, and control equipment for controlling initiation of the at least one detonator by causing energy from the blast energy source to be supplied to the at least one detonator, a mechanism which is held in a first state when a first acceptable set of conditions pertains in the blasting system and which is automatically released to a second state when an unacceptable condition arises in the blasting system, and wherein at least one component of the blasting system is physically movable by the mechanism from an operative position to a safe position, which is visible by an operator, at which blast energy from the energy source cannot be supplied to the at least one detonator, when the mechanism is released to the second state.

14. A blasting system according to claim **13** wherein the component is selected from the blast energy source and a link in the connection.

15. A blasting system according to claim **14** wherein the mechanism is biased to the second state.

16. A blasting system according to claim **13** wherein the mechanism is biased to the second state.

17. A blasting system according to any one of claims **13** to **16** wherein movement of the component to the safe position is due to at least one of the following:

(a) the elapsing of a predetermined period of time from a given starting time;

(b) the occurrence of a malfunction in the blasting system after communication was established on the connection by means of the control equipment; and

(c) the occurrence of a malfunction in part or all of the control equipment.

18. A blasting system according to any claim **17** wherein the control equipment includes an upstream control unit and a downstream control unit which is closer to the at least one detonator than the upstream control unit and wherein the downstream unit is incapable of generating a blast command signal but can receive a blast command signal from the upstream control unit and transfer the blast command signal to the at least one detonator.

19. A blasting system according to any one of claims **13** to **16** wherein the control equipment includes an upstream control unit and a downstream control unit which is closer to the at least one detonator than the upstream control unit and wherein the downstream unit is incapable of generating a blast command signal but can receive a blast command signal from the upstream control unit and transfer the blast command signal to the at least one detonator.

20. A blasting system in which detonators are connected to a blast energy source by means of a component which forms part of the blasting system and which is automatically physically movable to a safe position, visually ascertainable by an operator, at which detonator firing cannot take place if an unwanted or unsafe condition arises in the blasting system.

21. A method of operating a blasting system which includes the steps of establishing a connection between a blast energy source and at least one detonator, and of automatically physically moving a component of the blasting system from an operative position to a safe position, which is visible by an operator, at which blast energy from the energy source cannot be supplied to the at least one detonator when an unacceptable or unsafe condition arises in the blasting system.

22. A method according to claim **21** wherein the component is selected from the blast energy source and a link in the connection.

23. A method according to claim **21** or **22** wherein movement of the component to the safe position is caused or initiated by at least one of the following: the elapsing of a predetermined period of time from a given starting time; the occurrence of a malfunction after communication was established on the connection; and the occurrence of a malfunction in control equipment which is used to generate a blast command signal.

* * * * *