Aug. 17, 1948. H. J. BROWN 2,447,230

VIBRATOR

Filed June 11, 1946

Fig. 1

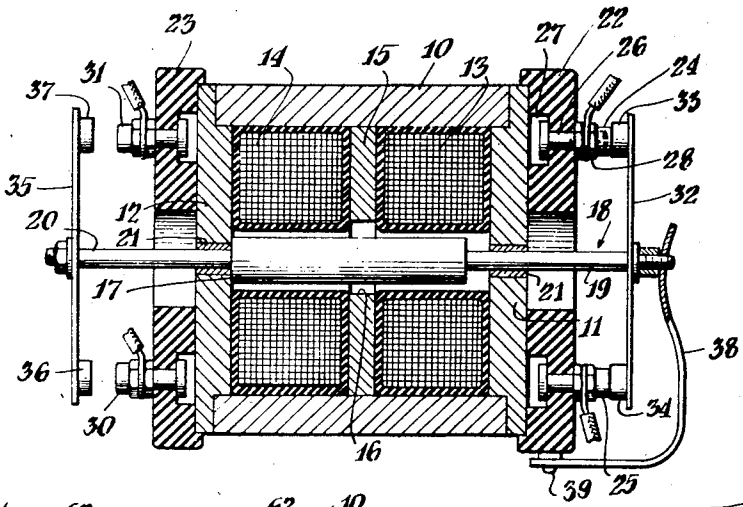


Fig. 4

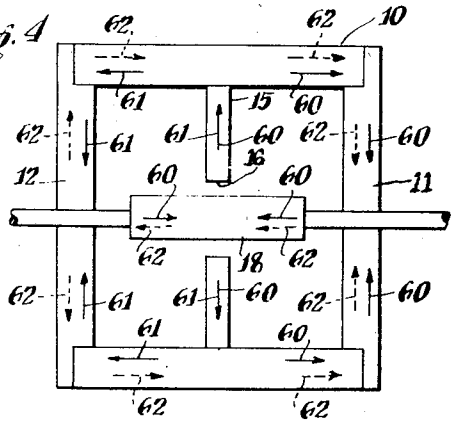


Fig. 2

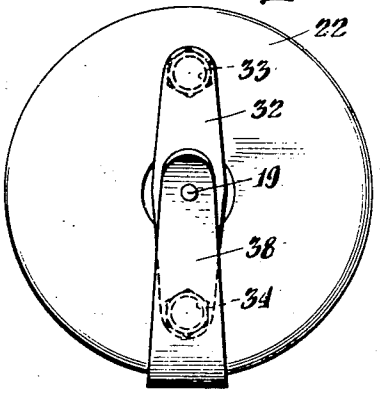
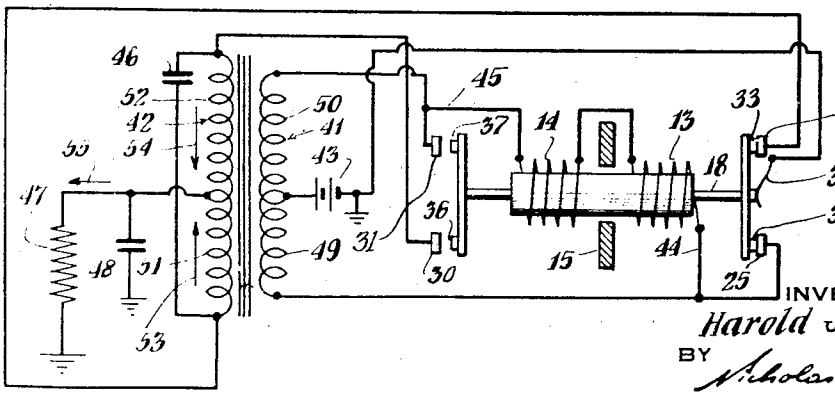


Fig. 3



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VIBRATOR

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5 Claims. (Cl. 171—97)

1

This invention relates to vibrators, and, more, particularly, to vibrators wherein the contacts are actuated by a reciprocatory armature.

Conventional vibrators heretofore utilized have ordinarily included a resilient reed or armature which alternately closes one or more sets of contacts disposed at the respective opposite sides of the reed to thereby alternately energize the sections of a split transformer primary winding. In such vibrators a driver coil is provided for maintaining the reed in continuous vibration, said driver coil being energized when the reed is in its original position and the current is turned on to deflect the reed. Thereupon the circuit of the driver coil is broken thus permitting the reed to return to its original position. In this fashion, the reed is maintained in continuous vibration at a frequency determined by the mechanical construction and arrangement of the parts constituting the vibratory system. This system has certain disadvantages in that it is difficult to obtain satisfactory and efficient operation particularly when the vibrator is operated at the higher frequencies now utilized. The use of a driver coil which is mounted, in most cases, beyond the end of the reed creates difficulties in reducing the size of the vibrator, although this reduction in size is desirable in view of the recent tendency toward using smaller power supply units and radio sets.

It is an object of this invention to overcome or substantially minimize the difficulties heretofore experienced with conventional vibrator units.

It is a further object of the invention to provide a vibrator in which the armature is energized and supplied with power during the whole of each operating cycle.

It is a still further object of the invention to provide a vibrator having a substantially closed magnetic flux path so that extremely efficient operation of the driver coil is obtained.

It is a still further object of the invention to provide a vibrator of an extremely small size which is efficient at high frequencies of operation.

It is a still further object of the invention to disclose a vibrator having a polarized reciprocatory armature which is positively driven in both directions to effect alternate energization of the vibrator contacts.

Other objects of the invention will be apparent from the following description and accompanying drawings taken in connection with the appended claims.

The invention accordingly comprises the features of construction, combination of elements, arrangement of parts, and methods of manufacture, referred to above or which will be brought out and exemplified in the disclosure hereinafter set forth, including the illustrations in the drawings, the scope of the invention being indicated in the appended claims.

2

For a fuller understanding of the nature and objects of the invention as well as for specific fulfillment thereof, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a sectional view of the novel vibrator;

Figure 2 is a plan view of the vibrator shown in Figure 1;

Figure 3 is a schematic diagram showing a suitable circuit for operating the vibrator; and

Figure 4 is a diagrammatic view illustrating a feature of the invention.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring now to the drawings in detail, and particularly to Figure 1, the novel vibrator comprises a paramagnetic core structure including a cylindrical shell 10 having ferromagnetic end plates 11, 12 secured thereto in any suitable manner such, for example, as by press fitting. A dual section annular driver coil is mounted within the shell 10, the coil section 13 being adjacent end plate 11 and the coil section 14 being adjacent end plate 12. The two sections of the driver coil are connected in series and wound in the same direction, as indicated in Figure 3, and both sections have substantially the same number of turns. The coil sections 13 and 14 are separated by a disc shaped permanent magnet 15, the periphery of which fits closely against the ferromagnetic shell member 10. Preferably, the permanent magnet 15 is radially magnetized so that one pole thereof is disposed at the periphery in engagement with the shell 10 while the other pole is located along the inner edge 16. It will be noted that the inner edge 16 defines a circular aperture which is of sufficient diameter to receive an enlarged portion 17 of a plunger or armature 18. Likewise, the coil sections 13 and 14 are formed with central passages of sufficient diameter to accommodate the enlarged plunger

portion 17. As shown, the plunger has reduced end portions 19 and 20 of smaller diameter than the enlarged portion 17 and these ends are mounted or journaled, respectively, in the end plates 11, 12 as by bushings 21.

The novel vibrator is provided with insulating members 22, 23 which may be molded onto the respective end plates 11, 12. It will be seen that the insulating members have suitable passages or apertures therein for receiving the ends of the plunger 18. The insulating member 22 carries a rectifier contact 24 and an interrupter contact 25, each contact being secured to the insulating member by a screw 26, the head of which fits into a recessed portion 27 of the insulating member. As shown, a pair of nuts 28, which are adapted to receive a lead or conductor between them, are threaded on each of the screws 26. The insulating member 23 carries a rectifier contact 30 and an interrupter contact 31 which are mounted thereon in the manner already described with respect to the contacts 24 and 25.

A spring arm 32 is fixed to the end portion 19 and this arm carries contacts 33, 34 which are adapted, respectively, to engage the contacts 24, 25. Likewise, the end portion 20 carries a spring arm 35 on which is mounted a pair of contacts 36 and 37 which are adapted, respectively, for engagement with the contacts 30 and 31. A spring member 38 is secured to insulating member 22 and bears against the end portion 19 of the plunger thus urging it to the extreme end position in which the enlarged portion 17 is in engagement with end plate 12. It will be obvious that the enlarged portion 17 engages end plate 11 at the other extreme end position of the armature. In addition to acting as a biasing member in the manner described, the spring 38 is provided with a projection 39 which is adapted for use as a terminal to afford an electrical connection to the armature.

A suitable circuit for operating the vibrator is illustrated in Figure 3. It will be noted that this circuit comprises a transformer having a center tapped primary winding 41 and a center tapped secondary winding 42. The center tap of the primary winding is connected to one terminal of a battery 43, the other terminal of which is connected to the plunger 18 as through the spring member 38. The respective ends of the primary winding are connected to the interrupter contacts 31 and 25 and the series-connected sections 13, 14 of the driver coil are likewise connected to the respective ends of the primary winding as by conductors 44 and 45. The secondary winding 42 of the transformer has the ends thereof connected, respectively, to the rectifier contacts 24, 30 and the secondary winding may be shunted, if desired, by a condenser 46. The center tap of the secondary winding is connected through a load 47 to ground and the load may be shunted by a filter condenser 48, if desired.

The operation is as follows:

When cyclical reciprocatory motion is imparted to the plunger in the manner hereinafter described, the interrupter contacts 25, 34 and 31, 37 are alternately closed with the result that the primary winding sections 49, 50 are alternately energized, the current in the winding section 49 flowing in opposite direction with respect to the current flow through the winding section 50. The alternating current thus impressed upon the primary winding is stepped up by the transformer and appears as a high voltage alternating current across the secondary winding 42. The reciprocation of the plunger is also effective to alternately close the rectifier contacts 24, 33 and 30, 36 with the result that the load 47 is alternately connected in circuit with the lower section 51 and upper section 52 of the secondary winding. Thus the secondary current flows through winding section 51 in one direction, for example, in the direction of the arrow 53, during the first half of each cycle of operation and then current flows through winding section 52 in the opposite direction, as indicated by the arrow 54, during the second half of each cycle. Accordingly, it will be apparent that the current flow through the load 47 is always in one direction, as indicated by the arrow 55, the alternate closure of the rectifier contacts changing the alternating current appearing across the secondary winding 42 to a pulsating direct current which flows through the load 47. The filter condenser 48 smooths out the pulsations or "ripples" in the load current, in a well understood manner, to provide a more steady direct current.

In accordance with the invention, continuous reciprocatory motion is imparted to the plunger or armature 18 by the interaction of the magnetic field produced by permanent magnet 15 with the magnetic field produced by the driver coil. Before battery current is supplied to the vibrator, the plunger is urged to the position shown in Figures 1 and 3 by the spring 38 with the result that the contacts 24, 33 and 25, 34 are closed. When the battery current is turned on, current flows through the driver coil through a circuit which includes the battery 43, spring 38, plunger 18, contacts 25 and 34, the driver coil and the primary winding section 50. The resultant field established by the driver coil in the magnetic core structure interacts with the field established by the permanent magnet 15 to move the enlarged plunger portion 17 toward end plate 11. Thereupon the contacts 25, 34 are opened and the contacts 31, 37 are closed, thus breaking the original driver coil circuit and causing current to flow through the driver coil in the opposite direction through a circuit which includes the battery 43, spring 38, plunger 18, contacts 31 and 37, the driver coil, and the primary winding section 49. Responsive to the closure of this circuit, a magnetic field of reversed polarity is established in the core structure which interacts with the field produced by the permanent magnet to move the plunger toward end plate 12. Thereupon, the contacts 31, 37 are opened and the contacts 25, 34 are again closed to thereby initiate another cycle of operation. Responsive to the periodic reversal of polarity of the driver coil circuit, the plunger is maintained in continuous reciprocatory motion by the alternate closure of contacts 25, 34 and 31, 37 thus controlling the interrupter and rectifier circuits in the manner already described. When the battery current is turned off, the plunger is urged to the position shown in Figure 1 in readiness for a new period of operation.

I characterize the novel vibrator structure as a polarized vibrator by which I mean that the permanent magnet polarizes the plunger or armature with the result that the field established by the magnet in the plunger and in the magnetic core structure interacts with the driver coil field to effect continuous reciprocatory movement of the plunger.

At the present time, I consider that the permanent magnet establishes a dual field about the two sections of the driver coil, the first branch 60, Figure 4, of which extends radially outward

through permanent magnet 15, thence longitudinally of the shell 10 toward end cap 11, radially inward through end cap 11 and thence longitudinally of the plunger 18 to the edge 16 of the magnet, the other branch 61 of the permanent magnet field extending radially outward through permanent magnet 15, thence longitudinally of the shell 10 toward end cap 12, radially inward through end cap 12, and longitudinally through the plunger 18 to the edge 16 of the permanent magnet. When the plunger is in the position shown, and the driver coil is energized by the closure of contacts 25 and 34, a driver coil field is established as indicated by the dotted arrows 62, this field extending radially outward through end plate 12, longitudinally of the shell 10 to end cap 11, radially inward through end cap 11 and longitudinally of the plunger 18 to end cap 12. It will be apparent that the driver coil field augments the branch 60 of the permanent magnet field and opposes the branch 61 of the permanent magnet field. Responsive to this interaction, the polarized armature is moved toward end plate 11 and the direction of the field 62 is reversed by the opening of contacts 25, 34 and the closure of contacts 31, 37 in the manner previously described. Thereupon, the driver coil field 62 augments the branch 61 of the permanent magnet field and opposes the branch 60 of the permanent magnet field thus moving the plunger toward end plate 12 whereupon the driver coil field is again reversed and a new cycle of operation is initiated. Although I believe that the interaction of the magnetic fields occurs in the described manner, I do not confine myself to any particular theory of operation, as the invention resides in the structural features of the vibrator and the operating circuit therefor rather than in the theory of operation.

It will be noted that the shell 10, plates 11 and 12, together with the permanent magnet 15 define two substantially closed magnetic paths surrounding the respective driver coil sections 13 and 14. The efficient magnetic flux paths thus formed result in very high efficiency of operation in the driver coil circuit. The efficiency of the driver coil circuit with previously used vibrators has varied from about 6% to about 15%, for the most efficient types. However, with my novel core construction, I am able to obtain driver coil efficiencies as high as 30%. It will also be evident that the size of the vibrator may be very small as compared to conventional vibrators heretofore utilized. This follows from the fact that the space within the shell 10 is very efficiently utilized and substantially completely filled by the driver coil, the armature, and permanent magnet 15. Moreover, the contacts project only a short distance beyond the ends of the vibrator, so that very little space is utilized for this part of the apparatus.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a vibrator system; a transformer having a center tapped primary winding; a battery having one terminal connected to said center tap; and a vibrator including a paramagnetic core, an armature mounted for reciprocatory movement with respect to said core and connected to the other terminal of said battery, magnetic means for polarizing said armature, interrupter contacts connected to the respective ends of said primary winding and adapted to be alternately closed during reciprocatory motion of said armature to thereby alternately energize the respective sections of said primary winding, and a driver coil connected across said primary winding, the direction of current flow through said driver coil being cyclically reversed by the alternate closure of said contacts to effect reciprocatory movement of said polarized armature.

2. In a vibrator system; a transformer having center tapped primary and secondary windings; a battery having one terminal connected to the center tap on said primary winding; and a vibrator including a paramagnetic core, a plunger mounted for reciprocatory movement with respect to said core and connected to the other terminal of said battery, magnetic means for polarizing said plunger, a set of interrupter contacts and a set of rectifier contacts at each end of said plunger, each set including a contact secured to the plunger and a contact mounted on a stationary part of the vibrator, connections between said contacts and said transformer for alternately energizing the respective sections of said primary winding and said secondary winding during reciprocatory motion of said plunger, and a driver coil connected across said primary winding, the direction of current flow through said driver coil being cyclically reversed by the alternate closure of said contacts to thereby effect reciprocatory movement of said polarized plunger.

3. In a vibrator, the combination which comprises a closed ferromagnetic core structure including a shell and end plates secured to the respective ends of said shell, a ferromagnetic plunger mounted for axial reciprocation in said shell, compliant means for biasing said plunger to one of its extreme positions, a disc-shaped permanent magnet in said shell at equal distances from said end plates, said magnet having a central aperture through which said plunger may extend and being magnetized to have poles of opposite polarity at its circumference and at said aperture to maintain a pair of symmetrical and substantially closed magnetic circuits of low reluctance and of opposed flux directions in the shell, a dual driver coil in said shell arranged in the annular spaces between said end plates and said magnet surrounding said plunger and adapted when energized to establish a single closed magnetic circuit in said shell, a set of contacts under the control of said plunger, and connections between said contacts, said driver coil and a source of unidirectional electrical energy to produce alternate reversals of current flow through said driver coil responsive to axial displacement of said plunger thereby to maintain said plunger in vibration by the resultant of the fluxes of said three magnetic circuits.

4. In a vibrator, the combination which comprises a cylindrical ferromagnetic shell, ferromagnetic end plates for said shell constituting therewith a closed ferromagnetic structure, a ferromagnetic plunger having its ends slidably supported in central openings of said end plates for axial reciprocation in said shell, complaint means for biasing said plunger to one of its extreme positions, a disc-shaped permanent magnet in said shell at equal distances from said end plates, said magnet having a central aperture through which said plunger may extend and being magnetized to have poles of opposite polarity

at its circumference and at said aperture to maintain a pair of symmetrical and substantially closed magnetic circuits of low reluctance and of opposed flux directions in the shell, a dual driver coil substantially filling out the annular spaces between said end plates and said magnet surrounding said plunger and adapted when energized to establish a single closed magnetic circuit in said shell, a set of contacts under the control of said plunger, and connections between said contacts, said driver coil and a source of unidirectional electrical energy to produce alternate reversals of current flow through said driver coil responsive to axial displacement of said plunger thereby to maintain said plunger in vibration by the resultant of the fluxes of said three magnetic circuits.

5. In a vibrator, the combination which comprises a closed ferromagnetic structure including a cylindrical shell and a pair of end plates therefor, a ferromagnetic plunger mounted for axial reciprocation in said shell and having its end portions of reduced diameter slidably supported in and extending through openings in said end plates, a spring member having one of its ends fixed and its other end connected to one end of the plunger to bias said plunger to one of its extreme positions and to provide electrical connection to the plunger, a disc-shaped permanent magnet in said shell at equal distances from said end plates, said magnet having a central aperture through which said plunger may extend and being magnetized to have poles of opposite polarity at its circumference and at said aperture to maintain a pair of symmetrical and substantially closed magnetic circuits of low reluctance and of opposed flux directions in the shell, a dual driver coil substantially filling out the annular spaces between said end plates and said magnet surrounding said plunger and adapted when energized to establish a single closed magnetic circuit in said shell, at least one stationary contact insulatedly supported on each of said end plates, a vibratory contact compliantly mounted at each end of and electrically connected to the plunger for cooperation with the corresponding stationary contacts, and connections between said stationary contacts, said spring member, said driver coil and a unidirectional source of electrical energy to produce alternate reversals of current flow through said driver coil responsive to axial displacement of said plunger thereby to maintain said plunger in reciprocation by the resultant of the fluxes of said three magnetic circuits.

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