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(71) Applicant: **SAAB TRAINING SYSTEMS AB**
Box 2049
S-561 02 Huskvarna(SE)

(72) Inventor: **Lagervall, Per Göran**
Ingeryd
S-563 00 Gränna(SE)

(74) Representative: **Rustner, Lars**
SAAB-SCANIA AB Patent Department
S-581 88 Linköping(SE)

(54) **Method and device for detecting and firing a pyrotechnic charge in a multiple-charge system.**

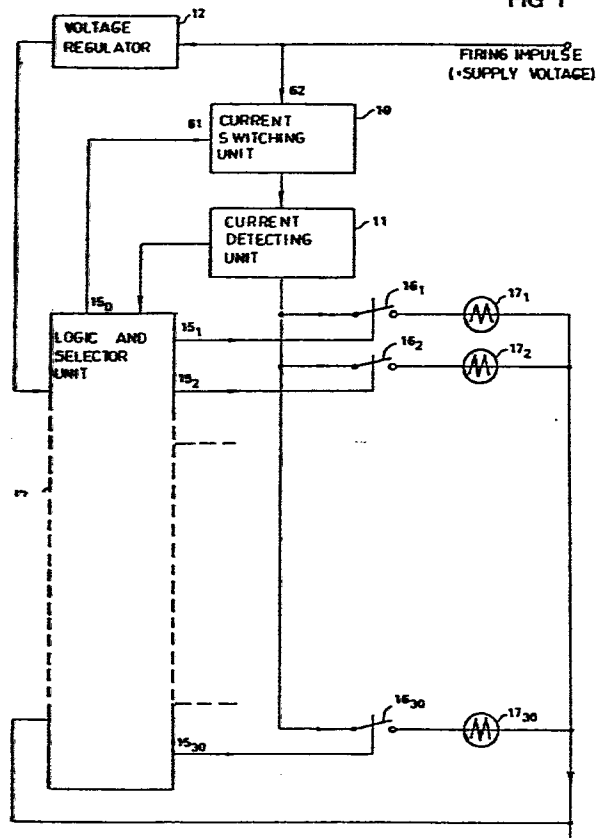
(57) The invention relates to a device which, upon receipt of a firing order in the form of a firing impulse, locates and fires a pyrotechnic charge connected in one of a plurality of firing circuits (17₁ - 17₃₀) in a firing unit. A current switching unit connects a current which is insufficient for firing a charge, to a firing circuit. After that, a current detecting unit checks whether or not a current is flowing in the firing circuit, i.e. whether or not a charge is connected. This is repeated by a logic unit (15) until a connected charge is located, whereupon a firing current is connected to the firing circuit comprising the connected charge, and the charge is fired.

The logic unit (15) controlling this course of events is supplied, like the device in its entirety, with its supply voltage from the said voltage pulse.

EP 0 160 628 A2

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FIG 1



METHOD AND DEVICE FOR LOCATING
AND FIRING A PYROTECHNIC CHARGE

The present invention relates to a device for locating and subsequent firing of a pyrotechnic charge connected in a firing circuit of charges, said device comprising, on the one hand, a current switching unit
5 which is adapted, upon receipt of a voltage pulse indicating that a charge is to be fired, to connect to one of the firing circuits of the firing unit a checking current insufficient for firing a charge, to check whether a charge is connected in the firing circuit concerned,
10 and adapted, if this is not the case, to repeat such connection of checking current for the remaining firing circuits until a connected charge is located and, when this found has happened, to connect a firing current sufficient for firing to the firing circuit in which the charge has been
15 found and, on the other hand, a current detecting unit adapted to effect the said check by detecting if current is flowing through the firing circuit concerned.

Devices for firing pyrotechnic charges are previously known from, for example, the brochure "BT 19 G
20 ELDMARKERINGSAPPARAT", SAAB-SCANIA, Jönköping, Sweden, and British patent specification 2361/1913. The first-mentioned device which is used mainly for simulating firing from a gun or a tank, comprises fifteen barrels which are loaded with pyrotechnic charges for electric firing,
25 a position selector whose position determines which charge is fired upon receipt of a firing impulse by said device, and a delay circuit preventing double firing upon contact bouncing. When a charge has been fired, the position selector is moved, under the action of a relay, through
30 one step, and when a period of time determined by the delay circuit has expired, the device is ready to fire a new charge. However, this device suffers from the disadvantage that, because there is no possibility of checking

if and where charges are provided in the firing unit, the charges must be placed in sequence in the barrels, beginning in the position indicated by the position selector. It is, however, desirable that it should be possible
5 to place the charges in optional positions in the firing unit.

The British patent specification discloses an apparatus comprising a current switching unit which consists of a manually activated switch which, upon activation,
10 connects a resistor in series with the firing circuit, thereby reducing the current to such an extent that firing cannot take place. A bell is used as current detecting unit for detecting whether current is flowing through the connected firing circuit. The apparatus thus
15 is essentially mechanical and is operated manually and in that a new firing impulse (a voltage pulse indicating that a charge is to be fired) must be provided for each firing circuit which is to be checked.

It therefore is an object of the present invention
20 to provide a device which is activated only upon receipt of the firing impulse and then automatically searches for and analyses whether a charge is present in any barrel and, if a charge is present, fires this charge.

A further object is to allow, upon supply of a
25 firing impulse, firing of the charge first found independently of the position this charge has in the firing unit.

The object of the invention is realised by means of a device having the characteristic features stated in the
30 appended claims.

According to the present invention, the device thus automatically locates the positions in which a charge is connected. This is done by connecting a current to one firing circuit at a time. If a charge is connected to
35 this firing circuit, a current will flow through the firing circuit, the charge will be fired, and the current will be detected by a current detecting unit. Scanning of

the firing circuits normally starts always on the same firing circuit, but according to a variant of the invention the operator himself may define the starting point of the scanning by not connecting any charge in the firing circuit before the desired starting point. According to this variant, the device first searches out a firing circuit without charge, the current connected to the firing circuits being insufficient for firing a charge. After that, the search for a connected charge is begun, and when such a charge is encountered, the firing current is connected to the corresponding firing circuit, and the charge is fired. The above-mentioned sequence is carried out automatically by a logic unit connected between the current detecting unit and the current switching unit, said units being activated only when a firing impulse is available on the input of the device.

An embodiment of the invention will now be described with reference to the accompanying drawings. Fig. 1 is a block diagram illustrating the principle of the present invention. Fig. 2 is a flow diagram illustrating the method according to the present invention. Fig. 3 is a more detailed block diagram of the logic and selector unit shown in Fig. 1. Fig. 4 is a circuit diagram illustrating a current switching unit, a current detecting unit, and a firing circuit.

The principles of the device according to the invention, which is intended to be connected to a firing unit capable of accommodating thirty charges, will be described below. As will appear from Fig. 1, the device comprises a current switching unit 10 which, via a current detecting unit 11, is connected to switches $16_1 - 16_{30}$. Between each switch $16_1 - 16_{30}$ and earth, a charge may be connected in any one of the firing circuits $17_1 - 17_{30}$ of a firing unit. Furthermore, the device comprises a logic unit 15 having thirty-one outputs $15_0 - 15_{30}$, of which an output 15_0 is connected to the current switching unit 10 for transmitting a control signal thereto, the remaining

thirty outputs $15_1 - 15_{30}$ being connected each to one switch $16_1 - 16_{30}$ for controlling the state thereof. The supply voltage to the logic unit 15 is derived from the firing impulse, i.e. the voltage pulse indicating
5 that a charge is to be fired, and is stabilised by means of a voltage regulator 12. The device thus is current-carrying only when the firing impulse has been supplied to the input of the device.

The function of the device will now be described
10 with reference to Figs. 1 and 2. When the device receives a firing impulse (20, Fig. 2), the logic unit 15 is supplied with current via the voltage regulator 12. The logic unit closes the first switch 16_1 (21, Fig. 2) and supplies a low control signal to the current switching unit
15 10 which supplies a checking current, i.e. a current which is smaller than the firing current (22, Fig. 2) required for the firing of a charge. If a charge is connected in the firing circuit between the said switch and earth, a current will flow through the detecting unit 11,
20 the switch 16_1 and the firing circuit 17_1 to earth. This current is detected by the detecting unit 11 which supplies a signal to the logic unit 15 signalling that a charge is connected. If, on the other hand, there is no connected charge at this location, the circuit is interrupted,
25 rupted, and no current will flow through the current detecting unit 11.

The device starts by searching for a firing circuit without connected charge (23, Fig. 2), said circuit defining the starting point of the actual search for a
30 connected charge. To begin with, the first switch 16_1 is closed. If a charge is connected at this location, the switch 16_1 is disconnected, and the next switch 16_2 is closed (24, Fig. 2). This procedure is repeated until a firing circuit without connected charge is found. Then
35 the search for a connected charge is begun. This search is effected in the same manner, i.e. the next switch is closed, and the detecting unit 11 detects if any current

is flowing in the circuit (25, 26, Fig. 2). If not, scanning is continued on the next firing circuit. When a connected charge is encountered, scanning is stopped, and the logic unit 15 supplies a high control signal to the current switching unit 10 which supplies a firing current to the connected charge which then is fired (27, Fig. 2). When a charge has been fired, the firing circuit may be short-circuited. To prevent this short-circuiting from blocking the device during its continued use, a test is made after a predetermined time delay to check if current is still flowing in the firing circuit (28, 29, Fig. 2). If this is the case, the device goes on and tries to fire the next charge (30, Fig. 2). If, however, there is no current flowing in the firing circuit, firing has been completed, and the logic is locked so that nothing more can happen during this firing impulse (31, Fig. 2).

The logic and selector unit will now be described in more detail, reference being had to Fig. 3. A gating network 51 has four outputs, two of which are connected to a JK-flip-flop 52, while the other two are connected to another JK-flip-flop 53. The Q-output of the JK-flip-flop 52 is connected on the one hand to one input A₂ of a status decoder 54 and, on the other hand, back to the gating network 51, while its complementary $\bar{Q}$ -output only is fed back to the gating network 51. The Q-output of the other JK-flip-flop 53 is fed back to the gating network 51, to the second input A₁ of the status decoder 54 and to an enable input on an address counter 55, while its complementary $\bar{Q}$ -output is connected to a reset input R on a maximum time counter 56, the output of which is fed back to the input M of the gating network 51. The address counter 55 has seven outputs corresponding each to one bit in an address. The most significant bit is fed back to the counter, and when this bit is set to one, the counter is stopped. The five least significant bits are connected to a demultiplexor 57, the data input of which is always set to one. The demultiplexor 57 has

thirty-two outputs of which the first one 57_0 is fed back to the gating network 51, the next thirty outputs $57_1 - 57_{30}$ are connected to the corresponding switches $16_1 - 16_{30}$ (see Fig. 1) and the last output 57_{31} is not being
5 used. The status decoder 54 which activates the demultiplexor 57 with a signal on its input E, has an output connected to the current switching unit 10 for transmission of a control signal thereto. The logic and selector unit also comprises a resetting circuit (not shown) which, at
10 the beginning of each firing impulse, resets the JK-flip-flops 52, 53, the address counter 55 and the maximum time counter 56. There is also a clock circuit (not shown) supplying clock pulses to the last-mentioned circuits.

When the device according to the present invention
15 receives a firing impulse, the JK-flip-flops 52, 53, the address counter 55 and the maximum time counter 56 are first reset. Then the demultiplexor 57 is activated, its first output 57_0 being set to one. This output is connected back to the gating network 51 in such a manner that
20 the inputs of the flip-flops 52, 53 will be zero, i.e. the status of the flip-flops cannot be changed when $I = 0$. This is utilised in order to get past the output 57_0 . At the next clock pulse, the address counter 55 is incremented one step, and the next output 57_1 on the demultiplexor 57 is set to one. The current through the corresponding firing circuit is sensed, and the result is
25 indicated by means of a signal from the current sensing unit 11 to the gating network 51. When a firing circuit without connected charge is encountered, the Q-output of the JK-flip-flop is set to one, whereupon the device begins to search for a connected charge. Scanning is effected in the same manner as before, and incrementation of the address counter 55 continues. When a connected charge is encountered, the Q-output of the JK-flip-flop 53 is set to
30 one, the address counter 55 being stopped and the status decoder 54 supplying a high control signal to the current switching means 10 which transmits a firing current

through the connected firing circuit. At the same time, the maximum time counter 56 begins to count. Before the time delay predetermined by this counter has expired, nothing happens, but when the output signal from the counter goes high, the current in the firing circuit of the charge just fired is sensed. If current still flows in the circuit, the Q-output of the JK-flip-flop 53 is cleared, and the address counter 55 is activated, the maximum time counter 56 is reset, and the search for a new connected charge is resumed. If, on the other hand, there is no current flowing in the firing circuit, the JK-flip-flop 52 is cleared, the enable input E of the demultiplexor 57 being cleared, and nothing more happens during the current firing impulse.

Finally, mention should be made of the case when charges are connected in all of the firing circuits of the device, and also the case when the device contains no charges. In the first case, the device will find no empty firing circuit when scanning the thirty firing circuits $17_1 - 17_{30}$. However, when the last output 57_{31} of the selector unit is addressed, no current will flow through the current detecting unit 11 because the addressed output is not connected to any firing circuit. This will then be interpreted as a firing circuit without charge, and the device begins to search for a connected charge on the output 57_0 . In the second case, on the other hand, a firing circuit without charge is found directly. The firing circuits are then scanned without encountering any connected charge. When the most significant bit of the addressed counter 55 is one, i.e. when all firing circuits have been scanned twice, scanning is stopped.

Fig. 4 illustrates the circuit diagram of the current switching unit 10, the current detecting unit 11 and a switch 16_1 for connection of a first firing circuit 17_1 . The current switching unit 10 has an input 61 which receives a control signal from the logic and selector unit

15, and an input 62 which receives the firing impulses. The input 61 is connected to a zener diode 63 which is connected to earth via a resistor 64 and to the base of a transistor 66 via a resistor 65. The input 62 is
5 connected to the collector of the transistor 66 via two resistors 68 and 69 between which the base of a Darlington amplifier 67 is connected. A resistor 70 limiting the firing current may be connected between the emitter of the Darlington amplifier 67 and a switch 16₁. The switch
10 16₁ is a Darlington amplifier which is biased from the corresponding output 15₁ of the logic unit 15, for connection of a firing circuit 17₁. The other switches 16₂ - 16₃₀ and the firing circuits 17₂ - 17₃₀ are similarly arranged.

15 The current detecting unit 11 comprises two transistor stages. The first stage comprises resistors 73, 74 connected in parallel with the Darlington amplifier 67 and the resistor 70, and a transistor 75 whose collector is connected to the second transistor stage. The
20 second transistor stage comprises two biasing resistors 76, 77, a collector resistor 78 which is connected to the voltage supply, and a transistor 79. The voltage between the collector and emitter of the resistor 79 constitutes the input signal to the logic unit 15.

25 When the output 15₁ of the logic and selector unit 15 goes high, the Darlington amplifier which constitutes the switch 16₁ is biased. If a charge is connected in the firing circuit 17₁ between the said switch 16₁ and earth, a closed circuit is formed from the input 62
30 via the Darlington amplifier 67, the resistor 70 limiting the firing current, the Darlington amplifier 16₁ and the firing circuit 17₁ to earth, as well as through the parallel branch comprising the resistors 73, 74. If the control signal on the input 61 of the current switching unit 10 in this instance is low, the Darlington amplifier 67 is throttled, and but a low current, the checking
35 current, flows through the resistors 73, 74 to the firing

circuit 17₁. If, instead, the said control signal is high, current flows through both branches to the firing circuit 17₁. Since the Darlington amplifier 67 is in a conductive state, the current in this branch
5 is greatly amplified and thus constitutes the firing current. In both of these cases, current is thus flowing through the resistors 73, 74 of the current detecting unit, the transistor 75 as well as the transistor 79 becoming conductive, and the logic unit receiving a
10 signal indicating that a charge is connected in the firing circuit. If, on the other hand, there is no charge in the firing circuit connected, the circuit from the input 62 to earth is interrupted, and no current will flow through the current detecting unit
15 11. In such a case, there is no biasing of the transistors 75 and 79, and the logic unit receives a signal indicating that there is no charge in the circuit.

It will be appreciated that the above described embodiment of a device according to the present inven-
20 tion is but an example and should not be interpreted as if the number of charges were restricted to thirty.

CLAIMS

1. A device for locating and subsequent firing of a pyrotechnic charge connected in a firing circuit ($17_1 - 17_{30}$) in a firing unit comprising a plurality of firing circuits for connecting charges, said device
5 comprising, on the one hand, a current switching unit (10) which is adapted, upon receipt of a voltage pulse indicating that a charge is to be fired, to connect to one of the firing circuits of the firing unit a checking current insufficient for firing a charge, to check
10 whether a charge is connected in the firing circuit concerned, and adapted, if this is not the case, to repeat such connection of checking current for the remaining firing circuits until a connected charge is found and, when this has happened, to connect a firing current
15 sufficient for firing to the firing circuit in which the charge has been found and, on the other hand, a current detecting unit (11) adapted to effect the said check by detecting if current is flowing through the firing circuit concerned, c h a r a c t e r i s e d by a
20 logic unit (15) connected between said current detecting unit (11) and said current switching unit (10) for controlling the supply of checking current and firing current by said current switching unit in response to the check made by said current detecting unit (11),
25 said logic unit being arranged such that its supply voltage is taken from the said voltage pulse.

2. A device as claimed in claim 1, c h a r a c - t e r i s e d by a selector unit (57) adapted to connect one firing circuit ($17_1 - 17_{30}$) at a time to said current
30 switching unit (10) and said current detecting unit (11) for checking whether a charge is connected in the respective firing circuit.

3. A device as claimed in claim 1 or 2, c h a r -
a c t e r i s e d in that said logic unit (15) comprises
a counter (56) adapted to supply, at a predetermined time
after firing of a charge, a signal which causes a check
5 to be made as to whether current is flowing in the firing
circuit of the fired charge ($17_1 - 17_{30}$).

4. A device as claimed in any one of claims 1-3,
c h a r a c t e r i s e d in that said logic unit (15)
comprises an address counter (55) adapted to indicate
10 which firing circuit ($17_1 - 17_{30}$) is to be connected to
said current switching unit (10) and to stop when all
firing circuits have been scanned twice without encounter-
ing any charge.

5. A device as claimed in any one of claims 1-4,
15 c h a r a c t e r i s e d in that the logic unit (15)
is so arranged that a search is made for a firing cir-
cuit ($17_1 - 17_{30}$) having no connected charge, before
the search for a connected charge is begun, whereby
the starting point of said last-mentioned search may
20 be varied.

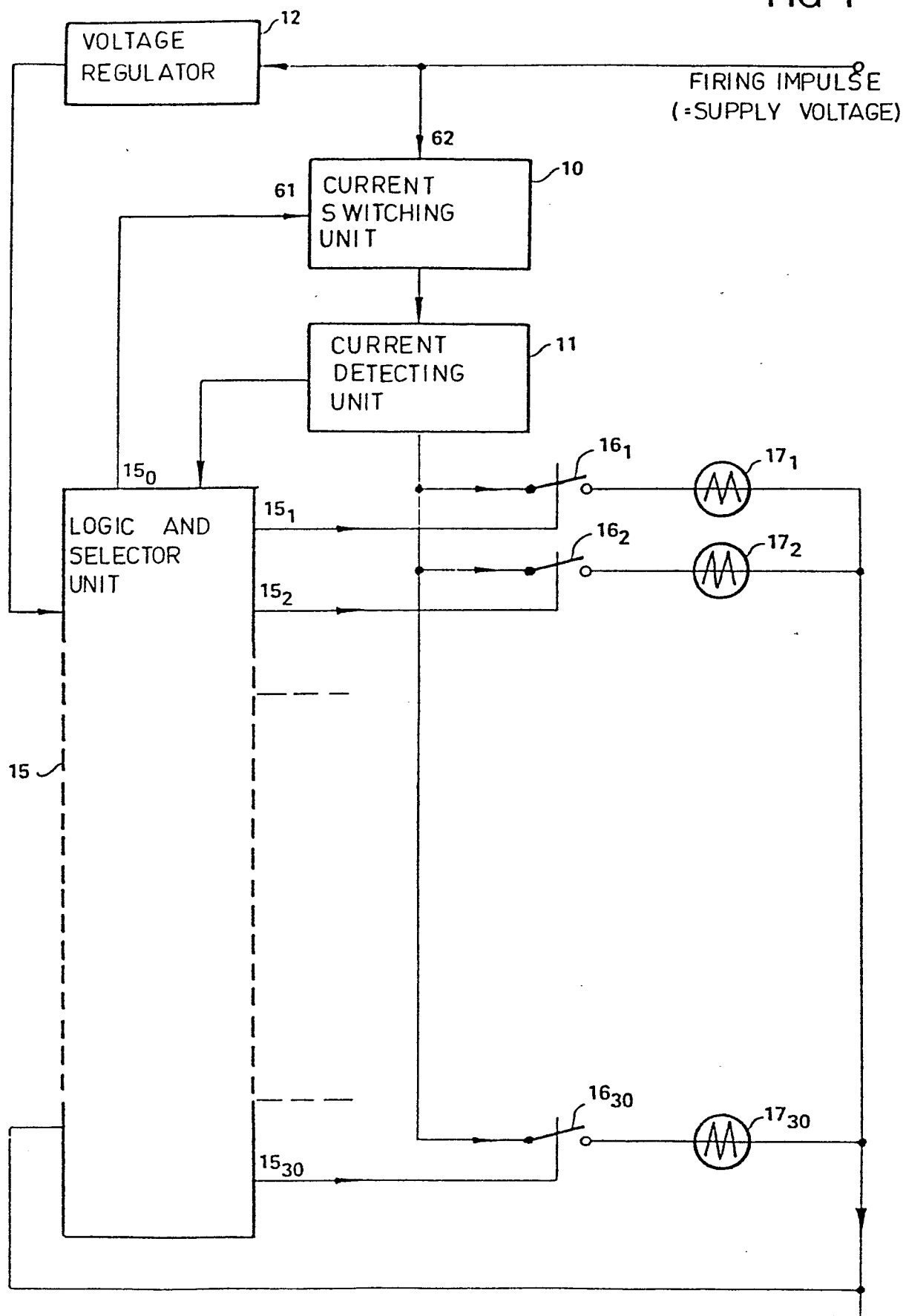


FIG 2

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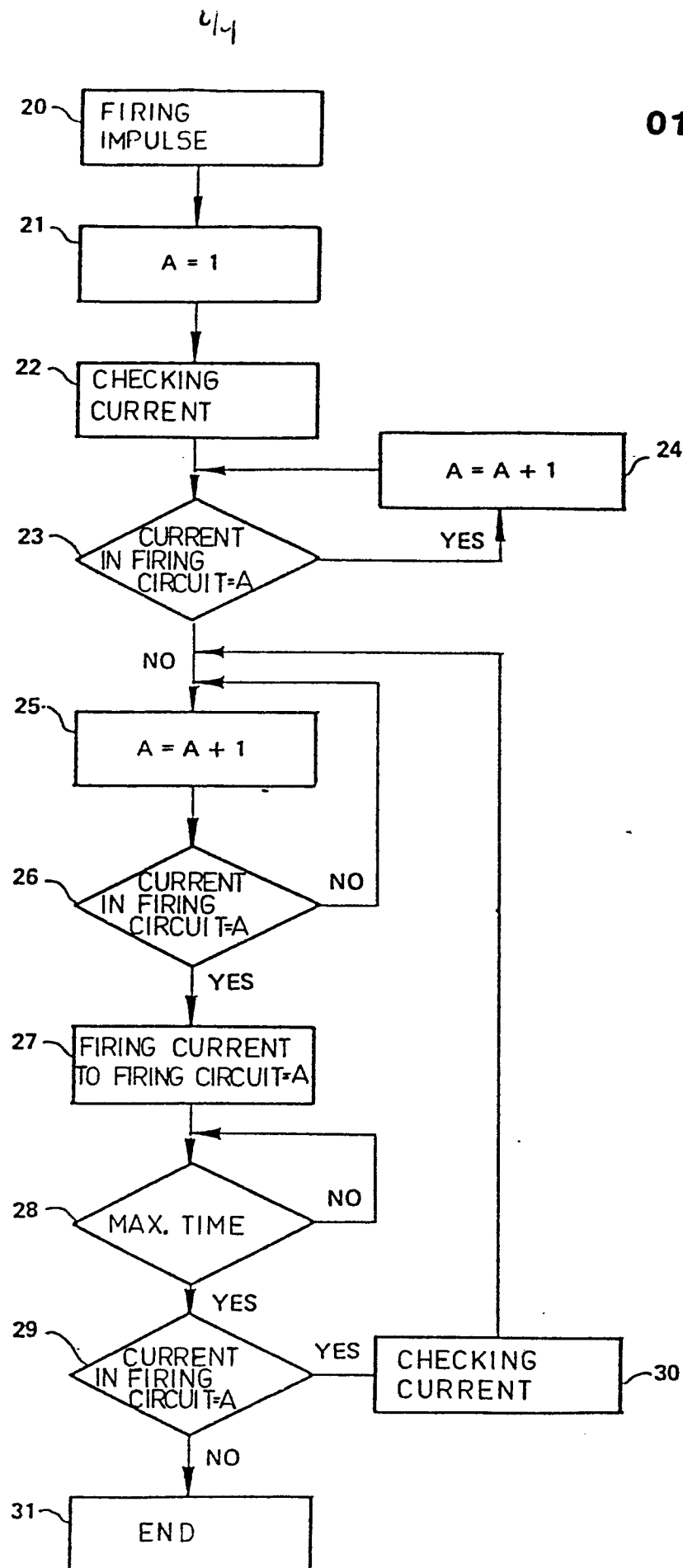


FIG 3

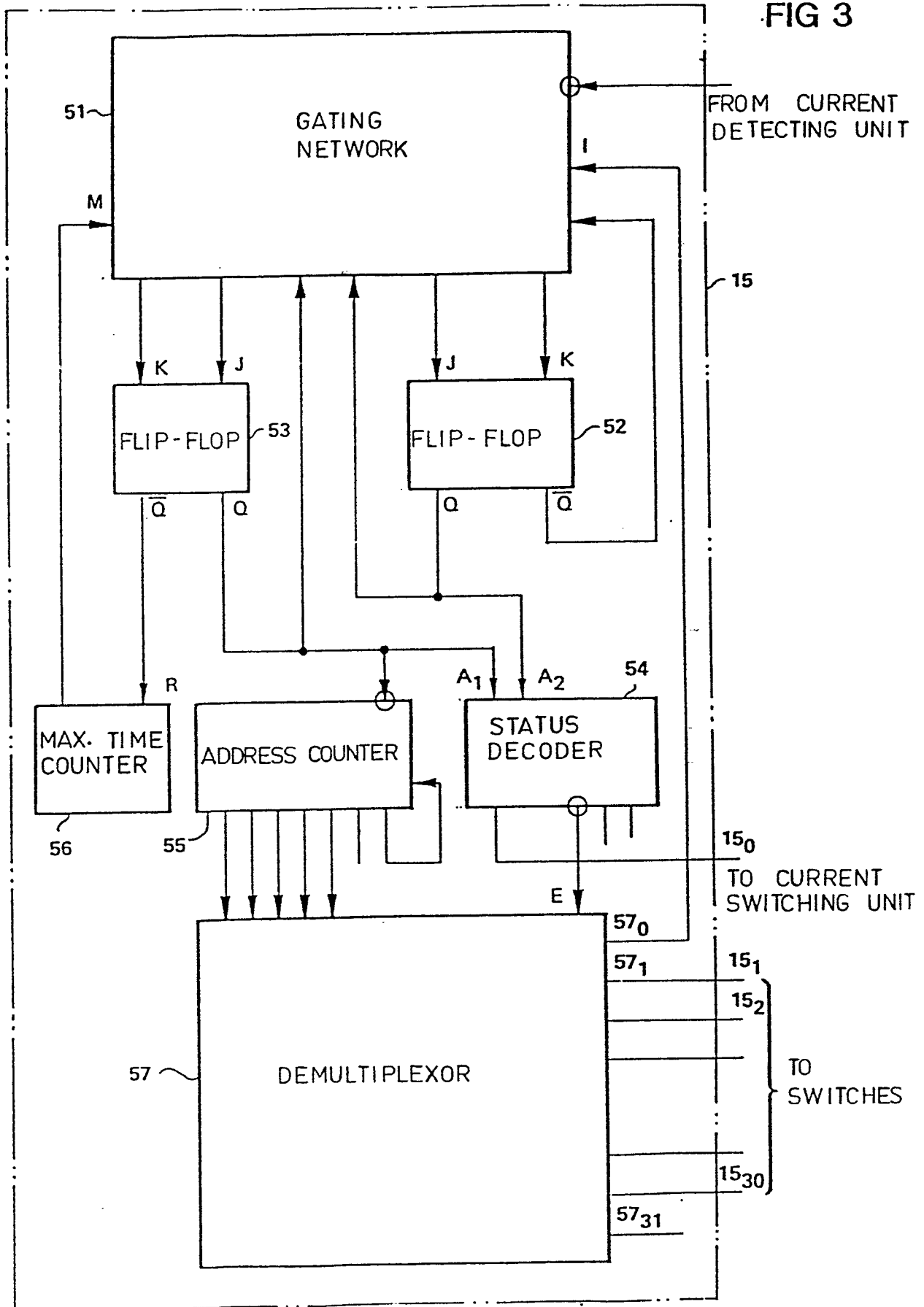


FIG 4

