

May 25, 1943.

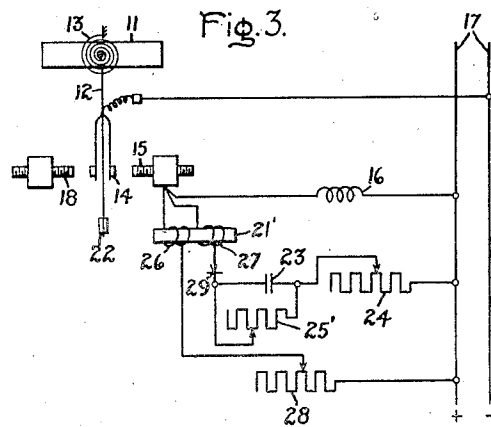
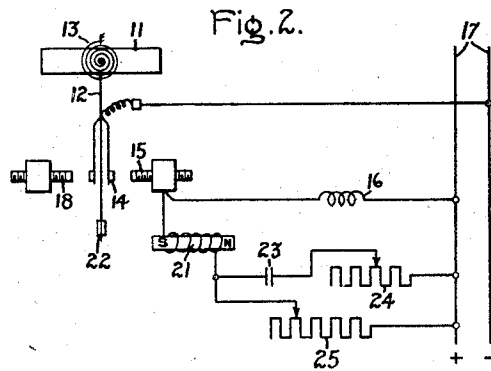
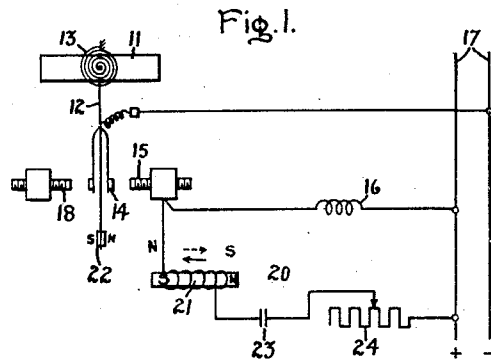
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2,320,208

CONTACT AMPLIFIER

Filed Aug. 16, 1940

2 Sheets-Sheet 1



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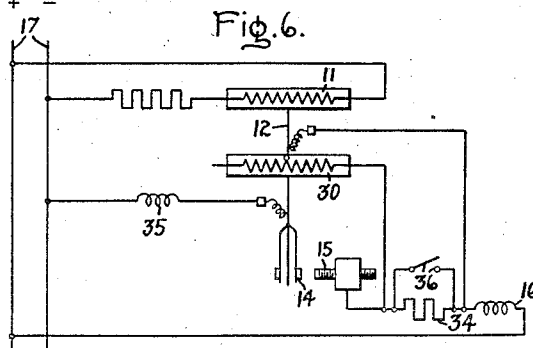
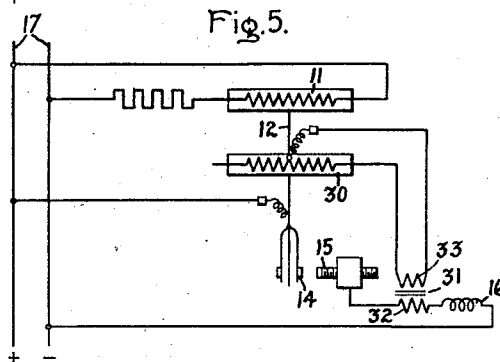
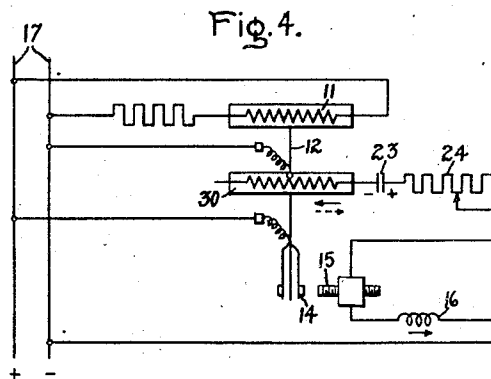
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CONTACT AMPLIFIER

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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CONTACT AMPLIFIER

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13 Claims. (Cl. 175—320)

My invention relates to arrangements for amplifying the contact pressure of contact-making instruments.

It is an object of my invention to provide means for insuring that sufficient pressure will be applied to the movable element to make adequate contact in the case of very delicate instruments, such as voltmeters and milliammeters, for example, having movable elements provided with contacts for control, regulating, signalling, or other purposes.

The use of so-called "contact amplifiers" of various types has been proposed to improve the regulating characteristics of contact-making regulators. In most cases, these means have consisted of a shift of response adjustment, short circuit, or insertion of resistance in the circuit of the current responsive element. Regulators have then been arranged for eliminating this additional torque upon operation. In such arrangements difficulties have been encountered in obtaining adequate amplification of the contact pressure, and at slow regulating speeds hunting occurs. Difficulties have also been encountered in the case of regulators subject to considerable vibration owing to the inadequacy of the contact pressure and the fact that contact may be broken by vibration before any amplification of the contact pressure has taken place.

It is accordingly an object of my invention to provide an improved contact amplifier in contact-making instruments and to overcome the disadvantages of previously existing arrangements.

In carrying out my invention in its preferred form, reliable closing of the contacts is obtained by providing means for exerting a strong additional torque on the movement of the instrument at the instant the contacts make, and the arrangement is such that the duration of the additional torque is only long enough to insure with certainty that a control impulse is given. For the purpose of providing such amplification of the contact pressure, an auxiliary torque-producing element is provided which is energized by a circuit closed simultaneously with the circuit to be controlled by the contacts of the contact-making instrument. The auxiliary circuit, however, contains such electric elements that it permits a strong, supplementary torque-producing current to flow upon making of the contacts and causes such current to taper off to a negligible value thereafter.

The invention will be understood more readily from the following detailed description when considered in connection with the accompanying drawings and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. In the drawings Fig. 1 is a circuit diagram

of one embodiment of my invention schematically representing a contact-making instrument with a contact-amplifying arrangement. Fig. 2 illustrates a modification in the arrangement of Fig.

1. Fig. 3 illustrates a modification in the arrangement of Fig. 2 with compensation for the continuing torque which is produced by the torque-amplifying arrangement of Fig. 2. Fig. 4 illustrates a modification in the arrangement of Figs. 1 to 3, in which an auxiliary instrument element is employed for producing an auxiliary torque. Fig. 5 represents a modification in the arrangement of Fig. 4 in which the time relationship between main and auxiliary torque is obtained by means of a transformer having a primary winding connected in series with the device to be controlled, instead of by a circuit of suitable time constant connected in parallel with the device to be controlled; and Fig. 6 illustrates a modification in the arrangement of Fig. 5 in which a resistor shunted by a time delay relay is utilized instead of a series transformer.

In the arrangement illustrated in Fig. 1 a deflecting, measuring, or indicating instrument is represented schematically as having a torque-producing element or movement 11, operating a movable arm or pointer 12 with a biasing spring 13 for providing the calibration in the customary manner of deflecting instruments. The movable member 12 carries a movable contact 14, cooperating with a stationary contact 15, causing a circuit to be closed through a device 16 from a current source 17 when the quantity to which the instrument 11 is responsive exceeds a predetermined value. The device 16 may either be a final device which is to be controlled or an intermediate relay. If desired, a second stationary contact 18 may also be provided for causing another circuit, not shown, to be closed when the value to which the instrument 11 is responsive falls below a predetermined value. Although omitted for the sake of simplicity in the drawing, it will be understood that apparatus similar to that associated with the contact 15 may be provided for the stationary contact 18.

For the purpose of momentarily increasing the contact pressure between the contacts 14 and 15 when the movable member 12 is deflected toward the contact 15, an auxiliary circuit 20 is provided, which includes a device 21 for exerting an auxiliary torque on the movable element 12 and has an impedance or opposition to the flow of current so varying with time that a large torque-producing current flows momentarily. In the arrangement of Fig. 1 the device 21 consists of an electromagnet having a soft iron armature 22 mechanically attached to the movable member 12 of the instrument 11. The circuit 20 includes, in series with the device 21, a condenser 23, and a rheostat 24. The elements

21, 23 and 24, constituting the series circuit 20, are connected in parallel with the device 16 which is to be controlled by the contacts 14 and 15.

The relationship between the inductance of the electromagnet 21 and the capacitance of the condenser 23 is such that the condenser effect predominates upon closure of the contacts 14 and 15. The current rush through the electromagnet 21 exerts a strong force upon the armature 22 to provide a supplementary torque for the instrument 11, causing contacts 14 and 15 to press together strongly. However, as the condenser 23 charges, the current through the circuit 20 tapers off and eventually falls to zero so that no interference is placed upon subsequent deflection in the down-scale direction of the movable member 12. The rate at which the supplemental torque falls off may be adjusted by adjustment of the rheostat 24. It will be understood that the maximum value of the supplementary torque depends upon the relative values of the electrical dimensions of the elements 16, 21, 23 and 24.

If desired, the arrangement in Fig. 1 may be modified by the addition of a rheostat 25 connected across the condenser 23 and the rheostat 24 to provide a discharge circuit for the condenser 23 when contacts 14 and 15 are opened.

In order to prevent the introduction by the shunt rheostat 25 of a torque tending to hold the contacts 14 and 15 closed after an initial impulse applied by the instrument 11, the apparatus may be modified, as shown in Fig. 3. In this modification the electromagnet 21 is replaced by an electromagnet 21', having a pair of oppositely acting windings 26 and 27. There is a resistor 28 connected in series with the winding 26 across the device 16. A shunt rheostat 25' for discharging the condenser 23 is connected directly across the condenser 23. In this case a rectifier 29 is connected in series with the winding 27 of the electromagnet 21', the circuit in shunt with the device 16 including also the condenser 23 and the rheostat 24. The rheostats 25' and 28 are so adjusted that the torque produced by the current flowing through one is compensated by the torque produced by the current flowing through the other, in order to permit the contact operation to remain highly sensitive. The rectifier 29 is so connected that current can pass through the winding 27 only in the direction of increasing contact pressure, thus preventing a discharge of the capacitor through the winding 27 of the electromagnet 21. Although I have shown a circuit employing a condenser 23, it will be understood that my invention is not limited thereto and does not exclude the use of an inductance instead, in which case, however, the discharge resistor 25' would be omitted, and the parallel circuits would be so adjusted that effects of the windings 26 and 27 approached balance after steady state current had been reached in the inductance.

If desired, the embodiment of Fig. 1 may be arranged to produce an auxiliary torque aiding the opening of the contacts 14 and 15 when the instrument 11 tends to move the contact 14 away from the contact 15. This may be done by making the armature 22 of permanent magnet material so that it is permanently polarized with the north pole toward the end of the electromagnet 21 which is normally a south pole when current starts to flow therein from the source 17, which in this case, is assumed to be a fixed-polarity

direct current source. The strength of the permanent magnet 22 must, of course, be small enough so that it alone does not draw the member 12 toward the core of the electromagnet 21 when no current is flowing in the electromagnet 21. When the contacts 14 and 15 are closed by the instrument 11 the current rush through the electromagnet 21 produces a magnetic flux of the proper polarity to attract the armature 22 strongly until the condenser 23 has charged. However, when the contacts 14 and 15 begin to open as a result of reverse torque produced by the instrument 11, the discharge current flows through the electromagnet 21 in a reverse direction and produces magnetic flux of reversed polarity and reversed torque acting on the armature 22, thus aiding in the contact-opening operation.

In the arrangement of Fig. 4 the supplementary torque is provided by an auxiliary instrument unit 30 which is connected, in place of the electromagnet 21 of Fig. 1, in a circuit paralleling the device 16, which is to be controlled by the contacts 14 and 15. The connections of the instrument 30 are such that the current rush therein when the contacts 14 and 15 are closed provides a torque tending to increase the pressure between the contacts 14 and 15. However, when the contacts 14 and 15 are drawn apart by the instrument 11 the discharge current of the condenser 23 produces current of the opposite polarity in the instrument 30, thus causing it to aid in the contact-opening operation. It will be understood that in the arrangement of Fig. 4 the source 17 must be a direct current source and the instrument element 30 must be a direct current device, such as a D'Arsonval galvanometer, producing torque in opposite directions in response to reverse in current.

In the arrangement of Fig. 5, a mutual inductance or transformer 31 is provided having a winding 32 connected in series with the controlled device 16, and having a secondary winding 33 connected across the auxiliary torque-producing instrument movement 30. In this embodiment of the invention when the contacts 14 and 15 are closed the current impulse through the winding 32 induces a current impulse in the winding 33 of such polarity to produce in the instrument 30 a torque aiding the contact-closing operation. However, when the contacts 14 and 15 are subsequently opened by the main instrument 11 the decay of current in the transformer winding 32 induces current of the opposite polarity in the winding 33, thus causing the element 30 to aid in the contact-opening operation.

In the embodiment of Fig. 6 there is a resistor 34 connected in series with the controlled device 16, and the auxiliary instrument element 30 is connected across the resistor 34. The connections are such that contact pressure is amplified by the current flowing through the instrument movement 30 when the contacts 14 and 15 are closed. A time delay relay is also provided which has an actuating winding 35 connected in series with the contacts 14 and 15, and the source 17, and has a pair of normally open contacts 36, connected across resistor 34. After a predetermined time delay the contacts 36 close, shunting out the instrument unit 30, and eliminating the auxiliary torque. In this case the source 17 may be either a D. C. source or an A. C. source, according to the nature of the devices 11, 30, 16 and 35.

I have herein shown and particularly described certain embodiments of my invention and certain methods of operation embraced therein for the purpose of explaining its principle and showing its application, but it will be obvious to those skilled in the art that many modifications and variations are possible and I aim, therefore, to cover all such modifications and variations as fall within the scope of my invention which is defined in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, a contact-making instrument having a pair of relatively movable contacts, a device to be controlled by such contacts, a source of current for energizing said device through said contacts, and a contact pressure amplifying circuit shunting said device to be controlled, the said shunt circuit comprising an auxiliary torque-producing device mechanically connected to the contact-making instrument and responsive to the current flow in the shunt circuit, and in series therewith an impedance, the value of which is relatively low upon the application of electromotive force and progressively increases.

2. A contact pressure amplifying circuit for a contact-making instrument comprising an auxiliary electrical torque-producing device responsive to current flow in the circuit and adapted to be mechanically connected to the contact-making instrument, and an impedance the value of which progressively increases after an application of electromotive force, said impedance and said auxiliary torque-producing device being adapted to be connected in series across the device to be controlled by the contacts of the contact-making instrument.

3. In combination, a contact-making instrument having a pair of contacts for controlling the current through a device to be controlled, an auxiliary torque-producing element responsive to current therein, a condenser and a resistor, said torque-producing element, condenser and resistor being adapted to be connected in series across the device to be controlled by the contacts of the contact-making instrument.

4. Apparatus of the type set forth in claim 3 in which the auxiliary torque-producing element is an electromagnet cooperating with an armature carried by movable element of the contact-making instrument.

5. Apparatus of the character set forth in claim 3 in which the auxiliary torque-producing element is an auxiliary instrument movement mechanically connected to the contact-making instrument.

6. In combination, a contact-making instrument having a movable element carrying a movable contact and having a stationary contact cooperating therewith, a device to be controlled by said contacts, a source of current for energizing said device through said contacts, an auxiliary torque-producing device having a moving element mechanically connected to the movable element of the contact-making instrument, an energizing winding for said auxiliary torque-producing device and an energizing circuit for said winding energized through said contacts from said source, said circuit including also an element for diminishing the flow of current through said energizing winding after the initial current impulse.

7. A contact pressure amplifying circuit for a contact-making instrument, adapted to be connected across a device to be controlled by the contacts of the contact-making instrument, said circuit including an electromagnet having an armature mechanically connected to the contact-making instrument, and having a pair of oppositely acting energizing windings, one of which is connected in series with a resistor to form one shunt branch of the circuit, a rectifier, and a condenser connected in series with the other of said windings of the electromagnet to form a second shunt branch of the circuit.

8. Apparatus of the character set forth in claim 7 in which a discharge rheostat is connected across the condenser.

9. Apparatus of the character set forth in claim 7 in which a rheostat is connected in the second branch of said circuit for adjustment of the time constant thereof.

10. Apparatus of the character set forth in claim 7 in which the resistances of the shunt branches are substantially balanced to eliminate continuance of amplifying torque after the initial current impulse.

11. A device for amplifying contact pressure of a contact-making instrument having a pair of contacts connected in series with a device to be controlled by said contacts, said contact pressure amplifying device comprising an auxiliary torque-producing device responsive to current flowing therein and adapted to be mechanically connected to the contact-making instrument, a transformer having a winding adapted to be connected in series with the device to be controlled and having a secondary winding connected to said auxiliary torque-producing device.

12. A device for amplifying contact pressure of a contact-making instrument having a pair of contacts connected in series with a device to be controlled by said contacts, said contact pressure amplifying device comprising an auxiliary torque-producing device responsive to current flowing through it and adapted to be mechanically connected to the contact-making instrument, a resistor adapted to be connected in series with the device to be controlled, connections shunting said auxiliary torque-producing device across said resistor, and a time delay relay having an energizing winding connected in series with said resistor, and normally open contacts connected across said resistor.

13. A device for amplifying contact pressure of a contact-making instrument having a pair of contacts connected in series with a device to be controlled by said contacts, said contact-pressure-amplifying device comprising an electrical circuit adapted to be connected to the device to be controlled by said contacts, so as to be energized with said controlled device when the contacts are closed, said electrical circuit including an auxiliary torque-producing device adapted to be mechanically connected to the contact-making instrument, and means for varying the current in said circuit in relation to time in order to produce momentarily in the auxiliary torque-producing device relatively great torque augmenting the contact-closing torque of the contact-making instrument when the said circuit is energized by the closure of said contacts.

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