

**April 24, 1951**

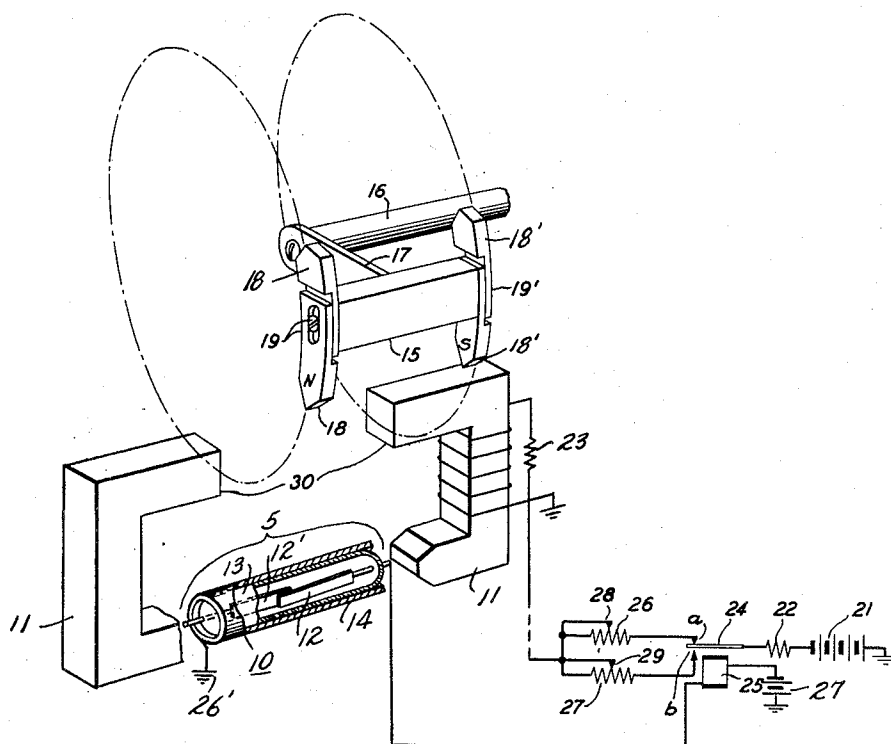
**A. K. SCHENCK**  
CIRCUIT CLOSING DEVICE

**2,550,605**

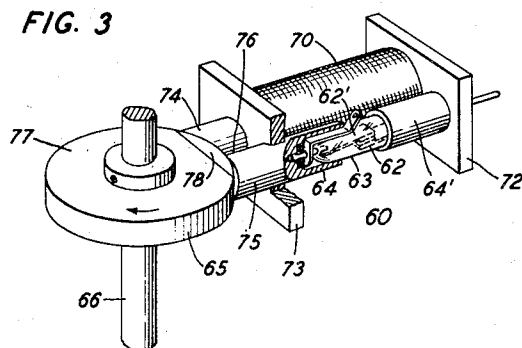
Filed July 25, 1945

2 Sheets-Sheet 1

**FIG. 1**



**FIG. 3**



INVENTOR  
A. K. SCHENCK  
BY  
N. D. Ewing  
ATTORNEY

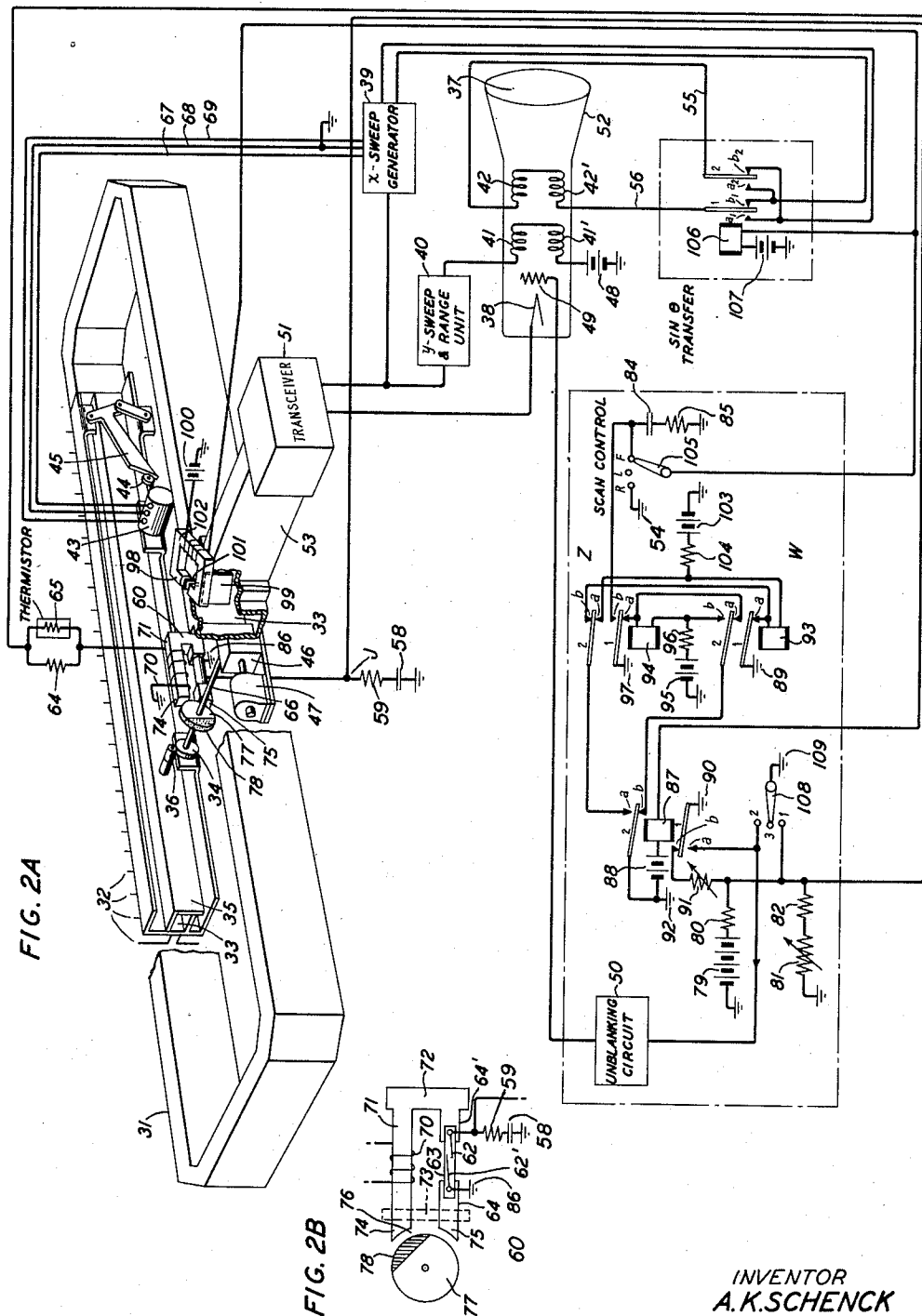
April 24, 1951

A. K. SCHENCK  
CIRCUIT CLOSING DEVICE

2,550,605

Filed July 25, 1945

2 Sheets-Sheet 2



INVENTOR  
A. K. SCHENCK  
BY  
N. A. Curing  
ATTORNEY

## UNITED STATES PATENT OFFICE

2,550,605

## CIRCUIT CLOSING DEVICE

Alfred K. Schenck, East Orange, N. J., assignor  
to Bell Telephone Laboratories, Incorporated,  
New York, N. Y., a corporation of New York

Application July 25, 1945, Serial No. 607,055

11 Claims. (Cl. 175-373)

1 This invention relates in general to electro-magnetic circuit-closing devices and in particular to a modification of the relay disclosed by Walter B. Ellwood in United States Patent 2,289,830.

An object of the invention is to facilitate adjustment of the period of closure of a magnetically responsive switch. Another object is to secure accurate time relation between the actuation of a magnetic switch and the movement of a control element.

Still another object is to secure synchronism between the periodic or regular motion of a mechanical member and the operation of switch contacts.

Another and more particular object of this invention is to provide a more efficient means for synchronizing the operation of auxiliary circuits with the sweep of the antenna beam in certain types of radio systems.

In embodiments of the invention hereinafter to be described in detail a pair of hermetically sealed resilient magnetic contact members are interposed in a gap in a magnetic circuit comprising magnetic material, and control means operate to vary the magnetic flux in the magnetic circuit and thereby to effect operation of the contact members. The control means may take the form of a magnetic member, that is, either an element of paramagnetic material or a permanently magnetized member arranged to be interposed in and withdrawn from a gap in the magnetic circuit, whereby to vary the operating flux associated with the magnetomotive force that is provided by either permanent magnetization of some part of the magnetic circuit or by an electric-current carrying coil enclosing some part thereof. More particularly, as will appear, the magnetic control member is arranged to be rotated in or through the gap in the magnetic circuit to provide operation of the switch in synchronism with the movement of a connected rotary element. In accordance with an important feature variable magnetic bias is provided by a current-carrying coil whereby the time of closure and the time of release of the contacts are accurately adjustable in relation to the movement of the magnetic control element.

A particular advantage of the present invention is that it is adapted for use in installations which are inaccessible for ordinary adjustment or servicing by an operator by virtue of providing a remote control feature.

Devices in accordance with the present invention are therefore particularly adapted to meet

2 the stringent requirements of a control system for auxiliary antenna operations such as disclosed in the copending application of C. N. Nebel, Serial No. 607,054, now Patent No. 2,518,561, filed of even date herewith. The disclosure of the said Nebel application is to be deemed incorporated herein.

In accordance with one specific embodiment of the present invention, the relay comprises a soft iron core having two gaps. In one of the gaps is disposed a glass-enclosed relay having a pair of resilient magnetic contacts. A permanent magnet mechanically connected to a periodically moving member is adapted to move in and out of the second gap periodically, causing the core to become magnetized periodically whereby the magnetic contacts are actuated to open and close at regular intervals. A bias winding disposed on the soft iron core functions to independently control the points of closure and release of the contacts in accordance with adjustments in resistance elements in a control circuit connected thereto because relay operation in the control circuit is adapted to change the current in the bias winding upon closure and release of the resilient contacts.

In accordance with a second embodiment of the invention the relay comprises a core having a pair of soft iron legs, one of which has an energizing electrical winding thereon, and the other of which contains in a gap thereof a longitudinally disposed glass-enclosed relay having resilient magnetic contacts. The two legs are held in parallel relation by a pair of spacers, one comprising magnetic material which is disposed to complete the magnetic circuit at one end of the relay, and the other comprising non-magnetic material, and disposed near the opposite end. Adjacent the latter end rotates a disk comprising a non-magnetic material upon which is mounted a soft iron shoe thereby varying the reluctance of the magnetic circuit and causing closure of the resilient contacts. The points of closure and release are related to the currents in the energizing winding at different times in the disk rotational cycle. These currents are adjustable by an auxiliary control circuit comprising a pair of variable resistances in parallel. As in the previous embodiment, a conventional electromagnetic relay is included in the auxiliary control circuit which is responsive to the closure and release of the resilient contacts to change the current in the bias winding.

The invention will be better understood by a study of the detailed description hereinafter, and the drawings, which show several embodiments

of relays in accordance with the present invention and their relation to the auxiliary control system disclosed in the application of C. N. Nebel cited hereinbefore.

Fig. 1 shows an embodiment of the present invention in which a relay of the type disclosed by Ellwood supra is positioned in one gap in a soft iron yoke, while a permanent magnet attached to the antenna shaft periodically moves in and out of a second gap;

Fig. 2A shows a control circuit such as disclosed in the copending application of C. N. Nebel, which includes a magnetically actuated circuit breaker designed according to the present invention;

Fig. 2B shows an enlarged and detailed schematic view of the switch 60 included in the system of Fig. 2A of the drawings,

Fig. 3 shows an enlarged and detailed view of the relay incorporated in Fig. 2A, which comprises a soft iron shoe attached to an aluminum disk which rotated in and out of the field of an electromagnet to periodically actuate an Ellwood relay.

The structure and operation of one embodiment of the invention will now be described with reference to Fig. 1. The relay there shown comprises a horseshoe-shaped yoke 11 formed of two symmetrical L-shaped members of soft-iron, wherein the outwardly-directed legs of the said members are separated by a relatively large gap 30 and the inwardly-directed legs of the said members are separated by a relatively smaller gap 5. The relay 10 of the type disclosed by Ellwood supra, which is positioned lengthwise in the gap 5 of the yoke 11, comprises resilient contact strips 12 and 12' comprising pure iron or other magnetizable material which are hermetically sealed in the glass tube 13 encased in a protective non-magnetic sleeve 14. The contacts 12, 12' are so disposed that the longitudinal dimensions thereof are substantially aligned with the direction of flux passing through the magnetic circuit comprising the yoke 11. The contact 12' is connected to ground 26', and the contact 12 is connected to a circuit which includes the electromagnetic relay 25 and the energizing battery 27.

The permanently magnetized bar magnet 15 is attached to the antenna drive shaft 16 by means of the arm 17 which is mounted rigidly on the shaft and rotated therewith. To the permanent magnet 15, the adjustable pole-pieces 18 and 18' are attached by means of the flister-head iron machine screws 19 and 19'.

Rotation of the permanent magnet 15 in and out of the gap 30 causes a periodic change in the magnetic flux passing through the yoke 11, thereby causing the periodic closure of the magnetic contacts 12 and 12'. The interval of closure of the contacts 12 and 12' is controlled by the current in the control winding 20, which is wound about the yoke 11 in such a manner as to produce the magnetic polarity indicated, that is, to oppose the induced flux produced by magnet 15.

Current is fed into the control winding 20 from the battery 21, and is regulated by means of a control circuit which functions as follows. When the relay 25 is unoperated, that is, when the contacts 12 and 12' are open, current from the battery 21 flows through the resistance 22, the armature 24 and its a contact, the rheostat 26, the brush 28, the resistance 23 and through the winding control 20 to ground. When the relay 25 is operated, that is, when the contacts 12 and 12' are closed, current from the battery 21 flows

through the resistance 22, the armature 24 and its b contact, the rheostat 27 and its brush 29, the resistance 23 and the winding 20 to ground.

In order to adjust the exact positions of opening and closing of the contacts 12 and 12' with respect to the position of the antenna beam, the following initial adjustments are made in the control rheostats 26 and 27. With the relay 25 deenergized as the magnet 15 swings into place in the gap 30, the position of closure of the contacts 12 and 12' is adjusted by means of the brush 28 on the rheostat 26. Similarly, with the relay 25 operated, as the rotating magnet 15 moves out of the gap 30, the opening position of the contacts 12 and 12' is adjusted by means of the brush 29 on the rheostat 27. Rough adjustments may be made by changing the positions of the pole-pieces 18 and 18' with their respective screws 19 and 19', thereby slightly adjusting the clearance between the ends of the yoke 11 and the magnet 15 as it passes through the air-gap 30.

Certain advantages are inherent in any relay designed according to the present invention which employs a permanent magnet—either a movable member such as the rotating member 15, or a fixed permanent magnet which might replace the yoke 11. In case of voltage failure in the control winding, the switch still operates, although remote control over the interval of contact closure is lost.

It is an important feature of the invention that the circuit for the control winding 20 is of such a nature that it may be located in a position quite remote from the main relay structure. For instance, in airplane installations, the relay structure may be positioned in the wing of the plane for convenient proximity to the antenna while the control rheostats 26 and 27 may be positioned on the instrument panel accessible for adjustment by the operator.

An embodiment of the present invention particularly designed for airplane use is incorporated in the auxiliary antenna control circuit shown in Fig. 2A, which is disclosed in the copending application of C. N. Nebel, Serial No. 607,054. A detailed view of the relay of the present invention is shown in Fig. 3.

For a detailed description of the structure and operation of the auxiliary antenna control circuit shown in Fig. 2A, reference may be made to the disclosure of the Nebel application supra, in which it will be noted that Figs. 1A and 1B exactly correspond to Figs. 2A and 2B in the present application.

The embodiment of the invention shown in Figs. 2A, 2B and 3 utilizes an electromagnet having a soft iron core, the reluctance of the magnetic circuit being varied by the rotation of a disk comprising magnetic and non-magnetic portions. The respective points of closure and release of the contacts of the Ellwood type contactor included in the magnetic circuit are regulated by variations in the currents in the energizing winding.

In Figs. 2a, 2b and 3, the relay 60, which is of the type disclosed in Patent 2,289,830 to Walter B. Ellwood, July 14, 1942, comprises a pair of iron strips 62 and 62' with amalgamated tips which are hermetically sealed in a longitudinal position in the glass envelope 63. The relay 60 is fitted into the recessed ends of the zinc-plated magnetic iron poles 64 and 64'. An electromagnet 70, which is wound on the soft iron core 71, is held by means of the spacers 72 and 73 in a position parallel to the relay 60, so that the latter lies in the path of the magnetic flux. The

spacer 72 comprises zinc-plated magnetic iron, while the spacer 73 comprises non-magnetic aluminum. The zinc-plated magnetic iron legs 74 and 75 protrude through the holes in the aluminum spacer 73 to enclose the air-gap 76.

The disk 65, which comprises an aluminum yoke 77 and soft iron shoe 78, is rigidly fixed on the antenna cam drive shaft 66 which is rotated by means of the antenna motor 47 as described in the application of Nebel cited hereinbefore. When the soft iron shoe 78 rotates into position closing the gap between the legs 74 and 75, the reluctance of the magnetic circuit is sufficiently reduced to cause the closure of the magnetically responsive contacts 62 and 62'.

The 0.5 microfarad condenser 58 and the 200-ohm resistance 59, which are connected to ground across the contacts 62-62', serve to protect these contacts during their operation from current surges due to inductive discharge.

The period of closure of the contacts 62-62' is controlled by regulation of the flux through the electromagnet 70, which is continuously energized from the 300-volt power supply 79 in series with the 15,000-ohm resistance 80. A current regulating circuit includes the 2,000-ohm variable resistance 81 in series with a 1,200-ohm resistance 82, which acts as a variable shunt to ground across the circuit of the electromagnet 70. The thermistor 65 in parallel with the resistance 64 is in series with the windings of the electromagnet 70, and functions to maintain constant current with changes in temperature.

A separate control for adjusting the precise release position of the contacts 62-62' of the switch 60 is provided by the 600-ohm variable resistance 91, which is adapted to be switched in and out of the current-controlling circuit for the energizing winding 70, under control of the relay 87, which is energized and deenergized in synchronism with the closure and release of contacts 60-62'. The relay 87, which is energized by means of the power source 88 connected to ground 92, is connected to the Ellwood contact 62 through the junction J. When the relay 87 is energized by closure of the contacts 62-62' connecting the ground contact 86 to the circuit thereof, the number 1 armature engages its b contact, thereby placing the resistance 91 in shunt to ground 90 across the resistances 81 and 82. Operation of the relay 80 is not affected by this reduction in voltage, since once the relay is in operation, only a relatively small current is necessary to keep it so.

The magnetically responsive relay of the applicant's invention may take other forms than those of the embodiments shown and may be useful in other systems than the one herein described.

What is claimed is:

1. A magnetic relay comprising in combination a core of magnetic material having a plurality of non-magnetic gaps therein, an electrical contactor comprising a resilient contact-bearing magnetic member mounted in one of said gaps and adapted to be moved between contact closure and release under the influence of magnetic flux passed through said member and said core, a control member of magnetic material, driving means mechanically coupled to said control member for driving said control member in a repetitive cycle of movement into and out of magnetic bridging relation with another of said gaps whereby the closure and release of said magnetic member is dependent on the position of said control member, a magnetizing winding on said core,

means for supplying substantially constant current of a first value to said winding when said contactor is released, and means responsive to closure of said contactor for changing said magnetizing current to a second substantially constant value, whereby the time of closure of said contactor is repeatedly controlled by the current of said first value to cause closure of said member at a first position, the same in each cycle of movement of said moving member, and whereby the time of release of said contactor is repeatedly controlled by the current of said second value to cause release of said member at a second position, the same in each cycle of movement of said moving member.

2. A magnetic relay comprising in combination a core of magnetic material having a plurality of nonmagnetic gaps therein, an electrical contactor comprising a resilient contact-bearing magnetic member mounted in one of said gaps and adapted to be moved between contact closure and release positions under the influence of magnetic flux passed through said member and said core, a control member of magnetic material, driving means mechanically coupled to said control member for driving said control member in a repetitive cycle of movement into and out of magnetic bridging relation with another of said gaps whereby the closure and release of said magnetic member is dependent on the position of said control member, a magnetizing winding on said core, means for supplying substantially constant current of a first value to said winding when said contactor is released, means responsive to closure of said contactor for changing said magnetizing current to a second substantially constant value, and means in circuit relation with said winding for adjusting the value of one of said substantially constant currents with respect to the value of the other of said substantially constant currents.

3. A magnetic relay comprising in combination a core of magnetic material having a plurality of non-magnetic gaps therein, an electrical contactor comprising a resilient contact-bearing magnetic member mounted in one of said gaps and adapted to be moved between contact closure and release positions under the influence of magnetic flux passed through said member and said core, a control member of magnetic material, driving means mechanically coupled to said control member for driving said control member in a repetitive cycle of movement into and out of magnetic bridging relation with another of said gaps whereby the closure and release of said magnetic member is dependent on the position of said control members, a magnetizing winding on said core, means for supplying substantially constant current of a first value to said winding when said contactor is released, means responsive to closure of said contactor for changing said magnetizing current to a second substantially constant value, and means in circuit relation with said winding for separately adjusting the value of each of said currents, thereby providing separate means for controlling the closure and release times of said contactor.

4. A magnetic relay comprising in combination a core of magnetic material having a plurality of non-magnetic gaps therein, an electrical contactor comprising a resilient contact-bearing magnetic member mounted in one of said gaps and adapted to be moved between contact closure and release under the influence of magnetic flux passed through said member and said

core, a control member of magnetic material, driving means mechanically coupled to said control member for driving said control member in a repetitive cycle of movement into and out of magnetic bridging relation with another of said gaps, whereby the operation of said magnetic member is dependent on the position of said control member, a magnetizing winding on said core, means for supplying substantially constant current of a first value to said winding, means responsive to closure of said contactor for changing said magnetizing current to a second substantially constant value, wherein said control member is magnetized, and wherein said current is poled to oppose the magnetization of said control member and of a strength insufficient to prevent closure of said contact device by said control member.

5. A magnetic relay comprising a core of magnetic material having a plurality of non-magnetic gaps therein, an electrical contactor comprising a resilient contact-bearing magnetic member mounted in one of said gaps and adapted to be moved between contact closure and release positions under the influence of magnetic flux passed through said member and said core, and a control member of magnetic material, driving means mechanically coupled to said control member for driving said control member in a repetitive cycle of movement into and out of magnetic bridging relation with another of said gaps whereby the closure and release of said magnetic member is dependent on the position of said control member, a magnetizing winding on said core, means for supplying substantially constant current of a first value to said winding, and means responsive to closure of said contactor for changing said magnetizing current in said winding to a second substantially constant value, said control member comprising a permanent magnet whereby said contactor is closed and then released as said control member moves into and then out of said bridging relation, said control member having a dimension which is adjustable thereby to control the times of closure and release of said contactor.

6. A switch comprising in combination a substantially U-shaped core of magnetic material having a pair of legs, an energizing winding disposed on one of the legs of said core, means comprising a substantially constant source for supplying current to said energizing winding, the other of said legs having a gap therein, an electrical contactor mounted in said gap, said contactor comprising a pair of resilient magnetic strips disposed in a direction parallel to at least a component of the magnetic flux produced in said gap by said energized winding acting on said core, said strips being mounted in overlapping spaced relation, whereby they are actuated to move into contacting position whenever the magnetic flux in said gap assumes a predetermined strength, a shoe of magnetic material rotatably mounted for movement into and out of magnetic bridging relation with said legs at the open end of said core, whereby to vary the magnetic flux in said gap actuating said strips to close and release contact under control of the movement of said shoe, a control circuit connected to said energizing winding, said control circuit including a pair of branches having separately adjustable attenuation, and means comprising an auxiliary relay having an energizing circuit including said resilient strips, whereby closure of said resilient strips energizes said auxiliary relay, and contact means under con-

trol of said auxiliary relay and connected to one of said branches to change the attenuation of said control circuit by controlling the connection of said branch as part of said control circuit.

7. In combination with a cyclically moving mechanical member and an auxiliary circuit to be operated in timed relation with the cyclical movement of said mechanical member, a control device, said control device comprising in combination a circuit-closing contactor comprising magnetic material, said contactor connected to said auxiliary circuit, a magnet having a plurality of gaps, said contactor positioned in one of the gaps of said magnet, an armature of magnetic material coupled to said mechanical member and moving synchronously therewith to periodically change the reluctance through another of the gaps of said magnet by a sufficient amount to cause a periodic closure of said contactor at the same time in each cycle of said mechanical member, a control winding on said magnet, a substantially constant source of power connected to supply current to said winding, a pair of circuit branches each including an adjustable attenuator connected to said control winding, and means responsive to closure of said contactor for controlling the connection of at least one of said circuit branches with said control winding to change the current in said control winding from one substantially constant value to another substantially constant value, whereby the instant and duration of closure of said contactor is controllable with respect to the cyclic position of said mechanical member.

8. A magnetic relay comprising in combination a core of magnetic material having a plurality of non-magnetic gaps therein, a pair of normally separated resilient contactors of magnetic material interposed in one of said gaps in a position to be moved magnetically from open contact relation to closed contact relation under the influence of magnetic flux passed through said contactors and said core, a control member of magnetic material mounted for a cycle of movement along a fixed path into and out of magnetic bridging relation with another of said gaps, a magnetizing winding on said core, means to supply magnetizing current of a first value to said winding of such strength and constancy as to cause said contactors to move into said closed contact relation whenever a first predetermined point is reached in the cycle of movement of said control member into said bridging relation, and means controlled by said contactors and operative for the duration of said closed contact relation for establishing the strength of said magnetizing current at a different constant value such as to allow said contactors to resume said open contact relation whenever a second predetermined point is reached in the cycle of movement of said control member out of said bridging relation.

9. A magnetic relay comprising in combination a core of magnetic material having a plurality of non-magnetic gaps therein, an armature of magnetic material interposed in one of said gaps and responsive under the influence of magnetic flux passed through said armature and said core to move from a normal position to a second position, a pair of electric contacts, one of said contacts attached to said armature, said contacts positioned to make contact with each other in one only of said armature positions, a control member of magnetic material mounted for a cycle of move-

ment along a fixed path into and out of magnetic bridging relation with another of said gaps, a magnetizing winding on said core, means to supply a biasing current to said winding of sufficient strength and constancy to force said armature into said second position whenever a first predetermined point is reached in the cycle of movement of said control member into said bridging relation, and circuit means controlled by said pair of contacts and operative only so long as said armature is in said second position for establishing the strength of said biasing current at a different constant value such as to cause said armature to resume said normal position whenever a second predetermined point is reached in the cycle of movement of said control member out of said bridging relation.

10. A magnetic relay in accordance with claim 9 wherein a periodically moving member is coupled to said control member.

11. A magnetic relay in accordance with claim 9 wherein said control member is permanently magnetized in a direction to alter the magneto-

motive force in said core when in said bridging position.

ALFRED K. SCHENCK.

#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name      | Date          |
|-----------|-----------|---------------|
| 580,988   | Moore     | Apr. 20, 1897 |
| 968,208   | Town      | Aug. 23, 1910 |
| 1,004,860 | Eastwood  | Oct. 3, 1911  |
| 1,142,852 | Simon     | June 15, 1915 |
| 1,561,263 | Maxfield  | Nov. 10, 1925 |
| 2,264,124 | Schreiner | Nov. 25, 1941 |
| 2,289,830 | Ellwood   | July 14, 1942 |
| 2,397,123 | Brown     | Mar. 26, 1946 |

#### FOREIGN PATENTS

| Number  | Country       | Date          |
|---------|---------------|---------------|
| 576,685 | Germany       | May 12, 1933  |
| 534,910 | Great Britain | Mar. 21, 1941 |