

July 20, 1948.

N. LANGER
VIBRATOR

2,445,401

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2 Sheets-Sheet 1

Fig. 1.

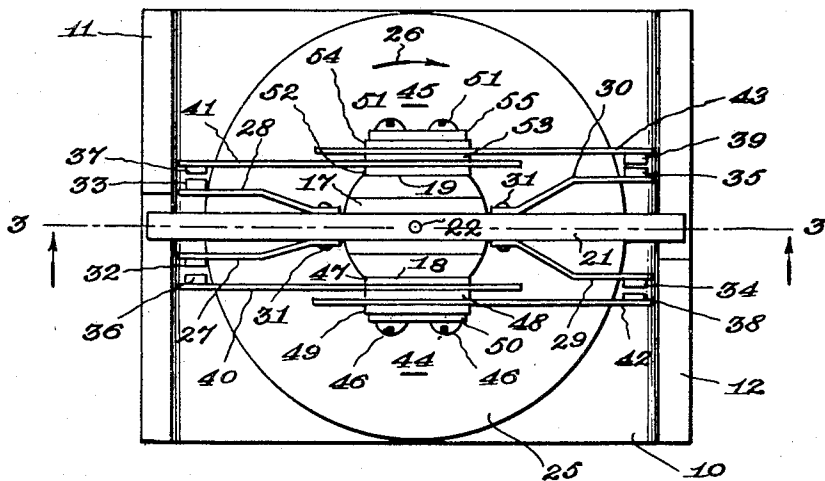


Fig. 2.

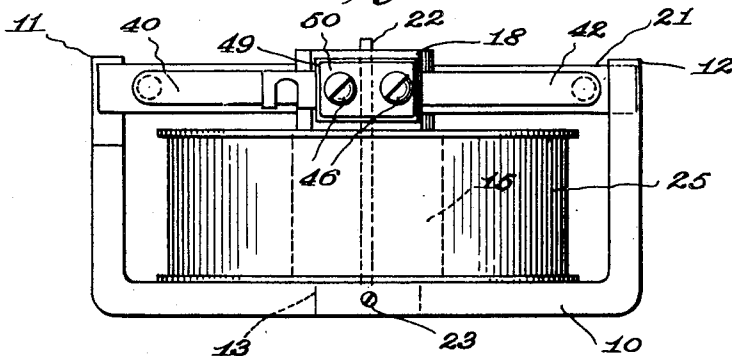
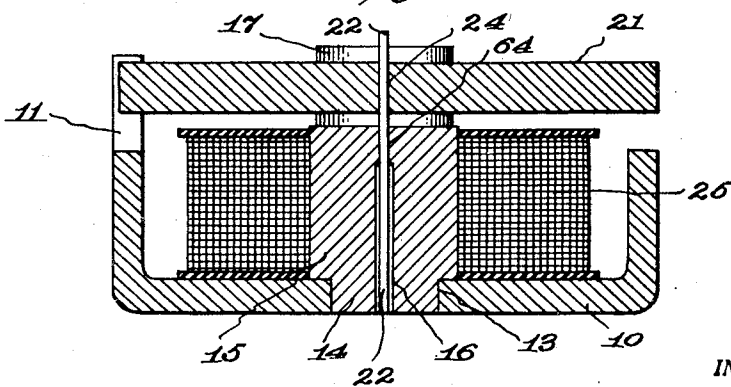


Fig. 3.



INVENTOR.
NICHOLAS LANGER
BY
Chester F. Carlson
ATTORNEY

July 20, 1948.

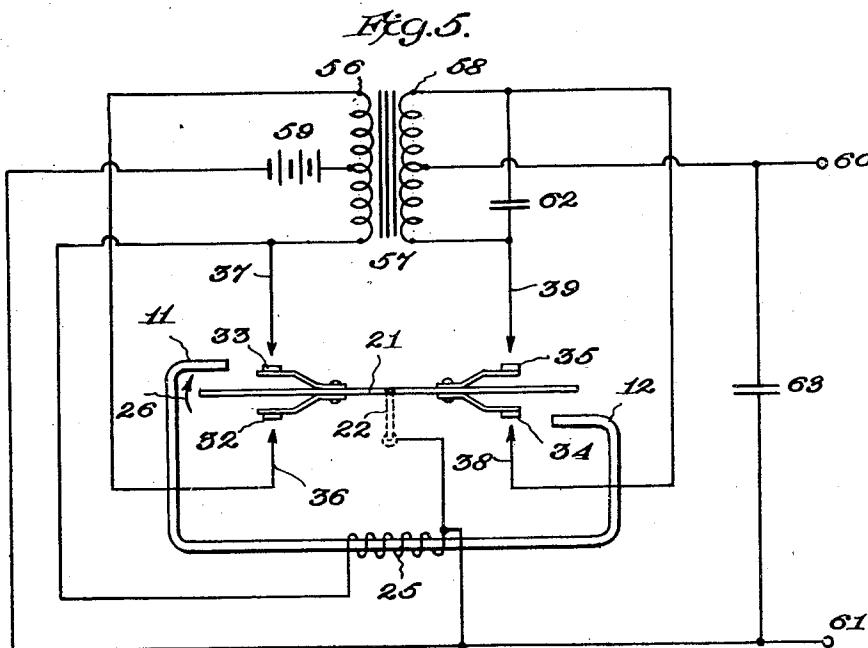
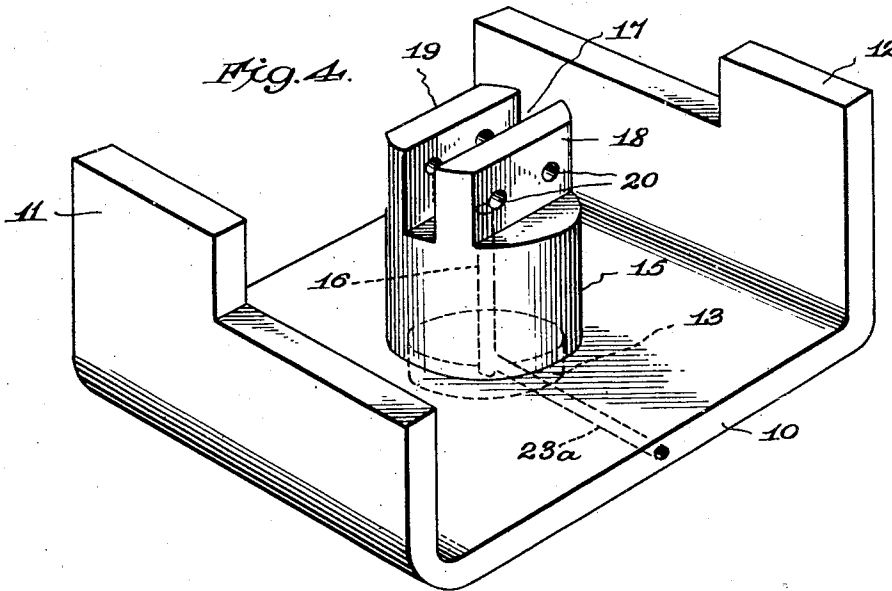
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2 Sheets-Sheet 2



INVENTOR.

NICHOLAS LANGER

BY *Chester F. Carlson*

ATTORNEY

UNITED STATES PATENT OFFICE

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VIBRATOR

Nicholas Langer, New York, N. Y., assignor to
P. R. Mallory & Co., Inc., Indianapolis, Ind., a
corporation of Delaware

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18 Claims. (Cl. 172—126)

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The present invention relates to vibrators, and, more particularly, to vibratory electromagnetic interrupters of novel and improved character.

As those skilled in the art know, practically all conventional electromagnetic interrupters employ a vibratory reed of some type clamped at one end thereof and adapted to be deflected by the field of an electromagnet at the other or free end thereof. The circuit of this driver electromagnet is controlled by a system of contacts operable by the deflection of the reed.

The manufacture of these conventional vibrators on a quantity production scale was connected with considerable practical difficulties. It was particularly difficult to produce reeds in large quantities which were completely uniform in their mechanical characteristics, including their compliance. The difficulty was further accentuated by the various complex shapes of reeds used in vibratory interrupters necessitating complicated stamping operations and expensive dies. Even so, the percentage of rejects was relatively high and breakage of the reeds during assembly and operation quite frequent. Also, prior vibratory interrupters built around a vibratory reed were relatively large in dimensions and rather uneconomical in using the space within a circular can which is at present the standard method of mounting vibrators. Generally speaking, only about 25% to 35% of the total space within a conventional circular can was filled out by the operating mechanism of the vibrator while the rest of the space was wasted. Although all of these difficulties connected with the construction, manufacture and operation of vibratory interrupters were well known to those skilled in the art and from time to time various suggestions and proposals were made to eliminate such difficulties, none, as far as I am aware, of these suggestions and proposals was completely satisfactory and successful when carried into practice on a practical and commercial scale.

It is an object of the present invention to provide a vibratory interrupter which eliminates the foregoing difficulties and which constitutes a complete solution for the outstanding problem.

It is another object of the present invention to provide a vibratory electromagnetic interrupter of novel and improved character which eliminates the conventional vibratory reed, characteristic of all prior vibrators, and substitutes a torsionally stressed elastic member therefor.

It is a further object of the present invention to provide a fundamentally novel vibratory interrupter organization in which an elongated

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member having torsional elasticity is clamped at one end thereof and carries an armature at the other end thereof, said armature being deflected by electromagnetic means under the control of contacts operable by the armature.

It is also within the contemplation of the invention to provide an electromagnetic vibratory interrupter in which an angularly displaceable armature member is resiliently held for rotation by means of a torsion member in the form of a metal shaft, pin, or wire, and is adapted to operate a system of contacts controlling a plurality of electrical circuits, including that of a driver electromagnet, so that the armature member is maintained in vibratory motion.

The invention also contemplates a vibratory interrupter built around a torsionally deformable member which is extremely simple in structure, reliable and foolproof in its operation, has greatly reduced physical dimensions, and which may be readily manufactured and sold on a practical and commercial scale at a low cost.

Other and further objects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings; in which

Fig. 1 illustrates a top elevational view of a vibrator embodying the principles of the present invention;

Fig. 2 depicts a side elevational view of the vibrator illustrated in Fig. 1;

Fig. 3 shows a vertical sectional view taken on line 3—3 of Fig. 1;

Fig. 4 shows a perspective view of the frame and core structure of the vibrator; and

Fig. 5 is a circuit diagram indicating a preferred form of circuit organization of the vibrator 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 more particularly to Figs. 1 to 4 of the drawing, reference character 10 denotes a generally U-shaped frame made of ferromagnetic material. The upwardly extending arms of frame 10 are provided with extensions 11 and 12, respectively, offset with respect to each other, constituting pole pieces for the mag-

netic circuit of the vibrator. An aperture 13 is formed in the center of frame 10 in which there is fixed by means of tight fit, riveting, welding, or the like, shouldered portion 14 of a generally cylindrical ferromagnetic core 15. An axial hole 16 of small diameter extends throughout the length of the core member and has the object of accommodating the torsion member, or pin, as it will be set forth more fully hereinafter.

In the upper end of core member 15 (Fig. 4) there is provided a slot 17 parallel with the length of frame 10. The upper end of said member is likewise provided with two faces 18 and 19, parallel with slot 17, each having two threaded holes 20 therein.

The vibratory system comprises an armature in the form of a transverse ferromagnetic bar or strip 21, the midportion of which is arranged in slot 17 of core member 15 and the ends of which extend into cooperative relation with pole pieces 11 and 12, respectively. The armature is supported by means of a torsion member 22 in the form of a substantially cylindrical wire or rod extending throughout bore 16 of core member 15. The lower end of said torsion member is clamped in said bore for example by means of a set screw 23 extending through a corresponding hole 23a in the frame member and core. (Fig. 2.) Of course, clamping the lower end of the torsion member may be accomplished in various other ways such as by giving to the end of said member a rotationless shape and tightly fitting it into the lower end of bore 16, welding, crimping, etc. The top portion of the torsion member extends through a bore 24 in the center of the armature 21 and is rotationlessly secured thereto in any suitable manner such as by welding, brazing, etc.

It will be noted that rotational displacement of armature 21 about its axis will cause corresponding torsional stressing of torsion member 22. By selecting suitable materials for the torsion member, such as spring steel, piano wire, hard-drawn steel wire, etc., and by maintaining rotational displacement of the armature within small angles, torsional deformation of member 22 may be easily maintained within the elastic limit. The depth of slot 17 in core member 15 is preferably made sufficient to accommodate the full height of the armature bar and the width of said slot is made sufficient to permit slight rotational displacement of the armature about its axis without having the armature strike against the side walls of the slot. A driver coil 25 is mounted around core member 15 and substantially fills out the space between the core and the upward extensions of the frame. Upon said coil being energized, the magnetic circuit established will comprise lines of force through core member 15 and passing through the armature in both directions from the center thereof to pole pieces 11 and 12 of the frame member and then through the two halves of the frame member back to the other end of the core. It will be noted that in the energized condition of the coil a rotary deflecting force in the direction of arrow 26 will be applied to the armature.

The system of contacts associated with the vibrator of the invention will be best observed in Fig. 1 of the drawing and comprises two pairs of side arms 27, 28 and 29, 30, one end of which is secured to the armature by means of rivets 31 and the other ends of which respectively carry vibratory contacts 32, 33, and 34, 35. These vibratory contacts respectively cooperate with relatively fixed contacts 36, 37 and 38, 39 carried at

the free end of side springs 40, 41, and 42, 43. The other ends of these side springs are clamped in two stacks generally denoted by reference characters 44 and 45. Stack 44 is mounted on surface 18 of core member 15 by means of screws 46 extending into threaded holes 20 and comprises an insulative spacer 47, spring arm 48, insulative spacer 48, spring arm 42 extending in a direction opposite to that of spring arm 48, insulative spacer 49, and metal spacer 50. Stack 45 is mounted on surface 19 of core member 15 by means of screws 51 extending into threaded holes 20 and comprises insulative spacer 52, spring arm 41, insulative spacer 53, spring arm 43 extending in a direction opposite to that of spring arm 41, insulative spacer 54, and metal spacer 55. Screws 46 and 51 are surrounded with insulative bushings (not shown) in the usual manner to electrically insulate the several spring arms from each other and from the screws. Preferably, the four spring arms 40, 41, 42 and 43 have their clamped ends extended beyond the stack to constitute soldering lugs to which electrical conductors may be conveniently secured.

The preferred circuit organization of the vibrator of the invention will be best understood from Fig. 5 in which the mechanical structure of the vibrator has been only diagrammatically shown and in which similar reference characters have been used to denote corresponding parts. It will be noted that relatively fixed interrupter contacts 36 and 37 are connected to the ends of primary winding 56 of a transformer 57, the ends of secondary winding 58 being connected to relatively fixed rectifier contacts 38 and 39. A source of low voltage direct current 59 has its terminals respectively connected to the center tap of primary winding 56 and through torsion member 22 to armature 21. Driver coil 25 has its ends connected between torsion member 22 and fixed interrupter contact 37. The high voltage rectified output is withdrawn at output terminals 60 and 61 of which 60 is connected to the center tap of secondary winding 58 and 61 is connected to torsion member 22. A buffer condenser 62 is connected across the secondary winding 58 and a filter condenser 63 is connected across the output terminals 60 and 61.

From the foregoing description the operation of the vibratory interrupter of the invention will be readily understood by those skilled in the art. At the outset, armature 21 is so adjusted that in the normal position of rest its center or midportion is parallel-spaced with slot 17 in core member 15, and that all of the cooperating contacts are open. This may be accomplished by proper adjustment of the torsion member in its clamped position by means of set screw 23 and by appropriately bending the contact-bearing side arms and spring arms in order to obtain the proper contact spacing. In general, and in accordance with the usual practice followed in the adjustment of self-rectifying or synchronous vibrators, the interrupter contacts should close slightly ahead of the rectifier contacts.

In the normal position of rest, current will flow from one of the terminals of source 59 through driver coil 25 and through the lower half of primary winding 56 back to the source. The driver coil now being energized, pole pieces 11 and 12 of the frame member will attract the ends of armature 21 and will impart a slight rotational displacement thereto in the direction of arrow 26, causing elastic torsional deformation of torsion member 22. This displacement will continue

until contacts 33 and 37 will be closed and will shortcircuit the driver electromagnet. The torsional elasticity of torsion member 22 will cause rotational deflection of armature 21 in the opposite direction, past the position of rest, until contacts 32 and 36 will be closed, but the driver electromagnet now being again energized, it will exert deflecting force upon the armature in the first direction, etc. It will be noted that the armature will be maintained in vibratory motion, the frequency of which will be substantially determined by the torsional elasticity of torsion member 22, the inertia or rotary momentum of the armature, and the compliances of the side arms and side springs. During vibration of the armature and alternate closing of contacts 33, 37 and 36, 32, current from source 59 will alternately flow through the two halves of the primary winding of transformer 57 and will induce an alternating current of considerably higher voltage in secondary winding 58. Rectifier contacts 35, 39 and 38, 34 will be operated substantially in synchronism (although with a slight phase difference) with the corresponding interrupter contacts and will alternately connect the two ends of the secondary winding 58 to output terminal 61, whereby rectification of the induced alternating current is effected.

During the vibratory movement of the armature, torsion member 22 will be subjected to alternate torsional deformation in opposite directions. In case the cross section of the torsion member is uniform throughout the operative length thereof, the elastic torsional deformation will be uniformly distributed along the same so that it can be readily maintained within the elastic limit and permanent deformation of the member or the detrimental effects of fatigue can be avoided. As in many cases the torsion member is of a relatively small diameter, it is desirable to provide positive support therefor to prevent its lateral displacement. This is accomplished in the illustrated embodiment by a constriction of bore 16 in the core member constituting a bearing member 64 (Fig. 3) for the upper portion of the torsion member.

In the simplest case, as shown in the preferred form of the invention, the torsion member is of a circular cross section and of a uniform character throughout, as this can be easily provided by cutting appropriate lengths from a wire or rod of spring metal, such as steel. Of course, similar results may be obtained by using elongated torsion members of a different cross section, such as rectangular, polygonal, oblong, etc., and it is also possible to provide constrictions and enlargements of the diameter of the torsion member at points where a reduced or increased torsional effect is desired.

It will be noted that the vibrator of the invention provides a number of important advantages. Thus, first of all, the novel vibrator completely eliminates vibratory reeds supporting the armature and substitutes torsional elasticity for the bending compliance of conventional vibrator reeds. This is a very important factor in facilitating quantity production of vibrators because torsional members may be easily and inexpensively manufactured from wire or rod stock which is cut into unit lengths. The necessity for complicated cutting dies is eliminated and the uniform mechanical characteristics of the torsion members can be easily maintained. It has been found that torsion members of the described character will operate satisfactorily over long pe-

riods of time without fatigue, breakage, or appreciable change in their compliance.

It is also to be observed that the mechanical organization of the novel vibrator is readily adaptable to the manufacture of vibrators of very small dimensions due to the very economical use of space. For example, in mounting the vibrator of the invention into a conventional circular can, a very substantial percentage of the space is utilized. All of the contacts are at the top of the vibratory system so that they are readily accessible for adjustment during the manufacturing process.

Although the principles of the invention have been described in connection with a preferred embodiment thereof, variations and modifications may be resorted to by those skilled in the art without departing from the principles of the present invention. Thus, the principles of the invention can be readily applied to the construction of non-synchronous vibrators. Also, the magnetic circuit may be modified in various ways, such as, for example, increasing the number of pole pieces and employing a ferromagnetic rotor member with extensions cooperating with such pole pieces instead of a single, rod-shaped armature. All of these variations and modifications are considered to be within the true spirit and scope of the present invention, as disclosed in the foregoing description, and defined by the appended claims.

What is claimed is:

1. A vibratory interrupter which comprises in combination an elongated self-supporting member fixed only at one end thereof and free for limited rotation at the other end thereof, said member having such stiffness and being so constructed and arranged as to retain its shape in any position of the interrupter with respect to gravity, electromagnetic means for torsionally stressing said member, and contact means operable by said member for controlling said electromagnetic means to cause periodical torsional stressing of said member.

2. A vibratory electromagnetic interrupter which comprises in combination an elongated and self-supporting torsionally deformable member fixed only at one end thereof and free for limited rotation at the other end thereof, an armature mounted on said member, electromagnetic means for deflecting said armature thereby to torsionally deform said member, said member having such stiffness and being so constructed and arranged as to retain its shape and to support said armature for free deflection in any position of the interrupter with respect to gravity, and contact means operable by said armature for controlling said electromagnetic means thereby to maintain said armature in vibration.

3. A vibratory electromagnetic interrupter which comprises in combination an elongated member having torsional elasticity clamped at one end thereof and free for limited rotation at the other end thereof, an armature mounted on said member away from the clamped end thereof, electromagnetic means for rotationally deflecting said armature when energized thereby to cause torsional deformation of said member, said member having such stiffness and being so constructed and arranged as to retain its shape and to support said armature for free deflection in any position of the interrupter with respect to gravity, interrupter contacts operable by said armature, and connections between said electromagnetic means, said contacts and a source of current to

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alternately energize and to deenergize said electromagnetic means thereby to maintain said armature in vibration.

4. A vibratory electromagnetic interrupter which comprises in combination an elongated straight shaft, having at least some torsional elasticity, clamped at one end thereof and free for limited rotation at the other end thereof, an armature mounted on the other end of said shaft and having axial symmetry with respect thereto, an electromagnetic system adapted when energized to apply rotational deflecting force to said armature thereby to torsionally deform said shaft, said shaft being sufficiently stiff and being so constructed and arranged as to retain its straightness and to support said armature for free deflection in any position of the interrupter with respect to gravity, a vibratory contact on said armature, and a relatively fixed contact adapted to cooperate with said vibratory contact to control the circuit of said electromagnetic system thereby to maintain said armature in vibration.

5. A vibratory electromagnetic interrupter which comprises in combination an elongated self-supporting straight metallic member having substantially uniform cross section and a degree of torsional elasticity fixed only at one end thereof and bearing a ferromagnetic armature on the other end thereof, said armature being symmetrical with respect to and extending transversely of said member and said member being sufficiently stiff and being so constructed and arranged as to retain its straightness and to support said armature for free deflection in any position of the interrupter with respect to gravity, a driver coil, ferromagnetic means for said coil to apply rotational deflecting magnetic force to said armature when said coil is energized thereby to torsionally stress said member, vibratory contacts mounted on said armature at a distance from said member, stationary contacts adapted to cooperate with said vibratory contacts to control at least one electrical circuit, and connections between said coil and said contacts and a source of current to periodically energize said coil and thereby to maintain said armature in vibration.

6. A vibratory electromagnetic motor which comprises in combination a torsion member constituted of relatively stiff and straight elastic wire of substantially circular cross section fixed only at one end thereof and bearing a ferromagnetic armature on the other end thereof, said armature extending transversely of said torsion member and said member being sufficiently stiff and being so constructed and arranged as to retain its straightness and to support said armature for free deflection in any position of the motor with respect to gravity, a ferromagnetic frame member having pole pieces extending in proximity to the free ends of said armature, a coil adapted when energized to magnetize said frame member to apply rotary deflecting force to said armature thereby to elastically deform said torsion member, and a set of contacts operable by deflection of said armature to control the circuit of said coil thereby to alternately energize and deenergize said coil and to maintain said armature in continuous vibratory motion.

7. A vibratory electromagnetic motor which comprises in combination a straight metallic torsion member of circular cross section fixed only at one end thereof and free for limited angular displacement at the other end thereof, a transverse ferromagnetic armature having its center

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attached to the other end of said torsion member, said member being sufficiently stiff and being so constructed and arranged as to retain its straightness and to support said armature for free deflection in any position of the motor with respect to gravity, an electromagnet having poles extending in proximity to the ends of said armature adapted when energized to angularly deflect the same and to torsionally deform said torsion member, contact means operable by said armature to control the circuit of said electromagnet thereby to maintain said armature in vibration, and bearing means for holding said torsion member against lateral displacement but free for torsional deformation.

8. A vibratory electromagnetic motor which comprises in combination an elongated and straight metallic torsion member, means for clamping said member only at one end thereof, a ferromagnetic armature having its center secured to the other end of said torsion member and having at least one pair of extensions symmetrical with respect to said member, said member being sufficiently stiff and being so constructed and arranged as to retain its straightness and to support said armature for free deflection in any position of the motor with respect to gravity, an electromagnet having pole pieces protruding in proximity to said extensions of the armature adapted when energized to rotationally deflect the same and to deform said torsion member, contact means operable by said armature to control the flow of current through said electromagnet so that said electromagnet is normally energized from a source of current and is disabled in the deflected condition of said armature whereby the armature is maintained in vibration, and means for adjusting the effective length of said torsion member thereby to control the frequency of said vibration.

9. A vibratory electromagnetic motor which comprises in combination a ferromagnetic frame member having extensions constituting pole pieces, a ferromagnetic center core for said member, a coil around said core adapted to establish a magnetic field between said core and said pole pieces, an armature extending from said core to said pole pieces and adapted to be deflected when said coil is energized, means for resiliently supporting said armature including a substantially self-supporting torsionally elastic straight rod the upper portion of which is attached to said armature and the lower portion of which is clamped in said frame member, said rod being sufficiently stiff and being so constructed and arranged as to retain its straightness and to support said armature for free deflection in any position of the motor with respect to gravity, and contact means operable by deflection of said armature for controlling the circuit of said coil whereby said armature will be maintained in continuous vibration.

10. A vibratory electromagnetic motor which comprises in combination a U-shaped ferromagnetic frame having pole piece-forming extensions, a ferromagnetic center core for said member, a coil around said core adapted when energized to establish a magnetic field between said core and the extensions of said frame, an armature extending between said pole pieces and across said core, an elongated torsion member extending through an axial bore in said core, said torsion member having one of its ends clamped in said bore and having its other end rigidly connected to said armature whereby upon deflection of the

armature said torsion member will be torsionally deformed, and contact means operable by said armature to control the circuit of said coil and to effect continuous vibration of said armature.

11. A vibratory electromagnetic motor which comprises in combination a U-shaped ferromagnetic frame having pole piece-forming extensions, a ferromagnetic center core extending from the center portion of said frame and having a transverse slot in the upper end thereof, an elongated armature having its midportion spacedly mounted within said slot and having its ends extending in proximity to said pole pieces, means including a torsion member within an axial bore of said core to compliantly support said armature for limited rotation, a driver coil around said core, and contact means operable by rotation of said armature to control the circuit of said coil and thereby to apply periodic deflecting force to said armature.

12. A vibratory electromagnetic motor which comprises in combination a U-shaped ferromagnetic frame having pole piece-forming extensions, a ferromagnetic cylindrical core extending from the center portion of said frame having a transverse slot and a stack-supporting face at the upper end thereof, an elongated armature having its midportion spacedly mounted within said slot and having its ends extending in proximity to said pole pieces, means including a torsion member extending through an axial bore in said core to compliantly support said armature for limited rotation, a driver coil around said core adapted when energized to impart such rotation to the armature, vibratory contact means compliantly mounted on said armature, relatively fixed contact means cooperating with said vibratory contact means, a stack secured to the said face of the core, a side spring clamped in said stack for supporting said relatively fixed contact means, and connections between said coil and said contact means to periodically energize said coil from a source of current.

13. In an electromagnetic vibratory motor, the combination which comprises an armature having an axis of symmetry, means including a torsion member having one of its ends fixed and its other end connected to said armature for compliantly supporting the armature for limited rotation, said member having torsional elasticity but sufficient resistance to flexing to maintain the armature in said axis in any position of the motor with

respect to gravity, electromagnetic means for deflecting said armature about said axis, and contact means operable by said armature to periodically energize said electromagnetic means from a source of current thereby to maintain the armature in vibration.

14. The vibratory interrupter claimed in claim 13 in which the torsion member is substantially circular in cross section and has a uniform diameter throughout the length thereof.

15. The vibratory interrupter claimed in claim 13 in which the torsion member has a polygonal cross section.

16. The vibratory interrupter claimed in claim 13 in which the diameter of the torsion member is different at different points along the length thereof to obtain preferred distribution of the torsional elasticity along said member.

17. The vibratory interrupter claimed in claim 13 in which at least a portion of the torsion member is circular in cross section and a bearing is provided for such portion to support said member against lateral displacement.

18. In a vibratory interrupter in which an armature is arranged for deflection by means of an electromagnetic system under the control of contacts operable by said armature, the improvement which comprises compliant means in the form of a torsion member clamped at only one end thereof for supporting said armature for vibration about the axis of said member, said member having torsional elasticity but sufficient resistance to flexing to maintain the armature in symmetrical relation to said axis in any position of the interrupter with respect to gravity.

NICHOLAS LANGER.

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