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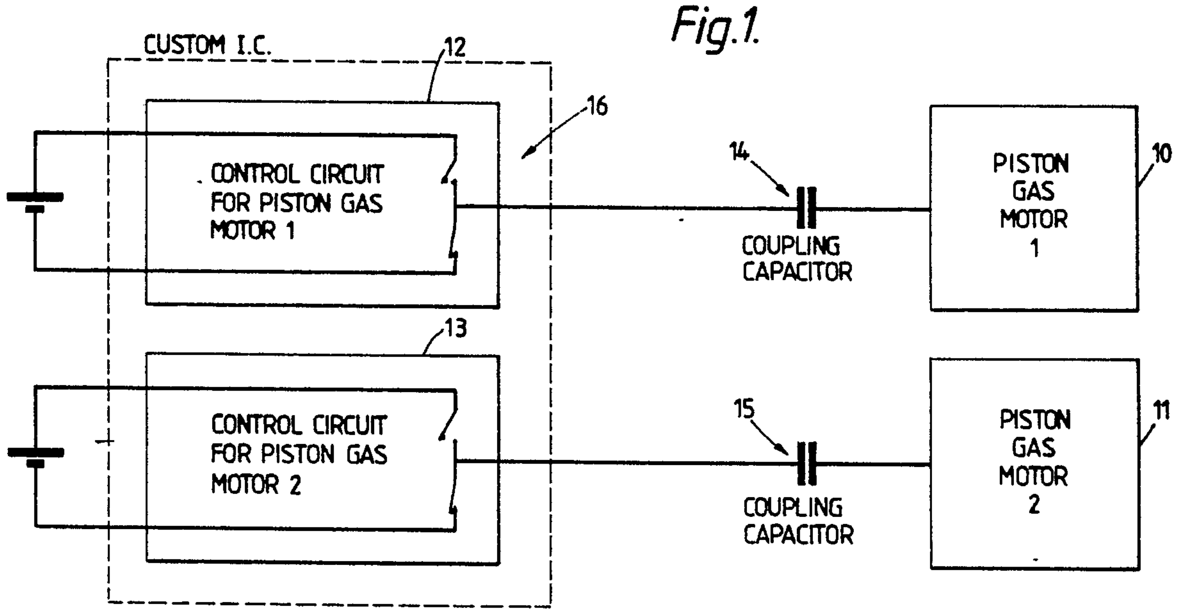
(54) **Safety system.**

(57) It is known to use safety systems in safety and arming units of a weapon. The system described herein uses a capacitor (14) coupled to an actuator and a control circuit and which is incapable of storing sufficient energy to actuate the actuator in the event of a control circuit malfunction.

Fig.1.



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SAFETY SYSTEMS

This invention relates to safety systems and in particular but not exclusively to such systems for use in safety and arming units for weapons.

In such systems it is a desirable that no single event shall arm the weapon. For example, a typical safety and arming unit would require two piston gas motors each to remove a lock from a shutter to allow the shutter to be withdrawn to arm the weapon.

According to one aspect of this invention, there is provided an actuator control circuit comprising an actuator for being actuated in response to electrical energy in excess of a predetermined level, a control circuit for providing an alternating electrical drive signal, and a capacitor coupling said actuator to said control circuit, said control circuit being operable to deliver sufficient energy to actuate said actuator, but said capacitor being incapable of storing sufficient energy to actuate said actuator.

According to another aspect of this invention, there is provided a safety system including first and second actuators, respective control arrangements for said first and second actuators, each arrangement comprising control circuit means for supplying an alternating electrical drive signal and a capacitor coupling said control circuit to the associated actuator, each of said control circuit means being operable to deliver sufficient electrical energy to actuate the associated actuator, and each of said capacitors being incapable of storing sufficient energy to actuate the associated actuator in the event of a control circuit malfunction.

Preferably, each of said control circuits is contained in a single package. This feature is of great practical significance insofar as it allows both control circuits to be formed in a single, common, custom integrated circuit, whilst still providing a high degree of safety. Should the environmental seal of the custom integrated circuit fail and both of the coupling capacitors discharge into the actuators, neither actuator would be actuated.

Further aspects will be apparent from the following description which is by way of example only reference being made to the accompanying drawings, in which:-

Figure 1 is a schematic diagram illustrating a twin channel safety system, and

Figures 2 a to 2g illustrate successive stages in a cycle of operation of one of the channels of Figure 1.

The system illustrated in the drawings is intended for use in a safety and arming unit which includes a shutter which may be moved from a "safe" position to an "armed" position in response to the occurrence of two independent events, for example predetermined levels of longitudinal acceleration and angular acceleration, and no single circumstance or fault must allow arming to occur before these events have occurred.

Referring to Figure 1, the system comprises two piston gas motors 10, 11 which are coupled to respective control circuits 12, 13 by means of capacitors 14, 15. The two control circuits 12, 13 are formed on an single custom integrated circuit 16 which is contained within an environmentally sealed package.

The piston gas motors 10, 11 are devices which are pyrotechnically actuated in response to the supply of a sufficient level of electrical energy to withdraw a lock (not shown) from the shutter (not shown).

Such devices are calibrated and have an "all fire level" which stipulates the level of energy supplied above which all devices will fire and a "no fire level" which stipulates the level of energy supplied below which no device will fire.

Referring to Figures 2a to 2g the control circuits are each illustrated schematically, comprising a voltage source 17 which applies a d.c. voltage V across two transistor switches S_1 and S_2 which are controlled alternately to open and close. The piston gas motor 10/11 (here represented as resistance R) is coupled in series with the coupling capacitor 14/15 (here represented as capacitance C) and the resultant alternating voltage appearing between switches S_1 and S_2 is applied across the piston gas motor and the coupling capacitor.

In operation, assuming the circuit to be in the state illustrated in Figure 2a, switch S_1 is open, switch S_2 is closed and there is no charge stored in the capacitor C and both plates of the capacitor are at 0V potential. At the instant switch S_1 closes and switch S_2 opens (Figure 2b), both capacitor plates instantly charge to potential +V with respect to 0V. Referring to Figure 2c the potential difference +V across resistance R (the piston gas motor) causes a current I to flow through resistance R according to the law

$$I = \frac{V}{R} \times e^{-t/CR}$$

where t is the time period for which switch S_1 is closed and switch S_2 is open.

The current through resistance R will eventually decay exponentially towards zero as the capacitor C charges up. There will now be a voltage difference between the two plates of the capacitor where the top plate will be a +V with respect to 0V and the lower one at 0V (Figure 2d).

The capacitor C would now be storing a charge energy of $\frac{1}{2}CV^2$.

At the instant S_1 opened and S_2 closed (Figure 2e) the top plate of the capacitor C will become 0V and since the capacitor is charged to voltage V the potential of the bottom plate will be -V with reference to 0V.

Referring to Figure 2f, the potential difference across resistance R will cause a current to flow through the resistance according to the law

$$I_2 = \frac{V}{R} \times e^{-t/CR}$$

where t is the time period for which S_1 is open and S_2 closed.

The current through the resistance will eventually decay expotentially to zero as the capacitor stored energy is discharged (Figure 2 g).

If the rate of performing the cycle of events, (Figures 2a -2g) is below a certain frequency f then the energy which is dissipated in the piston gas motor will be below the 'NO FIRE LEVEL' of the piston gas motor.

The energy transfer is given by

$$2 \times f \left(\tfrac{1}{2} CV^2\right)$$

When the frequency is above a certain limit then the energy level being transformed will be above the 'ALL FIRE LEVEL' of the piston gas motor.

It should be understood that the limits illustrated in Figures 1 and 2 are given for a full understanding of the system and that, in practice, the design of the circuit may be quite different, but operate on the same principles.

The advantage of the described technique is that by placing coupling capacitors in series with the piston gas motor lines a short circuit within the custom integrated circuit will not fire the piston gas motors thereby making the system as safe as a discrete system or a two custom integrated circuit system.

The piston gas motors will only be fired when the output driver circuit of the custom integrated circuit (equivalent to S_1 and S_2 in Figure 2) is driven at a sufficiently high frequency.

This arrangement will offer considerable cost advantages to the design of safety systems and furthermore will allow volume reduction of the electronics required for a given safety standard.

Claims

1. An actuator control circuit comprising an actuator for being actuated in response to electrical energy in excess of a predetermined level, a control circuit for providing an alternating electrical drive signal, and a capacitor coupling said actuator to said control circuit, said control circuit being operable to deliver sufficient energy to actuate said actuator, but said capacitor being incapable of storing sufficient energy to actuate said actuator.

2. A safety system including first and second actuators, respective control arrangements for said first and second actuators, each arrangement comprising control circuit means for supplying an alternating electrical drive signal and a capacitor coupling said control circuit to the associated actuator, each of said control circuit means being operable to deliver sufficient electrical energy to actuate the associated actuator, and each of said capacitors being incapable of storing sufficient energy to actuate the associated actuator in the event of a control circuit malfunction.

3. A safety circuit according to claim 2, wherein said control circuits are contained in a single package.

4. A safety circuit according to claim 2 or 3, wherein each control circuit comprises a d.c. voltage source and a pair of transistor switches which are controlled to be alternatively open and closed.

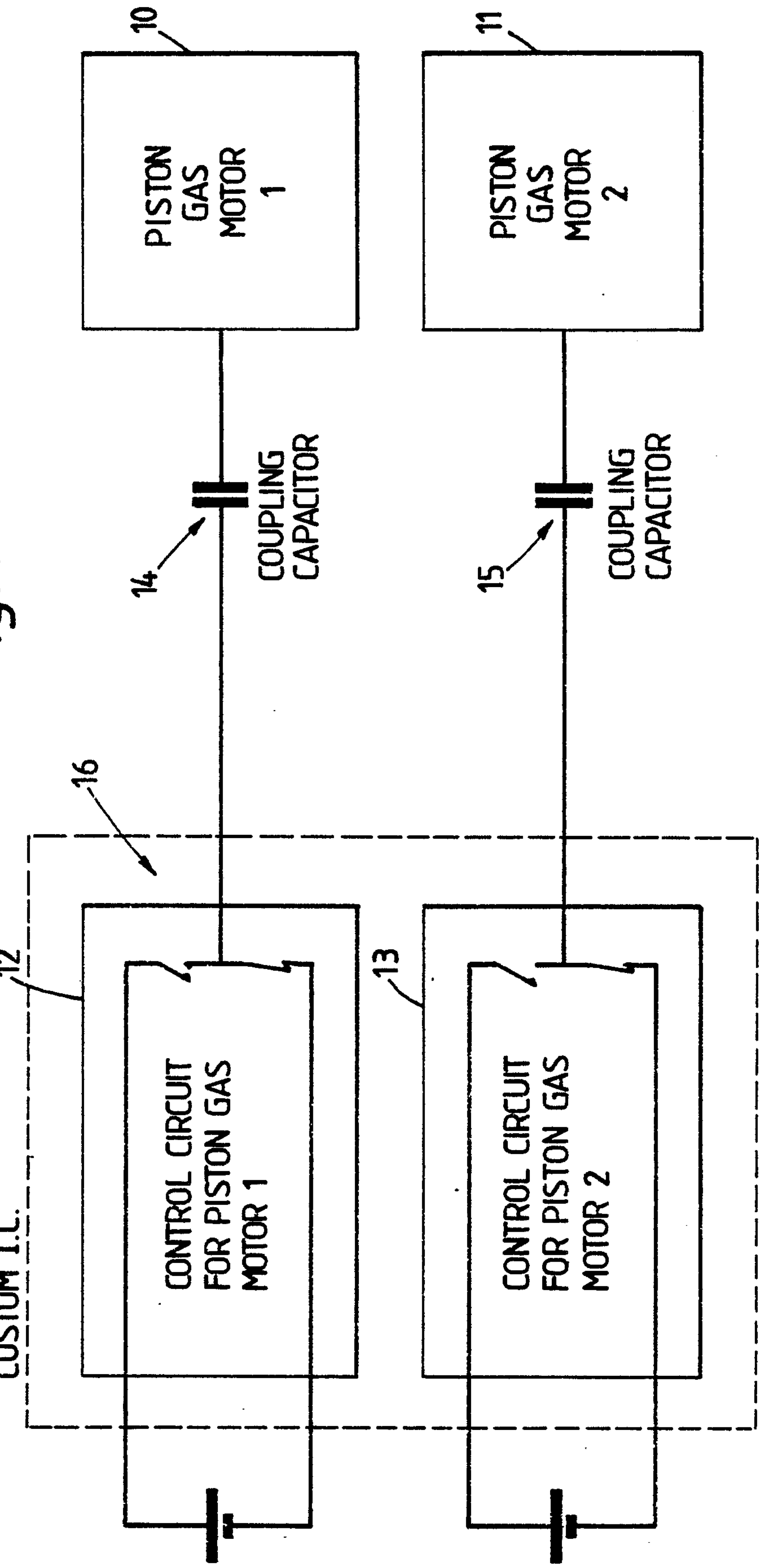
10
PISTON GAS MOTOR 1
11
PISTON GAS MOTOR 2
14
COUPLING CAPACITOR
15
COUPLING CAPACITOR
16
CUSTOM I.C.
12
CONTROL CIRCUIT FOR PISTON GAS MOTOR 1
13
CONTROL CIRCUIT FOR PISTON GAS MOTOR 2

Fig.1.

Fig.2(a).

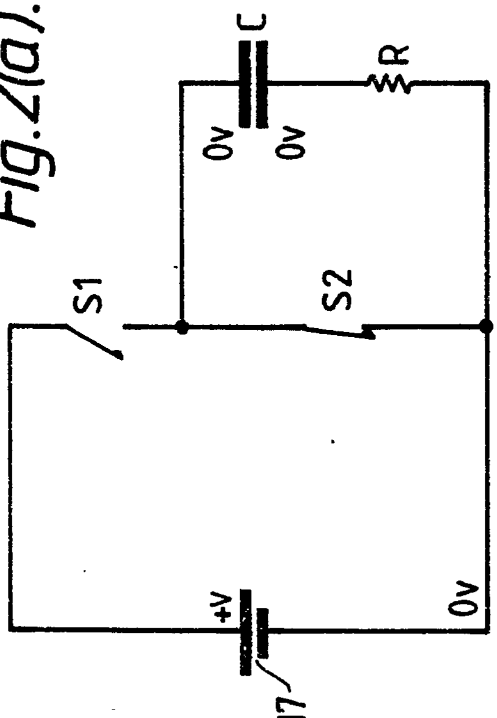

Fig.2(b).

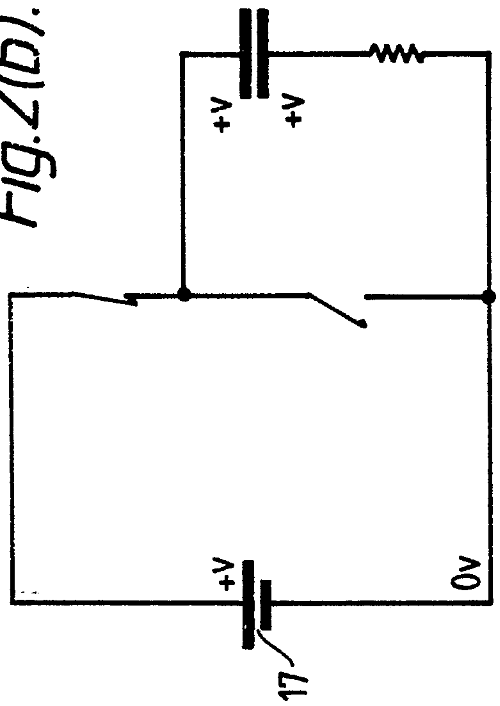

Fig.2(c).

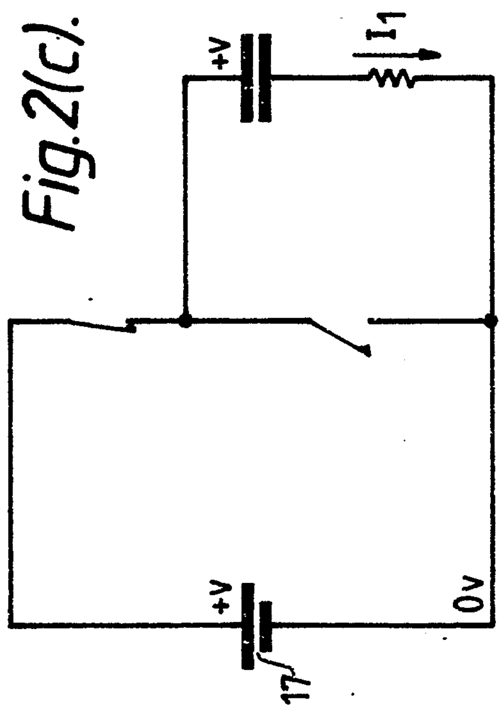

Fig.2(d).

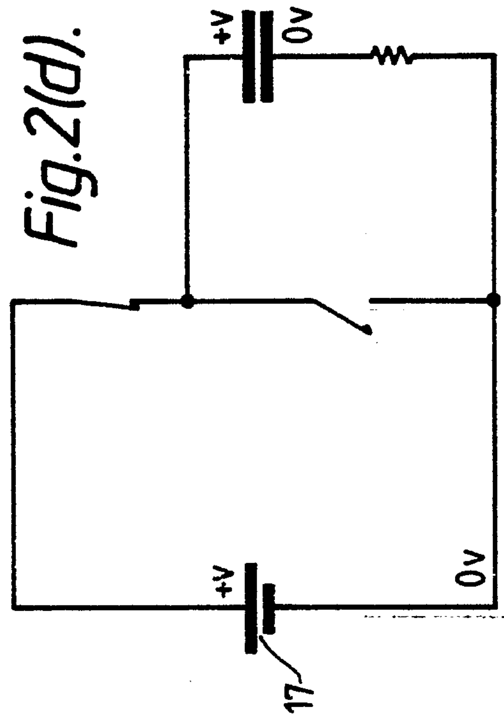

Fig.2(f).

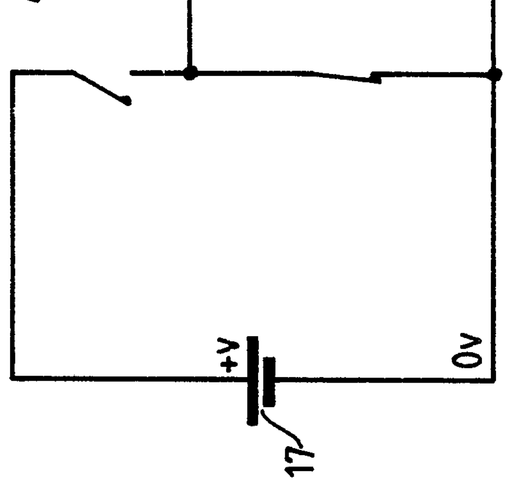

Fig.2(e).

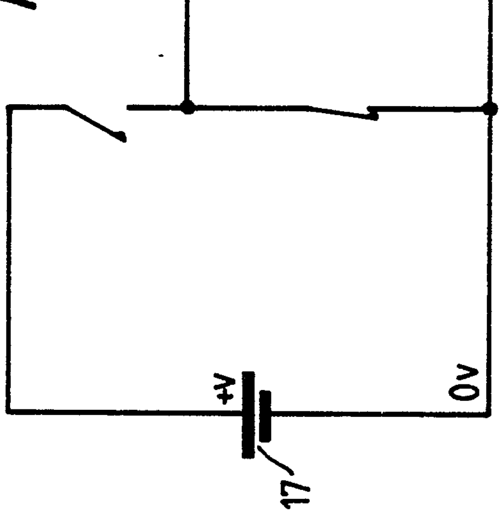

Fig.2(g).