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EXPLOSION SUPPRESSION SYSTEM

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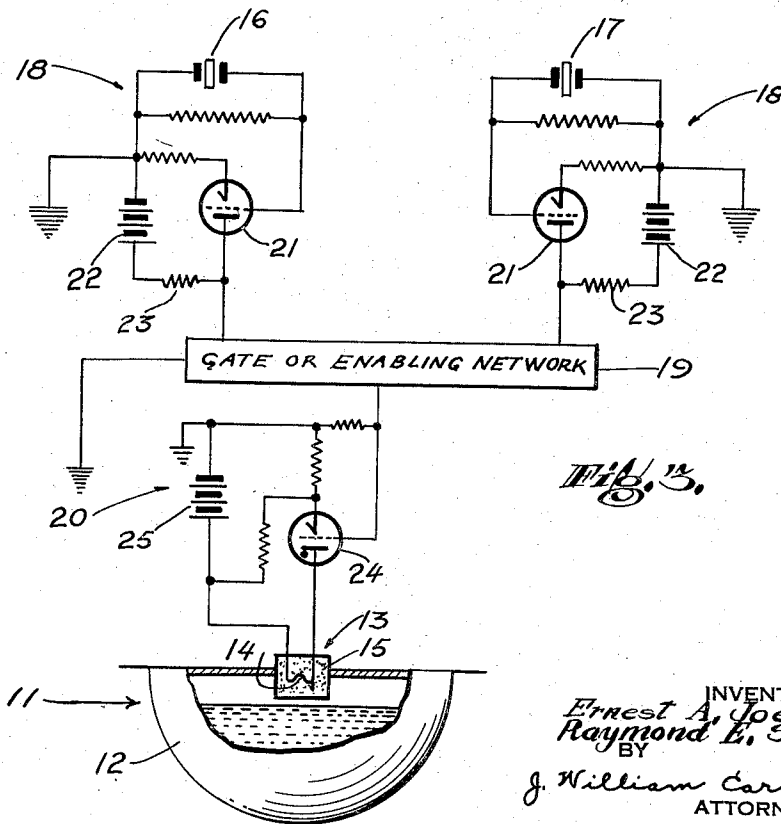
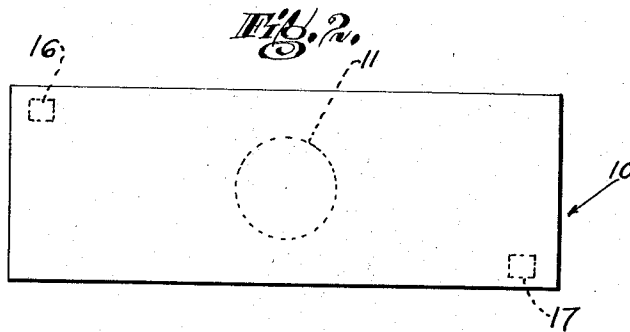
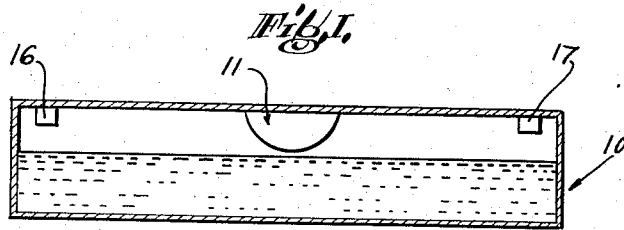


Fig. 3.

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EXPLOSION SUPPRESSION SYSTEM

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The present invention relates to fire preventing and extinguishing systems of the type adapted to suppress explosions in response to an abnormal rate of pressure rise, and, more particularly, to the improvement of such a system disclosed in co-pending application for Letters Patent of the United States, Serial No. 478,744, filed December 30, 1954, assigned to the assignee of this application, to render such system more suitable for installation on mobile craft and vehicles.

In the aforementioned application, it is proposed to detect an abnormal rate of pressure rise by means of a pressure transducer which controls the release of a fire preventing or extinguishing medium. In cases where such apparatus is to be installed within a fuel cell or tank of aircraft, vessel or land vehicles, there has been some concern that the fuel in sloshing about in the tank could simulate a rate of pressure rise condition to which the pressure transducer would be responsive, whereby the medium would be released prematurely and would not be available when required.

Accordingly, an object of the present invention is to provide an explosion suppression system which is not subject to the foregoing contingency.

Another object is to provide such a system and apparatus for use in connection therewith which is not unduly complicated, is light in weight, and compact in arrangement.

A further object is to provide such apparatus which is reliable in operation.

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 are accomplished by providing rate of pressure rise responsive apparatus wherein two or more pressure transducers are so located at the tank that the rate of pressure rise condition which might be simulated by the fuel sloshing about in the tank does not affect both or all of the pressure transducers, but so that the pressure transducers are simultaneously affected by the rate of pressure rise connected with an explosion at its very beginning, and wherein the pressure transducers are so connected in a network for controlling the release of the fire preventing or extinguishing medium that both or all of them must be simultaneously affected and develop an output in order to effect release of the medium.

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 schematic sectional view in elevation of a fuel tank illustrating the location of the pressure transducers therein.

Fig. 2 is a plan view of the fuel tank shown in Fig. 1.

Fig. 3 is a wiring diagram of a simplified network in

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which the pressure transducers are connected to control the release of the fire preventing or extinguishing medium.

Referring to Figs. 1 and 2 of the drawing in detail, there is shown an enclosure, space or zone 10 in which an explosion hazard is adapted to be confined. For example, such an enclosure or the like could be a fuel tank or cell installed on a mobile craft or vehicle wherein the fuel could slosh about due to movement of the craft or vehicle and create hydraulic and/or pneumatic pressure waves. Apparatus 11 for storing and releasing a fire extinguishing and/or preventing medium is associated with the tank to suppress explosions within the tank.

As shown in Fig. 3, such apparatus may comprise a receptacle 12 for storing the medium, and a squib 13 for effecting release of the medium from the receptacle 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 whereby its contents are discharged into the fuel tank to suppress explosions.

In furtherance of the present invention, the fuse is electrically controlled and connected in a network which includes two or more piezoelectric pressure transducers having a rate of pressure rise characteristic such as disclosed in the aforementioned application, for example. Such pressure transducers may be of the piezoelectric ceramic crystal type composed of barium titanate, calcium titanate, barium-calcium titanate or lead zirconate which have a high, that is, appreciable capacitance.

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

This, from the equation,

$$E=IR$$

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, at the grid of the thyatron

$$Eg = IRg = \frac{RCdE}{dt} = KRC \frac{dP}{dt}$$

As shown in Figs. 1 and 2 by way of example, two such transducers 16 and 17 are arranged about a tank at remote locations with respect to each other, that is, at opposite ends and/or diagonally opposite corners of the tank. These transducers are so connected in the network that the fuse is ignited or energized only when both transducers simultaneously produce an electrical output or signal. Where two or more such transducers are employed, the network can be arranged to operate the fuse only when all or a predetermined minimum number (greater than one) of transducers responds to a rate of pressure rise.

By so locating the transducers, a pressure wave induced by the sloshing of fuel and simulating a rate of pressure rise, such as is sought to be detected at the very start of an explosion, can only affect the transducers one at a time. For example, such a wave may affect the transducer 16 at a given moment, but, in traveling from one end of the tank to the other whereby it may affect the transducer 17, the time elapsed is sufficient to prevent simultaneous response of the transducers because the

transducer 16 no longer responds when the transducer 17 responds.

In Fig. 3, a simplified wiring diagram of a network for accomplishing the foregoing manner of operation is illustrated. This network generally comprises a pair of sub-networks each controlled by one of the transducers to produce a signal, a gate or enabling network 19, and a sub-network 20 under the control of the network 19 for controlling the energization of the fuse 14.

The networks 18 each include one of the piezoelectric pressure transducers 16, 17, an electron tube, such as a triode 21 having its cathode and grid connected across the terminals of the transducer, and a source of unidirectional current, such as a battery 22, connected in series with a load resistor 23, in the plate-cathode circuit of the triode with the negative side to the cathode and the positive side to the plate.

The gate or enabling network 19 is shown in block herein since the arrangement and function of various forms of such networks is well known in the art. Such a network has the plates of the triodes 21 connected therein so that it will give an output or signal only in response to two (or more) simultaneous triode signals. The function of this network is very much like that of two switches in series whereby current cannot pass unless both are closed. Analogously, when one triode fires and the other is inactive, the network 19 does not produce a signal. Such signal is produced only when both triodes fire simultaneously.

The network 20 includes an electron tube, such as a thyatron 24, and a source of uni-directional current, such as a battery 25, connected in series with the fuse 14 in the plate-cathode circuit of the thyatron with the negative side to the cathode and the positive side to the anode. The grid of the thyatron is controlled by the signal of the network 19, which signal is amplified to a value to fire the thyatron whereby current flows through the fuse 14 to energize the same and ignite the powder.

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 which is particularly useful for protecting zones wherein a pressure wave may be created otherwise capable of causing false operation.

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 a system for detecting rate of pressure rise in a confined space for containing liquid subjected to movement, the combination of an electrically controlled device, a network for controlling the energization of said device, a plurality of pressure transducers adapted to be arranged at the confined space in remote locations with respect to each other, said pressure transducers having a rate of pressure rise characteristic and being connected in said network to develop an electrical output, and means in said network for effecting energization of said device responsive only to a predetermined minimum number of electrical outputs developed simultaneously by said pressure transducers, whereby fluid pressure resulting from movement of the liquid and acting on less than all of said transducers will be rendered ineffective to energize said device.

2. In a system for detecting rate of pressure rise in a confined space for containing liquid subjected to movement, the combination of an electrically controlled device, a network for controlling the energization of said device, a plurality of pressure transducers adapted to be arranged at the confined space in remote locations with respect to each other, said pressure transducers having

a rate of pressure rise characteristic and being connected in said network to develop an electrical output, and means in said network for effecting energization of said device responsive only to electrical outputs developed simultaneously by all of said pressure transducers, whereby fluid pressure resulting from movement of the liquid and acting on less than all of said transducers will be rendered ineffective to energize said device.

3. In a system for detecting rate of pressure rise in a confined space for containing liquid and subjected to movement causing the liquid to surge within the space, the combination of a plurality of sub-networks each including a piezoelectric pressure transducer having a rate of pressure rise characteristic, an electron tube, and means for rendering said tube conductive by a signal from said transducer; and a sub-network including an electron tube, means for energizing said last mentioned tube only when a predetermined number of said first mentioned tubes conduct simultaneously, and a source of uni-directional current connected in series with an electrically controlled device in the plate-cathode circuit of said last mentioned tube, whereby pressure resulting from a surge of liquid and acting on less than all of said transducers will be rendered ineffective to energize said device.

4. In a system for detecting rate of pressure rise in a confined space for containing liquid and subjected to movement causing the liquid to surge within the space, the combination of a plurality of sub-networks each including a piezoelectric pressure transducer having a rate of pressure rise characteristic, a triode, and means for firing said triode by a signal from said transducer; and a sub-network including a thyatron, means for triggering said thyatron only when a predetermined number of said triodes fire simultaneously, and a source of uni-directional current connected in series with an electrically controlled device in the plate-cathode circuit of said thyatron, whereby pressure resulting from a surge of liquid and acting on less than all of said transducers will be rendered ineffective to energize said device.

5. In a system for detecting rate of pressure rise in a confined space for containing liquid and subjected to movement causing the liquid to surge within the space, the combination of a pair of sub-networks each including a piezoelectric pressure transducer having a rate of rise characteristic adapted to produce a signal, a triode, and means for firing said triode in response to the signal from said transducer to produce a signal; an enabling network controlled by the signals from said triodes including means for producing a signal only when both of said triodes fire simultaneously; and a sub-network including a thyatron arranged to be triggered by the signal from said enabling network, and a source of uni-directional current connected in series with an electrically controlled device in the plate-cathode circuit of said thyatron, said transducers being positioned adjacent the edges of the confined space and substantially opposite each other with respect to the vertical centerline of the confined space in a manner so that a liquid surge acting to produce a pressure on only one of said transducers will be rendered ineffective to energize said device.

6. In an explosion suppressing system, the combination of an enclosure adapted to confine an explosive liquid subjected to movement and thereby causing the liquid to surge within said enclosure, means for storing an explosion suppressing medium and releasing the medium into said enclosure including an electrically controlled device for effecting release of the medium, a network for controlling the energization of said device, a plurality of pressure transducers arranged at said enclosure in remote locations with respect to each other, said pressure transducers having a rate of pressure rise characteristic and being connected in said network to develop an electrical output, and means in said network for effecting energization of said device responsive only to a predetermined

minimum number of electrical outputs developed simultaneously by said pressure transducers, whereby pressure resulting from a surge of liquid and acting on less than all of said transducers will be rendered ineffective to energize said device.

7. In an explosion suppression system, the combination of an enclosure adapted to confine an explosive liquid subjected to movement and thereby causing the liquid to surge within said enclosure; means for storing an explosion suppressing medium and releasing the medium into said enclosure including an electrically controlled device for effecting release of the medium; a pair of sub-networks each including a piezoelectric pressure transducer having a rate of pressure rise characteristic adapted to produce a signal and being arranged at said enclosure in remote locations with respect to each other, an electron tube, and means for rendering said tube conductive in response to the signal from said transducer to produce a signal; an enabling network controlled by the signals from said tubes including means for producing a signal only when both of said tubes conduct simulta-

neously; and a sub-network including an electron tube arranged to be energized by the signal from said enabling network, and a source of uni-directional current connected in series with said electrically controlled device in the plate-cathode circuit of said last mentioned tubes, whereby said device is energized only in response to simultaneous signals from both of said pressure transducers and failing to respond to pressure acting on only one of said pressure transducers due to surge of the liquid.

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