

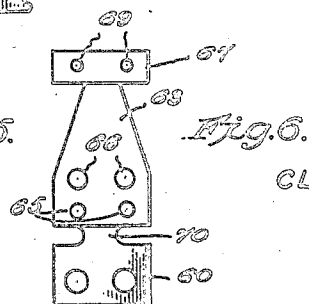
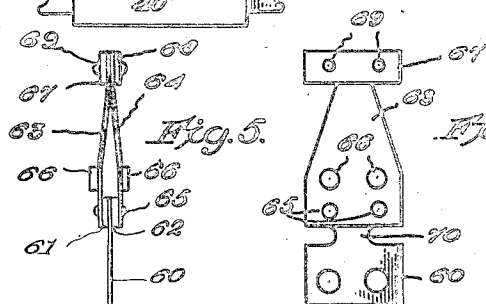
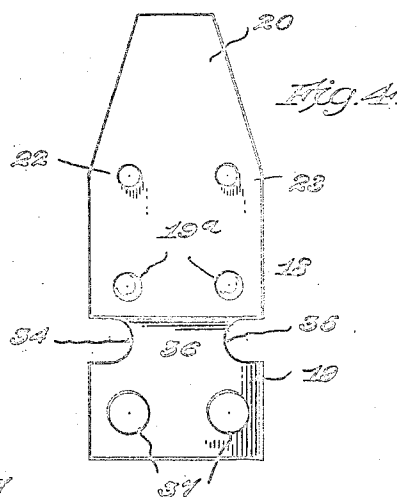
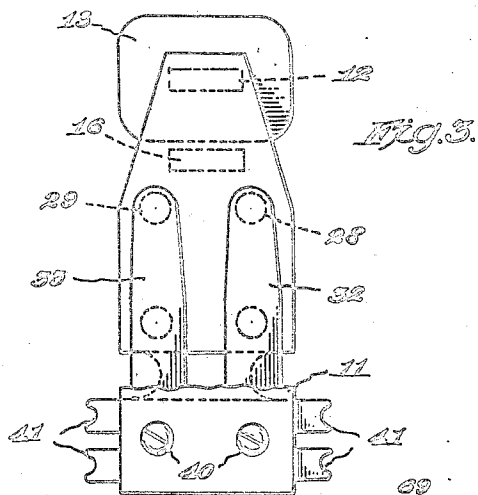
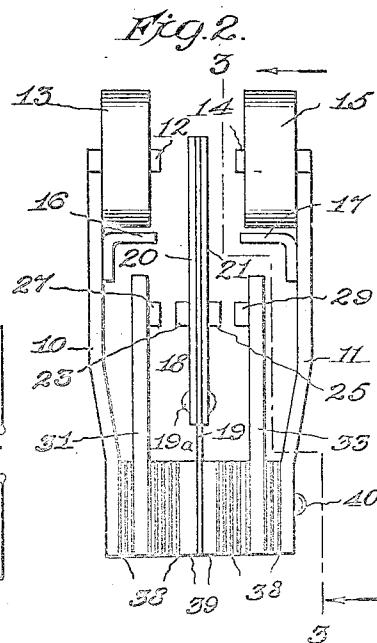
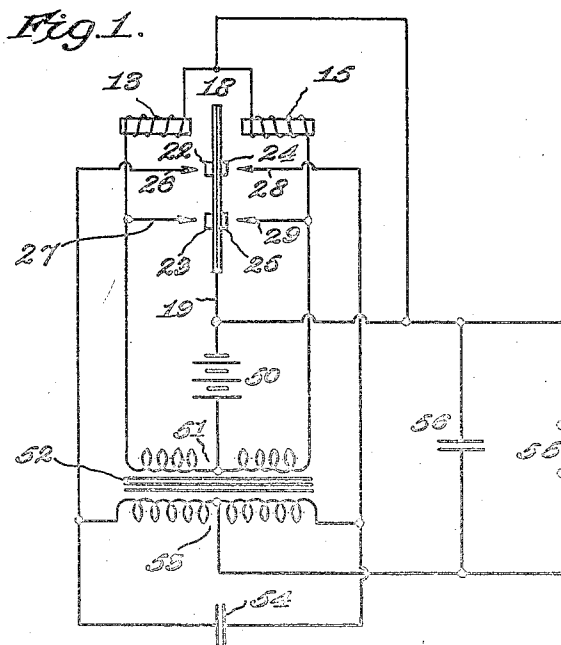
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2,440,145

ELECTRIC VIBRATORY INTERRUPTER

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ELECTRIC VIBRATORY INTERRUPTER

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

As those skilled in the art know, electric vibratory interrupters in combination with step-up transformers 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 that in general it is advantageous to employ high vibrator frequencies, as this allows the use of smaller transformers and smaller filters for obtaining the desired output. Great practical difficulties have been encountered, however, in the design 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 which in addition to the conventional compliance about a horizontal axis also possesses a degree of rotational compliance about a vertical axis whereby the proper and desired sequential operation of interrupter and rectifier contacts is positively obtained.

It is also within contemplation of the invention to provide a novel vibratory element organization in the form of a composite reed having valuable vibratory characteristics and which is capable of maintaining the vibratory rate substantially constant regardless of contact wear and changes in the operating voltage.

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 fol-

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lowing description, taken in conjunction with the accompanying drawing; in which

Fig. 1 illustrates a circuit diagram of a preferred electrical circuit organization employed in connection with the vibrator embodying the invention;

Fig. 2 depicts a side elevational view of a preferred embodiment of the invention into a vibrator;

Fig. 3 shows a longitudinal sectional view, having parts in elevation, taken on line 3-3 of Fig. 2;

Fig. 4 is a front elevation of the reed assembly of the vibrator shown in Figs. 2 and 3;

Fig. 5 is a side elevational view of a modified form of reed; and

Fig. 6 is a front elevation of the reed shown in Fig. 5.

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 means, 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. 2 to 4 of the drawing, in the preferred form of the invention a dual coil-frame structure is employed comprising two substantially L-shaped ferromagnetic frame members 10 and 11. The upper extremity of frame member 10 forms a central pole piece 12 and carries a driver coil 13, while the corresponding extremity of frame member 11 forms another central pole piece 14, facing the first pole piece, and carries another driver coil 15. Auxiliary pole pieces 16 and 17 are welded or otherwise secured to frame members 10 and 11, respectively, and cooperate therewith in producing a strong magnetic field for operating a reed assembly.

The reed assembly, generally denoted by reference character 18, comprises an elongated, upwardly tapering piece of thin spring metal, or hinge, 19. Two pieces 20 and 21 of heavy ferromagnetic sheet metal, such as silicon steel, or the like, of a shape corresponding to the upper portion of hinge 19, are secured to opposite faces of the hinge by means of rivets 19a and constitute the armature of the vibratory structure. Two vibratory contacts 22 and 23 are brazed on armature plate 20 and two similar contacts 24 and 25 are brazed on armature plate 21 in corresponding position. Vibratory contacts 22, 23, 24 and 25, respectively cooperate with relatively stationary

contacts 26, 27, 28 and 29, respectively carried at the ends of side arms 30, 31, 32, and 33. The four side arms are relatively rigid and in contrast to conventional practice have very slight compliance. The portion 36 of hinge 19 between the armature and the clamped end thereof is greatly weakened by cut-out portions 34 and 35 for reasons to be explained more fully hereinafter, and two holes 37 are punched in the lower extremity of the hinge. Similar aligned holes are provided in the lower end of the frame members and of the side arms whereby the several cooperating elements may be mounted in a stack spaced from each other by insulative spacer members 38 and metal spacers 39 and are held together by means of clamping screws 40. Soldering lugs or terminals 41 extend from the stack, some or all of which may be integrally formed with the side arms, if desired.

The circuit organization of the vibrator will appear from Fig. 1. It will be noted that the source of low voltage 50 has one of its terminals connected to reed assembly 18, while its other terminal is connected to the center tap of the primary winding 51 of a transformer 52. One end of the primary winding of the transformer is connected to stationary interrupter contact 27 and coil 13, the other end of said winding being connected to stationary interrupter contact 29 and coil 15. The two other ends of coils 13 and 15 are connected to reed assembly 18.

The ends of secondary winding 53 of the transformer are respectively connected to stationary rectifier contacts 26 and 28 respectively. 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 the reed assembly, 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 13 and 15 will be energized simultaneously. Each coil will exert an oppositely directed force on the armature so that it would be expected that no displacement of the armature will result. Experience, however, has surprisingly shown that the most minute asymmetry due to orientation, or possibly unequal magnetic forces, causes the reed 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 reed 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 displacement has taken place is strengthened while the force in the opposite direction is weakened, thus causing further displacement in the initial direction, etc. Assuming that the initial displacement is in the direction of coil 13, deflection of the reed assembly will continue until primary contact 27 is closed and thereby coil 13 is short-circuited. This will disable the magnetic field of coil 13 so that the field of coil 15 will be controlling and will deflect the reed assembly in the opposite direction until primary contact 29 is closed and coil

15 is deenergized, and so forth, whereby the reed assembly will be maintained in sustained oscillatory motion. It is worth noting that this type of operation is different from the operation of prior vibrators having a differential coil organization in which an intentional mechanical or magnetic asymmetry is introduced whereas in the instant case reliance is made on extremely slight asymmetrical relations in a structure which to all practical considerations is symmetrically built.

In order to provide self-rectifying operation of the vibrator, it is necessary that the rectifier contacts 26 and 28, respectively, 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 of the reed assembly 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 accordance with the present invention, the proper timing of the interrupter and rectifier contacts is obtained by introducing a slight degree of rotational compliance into the hinge section, about the vertical axis thereof. In the preferred embodiment of the invention, this rotational compliance is obtained by providing a substantially weakened portion 36 in the hinge, between the armature and the clamped end of the hinge. In addition, the side arms are made relatively rigid and non-yielding and are adjusted so as to have the stationary interrupter contacts a little closer to the corresponding vibratory contacts than the rectifying contacts. Thus, during vibration of the reed assembly, the force due to the moving armature together with the interrupter contact pressure will form a couple which will slightly rotate the armature about its vertical axis and will cause subsequent closure of the corresponding rectifier contact. In other words, the structure of the invention combines the necessary compliance for starting and for contacting sequence in a single element.

When two contacts come together at high speed, undesirable "bouncing" is produced, particularly at higher frequencies and such "bouncing" may comprise a major percentage of the cycle. In general, proper placement and design of the compliances is employed to reduced "bouncing." In the instant case magnetic forces replace the mechanical compliances, said magnetic forces exceeding the rotational forces of the making contacts. The circuit of the vibrator of the invention actuates the armature in relay fashion and comprises the central pole, the frame, the auxiliary pole and the armature, all in series. Of course, a number of modifications may be resorted to in order to obtain optimum results, the most obvious of these being changes in the mechanical arrangement, selection of suitable magnetic materials, lamination, and the like.

Additional advantages of this preferred embodiment of the invention are that as contacts wear, the armature will travel further whereby more energy is received into the system. This permits a greater range of wear on the contacts, than this was possible with conventional actuating means, thereby providing a considerably

longer useful life for the vibrator before replacement becomes necessary. No contact "rock" or "scoot" is involved in the operation of the novel vibrator so that these most important sources of high contact resistance are completely eliminated. With single-pole interrupter arrangements, the asymmetrical magnetic effect becomes very pronounced at high frequencies and this difficulty is fully remedied by the dual coil arrangement of the present invention. By using a vibrator of the described character, operating frequencies as high as 520 cycles per second, and over, have been successfully obtained and maintained over long periods of time.

Figs. 5 and 6 illustrate a modified reed structure which provides excellent results in the vibrator structure embodying the invention. This reed structure is of a composite character and comprises a thin spring steel stack part and hinge section 60, held between two spacers 61 and 62 and two outer auxiliary reed members 63 and 64 likewise made of spring steel, by means of rivets 65. These outer reed members have contacts 66 directly brazed to them in appropriate position. The other ends of the outer reed members are secured together between two ferromagnetic weights or armature members 67 and 68 by means of rivets 69. The hinge section of the composite reed is identical with that of the reed shown in Fig. 4 and is provided with a weakened portion 70 which imparts a rotational compliance to the hinge about a vertical axis. As the stationary interrupter contact exerts a pressure upon the corresponding vibratory contact, a torque is produced effective in rotating the vibratory rectifier contact to a contacting position without recurring to compliant side springs or independently sprung reed arms. The advantages of this improved structure, however, are not restricted to self-rectifying vibrators but substantial advantages, such as automatically equalized and balanced contact pressures, are assured in non-synchronous or interrupter vibrators.

The upper reed section of this novel composite reed structure has such mechanical characteristics that, upon application of a deflecting force, the reed will be bent in the immediate proximity to the weights, and such bending will progress downwards as the two auxiliary or outer reeds roll together. Hence, the greater the amplitude of the vibrations, the greater is the effective bending length of the reed. This tends to compensate for the frequency increase caused by the increase of amplitude when higher operating voltages are applied. In other words, the operating frequency may be maintained substantially constant even though the operating voltage may be subject to considerable variations. Thus, it was found that the operating voltage could be increased from 4 to 8 volts with a change of frequency of only $\frac{1}{2}$ cycle. Of course, this excellent frequency stability is of great practical value in vibrator power supply systems supplied from storage batteries where considerable changes in operating voltage are frequently unavoidable.

At comparatively low frequencies, such as 150 cycles per second, this reed assembly operated in conjunction with rigid mating contacts had a harmonic contact frequency of 3 to 1. At higher frequencies, however, this ratio becomes 1 to 1 and is not very critical. At even higher frequencies, the harmonic motion cannot be distinguished by stroboscopic observation. Also

at these higher frequencies the frequency compensation effect referred to in the foregoing becomes smaller.

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. In an electromagnetic vibratory interrupter including a vibratory reed, electromagnetic means for deflecting said reed, and interrupter and rectifier contact means operable by said reed and controlling said electromagnetic means thereby to maintain said reed in vibratory motion, the improvement which comprises a hinge plate for said reed having weakened portions to impart rotational compliance thereto, armature plates secured to both faces of said plate, and contact discs on said armature plates and forming the vibratory part of said contact means, said rotational compliance being so determined with respect to contact spacing as to cause sequential operation of said interrupter and rectifier contact means.

2. A composite reed structure for an electromagnetic vibratory interrupter adapted to co-operate with an electromagnetic driving system and with non-compliant stationary contacts for controlling a plurality of circuits including a driver circuit for said system, an interrupter circuit, and a rectifier circuit which comprises a hinge plate clamped at one end thereof, a pair of substantially non-compliant armature plates secured to the opposite faces of the upper portions of said hinge plate spacedly from its clamped end, cut-out portions in the hinge section of said hinge plate to impart rotational compliance thereto, and vibratory interrupter and rectifier contacts on each armature plate capable of sequential cooperation with said stationary contacts during rotational displacement of said reed structure about its vertical axis.

3. A high-frequency electromagnetic vibratory interrupter comprising in combination a symmetrically arranged dual electromagnetic driver system; a composite reed assembly substantially symmetrically mounted with respect to said system; said reed assembly including a hinge plate clamped at one end thereof, an armature plate secured to each side of said hinge plate spacedly from the clamped end thereof and defining a hinge section therein, and weakened portions in its hinge section to impart rotational compliance to the reed assembly; a plurality of substantially non-compliant stationary contacts, and a plurality of vibratory contacts on said armature plates adapted to cooperate with said stationary contacts to alternately disable one-half of said driver system and to sequentially control an interrupter and a rectifier circuit.

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