

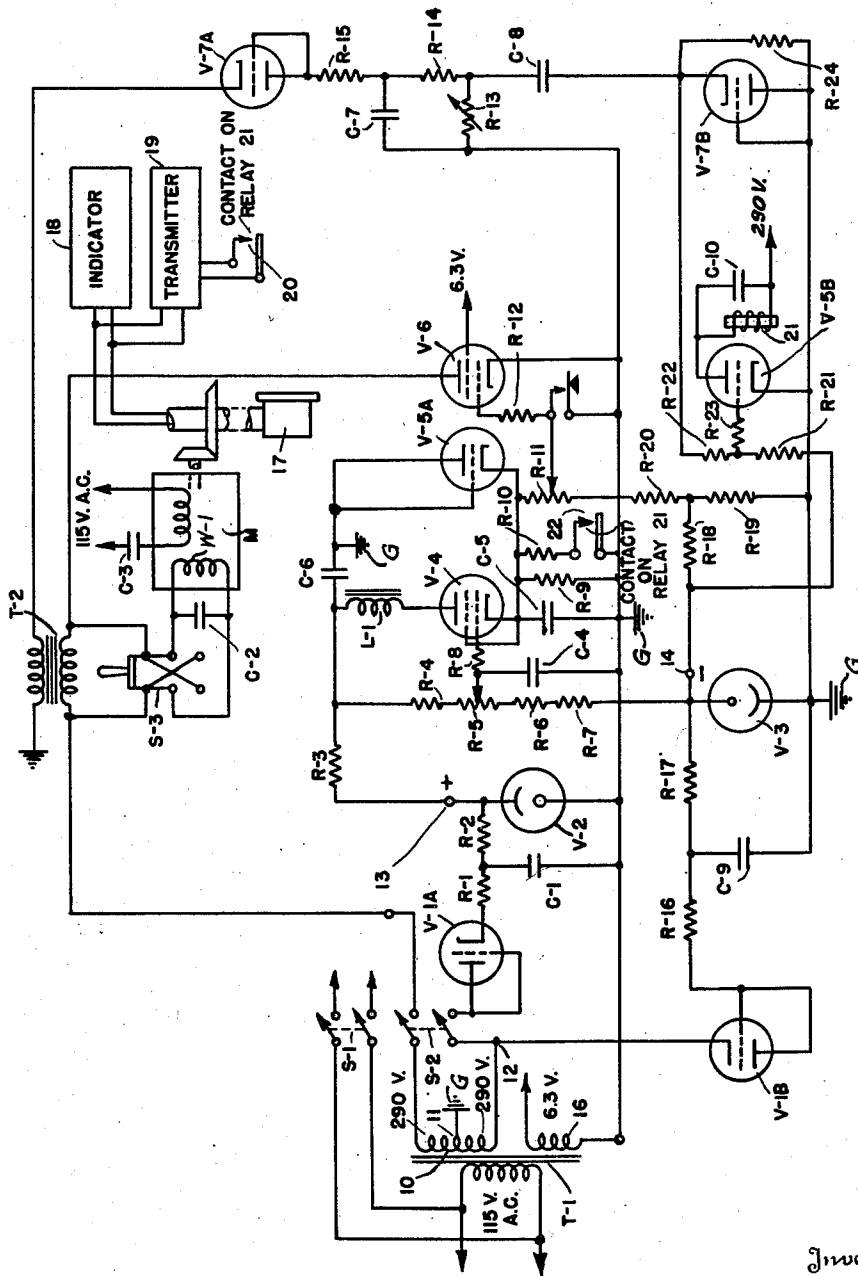
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ELECTRONIC CONTROL SYSTEM FOR ECHO-RANGING APPARATUS

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ELECTRONIC CONTROL SYSTEM FOR
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1

The present invention relates in general to wave-energy ranging and direction indication systems and more particularly to an electronic training and keying control system of special utility in an underwater sound echo ranging and direction indicating system.

The main object of the invention is the provision of an automatic search control system capable of controlling the keying and training of the directional transducer of an underwater sound echo ranging and direction indicating system in proper sequence to carry out a predetermined methodical search for underwater objects and through simple electronic means.

Another object is the provision of a system of the above type having adjustability of the keying interval or periodicity; adjustability of the unit of intermittent angular training movement of the directional transducer, and adjustability of the length or duration of signal impulse or ping.

Another object is to provide a circuit arrangement whereby a single discharge tube of the thyatron type will afford adequate control of an alternating current motor for training the sound projector or electrosonic transducer.

Another object is the provision of electronic means for assuring operation of the keying means only during non-operation of the training motor and substantially immediately after cessation of an operation of the motor.

Various other objects and advantages of the invention will become apparent upon a perusal of the following description and the accompanying drawing which is a diagrammatic representation of a preferred form of the invention.

Referring to the drawing in detail, a power transformer T-1 furnishes voltages of positive and negative sign relative to a common ground or intermediate potential, from the lower half of its center-tapped high voltage secondary 10. This is accomplished by connecting the center tap 11 to a common ground or return connection G and the lower terminal 12 in branch connection through a pair of opposed rectifiers V-1A and V-1B with associated filter circuits R-1, R-2, C-1, and R-16, R-17, C-9, and voltage regulators tubes V-2 and V-3, respectively, to the common ground or return connection G. A switch S-2 is inserted in the branch connection from the transformer to the first rectifier-filter circuit. Thus a constant voltage, positive relative to ground, may be maintained at the terminal 13 while a constant voltage, negative relative to ground, is maintained at the terminal 14. The rectifiers V-1A and V-1B here used are formed each from one half of a twin triode each grid being connected directly to its associated plate element to form the anode of a diode rectifier. In the present embodiment the power transformer T-1 receives an alternating current of 115 volts in its primary winding, developing 290 volts across the two secondary sections each side of the tap 11, to ground, while the

2

voltage regulator tubes V-2 and V-3 maintain the potential across their terminals at substantially 150 volts.

The positive voltage supplied at terminal 13 is used to time-charge a 1 microfarad condenser C-6 through a 100,000 ohm timing resistor R-3. This condenser is arranged to rapidly charge a 2 microfarad condenser C-5 through a discharge tube V-4, preferably a thyatron, and a suitable choke coil L-1, the lower side of the condenser C-5 being connected to ground as is the lower or negative side of condenser C-6. The thyatron V-4 has its shield grid connected to the cathode and is controlled by connection of its control grid through a 1 megohm resistor R-8 to the center point of a potentiometer R-5. The latter is connected at its upper terminal through a 2 megohm resistor R-4 to the junction of the timing condenser C-6 with the choke coil L-1, and at its lower terminal through a 150,000 ohm resistor R-6 and an additional 2 megohm resistor R-7 to the negative power supply point 14 of 150 volts negative with respect to the intermediate or ground potential. Thus the tube V-4 acts as a pulsing tube whose pulsing interval is determined by the setting of the potentiometer R-5. To prevent a negative charge from collecting on the upper side of the condenser C-5, the condenser is bridged by a rectifier V-5A of which latter the cathode is connected to the upperside of the condenser. In the present embodiment the rectifier V-5A is comprised of a triode used as a diode rectifier by connection of its anode and grid, and constituting one half of a twin triode of which the other half is the rectifier V-5B used in another portion of the system to be later described. Condenser C-5 is connected for control of a relay tube V-6, preferably a thyatron, through a potentiometer R-11 the upper extreme terminal of which connects directly to the upper or positive side of the condenser C-5 while the lower connects through a resistor R-20 to the center connection of a voltage divider comprised of the resistors R-18 and R-19 connected to the negative power supply terminal 14 and ground, respectively. The adjustable center tap from the potentiometer R-11 connects through a 2 megohm resistor R-12 to the control grid of the thyatron V-6. The plate of the thyatron is connected through the primary winding of a preferably one-to-one transformer T-2 to the 290 volt source of alternating current provided by the second or upper half of the power transformer secondary winding, the cathode of the thyatron V-6 being grounded to complete the circuit through ground to the center tap 11. To maintain the upper or shielding grid of this tube at a suitable negative potential relative to ground when the plate is positive, the grid is connected to the ungrounded terminal of the 6.3 volt heater winding 16 of the power transformer which latter is so phased as to be 180 degrees out of

3

phase with the plate voltage. A reversing switch S—3 provides reversible connection of a one microfarad condenser C—2 and one winding W—1 of the training motor M in multiple across the terminals of the primary winding of transformer T—2. The other winding of the training motor is connected through a one microfarad condenser C—3 to the 115 volt alternating current source indicated on the diagram by the legend "115 v. A. C." The motor M may be the training motor of any echo range and direction indicating system such as indicated by the trainable directional electrosonic-transducer 17, indicator 18, transmitter 19 and keying-relay contact 20.

To insure operation of the keying relay 21 only during non-operation of the training motor and substantially immediately after cessation of an operation of the motor, the secondary winding of the transformer T—2 by induction, takes alternating electrical energy from the motor energizing-circuit which is rectified and filtered through rectifier V—7A and a filter circuit comprised of condenser C—7 and resistors R—14 and R—15, to apply a substantially continuous charging potential to a one microfarad condenser C—8 through a rectifier V—7B arranged to conduct in the direction of the charging current. Thus so long as the motor is running the condenser C—8 is kept under a substantially continuous charging potential. Upon cessation of energization of the transformer, the condenser C—8 may discharge through resistors R—24 and R—13 producing a difference in potential across the terminals of resistor R—24 acting through resistors R—22 and R—23 to render less negative the normally blocking negative potential on the grid of a keying-control triode V—5B which controls the keying relay 21. One terminal of the relay connects through the triode V—5B to the common ground while the other terminal connects with one of the ungrounded terminals of the divided secondary of the power transformer at a potential of 290 volts relative to ground. A condenser C—10 smooths the self-rectified plate current of the triode V—5B.

Normally-blocking negative potential is applied to the grid of triode V—5B from the source of negative potential at 14 through resistors R—21 and R—23. The rate of discharge of condenser C—8 through R—24 and R—13 and consequently the duration of resultant reduction in negative bias on the control grid sufficient to maintain the triode conducting, is determined by adjustment of the variable resistor R—13. A normally open contact 20 on the keying relay 21 operates to connect the transmitter 19 with the directional transducer while another normally open contact 22 on the same relay operates to close a discharge or scavenging circuit for the condenser C—5 through a low-value spark-suppressing resistor R—10.

In the specific embodiment of the invention here described for the sake of disclosure, the several pairs of triodes, or triodes connected as diodes for use as rectifiers, specifically the pairs of triodes V—1A and V—1B, V—5A and V—5B, and V—7A and V—7B, are each the two halves of a single-envelope twin triode. However it will be understood that single triodes or other equivalents of these components may be substituted therefor without change in function or departure from the inventive concept.

Operation.—With the switches S—1 and S—2 closed, the storage condenser C—6 is continuously charged through 100,000 ohm resistor R—3

4

until the negative bias on the control grid of the thyratron tube V—4 is reduced to a value permitting the tube to fire, the charging time-interval being determined by adjustment of the voltage divider R—5. Firing of the tube V—4 charges condenser C—5 from condenser C—6, the electrical inertia of the choke coil L—1 insuring the quenching of the tube. At this instant the positive voltage applied to the voltage divider R—5 is reduced permitting the negative grid bias to become more negative thereby preventing the tube V—4 from refring. The positive charge on condenser C—5 now acting through voltage divider R—11 opposes the negative bias on the control grid of the second thyratron V—8 to an extent to permit this tube to become conductive and complete a circuit for pulsating current from the upper 290-volt ungrounded terminal of the power transformer through the primary of transformer T—2 or motor winding and tube V—6 to ground. This causes the training motor M to operate in the direction determined by the reversing switch S—3 which operation continues until the charge on condenser C—5 reduces to a point permitting the bias on tube V—6 to become sufficiently negative to block the tube. This time interval and consequently the degree of angular movement of the transducer 17 is determined by the adjustment of the potentiometer R—11.

During this operation of the motor M, the energization of the transformer T—2 by the pulsating current through its primary winding causes an alternating electrical potential to be generated at the terminals of the secondary winding by induction. This energy is rectified and filtered by the rectifier V—7A and filter network C—7, R—14 and R—15, to maintain a substantially continuous charging potential on condenser C—8 through rectifier V—7B the latter being arranged to provide a relatively high conductive path of current flow from ground to the positive side of condenser C—8 for rapid charging of the condenser at the polarity indicated. Immediately that the motor energizing circuit through transformer T—2 is opened at the thyratron V—6 the storage condenser C—8 starts to discharge through resistors R—24 and R—13, the voltage drop across R—24 opposing the negative bias on the control grid of the triode V—5B to make the bias less negative and permit the triode to close the energizing circuit of the keying-relay 21. This closes the keying contact 20 to operatively connect the transmitter 19 to the transducer 17 to cause the latter to project a signal pulse or ping of a length or duration determined by the adjustment of the variable resistor R—13 in the discharge circuit of condenser C—8. Substantially simultaneously with the closure of keying-relay contact 20, the contact 22 on the same relay closes to effect a relatively rapid scavenging discharge of the condenser C—5, again opening upon de-energization of the relay and readying the condenser C—5 for another measured charge.

After a predetermined interval of time the cycle of operations above narrated is repeated. This interval or periodicity of the cycle is determined by the adjustment of potentiometer R—5, the time-constant of the condenser C—6 and resistor R—3 for the voltage used, and the normal bias on the tube V—4, and is preferably considerably greater than the round-trip time of the signal between the transducer and the reflecting object plus the training interval plus

the duration of the signal pulse so that the reflection or echo of the signal pulse may be received at the indicator through the transducer without interference from a succeeding or outgoing pulse.

Manual control of slewing the transducer in either direction is accomplished by closure of the slewing push-button switch which grounds the grid side of the biasing potentiometer R—11 of the motor control tube V—6, the direction of rotation being determined by the position of the reversing switch S—3.

From the foregoing description it will be seen that it is possible to make adjustments in any one or more of the values of keying rate, degrees of training per cycle and length of ping, without affecting any of the others. It will also be noted that even where manual control of slewing is resorted to, pinging is automatically withheld, by action of the secondary winding of transformer T—2, during operation of the motor.

In one practical embodiment of the invention certain of the components indicated in the drawing are of the values and qualities noted below.

Condensers

C—1, 4 microfarads
C—2, 1 microfarad
C—3, 1 microfarad
C—4, 4 microfarads
C—5, 5 microfarads
C—6, 1 microfarad
C—7, 0.5 microfarad 400 volts
C—8, 1 microfarad
C—9, 4 microfarads
C—10, 2 microfarads

Resistances

R—1, 10,000 ohms 10 watts
R—2, 10,000 ohms 10 watts
R—3, 100,000 ohms 10 watts
R—4, 2.0 megohms
R—5, 100,000 ohms
R—6, 150,000 ohms
R—7, 2.0 megohms
R—8, 1.0 megohm
R—17, 10,000 ohms 10 watts
R—18, 2.0 megohms
R—19, 0.5 megohm
R—20, 1.0 megohm
R—9, 0.5 megohm
R—10, 100 ohms
R—11, 0.5 megohm
R—12, 2.0 megohms
R—13, 250,000 ohms
R—14, 25,000 ohms
R—15, 2,500 ohms
R—16, 10,000 ohms 10 watts
R—21, 1.0 megohm
R—22, 200,000 ohms
R—23, 1.0 megohm
R—24, 40,000 ohms

Tubes

V—1A, $\frac{1}{2}$ 6SN7
V—1B, $\frac{1}{2}$ 6SN7
V—2, VR150
V—3, VR150
V—4, 2050
V—5A, $\frac{1}{2}$ 6SN7
V—5B, $\frac{1}{2}$ 6SN7
V—6, 2050
V—7A, $\frac{1}{2}$ 6SN7
V—7B, $\frac{1}{2}$ 6SN7

Transformers

T—1, T13R11
T—2, "Ferranti" 10H
Coil L—1, T81C15

Keying relay 21 is a 6500 ohm 2-contact relay type AQC3C.

While but one specific embodiment of the invention is herein shown and described for the sake of disclosure, it is to be understood that the invention is not limited to such specific embodiment but contemplates all such modifications and variants thereof as fall fairly within the scope of the appended claims.

I claim:

1. In an underwater sound echo ranging apparatus having a directional transducer and a transmitter adapted to actuate the transducer to emit a pulse of sound wave energy, means to train the transducer step-by-step in a given direction of rotation periodically through successive predetermined arcs, means to vary the predetermined arc movement of said transducer training means, means to vary the periodicity of the operation of said transducer training means, keying means to energize the transducer from the transmitter to emit a pulse of sound wave energy substantially immediately following each training movement, said means being variable to control the duration of an emitted sound pulse.

2. In an underwater sound echo ranging apparatus having a directional transducer and a transmitter adapted to actuate the transducer to emit a pulse of sound wave energy, means to train the transducer step-by-step in a given direction of rotation periodically through successive predetermined arcs, means to vary the predetermined arc movement of said transducer training means, means to vary the periodicity of the operation of said transducer training means, means operable at the cessation of each training movement to energize the transducer from the transmitter, and means to vary the duration of an emitted sound pulse.

3. Apparatus in accordance with claim 1, in which said periodicity varying means includes a normally non-conducting thermionic tube and a control therefor which allows said tube to conduct at intervals by altering the grid potential of said tube, charge storing means filled upon firing of said tube, a second normally non-conducting tube having a control electrode connected to said charge storing means, whereby said second tube conducts whenever the potential of said charge storing means exceeds a predetermined value, and a training motor operated by power transmitted through said second tube when conducting.

4. In an underwater sound echo ranging apparatus having a directional transducer and a transmitter adapted to actuate the transducer to emit a pulse of sound wave energy, means to train the transducer step-by-step in a given direction of rotation periodically through successive predetermined arcs, said means including a normally non-conducting tube which is made conducting during the training period, and a training motor to which current is supplied by said tube when conducting, means to vary the periodicity of the operation of said training means, keying means to energize the transducer from the transmitter to emit pulses of sound wave energy following each training movement, said last means being variable to control the duration of an emitted pulse.

5. Apparatus in accordance with claim 1 in which said keying means includes a normally non-conducting thermionic tube having a control electrode, charge storing means connected to said electrode, means to charge said last means during each training movement, whereby, upon cessation of each said training movement, the charge storing means raises the potential of

7

said control electrode and causes said tube to conduct, and a connection in the anode circuit of said tube to key the transmitter.

6. Apparatus in accordance with claim 1 in which said means to vary the periodicity of the operation of said transducer training means comprises a normally non-conducting tube, a positive power supply connected to the anode of said tube, a negative power supply, variable voltage dividing means between said power supplies and adjustably connected to a control electrode of said tube, a capacitor in said anode circuit which, when sufficiently charged causes said tube to conduct, the degree of charge required, and hence the period of operation, being dependent on the potential and the time constant of the voltage divider and capacitor.

7. In an underwater echo ranging and direction indicating system, a trainable electrosonic transducer, means for automatically training the transducer step-by-step in a given direction of rotation through predetermined successive arcs of movement and energizing the transducer for a predetermined interval of time at the end of each training movement, means for varying the period of the cycle, means for varying the interval of time of energization of the transducer, and means for varying the extent of said successive training movement.

8. In an underwater ranging and direction indicating system a trainable electrosonic transducer, a transmitter adapted to actuate the transducer to emit pulses of sound wave energy, a keying relay to effect actuation of the transducer from the transmitter, a training motor for the transducer, an energizing circuit for the training motor energized intermittently to train the transducer step-by-step in a given direction, electrical storage means operable during discharge to maintain energization of said keying relay, means taking energy inductively from the training motor circuit only during energization of the motor to apply a charging potential to said storage means and differential conducting means offering a low impedance to charging-current to said storage means and a relatively high impedance to discharge-current from said storage means, whereby said relay is actuated to key the transmitter after each step of movement of the transducer.

9. In an underwater echo ranging and direction indicating system, a trainable electrosonic transducer, a transmitter to actuate the transducer to emit pulses of wave energy, a keying relay to effect actuation of the transducer from the transmitter, a training motor for the transducer, an energizing circuit for the training motor energized intermittently to train the transducer step-by-step in a given direction, electrical storage means operable during discharge to initiate and maintain energization of said keying relay for a predetermined and means taking energy inductively from the training motor circuit during energization of the motor to apply a charging potential to said storage means, whereby energization of the relay is prohibited during energization of the motor.

10. In an underwater echo ranging and direction indicating system, a trainable electrosonic transducer, a transmitter for actuating the transducer to emit signal pulses, a keying relay controlling operative connection of the transmitter with the transducer, a training motor for the transducer, an energizing circuit for the motor, electrical storage means, a normally non-con-

8

ducting tube operable when conducting to maintain energization of the motor and having a control electrode connected to said storage means whereby the tube conducts whenever the potential of said storage means exceeds a predetermined value, a second electrical storage means operable during discharge to maintain energization of the keying relay, means taking energy from the training motor circuit only during energization of the training motor to apply a charging potential to said second storage means, and means operable during energization of the keying relay to maintain said first storage means in discharged condition, and means for intermittently charging said first storage means whereby the transducer is trained step-by-step in a given direction and the transmitter is keyed only at the end of each training step.

11. In an underwater ranging and direction indicating system, a trainable electrosonic transducer, a normally non-conducting tube and a control therefor allowing said tube to conduct at intervals by altering the grid potential of the tube, charge storing means filled upon firing of said tube, a second normally non-conducting tube having a control electrode connected to said storage means whereby said second tube conducts whenever the potential of said charge storage means exceeds a predetermined value, a training motor for the transducer operated by power transmitted through said second tube when conducting, and a current rectifier device connected across the terminals of said storage means to prevent reversal of polarity of the storage means, whereby the training motor is operated to train the transducer step-by-step at predetermined intervals.

12. In an underwater ranging and direction indicating system, a trainable electrosonic transducer, a transmitter adapted to actuate the transducer to emit pulses of wave energy, a transformer having primary and secondary windings, an electronic control tube of the thyatron type connected in series with the primary winding and a source of alternating current to complete the series circuit when the tube is conducting, an alternating-current training motor for the transducer connected across the terminals of the primary winding, a condenser connected in multiple with the primary winding and the motor, a keying-control circuit controlling operative connection of the transmitter with the transducer, charge storing means for energizing said control circuit when discharging, and means deriving electrical energy from said secondary winding to charge said storing means and prevent discharge during energization of the transformer, whereby the transmitter is connected with the transducer only during discharge of the storage means after a training movement has stopped.

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