June 25, 1946. C. HUETTEN 2,402,815

VIBRATOR

Filed March 18, 1944

Fig.1.

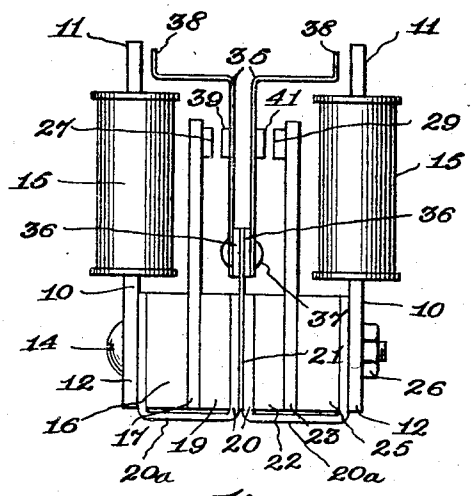


Fig.2.

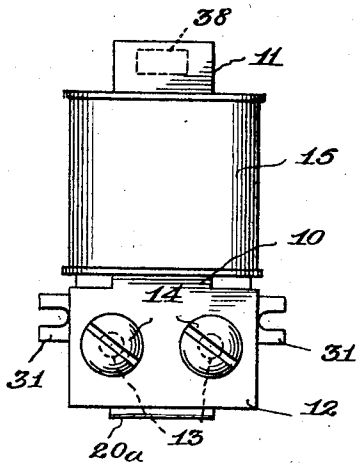


Fig.3.

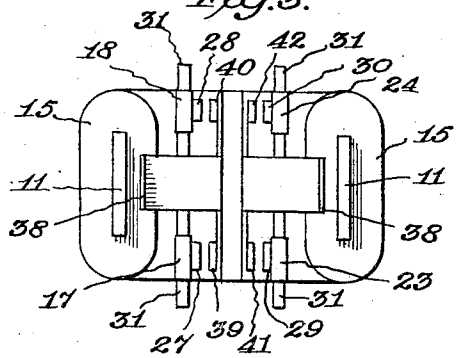


Fig.4.

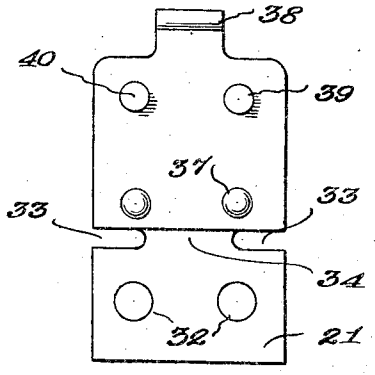
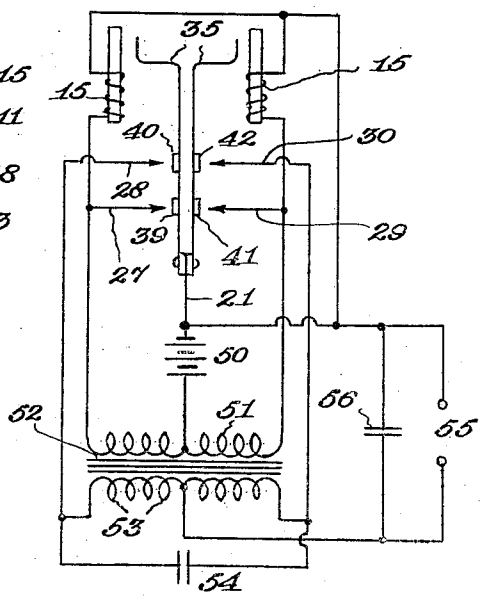


Fig.5.



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VIBRATOR

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Application March 18, 1944, Serial No. 527,061

8 Claims. (Cl. 200—90)

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The present invention relates to vibrators, and, more particularly, to electromagnetic vibratory interrupters adapted to be operated at relatively high frequencies.

As those skilled in the art know, electromagnetic vibratory interrupters are used at present on a substantial scale for converting current drawn from a low-voltage source into alternating current of relatively high voltage which after rectification may supply the plate circuits of radio transmitting and receiving equipment. It has been found to be advantageous to employ vibrators capable of being operated at relatively high frequencies as this made it possible to use transformers and filters of small dimensions. Great practical difficulties have been encountered, however, in the design and production of such high-frequency vibrators and although the suggestions and proposals in this direction have been quite numerous, none of these various suggestions and proposals was completely satisfactory and successful when carried into practice on a commercial scale.

It is an object of the present invention to provide a novel vibrator which overcomes the foregoing difficulties and which may be operated at relatively high frequencies.

It is another object of the present invention to provide a vibratory interrupter of novel and improved character having such balanced electrical, magnetic and mechanical organization as to permit the production of very high rates of interruptory action.

It is a further object of the present invention to provide a vibratory interrupter including a novel type of vibratory element in the form of a pair of individually sprung contact-bearing armature plates constituted of compliant ferromagnetic material.

It is also within contemplation of the invention to provide a novel vibratory interrupter organization in which an individually compliant ferromagnetic armature plate is coordinated to each of two driver coils, said armature plates bearing vibratory contacts adapted to cooperate with substantially non-compliantly supported fixed contacts.

The invention also contemplates a high-frequency vibrator which is very simple in structure, positive and foolproof in operation, 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 drawing; in which

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Fig. 1 illustrates a side elevational view of a preferred embodiment of the invention;

Fig. 2 depicts a front elevational view of the vibrator shown in Fig. 1;

Fig. 3 shows an end view of the vibrator embodying the invention;

Fig. 4 is a front elevational view of the vibratory structure forming part of the vibrator of the invention; and

Fig. 5 illustrates a circuit diagram of a preferred electrical circuit organization employed in connection with the vibrator shown in Figs. 1 to 4.

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, in the preferred form of the invention a dual and symmetrically arranged driver coil system is used comprising two flat strips or cores 10 constituted of ferromagnetic material. The upper ends of said cores constitute pole pieces 11, while their lower ends 12 are formed with lateral extensions in which there are provided holes 13 for stack screws 14. A driver coil 15 is surrounding each of cores 10.

Progressing from one end, the stack comprises one of the core plates 12, metal spacer 20*a*, an insulative spacer 16, a pair of substantially non-compliant side arms 17 and 18, insulative spacer 19, metal spacers 20 having the clamped end of hinge plate 21 therebetween, insulative spacer 22, side arms 23 and 24, insulative spacer 25, metal spacer 20*a*, and the other core plate 12. The stack is held together by means of two stack screws 14 and nuts 26. At the ends of side arms 17, 18, 23 and 24 there are mounted fixed contacts 27, 28, 29 and 30, respectively. The side arms are also provided with integrally formed soldering lugs 31. Metal spacers 20 and 20*a* are preferably integrally formed of ferromagnetic metal strips bent to a U-shaped configuration. The object of these strips is to provide electrical connection between core plates 12 and the reed assembly. At the same time they also complete

the magnetic circuit from the reed assembly to the core plates of the coils.

The vibratory system is constituted of a hinge plate 21 having its lower portion conforming in shape to the lower portion 12 of the core plates 10 and having two holes 32 therein for the stack screws. The intermediate portion of the hinge plate is cut out at 33 as indicated to obtain a weakened portion 34 whereby there is obtained a degree of rotational compliance, as this is more fully explained in my copending application Ser. No. 521,319 filed February 7, 1944. To the upper portion of the hinge plate there are secured two armature plates 35 with two interposed spacer plates 36 by means of rivets 37. The armature plates are constituted of compliant ferromagnetic sheet material, their lower portions extend vertically, their intermediate portions extend substantially horizontally toward pole pieces 11, while their end portions 38 are bent into parallel-spaced cooperating position with respect to said pole pieces. The upwardly extending portions of the armature plates have vibratory contacts 39, 40, 41 and 42 brazed thereon adapted to cooperate with the corresponding stationary contacts 27, 28, 29, and 30, respectively.

The circuit organization of the vibrator will appear from Fig. 5. It will be noted that the source of low voltage 50 has one of its terminals connected to the vibratory system at hinge plate 21, while its other terminal is connected to the center tap of the primary winding 51 of a transformer 52. The ends of the primary winding of the transformer are respectively connected to stationary interrupter contacts 27, 29 and also to one end of coils 15. The other end of coils 15 are connected to hinge plate 21.

The ends of secondary winding 53 of the transformer are respectively connected to stationary rectifier contacts 28 and 30. A buffer condenser 54 is connected across the secondary winding. The rectified output is taken off between terminals 55, one of which is connected to hinge plate 21, while the other is connected to the center tap of the secondary winding. A capacitor 56 may be connected across the output terminals in the conventional manner.

From the foregoing description the operation of the vibrator embodying the invention will be readily understood by those skilled in the art. It will be observed at the outset that upon closing the battery circuit, current will flow from one terminal of the battery through both halves of the primary winding and through both coils back to the other terminal of the battery so that both coils will be simultaneously energized. Each coil will exert an oppositely directed force on its corresponding armature plate 35 so that it would be expected that no displacement of the system of armature plates about hinge plate 21 will result. Experience, however, has surprisingly shown that the most minute asymmetry due to orientation, or possibly unequal magnetic forces, causes the system of armature plates to be deflected in one direction and that with a sufficiently compliant hinge section the force is cumulative. This may be explained by considering that as soon as the most minute displacement of the system of armature plates has taken place, this will move it further away from one pole piece and closer to the other pole piece so that the force in the direction in which the original displacement has taken place is strengthened, while the force in the opposite direction is weakened, thus causing further displacement in the initial direction. Assuming that the initial displacement is in the direction of the coil on the left-hand side, deflection of the system of armature plates will continue until primary contact 27 is closed and thereby the corresponding coil is short-circuited. This will disable one of the coils so that the field of the other will be controlling and will deflect the system of armature plates until primary contact 29 is closed and the other coil is deenergized, and so forth, whereby the vibratory system will be maintained in sustained oscillatory motion. It may be broadly stated that the predominating coil pulls its armature plate till contact is made and its travel has been limited by the contact pressure. The other armature plate maintains this contact pressure by its momentum and through its independent compliance. As this other armature plate swings back toward its own coil, its speed is reduced by the energy absorbed in accelerating the first armature plate and contacts. This results in a slow contact make which is a highly desirable mode of operation. To assure this mode of operation, the side arms carrying the fixed contacts are of a relatively non-compliant but at the same time adjustable character.

In order to provide self-rectifying operation of the vibrator, it is necessary that the rectifier contacts 28 and 30, make after the corresponding interrupter contacts 27 and 29, respectively. In prior self-rectifying vibrators, this was accomplished by introducing a sufficient amount of compliance in the side arms or by mounting the vibratory contacts on auxiliary arms of sufficient compliance. However, the compliance introduced into the vibratory system in this manner reduced the operating frequency and required that the ensuing harmonic oscillations either be tuned or dissipated during the off-contact period. It was found to be practically impossible to produce the desired high-frequency operation of the vibrator by these conventional expedients.

In the instant case, the proper timing of the interrupter and rectifier contacts is obtained by introducing a slight degree of rotational compliance into the hinge section, carrying the armature plates, about the longitudinal axis thereof. This rotational compliance is obtained by providing a substantially weakened portion 34 in hinge plate 21, between the clamped end of armature plates 35 and the clamped end of the hinged plate. In addition, the side arms carrying the fixed contacts are made substantially rigid and non-compliant and are so adjusted as to have the fixed interrupter contacts a little closer to the corresponding vibratory contacts than the rectifying contacts. Thus, during vibration of the armature plate assembly, the force due to the moving armature plate together with the interrupter contact pressure will form a couple which will slightly rotate the armature system about its longitudinal axis and will cause subsequent closure of the corresponding rectifier contact in the proper sequence. This structure and this type of sequential operation is more fully disclosed in my aforesaid application Ser. No. 521,319, to which reference is hereby made.

It will be noted that the vibrator of the invention provides important advantages. Thus, first of all, it comprises a two-coil arrangement with the obvious advantages of mechanical, magnetic and electrical symmetry. Also, the armatures work at the coil ends, which is the most effective position. More energy is obtained by the armatures because more armature travel is obtained

by having separately sprung armatures. The magnetic force acts through a greater distance and hence does more work on the approaching armature. Moreover, the need of compliant side arms or separately sprung reed arms is eliminated along with their spurious and at times uncontrollable harmonics.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. An electromagnetic vibratory interrupter comprising in combination a pair of driver coils, an individually compliant contact-bearing armature for each of said coils having one of its ends freely and independently extending into the magnetic field of the respective coil, a hinge section in common for said armatures connected to the other end thereof and supporting them for vibration, fixed contacts adapted to cooperate with the contacts on said armatures, substantially rigid mounting means for said fixed contacts, and connections constituting a symmetrical electrical system with said coils and contacts alternately to energize and to disable said coils thereby to maintain said armatures in vibration when energy is supplied to the system.

2. An electromagnetic vibratory interrupter comprising in combination a pair of driver coils mounted in parallel-spaced position, a pole piece for each of said coils, an armature constituted of compliant ferromagnetic material for each of said coils and having a portion freely and independently extending into the magnetic field of the respective pole piece in close proximity thereof, a hinge plate in common for said armatures connected at one end to the other end of said armatures and fixed at its other end to support said armatures for joint vibration, vibratory contacts on each of said armatures, fixed contacts adapted to cooperate with said vibratory contacts, and substantially non-compliant mounting means for said fixed contacts, said coils and said fixed and vibratory contacts being connected into an electrical circuit alternately to energize and deenergize said coils and to maintain said armatures in vibration when electrical energy is supplied to said circuit.

3. An electromagnetic vibratory interrupter comprising in combination a stack, a pair of ferromagnetic cores having one of their ends spacedly mounted in said stack and having their other end upwardly extending therefrom and constituting a pole-piece, a driver coil around each of said cores, a hinge plate clamped in said stack substantially equidistantly from said cores, a pair of compliant contact-bearing armature plates having one of their ends connected to the free end of said hinge plate and having their other end freely and independently extending into proximity of the respective pole pieces, a fixed cooperating contact for each of said armature contacts, and stack-clamped mounting means for said fixed contacts, said coils and said fixed and armature contacts being adapted to be connected into a circuit alternately to energize and deenergize said coils and thereby to maintain said armatures in vibration when electrical energy is supplied to said circuit.

4. An electromagnetic vibratory interrupter comprising in combination a stack, a pair of flat elongated ferromagnetic cores having one of their ends spacedly mounted in said stack and upwardly extending therefrom in parallel-spaced position, a driver coil around each of said cores, a hinge plate clamped in said stack substantially equidistantly from said cores, a pair of compliant ferromagnetic armature plates having one of their ends connected to the free end of said hinge plate, the main portion of said armature plates freely and independently extending upwardly and the terminal portions thereof being bent into opposite directions to extend into cooperating position with the free ends of the respective cores, vibratory contacts on said armature plates, a fixed cooperating contact for each of said vibratory contacts, and stack-clamped substantially non-compliant mounting means for said fixed contacts, said contacts being adapted to control a plurality of circuits including that of said coils thereby to maintain said armature plates in vibration.

5. An electromagnetic vibratory interrupter comprising in combination a stack, a pair of strips of ferromagnetic material having one of their ends spacedly mounted in said stack and constituting pole pieces at their other end, a driver coil around each of said ferromagnetic strips, a hinge plate clamped in said stack substantially equidistantly from said strips, a pair of compliant ferromagnetic armature plates having one of their ends secured to the free end of said hinge plate but being capable of individual relative displacement at their other end, the lower portion of said armature plates extending upwardly substantially parallel with said strips, the intermediate portion thereof extending transversely toward said pole pieces and the ends thereof extending into parallel-spaced cooperating position with respect to said pole pieces, vibratory contacts on said armature plates, a fixed cooperating contact for each of said vibratory contacts, and stack-clamped substantially non-compliant side arms for supporting said fixed contacts, said contacts being adapted to control a plurality of circuits including that of said coils thereby to maintain said armature plates in vibration.

6. A composite vibratory structure for an electromagnetic vibratory interrupter adapted to cooperate with a pair of driver coils for controling a plurality of circuits including that of said driver coils which comprises a hinge plate clamped at one end thereof, and a pair of contact-bearing armature plates constituted of compliant ferromagnetic material having one of their ends connected to the free end of said hinge plate and having their other end freely extending into the field of said coils, said armature plates being capable of limited but independent relative displacement with respect to each other.

7. An electromagnetic vibratory interrupter comprising in combination a stack, a pair of ferromagnetic cores having one of their ends spacedly mounted in said stack and having their other end extending therefrom and constituting a pole-piece, a driver coil around each of said cores, a hinge plate clamped in said stack substantially equidistantly from said cores, a pair of compliant contact-bearing armature plates having one of their ends connected to the free end of said hinge plate and having their other end freely and independently extending into proximity of the respective pole pieces, a fixed cooperating contact for each of said armature contacts, stack-clamped mounting means for said fixed contacts, and U-shaped ferromagnetic plates for electrically and

magnetically connecting the clamped ends of said cores with the clamped end of said hinge plate.

8. An electromagnetic vibratory interrupter comprising in combination a pair of driver coils, a contact-bearing armature constituted of compliant ferromagnetic material for each of said coils having one of its ends freely and independently extending into operative position with the respective coil, a hinge section in common for said armatures connected to the other end thereof and supporting them for vibration, relatively fixed contacts adapted to cooperate with said armature contacts, and connections constituting a symmetrical electrical system with said coils and contacts alternately to energize and to disable said coils thereby to maintain said armatures in vibration when energy is supplied to the system, said armatures being capable of limited relative displacement with respect to each other and to individually store and to non-synchronously release kinetic energy for causing slow contact "make" and strong contact pressure immediately after contact "make."

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