United States Patent

Harbonn

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[54] **AUTONOMOUS DEVICE FOR THE STORAGE AND USE OF ELECTRICAL POWER**

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[51] **Int. Cl.**.....**H02j 7/00,** H02p 9/04

[58] **Field of Search** 307/46, 48; 320/3, 4, 21, 61, 320/8; 317/20; 322/7, 8; 318/16, 139; 290/50, 44

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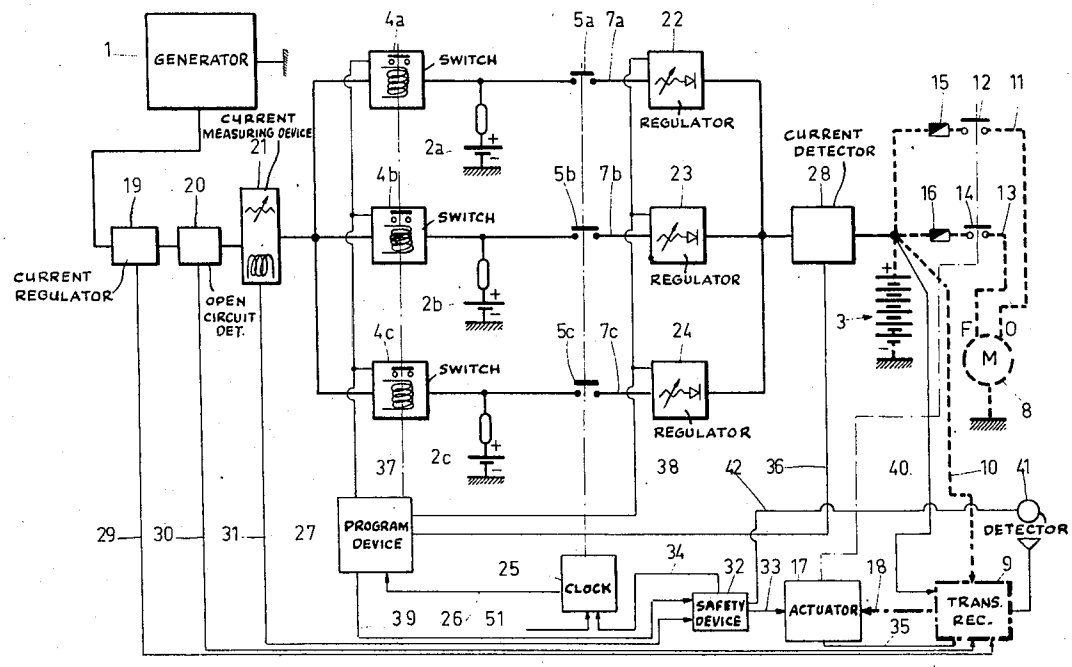
[57] **ABSTRACT**

Autonomous device for the storage and the use of electric power for controlling at least one member of a sub - station from a remote main station , comprising , at said sub - station , a low power autonomous generator , a main electric power accumulator , intermediary power accumulator means charged with the current supplied by the generator and discharged in said main accumulator , means for actuating said member , energized by said accumulator and controlled by control means remotely actuated from the main station , means for maintaining a minimum charge level of the accumulator which is sufficient for switching the member to be controlled to a security position and security means adapted to switch said member to its security position and to interrupt the charge current to said main accumulator in response to abnormal values of the current supplied by the generator.

8 Claims, 5 Drawing Figures



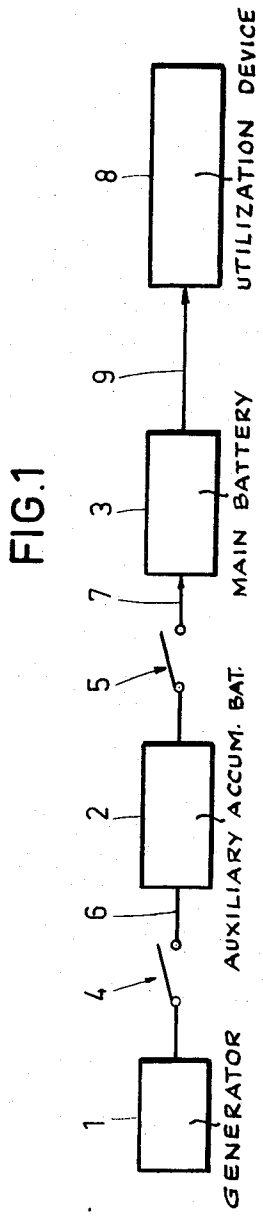


FIG.1

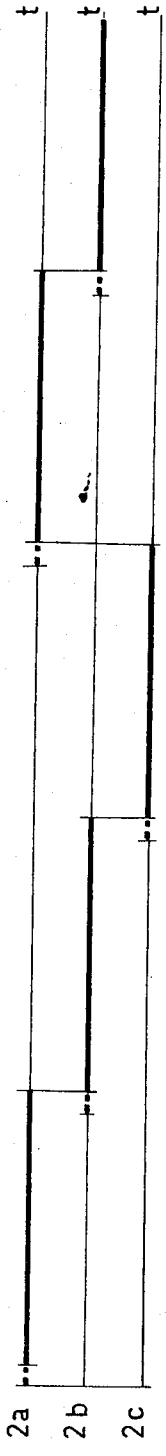


FIG.3

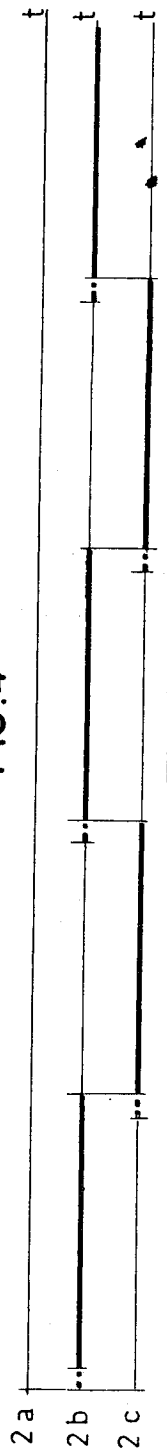


FIG.4

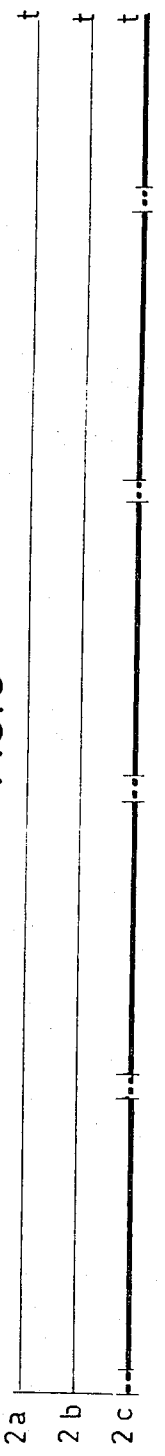
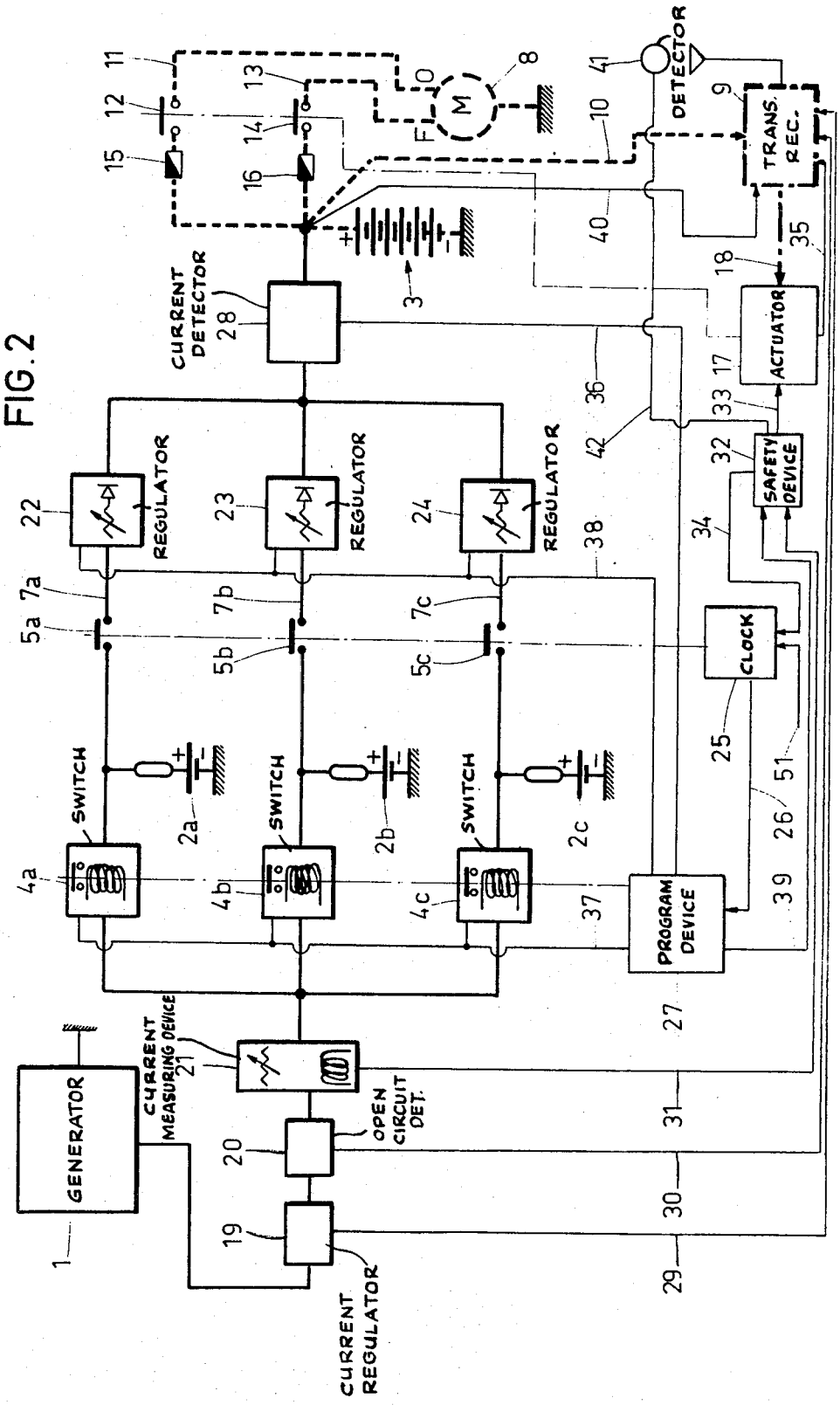


FIG.5

FIG. 2


GENERATOR
CURRENT MEASURING DEVICE
OPEN CIRCUIT DET.
CURRENT REGULATOR
CURRENT DETECTOR
REGULATOR
REGULATOR
REGULATOR
SWITCH
SWITCH
SWITCH
PROGRAM DEVICE
CLOCK
SAFETY DEVICE
ACTUATOR
DETECTOR
TRANS. REC.

AUTONOMOUS DEVICE FOR THE STORAGE AND USE OF ELECTRICAL POWER

This invention relates to an autonomous device for the storage and use of electrical power with a high safety of operation.

There are known devices for the remote control of one or more installations or secondary stations from a master or control station . In some cases the secondary station is very far from the master station and , for practical reasons , it is preferred not to make use of any material connection through conductors between the various installations . The connections are thus provided through transmission of acoustic and / or electromagnetic waves , the type of transmission depending on the medium in which the installations are placed .

There is no particular difficulty , as a general rule , for supplying power to the master or control station , which is always placed so as to be of an easy accessibility . On the contrary it may be difficult to supply power to the secondary stations which are not of an easy access and in such cases it may be necessary to provide such installations with an autonomous power source for their operation over vary long periods of, for example , several years .

A first solution would be to associate to the secondary station , when establishing the latter , a battery of electrical accumulators of a sufficient power for insuring the operation of the secondary installation over the desired period .

This solution cannot be contemplated at all in view of the present state of the art since the weight and the bulkiness of the power source would be excessive and , in addition , the latter would be difficult to manipulate and put in place .

The perfecting of autonomous power generators such as isotopic electrical generators , fuel cells and the like , seems to provide a better solution . These generators , of small bulkiness , may indeed have an operative life of several years . It is therefore obvious that they are of interest for the power supply of installations located at places difficult of access .

These installations may be , for example , automatic meteorological stations in the high mountain but the following description will refer more particularly , by way of non limitative example , to secondary installations , remotely controlled from a master installation , and associated to well heads submerged at depths which may attain several hundred meters and which are therefore difficult of access .

Moreover , in this particular , but not limitative,case of use , the absence of material connections between the master installation and the secondary ones is of particular interest since such connections often result in substantial troubles (congestions of water , loss of time when a breakage occurs , need for a watching and maintenance service and the like) and their cost is not negligible as investment .

Unhappily the presently available isotopic generators provide only small electric powers (a few tens of watts) and cannot be used directly for supplying power to elements which energize members , such as valves of producing well heads , which require several thousands watts for being actuated . However it is possible to make use of an autonomous electricity generator supplying electric power to an accumulator for the storage

thereof , in view of a subsequent use of the accumulated power for the operation of members requiring a high power supply .

One of the objects of the present invention is to provide an autonomous device for the storage and use of electrical power , making use of an autonomous generator of relatively small power but operative over a long time , such as an isotopic electrical generator or a fuel cell .

Another object of this invention is to provide an autonomous device for the storage and use of electric power , of the above - mentioned type , and comprising members for automatically watching the good operating order of the device and optionally of security members for the control of the whole installation equipped with this device , said security members being adapted to switch the installation to a security condition in case of a power supply failure .

According to this invention , the autonomous device for the storage and use of the electric power supplied by an autonomous generator of low power generating capacity , used for feeding with electric current an installation provided with at least one member to be controlled , having a security position , and with means for controlling said member , comprises the combination of :

a. a main electric power accumulator ,

b. connection means between said generator and said main accumulator in order to charge the same with an electric current supplied by said generator ,

c. means for connecting said main accumulator to said member to be controlled in order to supply said member with a control current , said connecting means being actuated by the means for controlling said member ,

d. Operating means adapted to periodically actuate said connection means so as to maintain the charge of said accumulator at a level higher than a predetermined value , sufficient for switching said member to be controlled to a security condition ,

e. Means for controlling the current supplied by said generator , said means being adapted to deliver a pulse in case of abnormal values of said current, and

f. Safety means , connected to said control means and to said operating means and adapted , in response to the reception of said pulse , to actuate , on the one hand, the means for controlling said member so as to place the latter in its security condition , and on the other hand, said operating means, so as to maintain open said connecting means , there-by interrupting the charge current to said main accumulator .

According to an advantageous embodiment of the device of this invention , said connection means between the generator and said main accumulator comprises several channels , each of which is provided with at least one intermediary element for the storage of the electric power supplied by said generator , said connecting means establishing the connection of each intermediary element with said generator on the one hand and with said main accumulator on the other hand in order to provide for the charge of the latter with the current supplied by said intermediary element . Still in this embodiment, said operating means com-

prises a program element for periodically and separately establishing the connection of each intermediary element , on the one hand with said generator and on the other hand, with said main accumulator, according to a connection program which may be chosen in a set of different programs, provided at will by said programmation element , said means for controlling the current supplied by each intermediary element being connected to said operating means and adapted to produce a signal when an anomaly is detected in at least one channel , said signal actuating said operating means for disconnecting the channel in which such anomaly occurred and modifying the program of said program element so as to make possible the charge of the principal accumulator through the remaining channels.

The invention will be better understood from the following description of a non limitative embodiment of the invention illustrated by the accompanying drawings wherein :

FIG. 1 is a basic diagram of an autonomous power generating device ;

FIG. 2 diagrammatically shows an embodiment of a device according to this invention , and

FIGS. 3 , 4 and 5 show various programs of charge and discharge of the auxiliary batteries .

In the following , by way of non - limitative example , there is contemplated the use of the device according to the invention for feeding with electric power devices for operating members forming part of the equipment of a submerged producing well head and comprising an acoustic transmitter - receiver of any known type , remotely controlled from a main installation , for example a surface floating installation which may be at a distance of several kilometers from the well head . In this case the members to be controlled may consist of valves and it is desired that any failure which might occur in the equipment operation would result , for obvious security requirements , in the closure of the valves, so as to prevent any uncontrolled production .

FIG. 1 diagrammatically illustrates an autonomous installation for the storage and use of electric power , fed with an autonomous generator of low power generating capacity , such as an isotopic electricity generator or a fuel cell .

The electricity generator of low power generating capacity , shown with reference **1** , is , for example, an isotopic electricity generator which may supply an electric power of **25** watts with a current intensity of about 0.3 A. This generator is connected through a cable **6** and a switch **4** to an auxiliary accumulator battery , diagrammatically shown with reference **2** . This battery is , in turn , connected to the main battery **3** of high power electrical accumulators , through a cable **7** and a switch **5** . The battery **3** supplies to the circuit of use **8** the required power through cable **9** .

The use of an auxiliary battery **2** is justified by the fact that generator **1** cannot directly charge the main battery **3** . As a matter of fact , it is well known in the art that the charging conditions (value of the current , charging time and the like) are dependent on the capacity of the battery to be charged .

There is therefore used at least one auxiliary battery having a capacity so selected that , on the one hand , its discharge current is compatible with the charge current of the main battery , and , on the other hand , its charge current is compatible with the value of the current supplied by the autonomous electricity generator .

Of course , if the value of the capacity of the main battery **3** is very high , it might be convenient to make use of a plurality of auxiliary batteries **2** , connected in series , so that the charging conditions for each battery be fulfilled , the operating principle of the assembly being unchanged .

The operation is very simple . By closing the switch **4** , the generator **1** supplies to the auxiliary battery **2** an electric power which is stored .

Once the battery **2** is charged , the switch is opened and the switch **5** is closed so that the power stored in the auxiliary battery **2** can be transferred to the principal battery **3** .

This cycle is repeated at regular intervals and there is thus accumulated in battery **3** the power required for feeding the circuit of use .

FIG. 2 diagrammatically illustrates an autonomous device for the storage and use of power , destined to the control of members of an immersed producing well head equipped with a transmitter - receiver for acoustic remote control (by ultrasonic waves).

On this figure are shown essentially three circuits :

The power circuit or circuit of use shown in dashed lines,

The charge circuit supplying the electric power , shown in heavy solid lines, and

The security circuit shown in thin lines.

The power circuit comprises a main battery **3** of high capacity electrical accumulators . This battery **3** supplies power to the remote controlled transmitter - receiver **9**, through cable **10** and electronic devices which will be described below and insure the operation of the device . However , for the sake of clarity in the drawings , only cable **10**, connecting the principal battery to the transmitter - receiver **9**, is shown .

The battery **3** also feeds driving elements **8** for actuating members , not shown , of the well head , particularly valves . For the simplicity of the drawing , there is shown only one driving element **8** having two separate positions , for example a position of opening (O) obtained when it is energized through cable **11** and switch **12** and a position of closure (F) when it is energized through cable **13** and switch **14** . Elements **15** and **16** , for the calibration of the electric current , protect element **8** against any accidental excessive current value .

Switches **12** and **14** are operated through an actuation member **17** when the latter receives , through cable **18** , a corresponding control signal delivered by the remote control transmitter - receiver **9** , after reception of an order signal received from the main installation .

The actuation member **17** may also receive , through cable **33** , control signals supplied by the security system which is described hereinafter . After the performance of the operation initiated by the reception of a control signal transmitted through any one of cables **18** and **33** , the member **17** is adapted to transmit to the transmitter receiver **9**, through cable **35** , a coded signal indicating the new status of the controlled driving element **8** .

The charging circuit of the main battery **3** comprises an autonomous isotopic generator of small power **1**(for

example 25 watts) supplying an electric direct current of low intensity(for example about 300 m A). The electric current supplied by generator 1 is maintained at a constant value by the current regulator 19 , adapted to detect the presence of any short - circuit in the discharge circuit of generator 1. A device 20 , indicating an open circuit , placed in series with the discharge circuit of generator 1 , detects the absence of current at the out put of generator 1 . A current measuring device 21 is also placed in series with the discharge circuit of generator 1 .

The object of these device 19 , 20 and 21 will be indicated hereinafter .

The output of the current measuring device 21 is connected to three circuits arranged in parallel(this number being not limitative).Each of said circuits comprises a switch (switches 4*a*, 4*b*, 4*c*) and , connected in series with each of said switches , auxiliary accumulators of the Cadmium-Nickel type , 2*a* , 2*b* and 2*c* respectively.These accumulators are charged by generator 1 in the manner indicated hereinafter.

After the power has been stored in the accumulators 2*a*, 2*b*, 2*c* , it is transferred to the main battery through cables 7*a* , 7*b* , 7*c* and switches 5*a* , 5*b* , 5*c* , respectively , while maintaining substantially constant , by means of the regulators 22 , 23 24,respectively , the intensity of the current supplied by the accumulators 2*a* , 2*b* and 2*c* , a current detector 28 , the purpose of which will be made apparent later , being connected in series between these regulators and the main battery 3.

The operation of the device is simple and conforms with the description of the simplified diagram of FIG. 1 .

A clock 25 actuates at regular time intervals , through cable 26 , a program device 27 , which , by successively controlling,in a periodic manner , the closure of switches 4*a* , 4*b* , and 4*c* , causes the successive charge of the auxiliary accumulators 2*a* , 2*b* and 2*c* , the clock 25 further actuating the switches 5*a* , 5*b* and 5*c* so that each of them is in open position during the charge of the corresponding auxiliary battery 2*a* , 2*b* or 2*c* . In another embodiment , the control of the switches 5*a* , 5*b* and 5*c* can be performed by the program device 27 . The charge of batteries 2*a* , 2*b* and 2*c* is performed under a current intensity compatible with the charge current of said batteries and with the current supplied by the generator 1 . For example , this charge will be performed with a current of 0.3 A during 6 hours . After the charge of each auxiliary battery has been completed , the same is discharged in the main battery by closing the corresponding switch 5*a* , 5*b* or 5*c* , with the provision of preliminarily opening the corresponding switch 4*a* , 4*b* or 4*c* . This discharge is performed in a shorter time but with a higher current intensity , compatible with the charge current of the main battery 3 and with the discharge current of the auxiliary batteries 2*a* , 2*b* and 2*c* (for example 1.7 A during 35 minutes).

By the use of several auxiliary batteries 2*a* , 2*b* , 2*c* , it is possible to establish a charge and discharge program for these batteries so that , at any moment , the generator 1 only charges an auxiliary battery and the charge of the main battery in performed from a single auxiliary battery .

FIG. 3 shows the normal charge and discharge program for the three auxiliary batteries versus time *t* , the charging periods being shown by solid line portions and the discharging periods by dashed line portions.

The control of the driving elements 8 must be very safe , i.e. any failure detected in the power generating device must automatically switch elements 8 to a security condition . In the case where element 8 is a valve of a producing well head , the security condition is that of closure of the valve . Moreover the power generating device must be adapted to be controlled remotely and at any instant .

There will be examined hereinafter the various control and security means used in the device of the invention and shown in FIG. 2 .

The current regulator 19 may be of a conventional type with transistors .

It further comprises a short - circuit detector which , when a short - circuit occurs in the discharge circuit of generator 1 , delivers a signal which , through cable 29 connected to the transmitter 9 , is transmitted at distance and displayed at the control station on the surface installation .

The device 20 is a detector of an open circuit which may also be of a conventional type and delivers , in open circuit , a signal which is transmitted through cable 30 , connected to the transmitter - receiver 9 , to the principal installation where the information is displayed .

By this way , a remote control of the good operating order of generator 1 is possible .

The device 21 provides for the measurement of the charge current of the auxiliary accumulators . For values of this current lower than a first predetermined value I_1 (for example $I_1 = 200$ mA) or for values of this current higher than a second predetermined value I_2 (for example $I_2 = 0.4$ A) the device generates a signal which is transmitted through cable 31 to a safety device 32 which delivers, in response thereto , on the one hand , a signal , transmitted through cable 33 to the operating member 17 which switches to the security position (closure of the valves) the driving element 8 , by closure of the switch 14 , and , on the other hand, a signal, transmitted through cable 34,which stops the clock 25 , there-by opening the switches 5*a* , 5*b* , 5*c* , the clock 25 thus supplying to the device 27 a signal for opening the switches 4*a* , 4*b* and 4*c* and disconnecting the regulators 22 , 23 , 24 . By this way , when , for any reason , the generator 1 is no longer able to produce power (failure , wear , etc ...) or when a short - circuit occurs in the discharge circuit of said generator, the members to be controlled are switched to a security condition before the charge of the main battery has decreased below the threshold allowing the switch to a security condition of all the members of the well head equipment .

At the main installation there is received a signal from the operating member 17 indicating the switch to the security position of the driving members 8 , said signal being transmitted to the transmitter 9 through cable 35 and from there to the main installation which further receives , in the above mentioned manner , a signal from member 20 indicating that the discharge circuit of generator 1 is open .

The regulators **22** , **23** , **24** ,of the discharge currents of the auxiliary accumulators **2***a* , **2***b* , **2***c*, are of a conventional type . They are furthermore adapted to prevent the discharge of the principal battery in the auxiliary accumulators (for example by the provision of diodes placed in series in the discharge circuit of the auxiliary batteries) . The discharge current of the batteries is adjusted by these regulators at a predetermined value I_3 for example $I_3 = 1.7$ A).

Any failure in the discharge of an auxiliary battery **2***a* , **2***b* , **2***c* is detected by the current measuring device **28** which, for a value of the current lower than a predetermined value (for example $I_4 = 1.4$ A) generates a signal which is transmitted through cable **36** to the program device **27** . This device acts , through cable **37** , on the charge circuit of that auxiliary battery **2***a* , **2***b* or **2***c* ,where a failure of the charge has been detected , by delivering a signal for locking the corresponding switch **4***a* , **4***b* or **4***c* in open position and also controls , through cable **38** , by action on the corresponding regulator **22** , **23** or **24**,the disconnection of said regulator .

Simultaneously the device passes to a new program stage of the charge cycle of the principal battery, using only the two remaining auxiliary batteries . This new cycle is illustrated in FIG. **4** , corresponding to the assumption of a failure of battery **2***a* . In the case of failure of a second battery , the charge program would be still modified by the device **27** , as shown in FIG. **5** , corresponding to the assumption of inoperativeness of both batteries **2***a* and **2***b* .

In the case of simultaneous failure of all the batteries , the program device **27** , after having disconnected the last regulator **22** , **23** or **24**,would generate a signal which , through cable **39** , would actuate the safety device **32** , acting in the above described manner so as to switch the driving element **8** to the security position .

A safety device , included in the operating member **17**, acts on the control circuit of the driving element **8** in the case where the energization of the latter would extend beyond a predetermined period t_1 (for example $t_1 = 10$ seconds).

In the case where the extended energization is due to the sticking of the switch on its contacts during the passage to an open position of the driving element **8** , this security device interrupts the energization of element **8** and produces the locking of the switch **12** in its open position .

By this way only the operation of closure of the corresponding valve can still be performed , any opening operation being prevented by the locking of the switch **12** .

In the case where the extended energization is due to the sticking of the switch **14** on its contacts during the passage to a position of closure of the driving element **8** , this device interrupts the energization of element **8** and produces the locking of switches **12** and **14** in their open position , so that it becomes impossible to operate the driving element **8** .

Detectors such as **41** (FIG. **2**) insure the watching of certain parameters such as the pressure and the temperature in the well head . These detectors , which are of conventional type , are adapted to deliver a signal when the controlled parameter reaches values which are critical for the operation of the well head . This signal , transmitted through cable **42** to the security device **32** , produces the switching of the driving element **8** to their security position .

In addition , the parameter values measured by the detectors may be optionally transmitted to the main surface installation by means of the transmitter - receiver **9** .

Other securities may be added to the device illustrated in FIG. **2** .

For example it is possible to control the electric current supply to all the electronic safety and control devices , e.g. , by means of a current detector which , when the intensity reaches abnormal values (too low or too high current) , switches the driving elements **8** to their security position .

What I claim as my invention is :

1. An autonomous device for the storage and use of the electric power supplied by an autonomous generator of low power generating capacity adapted to feed with electric current an installation provided with at least one member to be controlled, which has a security position, and means for controlling said member, comprising the combination of:

a main electric power accumulator;

connection means between said generator and said main accumulator, providing for the charge of the latter with an electric current supplied by said generator;

means for connecting said main accumulator to said member to be controlled in order to supply to said member a control current, said means for connecting being actuated by the means for controlling said member;

operating means adapted to periodically actuate said connection means, so as to maintain the charge of said accumulator above a predetermined value which is sufficient to insure the switching to its security position of said member to be controlled;

means for controlling the current supplied by said generator and adapted to issue a pulse is response to abnormal values of the current supplied by the generator;

means for controlling the current supplied to said main accumulator; and

safety means connected to said control means and to said operating means and adapted, at the reception of said pulse, on the one hand, to actuate said means for controlling said member, so as to switch the same to its security position and, on the other hand, to actuate said operating means for maintaining said connection means in open position, thereby interrupting the charge current to said main accumulator;

said connection means to said main accumulator having a plurality of channels, each of which comprises at least one intermediary storage element for the electric power supplied by said generator, said connection means connecting each intermediary element, on the one hand, to said generator and, on the other hand, to said main accumulator, to provide for the charge of the latter by the current supplied by said intermediary element;

said operating means comprising a program element adapted to periodically and separately connect each intermediary element, on the one hand, to said generator and, on the other hand, to said main

accumulator, in accordance with a connection program which may be selected within a set of different programs which may be established at will by said program element;

said means for controlling the current supplied to said main accumulator being connected to said operating means and adapted to issue a signal in response to any abnormal value of the current supplied by one of said intermediary elements occurring on at least one of said channels, said signal actuating said operating means so as to disconnect said channel on which occurred said abnormal value and to modify the program of said program element in order to make possible the charge of the main accumulator by means of the remaining channels.

2. A device according to claim 1, wherein said generator is an isotopic electricity source.

3. A device according to claim 1, wherein said generator is a fuel cell.

4. A device according to claim 1, wherein said means for controlling the current supplied by said generator comprises a short-circuit detecting device and a device for detecting an open circuit.

5. A device according to claim 1, further comprising means for controlling the electric current supplied to the installation by the main accumulator, adapted to issue a signal in response to abnormal values of said current, said means for controlling being connected to said safety means, and

means for monitoring of at least one parameter, characteristic of the operation of the installation, adapted to deliver a signal in response to abnormal values of said parameter, said means for controlling and means for monitoring being connected to said safety means which are adapted to actuate said means for controlling said member of the installation at the reception of at least one of said signals, so as to switch said member to its security position.

6. A device according to claim 5, for the electric power supply of a remotely controlled installation connected to a main installation through communication means connected to said means for controlling said member and adapted to operate said means for controlling upon reception of a specific order, wherein said means for controlling the current supplied by said generator, said monitoring means and said means for controlling said member are connected to said communication means and supply thereto signals representative of the status of the installation, said communication means transmitting to said main installation, in the form of a message, said signals representing the status of the remotely controlled installation.

7. A device according to claim 1, wherein said program element is connected to said safety means and is adapted to transmit to the latter, in the case of disconnection of all the channels, a signal ordering the switching of said member to be controlled to its security position.

8. A device according to claim 1, wherein said intermediary element is an electric accumulator.

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