June 30, 1959 J. B. GLENNON ET AL 2,892,404

MINE FIRING SYSTEM

Filed May 15, 1946 2 Sheets-Sheet 1

FIG. 1.

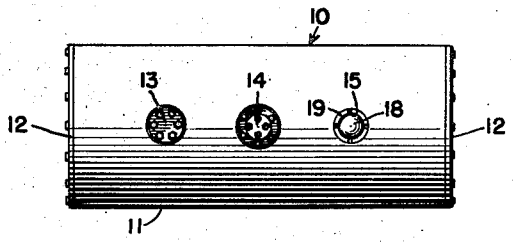


FIG. 2.

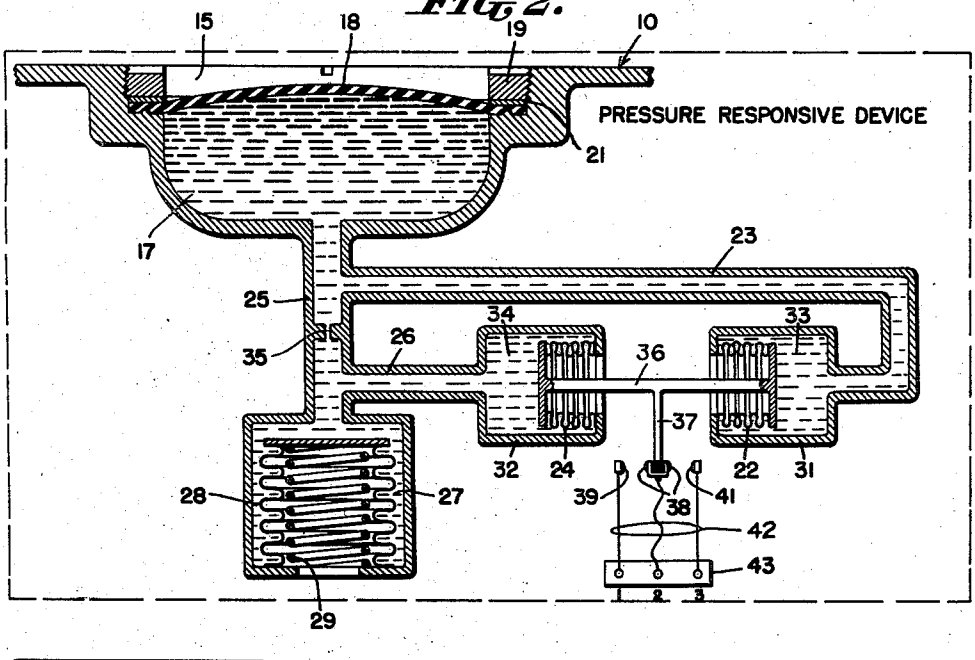
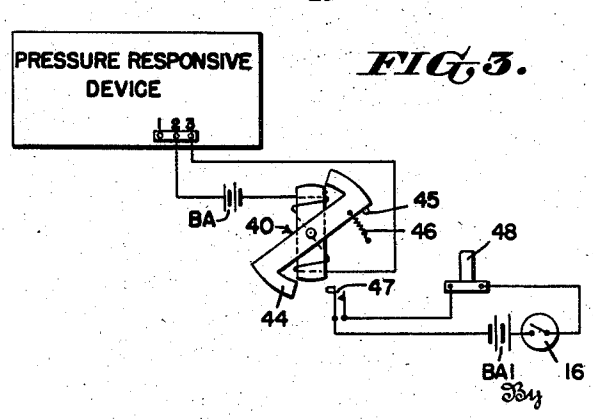


FIG. 3.



Inventors
J. B. Glennon
R. H. Park
By
Attorney

June 30, 1959 J. B. GLENNON ET AL 2,892,404

MINE FIRING SYSTEM

Filed May 15, 1946 2 Sheets-Sheet 2

FIG 4.

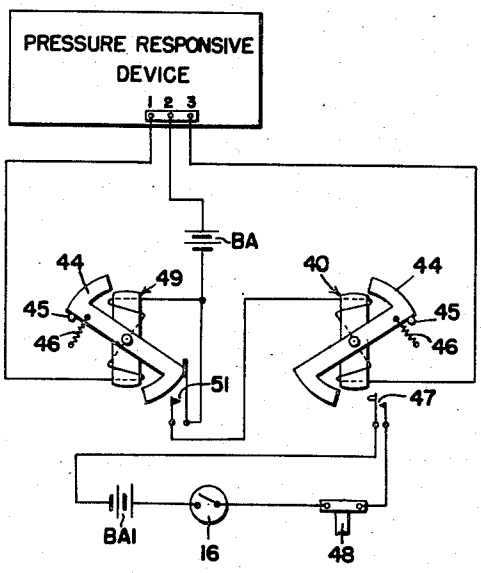


FIG 5.

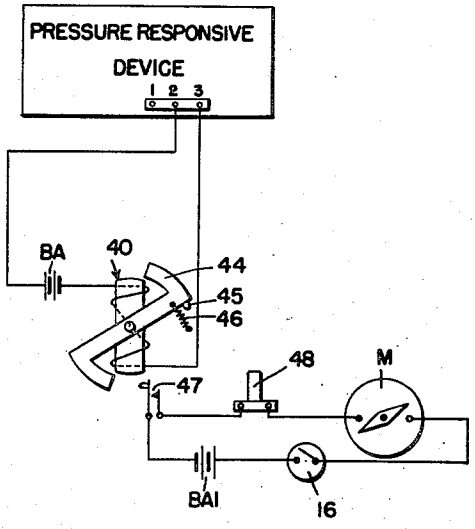
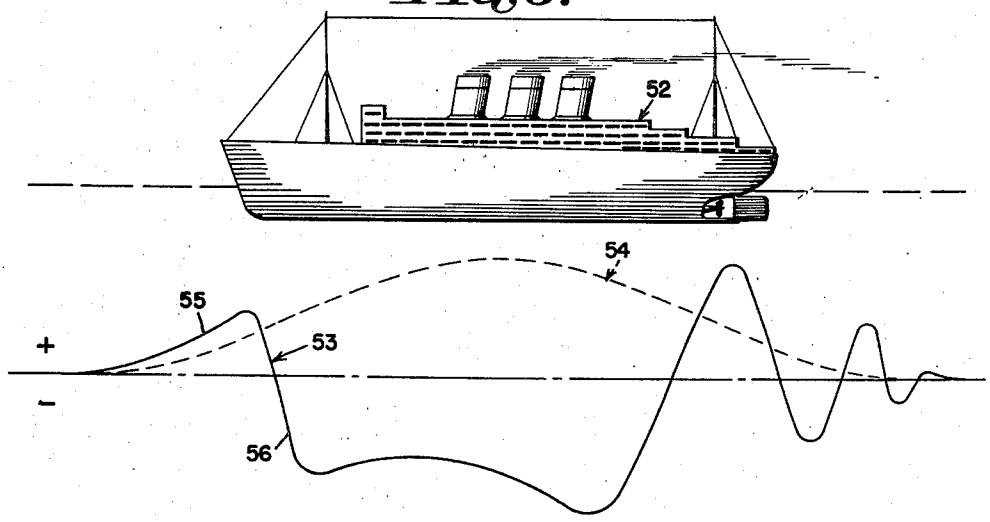


FIG 6.



Inventors
J. B. Glennon
R. H. Park
By M. O. Hayes
Attorney

United States Patent Office 2,892,404
Patented June 30, 1959

2,892,404

MINE FIRING SYSTEM

James B. Glennon, Washington, D.C., and
Robert H. Park, Bernardsville, N.J.

Application May 15, 1946, Serial No. 669,767
9 Claims. (Cl. 102—18)
(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to an influence firing control system for a marine mine and more specifically to a mine firing system controlled by changes in hydrostatic pressure substantially beneath the vessel caused by displacement of water in the path of the moving vessel and, if desired, by an additional control applied thereto as the result of a change in the terrestrial magnetism adjacent thereto caused by the vessel, and in which the primary object is to provide a system wherein the possibility of prematurely detonating the mine through the medium of mine sweeping apparatus is extremely remote.

Another object is to provide a mine which is actuated in response to the pressure field of a moving vessel and which is fired selectively in accordance with a predetermined characteristic of the field.

Another object is to provide mine firing apparatus which is armed in response to an increase in hydrostatic pressure caused by movement of a vessel above the mine and which is fired beneath the vessel in response to a predetermined decrease of said pressure.

Another object is to provide a new and improved firing control mechanism for a mine in which the mine is fired when a predetermined period of time has elapsed after the hydrostatic pressure beneath the vessel has been reduced to a predetermined value in accordance with the law of Bernouilli's theorem.

Still another object is to provide a new and improved mine firing control system which is adapted to be armed and fired by a change in the terrestrial field adjacent thereto caused by a moving vessel and by a predetermined decrease in the hydrostatic pressure adjacent the mine as the vessel passes over the mine, either respectively or conversely.

A still further object of the invention is to provide a new and improved mine firing mechanism adapted to fire the mine in response to a predetermined decrease in hydrostatic pressure caused by a vessel passing above the mine in which new and improved means are employed for disarming the mine after a predetermined period of time in the event that the mine is not fired by the vessel while the vessel is within the destructive zone of the mine.

The aforesaid objects are accomplished in accordance with the present invention by a pressure responsive element adapted to arm or fire the mine, as the case may be and, if desired, adapted to coact with a detecting element responsive to a change in the terrestrial magnetism adjacent thereto caused by the presence of the vessel to produce a firing operation of the mine. The pressure responsive element operates on a principle well known as Bernouilli's theorem which sets forth that the increase in the rate of flow of a fluid is accompanied by a reduction in the pressure of the fluid. The applicability of Bernouilli's theorem to the operation of the firing device of the present invention lies in the fact that a surface vessel moving through a body of water produces a flow of water beneath the vessel thereby causing a reduction in the pressure of the water beneath the vessel. In an

area immediately ahead of the vessel the pressure of the water is increased. This pressure component is employed to close a pair of contacts in response to the aforesaid increase in pressure immediately preceding the moving vessel, referred herein as positive pressure, and to close a second pair of contacts in response to the reduction of pressure within the area beneath the vessel, herein referred to as negative pressure.

The pressure responsive element employed with the invention in accordance with one embodiment thereof is provided with circuit closing means for controlling the operation of an electro-responsive time delay device adapted to be maintained continuously in operation as long as the operating circuit thereto remains closed by the pressure responsive device. When the operating circuit to the time delay mechanism has been maintained continuously closed for a predetermined period of time, the time delay mechanism closes a firing circuit thereby exploding the mine. When the operating circuit for the time delay mechanism is closed for a period of time less than the aforesaid predetermined period by variations in the pressure applied to the pressure responsive device resulting from disturbances in the surrounding water caused by wave action, the interruption of the operating circuit to the time delay device to restore to an initial unoperated condition without closing the firing circuit.

For a more complete understanding of the invention reference is made to the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a view of a mine suitable for use with the present invention;

Fig. 2 is a diagrammatic view partly in section of the pressure responsive device of Fig. 1 and contact elements controlled thereby;

Fig. 3 is a view in diagrammatic form of a complete electrical system suitable for use with the device of Fig. 2;

Fig. 4 is a view in diagrammatic form of a system suitable for use with the device of Fig. 2 according to an alternative form of the invention;

Fig. 5 is a diagrammatic view of a complete system suitable for use with the device of Fig. 2 in which an additional magnetic control is employed for firing the mine; and

Fig. 6 is a chart showing the variations in pressure and in the magnetic field along different portions of a moving vessel.

Referring now to the drawings on which like numerals of reference are employed to designate like parts throughout the several views, and more particularly to Fig. 1 thereof, there is shown thereon a mine indicated generally by the numeral **10** comprising a mine casing **11**, sealed at the ends thereof by the caps **12**, the mine being preferably of the type known in the art as a ground mine in which the specific gravity of the mine is sufficient to cause the mine to rest on the bed of a body of water. The casing **11** is provided with a filler hole **13** through which the usual explosive charge is induced in fluid form, a pressure responsive element being arranged within an aperture **14** of the mine casing for setting an arming clock into operation in response to the pressure of the sea water thereagainst. The casing is also provided with a third aperture **15** through which the pressure of the surrounding water controls the pressure firing mechanism. The arming clock indicated generally by the numeral **16**, Figs. 3, 4 and 5, comprises a pair of initially open contacts adapted to be closed when a predetermined time has elapsed after the clock has been set in operation by the pressure of the surrounding water against a hydrostatic element disposed within the aforesaid aperture **14** of the mine casing. The clock may be of any

type suitable for the purpose, for example, as the arming clock disclosed and claimed in the copending application of James B. Glennon et al. for Firing Mechanism for a Marine Mine, Serial No. 395,230, filed May 26, 1941.

Within the aperture 15 is formed a well 17 sealed by a flexible diaphragm composed of rubber or any of the synthetic varieties thereof and preferably retained in the assembled position by a clamping ring 19, a gasket 21 being disposed between the clamping ring and the diaphragm, as is well known in the art to which the invention pertains.

The chamber 17 is in communication with an expansive bellows 22 by a duct 23 and in communication with a second expansive bellows 24 by the ducts 25 and 26. The duct 25 also communicates with a chamber 27 within which is arranged an expansible bellows 28 urged inwardly by a resilient member 29. The bellows 22 and 24 are hermetically sealed to the casing 31 and 32 respectively thereby forming chambers 33 and 34 within which the bellows 22 and 24 are adapted to move under control of the pressure applied thereto. From the foregoing it will be apparent that the chambers 33, 34, and 27 are in communication with the well 17 by reason of the plurality of ducts, the structure comprising a closed system whereby variations in pressure applied through the surrounding sea water to the diaphragm 18 are transmitted to the bellows 22, 24 and 28 in varying degrees, as will appear more clearly as the description proceeds. The transmission of these pressures throughout the system is facilitated by a copious supply of oil, or any other fluid suitable for the purpose, with which the system is filled. The duct 25, it will be noted, is provided with a flow restricting member 35 having an orifice therein of reduced diameter whereby variations in pressure applied to the diahpragm 18 as a result of the pressure signal received from the surrounding sea water causes a pressure differential between the ducts 23 and 26.

In the specific arrangement of Fig. 2 the bellows 22 and 24 are connected together by a member 36 having an arm 37 secured thereto and provided with a pair of contacts 38 adapted to engage contacts 39 and 41 selectively in accordance with the instant position of the member 36. The contacts 39, 38, and 41 are connected respectively by the conductors 42 to the terminals 1, 2 and 3 of the terminal block 43. The member 36 and bellows 22 and 24 thus comprise a floating element adapted to be moved from an initial position of rest, in which the element is normally retained by the resiliency of the bellows with the contacts 38 intermediate and disengaged from the contacts 39 and 41, into engagement with the contacts 39 and 41 selectively in accordance with the pressure differential applied to the bellows 22 and 24. The floating element of Fig. 2 is adapted to be moved into circuit closing position with respect to contact 39 by an increase in the pressure applied to the diaphragm 18 and to be moved into engagement with the contact 41 in response to a decrease in pressure applied to the diaphragm 18 by the surrounding water, provided the variation in the pressure applied to the diaphragm 18 is in excess of a predetermined rate of change.

On Fig. 3 is shown in diagrammatic form a complete electrical system suitable for firing the mine of Fig. 1 in which the pressure responsive device of Fig. 2 is employed to control the firing. In the arrangement of Fig. 3 the terminals 2 and 3 are connected to a battery BA and operating winding of a time delay device 40 respectively, the other terminal of the battery being connected to the other end of the winding of the time delay device. The time delay device may be of any type suitable for the purpose such, for example, as a time delay device in which a rotatable arm 44 normally held against a stop 45 by a spring 46 is moved by the continuous energization of the operating magnet of the device sufficiently to close a pair of contacts 47 when current has been applied to the operating magnet continuously for a predetermined period of time, the delay in the movement of the arm 44 to the operative position thereon being accomplished in any suitable manner as by a clock work escapement mechanism. In the event that current flows through the winding of the time delay device for a period less than the aforesaid period of time, the deenergization of the operating winding of the device causes the arm 44 to be moved quickly to the inoperative position in engagement with the stop 45 by the spring 46 through the action of a ratchet mechanism as is well known in devices of this character.

Closure of contacts 47 of the time delay device closes a firing circuit from battery BA1 to the usual electroresponsive detonator 48 thereby causing the detonator to fire and operate the mine, the firing circuit including the closed contacts of the arming clock 16. The time required for the time delay device 40 to close the contacts 47 thereon is in excess of the time interval between successive waves whereby variations of the pressure due to wave action are ineffective to close the contacts 47 and fire the mine. The arrangement of Fig. 3 provides a system for firing the mine when negative pressure is applied to the diaphragm 18 for a predetermined period of time by a vessel moving above the mine and in which the firing of the mine is delayed by the time delay device 40 for a period of time sufficiently to cause the mine to explode beneath a vulnerable portion of the vessel, this delay in the firing of the mine being in excess of the time interval between pressure signals received from successive waves.

On Fig. 4 is shown in diagrammatic form a mine firing system suitable for use with the device of Fig. 2 in which the firing of the mine in response to a signal of negative pressure received for a predetermined period of time is accomplished only when this negative pressure signal is immediately preceded by a signal of positive pressure. In the arrangement of Fig. 4 time delay mechanism 49 is employed to close in part the operating circuit of the time delay mechanism of Fig. 3 in response to a signal of positive pressure received by the diaphragm 18. The time delay mechanism 49 is generally similar to the time delay device 40 except that the ratchet arrangement associated with the rotatable arm of 44 is reversed whereby the arm 44 is moved quickly to the operated position thereon by an impulse of current flowing through the winding of the device and maintained in the operative position until the flow of current to the winding is interrupted. When this occurs the arm 44 is actuated by the spring 46 to the normal inoperative position and concurrently therewith, the spring 46 operates a clock escapement mechanism or other time delay device whereby the arm 44 is prevented from moving into engagement with the stop 45 until a predetermined period of time has elapsed after the current to the winding of the device has been interrupted. As the arm 44 moves away from the normal inoperative position thereof in response to a flow of current to the winding of the device, a pair of contacts 51 are closed and remain closed until the arm 44 has returned to the inoperative position thereof.

As contacts 38 of the pressure responsive device move into engagement with contact 39, Fig. 2, in response to a positive pressure signal received by the diaphragm 18, a circuit is closed from battery BA, Fig. 4, to the winding of time delay device 49, thereby causing the rotatable arm 44 thereon to be moved away quickly from the stop 45 to the operative position thereof and, concurrently therewith, to close contacts 51. If contacts 38 of the pressure responsive device move into engagement with contact 41 in response to a signal of negative pressure received by the diaphragm 18, a circuit is closed from battery BA, Fig. 4, to the winding of time delay device 40, the circuit including the closed contacts 51 of the time delay device 49.

If this signal of negative pressure is continuously main-

tained on the diaphragm 18 for a period of time sufficient to cause the contacts 47 of the time delay device 40 to close, the mine is fired by closure of a firing circuit to the detonator 48, the firing circuit including contacts 47 of the time delay device 40, battery BA1 and the contacts of the arming clock 16. The time required for the contacts 51 of the time delay device 49 to open after the operating current to the device has been interrupted is in excess of the time required to close contacts 47 of the time delay device 40 after an operating current has been applied to the winding thereon. Any suitable period of time delay may be employed for each device 49 and 40 provided contacts 51 of the device 49 are not open until sufficient time has elapsed for the contacts 47 of the time delay device 40 to close and provided further that sufficient delay is effected in closing the contacts 47 to prevent firing of the mine by wave action.

On Fig. 5 is shown in diagrammatic form a complete system for firing a mine in accordance with an alternative form of the invention in which the firing is accomplished by a decrease in the pressure of the surrounding water accompanied by a change in the magnetic field adjacent the mine. In the arrangement of Fig. 5 the firing circuit includes a magnetic sensing device M adapted to close a circuit in response to a change in the magnetic field adjacent the mine caused by the presence of the vessel of the mine. This magnetic device may be of any type suitable for the purpose such, for example, as the firing needle disclosed in Patent 1,382,374 to H. Maxim for Method and Mechanism for Exploding Submarine Mines, issued June 21, 1921.

The operation of the system of Fig. 5 will be best understood by consideration of Fig. 6 on which is shown in graphic form the time relation with respect to a vessel 52 of the pressure and magnetic signatures of the vessel indicated generally by the numerals 53 and 54 respectively. The positive portion of the pressure signature preceding and at the bow of the vessel is indicated by the portion 55 of the curve 53. The negative portion of the pressure signature is indicated by the numeral 56, the negative portion of the curve extending substantially throughout the length of the vessel. As the stern of the vessel passes a fixed point of reference therebeneath, the mine receives a series of positive and negative impulses attenuating repeatedly to a stable condition of pressure when the stern of the vessel has moved past the reference point. The magnetic signature of the vessel increases in intensity as the vessel moves across the mine until the vessel is substantially in a mid position with respect to the mine and decreases as the vessel continues to move onwardly beyond this mid position, this signature being shown in graphic form by the curve 54. The contacts of the magnetic element M are closed by the change in the terrestrial field brought about by the magnetic signature of the vessel and remain closed during substantially the entire time that the vessel is above the mine. The closure of contacts 47 of the time delay device 40, Fig. 5, beneath the vulnerable portion of the vessel, therefore, causes the mine to be fired by reason of the fact that the contacts of the magnetic device M are closed at this time and, of course, the contacts 16 of the arming clock are closed.

From the foregoing it should now be apparent that a mine firing control system has been provided which is well adapted to fulfill the aforesaid objects of the invention.

While the invention has been described with reference to three examples thereon which give satisfactory results, it will be understood by those skilled in the art to which the invention pertains, after understanding the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention and it is intended, therefore, in the appended claims to cover all such changes and modifications.

The invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a mine of the character disclosed, the combination of a casing, a pair of expansible bellows mounted for expansion and contraction within said casing, a connection opposedly connecting said bellows to one another whereby said connection is adapted to be actuated from an initial setting to a predetermined moved setting, means in fluid communication with said bellows for establishing a pressure differential between said bellows and controlled by the pressure of the surrounding water for moving said connection to said moved setting in response to a predetermined change in the pressure of the surrounding water, an operating circuit, a normally inactive electro-responsive time delay device included in said circuit, means on said connection for closing said operating circuit when the connection is moved to said moved setting, a firing circuit, and means on said time delay device for closing the firing circuit when the time delay device has been continuously actuated for a predetermined period of time.

2. In a mine of the character disclosed, in combination, a plurality of expansible, mechanically interconnected pressure responsive elements adapted to be actuated from an initial setting to a predetermined moved setting, means controlled by the pressure of the surrounding water for moving said elements to said moved setting in response to a predetermined change in presusre of the surrounding water, an operating circuit, a normally inactive electro-responsive time delay device included in said circuit and controlled thereby, means connected to said elements for closing said operating circuit when the elements are moved to said moved setting thereby to actuate the time delay device, means for restoring the time delay device to an initial condition when the operating circuit therefor is interrupted within a predetermined period of time after the circuit is closed, a firing circuit, and means on said time delay device for closing said firing circuit when the operating circuit for the time delay device is not interrupted during said predetermined period of time.

3. In a mine of the character disclosed, in combination, a pressure responsive element adapted to be actuated from an initial setting to a predetermined moved setting, means including a pair of expansible bellows for moving said element to said moved setting selectively in accordance with the pressure differential applied thereto, means responsive to a negative pressure signal received through the surrounding water for applying said pressure differential to the bellows, a normally inactive electro-responsive time delay device, an operating circuit for said time delay device, means on said pressure responsive element for closing said circuit when the pressure responsive element is moved to said moved setting in response to a negative pressure signal received through the surrounding water by said pressure responsive means, a firing circuit, and means on said time delay device for closing said firing circuit when said operating circuit has been continuously closed for a predetermined period of time.

4. In a mine of the character disclosed, in combination, a floating element comprising a pair of opposedly connected expansible bellows and adapted to be moved from an initial position to a predetermined position selectively in accordance with the pressure differential applied to the bellows, means responsive to a negative pressure signal received through the surrounding water for applying said pressure differential to the bellows, a normally inactive electro-responsive time delay device, an operating circuit for said time delay device, means on said floating element for closing said circuit when the element is moved to said moved setting in response to a negative pressure signal received through the surrounding water by said pressure responsive means, a firing circuit, and means

on said time delay device for closing said firing circuit when said operating circuit has been continuously closed for a predetermined period of time.

5. In a mine of the character disclosed, in combination, a pressure responsive element adapted to be actuated from an initial setting to a predetermined moved setting, means including a pair of expansive bellows for moving said element to said moved setting selectively in accordance with the pressure differential applied thereto, means responsive to a negative pressure signal received through the surrounding water for applying said pressure differential to the bellows, a normally inactive electro-responsive time delay device, an operating circuit for the time delay device, means on said pressure responsive element for closing said circuit when the pressure responsive element is moved to said moved setting in response to a negative pressure signal received through the surrounding water by said pressure responsive means, a firing circuit, means on said time delay device for closing said firing circuit when said operating circuit has been continuously closed for a predetermined period of time, and means on said time delay device for preventing the closing of said firing circuit when said negative pressure signal is received for less than said predetermined interval of time.

6. In a mine of the character disclosed, the combination of a pressure responsive element adapted to be actuated selectively in either direction from an initial setting to a pair of moved settings, means controlled by the pressure of the surrounding water for moving said element to either one of said moved settings selectively in response to the positive or negative character of the pressure signal received through the surrounding water, means on said pressure responsive element adapted to close in succession two circuits as the pressure responsive element moves into each of said moved positions respectively, a time delay device operatively connected to one of said circuit closing means and adapted to be set into operation as the pressure responsive element moves into one of said moved positions in response to a positive pressure signal, a second time delay device operatively connected to the other one of said circuit closing means and adapted to be set into operation as the pressure responsive element moves into the other of said positions in response to a negative pressure signal, an operating circuit for said second time delay device, means on said first named time delay device for rendering said operating circuit effective for a predetermined period of time, a firing circuit, and means on said second time delay device for closing the firing circuit in time delayed relation to the closing of said operating circuit and within said predetermined period of time.

7. In a mine of the character disclosed, combination of a movable pressure responsive device, circuit controlling means mounted upon said device and adapted to be moved selectively in accordance with the polarity of pressure signals received to close a circuit, signal receiving means hydrostatically interconnecting said device with the water surrounding said mine for actuating said pressure responsive device in opposite directions, selectively, in accordance with the polarity of said pressure signals, a firing circuit, and means controlled by said circuit controlling means for closing said firing circuit when a positive pressure signal is followed by a negative pressure signal within a predetermined period of time.

8. In a mine of the character disclosed, the combination of a casing, a plurality of fluid passages within said casing, at least one pressure responsive element movably mounted within at least one of said passages and adapted to be actuated from an initial setting to a predetermined moved setting, means controlled by the pressure of the surrounding water for moving said element to said moved setting in response to a predetermined reduction in the pressure of the surrounding water, an operating circuit, a normally inactive electro-responsive time delay device included in said circuit and controlled thereby, arm means on said element, electrical contacts mounted upon said arm means for closing said operating circuit when the element is moved to said moved setting, a firing circuit, a pair of contacts included in said firing circuit, means responsive to the magnetic signature of a vessel for closing said contacts when the vessel is in the vicinity of the mine, and means on said time delay device for closing the firing circuit when said pair of contacts are closed and the time delay device has been continuously actuated for a predetermined period of time.

9. In a combination mine of the character disclosed, a casing, a plurality of fluid passages within said casing, fluid actuated means movably mounted within at least one of said passages and controlled by changes in the pressure of the surrounding water, an electrical contact arm secured to said means and positioned within said casing and exteriorly of said passages for closing a circuit, a restricted orifice in one of said passages for causing said circuit to be closed in predetermined time delayed relation with respect to said pressure changes, a firing circuit including means for firing the mine, means including a circuit closing device for arming said firing circuit in response to the magnetic signature of a passing vessel, and means on said time delay device for closing said firing circuit thereby to operate said mine firing means in time delayed relation with respect to said pressure changes and while the firing circuit is armed.

References Cited in the file of this patent

UNITED STATES PATENTS

1,382,374	Maxim	June 21, 1921
1,538,316	Duffie	May 19, 1925
2,359,168	Somes et al.	Sept. 26, 1944
2,391,916	Newell	Jan. 1, 1946

FOREIGN PATENTS

29,013	France	Jan. 27, 1925

(Addition to 557,110)