Dec. 11, 1951 C. F. COAKE 2,578,640

VIBRATOR

Filed April 18, 1946 2 SHEETS—SHEET 1

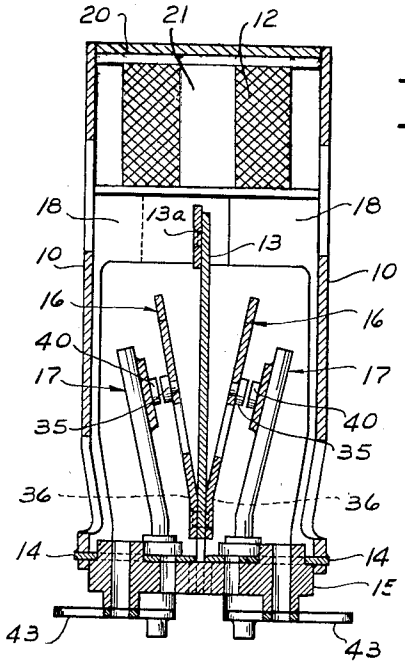


Fig 1

Fig 2

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Fig 3

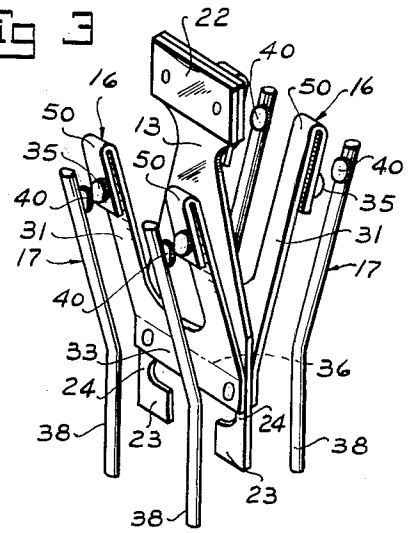


Fig 4

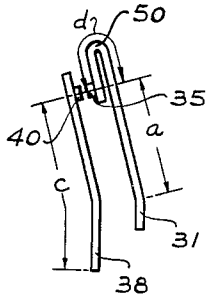


Fig 5

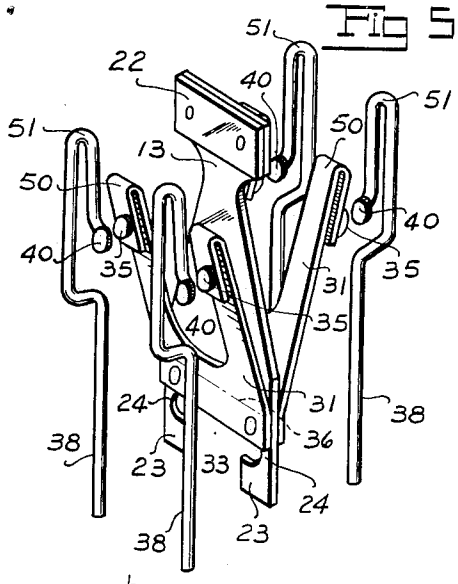


Fig 6

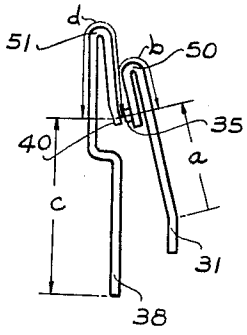


Fig 7

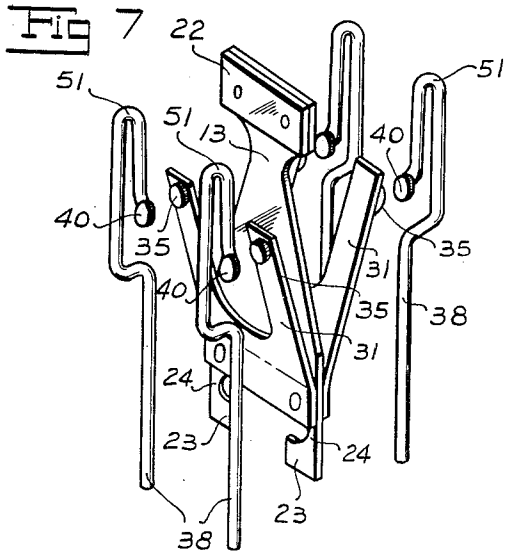
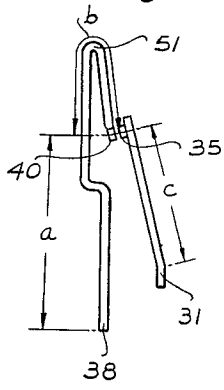


Fig 8



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UNITED STATES PATENT OFFICE

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VIBRATOR

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Application April 18, 1946, Serial No. 663,199

3 Claims. (Cl. 200—90)

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This invention relates to electromagnetic vibrators and is a continuation-in-part of my application Serial No. 532,962 filed April 27, 1944, now Patent No. 2,483,085, September 27, 1949.

An object of the present invention is to simplify the construction and increase the operating efficiency of electromagnetic vibrators.

Another object of the invention is to maintain the maximum contact area between the contacts of an electromagnetic vibrator under all operating conditions.

Another object is to provide a vibrator having cooperating inner and outer contact arms in which the ratio of compliances of said arms is such as to maintain their contacting surfaces parallel to each other under all conditions of use.

Another object is to provide a novel construction and mounting of contact arms in a vibrator of the foregoing type, whereby the effective length and tuning of said arms is maintained regardless of slight variations in the point of attachment of the arms in the vibrator assembly.

Still another object is to provide a novel type of electromagnetic vibrator which dispenses entirely with the conventional stack-type vibrator assembly and provides a basically novel structure in which the principal cooperating parts are fixed to a metallic frame by means of welding and similar operations.

A further object is to provide a vibrator structure which may be assembled in a manner comparable to the procedure followed in the manufacture of miniature vacuum tubes whereby an extremely strong structure may be combined with the desirable feature of very small dimensions.

Another object is to provide a vibrator in which a magnetic circuit of low reluctance is obtained by means of a novel frame member which also forms the principal structural member of the complete assembly supporting all of the other cooperating elements of the system.

A further object is to provide an electromagnetic vibrator of the foregoing type having novel and improved details of construction and features of operation.

Various other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

Heretofore, electromagnetic vibrators have usually been built and assembled on the stack principle. That is, the principal operative elements including the vibratory reed, the various spring contact arms, portions of the frame, etc. have been provided with suitably aligned holes and were clamped together by means of stack

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screws with interposed spacer members providing the proper spacing between the several stacked elements. Such a vibrator possesses a number of disadvantages, including the following: The structure is relatively complex and its assembly requires a great deal of manual labor; the distance between the cooperating elements is determined by the spacer members which have to be of uniform thickness and this condition is difficult to fulfill in quantity production, particularly when the spacer members are made of synthetic resins which may change their thickness even after the assembly is completed; and this type of construction is relatively bulky and makes the manufacture of vibrators of small dimensions practically impossible.

The foregoing disadvantages of stack type vibrators have been accentuated by the recent trend in vibrator design directed to the construction of vibrators of very small dimensions. This trend developed when the essential components of radio receivers and transmitters, such as vacuum tubes, condensers, etc. became available and permitted the development of apparatus of great compactness as in the case of automobile and portable receivers of all types. Furthermore, in recent years extremely small portable radio receivers, the so-called personal radios and small vacuum-tube operated hearing aid devices have been placed on the market in large quantities and these devices have created a demand for vibrators of greatly reduced dimensions which so far the industry has been unable to satisfy. Although these problems were well known, and various suggestions and proposals were made to eliminate the difficulties and disadvantages inherent in conventional vibrator structures, none of these suggestions and proposals has been completely satisfactory and successful on a practical and commercial scale.

The present invention overcomes the above-mentioned and other disadvantages of the prior art and provides a novel and improved electromagnetic vibrator which possesses all the advantages enumerated in the foregoing objects of the invention as well as numerous other advantages of simplicity of manufacture and assembly and increased operating efficiency, as will be hereinafter more fully described.

Although the novel features which are characteristic of this invention are set forth more in detail in the claims appended hereto, the nature and scope of the invention may be better understood by referring to the following description, taken in connection with the accompanying

drawings forming a part thereof, in which certain specific embodiments have been set forth for purposes of illustration.

In the drawings:

Fig. 1 is a longitudinal sectional view of an electromagnetic vibrator embodying the present invention;

Fig. 2 is an exploded perspective view of the vibratory reed and contact assembly of the vibrator;

Fig. 3 is a perspective view of a modified form of reed-contact assembly;

Fig. 4 is a diagrammatic view of the cooperating inner and outer contact members of Fig. 3;

Fig. 5 is a perspective view showing another form of reed-contact assembly;

Fig. 6 is a diagrammatic view of the cooperating inner and outer contact members of Fig. 5; and

Figs. 7 and 8 illustrate still another embodiment of the invention, the former being a perspective view of the modified reed-contact assembly and the latter being a diagrammatic view of the cooperating contact members thereof.

In the following description certain specific terms are used for convenience in referring to the various details of the invention. These terms, however, are to be interpreted as broadly as the state of the art will permit.

In the drawings, Figs. 1 and 2 show an electromagnetic vibrator comprising a pair of elongated magnetic frame members 10 supporting a driver coil 12, a vibratory reed 13 secured to base plates 14 which are seated in an insulating disc 15, inner contact arms 16 which are secured to opposite sides of the reed 13, and outer contact arms 17 which cooperate with the respective inner arms 16 as hereinafter more fully described.

The magnetic frame members 10 are preferably stamped out of sheet metal and are curved transversely throughout their length. Each frame member has a pair of outwardly extending arms 18 which overlap and are welded to the corresponding arms of the other frame member when the two members are brought together as shown in Fig. 1. The ends of the frame members adjacent the arms 18 comprise arcuate collars 19 which partly surround the driver coil 12 and are secured as by welding to a disc 20 of magnetic material which is attached to the core 21 on which the coil 12 is wound. The opposite end of each frame member 10 has an arcuate surface 22 which is adapted to be welded to the base plates 14 as hereinafter described.

The vibratory reed 13 is formed with an upwardly tapering width and has an armature 13a of magnetic material secured to its upper or free end as by welding. When the vibrator is assembled, as shown in Fig. 1, the armature 13a is encompassed by the arms 18 of the magnetic frame members 10 and its ends are spaced only slightly from said arms, thus forming a magnetic flux path of low reluctance which increases the sensitivity of the instrument. The lower extremity of the reed ends in two extensions or ears 23 connected with the body of the reed by means of weakened portions 24 constituting hinges which facilitate setting the reed in vibration upon energization of the driver coil 12. The ears 23 of the reed are seated between ears 26 depending from the base plates 14 and secured in place as by welding. The depending ears 26 seat in radial slots 27 in the insulating disc 15.

The plates 14 contain holes 28 which fit around diametrically opposed bosses 29 in the disc 15.

The two inner contact arms 16, which are secured to opposite sides of the vibratory reed 13, are preferably stamped out of flexible sheet metal and each comprises a pair of spaced parallel side arms 31 having their ends connected by top and bottom yokes or cross arms 32 and 33, respectively, and an inner arm or tongue 34 projecting from the center of the top yoke 32 into the space between side arms 31 and carrying a contact 35 having a flat contact surface. The bottom yokes 33 are bent transversely along a line 36 and the portions of said yokes below the bend 36 are secured to the reed 13 by riveting or welding, so that the entire contact arm 16 above the bend 36 stands out from the reed 13 and the two contact arms 16 together form a V-shape as shown in Fig. 1. A feature of this construction is that the bend line 36 in the contact arm 16 is in the comparatively rigid part of the arm, namely in the bottom yoke 33, below the lower ends of the flexible side arms 31. Hence the predetermined effective length and tuning of the side arms 31 remains unchanged even though the precise location of the bend 36 may vary slightly in different stamping operations and regardless of any variations in the effective width of the flat portion of the yoke 33 below the bend line 36 due to variations in welding or riveting pressure.

The two outer contact arms 17 each comprise a pair of spaced pins or side arms 38 having their outer or free ends connected as by welding to a bar 39 carrying a contact 40 having a flat contact surface which is adapted to cooperate with the contact 35 of the adjacent inner contact arm 16. The lower ends of the pins 38 extend downwardly through spaced bosses 44 in the insulating disc 15 and are attached to small M-shaped plates 43 below the disc 15. The pins 38 contain small flanges 45 which seat against the bosses 44 and thus determine the proper height of the contacts 40. The lower surfaces 22 of the frame members 10 are welded to the plates 14, as shown in Fig. 1. The electrical leads to the outer contact arms 17 may be soldered to the M-shaped plates 43; while the electrical leads to the inner contact arms 16 may extend upwardly through bosses 29 in insulating disc 15 and be soldered to the base plates 14. The pins or side arms 38 of the outer contact arms 17 are bent transversely just above the flanges 45 to enable the contacts 40 to mate in flat face-to-face engagement with the contacts 35 of the respective inner contact arms 16, as shown in Figs. 1 and 2.

In accordance with a feature of the invention, the compliances (i. e., the reciprocal of stiffness) of the inner and outer contact arms 16 and 17 of the vibrator are selected to maintain the contacts 35 and 40 of said arms parallel to each other throughout the working range, and thus prevent one contact from rocking on the other as the arms flex. Maximum contact area is thus maintained under all operating conditions and the contact efficiency and life is improved. The construction of the contact arms to achieve this result will be illustrated with reference to the cooperating inner and outer contact arms 16 and 17 adjacent the right-hand side of Fig. 2, to the salient parts of which the reference letters *a*, *b* and *c* are applied in order to facilitate the description.

With reference to Fig. 2, the compliance of the

contact arm 16 is the sum of the compliances of the component parts of said arm. One of such component parts of the inner contact arm 16 is the portion of the side arms 31 from the base of the free side arms 31 to the line of the contact 35, which is designated *a* in Fig. 2. The other component part of said arm 16 is the U-shaped distance *b* from the aforesaid line of the contact 35 around the yoke 32 and the tongue 34 to the contact 35 itself. The compliance of the outer contact arm 17 is simply the straight compliance *c* from the support of the arm to the contact 40. In such case, when only one of the two cooperating contact arms contains a reverse bend, the ratio of compliances of the various parts of the arms in order to maintain parallel contacts through the working range is:

$$b=a+c$$

For example, if *c* is rigid (compliance zero) then *b* equals *a*. Hence the contact 35 would remain parallel to the rigid contact 40 if the compliances *a* and *b* are made equal. The formula may also be expressed thus: When only one of the cooperating contact arms contains a reverse bend the compliance of the bent arm above the contact line is equal to the sum of the compliance of the remainder of that arm plus the compliance of the other arm. When the compliance ratio has the above characteristic the contact faces will remain parallel throughout the working range as the arms are flexed and their entire areas are available for carrying the current.

Figs. 3 and 4 illustrate a modified construction of the cooperating contact arms in which, however, the formula for determining the ratio of compliances is the same as above stated. In this embodiment of the invention the side arms 31 of the inner contact arms 16 do not have a top yoke (32 in Figs. 1 and 2) but have their outer free ends doubled over in the form of a reverse bend 50 and have contacts 35 secured to the extremities of both bent portions 50. Likewise the side arms 38 of outer contact arms 17 do not have a connecting bar (39 in Figs. 1 and 2) but have contacts 40 secured directly to each of the side arms 38 for cooperation with the contacts 35 of the respective inner contact arms 16. This construction is similar to that shown in Figs. 1 and 2, and the applicable formula is also:

$$b=a+c$$

where *b* represents the compliance of the bent arm 31 from the line of contact 35 around the bend 50 to said contact 35; *a* represents the compliance of the remainder of arm 31, and *c* represents the compliance of the cooperating arm 38, as illustrated diagrammatically in Fig. 4.

The construction illustrated in Figs. 5 and 6 differs from that of Figs. 3 and 4 only in that the side arms 38 of outer contact arms 17 of Figs. 5 and 6 contain a reverse bend 51 and the contacts 40 are carried by the ends of the bent portions 51. In this case the formula for determining the ratio of compliances is:

$$a+d=b+c$$

where *a* and *b* represent the compliances of one contact arm below and above the contact line as in Fig. 4 and *c* and *d* represent the compliances of the cooperating contact arm below and above the contact line respectively, as illustrated diagrammatically in Fig. 6.

Figs. 7 and 8 illustrate a modification of the invention in which the side arms 38 of the outer contact arms contain a reverse bend 51 as in Figs. 4 and 5, but in which the side arms 31 of the inner contact arms are straight. This construction is thus reverse of that shown in Figs. 3 and 4 where it is the inner contact arms which are bent and the outer contact arms which are straight. In this case the formula

$$b=a+c$$

also applies for determining the ratio of compliances, as illustrated diagrammatically in Fig. 8 where *a* and *b* represent the compliances of the parts of the arm 38 below and above the contact line and *c* represents the compliance of the straight arm 31.

In all of the above examples the contact surfaces remain parallel to each other when the compliances of the arms have the ratios specified. The contact pressure varies with the flexing of the arms, but the area of contact does not change. Contact wear is greatly reduced and the life of the contacts correspondingly increased.

Although certain specific embodiments have been shown and described herein for purposes of illustration, it will be evident to those skilled in the art that the invention is capable of various modifications and adaptations within the scope of the appended claims.

What is claimed is:

1. An electromagnetic vibrator comprising a vibratory reed, a pair of inner contact arms carrying contacts mounted on opposite sides of one end of said reed, and a pair of outer contact arms carrying contacts for engagement with the contacts of the respective inner contact arms mounted independently of and extending generally parallel to and in the same direction as said inner contact arms, all of said contact arms having reversely extending portions carrying their contacts and having compliances selected according to the formula

$$a+d=b+c$$

where *a* and *c* represent the compliances of the respective cooperating contact arms from their support to their contact lines, and *b* and *d* represent the compliances of said contact arms from said contact lines around the reverse portions to said contacts.

2. An electromagnetic vibrator comprising a vibratory reed mounted to vibrate in a fixed path, an armature on the free end of said reed, and extending transverse to said path, a pair of inner contact arms carried on opposite sides of said reed standing out from said reed at an angle and containing flat contacts, a pair of outer contact arms each supporting a flat contact for engagement with the contacts of the respective inner contact arms, a magnetic frame having arms extending parallel to said reed on each side thereof and lying beyond and normal to its path of vibration, a driver coil mounted in said frame above said armature, and magnetic arms extending between said first arms on opposite sides of said armature and parallel to said path of vibration to form with said first arms a closed magnetic loop within which said armature vibrates, said last arms being closely spaced from the two ends of the armature along said path of vibration to form therewith a magnetic path of low reluctance.

3. An electromagnetic vibrator comprising a metal base plate, a vibratory reed secured to said plate and extending upwardly therefrom, an armature on the free end of said reed extending

transverse to its path of vibration, a pair of inner contact arms mounted on opposite sides of said reed and supporting flat contacts, a pair of outer contact arms insulated from said base plate and supporting flat contacts for engagement with the contacts of the respective inner contact arms, a pair of elongated transversely curved magnetic frame members extending parallel to said reed on opposite sides thereof, lying beyond and normal to the path of vibration thereof and having their lower ends secured to said base plate, arcuate collars on the other ends of said frame members above said armature forming a supporting ring parallel to said plate, a magnetic-disc carrying a driver coil secured between said arcuate collars with the axis of said coil normal to the plane of said plate, and arms extending between said frame members closely spaced from the two ends of said armature along its path of vibration to form with said armature a magnetic path of low reluctance.

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