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EXPLOSION SUPPRESSING SYSTEM

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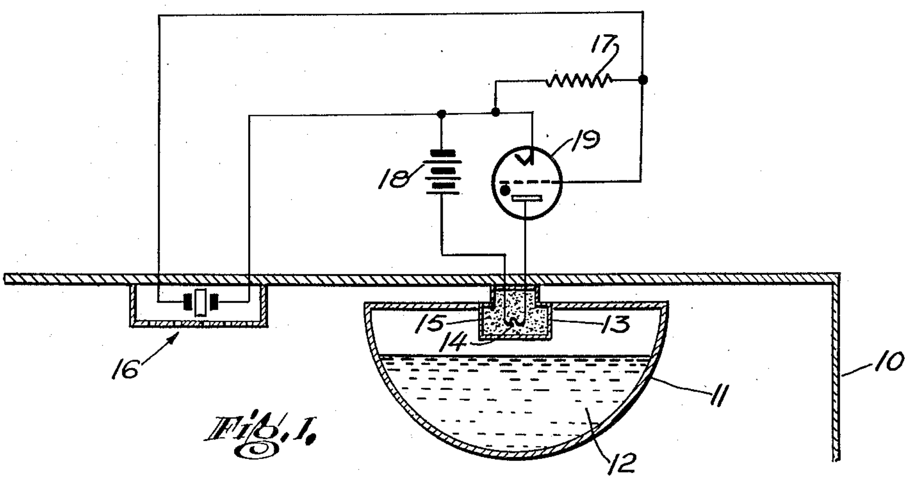

Fig. 1.

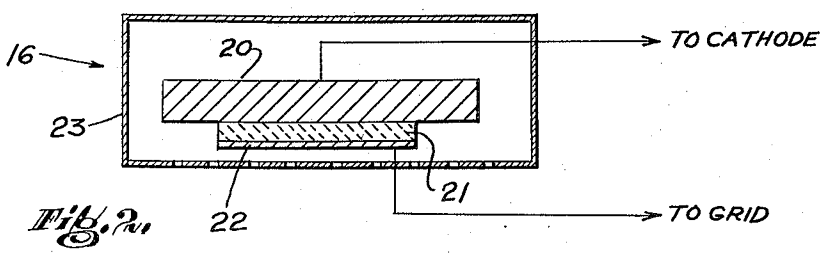

Fig. 2.

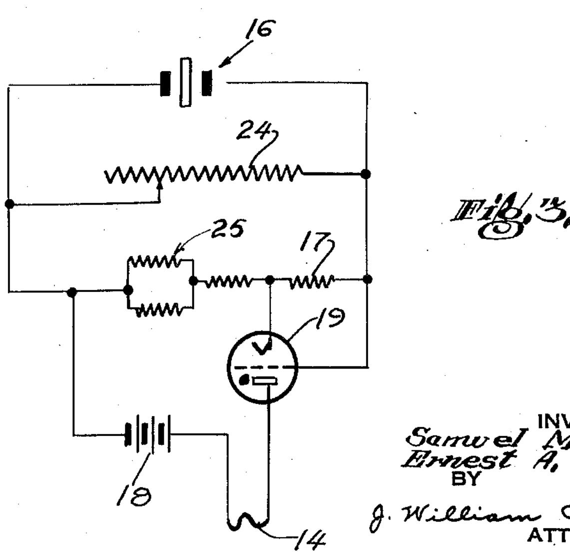

Fig. 3.

INVENTORS
Samuel M. Bagno
Ernest A. Joerren
BY
J. William Carson
ATTORNEY

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EXPLOSION SUPPRESSING SYSTEM

Samuel M. Bagno, Astoria, and Ernest A. Joerren, Brooklyn, N. Y., assignors to Specialties Development Corporation, Belleville, N. J., a corporation of New Jersey

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3 Claims. (Cl. 169—4)

The present invention relates to fire preventing and extinguishing, and, more particularly, to an improved system for preventing and extinguishing fires in response to an abnormal rate of pressure rise which may occur at the very start of an explosion, whereby the explosion or the fire which could result therefrom is suppressed before it can be established.

Heretofore, it has been proposed to accomplish the foregoing by apparatus including barometric pressure responsive diaphragm or bellows means for detecting a rise in pressure occurring in an incipient fire or explosion, the bellows means being connected in an electric circuit including a contact adapted to be closed by the operation of the means to release a fire or explosion suppressing substance and being formed with a bleed or vent orifice for preventing operation due to barometric pressure changes but providing for operation when the rate of pressure rise is in excess of a predetermined value.

The difficulty with such apparatus is that the responsive means can be adversely affected by humidity or temperature changes, aging and corrosion and its orifice can be blocked or partially blocked by foreign matter to induce false operation of the apparatus due to barometric pressure changes. Also, devices which depend on mechanical movement to close switch contacts tend to be too slow and sluggish to suppress explosions. Another disadvantage is that such apparatus is extremely difficult to adjust or calibrate and therefore is unreliable in performance.

Accordingly, an object of the present invention is to provide apparatus for an explosion suppressing system which is not subject to the foregoing difficulties and disadvantages.

Another object is to provide such apparatus which is extremely sensitive to pressure variations but responds only when the pressure rise exceeds a predetermined rate.

Another object is to provide such apparatus which is readily and accurately adjusted and is reliable in operation.

Another object is to provide such apparatus which compensates for temperature extremes to maintain its sensitivity, rapid response and accuracy near the ground and at high altitudes.

A further object is to provide such apparatus which is light in weight, compact in arrangement and economical to manufacture and install.

A still further object is to provide such apparatus adapted to act in conjunction with other detecting devices in a coincidence circuit.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the present invention, the foregoing objects generally are accomplished by providing a system of the character indicated herein which comprises an electrically controlled device adapted for effecting the release of an explosion suppressing medium at or in the vicinity of the explosion zone, a network for controlling the energization of the device, and a piezoelectric pressure transducer having a rate of pressure rise characteristic and being connected in the network to effect energization of the device in response to a predetermined rate of pressure rise.

It has been found that certain types of piezoelectric crystals have such rate of pressure rise characteristic, for example, crystals of the so-called high capacitance type. Such crystals may be visualized as including a source of electrical current, a switch for releasing the current by conversion of pressure energy to electrical energy, a condenser, and resistances in series and/or in parallel with the condenser which control the flow of current in response to rate of pressure rise.

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawing, forming a part of the specification, wherein:

Fig. 1 is a fragmentary schematic elevational view of a basic system embodying the present invention for suppressing explosions including a simplified wiring diagram.

Fig. 2 is a schematic detail view of the pressure transducer utilized in the system.

Fig. 3 is a wiring diagram of a network provided with elements for adjustment and temperature compensation.

Referring to Fig. 1 of the drawing in detail, there is shows a system for suppressing explosions in a tank or hazard zone **10** for storing explosive substances such as gasoline or other highly volatile materials. The system generally comprises a receptacle **11** (located in or adjacent the zone **10**) for storing a fire extinguishing and/or fire preventing medium **12** adapted to be released into the zone to establish an atmosphere which will extinguish flame or prevent combustion; a squib **13** operatively associated with the receptacles **11** including a fuse or filament **14** and a charge of explosive substance **15** adapted to be ignited by the fuse and rapidly disrupt the receptacle to release the medium **12** therefrom; a piezoelectric pressure transducer **16** (located within or closely adjacent the zone **10**) which is adapted to respond to a rise of pressure exceeding a predetermined rate; and an electrical network for connecting the fuse **14** and the transducer **16** in a manner whereby the latter controls the energization of the former to ignite the explosive substance **15**.

The aforementioned network generally comprises a source of uni-directional electrical energy, such as a battery **18** adapted to energize the fuse; an electron tube, such as a triode **19** for controlling the flow of current through the fuse in response to the transducer; and a time constant calibrating resistor **17**. In cases where the installation of the system permits the use of a transducer having a sufficient output to energize the fuse, the battery **18** and tube **19** are not required, and, in such cases the battery shown may be visualized as being included in the transducer.

It will be understood that the network may include conventional resistance and capacitance components to meet operational requirements and to facilitate adjustment and calibration and balancing of the network.

In this network, the cathode and the grid of the triode are connected across the terminals of the transducer, with the cathode to the negative side of the grid to the positive side; the resistor **17** is connected across the cathode and the grid; and the fuse **14** and the battery **18** are connected in series across the cathode and plate of the triode, with the negative side of the battery to the cathode and the positive side of the battery to the plate. The triode, as shown, preferably is of the gas-filled or thyratron type which continues to fire and permit current to flow through the fuse **14** once the tube is triggered by current developed by the transducer which energizes the grid. However, it is contemplated that other types of electron tubes may be utilized.

In Fig. 2, the pressure transducer is shown in detail to illustrate the essential elements thereof. For example, the pressure transducer comprises a holder **20** formed of high inertia metal such as iron, ferrous alloys or lead, which is electrically connected to the cathode of the triode; a crystal **21** suitably attached to the holder; and a pressure plate **22**, such as a strip of metal foil, suitably attached to the crystal to be pressed against the same in response to the ambient pressure and cause the crystal to develop an electrical output, which is electrically connected to the grid of the triode. These elements preferably are placed in a casing or housing **23** which is adapted to protect the same and is formed with suitable openings, perforations or screening to enable the transducer to sense the pressure within the hazard zone.

As previously indicated, the pressure transducer may have a high, that is, appreciable capacitance, and, to accomplish such purpose, a piezoelectric, ceramic type crystal composed of barium titanate, calcium titanate, barium-calcium titanate or lead zirconate may be utilized. Alternatively, other types of crystals may be employed in conjunction with a condenser to provide a transducer device having the desired capacitance.

In such a transducer, the output voltage E thereof varies directly as the force P which is applied to the crystal **21** by the pressure plate **22**. Since the crystal has a relatively low resistance R and a high capacitance C, it acts primarily as a condenser network having a time or rate of pressure rise function (*dt*) which determines the conditions under which electrical energy is released to trigger the thyratron.

Thus, from the equations,

$$E=IR$$

and

$$Q=CE$$

and, since the voltage across the crystal is $E=KP$, where K is the constant of the crystal, it follows that,

$$I=\frac{dQ}{dt}=\frac{CdE}{dt}$$

and

$$Eg=IRg=\frac{RCdE}{dt}=\frac{KRCdP}{dt}$$

In Fig. 3, a modified network is illustrated which includes a variable calibrating resistor **24** for enabling the rate of pressure rise response of the pressure transducer to be accurately adjusted to satisfy a predetermined or desired condition; and which further includes a thermistor network has a negative temperature coconnected in the network between the cathode of the triode **19** and the negative side of the battery **18**. Such a thermistor network has a negative temperature coefficient of resistivity and the other conductive components of the system have a positive temperature coefficient of resistivity, whereby changes in resistance in the system due to temperature changes are compensated for by the thermistor network to maintain a uniform negative bias on the cathode of the triode.

In operation, the pressure transducer **16** senses the pressure in the zone **10**, and, while the pressure is constant within the usual atmosphere range, the pressure transducer is inactive. Should this pressure increase rapidly from one atmospheric pressure value to another, such as may be effected when aircraft dives or plummets to the ground from a high altitude, such pressure change affects the pressure transducer, but, by reason of its high capacitance and rate of pressure rise characteristic, no appreciable electrical output is developed. This is because such pressure changes are not within the range for which the transducer is designed and any current developed is stored and/or dissipated without energizing the grid of the triode. However, should the pressure sensed by the transducer increase from an atmospheric value to say 40 or 60 p. s. i. in one milli-second, which may occur at the very beginning of an explosion, the crystal by reason of its sensitivity to such rate of pressure rise develops an output current in even less than one milli-second which is effective to energize the grid and trigger the triode, whereby the fuse **14** or other electrically controlled device is actuated to effect release of the explosion suppression or fire preventing or fire extinguishing medium and the explosion is prevented from continuing.

The response of the apparatus disclosed herein is so rapid that the explosion can be suppressed even before sufficient pressure is developed which might damage an aircraft fuel tank or cell. It will thus be appreciated that the pressure transducer utilized is by far superior to pressure bellows or other mechanisms involving moving parts because of its high accuracy, reliability and quick response.

From the foregoing description, it will be seen that the present invention provides an improved system and apparatus for detecting rate of pressure rise and suppressing explosions. The apparatus does not include any parts which get out of order due to corrosion or mechanical defects and can readily withstand such usage to which it may normally be subjected in connection with fixed installations on land or on mobile craft or vehicles adapted to travel on land or sea or in the air.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

We claim:

1. In an explosion suppressing system, the combination of means for storing an explosion suppressing medium and releasing the medium in the vicinity of an explosion hazard, said means including an electrically controlled device for effecting release of the medium, a network for controlling the energization of said device, and a piezoelectric pressure transducer in the vicinity of the hazard having a rate of pressure rise characteristic and being conencted in said network to effect energization of said device in response to a predetermined rate of pressure rise at the incipience of an explosion.

2. In an explosion suppressing system, the combination of an enclosure constituting an explosion hazard, means for storing an explosion suppressing medium and discharging the medium into the enclosure, said means including an electrically controlled device for effecting release of the medium from said storing means, a network for controlling the energization of said device, and a piezoelectric pressure transducer in the vicinity of said enclosure having a rate of pressure rise characteristic and being connected in said network to effect energization of said device in response to a predetermined rate of pressure rise within said enclosure at the incipience of an explosion.

3. In a system according to claim 2, wherein said enclosure is a tank for storing an explosive substance, and said storing means and said transducer are located within said tank.

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