Dec. 13, 1949 R. J. AUST ET AL 2,490,895

HIGH-FREQUENCY VIBRATOR

Filed Feb. 22, 1945

Fig. 1

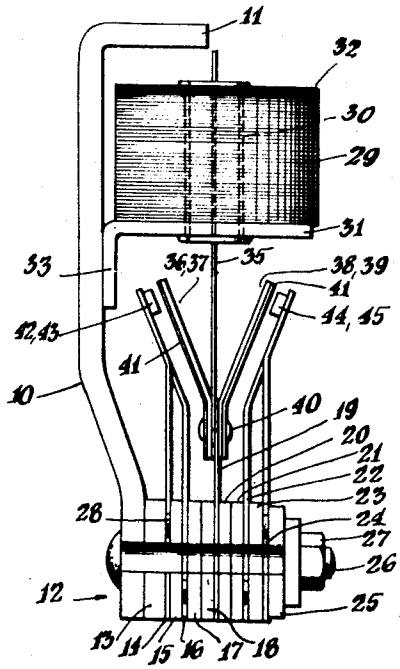


Fig. 2

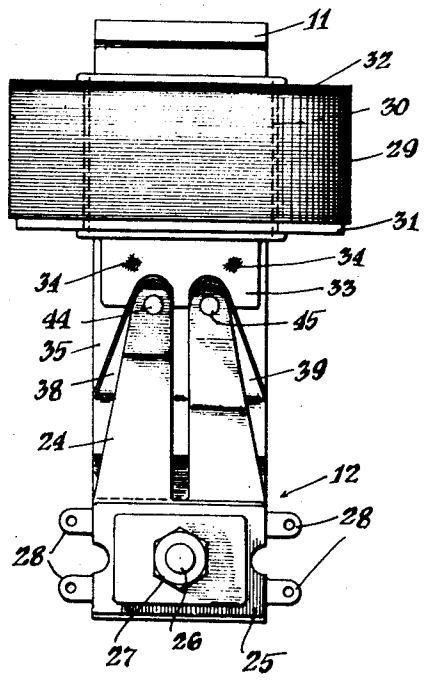


Fig. 3

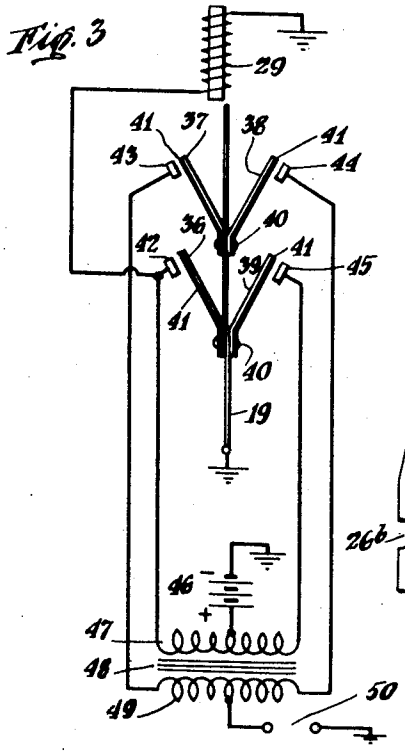


Fig. 5

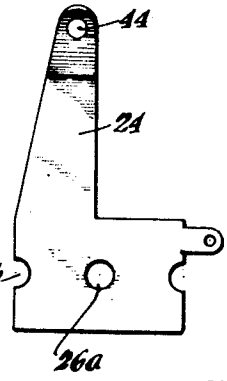
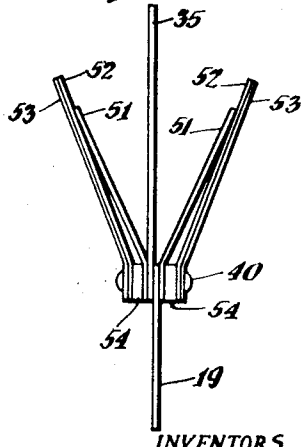


Fig. 4



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HIGH-FREQUENCY VIBRATOR

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11 Claims. (Cl. 200—90)

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This invention relates to vibrators, and, more particularly, to electromagnetic vibratory interrupters having relatively high operating frequencies.

It is an object of the present invention to provide a vibrator including a full-length armature extending through the axial space of a driver coil, characterized by great simplicity of construction, small dimensions and ready adjustability of the air gap and of the reed height by bending the frame of the vibrator.

It is another object of the invention to provide a vibratory electromagnetic interrupter of novel character particularly adaptable to high operating frequencies having an improved one-hole stack construction thereby reducing the overall dimensions of the vibrator by more fully utilizing the available stack surface.

It is a further object of the present invention to provide a vibrator wherein the mass of the reed contacts is greatly reduced whereby optimum conditions for efficient operation at high frequencies are readily obtained and maintained.

Still another object of the invention is to substantially completely eliminate the conventional contact discs from the vibratory system of a vibrator and to replace such discs with a plating or layer of suitable metal upon the surface of the reed arms, adapted to cooperate with relatively rigidly mounted stationary contacts.

It is also within the contemplation of the invention to provide an improved high-frequency vibratory interrupter having plated reed arm surfaces cooperating with fixed contact discs in a novel type of circuit organization to impart negative polarity to the reed arms and thereby effectively to prevent the transfer of contact material from the reed arms to the said contact discs.

The invention also contemplates a novel vibratory electromagnetic interrupter which combines very small dimensions of the operating parts with very slight mass of the vibratory system whereby high frequency operation may be readily attained, and which is excellently adaptable for quantity production 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:

Fig. 1 is a side elevational view of a vibrator embodying the principles of the present invention;

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

Fig. 3 is a circuit diagram of a preferred form of circuit organization in which the vibrator of the invention may be used;

Fig. 4 is a side elevational view of a modified form of reed structure which may be employed in the vibrator of the invention; and

Fig. 5 is a plan view of one of the side arms of the vibrator shown in Figs. 1 and 2.

In the design of vibrators, particularly of vibrators for operation above 200 cycles per second, it is of critical importance to control the effects due to the mass of the contacts mounted at the ends of compliant contact arms or side spring members. The problem is aggravated by the high specific weight of tungsten, which in most cases is the preferred contact material. In lower frequency vibrators, this control may be obtained by various expedients, such as by the use of rigid stops, by tuning the reed arms to a controlled free frequency vibration so that the contact is slowed up and makes with the fixed side spring contact at a low speed without bouncing, or by tuning the oscillations of both the reed arms and of the side springs.

In order to adapt vibrators of the described character to high frequency operation, it would be necessary to reduce the contact mass or to increase the stiffness of the contact-supporting arms, or to employ a combination of these expedients. The contact mass is determined by considerations of contact wear and cannot be reduced by an appreciable amount without greatly reducing the useful life of the vibrator. Increasing the stiffness of the contact-bearing springs is likewise connected with almost unsurmountable difficulties as it reduces the free oscillation amplitude of the said springs and thereby precludes obtaining the benefit of such free oscillations in slowing down contact "make" and in reducing contact bounce.

The principal aspects of the present invention are based on the discovery that in high frequency vibrators the primary interrupter contacts that are positive in polarity tend to erode and wear out, the eroded contact material being transferred to the contacts of negative polarity. In self-rectifying vibrators, the situation is the same with respect to the interrupter contacts, while the rectifier contacts in general show very little or negligible wear, the transfer of contact

material tending to occur in both directions and to a very slight degree.

In accordance with the principles of the invention, this discovery is utilized in the construction of high frequency vibrators of novel and improved character wherein most of the compliance is placed in the reed arms, while the side spring contacts are mounted on substantially rigid members. The heavy contact discs provided on the reed arms of conventional vibrators are dispensed with by employing reed arms which may be plated with a suitable contact material, such as silver, and the like. By providing a circuit organization of such character that the reed arms are of negative polarity, it is assured that the wear or erosion of the contact material, if any, will exclusively occur on the stationary contact discs and that the eroded material will be transferred to the cooperating portion of the surface of the reed arms. Thus, continued operation of the vibrator will not destroy the contact surface of the reed arms but actually will tend to build up such originally thin surface to a contact layer of appreciable and increasing thickness. The thin layer of contact material on the reed arms has merely the object of providing a low resistance surface until the vibrator has been operated long enough for the positive contact material to be transferred over to the negative side thereby providing the desired contact surface.

Reed arms of the desired characteristics may be made of spring steel to the operating surface of which the contact material may be attached by sputtering or spraying on a thin layer thereof. As an alternative, the reed arm contact may be obtained by employing a thin sheet of the contact material biased against the compliant reed arms of spring steel. The desired total reed arm compliance may be also obtained by using spring members, preferably made of spring steel, backing up Phosphor bronze or beryllium copper springs whose surface is plated or inlaid with the desired contact material. In this case an additional advantage is usually obtained, that of the damping effect of free oscillations due to the slight sliding friction obtained at the ends of the two springs of different material.

Of course, the new results and advantages obtainable by the invention are predicated upon a definite polarization of the vibrator in its circuit applications. If the negative side of the battery or other direct current source is grounded then the vibrator reed is likewise grounded and the positive side of the source is connected to the center tap of the primary winding of the transformer. On the other hand, when the positive side of the source is grounded, the primary center tap is also grounded and the reed of the vibrator is connected to the negative side of the source, as it will be set forth more fully hereinafter.

Referring now more particularly to Figs. 1 and 2 of the drawing, reference character 10 denotes a frame member constituted of ferromagnetic material. One end of the said frame member is bent at right angles to the body thereof and constitutes a pole piece 11, and a stack generally denoted by reference character 12 is secured to the other end of the frame member.

Progressing from the frame member, the stack comprises an insulative spacer 13, interrupter side arm 14, insulative spacer 15, rectifier side arm 16, spacers 17 and 18, reed or hinge plate 19, spacers 20 and 21, rectifier side arm 22, insulative spacer 23, interrupter side arm 24, and pressure plate 25. As it will be observed in Figs. 2 and 5, each of the clamped elements is provided with a single mounting hole 26a in the stack portion thereof, such holes or apertures being arranged in registering position and having a single bolt 26 extending therethrough which cooperates with a nut 27 to maintain the structure in its clamped position. The bolt may be surrounded by an insulative sleeve (not shown) in the conventional manner in order to prevent shorting of the metallic elements by the bolt. This one-hole mounting of the stack assembly is made possible by the special construction of the side springs, shown in Fig. 5, each of which comprises a stack portion and an upwardly extending spring portion carrying the contact at its ends, the spring portions of the interrupter and rectifier side springs extending in staggered relation. Preferably, the stack portions of the side springs are provided with integrally formed lateral extensions constituting soldering lugs 28 to facilitate the attachment of electrical conductors thereto. In addition, cut-out portions 26b are provided in the stack portion of the side arms and also in all stack-clamped elements. These cut-out portions may be engaged by means of a suitable tool or jig thereby to positively assure exact registry of all elements of the stack before permanently clamping them together by means of the single stack screw 26 and nut 27.

To an intermediate portion of frame 10 there is secured a driver coil 29. This coil comprises a sleeve or shell 30 of nonmagnetic material, such as brass, having at one end thereof an apertured ferromagnetic flange 31 and at its other end an insulative flange 32 made of fibre, or the like. Ferromagnetic flange 31 has an extension 33 at right angles thereto, which is spot welded or otherwise secured to the frame member, as this is indicated at 34. Sleeve 30 and flanges 31 and 32 jointly define a winding space in which there are arranged the windings of wire constituting the driver coil.

The vibratory system comprises reed or hinge plate 19 clamped in stack 12 at one end thereof and having an armature 35 and four reed arms 36, 37, 38 and 39 secured to the other end thereof by means of rivets 40. It will be noted that in contrast to conventional practice, the reed arms do not carry any contact discs but merely comprise springs of steel or some other metal of equivalent characteristics, which are provided with a thin layer 41 of contact metal. The reed arms cooperate with contact discs 42, 43, 44 and 45, mounted at the ends of side springs 14, 16, 22 and 24, respectively. Good results have been obtained by using silver-plated spring steel reed arms operating against interrupter side spring contact discs constituted of a suitable silver alloy and by using spring steel reed arms plated with any one of the noble metals, such as platinum, or its alloys, operating against rectifier side spring contact discs constituted of tungstem. In both cases the unit is operated with negative potential on the reed whereby the metal transfer will tend to go to the reed arms on the interrupter side. Armature 35 extends through ferromagnetic flange 31, sleeve 30 and fibre flange 32 into closely spaced cooperating relation with respect to pole piece 11 whereby it is exposed to the deflecting effect of driver coil 29, when such coil is energized.

The operation of the vibrator of the invention will be best understood by reference to Fig. 3

illustrating a preferred form of circuit organization in which the vibrator may be used. Similar reference characters have been used in Figs. 1 and 2 and Fig. 3 to denote corresponding parts. It will be noted that reed 19 is grounded and that the negative terminal of direct current source 46 is likewise grounded in order to impart negative polarity to the reed arms. Stationary interrupter contact discs 42 and 45 are respectively connected to the two ends of primary winding 47 of step-up transformer 48 and the center tap of the primary winding is connected to the positive terminal of the source. One end of driver coil 29 is connected to stationary interrupter contact 42 while its other end is connected to ground. Rectifier contact discs 43 and 44 are respectively connected to the two ends of secondary winding 49, and the rectified voltage is withdrawn between terminals 50, one of which is connected to the center tap of the secondary winding and the other is grounded. In view of the fact that, apart from the critically important polarity of the reed and of the reed arms, the circuit is similar to that of a conventional shunt type synchronous vibrator, its operation will be readily understood by those skilled in the art without any further description. It will be sufficient to state that as a result of the negative polarity of the reed and of the reed arms, there will be no erosion of contact material 41 on the said arms and that the layer of contact material on the interrupter reed arms will be built up by transfer of material from the interrupter contact discs thereto. On the other hand, erosion on the rectifier contacts, if any, will occur in both directions, and will not interfere with the proper operation of the vibrator.

Additional advantages of the vibrator of the invention are its small dimensions made possible by having the armature extend through the axial space of the driver coil and by the special one-hole stack construction. Thus, a full length armature may be employed, adjustment of the air gap between the pole piece and the free end of the armature being accomplished by bending the frame. In general, conventional 40 ohm shunt coils are used in the electromagnetic driver system for operation at 6 volts.

Vibrators of the described character have been built for operation at 250 to 300 cycles per second having an overall length of only 1⅝" and vibrators for operation at 400 cycles per second having an overall length of about 1⅝", with excellent performance characteristics. Vibrators as short as 1½" have been built having completely satisfactory performance.

Fig. 4 illustrates a modified reed construction embodying the principles of the present invention comprising a reed 19 having an armature 35 and two reed arms secured thereto by means of rivets 40. The said reed arms each comprise a steel spring 51, backing up a Phosphor bronze or beryllium copper spring 52 whose surface is plated with a layer of contact material 53. A spacer plate 54 is interposed between the clamped portion of springs 51 and 52 in order to have them extend at slightly different angles and to have the ends of springs 51 slidably engaging the terminal regions of springs 52. This type of structure has the added advantage that it provides a damping effect upon the free oscillations of the reed arms by the sliding friction produced at the corresponding regions of springs 51 and 52.

Although the present invention has been disclosed in connection with a few preferred embodiments thereof, variations and modifications may be resorted to by those skilled in the art without departing from the principles of the present invention. 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 comprising in combination a substantially L-shaped ferromagnetic frame, a stack mounted at one end of said frame, a pole piece defined by the other end of said frame, a driver coil with an axial space therein mounted on an intermediate portion of said frame, a vibratory armature clamped in said stack and freely extending through said coil into cooperating relation with said pole piece, vibratory contacts carried by said armature, and stack-clamped relatively fixed contacts adapted to cooperate with said vibratory contacts to control a plurality of electrical circuits including that of said driver coil thereby to maintain the armature in vibration.

2. A vibratory interrupter comprising in combination an elongated ferromagnetic frame plate having one of its ends bent up to constitute a pole piece, a stack mounted on the other end of said plate, a driver coil having a ferromagnetic flange secured to an intermediate portion of said frame plate adapted when energized to set up a magnetic field between said flange and said pole piece and through the axial space of said coil, an armature mounted for vibration in said stack freely extending through said flange and said coil into cooperating relation with said pole piece, vibratory contacts compliantly mounted on said armature, and stack-clamped relatively fixed contacts adapted to cooperate with said vibratory contacts to alternately energize and deenergize a plurality of electrical circuits including that of said driver coil thereby to maintain the armature in vibration.

3. A vibratory interrupter comprising in combination an elongated ferromagnetic frame plate having one of its ends bent up to constitute a pole piece, a stack mounted on the other end of said plate, a driver coil having a ferromagnetic flange welded to an intermediate portion of said frame plate extending along the plate in proximity to said pole piece adapted when energized to set up a magnetic field between said flange and said pole piece through an axial space in the coil, an armature mounted for vibration in said stack freely extending through said flange and coil into cooperating relation with said pole piece, compliant reed arms carried by said armature bearing vibratory contact surfaces, and stack-mounted substantially non-compliant fixed contacts adapted to cooperate with said vibratory contacts, the air gap and armature position with respect to the pole piece being adjustable by bending said frame plate.

4. A short vibrator particularly for high-frequency operation comprising in combination a driver coil having a ferromagnetic flange at one end thereof and an axial space therein, a ferromagnetic plate secured to said flange and transverse thereto, a stack on one end of said plate and a bent-up pole piece at the other end of said plate, an armature mounted for vibration in said stack and freely extending through said coil in proximity to said pole piece, and contact means operable by said armature adapted

to control a plurality of electric circuits including that of said coil thereby to maintain the armature in vibration.

5. A vibratory interrupter comprising in combination a stack, a vibratory reed clamped in said stack bearing vibratory contacts, electromagnetic driving means for said reed, stationary contacts for cooperation with said vibratory contacts, a side spring for each of said stationary contacts, each of said side springs having a stack-clamped main portion and an elongated spring portion carrying the contact, the spring portions of adjoining side springs being staggered with respect to each other, insulative spacers interposed between said main portions of the springs, a bolt extending through a single aperture provided in registering position in said springs and spacers to hold the stack together, and cut-out portions in the stack portions of said side springs and in said spacers adapted to cooperate with corresponding surfaces of a suitable tool to hold the said elements in registry during the clamping operation.

6. A vibratory interrupter comprising a combination a stack, a vibratory reed clamped in said stack bearing vibratory interrupter and rectifier contacts, a driver coil for said reed, relatively stationary interrupter and rectifier contacts for cooperation with said vibratory contacts, a side spring for each of said stationary contacts, each side spring having a stack portion with a single aperture therein clamped in said stack and an elongated spring portion carrying the contact at the end thereof, the spring portions of the interrupter and rectifier contacts being staggered and extending side by side with respect to each other, apertured insulative spacers interposed between the stack portions of the springs, and locking means extending through the single aperture of the springs and spacers to hold the stack together.

7. A vibrator comprising in combination a ferromagnetic frame, a stack mounted on one end of said frame, a pole piece defined by the other end of said frame, a vibratory reed clamped in said stack and carrying an armature extending in proximity to said pole piece, a driver coil carried by said frame, vibratory interrupter and rectifier contacts compliantly mounted on said reed, relatively stationary interrupter and rectifier contacts for cooperation with said vibratory contacts, a side spring for each of said stationary contacts, each side spring having a stack portion with a single aperture therein clamped in said stack and an elongated spring portion carrying the contact at the end thereof, the spring portions of the interrupter and rectifier contacts being staggered and extending side by side with respect to each other, insulative spacers each having a single aperture interposed between the stack portions of the springs, and means extending through the registering apertures in said frame, reed, springs and spacers to hold the stack together.

8. A vibrator comprising in combination a ferromagnetic frame, a stack mounted on one end of said frame, a pole piece defined by the other end of said frame, a driver coil with a ferromagnetic flange secured on an intermediate portion of said frame, a vibratory reed clamped in said stack and supporting an armature extending through said flange and said coil into cooperative relation with said pole piece, vibratory interrupter and rectifier contacts compliantly mounted on said reed, relatively fixed interrupter and rectifier contacts for cooperation with said vibratory contacts, a side spring for each of said stationary contacts,

each side spring having a stack portion with a single aperture therein clamped in said stack and an elongated spring portion carrying the contact at the end thereof, the spring portions of the interrupter and rectifier contacts being staggered and extending side by side with respect to each other, apertured insulative spacers interposed between the stack portions of the springs, and a single bolt extending through the registering apertures in said frame, reed, springs and spacers to hold the stack together.

9. A vibratory interrupter comprising in combination a stack, a reed clamped in said stack at one end and carrying an armature at the other end, a driver coil for said armature, a pair of composite reed arms on said reed, each of said arms including a strip of spring metal and a superposed strip of resilient metal of high conductivity having a substantially continuous deposit of contact material thereon surface portions of which directly constitute vibratory contacts of negligible mass, said superposed strips having one of their ends spacedly mounted on the reed and having their free portions extending at slightly different angles for sliding frictional engagement at their other ends, and stack-mounted stationary contacts of appreciable mass adapted to cooperate with said surface portions of the said deposits of contact material to control the current flow in a plurality of circuits including that of said driver coil, the direction of said flow being so selected as to impart negative polarity to the reed and to the contact material thereon.

10. A vibratory interrupter comprising in combination a substantially L-shaped ferromagetic frame, a stack mounted at one end of said frame, a pole piece defined by the other end of said frame, a driver coil with an axial space therein mounted on an intermediate portion of said frame, a plurality of single apertured elements including a vibratory armature stack-mounted by said aperture, said armature freely extending through said coil into cooperating relationship with said pole piece, vibratory contacts carried by said armature, said contacts being constituted by a thin coating of contact metal, and single apertured stack-clamped relatively fixed contacts adapted to cooperate with said vibratory contacts to control a plurality of electrical circuits.

11. A vibratory interrupter comprising in combination a stack, a vibratory reed clamped in said stack bearing vibratory contacts, said contacts being formed as a thin layer of contact metal, electromagnetic driving means for said reed, stationary contacts for cooperation with said vibratory contacts, a side spring for each of said stationary contacts, each of said side springs having a stack-clamped main portion and an elongated spring portion carrying the contact, the spring portions of adjoining side springs being staggered with respect to each other, insulative spacers interposed between said main portions of the springs, a bolt extending through a single aperture provided in registering position in said springs and spacers to hold the stack together, and cut-out portions in the stack portions of said springs and in said spacers adapted to cooperate with corresponding surfaces of a suitable tool to hold the said elements in registry during the clamping operation.

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