March 26, 1946. W. SCHAELCHLIN 2,397,209

MINE SWEEPING CONTROL

Filed Feb. 27, 1942 2 Sheets-Sheet 1

Fig. 1.

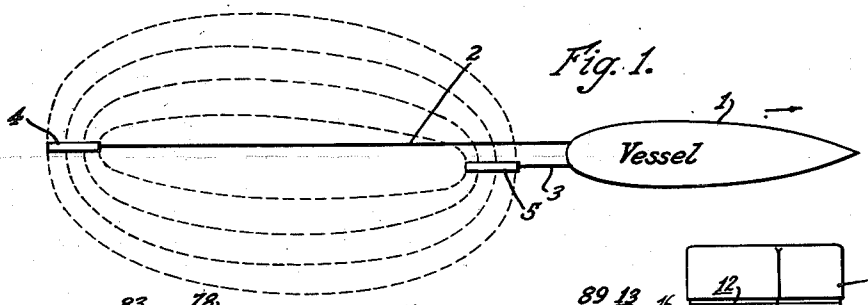
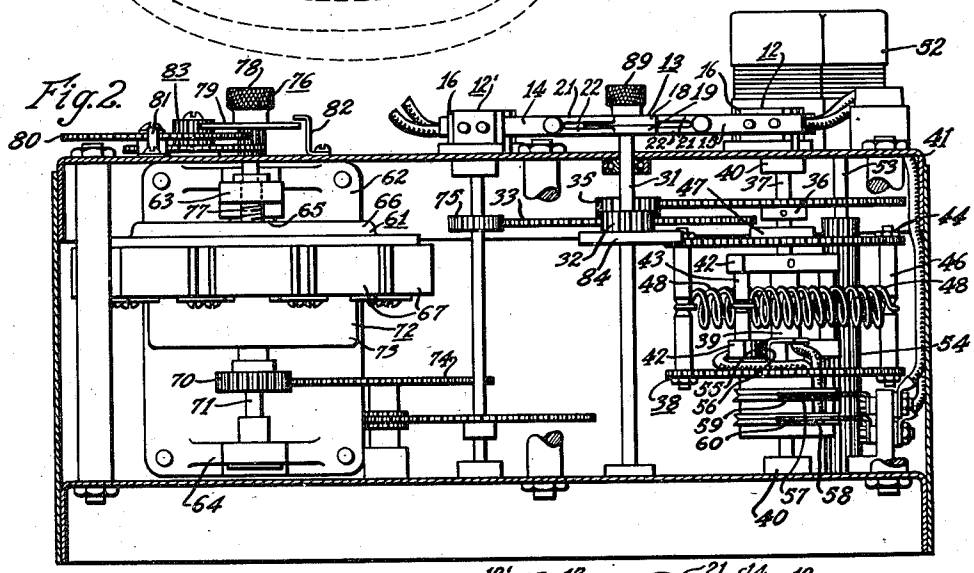
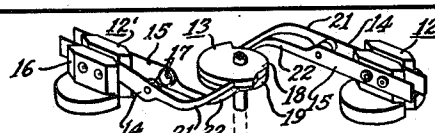


Fig. 2.





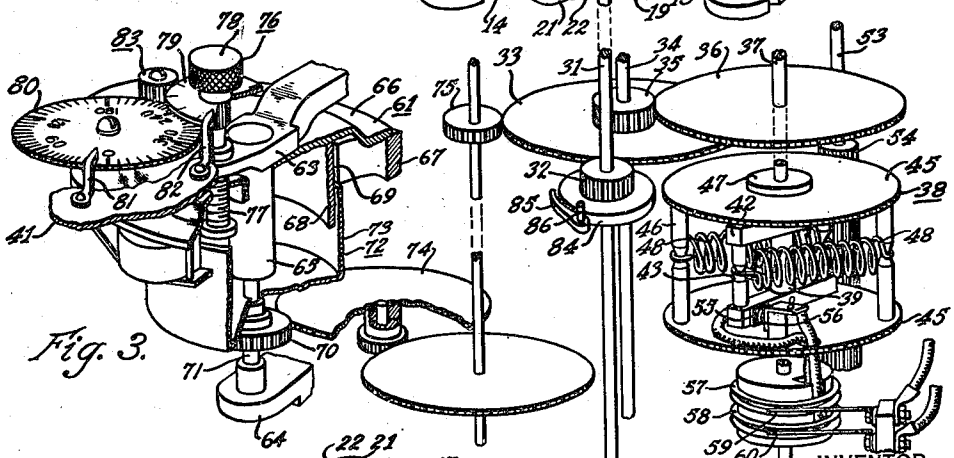


Fig. 3.

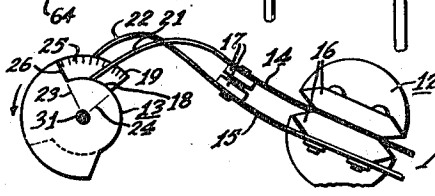


Fig. 5.

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MINE SWEEPING CONTROL

Filed Feb. 27, 1942 2 Sheets-Sheet 2

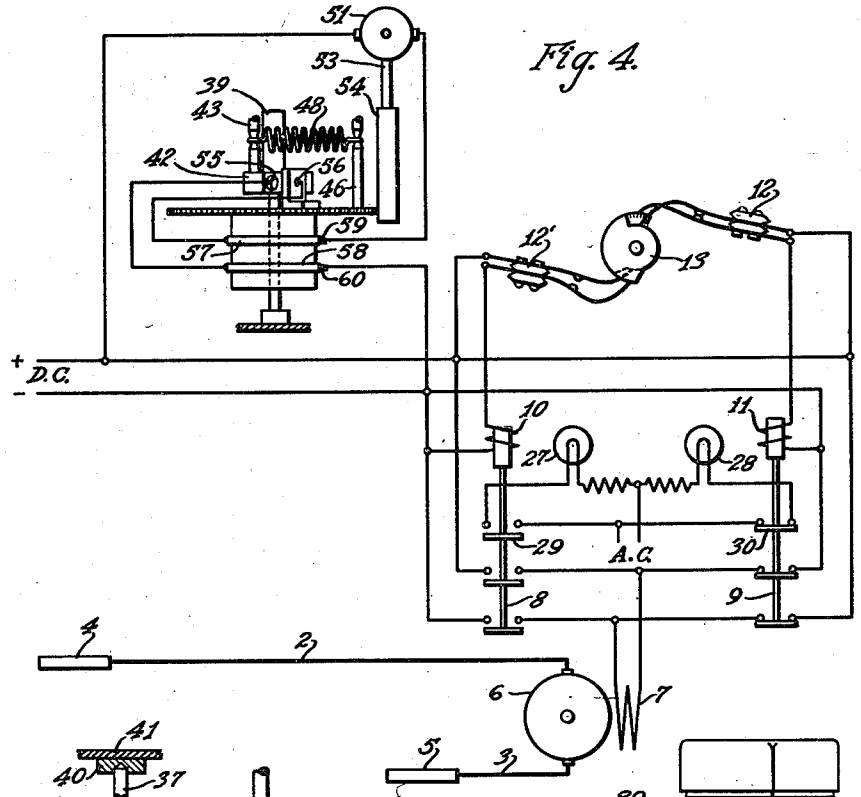


Fig. 4.

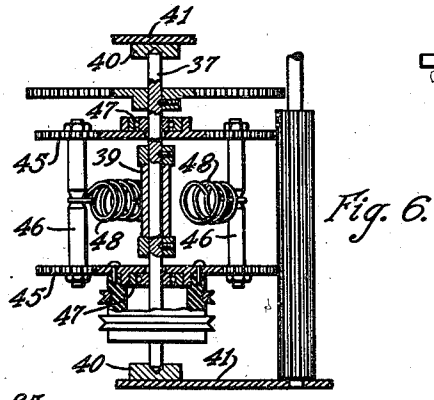


Fig. 6.

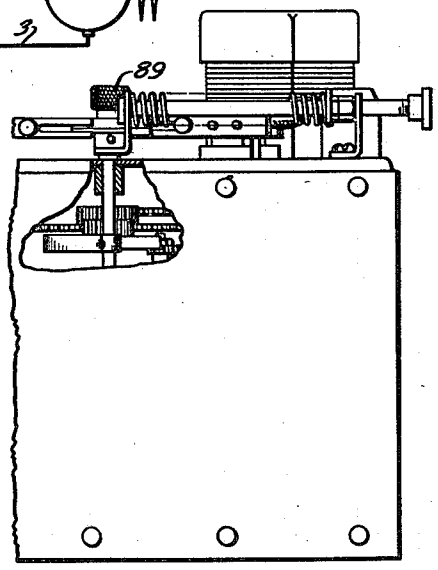


Fig. 9.

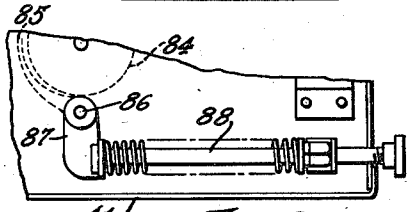


Fig. 8.

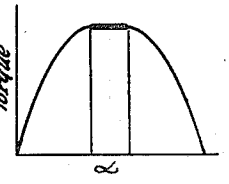


Fig. 7.

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Patented Mar. 26, 1946 2,397,209

UNITED STATES PATENT OFFICE

2,397,209

MINE SWEEPING CONTROL

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Application February 27, 1942, Serial No. 432,651

12 Claims. (Cl. 114—221)

The practice of planting mines in navigable waters for the purpose of destroying merchant shipping is well known. Such mines are provided with detonating mechanism which is magnetically responsive to the magnetic field set up by the steel hull of a passing ship. Accordingly, in those cases where it has been known or suspected that waters have been planted with mines, it has been customary to conduct mine sweeping operations to clear such waters of mines prior to the further passage of merchant shipping, the mine sweeping being done by traversing the suspected waters with a vessel towing an energized cable to provide a magnetic field of intensity and direction equal to the distortion caused by the steel hull of a passing ship.

A recent development in the structure of magnetic mines has provided such mines with a delayed action whereby such mines would be operated only after being subjected to a predetermined number of separate magnetic impulses. Assuming that such a mine had been set to explode upon the seventh impulse, six vessels could pass over the mine safely before the mine would be responsive to a passing ship. To effectively clear a field of such mines by sweeping operations, as heretofore practiced, several traverses of the mine field by a sweeping vessel would be required, a single traverse being no longer reliable. In addition to the increased time required for sweeping, an undesirable element of doubt has been raised since the actual number of sweeping traverses necessary to clear the field could not be determined.

One of the principal objects of this invention is to provide an apparatus which is effective to activate a delayed action mine on a single traverse of the sweeping vessel. To this end, the sweeping cables carried by the mine sweeping vessel are provided with means by which such cables may be periodically energized to impart a plurality of separate magnetic impulses to the mines being swept. In this manner, mines in a given area being swept may be subjected to any desirable number of magnetic impulses to provide the same effect as would be had by the passage of several ships. A mine sweeping vessel is thus enabled to accomplish in one traverse that which has heretofore required several traverses.

A further object of this invention is to provide mechanism which is automatically operable to interrupt and reestablish the field created by a mine sweeping cable.

A further object of this invention is to provide a timing control for a mine sweeping cable having means for energizing the same which is operable to cause the cable to be energized in a timed intermittent manner, and which is adjustable to vary the frequency of the current pulses flowing through the cable.

A further object of this invention is to provide a control for a mine sweeping cable which is operable to alternately reverse the flow of current through the cable to thereby intermittently reverse the magnetic field which is set up by such cable.

A further object of this invention is to provide a control which is operable to interrupt and reestablish the current flowing through a mine sweeping cable and which is further adjustable to vary the length of time during which current is flowing through the cable and to vary the length of time during which current is not flowing through the cable.

A further object of this invention is to provide a timing control for a mine sweeping cable which is variable over wide limits for adjusting the frequency of the current pulses flowing through the cable.

A further object of this invention is to provide an improved form of timing control comprising a constant torque motor for operating a rotatable timing member and a variable magnetic braking member which is adjustable to vary the speed of rotation of the timing member.

Further objects and advantages of the invention will become apparent during the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating the arrangement of mine sweeping cables with respect to a sweeping vessel;

Fig. 2 is a vertical sectional view of control apparatus constructed in accordance with the principles of my invention;

Fig. 3 is an exploded perspective view, parts thereof being shown in section, of the mechanism shown in Fig. 1;

Fig. 4 is a control circuit diagrammatically illustrating the manner in which the apparatus of my invention is made to control the flow of current through a mine sweeping cable;

Fig. 5 is a top plan view of a rotatable camming member showing its relation with respect to one of the control switches shown in Fig. 4;

Fig. 6 is a vertical sectional view of a constant torque spring motor further shown in Figs. 2 and 3;

Fig. 7 is a graph illustrating the torque-deflection characteristics of the torque motor shown in Fig. 6;

Fig. 8 is a top plan view of a part of the control casing shown in the arrangement of a brake lever with respect thereto; and

Fig. 9 is a side elevational view of the brake lever and associated parts shown in Fig. 8.

In Fig. 1, the numeral 1 designates a sweeping vessel for sweeping cables 2 and 3 which are respectively provided with electrodes 4 and 5. As best shown in Fig. 4, the terminals of the cables 2 and 3 are connected to the armature of a direct-current generator 6 having an exciting field 7. In practice, the cables 2 and 3 are arranged in such manner that the distance between the electrodes 4 and 5 is approximately 2000 feet. The generator 6 supplies the cables with a current of from about 2000 amperes to about 3000 amperes, and in one part of the circuit such current will flow through the water between the electrodes 4 and 5. The current flowing through the water between the electrodes 4 and 5 thus sets up, for the value of the current selected, a magnetic field of intensity and direction substantially equal to the intensity and direction of the field caused by a steel hull of a passing ship.

If the generator 6 is operated in such manner that the current flows continuously in the same direction between the electrodes 4 and 5, the effect on a mine subjected to the action of the magnetic field set up by such current will be similar to the passage of a single ship. If such mine is provided with a delayed action mechanism, it will be necessary to sweep the field several times in order to make the mine responsive to the magnetic field set up. The control of this invention is adapted to interrupt and reestablish the current through the cables 2 and 3 in order that the magnetic field may be applied a plurality of times to a mine within the range of the cable 2 and 3. In this manner, an effect similar to the passage of several ships is produced. Since the sweeping mechanism is installed on ships of various sizes and speeds, it is necessary that the frequency of the current pulses flowing in the cables 2 and 3 be variable over wide limits in order that a given area of a mine field being traversed will be subjected to a given number of magnetic impulses notwithstanding the speed of the sweeping vessel. As will be apparent, the timing control of this invention is adjustable over wide limits to compensate for the speed of the sweeping vessel. The control of this invention is also adapted to reverse the flow of current through the cables 2 and 3 in order to reverse the polarity of the magnetic field, a feature which has been found desirable in mine sweeping operations.

Referring now to Fig. 4, the field 7 is energized from a direct-current source through either of the control switches 8 or 9. The control switches 8 and 9 reverse the connections on the field 7 to the direct-current source and are thus operable to reverse the polarity of the generator 6 and the direction of current flow through the cables 2 and 3. The switches 8 and 9 are respectively operated by solenoids 10 and 11, which are operated by small switches 12 and 12' under the control of means, or device, 13.

As best shown in Figs. 3 and 5, each of the control switches comprises upper and lower resilient conducting members 14 and 14' and 15 and 15', carried by insulating supports 16 and 16'. The conducting members are provided with contacts 17 and 17' which are engageable to complete the operating circuit for the solenoids 10 and 11 respectively. The rotatable control means 13 comprises like upper and lower cams 18 and 19 which are angularly adjustable relative to each other to selected fixed positions on rotatable shaft 31. The upper conducting members 14 and 14' are provided with projecting fingers 21 and 21' for engagement with the peripheral surface of the upper cam 18 and the lower conducting members 15 and 15' are provided with projecting finger 22 for engagement with the peripheral surface of the lower cam 19. The resiliency of the conducting members maintains the fingers in engagement with the camming surfaces of the cams 18 and 19.

The construction of the cams 18 and 19 is such that the contacts 17' (referring to Fig. 5 only) are engaged only during that time in which the finger 21' is in engagement with the portion of the cam 18 lying between the radial lines 23 and 24 provided the finger 22' is at such time in engagement with that portion of the cam 19 lying between the radial lines 23 and 24. Upon movement of the finger 22' beyond the line 24, the finger 22' will drop inwardly to move the contacts 17' out of engagement and thus interrupt the circuit to one of the operating solenoids, as solenoid 11. Such circuit will not again be reestablished until subsequent rotation of the means 13 to again hold the position shown in Fig. 5, permitting the finger 21' to move inwardly to close the contacts 17'.

During that time in which the fingers 21' and 22' are in engagement with any portion of the cams between the radial lines 23 and 24, the operating solenoid 11 will be energized and the field 7 will be energized and current will flow through the cables 2 and 3. As the fingers 21' and 22' move out of engagement with those portions of the cams lying between the lines 23 and 24, the solenoid 11 will be energized and its associated switch 9 will drop open to deenergize the field 7 and thus stop the flow of current through the cables 2 and 3. The device 13 is thus operative to cause current to flow through the cables 2 and 3 in an intermittent manner.

By angularly shifting the cams 18 and 19 relative to each other to increase the angle between the lines 23 and 24, the portion of the cycle during which current is caused to flow is increased and the portion of the cycle during which no current flows is correspondingly decreased. The construction of the cams 18 and 19 is such that adjustments may be made to cause closure of the contacts 17' and consequent flow of current in the cables 2 and 3 during from about 5% to about 90% of the time of any given cycle. In this manner, the device 13 is adjustable to vary the length of time during which current is flowing through the cables and to vary the length of time during which current is not flowing through the cables. Indicia may be marked on the surface 25 of the cam 19 for cooperation with the edge 26 of the cam 18 to indicate the portion of the cycle during which current will be caused to flow through the cables 2 and 3.

In the arrangement shown in Fig. 4, rotation of the device 13 is effective to close first the switch 12' to energize the solenoid 11 and thereby close the switch 9 to energize the field 7. Continued rotation of the device 13 opens the switch 12' and interrupts the flow of current through the field 7 and thus stops the flow of current through the cables 2 and 3. Further rotation of the device 13 closes switch 12 to energize solenoid 10 and

thereby close the switch 8 to reverse the excitation of the field 7 and thus reverse the flow of current in the cables 2 and 3. Continued rotation of the device 13 is thus operative to alternately reverse the direction of current flow through the cables 2 and 3 and to provide time intervals between the current reversals during which no current flows through the cables 2 and 3.

Since two or more ships are frequently operated side by side in sweeping operations and the switches 8 and 9 operate to reverse the flow of current in the field 7, lights 27 and 28 are provided to indicate which of the switches 8 and 9 have been operated. The lights 27 and 28 are operated from an alternating-current source and their circuits are controlled by contacts 29 and 30, respectively, carried by the switches 8 and 9. Upon operation of one of the switches 8 or 9, the corresponding light 27 or 28 will be operated to indicate not only which switch has been operated, but also the time during which the field 7 is energized. By this arrangement, it is possible to synchronize the operation of different units mounted on different ships in order that the polarity of the fields established by the sweeping cables will be the same and will not buck each other. It is also possible through the lights 27 and 28, to adjust the cams 18 and 19 so that the duration of current flow in the different cables on different ships will be the same.

Since the delayed action of some mines may require as many as 15 impulses before the mine will be responsive to a magnetic field, it is necessary that the speed of rotation of the timing member 13, and thereby the frequency of magnetic impulses developed by the sweeping cables, be adjustable according to the speed of the ship on which the control is mounted. It has been determined that the frequency of magnetic impulses should vary between 5 and 140 seconds per cycle in order that the control will be adjustable to compensate for the various speeds of sweeping. The driving mechanism of this invention for the device 13 answers these requirements and is best shown in Figs. 2, 3 and 6.

Referring to Figs. 2 and 3, the cams 18 and 19 comprising the rotatable device 13 are adjustably mounted on a shaft 31 which has a driving pinion 32 keyed thereto. The pinion 32 is driven by a gear 33 mounted on a shaft 34 which, in turn, is driven by a pinion 35 meshing with a driving gear 36 keyed to a driving shaft 37. The driving shaft 37 is driven by a constant torque motor of novel design indicated as a whole by the numeral 38.

The constant torque motor 38 comprises a sleeve member 39, best shown in Fig. 6, which is keyed to the shaft 37, the shaft 37 being rotatably mounted in bearing blocks 40 carried by the casing 41. A pair of lever arms 42 project outwardly from the sleeve 39 and have their opposite ends tied together by connecting members 43. A gear cage 44 comprising a pair of spaced gears 45 tied together by connecting members 46 is mounted by bearings 47 for rotation about the shaft 37. Torque is applied to the shaft 37 through the lever arms 42 by a pair of springs 48. Each of the springs 48 has one of its ends anchored to one of the gear cage connecting members 46 and its other end to one of the lever arm connecting members 43. The springs 48 are placed under tension which is effective to transmit torque to the lever arms 42. The torque applied to the lever arms 42 is a function of the tension in the springs 48 and the angular displacement of the lever arms 42 relative to the cage 44. Fig. 7 graphically illustrates the torque developed by the lever arms 42 against the angular displacement of the cage 44 relative to the lever arms 42. It will be noted that the torque-angular displacement curve is substantially flat and a maximum between the vertical lines 49 and 50. The angular displacement of the lever arms 42 represented by the distance between the lines 49 and 50 represents about a 10° travel of the arms 42. The torque motor 44 is operated in such manner that the angular displacement of the lever arms 42 relative to the cage 44 is not more than 5° and is maintained between the lines 49 and 50 so that the tension of the springs 48 and torque transmitted to the arms 42 will be substantially constant.

To maintain the tension of the springs 48 substantially constant, a suitable motor 51 is mounted in a housing 52 carried by the casing 41 and is operated to drive a shaft 53 carrying a pinion 54 meshing with the gears 45 of the gear cage 44 after angular displacement of the lever arms 42 relative to the gear cage 44. This action is had through a follow-up arrangement of contacts 55 and 56 respectively carried by one of the lever arms 42 and one of the gears 45, the contacts 55 and 56 controlling the circuit to the motor 51. The contacts 55 and 56 are electrically connected to slip rings 57 and 58 which are tied in with the control circuit for the motor 51 through brushes 59 and 60. The control circuit for the motor 51, as best shown in Fig. 4, is energized from the direct-current bus bars upon movement of the contactors 55 and 56 into engagement with each other. Upon movement of the lever arms 42 by the tension of the springs 48 the contact 55 carried by one of the lever arms 42 will move into engagement with the contact 56 carried by one of the gears 45, and the motor 51 will then be energized to rotate the pinion 54. Rotation of the pinion 54 will impart movement to the gears 55 to displace the cage 44 approximately 5° with respect to the lever arms 42. Such movement of the cage 44 will move the contact 56 out of engagement with the contact 55 and interrupt the circuit to the motor 51, thus stopping the motor until further movement of the lever arms 42 operates to move the contact 55 into engagement with the contact 56.

The various shafts carrying the gear units constituting a gear train intermediate the motor 38 and rotatable driving shaft 31 are carried by suitable bearings selected so as to introduce as little friction as possible. Since the motor 38 is a constant torque motor, braking means is provided to control the speed of rotation of the shaft 31. The braking means is indicated as a whole by the numeral 61 and comprises a vertical support 62 secured to the casing 41 and having a pair of arms 63 and 64 projecting outwardly therefrom. The upper arm 63 has a stationary support 65 depending downwardly therefrom on which a magnet carrying member 66 is slidably mounted. The member 66 is provided with a plurality of U-shaped permanent magnets 67 and an annular ring 68 of magnetic material spaced from the pole faces of the magnets 67. The space 69 intermediate the magnet 67 and the ring 68 constitutes an air gap for the magnetic circuit of the magnets 67. A pinion 70 is mounted on a shaft 71 having its ends rotatably mounted in bearings formed in the lower end of the depending member 65 and on the upper surface of the inwardly projecting bracket member 64. An aluminum disc 72 is secured to the pinion

70 for rotation therewith and is provided with a flange 73 adapted to project into the space 69 intermediate the ring 68 and magnet 67 a distance dependent upon the position of the magnet carrying member 66 with respect to the stationary depending member 65. The pinion 70 and thereby the disc 72, are driven by a gear train 74 which is operated by a driving pinion 75 meshing with a gear 33. The gear train for driving the gear 33 from the motor driving shaft 37 constitutes a part of the gear train 74 for driving the disc 72. This gear train is designed to impart a high speed of rotation to the disc 72, and more particularly, is designed to rotate the disc 72 at a ratio of 500:1 with respect to the driving shaft 37.

The magnets 67 exert a braking force upon rotation of the flange 73 which is increased proportionately to the amount of the flange 73 extending into the space or air gap 69. The speed of rotation of the disc 72 varies directly with the position of the member 66 and a curve plotting the speed of rotation of the disc 72 against the vertical displacement of the magnet carrying member 66 will be found to be a straight line. In order to adjust the vertical position of the member 66 with respect to the disc 72 an adjusting member 76 is rotatably mounted in the bracket member 63 and is provided with a threaded end 77 having threaded engagement with the plate 66. Upon rotation of the member 76 by the knurled knob 78, the magnet 66 will be moved up or down to vary the braking effect on the flange 73 and thereby the speed of rotation of the disc 71 and the driving shaft 31 for the rotatable control member 13. The knob 78 is a calibrating knob and is provided with two dials 79 and 80 marked in degrees. Indicating members 81 and 82 are carried by the casing 41 to indicate the relative positions of the dials 79 and 80. The dial 80 is driven from a knob 78 through a gear train 83 which gives a 30:1 ratio. The vernier dial 79 attached to the knob 76 is marked 12° for one revolution and the large dial 80 is marked 360° for one revolution. By suitable operation of the adjusting knob 78, the speed of rotation of the control member 13, and thereby the frequency of current pulses imparted to the sweeping cables 2 and 3, may be adjusted to compensate for the speed at which the sweeping operation is to take place.

The driving shaft 31 has an annular braking member 84 keyed thereto for engagement by a brake shoe 85 carried by a shaft 86. The shoe 85 may be moved into engagement with the brake 84 by a bracket member 87 keyed to the shaft 86. An operating member 88 is provided on the top of the casing 41 as best shown in Figs. 8 and 9, for imparting movement to the brake shoe 85. Upon movement of the member 88 to the left, as viewed in Fig. 8, the brake shoe 85 will be moved into engagement with the brake 84 to effect a momentary slowing down of the control. This feature is desirable when operating controls on different ships in synchronism and one of the controls gets slightly out of step with another control.

The necessary adjustments to place the apparatus in condition for operation are easily made. The knob 89, Fig. 2, is first loosened to permit angular adjustment of the cams 18 and 19 relative to each other in order to vary the time "on" and time "off" period of the current flowing in the sweeping cables. Thereafter the vernier dial 78 is operated to adjust the vertical position of the magnet carrying member 66 and thereby the braking effect on the gear train 74 to secure the proper speed of rotation of the control member 13. This latter adjustment controls the frequency of the current pulses flowing in the sweeping cables. In the event that two or more ships are to be operated side by side, it is possible to synchronize the controls mounted on the different ships by watching the lights 27 and 28, which preferably are colored differently, and adjusting the cams 18 and 19 and the vernier control 78 until such lights flash synchronously. In the event that it is necessary to stop one of the controls in order to adjust the angular position of the cams 18 and 19 to vary the length of the time "on" period of current flow, the brake operating member 88 enables such control to be synchronized with other controls with a minimum of effort after such an adjustment. After making the adjustment of the angular position of the cams 18 and 19, the control is then placed in operation. If, after adjustment, such control is out of phase with controls on other ships, it is merely necessary to operate the braking control 88 to effect a momentary slowing down of the control until it is placed in proper phase relationship with the other controls.

From the foregoing it will be apparent that the apparatus of this invention provides an effective means for controlling the flow of current through a mine sweeping cable. The rotatable control member 13 together with the switches 12 and 12' provides means for causing the current to flow through the sweeping cables intermittently in timed pulses of adjustable duration. As pointed out above, adjusting the angular positions of the cams 18 and 19 is effective to vary the time "on" and time "off" periods of the current pulses. By the use of the two switches 12 and 12' and their associated circuit controls, the current flow through the sweeping cable is alternately reversed. In the event that reversal of current flow in the sweeping cable is not desired, it is merely necessary to eliminate one of the switches 12 or 12' and the other switch will thereafter be operative to cause current to flow intermittently through the sweeping cable in a single direction.

It will also be apparent that the timing control comprising the constant torque motor 38, the magnetic braking means 61, and the intermediate gear train 64 provides an effective means for varying the speed of rotation of the control 13 and thereby the frequency of the current pulses supplied to the sweeping cable.

Since certain changes may be made in the above described construction and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In apparatus for sweeping mines responsive to a plurality of consecutively applied impulses, the combination with transmitting means operative to produce a mine affecting condition, of control means for periodically rendering said transmitting means operative to cause the consecutive transmission of a plurality of intermittent mine affecting impulses.

2. In apparatus for sweeping mines responsive to a plurality of consecutively applied impulses, the combination with transmitting means operative to produce a mine affecting condition, of con-

trol means actuable to render said transmitting means operative, and timing means for periodically actuating said control means to produce a succession of mine affecting impulses.

3. In apparatus for sweeping mines responsive to a plurality of consecutively applied magnetic impulses, the combination, with transmitting means operative to create a magnetic field to produce a mine affecting magnetic condition, of control means for periodically rendering said transmitting means operative to cause the consecutive transmission of a plurality of intermittent mine affecting impulses.

4. In apparatus for sweeping mines responsive to a plurality of consecutively applied magnetic impulses, the combination with transmitting means operative to create a magnetic field to produce a mine affecting magnetic condition, of control means actuable to render said transmitting means operative, and timing means for periodically actuating said control means to produce a succession of mine affecting magnetic impulses.

5. In a control system for a mine sweeping cable, a cable, disposed in the sea, of the type for carrying an electric current to produce an electric condition in the sea to detonate mines, control means operable to cause current to flow through said cable in one direction, a second control means operable to cause current to flow through said cable in a reverse direction, and means for alternately operating one and then the other of said control means in timed relation.

6. In a control system for a mine sweeping cable, a cable, disposed in the sea, of the type for carrying an electric current to produce an electric condition in the sea to detonate mines, control means operable to cause current to flow through said cable in one direction, a second control means operable to cause current to flow through said cable in a reverse direction, means for selectively operating said control means, and separate means associated with each of said control means for indicating the control means operated.

7. In a control for a mine sweeping cable, a cable, disposed in the sea, of the type for carrying an electric current to produce an electric condition in the sea to detonate mines, electric current generating means for energizing the cable, a switch for controlling the energization of said cable, and a timing device periodically operating said switch to effect intermittent energization of said cable.

8. In a control for a mine sweeping cable, a cable, disposed in the sea, of the type for carrying an electric current to produce an electric condition for affecting mines placed in the sea, electric current generating means for energizing the cable, a pair of switches for controlling the time of energization and time of deenergization of said cable, and a timing device for operating one and then the other of said switches in consecutive fashion to intermittently energize said cable for predetermined periods.

9. In a control for a mine sweeping cable, a cable, disposed in the sea, of the type for carrying an electric current to produce an electric condition for affecting mines placed in the sea, electric current generating means for energizing the cable, a switch controlling the energization of said cable, a rotatable member for operating said switch, and timing means for driving said member comprising a constant torque motor, a gear train connecting said member to said motor, and retarding means controlling the speed of rotation of said member.

10. In a control for a mine sweeping cable, a cable, disposed in the sea, of the type for carrying an electric current to produce an electric condition for affecting mines placed in the sea, electric current generating means for energizing the cable, a switch controlling the energization of said cable, a rotatable member for operating said switch, and timing means for driving said member comprising a constant torque motor, a gear train connecting said member to said motor, and retarding means controlling the speed of rotation of said member, comprising a stator providing a magnetic field, and a rotor rotatable in said magnetic field and driven by said gear train, said field exerting a braking effect on said rotor.

11. The combination as claimed in claim 10, together with means to adjust the position of said stator with respect to said rotor to thereby vary the braking effect of its field on said rotor and the speed of rotation of said member.

12. The combination as claimed in claim 9, wherein said train is provided with a driving shaft and a driving gear keyed thereto, and said torque motor comprises a driving lever arm keyed to said shaft, a support rotatable independently of said shaft, a spring connected to said lever arm and said support, and means for rotating said support to maintain a substantially constant tension in said spring.

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