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VIBRATOR CIRCUIT

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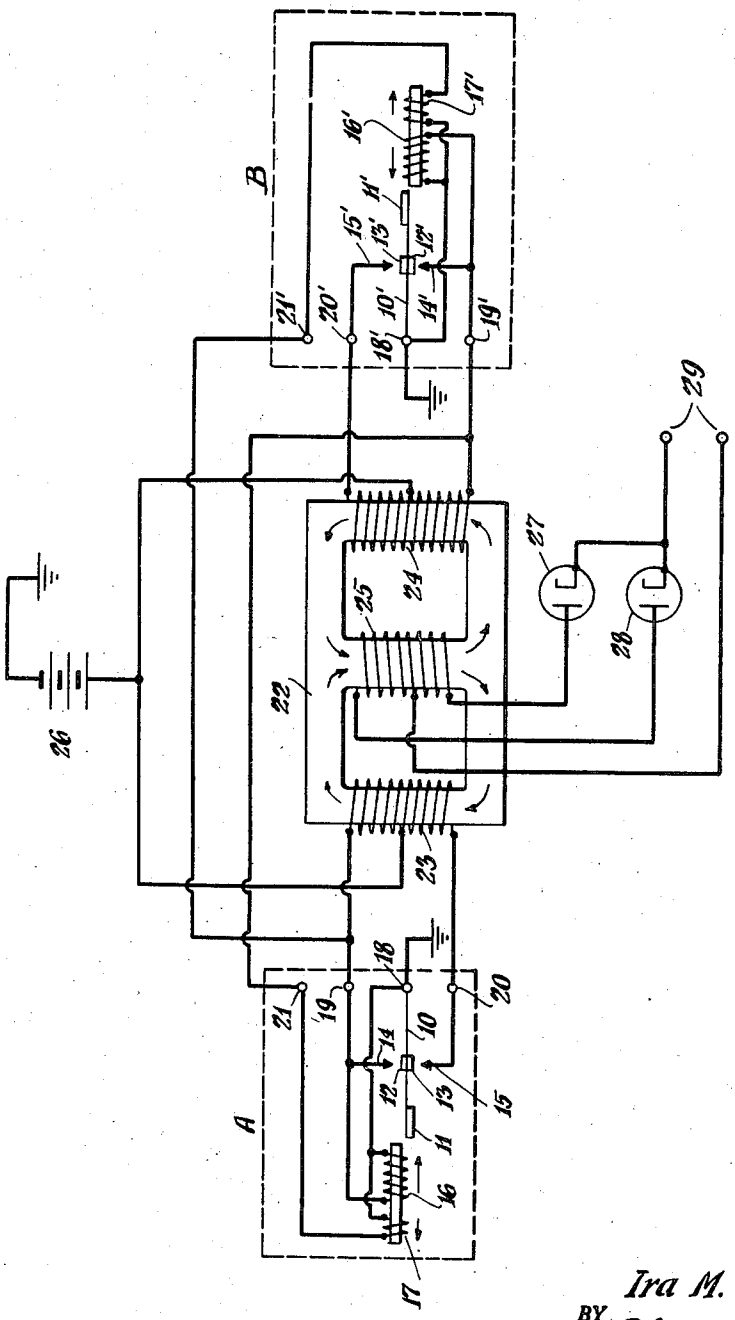

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VIBRATOR CIRCUIT

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The present invention relates to vibratory electromagnetic interrupters, and more particularly, to a vibrator circuit of novel and improved character.

As those skilled in the art know, conventional vibrators essentially comprise a vibratory reed adapted to control a system of contacts and an electromagnetic driver system whereby the reed may be maintained in vibration to interrupt the flow of current in the primary winding of a transformer at a rapid rate. The amount of current which may be controlled by a vibrator is limited by the current-carrying ability of the system of contacts as excessive currents cause strong contact sparking and greatly reduce the useful life of the vibrator. In general, it is not considered advisable to handle currents over five amperes by means of a single vibrator, and when currents in excess of five amperes are to be interrupted, parallel connection of vibrators is resorted to.

Various systems have been worked out to operate two, or more, vibrators in parallel, but practical difficulties were frequently encountered in the applications of such systems. Parallel operation of a plurality of vibrators is predicated upon maintaining perfectly synchronous operation of the several vibratory reeds, this condition being obtained in most cases by initially tuning the reeds to the same natural frequency and by connecting their driver coils together so that they are substantially synchronously energized. While these operating conditions could be obtained by a sufficient amount of part selection during the manufacturing process, experience has shown that the synchronous conditions thus obtained are maintained with difficulty for extended operative periods as the wear upon the contacts of the several vibrators, the distribution of load therebetween, etc., would change their operating frequencies. Although from time to time various suggestions and proposals were made to eliminate the foregoing difficulties and to provide a completely reliable synchronous vibrator system, none, as far as is known, of these suggestions and proposals was completely satisfactory and successful when carried into practice on a practical and commercial scale.

It is an object of the present invention to provide a completely satisfactory solution of the outstanding problem.

It is another object of the present invention to provide a vibrator system in which two vibrators initially tuned to substantially identical frequencies may be maintained in synchronous operation throughout the useful life of the vi-

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brators and regardless of contact wear, changes in contact adjustment, and other variables.

It is also within the contemplation of the invention to provide a vibrator circuit, including a pair of vibrators tuned to the same operating frequency, in which each vibrator during the operation thereof transmits a controlling or synchronizing signal to the other, whereby the condition of exact synchronism is positively maintained under the most rigorous operative conditions.

The invention also contemplates a vibrator system constituted of two vibrators mutually influencing their operating frequency towards exact synchronism which is simple in character, 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, illustrating a typical circuit organization embodying the invention.

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 the drawing, the preferred organization of the invention includes two vibratory interrupters generally denoted by A and B. Vibrator A comprises a vibratory reed 10 clamped at one end thereof, and carrying a pair of vibratory interrupter contacts 12 and 13 at an intermediate portion thereof. Vibratory contacts 12 and 13 cooperate with relatively fixed contacts 14 and 15, respectively. The armature is under the control of two coils placed around the same iron core, of which coil 16 is the driver coil, while coil 17 is a synchronizing or control coil. In general, the driver coil is constituted of many turns of wire, while the synchronizing or control coil is constituted of a few turns of wire so that its magnetic effect is merely a small fraction of that of the main driver coil, such as, for example, 10%. The two coils are connected to produce magnetic fields of opposite direction, for reasons which will appear more fully as the description proceeds. Reed 10 is connected to terminal 18 of the vibrator and

to ground, stationary contacts 14 and 15 are connected to terminals 19 and 20, respectively. One end of coils 16 and 17 is connected together and to reed 10, the other end of coil 16 is connected to stationary contact 14, while the other end of coil 17 is connected to terminal 21.

Vibrator B is the exact duplicate of vibrator A and is tuned to substantially the same operating frequency. Its elements are denoted by similar reference characters 10' to 21' in exact correspondence with elements 10 to 21 of vibrator A so that it will not be necessary to repeat description of the vibrator organization.

The two vibrators are electrically associated with the same step-up transformer 22, having two primary windings 23 and 24 and a common secondary winding 25, and are energized from the same source 26 of low direct current voltage, one terminal of which is connected to the center tap of both primary windings and the other terminal of which is grounded. The two fixed contacts of vibrator A, 14 and 15, are connected to the two ends of primary winding 23 through vibrator terminals 19 and 20, respectively, whereas the fixed contacts of vibrator B, 14', 15', are connected to the two ends of primary winding 24 through vibrator terminals 19' and 20', respectively. In addition, terminal 21 of vibrator A is connected to terminal 19' of vibrator B and terminal 21' of vibrator B is connected to terminal 19 of vibrator A.

From the foregoing description, the operation of the vibrator system of the invention will be readily understood by those skilled in the art. Considering first vibrator A and disregarding the operation of synchronizing or control coil 17, it will be noted that driver coil 16 will be energized, its circuit being from the positive terminal of source 26, the upper half of primary winding 23, driver coil 16, terminal 18, and through ground back to the negative terminal of the source. Reed 10 will be deflected, until vibratory contact 12 closes with fixed contact 14, and short-circuits the driver coil. Upon the driver coil being de-energized, reed 10 will be returned by its compliance beyond its original position to bring contacts 13 and 15 into engagement and then swings back into its center position where the deflecting force of the driver coil becomes again effective and a new cycle of operation is initiated. Thus, the reed will be maintained in continuous vibration and will alternately ground the two ends of primary winding 23 through fixed contacts 14 and 15, alternately passing current in opposite directions through the two halves of the said primary winding in a manner well understood.

The same remarks apply to vibrator B which will be operated in exactly the same manner and will alternately pass current in opposite directions through the two halves of primary winding 24. As is indicated by the arrows on transformer 22, the two primaries are so wound and connected in circuit that their fluxes are additive in the portion of the core within secondary winding 25 so that an alternating current voltage corresponding to the vectorial sum of both primary currents will be induced in the said secondary winding. This alternating voltage may be rectified by means of a pair of half-wave rectifier tubes 27 and 28, the plates of which are respectively connected to the two ends of the secondary winding. The direct current output may be taken off between terminals 29 of which one is connected to the cathodes of both rectifier tubes, while the other is connected to the center tap of the secondary winding. Of course, this manner of operation is only true in case the two vibrators are operating in exact synchronism as a result of their initial tuning to the same frequencies. It is, of course, possible to eliminate the rectifiers where A. C. output is desired.

To understand the function and the operation of control or synchronizing coils 17 and 17', let us first assume that the two vibrators are operating in exact synchronism. Control coil 17 being connected across driver coil 16', it will be energized synchronously and in phase with the said coil. The same applies to control coil 17' of the other vibrator which is energized from and in phase with the current in driver coil 16. As the fields of control coils 17 and 17' are oppositely directed to those of the respective driver coils on the same core, they will have no effect upon the synchronism of the two vibrators except that they will slightly weaken the magnetic field of each and will slightly reduce their amplitudes by equal amounts. This condition will be maintained as long as the two vibrator reeds are moving in exact synchronism. It will be understood that the term "synchronism," as used in the specification and the appended claims, refers to operation of the two interrupters at the same frequency and in the same phase relationship.

In case for any reason vibrator A will operate at a frequency in excess of that of vibrator B, reed 10 will lead reed 10', and contact 14 will be closed before contact 14'. In other words, driver coil 16 will be de-energized before driver coil 16'. Therefore, control coil 17 of vibratory A, energized in phase with driver coil 16' of vibrator B, will remain energized for a short interval even after driver coil 16 has been already de-energized. Since the field of control 17 is oppositely directed to that of driver coil 16, it will cause a more rapid collapse of the flux in the core, to more rapidly reduce the pull of the electromagnet on armature 11 of reed 10, thereby slowing down the operation of vibrator A.

In case vibrator A operates at a frequency below that of vibrator B, contact 14' will close before contact 14, and thus control coil 17 will be de-energized before driver coil 16. As the fields of coils 16 and 17 are oppositely directed, the absence of the field of coil 17 will increase the field of driver coil 16 so that the reed 10 will be subjected to a stronger deflecting force and will be speeded up. Of course, the frequency control between the two vibrators is mutual, because whenever one of the vibrators is operating slower than the other, the other is operating faster than the first, and vice versa, so that the frequency of both vibrators will be influenced in such direction as to eliminate any frequency difference and to stabilize the frequency of operation somewhere between the two frequencies the vibrators would have in the absence of any stabilizing means.

As the control coils should have a much weaker magnetic field than the driver coils, they should be designed to have higher resistance or be connected in series with external regulating resistances.

The advantages of the circuit of the invention are numerous. First of all, synchronous operation is obtained within a few cycles after the operation of the vibrators has been initiated and such synchronism is automatically maintained substantially throughout the useful life of the vibrators, regardless of normal contact wear, and other variables. Also, while the two vibrators are

interrelated for mutual frequency control, their load circuits are substantially independent so that upon failure of either one of the vibrators, the other vibrator will remain in operation and may provide emergency service until the defective vibrator is replaced. This feature is of very great practical importance in certain applications such as when operating police radios, army transmitters and receivers, etc., where service has to be maintained under all conditions. Moreover, the circuit of the invention is extremely simple and provides a simple and efficient way of taking care of power supply requirements in excess of the normal power-handling ability of a single vibrator. The twin vibrator system of the invention also may be advantageously employed in cases where the current requirements could be handled by a single vibrator. By splitting up the load between two vibrators, a useful life many times longer than that of a single vibrator may be realized with attendant greatly increased safety of operation.

While the present invention, as to its objects and advantages, has been described herein as carried out in a specific embodiment 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. A vibrator system comprising, in combination, a pair of vibratory interrupters having substantially the same operating frequencies, each of said interrupters including a vibratory reed, a driver coil, and a synchronizing coil, a driver circuit for said interrupters including a source of current and said driver coils thereby to effect vibratory motion of said reeds, and a synchronizer circuit including leads connecting the synchronizing coil of each interrupter in parallel with the driver coil of the other thereby maintaining said reeds in exact synchronism.

2. A vibrator system comprising, in combination, a pair of vibratory interrupters having substantially the same operating frequencies; each of said interrupters including a vibratory reed, a system of contacts actuated by said reed, a driver coil, and a synchronizing coil having substantially fewer turns than said driver coil; a driver circuit for said interrupters including a source of current, said system of contacts, and said driver coils thereby to effect vibratory motion of said reeds; and a synchronizer circuit including leads connecting the synchronizing coil of each interrupter in parallel with the driver coil of the other thereby maintaining said reeds in exact synchronism.

3. A vibrator system comprising, in combination, a pair of vibratory interrupters having substantially identical operating frequencies; each of said interrupters including a vibratory reed, a paramagnetic core member, a driver coil and a synchronizing coil mounted on said core member; a driver circuit for each interrupter including the driver coil thereof and a current source, each energization of said driver coil producing a field in said core member of proper polarity to maintain vibration of the associated reed; and means for electrically coupling the synchronizing coil of each interrupter with the driver coil of the other so that each energization of the synchronizing coil produces a field in the associated core member of opposite polarity from the driver coil field whereby fields of unequal intensity are produced in the respective core members when the interrupters are out of synchronism, said unequal fields shifting the operating frequencies of the interrupters in opposite directions converging towards a common mean frequency.

4. A vibrator system comprising, in combination, a pair of vibratory interrupters having substantially identical operating frequencies; each of said interrupters including a vibratory reed, a paramagnetic core member, a driver coil and a synchronizing coil mounted on said core member; a driver circuit for each interrupter including the driver coil thereof and a current source, each energization of said driver coil producing a field in said core member of proper polarity to maintain vibration of the associated reed; and a synchronizer circuit including leads connecting the synchronizing coil of each interrupter in parallel with the driver coil of the other so that each energization of the synchronizing coil produces a field in the associated core member of opposite polarity from the driver coil field whereby fields of unequal intensity are produced in the respective core members when the interrupters are out of synchronism, said unequal fields shifting the operating frequencies of the interrupters in opposite directions converging towards a common mean frequency.

5. A vibrator system comprising, in combination, a pair of vibratory interrupters having substantially identical operating frequencies each of said interrupters including a vibratory reed, a system of contacts operable thereby, a paramagnetic core member, a driver coil and a synchronizing coil mounted on said core member, said synchronizing coil having substantially fewer turns than said driver coil; a driver circuit for each interrupter including the driver coil thereof, said system of contacts, and a current source, each energization of said driver coil producing a field in said core member of proper polarity to maintain vibration of the associated reed; and a synchronizer circuit including leads connecting the synchronizing coil of each interrupter in parallel with the driver coil of the other so that each energization of the synchronizing coil produces a field in the associated core member of opposite polarity from the driver coil field whereby fields of unequal intensity are produced in the respective core members when the interrupters are out of synchronism, said unequal fields shifting the operating frequencies of the interrupters in opposite directions converging towards a common mean frequency.

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