# United States Patent

**Madlener et al.**

[15] **3,703,867**

[45] **Nov. 28, 1972**


[54] **MINE DETONATOR WITH ELECTRIC IGNITION**


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[22] Filed: **Dec. 24, 1968**

[21] Appl. No.: **790,504**

[30] **Foreign Application Priority Data**

Dec. 27, 1967 Germany.....P 15 78 488.0

[52] **U.S. Cl.** .....**102/70.2 R**

[51] **Int. Cl.**.....**F42c 11/02,** F42c 15/40, F42c 19/06

[58] **Field of Search** .....102/70.2, 70.2 P, 70.2 GI



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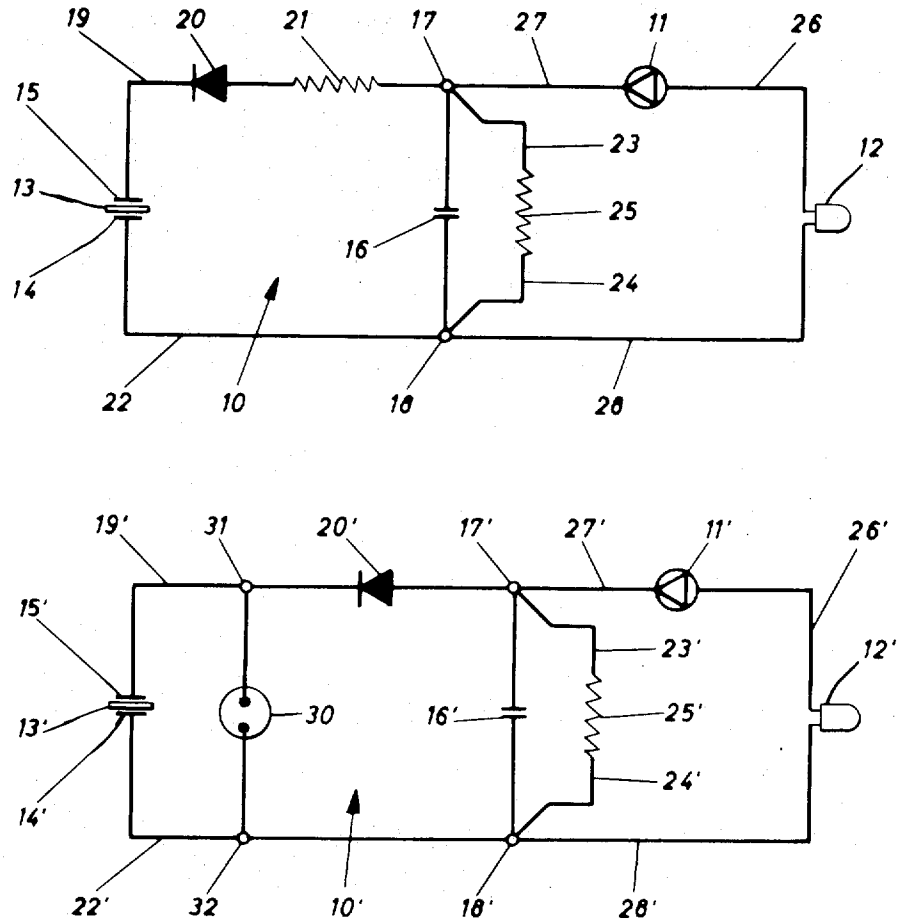
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[57] **ABSTRACT**

A detonator for a land mine used in tank warfare is provided with an ignition circuit in which the source of voltage for ignition of the primer capsule is formed by a piezo-crystal transmitter. The latter when subjected to impact impulse produces voltage impulses which are applied to a summation device for building up and ignition voltage of the required magnitude to cause an ignition of the primer capsule in the mine.


**6 Claims, 4 Drawing Figures**



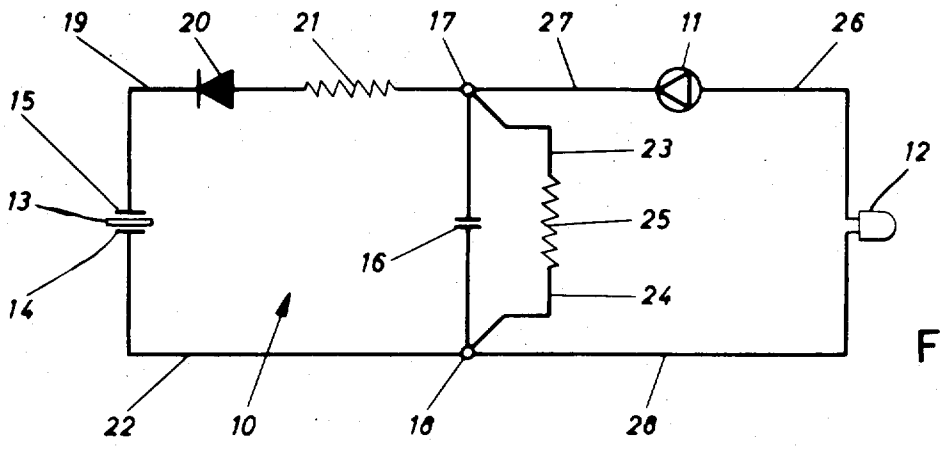



FIG. 1

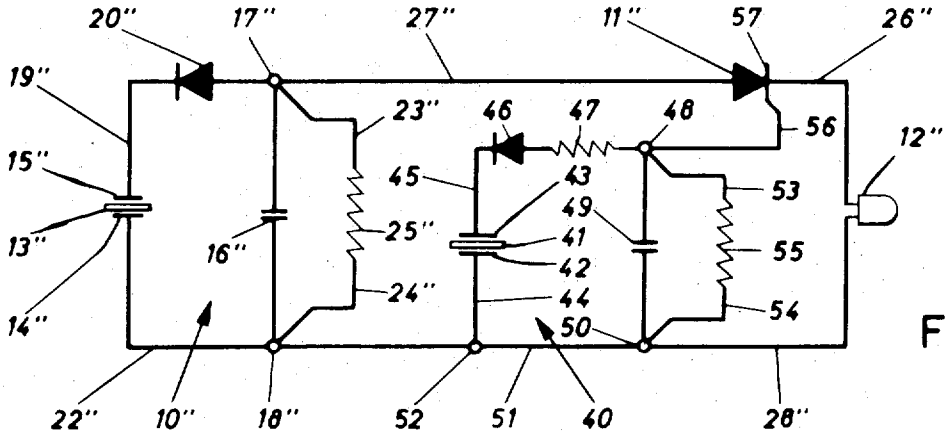



FIG. 3

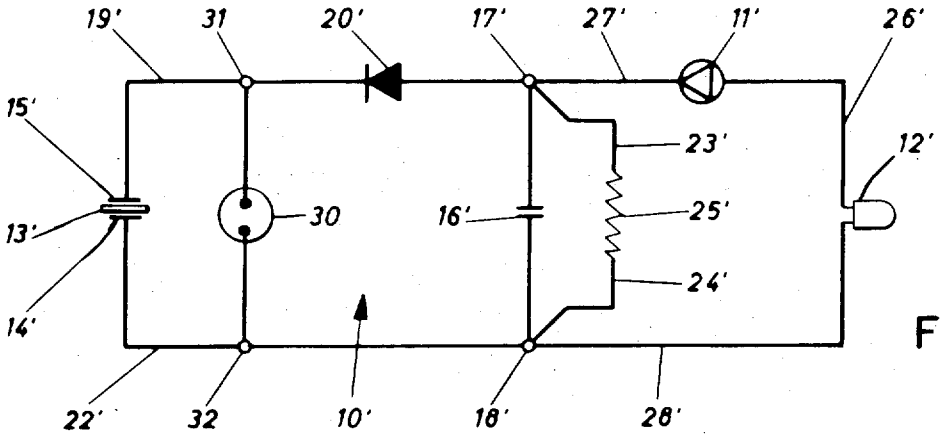
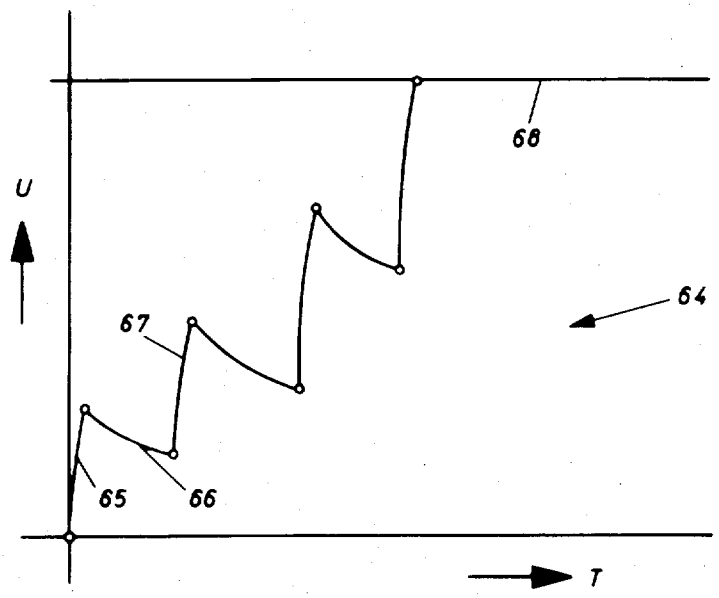


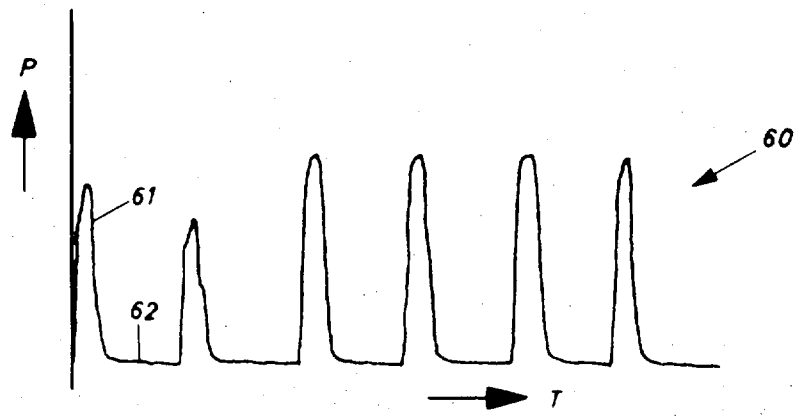

FIG. 2

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# MINE DETONATOR WITH ELECTRIC IGNITION

The invention relates to a mine detonator with electric ignition, particularly for use in tank mines, which are actuated solely upon the occurrence of a definite number of impact-impulses and/or exceeding a definite size of impact-impulses.

Mine detonators with electric ignition are already known, which - in dependence on the movement of a release member or as a result of changes in position - close a normally open ignition switch in the ignition circuit and thereby release the mine detonation. This type of detonators employs a battery as a source of ignition voltage.

All detonators which are battery-energized are beset with the principal disadvantage that batteries as sources of ignition voltage have only a limited durability and are additionally sensitive to temperature. An increased sensitivity to temperature exists with the detonators having a movable release member, which at low temperatures must perform a longer release movement than at high temperatures. With temperatures below the freezing point, buried mines of this type at times actually do not come to ignition in spite of the application of the load on the release member necessary for the release, as on the one hand, the layer of earth located above the release member of the mine possesses in hard-frozen condition a certain bearing strength, while on the other hand, the release member, usually comprising a pressure cover for the mine housing, may be frozen tight.

Detonators with electric ignition and responsive to changes in position are indeed free from the aforementioned disadvantages, however, these detonators do not satisfy all requirements of use. As a rule, detonators actuated in response to changes in position are utilized solely in combination with a detonator responsive to pressure, in order that also upon non-direct load on the release member an ignition release may be insured, for example, when a vehicle travels by past a placement point of a mine and due to its ground pressure produces a minor change in position of the mine.

The known detonators of the above described type normally come to detonation directly after the actuation of the release member, i.e., directly after the depression of a pressure-plate or after occurrence of a corresponding change in position. A mine brought to detonation in this way acts, in tank combating in the first place against the caterpillar belts and the forward, heavily armored part of the gunner's pit of a tank. Whenever, a tank through damage to its caterpillar belts becomes practically incapable of movement, it is only seldom that the detonation of a mine of the aforementioned type causes complete fight incapability of such a tank.

The object of the present invention consists in view of the deficiencies inherent in the known mine detonators in the improvement of such detonators. Proceeding from a mine detonator of the above described type having an ignition circuit which includes a source of voltage supplying the detonation current, a primer capsule releasing the detonation when activated by ignition current and a switch member connected in series with the primer capsule and closable upon actuation of the detonator while with non-actuated detonator maintaining the ignition circuit open, the object of the invention



is solved by the provision of a counting or summation device which in dependence upon the occurrence of a definite number of impact impulses and/or of an impact intensity defined by an impact impulse actuates the switch member into a switch position in which the ignition circuit is closed, said counting- or summation device in a further development of the invention consisting of a piezoelectric crystal transmitter serving at the same time as a source of the ignition voltage and a condenser chargeable by the piezo-transmitter over a rectifier means in the form of an one-way blocking diode.

As is known, a piezo-crystal-transmitter produces pressure dependent charges, so that the transmitter when subjected to a pressure impulse furnishes a voltage impulse which in the arrangement of the present invention serves as ignition voltage. For the application of a pressure impulse on the pressure plates of the piezo-crystal-transmitter, there is required solely the smallest elastic movements, so that the detonators are responsive to impact impulses even in the frozen ground up to a predetermined depth. A movable pressure cover is not required as a release member such as is the case with known detonator constructions.

In order to insure that the ignition takes place only at a definite ignition voltage, namely, when pressure impulse of predetermined value or a predetermined member of pressure impulses acts upon the piezo-crystal-transmitter, a further development of the invention provides that the switch member connected in series with the primer capsule may be an ignition tube controllable in dependence on the potential of the condenser of the counting or summation device, said ignition tube blocking the flow of current in the ignition circuit up to a predetermined voltage, while when this predetermined voltage is exceeded, a voltage-breakdown takes place, thereby permitting a flow of current through the primer capsule, so that the latter effects the detonation. The switch member may for example consist of a four-layer diode. In place of a four-layer diode, a thyristor may also serve as ignition tube, the control electrode of which is connected to a source of control voltage, which depending upon the loads acting upon the detonator is connectable to or disconnectable therefrom. This source of control voltage according to a further feature of the invention may consist of a piezo-crystal transmitter chargeable by means of impact impulses and a condenser connected therewith by a one-way blocking diode and serving as second summation device for the control and having one, output connected to the grid of the thyristor while its other output is connected between the primer-capsule and one output of the first counting and summation device in the ignition circuit.

With this arrangement it is possible to exactly define the targets to be hit by the mines. The counting and summation device forming the core of the invention responds in dependence upon its adjustment only to an exactly defined number of impact impulses or an impact impulse of definite impact intensity, not, however, to all other imaginable types of load. Thus a mine equipped with the detonator of the invention may be passed over by a wheeled vehicle, from which, in dependence upon the number of its wheels, two or three impact impulses emanate, without that a release of igni-

tion takes place. If, to the contrary, such a mine is passed over by a tank, which as a rule possesses five or six caterpillar rollers, then the piezo-transmitter corresponding to the number of caterpillar rollers is subjected to a number of impact impulses which lead to the charging of the condenser associated with the counting or summation device, in view of the voltage impulses emanating from the impact impulses from the piezo-transmitter and thereby lead to a voltage breakdown on the ignition tube. The mine is therefore detonated. In contrast to known mine detonators, the ignition of the detonator of the invention takes place, not at the start of the action of the load on the igniter, but at the end of the same. Accordingly a mine equipped with the detonator of the invention comes to detonation in the vicinity of the rear end of a tank or in any case in the center of the same, so that the explosive effect of the mine is directed mainly against the less strongly armored motor of the tank. In this manner, almost in all cases a complete battle-incapacity of a tank attacked by means of such a mine may be attained.

In a further development of the invention a preferably high-ohmic resistance may be connected in parallel to at least one of the condensers acting as summation members. This high-ohmic resistance effects a slow discharge of the associated condenser and therewith returns it to the original condition, if the condenser on account of previous ignition load has collected a charge, which is not sufficient for the actuation of the switch member controlling the flow of the ignition current and thereby is not able to effect an ignition. If a mine with the detonators according to the invention is passed over by several consecutive wheeled vehicles, it may happen that without anything further an ignition takes place, because the impact impulses produced by the wheels of the wheeled vehicles follow one another in relatively short time. If, however, such a mine is being passed over by two wheeled vehicles at great spacing in time, then no ignition is effected, because the high-ohmic resistance parallel to the condenser of the counting- or summation device has meanwhile weakened the potential on the condenser due to the previous load. The discharge time of the condenser may be varied by means of suitable selection of the resistance, within wide limits.

For the limitation of the voltage impulses, upon charging of the piezo-transmitter of a summation member, the associated condenser may be connected in series with a compensating resistance, so that the series resistance and condenser together form a timing member.

Finally in a still further development of the invention, there may be connected also an excess voltage tube, for example, a glow lamp or a glow-discharge tube, parallel to the piezo-transmitter of at least one summation member, which is actuated only upon a definite value of an impulse emanating from the associated transmitter, and therefore effects an impulse standardization.

In the following the invention is described in greater detail with reference to the accompanying drawings.

In the drawings

FIG. 1 illustrates diagrammatically the basic construction of a detonation device in the form of a circuit diagram.

FIG. 2 illustrates a circuit diagram similar to the one according to FIG. 1, however, with impulse standardization by employing an excess voltage tube.

FIG. 3 illustrates a circuit diagram of a detonation device equipped with two summation members.

FIG. 4 illustrates in a schematic diagram the relation between impact loads on a piezo-transmitter and the charging of a condenser effected thereby up to the ignition voltage.

The ignition circuit of the mine detonator according to the invention as illustrated diagrammatically in FIG. 1 includes a counting or summation device **10**, an ignition tube **11** (for example, a four-layer-diode) serving as a switch member, and a primer capsule **12** arranged in series therewith. The counting- or summation device **10** consists essentially of a piezo-crystal-transmitter **13**, disposed between the pressure plates **14** and **15** and a condenser **16** with the connecting terminals **17** and **18**. In the conductor line **19** between the pressure plate **15** of the piezo-transmitter **13** and the terminal **17** are arranged in series a one-way-blocking diode **20** and a resistance **12**, while the terminal **18** is connected by a conductor line **22** directly with the pressure plate **14** of the piezo-transmitter **13**. The one-way blocking diode **20** is so connected that a current may flow from the piezo-transmitter **13** to the condenser **16**, while a return flow of the current and therewith a charging of the condenser cannot take place. Parallel to the condenser **16** is arranged a high-ohmic discharge resistance **25** by means of conductor lines **23, 24** leading from the resistance **25** to the terminals **17**, and **18**. The serially arranged ignition tube **11** and primer capsule **12** are connected by the conductor line **26, 27** and **28** with the terminals **17** and **18**.

In the ignition circuit according to FIG. **2**, the same reference characters have been utilized for similar parts as in the ignition circuit according to FIG. **1**, except that the reference numerals are provided with a prime character. The basic construction of both ignition circuits is the same. In the ignition circuit according to FIG. **2**, however, there is omitted the series resistance **21** between the one-way-blocking diode **20'** and the connecting terminal **17'**. However, there is arranged parallel to the piezo-crystal-transmitter **13'** which is arranged between the pressure plates **14', 15'** an excess voltage tube **30** (for example, a glow lamp), which is connected to the connecting terminal **31** in the conductor line **19'** leading to the piezo-transmitter-pressure-plate **15'** and to the connecting terminal **32** in the conductor line **22'** leading to the pressure plate **14'** of the piezo-transmitter.

In the circuits shown in FIG. **3** there are likewise utilized for similar parts similar reference characters as in FIGS. **1** and **2**, however, identified by two prime marks. In the ignition circuit according to this FIG. **3**, a second summation device **40** is provided which basically is constructed in the same manner as the summation device **10** of the ignition circuit illustrated in FIG. **1**. This second summation device **40** includes a piezo-crystal-transmitter **41**, which is disposed between two pressure plates **42, 43**. The pressure plate **43** has connected thereto a conductor line **45**, in which are arranged a one-way blocking diode **46** and a series resistance **47**. This series connection from the one-way-blocking-diode **46** and the resistance **47** is connected to the terminal **48** of a condenser **49**, the other terminal

50 of which is connected by the conductor lines 51 and 44 with the pressure plate 42 of the piezo-crystal-transmitter 41. The summation device 40 is connected with the terminal 50 to a conductor line 28'' and with the terminal 52 which is connected to the conductor lines 51 and 44 and to the conductor line 22'' of the first summation device. In similar manner as in the above described summation device, the conductor lines 53, 54 connect a discharge resistance 55 with the terminals 48, 50, and therewith parallel to the condenser 49. From the terminal 48 a conductor line 56 leads to the grid 57 of a thyristor 11'' utilized in this embodiment as an ignition tube. In place of the thyristor 11 there may of course also be used a cold cathode tube or another suitable electronic element.

The impact impulses emanating from the caterpillar rollers of a vehicle, for example a tank, are graphically illustrated in the diagram 60 at the lower portion of FIG. 4, thus showing the impact intensity P in relation to the time T. Each caterpillar roller produces upon rolling over a place at which the mine detonators of the invention are placed, an impact impulse 61 of considerable intensity, however, of very short duration. The load emanating solely from the caterpillar beet around the rollers of such a vehicle is graphically indicated at 62. If now such a place is passed over by the chain of a caterpillar vehicle, in the time sequence shown in the diagram, then consecutively several impact impulses are introduced into the ground and thereby take effect on the detonators of a mine placed at the point traversed. Each impact impulse taking effect on a piezo-crystal-transmitter produces as is shown in diagram 64 at the upper part of FIG. 4, a voltage impulse 65, 67 emanating from the piezo-crystal-transmitter, which in spite of the discharge of the condenser of the summation device occurring between two consecutive impulses, as shown at 66, add up to the attainment of an ignition voltage 68. As soon as the ignition voltage 68 has been reached, the ignition tube shown in FIGS. 1 and 2, breaks down or the ignition tube shown in FIG. 3, on account of the voltage applied to its grid is connected to permit the passage of current so that an electric current is conducted through the primer capsule and accordingly the detonation takes place.

What we claim is:

1. In an electrically ignited detonator particularly for use with tank mines, a piezoelectric crystal transmitter having opposite output terminals, an ignition circuit interconnecting said output terminals, a primer capsule in said circuit, a condenser in said circuit connected in series with said primer capsule, normally open switch means in said circuit connected in series with said primer capsule between said condenser and said primer capsule, said circuit being closed when the sum of a plurality of voltage impulses generated by an equal number of mechanical impacts on said piezoelectric transmitter reaches a predetermined total value, rectifier means in said circuit between said piezoelectric transmitter and said condenser, and high-ohmic resistor means in said circuit connected in parallel with said condenser so that upon each of said mechanical impacts on said piezo-electric transmitter said condenser is successively charged by the resulting voltage impulses from said piezoelectric transmitter and is partially discharged through said high-ohmic resistor means until the sum of the residual charges on said condenser reaches said predetermined total value thereby to close said switch means and cause said primer capsule to ignite and detonate the mine.

2. A mine detonator according to claim 1, including a resistance in said circuit connected in series between said piezoelectric transmitter and said condenser.

3. A mine detonator according to claim 1, including an excess voltage tube in said circuit connected in parallel with said piezoelectric transmitter to standardize the voltage impulses therefrom.

4. A mine detonator according to claim 3, in which said excess voltage tube comprises a glow lamp.

5. A mine detonator according to claim 1, in which said switch means comprises an ignition tube.

6. A mine detonator according to claim 1, in which said switch means comprises a thyristor having a grid, means connecting said grid to a second set of elements comprising a piezoelectric crystal transmitter, a condenser, rectifier means and high-ohmic resistor means interconnected in said ignition circuit similarily to the corresponding first mentioned elements, thereby constituting a source of control voltage.

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