Jan. 6, 1942.   J. D. HUBBELL ET AL   2,269,108

TELEPHONE RINGER

Filed March 14, 1939

FIG. 1

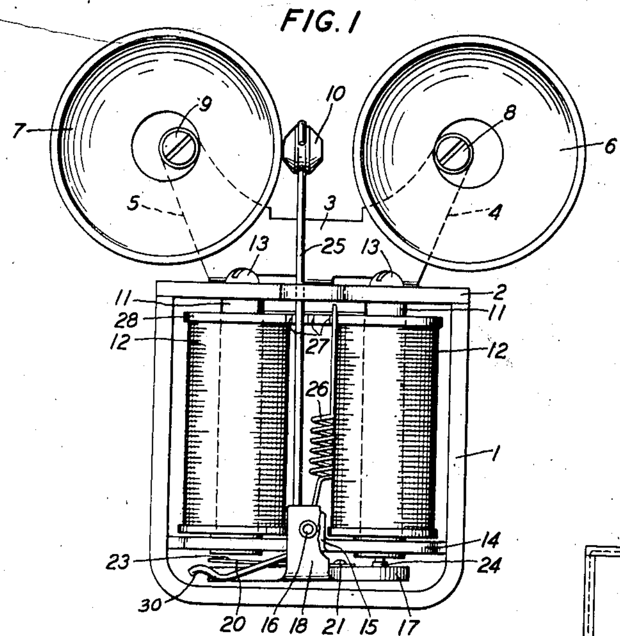


FIG. 5

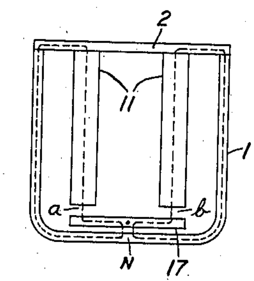


FIG. 2

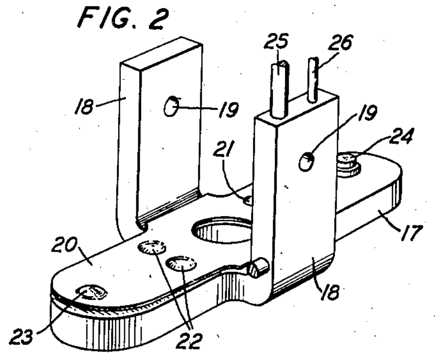


FIG. 3

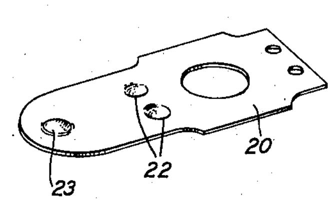
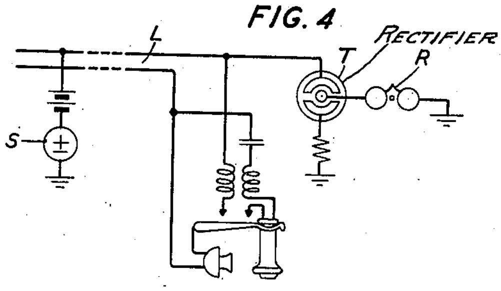


FIG. 4



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2,269,108

TELEPHONE RINGER

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Application March 14, 1939, Serial No. 261,698

6 Claims. (Cl. 177—7)

This invention relates to electromagnetically operated devices and particularly to polarized ringers of the type extensively used for signaling purposes in telephone systems.

It is the object of this invention to provide an improved type of biased telephone ringer which is particularly suitable for operation on rectified current pulses of relatively low magnitude.

This object is attained in accordance with a feature of the invention by the provision of means, in a polarized ringer structure, which functions to oppose the movement of the ringer armature, when the ringer is energized, with a force which is equal to and opposite in effect to that produced by the permanent magnetic air-gap flux. More specifically, the ringer armature has permanently affixed thereto a sheet spring whose free end engages the ringer electromagnet core as the armature is actuated and is flexed as the armature end approaches the core end to exert an opposing influence upon the armature. The magnitude of the opposing influence upon the armature is determined by the natural stiffness of the spring imparted to it by its physical characteristics and dimensions, which are such as to cause the spring to counterbalance the force exerted upon the armature by the permanent magnetic air-gap flux. The balancing spring, therefore, acts to maintain the armature in a condition of balanced equilibrium in so far as the influence of the permanent magnetic air-gap flux upon the armature is concerned, thereby substantially obviating the necessity for applying an appreciable initial bias to the armature to insure its return to normal position after the ringer energizing current has been removed or interrupted.

A related feature of the invention permits the usual armature-biasing spring to serve merely in the capacity of vernier to the balancing spring thereby maintaining a relative ease of adjustment.

These and other features of the invention will be readily understood from the following detailed description made with reference to the accompanying drawing in which:

Fig. 1 is a front elevation of a ringer structure embodying the features of the invention;

Fig. 2 is an enlarged perspective view of the ringer armature showing the armature balancing spring mounted thereon;

Fig. 3 is an enlarged view of the armature balancing spring;

Fig. 4 is a circuit schematic illustrating the manner in which a ringer designed in accordance with the present invention may be associated with a telephone subscriber's line circuit for operation by rectified current pulses; and

Fig. 5 is a schematic illustration of the magnetic circuit embodied in the ringer design.

The ringer structure shown in Fig. 1 includes a U-shaped permanent magnet 1 which is magnetized so as to have a consequent pole at its center and whose upper ends are bridged by a gong-supporting bracket of magnetic material comprising the bridge portion 2 and the gong-supporting portion 3, the plane of the latter being substantially at right angles to the plane of the former. The bridge portion 2 is secured to the ends of the permanent magnet 1 preferably by welding the parts together. The gong-supporting portion 3 terminates in two diverging ear-like projections 4 and 5, to the ends of which the gongs 6 and 7 are secured by means of screws 8 and 9, respectively. The gongs are eccentrically mounted to permit adjustment thereof relative to the striker 10.

The ringer electromagnet consists of a pair of coils 12 which are force fitted to the cores 11 whose upper extremities are tapped to receive the screws 13, by virtue of which the cores are suspended from the bridge portion 2 in spaced relation. The knurled lower ends of the cores 11 are enlarged and extend through apertures in the yoke 14. The diameter of the apertures in yoke 14 through which the enlarged knurled ends of the cores 11 extend is slightly less than the outside diameter of the lower core ends so that by force fitting the yoke on the core ends it is rigidly held in position. The rear edge of the yoke 14 projects at each end to form integral extensions which the rear edges of the vertical legs of permanent magnet 1 abut. Extending upwardly from the center of the yoke 14 are two spaced arms or projections 15 (a portion of one only, is seen in Fig. 1) each of which is provided with a circular aperture which constitutes bearings for the pin 16.

The armture 17 is of sufficient length to extend from one core 11 to the other and is spaced from the lower extremities thereof. The armature is provided with oppositely disposed upturned integral projections 18 which are in substantial alignment with the projections 15 of yoke 14 and are provided with corresponding circular apertures 19 into which the ends of the pin 16 extend, the pin, therefore, constituting a support for the armature. The pin 16 is preferably staked in the armature apertures 19.

To the right of the forward armature extension 18 (viewing Fig. 1), a thin sheet spring 20 is riveted or otherwise secured to the inner face of armature 17, as indicated at 21. The spring 20, preferably of nickel-silver, extends to the left from its point of attachment to the armature 17 to the outer extremity thereof and covers substantially the entire face of that portion of the armature. On its under surface, that is, the surface towards the armature, the spring 20 is provided with a pair of bosses 22 which abut against the armature and maintain the spring spaced therefrom. At its extreme outer end the spring is provided with a single boss 23 on its upper surface which engages the lower face of the core 11 opposite which the spring is located, when the armature is actuated, as will be more fully described hereinafter.

A non-magnetic armature stop 24 integrally associated with the armature 18 is located in such a position on the upper surface of the armature as to normally engage the lower extremity of the right-hand core 11.

A striker rod 25 is staked to the forward armature extension 18 and extends vertically therefrom through an aperture in the bridge-piece 2. The upper end of the striker rod 25 is provided with a hooked portion which is recessed in a centrally located circumferential groove in the striker 10.

A biasing coil spring 26 has one end also staked to the forward armature projection 18 and its free end located in one of three slots 27 located on the edge of a common insulating spool head 28. The spool head 28 is a relatively stiff rectangular strip of insulating material and is provided with two spaced apertures through which the reduced upper ends of cores 11 extend. Also staked to the forward armature projection 18 is a wire-like member 30 having a reversely curved free end. This member constitutes an adjustable stop which serves to limit the stroke of the armature and to thus adjust the stroke of the clapper rod 25 and regulate the sound output of the ringer. By bending, the free end of stop 30 may be moved nearer the yoke 14 to limit the armature stroke.

Referring to Fig. 4, it will be noted that the ringer R, which represents the ringer of the present invention, is connected to the telephone line L by way of a cold cathode gas discharge tube T. Direct current with superimposed alternating current from source S is employed to actuate the ringer R through the medium of the tube T. The tube T acts in the capacity of a rectifier so that the ringer R is operated by rectified current pulses. It is intended that the elements T and R represent the signaling equipment at one of a plurality of stations associated with the party line L, the other stations (not shown) being provided with similar equipment connected to either the tip or ring conductors of the line L in such a manner as to selectively respond to polarized impulses. When current from the signaling source associated with line L is applied thereto in the well-known manner and impressed on the control electrodes of tube T, the tube breaks down permitting rectified impulses to traverse the windings of the ringer R.

The direction of the rectified pulses through the ringer coils is such as to cause the armature 17 to rotate in a clockwise direction with the pin 16 serving as the axis of rotation. In other words, the direction of current through the coils 12 is such as to produce a flux which adds to the permanent magnet flux in the left air-gap, viewing Fig. 1 (air-gap *a* of Fig. 5) and subtracts in the right air-gap (air-gap *b* of Fig. 5). As the left side of the armature is moved towards its oppositely disposed magnet core, the boss 23 of spring 20 engages the core end, causing the spring to flex about the bosses 22 which act as a fulcrum. The flexing of spring 20 introduces a force which increases in magnitude as the armature approaches the core and with the extent to which the spring is flexed. The purpose of this force will readily appear from the following description which is made with particular reference to Fig. 5. When the armature 17 reaches the limit of its clockwise rotation, the striker 10 which, by means of the rod 25 is carried by the armature, strikes the gong 6 to cause it to vibrate. At the termination of the rectified impulse through the ringer windings 12, the armature is caused to return to its normal position under the action of spring 26, which is so tensioned as to restore the armature with sufficient force to cause the striker 10 to strike the gong 7 and cause it to vibrate. It is essential that the spring 26 function to restore the armature with sufficient force to cause the operation of gong 7 by the striker 10, since there is no reversal of current in the ringer windings to effect a reversal of the flux in the armature air-gaps and the consequent counter-clockwise rotation of the armature. It will be noted that the springs 20 and 26 both function so as to oppose the clockwise movement of the armature 17 caused by the energization of the ringer coils 12. The biasing effects of the two springs are thus additive.

The elements which constitute the permanent magnetic circuit of the ringer are schematically illustrated and comprise the permanent magnet 1, the bridge-piece 2, the magnet cores 11 and the armature 17 which is shown, for simplicity, pivoted at its transverse center line. The permanent magnet 1 is so magnetized that the point designated N will repel the north-seeking pole of a compass needle. The permanent magnetic flux, therefore, emanating from the point N will traverse the two parallel paths indicated by the broken lines. If it is assumed that the reluctances of the two parallel magnetic circuits indicated are identical and the paths physically similar and symmetrical, the armature 17 would repose in a condition of balance, since the force (due to the permanent magnetic air-gap flux) tending to rotate the armature in a clockwise direction would be equal to that tending to produce counter-clockwise rotation.

When the ringer is energized by a rectified current pulse, the armature 17 is rotated in a clockwise direction as hereinbefore mentioned. As the armature starts to rotate, the length of air-gap *a* decreases and that of air-gap *b* increases so that the reluctance of the left magnetic path decreases and that of the right path increases. There are, therefore, two forces, due to the permanent magnet flux acting upon the armature and though these two forces do not each vary as a linear function of the distance moved by the armature, their resultant does vary substantially in this manner and is substantially proportional to the armature displacement over the working range of the armature. There is accordingly a greater force (due to the permanent magnetic air-gap flux) tending to rotate the armature in a clockwise direction than tends to rotate the armature in a counter-clockwise direction and this force increases in magnitude as the armature continues to rotate until it reaches a maximum when the armature is fully actuated. When the energizing current is removed or interrupted, the armature is still acted upon by this force and would remain in its operated position due to this force unless some mechanical means was furnished to overcome this force and restore the armature to normal. The force which tends to facilitate the movement of the armature during its operation and which acts to prevent the return of the armature to normal after the ringer energizing current has been interrupted is herein ascribed to the negative stiffness of the armature due to the permanent magnetic air-gap flux.

Usually such ringers are provided with an armature biasing spring which functions to restore the armature to normal position when the ringer is deenergized. Heretofore, such a spring was necessarily pretensioned to an appreciable extent which would insure its being sufficiently tensioned, when the armature was fully operated, to at least overcome the negative stiffness due to the permanent magnetic air-gap flux and return the armature to its normal position. Obviously, to apply an appreciable initial tension to the armature biasing spring necessitates a relatively large current to energize the ringer and overcome this initial bias, thereby reducing the sensitivity of such ringers.

The sensitivity of the ringer of the present invention is materially increased by the use of the armature balancing spring **20**, which, as hereinbefore described, functions to apply a force of opposition or to impart a positive stiffness to the armature. This opposition force increases as the force due to the negative stiffness of the permanent magnetic air-gap flux increases. Since this negative stiffness is a measurable force, the spring **20** may be designed so that its stiffness will balance as closely as possible the negative stiffness. The armature is therefore acted upon by two opposing forces which, within the operating range of the armature, are at all times substantially equal and accordingly is maintained in a condition of balance in so far as the permanent magnetic air-gap flux is concerned. The biasing spring **26** can then be adjusted with comparatively low tension to always return the armature to normal since it is not called upon to overcome the negative stiffness due to the permanent magnetic air-gap flux. With the biasing spring adjusted to comparatively low tension, the value of current required to operate the ringer is correspondingly reduced, thereby rendering the ringer operable on lower current pulses than would otherwise be possible and a relative ease of adjustment is, at the same time, maintained since the biasing spring **26** acts in the capacity of a vernier to the balancing spring.

The magnitude of the positive stiffness of the balancing spring, as hereinbefore mentioned, is determined by the physical characteristics and dimensions thereof. These dimensions and characteristics are selected to impart a natural stiffness to the spring such that it balances as closely as possible the negative stiffness due to the permanent magnetic air-gap flux.

With the ringer of this invention it will be noted that, when the armature is fully actuated, it is acted upon by the permanent magnetic air-gap flux which tends to hold it operated and by the force exerted by spring **20** which tends to restore the armature to normal. Since, by design, these two forces are equal, the armature is in a condition of substantial balance when the ringer becomes deenergized and the spring **26** need only be tensioned so as to just overcome this balance to restore the armature.

What is claimed is:

1. In an electromagnetically operated device, a core, an armature spaced from said core, means for energizing said device to cause said armature to be actuated and to approach said core, a permanent magnet so disposed with respect to said armature and said core as to produce a flux which tends to hold said armature and core together with a force of measurable magnitude when said device is deenergized, a biasing spring for restoring said armature to normal when said device is deenergized, and means independent of said biasing spring for applying to said armature a force equal to and opposite in effect to said force of measurable magnitude.

2. In an electromagnetically operated device, a core, an armature spaced from said core, means for energizing said device to cause said armature to be actuated and to contact said core, a permanent magnet so disposed with respect to said armature and said core as to produce a flux which tends to hold said armature actuated with a force of measurable magnitude when said device is deenergized, a biasing spring for restoring said armature to normal, and means independent of said biasing spring for applying to said armature, when fully actuated, a force equal to and opposite in effect to said force of measurable magnitude, said means comprising a flexible spring carried by said armature and interposed between said armature and said core.

3. In an electromagnetically operated device, a core, an armature spaced from said core, means for energizing said device to cause said armature to approach said core, a permanent magnet so disposed with respect to said armature and core as to produce a flux which tends to aid in the movement of said armature with a measurable force which increases in magnitude as the armature approaches the core, means comprising a flexible spring carried by said armature and interposed between said armature and said core for applying to said armature a force which at all positions of the armature balances said measurable force, and a biasing spring independent of said balancing means for said armture.

4. In an electromagnetically operated device, an electromagnet having a pole, a centrally pivoted armature spaced from said pole by an air-gap, means for energizing said electromagnet to cause said armature to approach said electromagnet pole, a permanent magnet for producing a flux in said air-gap which imparts to said armature a negative stiffness which tends to facilitate the movement of said armature when said electromagnet is energized and to prevent the return of said armature when said electromagnet is deenergized, and means located in said air-gap for imparting a positive stiffness to said armature upon the energization of said electromagnet which balances the negative stiffness due to the permanent magnet air-gap flux.

5. In an electromagnetically operated device, an electromagnet having a pole, a centrally pivoted armature spaced from said pole by an air-gap, means for energizing said electromagnet to cause said armature to approach said electromagnet pole and decrease the length of said air-gap, a permanent magnet for producing a flux in said air-gap which imparts to said armature a negative stiffness which increases in magnitude as the armature approaches the electromagnet pole and which tends to facilitate the movement

of the armature when the electromagnet is energized and to prevent the return of the armature when the electromagnet is deenergized, and means located in the air-gap for imparting to said armature a positive stiffness which increases in magnitude as the armature negative stiffness increases and is at all positions of the armature equal thereto.

6. In a telephone ringer, a pair of electromagnet poles, an armature spaced from said poles and having an axis of rotation which is in substantial alignment with the transverse center line of the armature, a permanent magnet so disposed with respect to said armature and said electromagnet poles as to cause each end of said armature to experience a force which tends to move the armature ends towards their respective electromagnet poles, means for energizing the electromagnet to cause one end of said armature to approach its corresponding electromagnet pole and the other end to move away from its corresponding electromagnet pole whereby the force exerted by said permanent magnet on one end of said armature increases and the force exerted on the other end of said armature decreases, and means for counterbalancing the increasing force effected by said permanent magnet when said armature is operated, said means comprising a sheet spring anchored to said armature at one side of its transverse center line and extending beyond the other side thereof to the end of said armature and interposed between the armature and one of said poles.

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