Sept. 29, 1959 A. E. GIMSON 2,906,837

ELECTRICAL APPARATUS

Filed Dec. 5, 1957 2 Sheets-Sheet 1

FIG. 1

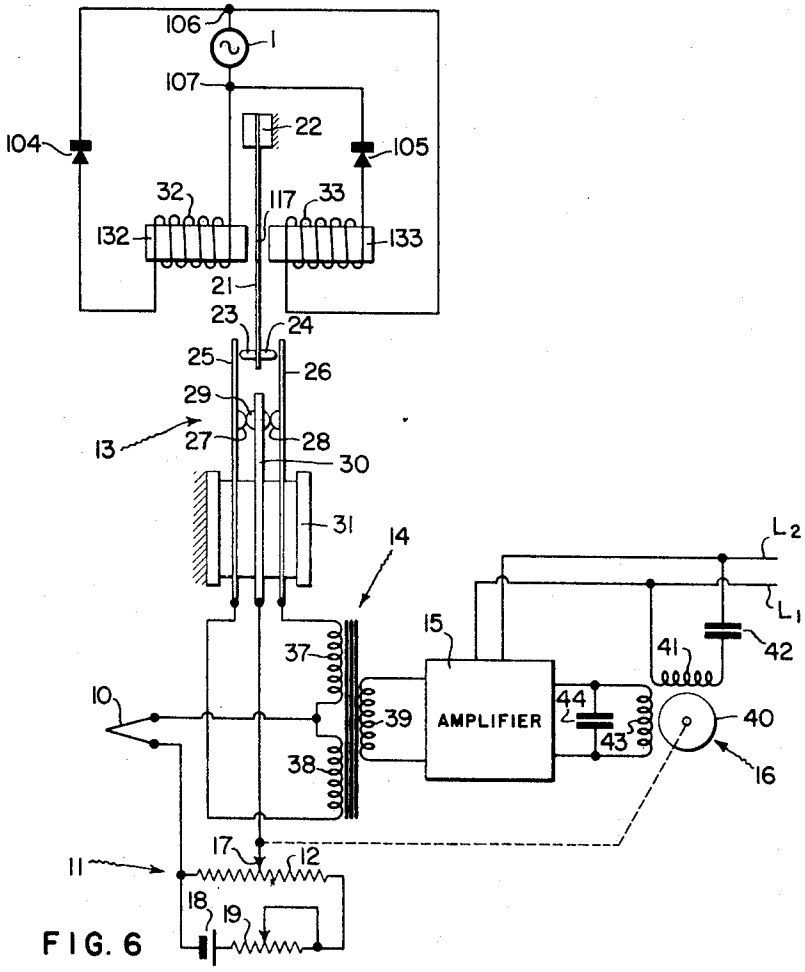

FIG. 6

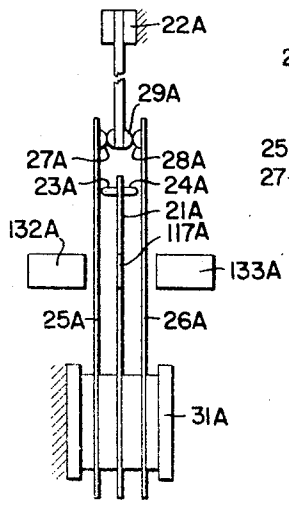

FIG. 2

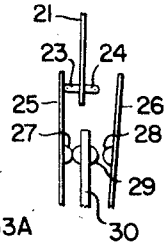

FIG. 3

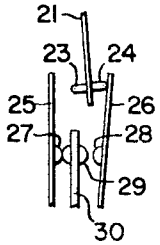

FIG. 4

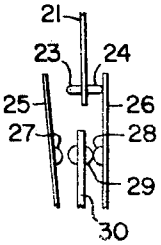

FIG. 5

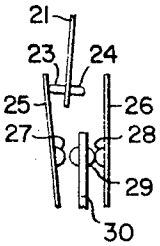

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FIG. 7

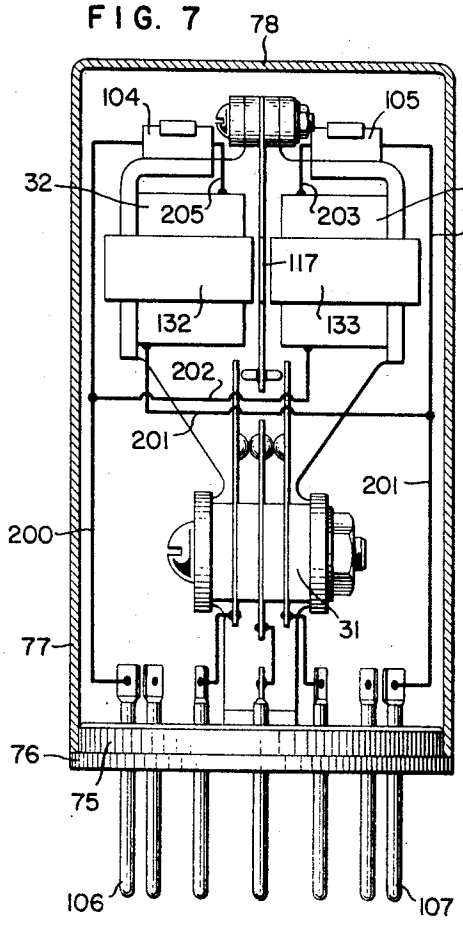
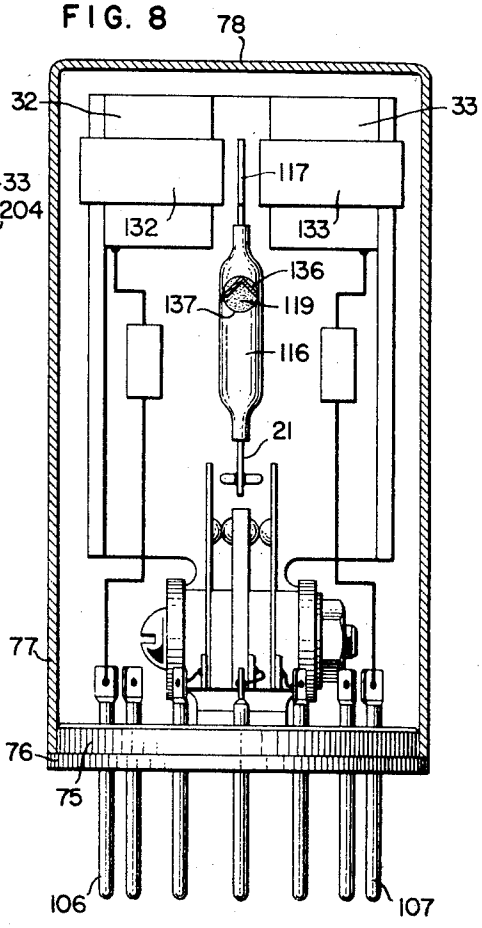


FIG. 8



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2,906,837

ELECTRICAL APPARATUS

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Application December 5, 1957, Serial No. 700,839

4 Claims. (Cl. 200—90)

The general object of the present invention is to improve electrical switching devices or choppers, such as those shown in the following U.S. patents in the name of F. W. Side: 2,423,524, patented July 8, 1947; 2,587,236, patented February 26, 1952; 2,675,441, patented April 13, 1954.

The present invention, like the inventions of the above mentioned prior patents, has special utility for use in converting a small, unidirectional, electric current into an alternating current, which may be readily amplified for measuring and other purposes, in the manner disclosed in U.S. Patent 2,423,540; patented July 8, 1947, to W. P. Wills.

The present invention, as in the above mentioned prior patents, makes use of a vibratile element or a resilient reed which closes and opens electric contacts as it moves back and forth between its two limits of motion. Such electrical switching devices having vibrating reed structures and particularly the electro-mechanical vibrator or chopper which has a vibrating reed actuating movable contacts with respect to a stationary, central contact are well known.

It is an object of this invention to make provision to prevent any spurious or secondary vibration of the contacts and thus to provide a chopper in which the contacts are free of chatter or bounce.

In general, in the prior art structures the vibrating reed drives movable contacts to cooperate with a fixed contact. The fundamental frequency of the vibrating reed is generally lower than the resonant frequency of the movable contacts. This is possible because the length of the movable contact arm is less than the length of the vibrating reed for a given mass and compliance. In the past, attempts have been made to utilize the higher resonant frequency of the movable contact arms to eliminate bounce by establishing this frequency at a third or a fifth harmonic. Normally the interval during which the contacts are open is small compared to the displacement or excursion of the weighted end of the vibrating reed.

The movable contacts have inertia which tends to cause chatter under the accelerations imparted to the contacts by the vibrating reed. Accordingly, it is an object of this invention to provide a vibrator structure wherein a minimum of energy is transferred from the vibrating reed to the movable contacts which are opening and a maximum of energy is transferred from the movable contacts which are closing to the movable contacts which are opening so that there is a chatter-free or bounce-free closure of the contacts.

A better understanding of the present invention may be had from the following detailed description when read in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic or schematic showing of the mechanical parts of this device and of the electrical connections between them.

Figs. 2, 3, 4 and 5 are diagrammatic or schematic showings of the vibrating reed, the side contacts, and the center contact in various positions which these elements assume during the cycle of operations.

Fig. 6 is a diagrammatic or schematic showing of a modification.

Fig. 7 is a side elevation of the modification of Figs. 1–5.

Fig. 8 is a side elevation of a second modification.

In Fig. 1 the chopper of this invention is diagrammatically and schematically shown as applied to a measuring, recording and/or control apparatus of the type shown in U.S. Patent 2,423,540; patented July 8, 1947, to W. P. Wills. In Fig. 1, **10** designates a thermocouple responding to a condition such as the temperature within a furnace which produces a direct current (D.C.) or steady potential which corresponds directly to the temperature existing within the furnace. This D.C. potential produced by the thermocouple **10** is opposed by a D.C. or steady potential produced by a potentiometer circuit arrangement designated generally at **11** and including a slidewire **12**.

The differential D.C. or steady current produced by these steady potentials is controlled by a vibrator, designated generally at **13**, and is applied to transformer **14** to produce a fluctuating or alternating potential across the secondary of the transformer **14** which potential is of one phase or of opposite phase depending upon the direction of unbalance of the potentiometer circuit **11**. This fluctuating or alternating potential across the secondary of transformer **14** is amplified by an amplifier, designated generally at **15**. The current output of amplifier **15** is applied to a reversible, electric motor, designated generally at **16**. Reversible, electric motor **16** operates to position a contact **17** along slidewire **12**. Electric motor **16**, in addition to operating contact **17** along slidewire **12**, may also position indicating and/or recording means for indicating and/or recording the temperature at the thermocouple **10** and, alternatively or in addition, may operate control apparatus for controlling a condition, such as the temperature affecting the thermocouple **10**. The contact **17** and the indicating recording and/or control mechanism assume positions corresponding to the temperature existing within the furnace and to which the thermocouple **10** responds.

The potentiometer circuit arrangement includes a battery **18** and a standardizing resistance **19** for applying a D.C. or steady potential across the slidewire **12** which potential is in opposition to the D.C. or steady potential produced by the thermocouple **10**. When the contact **17** is moved to the right, as shown in Fig. 1, the potential at contact **17** is increased and when the contact **17** is moved to the left this potential is decreased.

The vibrator **13**, as diagrammatically shown in Fig. 1, includes a vibrating reed **21** carried by a support **22**. Vibrating reed **21** carries a pair of actuators **23** and **24** which are adapted to engage and disengage spring arms **25** and **26** upon movement of the vibrating reed. When the vibrating reed is stationary and in the middle position actuators **23** and **24** are disengaged from spring arms **25** and **26**. As the vibrating reed **21** is operated, first one and then the other actuator **23** or **24** engages the spring arm **25** or **26**. The spring arms **25** and **26** may be resiliently mounted to provide this operation. Spring arms **25** and **26** respectively carry side contacts **27** and **28** which each has a mass preferably but not necessarily equal to that of the other. These contacts normally engage and are in close contact with a central contact **29** mounted on a central, relatively stationary, spring arm **30**. Spring arms **25**, **26** and **30** are each insulated from the others and mounted on a stationary support **31**.

Vibrator **13** includes a pair of coils **32** and **33** for operating the vibrating reed **21**. The driving circuit for the

vibrating reed 21 includes the diodes 104 and 105. These diodes may be one N nine one such as those manufactured by CBS-Hytron Corporation of Danvers, Massachusetts. The diodes 104 and 105 are connected to the terminals of the circuit which drives the vibrating reed 21 and are adapted to be connected to a suitable source 1 of alternating current (A.C.) electricity having the desired frequency for driving the vibrating reed 21. This circuit can be traced from the terminal 106 of the source 1 through the diode 104 and the coil 32 of the vibrator 13 to the terminal 107. A parallel circuit extends from terminal 106 through coil 33 and diode 105 to terminal 107.

Coil 32 is mounted on a core 132 of magnetic material. Coil 33 is mounted on a core 133 of magnetic material. Vibrating reed 21 has a portion 117 of magnetic material fastened to it and located adjacent the one end of each of the cores 132 and 133.

Transformer 14 includes a pair of primaries 37 and 38 and a secondary 39, which is connected to the amplifier 15. The upper end of primary 37 is connected to the side contact 28 through the spring arm 26 and the lower end of primary 38 is connected to side contact 27 through spring arm 25. The adjacent ends of the primaries 37 and 38 are connected to the positive element of the thermocouple 10. The negative element of the thermocouple 10 is connected to the left end of the slidewire 12. The contact 17 engaging the slidewire 12 is connected to the central contact 29 by the spring arm 30.

The reversible motor 16 is shown to be a rotating field type motor having a rotor 40 provided with conductor bars. A power winding 41 is connected in series with a condenser 42 across the line wires L1 and L2, which may be connected to the source 1 or to another source of alternating current of electricity of suitable frequency. The condenser 42 is so selected with respect to the field winding 41 as to produce a resonant circuit to cause the current flow through the power winding to be approximately in phase with the alternating potential of the line wire L1 and L2 while permitting the alternating voltage across the power winding 41 to lead the current by substantially 90 electrical degrees. The reversible electric motor 16 also includes a control winding 43 connected to the output of amplifier 15. A condenser 44 is connected in parallel to control winding 43 to provide a resonant circuit so that the alternating or fluctuating potential across the control winding 43 leads the current through the control wind 43 by substantially 90 electrical degrees. Power is supplied to the amplifier 15 from the line wires L1 and L2.

Since the details of the construction and mode of operation of the potentiometer circuit arrangement 11, the transformer 14, the amplifier 15, and the electric motor 16 are disclosed in the above-referred-to patent of W. P. Wills a further description herein is not considered necessary. Reference is made to Patent 2,423,540 for the details of construction and mode of operation of the apparatus shown therein.

Starting from the position in which the parts are shown in Fig. 1, the operation of the chopper is as follows: When the polarity of the A.C. driving signal is such that the terminal 106 is negative with respect to the terminal 107, the coil 32 of the vibrator 13 is energized, attracting the vibrating reed 21 and thereby causing the actuator 23 to engage the spring arm 25 and to cause the side contact 27 to disengage the central contact 29. This movement of actuator 23 to the left, as seen in the drawings, continues as long as coil 32 is energized. During the next half cycle of the energizing current, when the terminal 107 is negative with respect to the terminal 106, the coil 32 is de-energized and the coil 33 is energized. Coil 33 therefore attracts the vibrating reed 21 and causes the actuators 23 and 24 to reverse their direction of movement and to move to the right, as seen in the drawings. Fig. 2 shows the position in which the actuator 23 is about to disengage spring arm 25. Contact 27 has engaged contact 29 and imparted the kinetic energy possessed by contact 27 to contact 29 and, thence, to contact 28. This kinetic energy has caused contact 28 to disengage contact 29 even before spring arm 26 is engaged by operator 24. Fig. 3 shows the next position in which the contact 28 remains disengaged from the central contact 29 while the actuator 24 has engaged the spring arm 26. This movement of the actuator 23 and 24 to the right, as seen in the drawing, continues during this half cycle of the energizing current until the coil 33 is de-energized and the coil 32 is again energized. Fig. 4 shows the position of the parts when contact 28 has again re-engaged central contact 29 so that the kinetic energy of the contact 28 has been transmitted through the central contact 29 to the side contact 27 and caused the side contact 27 to disengage the central contact 29. This movement of the actuators 23 and 24 to the left, as seen in the drawings, continues during this half cycle of the energizing current and the contact 27 remains separated from the central contact 29 and then is again reengaged therewith so that the parts assume the position in which they are shown in Fig. 1.

Because the vibrating reed 21 imparts a minimum of energy to that side contact which is disengaging the central contact and a maximum of energy is transferred from that side contact which is engaging the central contact to that side contact which is disengaging the central contact, the contacts close without spurious and unwanted vibration and therefore operate without chatter or bounce.

Fig. 6 shows diagrammatically and schematically a modification of the chopper of this invention. In this modification the cores 132A and 133A are located adjacent the magnetic portion 117A of the vibrating reed 21A. The actuators 24A and 23A are located between the spring arms 25A and 26A. The side contacts 27A and 28A are located at a greater distance from the stationary support 31A than are the actuators 23A and 24A which are mounted in the support 31A. The central contact 29A is mounted on a separate stationary support 22A but is connected in the circuit in the same manner as shown in Fig. 1 as are the stationary contacts 27A and 28A.

Fig. 7 shows in greater detail the vibrator 13 of Fig. 1. The cores 132 and 133 carrying the coils 32 and 33 respectively are secured to a base 75, preferably made of insulating material. Contacts 106 and 107 are secured to base 75. Base 75 has at its rim a protruding flange 76 which engages with the open end of a cup 77 which is closed at its upper end and which encloses all the mechanism constituting the vibrator 13. From contact 106 a wire 200 extends to diode 104 and whence wire 205 extends to coil 32. From coil 32 a wire 201 extends to contact 107.

From contact 106 and wire 200 extends a branch wire 202 which connects with coil 33 and thence by wire 203 with diode 105. From the opposite side of diode 105 a wire 204 joins wire 201 to connect to contact 107.

Spring arms 25, 26 and 30 are mounted on base 75 and are insulated from each other by support 31.

Fig. 8 shows a third modification of the vibrator 13. The principal difference of this modification from those disclosed in Fig. 1 and in Fig. 6 is the torsion spring pivot on which the vibrating reed 21 is mounted. The vibrating reed 21 is held in a tubular member 116 by means of an epoxy resin 119. Accordingly, the vibrating reed 21 is insulated electrically and thermally from the tubular member 19.

The vibrating reed 21 has attached to it a magnetic portion 117 which is positioned in a narrow gap between cores 132 and 133 on which the coils 32 and 33 are mounted respectively. The pivot for vibrating reed 21 is a torsion angle pivot 136 which extends through an opening 137 in the tubular member 116. Pivot 136 is mounted on base 75 and supports vibrating reed 21 for

limited movement about the line in which the upper faces of the torsion angle pivot **136** intersect. The center of gravity of the structure supporting the vibrating reed **21** is at the intersection of the faces of the plates of the pivot **136**.

Many features of the modification of Fig. 8 cooperate to provide improved operation. The use of a low mass, rigid, balanced vibrator **13** provides rapid response to the magnetic driving forces and less response to vibration and also makes the chopper independent of its mounting position. The mass of the converter armature is low and rigidity is retained by the use of the thin-walled member **116** as the body of the vibrating reed structure. The rigidity of the armature structure helps to reduce the phase lag between the armature motion and the armature driving signal and eliminates any spurious binding along the armature which interfere with a positive motion of the vibrating reed as can occur in flat reed converters.

The diodes **104** and **105** in series with the converter driving coils **32** and **33** provide two alternating magnetic attractions of the vibrating reed **21** per signal of alternating current excitation without the use of a polarizing permanent magnet.

The novel design of the stationary contact structure provides efficient, long-lasting, electrical contact without bounce or chatter of the contacts due to the mass or inertia of the contacts as movable contact is picked up by the vibrating reed **21** just before its mate, thereby giving a suitable increase in gradient to absorb the energy of the moving contact. The use of a suitable length of spring arm to support the contacts provides a suitable mass and high natural frequency required to engage and disengage the central, relatively stationary contact without bounce or chatter.

What is claimed is:

1. A chopper, including in combination, a resilient reed fixed at one end and movable at the other end, electromagnetic means including a coil and a core located in their entirety adjacent the movable portion of the resilient reed for creating an alternating magnetic field which reacts to vibrate the resilient reed, a central contact, and a pair of side contacts each located on the side of said central contact opposite to the other and located remotely with respect to the magnetic field produced by said electromagnetic means and operated by said resilient reed for engaging and disengaging said central contact, said central contact and said side contacts each having a relatively movable portion of sufficient mass such that the kinetic energy of the side contact which is closing is absorbed by the inertia of the central contact and the kinetic energy of the central contact is transmitted by said central contact to the side contact which is opening, so that the closed contacts remain closed during a portion of each cycle of operation and the open contacts remain open during a portion of each cycle of operations without chattering or bouncing.

2. A chopper according to claim 1 in which said resilient reed is out of contact with each of said side contacts during a portion of each cycle of operations.

3. A chopper according to claim 1 in which said side contacts are normally in an engagement with said central contact.

4. In a chopper, a central contact, a pair of side contacts each located on the opposite side of said central contact from the other and normally in engagement with said central contact, electromagnetic means alternatingly operating one of said side contacts out of engagement with said central contact and into engagement therewith and then operating the other of said side contacts out of engagement with said central contact and into engagement wherewith, and a spring arm fixed at one end and carrying the central contact near the other end and biased to move the central contact toward the side contact which is closing and to permit movement of the central contact in the opposite direction when it is engaged by the side contact which is closing to overcome the inertia of the side contact and to allow it to close without chattering and biased to move the central contact toward the side contact which is opening and to permit the side contact which is opening to disengage the central contact, said central contact transmitting the energy of the side contact which is closing to the side contact which is opening to overcome the inertia of the side contact which is opening and to open the side contact which is opening and to cause it to remain open until engaged by the electromagnetic means to cause the contacts to open and close without chattering.

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