July 8, 1958 R. E. FOSTER 2,842,636

NONSYNCHRONOUS VIBRATOR

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FIG. 1.

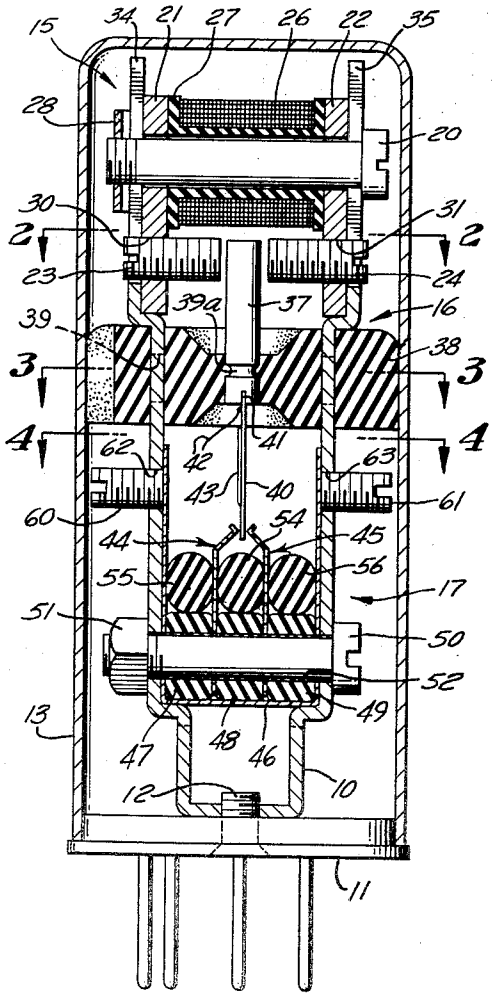


FIG. 2.

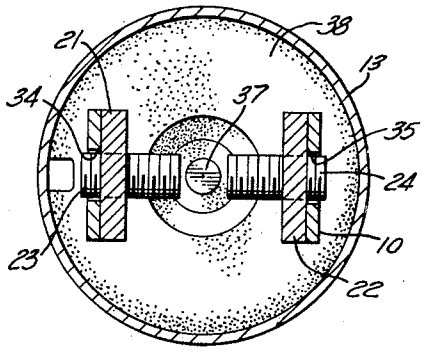


FIG. 3.

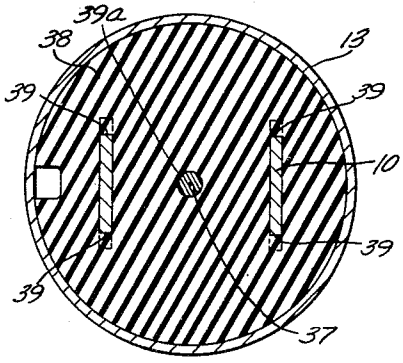


FIG. 4.

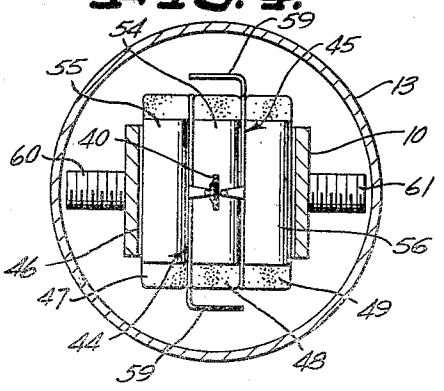
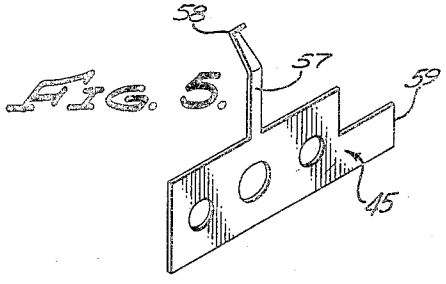


FIG. 5.



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FIG. 6.

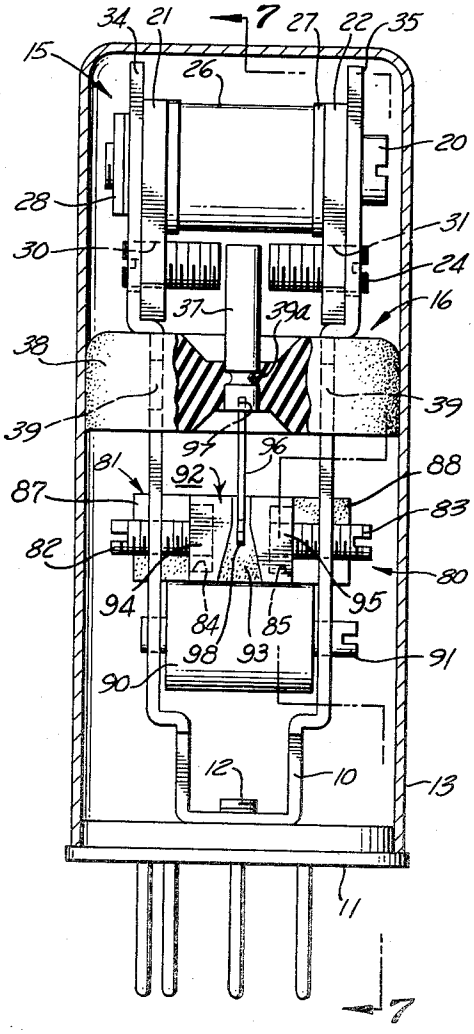


FIG. 7.

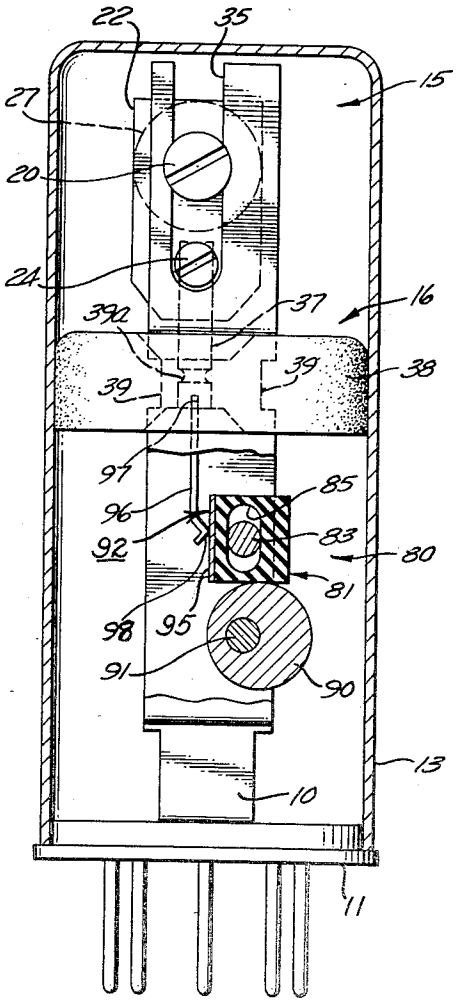
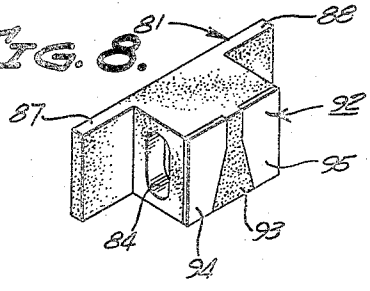


FIG. 8.



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NONSYNCHRONOUS VIBRATOR

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13 Claims. (Cl. 200—90)

This invention relates to electromagnetic vibrators, and, in particular, to a vibrator of the nonsynchronous type having a broad operating frequency.

In a vibrator, an alterating current voltage is used to produce an alternating magnetic flux, which, in turn, drives a vibrating reed or armature in an oscillatory manner. The oscillating or vibrating reed actuates one or more electrical contacts, opening and closing suitable electrical circuits periodically. In the conventional vibrator, the frequencies at which the unit may be operated is limited to a small range for any particular unit due to undesirable resonance conditions arising when the frequency of the driving voltage varies from the desired value.

An object of the invention is to provide a vibrator which may be operated over a broad range of driving frequencies, this range being in the order 20 to over 2000 cycles per second. Another object of the invention is to provide a vibrator which is capable of operating with wide variations in driving voltage, the exemplified embodiments being operative over a range of 1 to 50 volts A. C.

Because of time lags in the unit due to the mechanical and magnetic characteristics of the components thereof, there will be a difference between the phase of the driving voltage and the phase of the output of the vibrator, this difference ordinarily being referred to as the phase shift in the unit. This phase shift varies as a function of the frequency of the driving voltage. A vibrator exhibiting this characteristic is commonly referred to as a nonsynchronous vibrator.

Another object of the invention is to provide a nonsynchronous vibrator in which the characteristics of the magnetic circuit may be adjusted for symmetry or to any desired asymmetrical condition without disturbing the contact dwell time or the wave form of the output. A further object of the invention is to provide a nonsynchronous vibrator in which the contact dwell time and the wave form of the output may be adjusted without disturbing or affecting the magnetic circuit of the vibrator.

An object of the invention is to provide a magnetic circuit for a vibrator, or the like, having an air gap, the size of which may be varied and the position of which relative to a moving armature may be varied in two mutually perpendicular directions, thereby providing control over the gap flux characteristics without requiring movement of the armature.

Another object of the invention is to provide a stationary contact assembly for use with a moving contact, the contact assembly including a pair of contact elements mounted between two pressure plates, the contact elements being spaced from each other and from the pressure plates by relatively rigid insulating spacers, the above units being rigidly fixed together, pressure being transmitted from either pressure plate to both contact elements through relatively resilient spacers which fill

the gaps between the pressure plates and the contact elements and between the contact elements.

A further object of the invention is to provide a fulcrum for a nonsynchronous vibrator which maintains an armature in a center position relative to a mounting frame and a cover, the fulcrum, armature and frame being molded in a unitary interlocked structure.

The invention also comprises novel details of construction and novel combinations and arrangements of parts which will more fully appear in the course of the following description. The drawings merely show and the description merely describes preferred embodiments of the present invention as applied to a nonsynchronous vibrator operable over the frequency range of 20 to 2,000 cycles per second, which are given by way of illustration or example.

In the drawings, wherein like numbers in the various figures refer to identical parts:

Fig. 1 is a sectional view of a preferred embodiment of the invention;

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 1;

Fig. 5 is an isometric view of a contact element utilized in the embodiment of Fig. 1;

Fig. 6 is a view shown partially in section of an alternative embodiment of the invention;

Fig. 7 is a sectional view taken along the line 7—7 of Fig. 6; and

Fig. 8 is an isometric view of the contact carrier block of the embodiment of Fig. 6.

In the embodiment of Fig. 1, the various elements of the vibrator are supported in an upstanding U-shaped frame **10** which is attached to a conventional tube base **11** by suitable means such as a screw **12**, the unit being enclosed and preferably hermetically sealed in a can **13**. A magnetic circuit **15**, an armature support assembly **16**, and a contact assembly **17** are mounted on the frame **10**.

The novel and unique magnetic circuit **15** includes a clamping screw **20**, plates **21** and **22**, and pole pieces **23** and **24**. Each of these components are preferably made of soft iron or a similar magnetic material. An electrical coil **26** provides excitation for the magnetic circuit when connected to an alternative current source, the coil being wound on a form **7** which the clamping screw **20** passes through. The pole pieces **23**, **24** are screws which pass through tapped holes **30** and **31** in the plates **21**, **22**, respectively, thus providing for lateral and width adjustment of the space between the adjacent ends of the pole pieces. It is thus seen that the magnetic circuit consists of a simple loop concentrating the energy in a single path, thereby materially increasing the efficiency of the unit while still providing the other desirable features described.

Opposing slots **34**, **35** are provided in the upper ends of the frame **10**, the magnetic circuit being clamped in place between the upper ends by the clamping screw **20** and nut **28**. The magnetic circuit may be moved in the slots **34**, **35** relative to the armature support assembly **16**, thereby permitting control of the magnetic coupling of the flux in the gap between the pole pieces and the armature **37**. Minimum phase shift between the driving voltage and the output is achieved when the armature extends all the way into the gap, the phase shift being greater when the armature occupies only a portion of the gap.

The armature support assembly **16** provides a pivotable suspension for the vibrating element of the vibrator. An

armature 37 having one end located between the pole pieces 23, 24 and the other end fixed in a fulcrum 38 is the vibrating or pivoting element. The armature 37 is made of a rigid material so that it does not bend or flex when the vibrator is operating, the fulcrum 38 being made of a resilient material which provides for the pivoting of the armature 37. It is preferred that the fulcrum 38 be sufficiently stiff to maintain the armature in a center position when the unit is not operating but that it present very small resistance to the pivoting of the armature. It has been found that a fulcrum comprising a resilient material having a nonlinear response to deformation and to temperature variation permits a wider range of operating frequencies than would be possible in a vibrator in which the armature or moving element is rigidly clamped to its support, or one in which the armature merely rests against its fulcrum. The fulcrum material may be a nonconductor of electricity, thereby insulating the armature from the frame. I prefer to use a material such as a synthetic rubber of the silicone type.

In the embodiment illustrated in Fig. 1, a preferred construction of this armature support assembly is illustrated. The fulcrum 38 is a molded resilient material in which the armature 37 and the frame 10 have been imbedded at the time of molding, notches 39 being provided in the frame and a peripheral groove 39*a* being provided in the armature to lock the elements together. This unique structure provides a simple and compact assembly which meets the requirements of the invention. The periphery of the fulcrum extends beyond the frame 10, engaging the can 13 and spacing it from the frame and the components mounted therein.

A contacting element 40 is rigidly fixed in a slot 41 provided in the lower end of the armature 37, the contacting element being electrically connected to one of the pins of the tube base 11 by a conductor 42. In the embodiment of Fig. 1, the contacting element 40 is a flat strip of electrical conducting material which may have a longitudinal dimple 43 formed therein to increase its rigidity.

The novel contact assembly 17 includes a contact stack comprising two contact elements 44, 45 and a U-shaped strip 46, the contact elements 44, 45 being spaced within the U-shaped strip 46 by insulating blocks 47, 48, 49 which are constructed of a relatively rigid material. Each of the components of the contact assembly have an opening therein, the units being aligned and clamped in the frame 10 by a mounting screw 50 and nut 51 with a tubular bushing 52 of insulating material placed over the screw 50 to insulate the contacts from the screw.

A spacer 54 consisting of a length of relatively resilient insulating material having a normally circular cross section is inserted between the contact elements 44 and 45. Similar spacers 55, 56 are positioned between each of the contact elements and the adjacent arm of the U-shaped member 46. The contact element 45, shown in detail in Fig. 5, includes an upstanding arm 57 having the end portion thereof bent to form a contact point 58, and a terminal portion 59, shown straight in Fig. 5 but which may be bent as in Fig. 4, the terminal portion being connected to one of the pins of the tube base 11 by a conductor (not shown). The contact element 44 has a similar contact point and a terminal formed thereon, the two contact points being positioned on opposite sides of the contacting element 40. Setscrews 60, 61 are positioned in two opposing tapped holes 62, 63 in the frame 10, the ends of the setscrews bearing against the upstanding arms of the U-shaped member 46.

The wave form of the output from the vibrator is controlled by the length of time the contacting element 40 is in contact with each of the contacts 44, 45 and by the length of time spent in moving from one contact to the other. The unique contact assembly described above provides a convenient, accurate and novel method of adjusting the relative positions of the contacts. The opening between the contacts may be increased or decreased, thereby producing longer or shorter offtime, respectively. The contacts may be displaced laterally relative to the moving contact to give an asymmetrical output, the moving contact engaging one stationary contact for a longer period than the other.

The unitary resilient fulcrum in which the armature is imbedded tends to maintain the armature in a particular center position. It has been found that the range of operating frequencies for the vibrator will be maximized if the oscillatory excursions of the armature from this center position are maintained equal in both directions. The motion of the armature is affected by the characteristics of the flux in the air gap of the magnetic circuit, hence the control of the air gap permitted by the magnetic circuit of the invention contributes to the achievement of the broad operating band. Since the flux characteristics may be controlled without changing the center position of the armature, it is seen that the wave form of the output of the unit is not affected by the magnetic flux adjustments. This concept of providing a centering support for the moving armature which is independent of the magnetic circuit and its variables, and also independent of the contact assembly and its variables, is an important advantage and a unique feature of the invention.

The resilient spacers 54, 55, 56 in the contact assembly transmit pressure from the upstanding arms of the U-shaped member 46 to the contact elements 44 and 45, thereby uniquely changing the positions of the fixed contacts relative to each other and to the moving contact and also damping any vibrations in the contacts. Thus, the wave form of the output may be set to any desired shape without affecting the motion of the armature or the flux in the magnetic circuit, and without changing the center position of the armature.

The embodiment of Figs. 6 and 7 utilizes the magnetic circuit 15 and the armature assembly 16 of the embodiment of Fig. 1. However, an alternative novel contact assembly 80 is shown therein.

A contact carrier 81, shown in detail in Fig. 8, is mounted between the upstanding members of the frame 10 by two screws 82, 83, the screws passing through tapped holes in the frame. The ends of the screws 82, 83 engage opposing slots 84, 85 in the contact carrier so that adjustment of the two screws will move the contact carrier laterally, as viewed in Fig. 6. Opposing arms 87, 88 on the carrier 81 engage vertical edges of the frame 10, preventing rotation of the carrier about the screws 82, 83. The arms 87, 88 also act as guides for vertical movement of the carrier. The carrier is driven vertically by a cam 90 eccentrically mounted on a slotted shaft 91 extending through the frame 10.

A contacting surface 92 on one face of the carrier 81 has a nonconducting area 93 and two conducting areas 94, 95. The surface 92 is positioned so that it lies in a plane parallel to the pivot plane of the armature 37. A contacting element 96 is fixed in an opening 97 in the armature 37 in a manner similar to the contacting element 40 of Fig. 1. The free end of the contacting element 96 is bent to form a contact point 97 substantially as shown in Fig. 7, with the carrier block 81 positioned so that the contact point 97 engages the contacting surface 92. The two conducting areas 94, 95 and the contacting element 96 are each connected to pins of the tube base 11 by conductors not shown.

The width of the nonconducting area 93 varies so that the offtime or time lapse between the creation of a circuit between the contacting element 96 and the conducting area 94, and between the contacting element 96 and the conducting area 95, may be controlled by varying the vertical position of the contact carrier 81 relative to the armature assembly of the vibrator. This is accomplished by rotating the cam 90 via the slotted shaft 91. Similarly, the ratio of the time which the contacting element 96 is engaging the two conducting areas 94, 95 may be

varied by moving the contact carrier laterally with respect to the armature assembly. The novel construction disclosed in Figs. 6 through 8 provides a means for adjusting the output wave form to any desired condition without affecting the mechanical motion of the armature or changing the loading on the armature resulting from engagement of the moving contact with the stationary contacts.

The armature **37** is preferably a permanent bar magnet having one pole positioned within the gap between the pole pieces **23**, **24**. While it is possible to construct a vibrator of the type disclosed herein using unmagnetized iron or similar material for the armature, the use of a permanent magnet permits much smaller and more compact construction, thereby reducing the possibility of undesirable mechanical bending or resonance in the structure.

Vibrators constructed according to this specification may be operated as very fast-acting, polarized direct current relays, if desired. This application demonstrates one advantage of the unique construction employed. In order to so operate the unit, one of the pole pieces, for example, the pole piece **24**, is advanced until it contacts the armature at rest in the center position. The other pole piece **23** may be moved away from the armature to give a greater travel distance for the armature. The contact **44** is moved into engagement with the moving contact **40** while the contact **45** is moved away from the center position so that the moving contact will engage it only when the armature has pivoted in the fulcrum to also engage the pole piece **23**. There contact movements are accomplished by the use of the screws **60**, **61** and the arms of the member **46**. When the coil **26** is energized with a direct current of one polarity, the armature will be urged toward the pole piece **24** with no movement resulting. When the coil is energized with the opposite polarity, the armature will move to engage the pole piece **23**, producing the polarized relay action.

Although several exemplary embodiments of the invention have been disclosed and discussed, it will be understood that other applications of the invention are possible and that the embodiments disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

I claim as my invention:

1. In a nonsynchronous vibrator, the combination of: a magnetic circuit having an air gap therein, said magnetic circuit including coil means, said coil means generating an alternating magnetic flux across said air gap when coupled to an alternating current voltage source; a fulcrum spaced from said magnetic circuit, said fulcrum comprising a diaphragm of resilient material; a rigid armature fixed in and extending through said diaphragm substantially perpendicular to the plane of said diaphragm for pivotal movement about an axis lying in the diaphragm, one end of said armature being positioned adjacent said air gap, said armature being pivoted by said alternating magnetic flux, said armature including electrical contact means; and at least one contact element positioned adjacent said armature, said contact element being contactable by said contact means of said armature when said armature pivots in said fulcrum.

2. A nonsynchronous vibrator as defined in claim 1, in which said fulcrum is integrally molded with said armature of a resilient material having a nonlinear response to deformation and to temperature variation.

3. In a nonsynchronous vibrator, the combination of: a U-shaped frame; a single loop magnetic circuit carried at one end of said frame, said magnetic circuit having an air gap therein and including coil means, said coil means generating an alternating magnetic flux across said air gap when coupled to an alternating current voltage source; a fulcrum mounted in said frame spaced from said magnetic circuit, said fulcrum comprising a

molded resilient diaphragm; a rigid armature centrally positioned in said fulcrum substantially perpendicular to the plane of the diaphragm, said armature and frame being integrally formed with said fulcrum, one end of said armature being positoned adjacent said air gap, said armature being pivotable about said fulcrum by said alternating magnetic flux, said armature including electrical contact means; and at least one contact element positioned adjacent the other end of said frame, said contact element being contactable by said contact means of said armature when said armature pivots in said fulcrum.

4. In a nonsynchronous vibrator, the combination of: a single loop magnetic circuit having an air gap therein; coil means encircling a portion of said magnetic circuit, said coil means generating an alternating magnetic flux across said air gap when coupled to an alternating current voltage source; a fulcrum spaced from said magnetic circuit, said fulcrum comprising a resilient material; armature means pivotally fixed in said fulcrum, said armature means being outside said encircling coil means and said magnetic circuit, one end of said armature means being positioned within said air gap, said armature means including electrical contact means; and at least one contact element positioned adjacent said armature means, said contact element being contactable by said contact means of said armature means when said armature means pivots in said fulcrum.

5. A nonsynchronous vibrator as defined in claim 4, in which said armature means includes a permanent magnet, one pole of said permanent magnet being said one end of said armature means which is positioned adjacent said air gap.

6. In a vibrator, the combination of: a frame; a magnetic circuit mounted in said frame; coil means for creating an alternating magnetic flux in said magnetic circuit; a rigid armature pivotally suspended in said frame, one end of said armature being adjacent said magnetic circuit, said alternating magnetic flux actuating said armature to cause pivoting thereof, said armature including a moving contact element; a contact stack mounted in said frame, said stack including a pair of stationary contact elements and a pair of pressure plates, said pair of stationary contact elements being separated by a first resilient spacer forming a contact assembly, said pressure plates being spaced from opposing sides of said contact assembly by second and third resilient spacers, respectively, said moving contact element of said armature being positioned between said pair of stationary contact elements; first adjustment means mounted on said frame engaging one of said pressure plates; and second adjustment means mounted on said frame engaging the other of said pressure plates, each of said adjustment means being movable relative to said frame to move the respective pressure plate engaged therewith, said motion of said pressure plates being coupled through said resilient spacers to said stationary contact elements.

7. In a contact assembly for a vibrator or the like, the combination of: a contact stack comprising a first pressure plate, a first insulator, a first contact element, a second insulator, a second contact element, a third insulator and a second pressure plate, said insulator being of a relatively rigid material; means for clamping the components of said stack together, portions of said pressure plates and said contact elements extending beyond said insulator; and first, second and third spacers positioned between and contacting said extending portions of said first pressure plate, said first contact element, said second contact element and said second pressure plate, respectively, said spacers being of a relatively resilient insulating material.

8. A contact assembly as defined in claim 7, including first and second adjustment means engaging said extending portions of said first and second pressure plates respectively, each of said adjustment means being movable

to urge the engaged pressure plate toward said contact elements.

9. In a contact assembly for a vibrator or the like, the combination of: a first U-shaped member; a second U-shaped member nested within said first U-shaped member; at least one contact element; means for clamping said contact element between the arms of said second U-shaped member, said means providing spacers between portions of said contact element and said arms; a plurality of resilient spacers, one of said spacers being positioned in each of said spaces and contacting the components which define each side of the space; a first screw threaded in one arm of said first U-shaped member and engaging the adjacent arm of said second U-shaped member; and a second screw threaded in the other arm of said first U-shaped member and engaging the adjacent arm of said second U-shaped member.

10. In a vibrator, the combination of: a frame; a magnetic circuit mounted in said frame; coil means for creating an alternating magnetic flux in said magnetic circuit; a rigid armature pivotally suspended in said frame, one end of said armature being adjacent said magnetic circuit, said alternating magnetic flux actuating said armature to cause pivoting thereof, said armature including a moving contact element; a contact carrier having a plane contacting surface thereon, said contacting surface including a nonconducting area and a conducting area; and mounting means for positioning said carrier in said frame, said carrier being positioned so that said moving contact of said armature engages said contacting surface for pivoting movement between said nonconducting area and said conducting area.

11. In a vibrator, the combination of: a frame; a magnetic circuit mounted in said frame; coil means for creating an alternating magnetic flux in said magnetic circuit; a rigid armature pivotally suspended in said frame, one end of said armature being adjacent said magnetic circuit, said alternating magnetic flux actuating said armature to cause pivoting thereof, said armature including a moving contact element; a contact carrier having a contacting surface thereon, said contacting surface including a nonconducting area and a conducting area; and mounting means for movably positioning said carrier in said frame, said carrier being postioned so that said moving contact of said armature engages said contacting surface, said contacting surface lying in a plane parallel to the pivot plane of said armature, said carrier having guide means for guiding movement of said carrier in a plane parallel to the plane of said contacting surface.

12. In a vibrator, the combination of: a frame; a magnetic circuit mounted in said frame; coil means for creating an alternating magnetic flux in said magnetic circuit; a rigid armature pivotally suspended in said frame, one end of said armature being adjacent said magnetc circuit, said alternating magnetic flux actuating said armature to cause pivoting thereof, said armature including a moving contact element; a contact carrier having a contacting surface thereon, said contacting surface including a central symmetrical nonconducting surface and two conducting surfaces located on opposite edges of said nonconducting surface, said nonconducting surface being wider at one end than at the other end thereof; and mounting means for positioning said carrier in said frame, said carrier being positioned so that said moving contact of said armature engages said contacting surface.

13. A vibrator as defined in claim 11, including cam means mounted in said frame, said cam means engaging said carrier so that rotation of said cam means moves said carrier relative to said frame.

References Cited in the file of this patent

UNITED STATES PATENTS

1,193,678	Fowle	Aug. 8, 1916
1,400,126	Wotton	Dec. 13, 1921
1,624,476	Cummings	Apr. 12, 1927
1,924,082	Barrett	Aug. 22, 1933
1,989,057	Kongsted	Jan. 22, 1935
2,209,382	Blattner	July 30, 1940
2,357,834	Leifer et al.	Sept. 12, 1944
2,412,123	Carpenter	Dec. 3, 1946
2,427,990	Coake	Sept. 23, 1947
2,443,784	Bullen et al.	June 22, 1948
2,458,822	Aust	Jan. 11, 1949
2,579,523	Terry	Dec. 25, 1951
2,614,188	Williams et al.	Oct. 14, 1952
2,698,366	Howell	Dec. 28, 1954
2,718,570	Caldwell	Sept. 20, 1955