Dec. 5, 1961 H. BRADNER 3,011,440

MINE FIRING MECHANISM

Filed Sept. 13, 1944 2 Sheets-Sheet 1

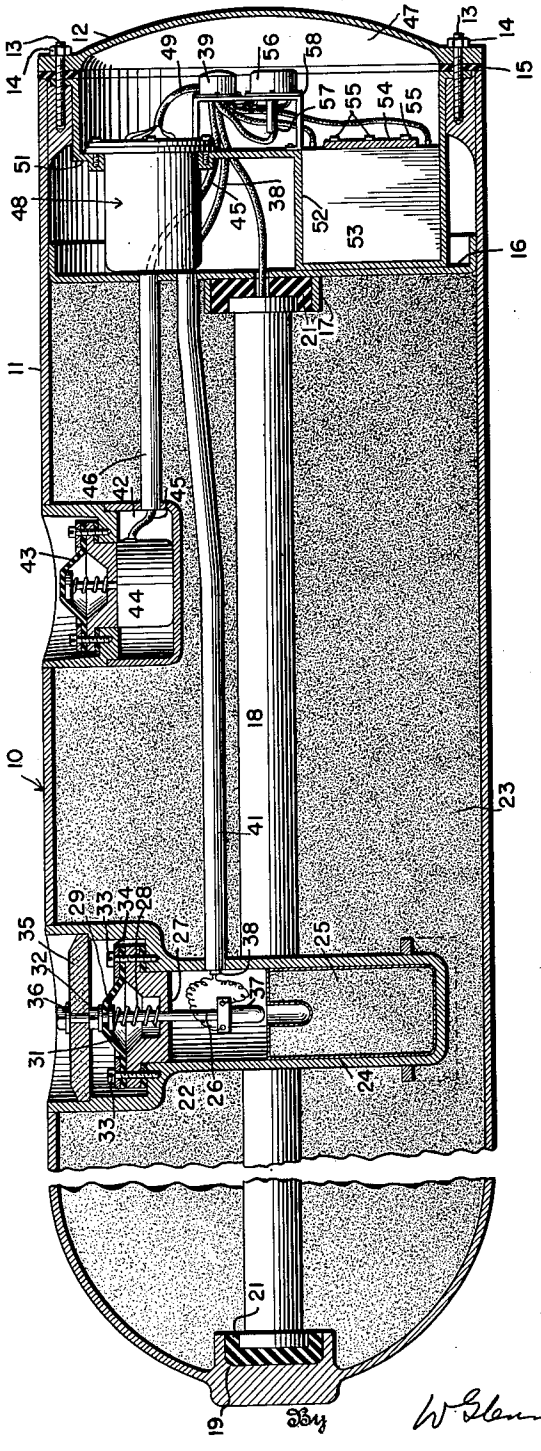

FIG. 1.

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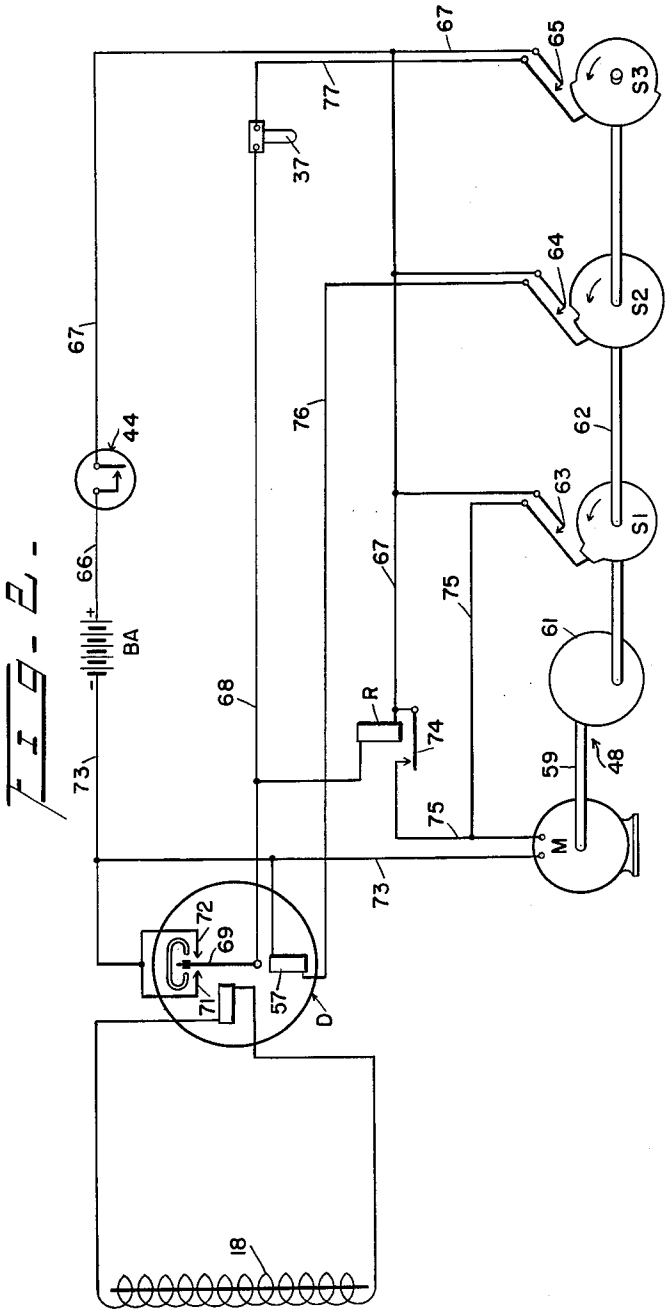

FIG. 2.

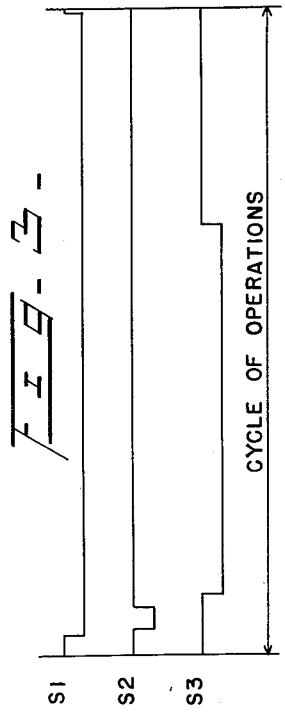

FIG. 3.

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MINE FIRING MECHANISM

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10 Claims. (Cl. 102—18)
(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to firing mechanisms for a mine and more particularly to a firing mechanism in which a plurality of control circuits are closed in predetermined time relation by a motor driven timing device selectively under control of a signal corresponding to a change in the magnetic field adjacent to the mine and received by a magnetic signal detecting device.

It is the usual practice, in certain types of mines, to cause the mine to become active in response to a change in the magnetic field adjacent thereto corresponding, for example, to a particular characteristic or signal comprising the magnetic field or signature of a vessel moving within the vicinity of the mine. Various means are employed for preventing the mine from being fired until a predetermined period of time has elapsed after the particular characteristic of the signal has been received whereby the mine cannot be swept by an aircraft adapted for magnetic minesweeping for the reason that the magnetic field set up by the moving aircraft within the vicinity of the mine has moved beyond the mine during this predetermined period sufficiently to prevent a firing operation of the mine. When this predetermined period of time has elapsed the mine is armed or merely placed in condition to receive a second signal or a second characteristic of the original signal accompanying the vessel, as the case may be, and remains armed for a period of time sufficient to receive a second characteristic or signal. In the event that the second characteristic or signal is received within the armed period of the mine, the mine is exploded. In the event, however, that a second signal is not received during the armed period of the mine, as in the case of the magnetic minesweeping aircraft, the mine firing control mechanism is restored to normal without firing the mine.

In devices heretofore proposed for controlling the firing of the mine selectively in accordance with the reception of a pair of signals corresponding to different characteristics or elemental portions of the signal received through the water or from two signals received through the water, as the case may be, within a predetermined period of time, it has been the usual practice to employ certain storage mechanisms and time measuring delay devices comprising switch mechanisms, both of the step-by-step type and of the type adapted to control the time of operation of the switching contacts thereof by clock movements, escapement devices, dash pots, and the like. Such devices have not proved altogether satisfactory in service for the reason that the devices are relatively susceptible to damage or injury thereto as the result of the shock or blow which the mine receives at the moment of launching, particularly in the case where the mines are launched from an aircraft in flight, by reason of the relatively delicate elements comprising the structure employed for controlling the firing of the mine.

In the arrangement of the present invention these defects are obviated by providing a rugged circuit controlling mechanism comprising a plurality of cam controlled electrical contacts adapted to be operated in succession in predetermined sequential order by an electric motor by reason of the relative position of the cams on the cam shaft and the position of the contacts with respect to one another. The cam shaft is connected by way of a speed reducing device to the electric motor whereby the cams are adapted to make one revolution at a relatively slow

rate of speed corresponding to a cycle of operations of the device.

One of the objects of the present invention is to provide a new and improved motor driven timing mechanism for selectively controlling the firing of a marine mine.

Another of the objects is to provide a new and improved control mechanism for a mine adapted to fire the mine in response to a signal indication comprising two elemental signal portions received in predetermined time spaced relation and corresponding respectively to different portions of the magnetic field of the vessel moving past the mine.

Another object is to provide a new and improved mechanism for firing a mine selectively in accordance with a pair of changing magnetic conditions detected in predetermined time spaced relation in which the second one of the changing magnetic conditions is employed to fire the mine.

Another object resides in the provision of a mine firing arrangement comprising a timing and control mechanism adapted to be set in operation by a signal received from a vessel regardless of the polarity of the signal, in which the mechanism is brought to rest at the completion of a cycle of operations thereof within a predetermined period of time in the event that a second signal is not received within a predetermined fractional portion of said period of time.

Another object is a new and improved mine firing mechanism having means for preventing the firing of the mine in response to a magnetic sweep operation of an aircraft in flight.

Still another object is the provision of a new and improved mine firing system adapted to arm the mine in response to a change in the magnetic field adjacent thereto and to fire the mine in response to a second change in the field occuring in predetermined time delayed relation to the first named change in which a minimum of control and timing elements and circuits therefor are employed.

A further object is the provision of a timing mechanism for a mine adapted to close a plurality of contact elements invariably in predetermined time spaced relationship, which is economical to manufacture, rugged in construction, durable in service and which possesses the additional quality of reliability of operation in service.

Still other objects, advantages and improvements will be apparent from the following description taken in connection with the accompanying drawings of which:

FIG. 1 is a view in section and partly broken away of a mine suitable for use with the device of the present invention;

FIG. 2 illustrates in diagrammatic form a complete system suitable for use with the mine of FIG. 1; and,

FIG. 3 illustrates diagrammatically in chronological sequence the operation of the various cam actuated contacts of the timing and control mechanism of FIG. 2 during a cycle of operation thereof.

Referring now to the drawings for a more complete understanding of the invention and more particularly to FIG. 1 thereof, there is shown thereon a mine indicated generally by the numeral **10** having a casing **11** adapted to be sealed by a cap or cover **12** secured thereto as by the studs **13** and nuts **14** threaded thereon, a gasket **15** being preferably arranged between the cover and the casing to insure a watertight joint therebetween. There is arranged within the casing **11** a wall or partition **16** having an annular support **17** secured thereto and adapted to receive one end of an induction pick-up coil **18** comprising a relatively large number of turns of wire arranged about a rod of iron or composed of a material sold under the trade name of Permalloy or Mumetal. The other end of the coil is disposed within a recessed

portion 19 of the casing 11, suitable pads or cushions 21 being arranged between the ends of the coil and the recessed portion 19 and support 17 respectively to prevent damage or injury to the coil as the mine is launched.

The partition 16 also forms a chamber within which is arranged an explosive charge 23 of TNT or the like sufficient to destroy the vessel and to impart a negative degree of buoyancy of the mine whereby the mine is adapted to come to rest on the bed of a body of water after being launched therein.

There is also provided within the chamber 22 a well within which is arranged an explosive booster charge 25 as is well known in the art to which the invention pertains. There is also arranged within the well 24 a hydrostat mechanism comprising a plunger or rod slidably arranged within the support 27 and normally urged outwardly therefrom by a spring 28 in engagement with the collar 29 secured to the plunger. A flexible diaphragm 31 is clamped to the collar as by the nut 32, the diaphragm being maintained in watertight relation with respect to the well 24 as by the bolts 33 and clamping ring 34. A soluble washer 35 secured to the plunger as by the nut 36 prevents the inward movement of the plunger until the mine has been planted for a period of time sufficient to dissolve or soften the soluble washer.

When this occurs, the detonating device 37 is moved by the plunger into operative relation with respect to the booster charge 25. The detonating device 37 is connected electrically by means of a pair of conductors with the cable 38 to a junction or connection box 39, a tube or duct 41 being provided between the well 24 and the partition 16 to support and protect that portion of the cable disposed within the explosive charge within the chamber 22.

The mine is also provided with a recess or well 42 within which is arranged a hydrostat 43 adapted to set an arming clock 44 into operation in response to the movement of the hydrostat under the influence of the pressure of the surrounding water. The arming clock may be of any type suitable for the purpose adapted to close the circuit between the pair of conductors within the cable 45 connected thereto such, for example, as the arming clock described and claimed in the copending application of James B. Glennon et al. for Firing Mechanism For A Submarine Mine, Serial No. 395,230, filed May 26, 1941, now Patent No. 2,905,088. The cable 45 is preferably arranged within a tube or duct 46 extending between the well 42 and the partition 16.

From the foregoing it will be apparent that the partition 16 divides the casing of the mine into two portions or chambers of which the chamber 22 is filled with an explosive charge. The remaining chamber, indicated generally by the numeral 47, has arranged therein the timing and mine firing control mechanism indicated generally by the numeral 48. The mechanism 48 is electrically connected to the connecting box by a plurality of electrical conductors arranged within the cable 49. The device 48 is secured to the casing of the mine in any suitable manner as by the support 51, the support preferably having a well 52 therein within which is arranged a battery 53, hereinafter referred to as BA, a clamping device 54 secured to the support 51 as by the bolts 55 preferably being provided to prevent damage or injury to the battery as the mine is launched.

A polarized relay 56, hereinafter referred to as D, is operatively connected to the coil 18, the relay having a reset magnet adapted to restore the moving element of the relay to an initial neutral position intermediate a pair of contacts. The relay is mounted in any suitable manner as by the support 58.

The timing and control mechanism 48 will best be understood by consideration of FIG. 2 on which is shown in diagrammatic form a timing and control structure according to a preferred embodiment of the invention,

the mechanism comprising, among other elements, an electric motor M connected by way of a shaft to a gear box 61 employed for causing the shaft 62 to make a single rotation during a cycle of operations of the device at a greatly reduced speed of rotation with respect to the motor, a speed of rotation of one revolution a minute of the shaft 62 having been found to be satisfactory. Secured to the shaft 62 in any convenient manner are the cams S1, S2 and S3 adapted to cause the pairs of normally open contacts 63, 64 and 65 respectively associated therewith to be operated in predetermined sequential order during the aforesaid cycle of operations.

As shown in diagrammatic form on FIG. 3 the cam S1 is adapted to close the contacts 63 two seconds after the motor M has been set into operation at the beginning of a cycle of operations of the device and remain closed until the cycle of operations is substantially complete. The interruption of contacts 63 causes the motor M to come to rest and the cycle of operations to be complete, as will be more clearly apparent as the description proceeds.

Contacts 64 are closed substantially three seconds after the motor starts and remain closed for a suitable period of time such, for example, as two and one half seconds, the contacts 64 thereafter remaining open throughout the remainder of the cycle of operations.

Contacts 65, it will be noted, are adapted to be closed by cam S3 six seconds after the motor M has been started and remain closed for substantially 34 seconds.

There is also provided a relay R having a pair of normally open contacts adapted to be closed as the relay operates and thereby set the motor M into operation.

The operation of the system will best be understood by consideration of a specific example. Let it be assumed, by way of example, that the mine has been planted within a body of water of sufficient depth to cause the clock hydrostat 43 to operate thereby setting the arming clock 44 in operation, and that a period of time has elapsed sufficient for the soluble washer 35 to dissolve and allow the detonating device 37 to be moved into operative relation with respect to the explosive booster charge 25 by the pressure of the surrounding water against the flexible diaphragm 31 of the extender hydrostat. When the contacts of the arming clock 44 are moved into engagement with each other by the clock mechanism, a circuit is closed from the positive terminal of battery BA by way of conductor 66, contacts of the arming clock 44, conductor 67, winding of relay R, conductor 68, armature 69 and contacts 71 or 72, as the case may be, with which the element 69 is engaged as the result of the shock received from the planting of the mine, and thence by conductor 73 to the negative terminal of battery BA thereby operating relay R. As armature 74 of relay R moves into engagement with the make contact thereof a circuit is closed from positive terminal of battery BA by way of conductor 66, contacts of the arming clock 44, conductor 67, armature 74 and make contact of relay R, conductor 75 to the motor M, from whence the circuit is continued by way of conductor 73 to the negative terminal of battery BA thereby setting the motor M into operation and initiating a cycle of operations of the timing and control mechanism 48. At the completion of a two second interval, contacts 63 are closed by cam S1 thereby maintaining the motor continuously operated regardless of the operated condition of relay R until the cycle of operations has been completed.

At the completion of a two and one half second interval after the cycle of operations of the timing and control mechanism 48 has been initiated, contacts 64 are momentarily closed by cam S2 thereby applying positive battery by way of conductor 76 to the reset magnet 57 of relay D, from whence the circuit is continued by way of conductor 73 to the negative terminal of battery BA thereby causing the reset magnet to operate and restore

the movable element 69 to an initial neutral position intermediate contacts 71 to 72 and disengaged therefrom. As the moving elements 69 moves away from contact 71 or 72, as the case may be, negative battery is removed from relay R and relay R releases. The motor M, however, continues to operate by reason of the closure of contacts 63 aforesaid. At the completion of an additional period of time of substantially two and one half seconds, contacts 64 are disengaged by cam S2 thereby interrupting the aforesaid circuit to the restore magnet 57 and causing the restore magnet to release and remove the restraint from the movable element 69. The relay D is now in a condition to respond to a changing magnetic field adjacent to the mine.

At the completion of an interval of six seconds following the start of the cycle of operations, contacts 65 are closed by cam S3 and remain closed for 34 seconds. The closure of contact 65 at this time, however, performs no useful function for the reason that the magnetic field adjacent to the mine is assumed to be unchanged during this interval of time. When the shaft 62 has made substantially a complete rotation, corresponding to a cycle of operations of the timing mechanism, contacts 63 are disengaged by cam S1 thereby interrupting the operating circuit to the motor M and causing the timing and control device 48 to come to rest at the completion of an initial cycle of operations thereof.

Let it now be assumed, by way of example, that a vessel having a magnetic field or signature comprising an elemental portion or characteristic followed by a second elemental portion or characteristic of the same or opposite polarity, as the case may be, moves within the vicinity of the mine or passes above the mine. The term "polarity" as applied to the magnetic signature of the vessel is defined herein as a variation in the direction of the magnetic field at a fixed point of reference as different portions of the vessel move past the point of reference. As the first portion of the magnetic signature moves into proximate relation with respect to the pick-up coil 18, an electromotive force is generated within the pick-up coil sufficient to operate relay D and cause the armature thereof to be moved into engagement with contact 71 or 72, as the case may be.

For the purpose of description it may be assumed that the armature of relay D now moves into engagement with contact 71. When this occurs, negative battery is applied to one end of the winding of relay R thereby causing relay R to operate and at armature 74 and make contact thereof close an operating circuit to the motor M thereby causing motor M to operate and set the timing and control mechanism 48 into operation. When the timing device 48 is operated for substantially two seconds, contact 63 thereof is closed by cam S1 thereby maintaining the motor M in operation after relay R is released until a cycle of operations of the timing device has been completed. Contacts 64 are closed substantially two and one half seconds after the motor starts thereby operating the restore magnet 57 and causing the movable element 69 of relay D to be restored forcibly to an initial unoperated position intermediate the contacts 71 and 72 and disengaged therefrom.

Contacts 64, it will be recalled, are disengaged at the expiration of a period of two and one half seconds after the contacts are closed. When this occurs the operating circuit to the reset magnet 57 is interrupted and the reset magnet releases thereby removing the restraint from the movable element 69 of relay D and causing relay D to be responsive to an additional signal received from the pick-up coil 18 at the completion of a predetermined interval of time after the first portion of the moving magnetic signature is received by the pick-up coil 18. As the movable element 69 of relay D moves away from contact 71, relay R releases. The motor M, however, continues to operate by reason of the closed condition of contacts 63 of the timing mechanism.

As the armature of relay D moves into engagement with contact 71 or 72 in response to the second elemental portion of the signal received from the moving vessel, a circuit is closed from the negative terminal of battery BA by way of conductor 73, contacts 71 or 72 and movable element 69 of relay D, conductor 68 and thence to one terminal of the electroresponsive detonating device 37, from whence the circuit is continued by way of conductor 77 to one of the contacts 65. When six seconds have elapsed after the timing and control device 48 has been set in operation, contacts 65 are closed by cam S3 thereby applying positive battery to conductor 77 and closing a firing circuit to the detonating device 37. The closure of the firing circuit causes the detonating device to operate thereby exploding the mine beneath a vulnerable portion of the vessel.

From the foregoing it will be apparent that the firing circuit through the detonating device 37 is adapted to be closed at any time within the time interval of 34 seconds following the six second interval after the timing and control mechanism 48 has been set into operation, this period of time being controlled by contacts 65 and cam S3 associated therewith. In the event that the moving element 69 of relay D should be moved to a closed position in response to the second elemental portion of a ship's magnetic signature during the time that contacts 65 are closed, the detonating device 37 will be fired as relay D operates.

By employing an arrangement in which the mine is fired only in response to changes in the magnetic field detected by the pick-up coil 18 within predetermined intervals of time corresponding to changes in the magnetic field such as are caused by elemental portions of a ship's magnetic signature received in succession as the vessel moves past the mine, and in which the firing circuit to the detonating device is rendered effective for a fractional portion only of the time required for the timing and control mechanism to complete a cycle of operations, the mine is thus made difficult to sweep by a magnetic field set up within the water by a mine sweeping aircraft in flight. Furthermore by employing a motor driven timing and control mechanism comprising a plurality of cam operated contacts of sturdy construction and adapted to be closed in predetermined time delayed relation during a cycle of operations of the mechanism, there is no possibility of prematurely closing the contacts and firing the mine as the result of the shock received during the planting thereof or resulting from a countermine explosion within the vicinity of the mine.

Briefly stated in summary, the present invention contemplates the provision of a new and improved mine firing system and timing control mechanism therefor which is characterized by simplicity of the various control elements and circuits therefor and in which the timing and switching control elements are of sufficient sturdy and rugged construction to withstand damage or injury thereto and adapted to prevent the premature operation of the various switching elements in response to the shock received thereby as the mine is launched, in which mechanical means are employed to insure reliability and accurate timing of the various control and firing circuits, and in which the mine is adapted to be fired by a pair of signals received in predetermined time spaced relation and respectively corresponding to elemental signal portions of the magnetic signature of a vessel moving within the vicinity of the mine.

While the invention has been described with reference to an example thereof which gives satisfactory results, it will be understood that this has been done for purposes of disclosure and that various changes and substitutions may be readily apparent to those skilled in the art, after understanding the invention herein disclosed, and that the terms employed in the claims are to be considered as words of description rather than of limitation.

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 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 marine mine of the character disclosed arranged within a magnetic field, in combination, means for detecting changes in the magnetic field, a relay connected to said detecting means and adapted to be operated thereby, a normally inactive motor driven time measuring device adapted to operate in uniform cycles, a source of electrical power, a pair of normally open contacts on said relay adapted to connect the motor to said source of power and thereby initiate a cycle of operations of the time measuring device as the relay operates in response to a change in the magnetic field, means including a pair of cam actuated contacts on the time measuring device for momentarily restoring said relay to an initial unoperated condition when a predetermined period of time has elapsed after the time measuring device has been set in operation, electroresponsive detonating means, and means including a second pair of cam actuated contacts on the time measuring device for connecting the detonating means to the contacts of the relay whereby the detonating means is adapted to be operated by said source of power as the relay contacts are closed in response to a second change in the magnetic field detected by the detecting means during the remaining portion of said cycle of operations of the time measuring device after the relay has been momentarily restored to said initial condition.

2. In a system of the character disclosed for firing a mine in response to variations in the magnetic field adjacent thereto corresponding respectively to different portions of the magnetic signature of a vessel, means including a relay for detecting variations in said magnetic field, a normally inactive motor driven timing device adapted to be set in operation as the relay operates in response to the first of said variations in the magnetic field, means on said timing device for maintaining the motor in operation until the timing device has completed a cycle of operations, a pair of normally open contact devices on said timing device and adapted to be closed momentarily when the motor has operated for a predetermined period of time during said cycle of operations, means controlled by said contact devices for momentarily restoring the relay to an initial unoperated condition as the contact devices are momentarily closed, a firing circuit having electroresponsive detonating means therein, and means including a second pair of contact closing devices on the timing device for operatively connecting said firing circuit to said relay when the relay has been restored to said initial unoperated condition whereby the detonating means is adapted to be operated by the relay as the relay operates in response to a second variation of the magnetic field during the remainder of the cycle of operations of the time measuring device.

3. In a system of the character disclosed for firing a mine in response to variations in the magnetic field adjacent thereto caused by a vessel moving within the vicinity of the mine, means including an electrical relay for detecting said variations in the magnetic field, a normally inactive timing mechanism comprising a plurality of contact elements, a plurality of cams on said timing mechanism adapted to operate the contact elements in predetermined sequential order during a cycle of operations of the mechanism, a source of electrical power, means including a plurality of circuit connections for causing the motor to be operated by said source of power selectively under control of said relay, means operated by one of said contact elements for restoring the relay to an initial unoperated condition during said cycle of operations when a predetermined period of time has elapsed after the timing mechanism has been set in operation, an electroresponsive detonating device, and means including another of said contact elements for operatively connecting said detonating device to said relay when the relay has been restored to an initial unoperated condition whereby the detonating device is adapted to be fired by the relay during the remainder of the cycle of operations of the timing mechanism.

4. In a system for firing a mine selectively under control of variations of the magnetic field adjacent thereto, a mine casing having an induction coil therein and adapted to generate an electromotive force in response to each of said variations in the magnetic field, a relay connected to said induction coil and adapted to be operated by said electromotive force, a pair of normally open contacts on said relay and adapted to be closed as the relay operates, a motor driven timing device having a plurality of contact elements adapted to be operated in predetermined successive order during a cycle of operations of the device, a source of electrical power, means controlled by said relay for connecting the motor to said source of power as the relay operates in response to a variation in said magnetic field thereby to cause the timing device to perform a cycle of operations, means controlled by said timing device for momentarily resetting the relay to an initial unoperated condition during said cycle of operations when a predetermined period of time has elapsed after the motor has been set in operation, an electroresponsive detonating device, and means controlled by said timing device for operatively connecting the detonating device to the contacts of said relay when the relay has been reset whereby the detonating device is adapted to be operated by said source of power as the relay operates in response to a second variation in said magnetic field during the remaining portion of the cycle of operations of said timing device.

5. In a system of the character disclosed for firing a mine in response to variations in the magnetic field adjacent thereto caused by a vessel moving within the vicinity of the mine, means for detecting said variations in the magnetic field, a sensitive relay connected to said detecting means and adapted to be operated thereby, said relay having a pair of normally open contacts adapted to be closed as the relay operates, a control circuit including a source of electrical power connected to said contacts and adapted to be closed thereby, means controlled by the pressure of the surrounding water for rendering said control circuit effective when a predetermined period of time has elapsed after the mine has been planted, a second relay included within said control circuit and adapted to be operated by said source of power as the contacts of the sensitive relay are closed, a motor driven timing mechanism having a plurality of pairs of cam actuated contact elements adapted to be closed in predetermined sequential order during a cycle of operations of the mechanism, means on said second relay for setting the timing mechanism in operation to perform a cycle of operations, means including one of said pairs of contact elements for causing the timing mechanism to complete a cycle of operations after the second relay has released, means controlled by a second pair of contact elements on the timing mechanism for momentarily restoring the sensitive relay to an initial unoperated condition when a predetermined period of time has elapsed after the timing mechanism has been set in operation, electroresponsive detonating means, and means including a third pair of contact elements on the timing mechanism for connecting the detonating means in parallel with said second relay whereby the detonating means is adapted to be operated by said source of power as the contacts of the sensitive relay are closed in response to a second variation in the magnetic field detected by the detecting means during the remaining portion of said cycle of operations of the timing mechanism after the sensitive relay has been momentarily restored to said initial condition.

6. In a marine mine of the character disclosed arranged within a magnetic field, the combination of a

mine firing circuit, rotatable timing means adapted to measure a predetermined interval of time and having means for closing said firing circuit in part during a predetermined fractional portion of said predetermined interval of time, and means including a sensitive relay and responsive to changes in the magnetic field caused by a vessel moving with respect to the mine for initiating operation of said rotatable means when a first change occurs in said field and for closing said circuit when a second change in said field occurs during said fractional portion of said interval of time.

7. In a marine mine of the character disclosed arranged within a magnetic field, a mine firing circuit, means for detecting changes in the magnetic field and generating electrical signals respectively corresponding thereto, rotatable timing means for measuring a predetermined interval of time, means controlled by the timing means for causing the firing circuit to be armed for a predetermined period of time corresponding to a fractional portion of said predetermined interval of time, and means including a sensitive relay controlled by said signals for initiating the operation of the timing means when a first signal is generated and for closing the firing circuit when a second signal is generated during said armed period of time.

8. In a marine mine of the character disclosed arranged within a magnetic field, in combination, a relay, means including an induction pickup coil for operating said relay in response to a change in said field, a normally inactive time measuring device adapted to be set in operation by said relay as the relay operates, means on the time measuring device for causing the time measuring device to operate in unit cycles, electroresponsive means on the relay and adapted to reset the relay to an initial unoperated position thereof, circuit closing means on said time measuring device for momentarily operating the relay resetting means when a predetermined period of time has elapsed after the time measuring device has been set in operation, a firing circuit including contact means controlled by said relay, and means on said time measuring device for rendering said firing circuit effective to fire the mine when the relay operates during a predetermined fractional portion of said cycle of operations and after the relay has been momentarily reset.

9. In a marine mine of the character disclosed arranged within a magnetic field, the combination of means for detecting changes in the magnetic field and generating electrical signals respectively corresponding thereto, a relay operatively connected to said detecting means and

having a pair of normally open contact elements adapted to be closed as the relay operates, a normally inactive motor driven time measuring device operable in unit cycles and having a shaft adapted to make one revolution during each cycle of operations of the device, means including a plurality of circuit connections for causing said motor to be set in operation as said contact elements are closed, electroresponsive means on said relay for forcibly disengaging said contact elements, a cam member on said shaft, a circuit closing device controlled by said cam member for momentarily operating said electroresponsive means when a predetermined period of time has elapsed after the time measuring device has been set in operation, a firing circuit having electroresponsive detonating means therein and adapted to be closed by said contact elements as the relay operates in response to a change in said magnetic field detected by said detecting means after said contact elements have been disengaged, a second cam member on said shaft, and means controlled by said second cam member for rendering said firing circuit effiective to operate said detonating means during a predetermined portion of said cycle of operations after said contact elements have been disengaged.

10. In a marine mine of the character disclosed arranged within a magnetic field, the combination of a mine firing circuit, rotatable timing means adapted to measure a predetermined interval of time and having means for closing said firing circuit in part during a predetermined fractional portion of said predetermined interval of time, means including a sensitive relay and responsive to changes in the magnetic field caused by an airborne sweep operation for intiating operation of said rotatable means when a first change occurs in said field, means for closing said circuit when a second change in said field occurs during said fractional portion of said interval of time, and means for preventing the closing of said circuit for an interval of time immediately following the first change in the magnetic field sufficient to render the mine additionally unresponsive to said sweep operation.

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