

May 21, 1946.

J. B. GLENNON ET AL

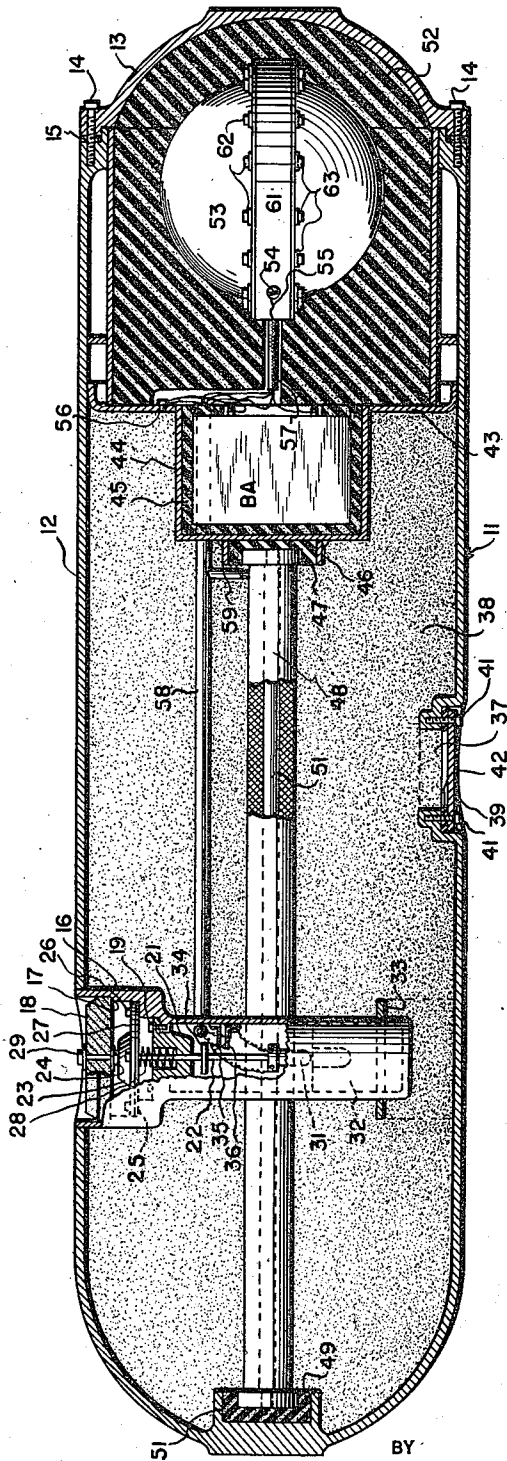
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MINE FIRING DEVICE AND CONTROL MEANS THEREFOR

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6 Sheets-Sheet 1

Fig. 1.



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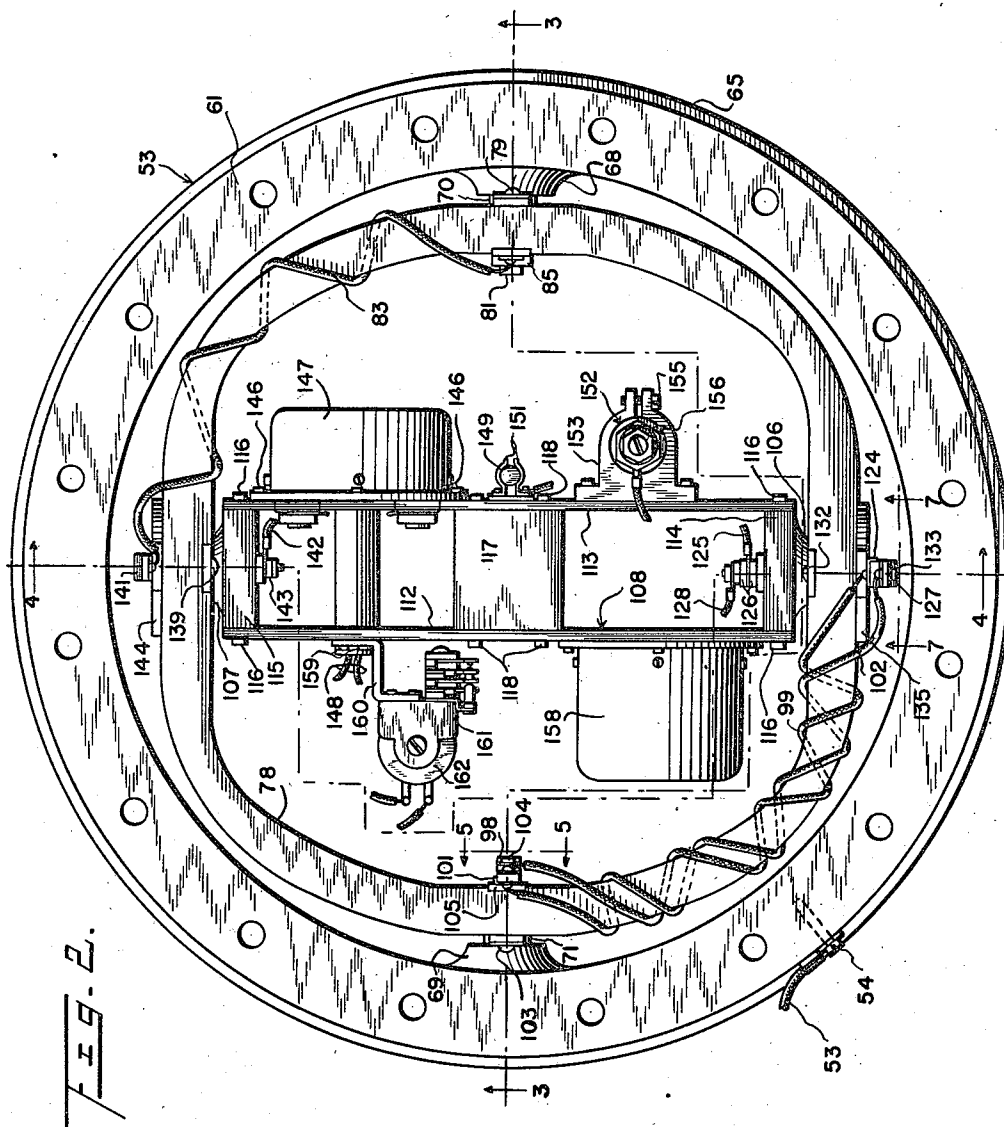
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6 Sheets-Sheet 2



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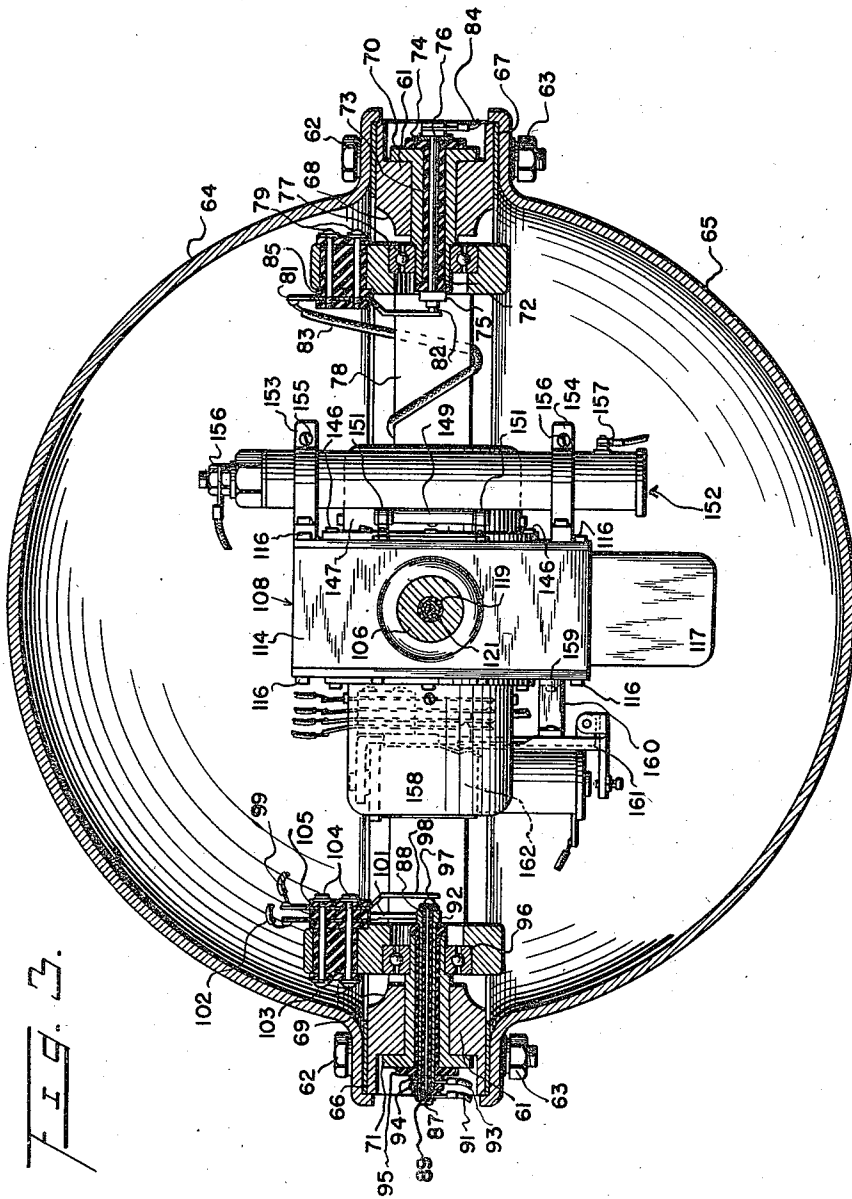
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MINE FIRING DEVICE AND CONTROL MEANS THEREFOR

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6 Sheets-Sheet 3



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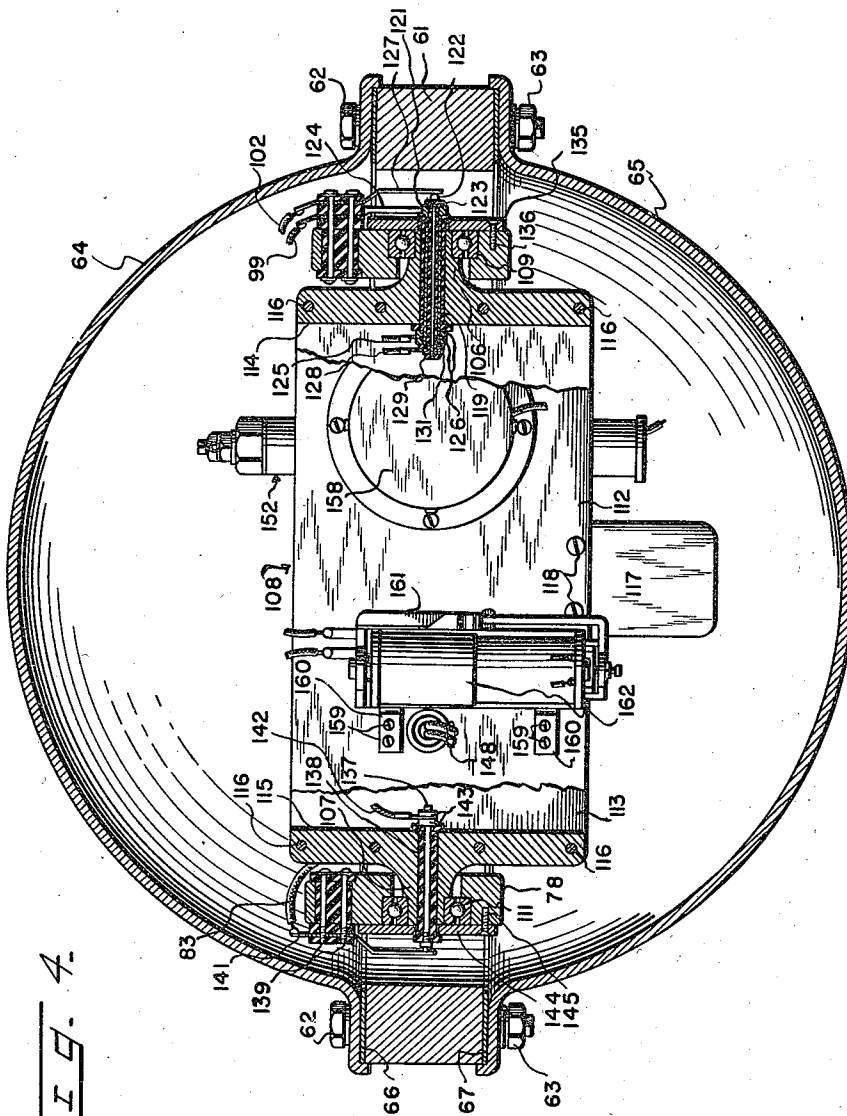
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MINE FIRING DEVICE AND CONTROL MEANS THEREFOR

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6 Sheets-Sheet 4


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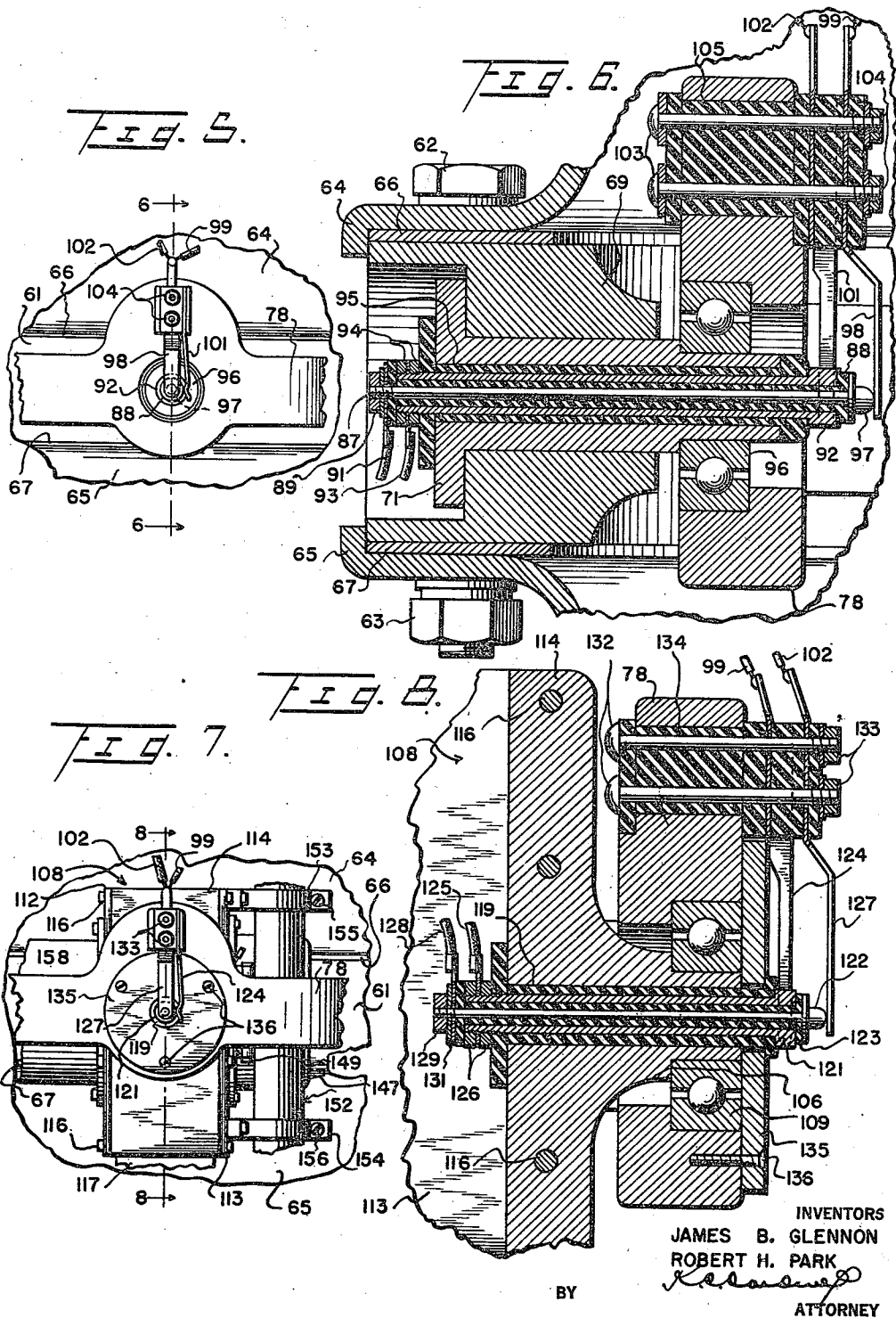
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MINE FIRING DEVICE AND CONTROL MEANS THEREFOR

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6 Sheets-Sheet 5



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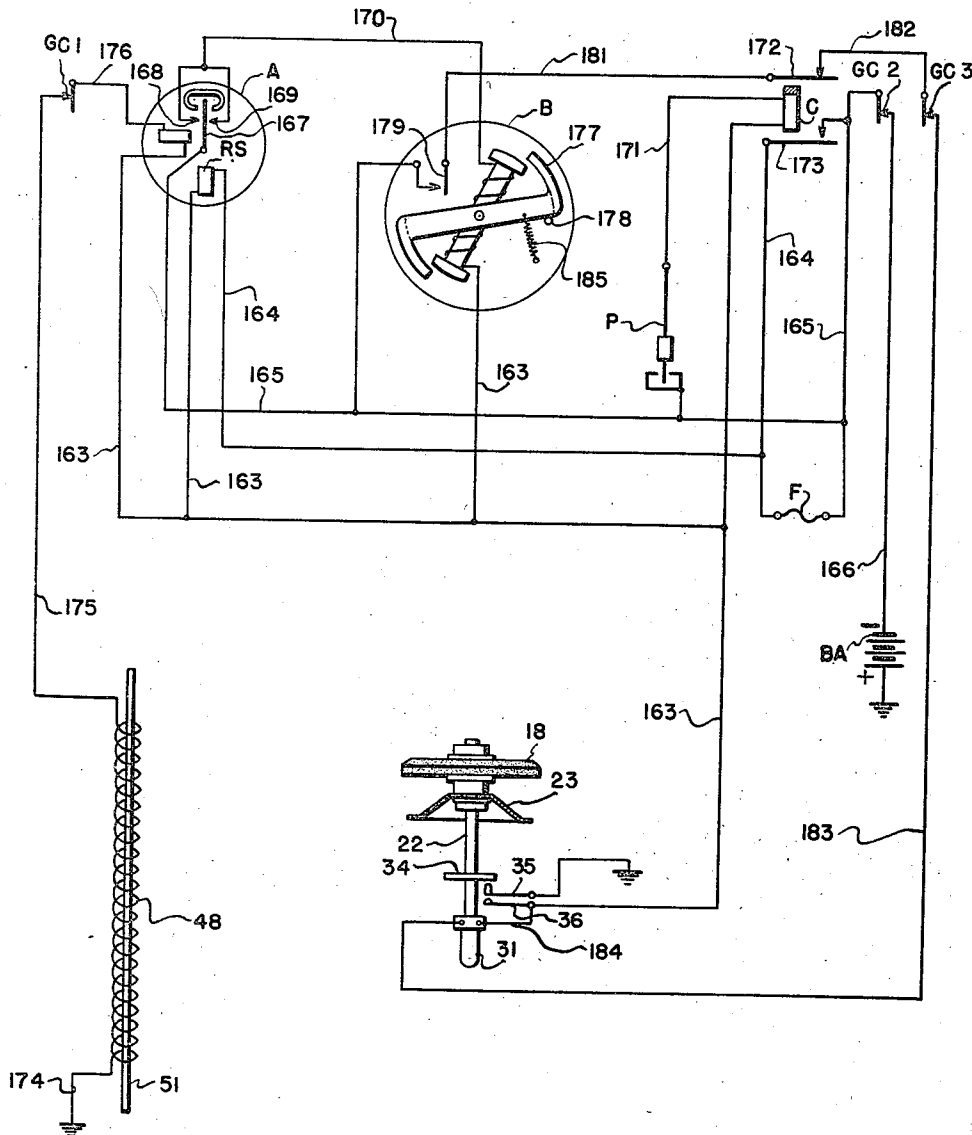
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MINE FIRING DEVICE AND CONTROL MEANS THEREFOR

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6 Sheets-Sheet 6

Fig. 9.



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UNITED STATES PATENT OFFICE

2,400,549

MINE FIRING DEVICE AND CONTROL
MEANS THEREFORJames B. Glennon, Washington, D. C., and
Robert H. Park, Pluckemin, N. J.

Application February 3, 1942, Serial No. 429,404

11 Claims. (Cl. 102-18)

(Granted under the act of March 3, 1883, as
amended April 30, 1928; 370 O. G. 757)

This invention relates to firing devices for a submarine mine and control means therefor in which the mine is prevented from detonation as the result of a shock or pressure impulse received from a countermining operation or the mine is otherwise disturbed. More specifically the invention provides a system for firing a submarine mine in response to a change in the magnetic field adjacent thereto caused by the approach of a steel vessel or other ponderous mass of magnetic material moving within the vicinity of the mine in which the mine is armed within a predetermined period of time after the mine has been launched within a body of water and in which a pendulum device is employed to control the operation of a slow acting relay to interrupt the firing circuit and prevent the premature detonation of the mine as a result of countermining operations.

In devices heretofore proposed for preventing the explosion of a submarine mine as the result of countermining operations it has been the general practice to employ a pendulum arrangement in which the firing circuit passes through normally closed contacts of the pendulum or in which the pendulum is employed to interrupt the control circuit to the detecting mechanism at the pendulum contacts as the pendulum operates. Such arrangements have not proven altogether satisfactory in service for the reason that the circuits above referred to are closed by the pendulum as the pendulum returns to a normal unoperated position or passes through the normal position during each swing or oscillation thereof while the mine is in a disturbed state as the result of the vibrations or pressure impulses received through the surrounding water and, for this reason, there is a possibility of the mine being prematurely fired as the result of a countermining operation or other disturbance of the mine.

In the system of the present invention a pendulum assumes a vertical position by reason of the provision of gimbals upon which the pendulum is mounted such that the pendulum contacts are normally disengaged from each other. When the mine is disturbed the pendulum contacts are closed thereby causing a slow-to-release relay to be operated and interrupt the firing circuit continuously during the time the pendulum is oscillating or vibrating through an angle sufficient to close the contacts thereof. The slow-to-release relay also causes the armature of a sensitive detecting relay to be maintained in a predetermined position such that the armature contacts thereof are disengaged from a pair of control con-

tacts adjacent thereto and the operation of a slow acting time delay device having a pair of firing contacts thereon adapted to operate a detonating device is thus prevented.

5 The system of the present invention comprises means for detecting a change in the magnetic field adjacent the mine such, for example, as an induction pick-up coil operatively connected to the winding of a sensitive relay whereby the relay is caused to close a pair of electrical contacts in response to a change in the earth's magnetic field produced by an approaching steel vessel or other ponderous mass of magnetic material moving within the vicinity of the mine. The sensitive
10 relay is provided preferably with a resetting mechanism comprising a reset or a restoration magnet adapted to reset the relay to a neutral or null position as the reset magnet is energized. There is also provided a time delay device controlled
15 by the sensitive relay adapted to close a firing circuit after a predetermined period of time has elapsed immediately following the operation of the sensitive relay.

A detonator is inserted within an explosive
25 booster charge by the pressure of the water on a flexible diaphragm having one side thereof in communication with the water after a soluble washer connected thereto has dissolved or softened sufficiently to permit inward movement of the diaphragm. The movement of the diaphragm inwardly causes a pair of electrical contacts to be closed thereby operatively connecting the system with a source of electrical power and causing the restoration magnet to operate over a circuit including a slow acting fuse, the fuse being
30 sufficiently slow in operation to insure the resetting of the sensitive relay to the null position before the fuse blows and the circuit to the reset magnet is interrupted thereby.

40 One of the objects of the present invention is the provision of new and improved means for preventing the premature detonation of a mine in response to a countermining operation.

45 Another of the objects is the provision of new and improved means for arming a submarine mine within a predetermined period of time after the mine has been launched within a body of water.

50 Another object is the provision of a mine firing control system which will be economical to manufacture, reliable in operation and which possesses all of the qualities of ruggedness and dependability in service.

55 Still other objects, advantages and improve-

ments will be apparent from the following description taken in connection with the accompanying drawings of which:

Fig. 1 is a view in section partly broken away of a submarine mine according to a preferred form of the invention;

Fig. 2 is a plan view of the firing control device of Fig. 1 with the upper cover thereof removed;

Fig. 3 is a view of the device taken substantially along the line 3—3 of Fig. 2;

Fig. 4 is a view partly broken away taken along the line 4—4 of Fig. 2;

Fig. 5 is a fragmentary view taken along the line 5—5 of Fig. 2;

Fig. 6 is a view considerably enlarged taken along the line 6—6 of Fig. 5;

Fig. 7 is a view partly broken away taken along the line 7—7 of Fig. 2;

Fig. 8 is a fragmentary view considerably enlarged taken along the line 8—8 of Fig. 7, and;

Fig. 9 illustrates in diagrammatic form the electrical circuit arrangement of the entire system.

Referring now to the drawings and more particularly to Fig. 1 thereof there is shown thereon a submarine mine indicated generally by the numeral 11 comprising a casing 12 preferably rounded at one end thereof and provided with a cap 13 secured thereto as by the bolts 14, a suitable gasket 15 being provided between the casing and the cap to prevent the seepage or leakage of water therebetween. The mine is also provided with a recessed portion 16 having a shoulder 17 adapted to engage a soluble washer 18 of any material suitable for the purpose such, for example, as a composition of salt, glue, glycerin and the like. Secured to the recessed portion 16 as by the bolts 19 is an insert or bearing support 21 adapted slideably to support a hydrostat device comprising a shaft or plunger 22 having a flexible diaphragm 23 secured thereto in any suitable manner as by the nut 24, the outer edge of the diaphragm being clamped to a shoulder 25 within the recessed portion 16 as by the bolts 26 and clamping ring 27. A spring 28 disposed about the shaft 22 normally urges the diaphragm outwardly.

The soluble washer 18 is secured to the outer end of the shaft 22 in any suitable manner as by the nut 29, suitable washers being arranged preferably between the nuts 24 and 29 and the soluble washer. Secured to the shaft 22 in any suitable manner at the innermost end thereof is a detonator 31 adapted to be inserted within a booster charge 32 as the hydrostat operates. The recessed portion 16 is preferably braced at the lower end thereof to the casing 12 of the mine as by the member 33 extending therebetween. There is also secured to the shaft 22 a collar 34 adapted to cause a flexible contact spring 35 to be moved into electrical engagement with the insulated contact spring 36 as the hydrostat operates. The contact spring 35 is in electrical contact with the mine casing 12 as by riveting or clamping the parts together whereby the insulated spring 36 is grounded to the casing of the mine as the contact spring 35 engages the contact spring 36 in response to the operation of the hydrostat.

The casing is also provided preferably with an aperture 37 whereby an explosive mixture 38 such as TNT or the like is introduced within the mine casing, the aperture being sealed by a plate or cover 39 secured thereto as by the bolts 41, a gasket 42 being provided to insure a hermetically sealed joint therebetween.

There is also provided within the mine casing

a wall or partition 43 having a recessed portion 44 therein within which is disposed a battery BA, a suitable resilient pad or cushion 45 being disposed between the battery and recessed portion 44 to prevent injury to the battery or the parts adjacent thereto during the handling, transportation and planting of the mine.

There is also provided a well 46 secured in any desired manner to the recessed portion 44 having a pad or cushion 47 therein adapted to receive and support one end of an induction coil 48, the other end of the induction coil being supported by a similar pad or cushion 49 disposed within the well 51 secured to an inner end of the casing 12. The coil 48 consists preferably of a large number of turns of fine wire arranged about an iron core or a core composed of a material known in the art as Permalloy having a composition of substantially 87½ percent iron and 12½ percent nickel thereby to increase the electromotive force generated by the coil in response to a predetermined change in the magnetic field adjacent thereto.

Disposed between the well 43 and the cap 13 is a resilient pad or cushion 52 of material suitable for the purpose such, for example, as sponge rubber adapted to receive and support a mine firing and control mechanism indicated generally by the numeral 53 having a screw terminal 54 thereon adapted to establish an electrical connection between the mine firing control mechanism and an electric conductor 55, the other end of the conductor 55 being connected to the casing of the mine as by the screw or bolt 56. The battery EA is connected at one terminal thereof to the mine firing control mechanism 53 by one of the conductors within the electrical cable 57 extending therebetween, the other pole of the battery being connected to the casing of the mine by the screw 56. A tube or cable duct 58 extends between the partition or wall 43 into the recessed portion 16 of the mine casing whereby an external electrical connection between the mine firing control device 53 and the detonator 31 may be established by way of the electrical conductors arranged within the tube and insulated therefrom. The tube is provided with a branch 59 extending therefrom within which are disposed a pair of electrical conductors extending to the induction coil 48.

On Figs. 2 to 8 are shown several views of a mine firing control mechanism suitable for use with the present invention, the mechanism comprising, among other elements, a mounting ring 61. Affixed to the mounting ring in any suitable manner as by the bolts 62 and nuts 63 are the detachable upper and lower covers 64 and 65 respectively, a pair of gaskets 66 and 67 being provided preferably between the upper and lower covers respectively and the ring 61 additionally to protect the mine firing control mechanism from exposure to the effects of water which might seep into the mine as the result of damage or injury to the casing thereof.

The mounting ring 61 is provided with a pair of bosses or bearing supports 68 and 69 diametrically arranged in respect thereto, each of the bosses having an insert or sleeve 70 and 71 respectively arranged therein. The sleeve 70 is provided with a bolt or contact rod 72 insulated therefrom as by the insulating sleeve 73 and washer 74 held securely in clamped position by the nuts 75 and 76 threaded on the bolt 72. The sleeve 70 also supports a ball bearing 77 in registered engagement with a gimbal ring 78 whereby the gimbal ring is adapted to be rotated about the axis of the sleeve

70. Secured to the gimbal ring as by the screws 79 is a contact spring 81 adapted to engage a contact 82 on the end of the rod 72 whereby an electrical connection is established between the conductors 83 and 84 connected to the contact spring 81 and the rod 72 respectively. The contact spring 81 is insulated from the gimbal ring as by the bushing 85 composed of suitable insulating material such, for example, as Bakelite, hard rubber or the like.

In a similar manner the sleeve 71 within the bearing support 69 supports a contact rod 87 arranged within an insulating sleeve 88 and provided preferably with a nut 89 for establishing a circuit with an electrical conductor 91. Disposed about the sleeve 88 is a conducting sleeve 92 to which is secured the conductor 93 as by the nuts 94, the sleeve 92 being electrically insulated from the sleeve 86 by the insulating sleeve 95. The ball bearing 96 is mounted upon the sleeve 71 and in registered engagement with the gimbal ring 78 whereby the gimbal ring is adapted to rotate freely about the sleeve 71.

The stud 87 is provided with a rounded or pointed end 97 adapted to engage a contact spring 98 continuously and thereby maintain a continuous electrical circuit between the conductors 91 and 99 affixed to the rod 87 and contact spring 98 respectively. The sleeve 92 is provided with a cylindrical portion at one end thereof in continuous engagement with the contact spring 101 having a conductor 102 secured thereto thereby providing an arrangement in which a continuous electrical circuit is established between the conductors 93 and 102. The contact springs 99 and 102 are clamped to the gimbal ring 78 as by the screws 103 and nuts 104 and suitably insulated therefrom as by the insulating bushing 105.

There is also provided two supports or bosses 106 and 107 whereby the mounting frame 108 is rotatably supported by the ball bearings 109 and 111. The frame 108 comprises two plates 112 and 113 secured to the end members 114 and 115 as by the bolts 116. An arrangement is thus provided in which the frame 108 is rotatably mounted on gimbals within the supporting ring 61, the frame being maintained in a predetermined upright position by reason of a suitable counterweight 117 secured thereto as by the bolts 118.

The end plate 114 is provided with a centrally arranged aperture adapted to receive an insulated sleeve 119 within which is arranged a metallic sleeve or bushing 121 of material suitable for the purpose such, for example, as brass or phosphor-bronze. Within the sleeve 121 is disposed a rod 122 electrically insulated therefrom as by the insulating sleeve 123. The sleeve 121 is adapted to be engaged by the contact spring 124 whereby an electrical connection is continuously maintained between the conductor 99 and the conductor 125 secured to the sleeve 121 as by the nuts 126. The rod 122 is provided preferably with a rounded or pointed end adapted to engage the contact spring 127 and thereby maintain a continuous electrical connection between the conductor 102 and the conductor 128 secured to the rod 122 as by the nut 129 and washer 131. The contact springs 124 and 127 are clamped to the gimbal ring 78 as by the screws 132 and nuts 133, a bushing 134 of material suitable for the purpose such, for example as hard rubber, Bakelite or the like being provided to insulate the contact springs 124 and 127 from the gimbal ring and from each

other. There is also provided a disk or plate 135 secured to the gimbal ring 78 as by the screws 136 thereby securely maintaining the bearing 109 in fixed relation with respect to the gimbal ring 78, the plate 135 having an aperture therein within which is disposed the insulating bushing or sleeve 119.

The plate 115 is provided with an aperture within which is arranged a contact stud or rod 137 electrically insulated therefrom by an insulating sleeve 138. Mounted on the gimbal ring 78 as by the screws 139 is a contact spring 141 adapted to engage one end of the contact stud 137 and maintain a continuous electrical connection between the conductor 83 affixed to the contact spring 141 and the conductor 142 secured to the contact stud 137 as by the nuts 143. In a similar manner the bearing 111 is secured to the gimbal ring 78 by the plate 144 and screws 145. Secured to the plate 113 in any suitable manner by the screws 146 is a sensitive relay 147, hereinafter referred to as relay A having the operating winding thereof connected to the induction pick-up coil and adapted to be operated by the current received from the induction coil in response to a change in the magnetic field adjacent thereto, the relay comprising, among other elements, a pair of conductors 148 whereby the external circuit to the reset magnet of the relay A is established.

There is also provided a fuse 149 hereinafter referred to as F supported preferably by the fuse clips 151 secured to the plate 113 and suitably insulated therefrom, the fuse being in electrical circuit with the reset magnet of relay A and adapted to cause the reset magnet to operate after the mine has been launched within a body of water and thereafter interrupt the circuit to the reset magnet as the fuse operates. A pendulum device 152, hereinafter referred to as P, is secured to the plate 113 as by the supports 153 and 154 in the manner illustrated, the supports 153 and 154 being provided preferably with clamping screws 155 and 156 respectively whereby movement of the pendulum device 152 with respect to the frame 108 is prevented. The pendulum device may be of any type suitable for the purpose such, for example, as the pendulum disclosed in the copending patent application of James B. Glennon and Chester M. Van Atta, Serial No. 395,230, filed May 26, 1941, for improvements in Firing mechanism for a submarine mine, the pendulum including a pair of normally disengaged electrical contacts adapted to close a circuit between the terminals 156 and 157 thereof whenever the pendulum device is disturbed as the result of a vibration or pressure impulse received through the surrounding water such, for example, as may be caused by a countermining operation.

There is also provided an electro-responsive time delay device or relay 158, hereinafter referred to as B, having a pair of normally open contacts adapted to be moved to closed position after a predetermined period of time has elapsed immediately following the energization of the operate winding thereof. The relay may be of any well known type of construction in which a time delay mechanism comprising a dash pot, gear train and escapement mechanism or the like may be employed to delay the closing of the relay contacts for a predetermined period of time.

Secured to the plate 112 as by the screws 159 and supporting member 160 is a slow acting relay 161, hereinafter referred to as C, having a pair of normally closed contacts adapted to be

disengaged as the relay operates and a pair of normally open contacts adapted to be moved into engagement with each other as the relay operates, the relay being provided preferably with a copper slug 162 disposed about the core of the electromagnet thereby to cause the relay to be slow in releasing as the operate circuit thereto is interrupted. The winding of the relay is connected to the contacts of the pendulum device 152 and adapted to be operated in response to a movement of the pendulum sufficiently to close the contacts thereof.

The operation of the system will now be described. Let it be assumed, by way of example, that the mine has been planted within a body of water for a period of time sufficient to cause the soluble washer 18 to dissolve or become sufficiently soft to allow the hydrostat to be operated by the pressure of the water against the flexible diaphragm 23 thereof. When this occurs contact spring 35 is moved into engagement with contact spring 36 thereby applying ground to conductor 163, Fig. 9, the circuit continuing by way of the reset magnet RS of relay A, conductor 164, fuse F, conductor 165, gimbal contacts GC2, conductor 166, battery BA and thence to ground. The reset magnet RS of relay A operates and causes the armature 167 thereof to be moved to a neutral or central position intermediate the contacts 168 and 169 of the relay. The fuse F, it will be recalled, is a slow acting fuse and for this reason the reset magnet RS is operated for a period of time sufficient to reset the armature 167 to the null position intermediate the contacts 168 and 169 and disengaged therefrom before the fuse F operates. As the fuse operates the circuit to the reset magnet RS is interrupted and the armature 167 of relay A is released for movement in either direction from the reset position in accordance with the direction of flow of the current generated by the induction pick-up coil 48 as the number of flux linkages thereof varies in response to a change in the magnetic field adjacent thereto. The mine is now in an armed condition.

Let it be assumed that a countermining operation occurs within the vicinity of the mine thereby sending a wave or impulse of pressure through the water of sufficient intensity to cause the pendulum P to vibrate sufficiently to close the contacts thereof. When this occurs a circuit is closed from battery by way of conductor 166, gimbal contacts GC2, conductor 165, contacts of pendulum P, conductor 171, winding of relay C, conductor 163, contacts 36 and 35 of the hydrostat and thence to ground thereby causing relay C to operate and at the armature 172 thereof interrupt the circuit to the detonator 31. The premature operation of the detonator during the time relay C is operated is thus prevented and the mine is in an unarmed condition until relay C releases. As armature 173 of relay C moves into engagement with the make contact thereof a circuit is closed from battery BA by way of conductor 166, gimbal contacts GC2, make contact and armature 173 of relay C, conductor 164, winding of reset magnet RS of relay A, conductor 163, contacts 36 and 35 of the hydrostat and thence to ground thereby causing the reset magnet to operate and maintain the armature 167 of relay A in a position intermediate the contacts 168 and 169 of relay A and disengaged therefrom.

Relay C, it will be recalled, is a slow-to-release relay and for this reason does not release while

the contacts of pendulum P are momentarily disengaged during the oscillation or vibration of the pendulum. When the disturbance or pressure impulses received from the countermining operation have subsided sufficiently to cause the contacts of pendulum P to remain continuously disengaged, the operate circuit to the winding of relay C is interrupted and the armatures 172 and 173 thereof are restored to their unoperated position after a predetermined period of time has elapsed following the interruption of the operate circuit to the relay. As armature 173 moves to the unoperated position, battery is removed from the winding of the reset magnet RS of relay A thereby removing the restraint from armature 169 thereof and rendering the relay responsive to signals received from the induction pick-up coil 48 as the magnetic field adjacent thereto is varied by the movement of a steel vessel or other ponderous mass of magnetic material within the vicinity of the mine. As armature 172 of relay C moves to its unoperated position a circuit is closed from the contacts of the time delay device B to the detonator 31 whereby the detonator is adapted to be operated as the contacts of the time delay device B are moved into engagement with each other. The mine is again in an armed condition.

Let it now be assumed that a steel vessel moves within the vicinity of the mine thereby causing a change in the terrestrial magnetic field adjacent the mine and an electromotive force within the induction pick-up coil 48 to be set up of sufficient magnitude to cause the relay A to operate over the following circuit: ground at conductor 174, winding of induction pick-up coil 48, conductor 175, gimbal contacts GC1, conductor 176, winding of the operate magnet of relay A, conductor 163, contacts 36 and 35 of the hydrostat device from whence the circuit is continued to ground. As armature 167 of relay A moves into engagement with contact 168 or 169, as the case may be, battery is applied by way of conductor 166, gimbal contact GC2, conductor 165, armature 167 and make contact thereof, conductor 170, winding of the electromagnet of time delay relay B, conductor 163, contacts 36 and 35 of the hydrostat device and thence to ground thereby causing the electromagnet of the time delay clock B to be energized and move the armature 177 thereof away from the back stop 178. As armature 177 moves away from the back stop 178 a gear train connected thereto is set in motion to cause an escapement mechanism to operate and retard the movement of the armature 177 in response to the energization of the electromagnet thereof whereby the contacts 179 of the clock B are moved to closed position when a predetermined interval of time has elapsed after the operate circuit to the electromagnet of the clock is closed. When the armature 177 has moved through an angular distance sufficient to cause the contacts 179 to be engaged, a firing circuit is closed from battery BA, conductor 166, gimbal contacts GC2, conductor 165, timing clock contacts 179, conductor 181, armature 172 and break contact of relay C, conductor 182, gimbal contacts GC3, conductor 183, detonator 31, conductor 184, contacts 36 and 35 of the hydrostat device and thence to ground thereby causing the detonator to operate and explode the mine.

Contacts 179 of relay B, it will be noted, are moved to closed position in predetermined time delay relation with respect to the operation of relay A whereby the vessel is allowed to proceed

on its course until it has attained a position substantially directly above the mine before the firing circuit is closed by the contacts 179 whereby the mine is caused to explode beneath a vulnerable portion of the vessel.

Armature 177 of the time delay relay device B is normally urged against the back stop 178 by the retractile spring 185 connected thereto of strength sufficient to cause the armature to be quickly restored to the unoperated position in engagement with the back stop 178 in the event that the operate circuit to the electromagnet thereof is interrupted before the armature has moved through a distance sufficient to cause contacts 179 to be engaged as may occur, for example, as the result of the momentary movement of armature 167 of relay A into engagement of either of the contacts thereof as the result of a disturbance of the mine before armature 169 is forcibly moved to the neutral or null position by the operation of the restore magnet RS. The retractile spring 185 is insufficiently strong to prevent movement of the armature 177 by the pull of the electromagnet of the time delay device as the electromagnet is energized.

Briefly stated in summary, the present invention contemplates the provision of new and improved means for controlling the firing of a submarine mine by changes in the magnetic field adjacent thereto, in which the arming of the mine is delayed until a predetermined period of time has elapsed after the mine has been launched within a body of water, and in which the premature explosion of the mine as the result of a countermining operation is prevented. Furthermore, the present invention provides a system in which the firing of the mine in response to a change in the magnetic field adjacent thereto as a steel vessel approaches within the vicinity of the mine, is delayed until the vessel has reached a position substantially directly above the mine whereby the maximum destructive effect of the mine is obtained.

While the invention has been described with reference to a certain preferred example thereof which gives 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 our intention, therefore, in the appended claims to cover all such changes and modifications.

The invention herein disclosed and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without 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 system of the character disclosed for controlling the firing of a submarine mine arranged within the terrestrial magnetic field on the bed of a body of water adjacent the path of travel of a vessel, means for detecting a change in said magnetic field, a sensitive relay electrically connected to said detecting means and adapted to be operated thereby, an electro-responsive time delay device controlled by said sensitive relay and having a pair of normally open contacts adapted to be closed as the time delay device operates, a slow releasing relay having a pair of normally closed contacts in series circuit with said normally open contacts of said time delay device, a pendulum device having a pair of normally open

contacts operatively connected to said slow releasing relay and adapted to cause said slow releasing relay to operate as the pendulum device is moved from a position of rest, a source of electrical power, detonating means operatively connected to the normally closed contacts of said slow releasing relay, and means controlled by the pressure of the water for causing said detonating means to be operated by said source of electrical power as said normally open contacts of the time delay device are moved to closed position.

2. In a system of the character disclosed for controlling the firing of a submarine mine arranged within a body of water, a firing circuit, means responsive to a predetermined change in the magnetic field adjacent the mine for closing said firing circuit, a pendulum device having a pair of normally open contacts adapted to be closed as the mine is disturbed, and a slow releasing relay electrically connected to the contacts of said pendulum device and adapted to be operated thereby as the pendulum device operates, said slow releasing relay having a pair of normally closed contacts adapted to be disengaged from each other and prevent the closure of said firing circuit while the slow releasing relay is operated a pair of normally open contacts adapted to be engaged with each other, and means controlled thereby to render said magnetic field responsive means ineffective to close the firing circuit while said slow releasing relay is operated.

3. In a system of the character disclosed for controlling the firing of a submarine mine, a source of electrical power, detonating means, a firing circuit adapted to establish an electrical connection between said detonating means and said source of power, said firing circuit including an electro-responsive device having means for closing said firing circuit in time delayed relation as the device operates, means including a sensitive relay controlled by a change in the magnetic field adjacent the mine for causing said electro-responsive device to be set in operation, a control circuit, a pendulum device having means for closing the control circuit as the mine is disturbed, and a slow releasing relay connected to said control circuit and controlled by said pendulum device adapted to interrupt said firing circuit as the mine is disturbed.

4. In a system of the character disclosed for controlling the firing of a submarine mine disposed within a body of water adjacent the path of travel of a vessel, the combination of a firing circuit adapted to be closed in response to a change in one of the natural phenomena caused by the approach of a vessel within the vicinity of the mine, means for closing said firing circuit, a control circuit, a pendulum device having means for closing the control circuit as the pendulum device operates, a slow releasing relay electrically connected to said control circuit and adapted to be operated by said pendulum device, a pair of normally closed contacts on said slow releasing relay adapted to interrupt said firing circuit as the relay operates, a pair of normally open contacts on said slow releasing relay adapted to be closed, and means controlled thereby to render said firing circuit closing means ineffective to close the firing circuit as the relay operates.

5. In a system of the character disclosed for controlling the firing of a submarine mine arranged within a body of water adjacent the path of travel of a vessel, means for detecting a change in the terrestrial magnetic field adjacent the mine, a sensitive relay having a pair

of fixed contacts and a movable contact element adapted to be brought into engagement selectively with said fixed contacts as a change in said magnetic field is detected by said detecting means, means including a reset magnet for moving said movable contact element to a predetermined open position intermediate said fixed contacts, a source of electrical power, means effective when the mine has been launched within said body of water for a predetermined period of time for establishing an electrical connection between said reset magnet and the source of electrical power thereby to actuate the movable contact element of said sensitive relay to said predetermined open position, a slow acting fuse device adapted to disconnect said reset magnet from said source of power after the movable contact element has been actuated to said predetermined open position, a time delay relay device electrically connected to said sensitive relay and adapted to be operated thereby as said fixed contacts are selectively engaged by said movable contact element in response to a change in the magnetic field detected by said detecting means, said time delay relay device having a pair of normally open contacts adapted to be engaged as the time delay relay device operates, a mine firing circuit adapted to be closed as the contacts of said time delay relay device are brought into engagement with each other, a detonating device adapted to be operated as the mine firing circuit is closed, a pendulum device having means for closing an electrical control circuit as the pendulum device operates, and means including a slow operating relay electrically connected to said electrical control circuit and controlled by said pendulum device for interrupting said mine firing circuit when the time delay relay device is operated.

6. In a system for controlling a submarine mine, a source of electrical power, means controlled by the pressure of the water within which the mine is submerged for establishing an electrical connection to said source of electrical power, a sensitive relay having a movable element adapted to engage a pair of contacts selectively as the relay operates, means controlled by said pressure responsive means for setting said movable element in a predetermined position intermediate said pair of contacts and disconnected therefrom, means for releasing said setting means, means responsive to a change in the magnetic field adjacent the mine for causing said movable element to engage said pair of contacts selectively, an electroresponsive time delay mechanism operatively connected to said sensitive relay and adapted to be set in operation as one of said pair of contacts is engaged by said movable element, said time delay mechanism having a pair of normally open contacts adapted to be closed as the time delay mechanism operates, a detonating device in electrical connection with the normally open contacts of said time delay mechanism and adapted to be operated as the contacts are closed, a slow releasing relay having a pair of normally closed contacts adapted to be disengaged and interrupt said electrical connection as the relay operates, and a pendulum device having means for closing an electrical circuit to said slow releasing relay as the mine is disturbed thereby to cause the slow releasing relay to be operated by said source of electrical power.

7. In a system of the character disclosed for preventing the detonation of a submarine mine in response to a disturbance caused by a coun-

termining operation, a source of electrical power, a mine firing circuit connected to said source of electrical power, means responsive to the approach of a vessel for closing said mine firing circuit when the mine is undisturbed, a control circuit, a pendulum device having means for closing the control circuit from said source of power as an impulse of hydrostatic pressure sufficient to disturb the mine is received, a slow releasing relay adapted to be operated by said source of electrical power as the control circuit is closed, a pair of normally closed contacts on said slow releasing relay adapted to interrupt said firing circuit as the slow releasing relay operates in response to the operation of said pendulum device, a pair of normally open contacts on said slow releasing relay, and means controlled thereby adapted to render said firing circuit closing means ineffective to close the firing circuit as the relay operates.

8. In a mine firing control mechanism, the combination of a sensitive relay adapted to close a pair of contacts as the relay operates, means responsive to a change in the magnetic field adjacent the mine for operating said sensitive relay, electro-responsive means for resetting said sensitive relay to a predetermined unoperated condition, a hydrostat device, a source of electrical energy, means controlled by said hydrostatic device for operatively connecting said electro-responsive resetting means to said electrical source of power thereby to reset said sensitive relay to said predetermined unoperated condition, means for disconnecting said electro-responsive resetting means from said source of electrical power when the sensitive relay has been reset, a time delay relay adapted to be operated by said sensitive relay as the contacts of said sensitive relay are closed, a firing circuit adapted to be closed by said time delay relay after a predetermined period of time has elapsed following the operation of said sensitive relay, a pendulum device having means for closing a control circuit as the pendulum device operates in response to a disturbance of the mine, a slow releasing relay adapted to be operated by the circuit closing means of said pendulum device, a pair of normally closed contacts on said slow releasing relay adapted to interrupt said firing circuit as the slow releasing relay operates, and a pair of normally open contacts on said slow releasing relay adapted to operate said electro-responsive resetting means thereby to maintain said sensitive relay in a predetermined unoperated condition until the slow releasing relay has released.

9. In a system of the character disclosed for controlling the firing of a submarine mine arranged on the bed of a body of water adjacent the path of travel of a vessel, means including a sensitive relay for detecting a change in the terrestrial magnetic field adjacent the mine, a mine firing circuit, means controlled by said sensitive relay for closing the mine firing circuit in delayed time relation with respect to said change in the magnetic field, a switch in said mine firing circuit, and means responsive to a disturbance of the mine for concurrently rendering the sensitive relay ineffective and opening said switch for a predetermined period of time after said disturbance has subsided.

10. In a system of the character disclosed for firing a submarine mine selectively in response to a predetermined change in the magnetic field adjacent thereto, an induction pick-up coil adapted to generate an electrical signal as the

number of flux linkages thereof with the magnetic field is varied by a change in said magnetic field, a control circuit, a detecting relay having means adapted to close the control circuit as the detecting relay operates in response to the electrical signal received from said induction pick-up coil, a relay clock mechanism having a rotatable element adapted to be actuated from an initial position to a predetermined moved position, electro-responsive means operatively connected to said control circuit adapted to actuate said rotatable element from said initial position to the predetermined moved position as the electro-responsive means is energized in response to the closure of said control circuit, a pair of normally open contacts on said relay clock mechanism adapted to be closed when said rotatable element has been actuated to said predetermined position, detonating means, a firing circuit adapted to be closed by said normally open contacts when said rotatable element has moved to said predetermined position, means responsive to a disturbance of the mine for forcibly releasing said detecting relay, and means for restoring the rotatable element of said relay clock mechanism to said initial position when the circuit to the electro-responsive means thereof is interrupted at the contacts of said detecting relay before the rotatable element thereof is moved to said predetermined position.

11. A mechanism for controlling the firing of

a submarine mine comprising a control circuit, a sensitive relay having means for closing the control circuit as the relay operates, detecting means responsive to a change in the magnetic field adjacent the mine adapted to operate said sensitive relay, means controlled by the pressure of the water within which the mine is submerged for operatively connecting said detecting means to the sensitive relay, means for restoring said sensitive relay to an initial unoperated condition within a predetermined period of time after the mine has been launched within a body of water, a time delay device having an electromagnet operatively connected to said sensitive relay and adapted to be energized as the sensitive relay operates, means including a rotatable armature adapted to actuate an escapement mechanism as the electromagnet is energized, a firing circuit, a source of electrical power, means for connecting said firing circuit to the source of electrical power when said armature has performed a predetermined angular movement in response to the energization of said electromagnet, and means including a slow releasing relay adapted to be operated when the mine is disturbed for interrupting said firing circuit and concurrently restoring said sensitive relay to said initial unoperated condition.

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