May 10, 1955 C. P. WERNER 2,708,245

ALTERNATING CURRENT VIBRATORY DEVICE

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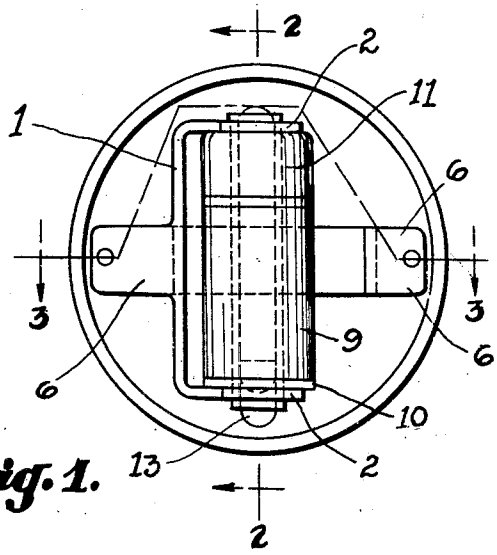


Fig. 1.

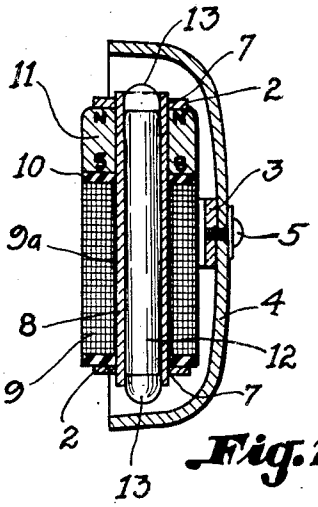


Fig. 2.

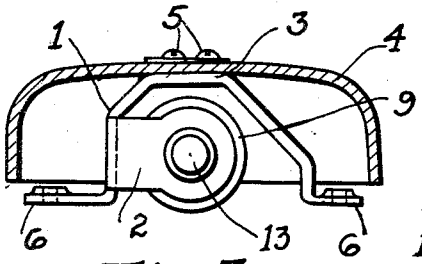


Fig. 3.

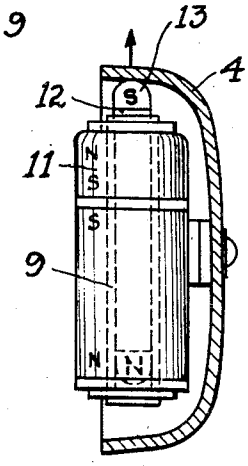


Fig. 5.

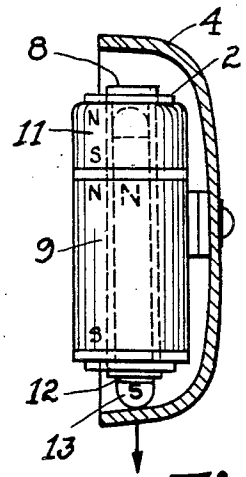


Fig. 4.

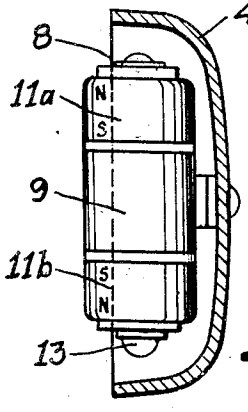


Fig. 6.

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# ALTERNATING CURRENT VIBRATORY DEVICE

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4 Claims. (Cl. 310—30)

The present invention relates to an alternating current vibratory device suitable for use in signals of the audible type, such as bells, gongs or buzzers, and has for its object to provide an improved device of the above indicated type which is adapted for operation by alternating current, so as to impart a vibratory movement to a striking member with a frequency substantially corresponding to that of the alternating current source.

The device of the present invention is particularly characterized by its simplicity of construction and low manufacturing cost, due to the elimination of all moving parts, except the striking member, and the fact that the device operates automatically without the use of current carrying contacts, or springs, that are liable to get out of adjustment. Furthermore, the device, when used as a signal may be produced in different sizes in accordance with the volume of sound that is to be produced, without requiring any variations in the basic design.

The above and other advantageous features of the invention will hereinafter more fully appear from the following description when considered in connection with the accompanying drawings, in which,

Fig. 1 is a view in rear elevation of an electromagnetic device embodying the present invention, used as a signal.

Fig. 2 is a vertical sectional view along the line 2—2 of Fig. 1, looking in the direction of the arrows.

Fig. 3 is a horizontal sectional view along the line 3—3 of Fig. 1, looking in the direction of the arrows.

Figs. 4 and 5 are partial sectional views similar to Fig. 2, with the operating coil in elevation, and showing the extreme positions occupied by the striking member in response to reversals in its polarity when subjected to an alternating magnetic flux.

Fig. 6 illustrates a modified construction of the device shown in Fig. 2.

Referring first to Figs. 1 and 3, the device of the present invention comprises a frame **1** composed of magnetic material, such as iron, with a portion of the frame being in the form of a yoke, providing a pair of spaced parallel arms **2** for supporting between them the striker assembly which is later described in detail. The frame **1** also comprises a bracket **3**, to the center of which a resonant member in the form of a bell shell **4** is attached by means of screws **5**. The bracket **3** also provides feet **6** extending on opposite sides of the yoke so that the signal may be readily mounted on a flat surface.

As best shown in Fig. 2, the arms **2** of the yoke are provided with openings **7** for receiving a tube **8** composed of non-magnetic material, and a coil **9**, wound on a suitable sleeve **9a**, surrounds the tube **8** between spacers **10** of insulating material. The coil **9** is of such length that it occupies only a portion of the space between the arms **2**, and the remainder of this space is occupied by a permanent magnet **11** in the form of a ring, the inside of which fits around the tube **8**. The magnet **11** is composed of metal having permanent



magnetic properties, such as the well-known Alnico metal, so that when the magnet **11** is assembled between the arms **2** of the frame **1**, the ends of the magnet **11** will be of opposite polarity, as indicated in Fig. 2.

A striking member in the form of a plunger **12**, composed of iron, or other magnetic material, is located within the tube **8** and is adapted for free sliding movement therein. The ends of the plunger **12** are provided with non-magnetic striker tips **13**, and the length of the magnetic portion of plunger **12** is substantially equal to the distance between the arms **2** of the yoke **1**. When the coil **9** is in a de-energized condition, the plunger tends to occupy the position of Fig. 2, wherein the upper portion of the plunger is within the magnet **11**, and the force of the magnet **11** is sufficient to exert an upward pull on the plunger and maintain its lower striker tip **13** just out of engagement with the bell shell **4**. In this position, the major portion of the plunger **12** is disposed within the coil **9**, although as long as the coil remains de-energized, the plunger **12** will have a definite polarity imparted thereto, by the magnet **11**.

However, when the coil **9** is energized from a source of alternating current, the plunger **12** will be subjected to an alternating magnetic flux, with the result that as soon as the alternating flux overcomes the polarity imposed on the plunger by the magnet **11**, the ends of the plunger will be polarized alternately, N–S and S–N. When the upper end of the plunger is polarized N, this end will be attracted by the lower end of the magnet **11**, due to the fact that the lower end of the magnet **11** has a permanent S polarity, so that the plunger will strike the bell shell **4** at the bottom, as shown in Fig. 4. However, when the upper end of the plunger **12** is polarized S, the plunger will be drawn upwardly and will strike the bell shell **4** at the top, as shown in Fig. 5 with the upper end then being attracted by the N pole. If the bell shell did not limit the plunger travel, it would seek a position with its ends moving back and forth beyond the ends of the magnet and coil.

The above described action resulting from reversals in the polarity of the plunger **12**, will continue as long as the coil **9** is energized from an alternating current source, and since the reversals in the polarity of the plunger will occur very rapidly, in accordance with the frequency of the source, the plunger will vibrate back and forth within the tube **8** to strike the bell shell **4** a series of quick blows. In the foregoing description of the operation of the plunger, references to the upper and lower ends of the plunger are used only in a relative sense, with respect to the particular showing of the position occupied by the plunger in Fig. 2, wherein the tube **8** is vertical, it being obvious that the signal will operate just as effectively in other positions.

In the foregoing discussion of the operation of the device, the reciprocation of the plunger **12** has been described with reference to reversals in the polarity of the plunger in response to energization of the coil **9** from an alternating current source. However, there is another way of explaining the operation of the device in terms of several magnetic circuits or flux loops set up by the frame assembly with its spaced arms **2**, solenoid winding or flux-inducing source **9**, permanent magnet or flux-inducing source **11** and magnetic plunger **12**.

The magnetic flux from one of the flux-inducing sources, i. e. the permanent magnet **11** enters the plunger **12** through an air gap intermediate the plunger ends, whereupon it divides. One divided portion passes to one end of the plunger and into an arm **2** through another or second air gap. The other divided portion passes to the opposite end of the plunger and into the other arm **2** through yet another or third air gap so that there are, for the flux-inducing source **11**, two separate magnetic

circuits affording flux loops which flow in the same direction through the intermediate air gap but which flow respectively and in opposite directions through the two air gaps at the ends of the plunger. This is accomplished by magnetically coupling one and the same pole of the flux-inducing source **11** to both of the end air gaps and by magnetically coupling the other pole to the third or intermediate air gap.

In the design of the two end gaps, it is important that the plunger **12** be of such length as to establish balanced, inversely variable reluctances in the gaps as the plunger reciprocates. The gap in which the reluctance has momentarily been increased at the completion of a stroke of the plunger must always be of such magnitude that flux concentrations therein from the two flux-inducing sources, will be able to move the plunger to close the gap to bring about the next and reverse stroke of the plunger.

With the flux from the permanent magnet **11** flowing into (or out of) both ends of the plunger **12**, the second flux-inducing source including the coil **9** is arranged to induce a flux which, for one polarity of energizing current, flows in opposite directions in the two air gaps at the ends of the plunger, e. g. out of one end of the plunger and in the other end. For the other polarity of energizing current, the flux flow will be reversed in the two gaps. This is accomplished by magnetically coupling one pole of the source **9** to one of the two end air gaps and the other pole to the other. Therefore, in one variable reluctance air gap the fluxes from the two independent sources **9** and **11** will be added to each other, while in the other the fluxes will oppose each other. The net result is that the plunger **12** will move to close the relatively open gap, while opening the other gap and since the coil flux is alternating, the moving force exerted on the plunger will be first in one direction and then the other. This back and forth movement will continue as long as the coil **9** is energized from an alternating source, with the force for moving the plunger being developed first at one air gap and then at the other.

In Fig. 6, a modified construction is shown, wherein two permanent magnets **11***a* and **11***b* are mounted on the tube **8** above and below the energizing coil **9**. In this modified arrangement, the outer ends of both magnets **11***a* and **11***b* have N polarity, so that when the plunger **12** is polarized alternately, one magnet will attract, and the other repel, opposite ends of the plunger, with the combined forces always being in the same direction with respect to the plunger axis, thereby imparting an increased striking force to the plunger.

From the foregoing, it is apparent that by the present invention there is provided an improved electro-magnetic device for use as a signal of the audible type, that is characterized by its simplicity of construction and reliability in operation due primarily to the fact that the only moving part in the signal is the striking member, and that the signal does not employ any electrical contacts or springs to cause operating difficulties.

I claim:

1. An alternating current vibratory device comprising in combination a frame assembly comprised of parts including spaced apart arms of magnetic material, a plunger of magnetic material mounted between the arms for axial reciprocatory movement and having a length extending substantially the distance between the arms, first flux-inducing means in the form of permanent magnet means, and second flux-inducing means in the form of solenoid winding means, the plunger having two ends which define, cooperatively with the arms, first and second air gaps for passing magnetic flux, the first and second gaps having reluctances which vary inversely with axial reciprocation of the plunger, one gap developing a relatively small reluctance while the other develops a relatively large reluctance, and vice versa, the frame assembly defining a third air gap for the passage of magnetic flux to or from the plunger intermediate of its ends, one of said flux-inducing means having one pole coupled magnetically to the first and second air gaps and the other pole coupled magnetically to the third air gap, thereby to set up at least two flux loops which pass in opposite direction through the first and second gaps and in the same direction through the third gap, the other flux-inducing means having one pole coupled magnetically to the first gap and the other pole to the second gap, thereby to set up flux flow in the same direction in the first and second gaps, whereby energization of the solenoid winding by an A. C. signal will establish additive and subtractive fluxes alternately in the first and second gaps to cause the plunger to be driven axially back and forth, reducing the reluctance of the gap in which the fluxes are additive and increasing the reluctance of the gap in which they are subtractive.

2. An alternating current vibratory device comprising in combination a frame assembly comprised of parts including first flux-inducing means including solenoid winding means, second flux-inducing means including permanent magnet means, and spaced arms of magnetic material and a plunger of magnetic material mounted for axial reciprocatory movement between the arms and having a length extending substantially the distance between the arms and defining in cooperation with the arms first and second air gaps, the reluctances of which increase and decrease in reverse alternation with reciprocation of the plunger, the said first and second air gaps being adapted to accommodate magnetic flux passing between the respective plunger ends and the arms, said frame assembly including a third air gap for the passage of flux to and from the plunger intermediate its ends, one of the flux-inducing means and said frame assembly cooperatively setting up a flux path in which the flux flows in the same direction through the first and second air gaps, and the other flux-inducing means and frame assembly setting up at least a pair of flux loops which flow in opposite directions and both of which pass through the third air gap in the same direction, with one loop being completed through the first air gap and the other through the second air gap, the pair of flux loops thereby flowing respectively in opposite directions in the first and second air gaps, whereby energization of the solenoid winding by an alternating signal will create alternately additive and subtractive fluxes in the first and second air gaps, thereby causing the plunger to move axially back and forth, increasing and decreasing in reverse alternation the reluctances of the first and second air gaps.

3. An alternating current vibratory device comprising in combination a frame assembly comprised of parts including spaced arms of magnetic material, permanent magnet means comprising at least one permanent magnet disposed between the arms and having an aperture therein aligned with an axis between the arms, one pole of the permanent magnet means being coupled magnetically with both of the arms and the other pole being disposed adjacent an area along the axis between the arms, a solenoid winding disposed coaxially of the said axis, and a plunger of magnetic material mounted in the solenoid and aperture of the magnet and between the arms for axial reciprocatory movement, said plunger having an effective length extending substantially the distance between the arms to afford first and second air gaps between the respective arms and the plunger ends, said plunger bridging the said area between the arms to afford a third air gap, the permanent magnet means thereby setting up two flux loops both flowing to or from the plunger through the third air gap and flowing respectively in opposite directions in the plunger and through the first and second air gaps, the solenoid winding being mounted to set up a flux flow through the first and second air gaps in the same direction, whereby energization of the solenoid winding by an alternating signal will establish alternately additive and subtractive fluxes at the first and second air gaps to cause the plunger to move axially back

and forth, increasing and decreasing in reverse alternation the reluctances of the first and second air gaps.

4. An alternating current vibratory device comprising a frame assembly including spaced arms of magnetic material joined by a frame piece also of magnetic material, said arms having aligned apertures formed therein, a sleeve of non-magnetic material received in the apertures, permanent magnet means surrounding the sleeve and disposed between the arms, one pole of the permanent magnet means abutting one of the arms, thereby establishing a magnetic coupling to both arms, the other pole of the permanent magnet means being disposed intermediate the arms, a plunger of magnetic material received within the sleeve for axial reciprocatory movement therein, the plunger having an effective length extending substantially the distance between the arms to afford at its ends first and second air gaps, one between one end of the plunger and one arm and the other between the other end of the plunger and the other arm, the first and second gaps thereby affording reluctances which vary inversely in accordance with the reciprocation of the plunger, the plunger intermediate its ends passing adjacent the said other pole of the permanent magnet means to form a third air gap, the flux from the permanent magnet means thereby setting up two flux loops both passing to or from the plunger through the third air gap and passing between the plunger ends and the arms through the first and second air gaps respectively, the permanent flux loops thereby flowing in opposite directions in the first and second gaps, and a solenoid winding surrounding the sleeve in alignment with the permanent magnet to set up a single flux loop passing along the length of the plunger and also serially through the first and second air gaps, the solenoid flux loop thereby flowing in the same direction in the first and second air gaps, whereby an alternating signal in the solenoid winding will cause the plunger to reciprocate axially, decreasing the reluctance of the gap in which the permanent and solenoid fluxes are additive and increasing the reluctance of the gap in which the fluxes are subtractive.




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