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G. W. PLICE ETAL
 HIGH FREQUENCY VIBRATOR OR CHOPPER AND FREQUENCY
 DOUBLING CIRCUIT DERIVED THEREFROM
 Original Filed April 28, 1958

3,181,054

2 Sheets-Sheet 1

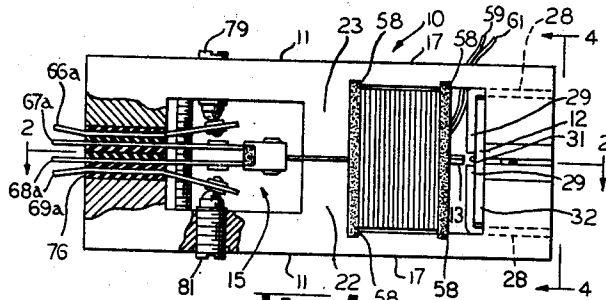


Fig. 1

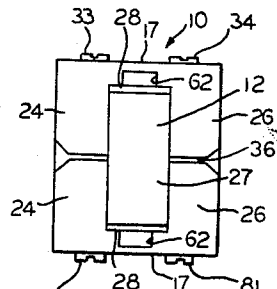


Fig. 4

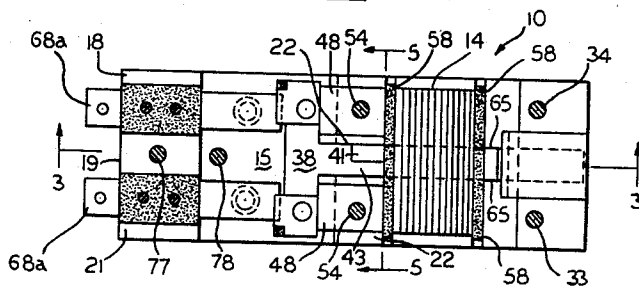


Fig. 2

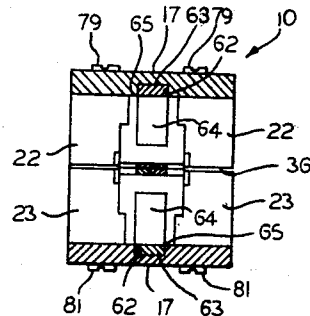


Fig. 5

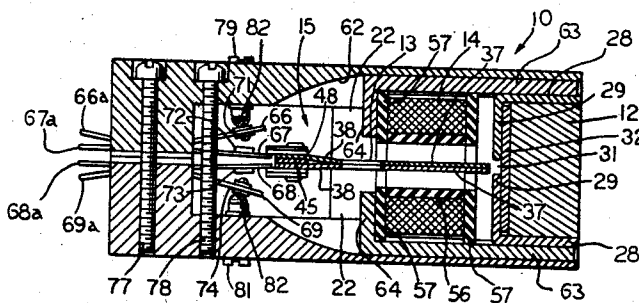


Fig. 3

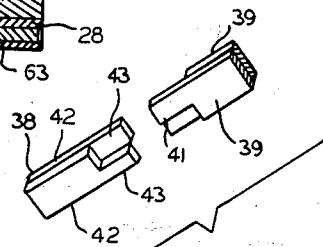


Fig. 7

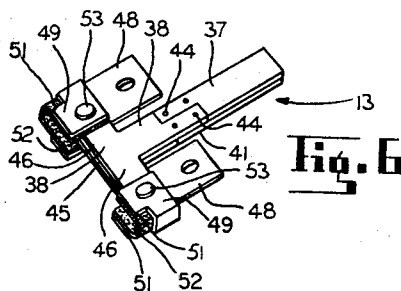


Fig. 6

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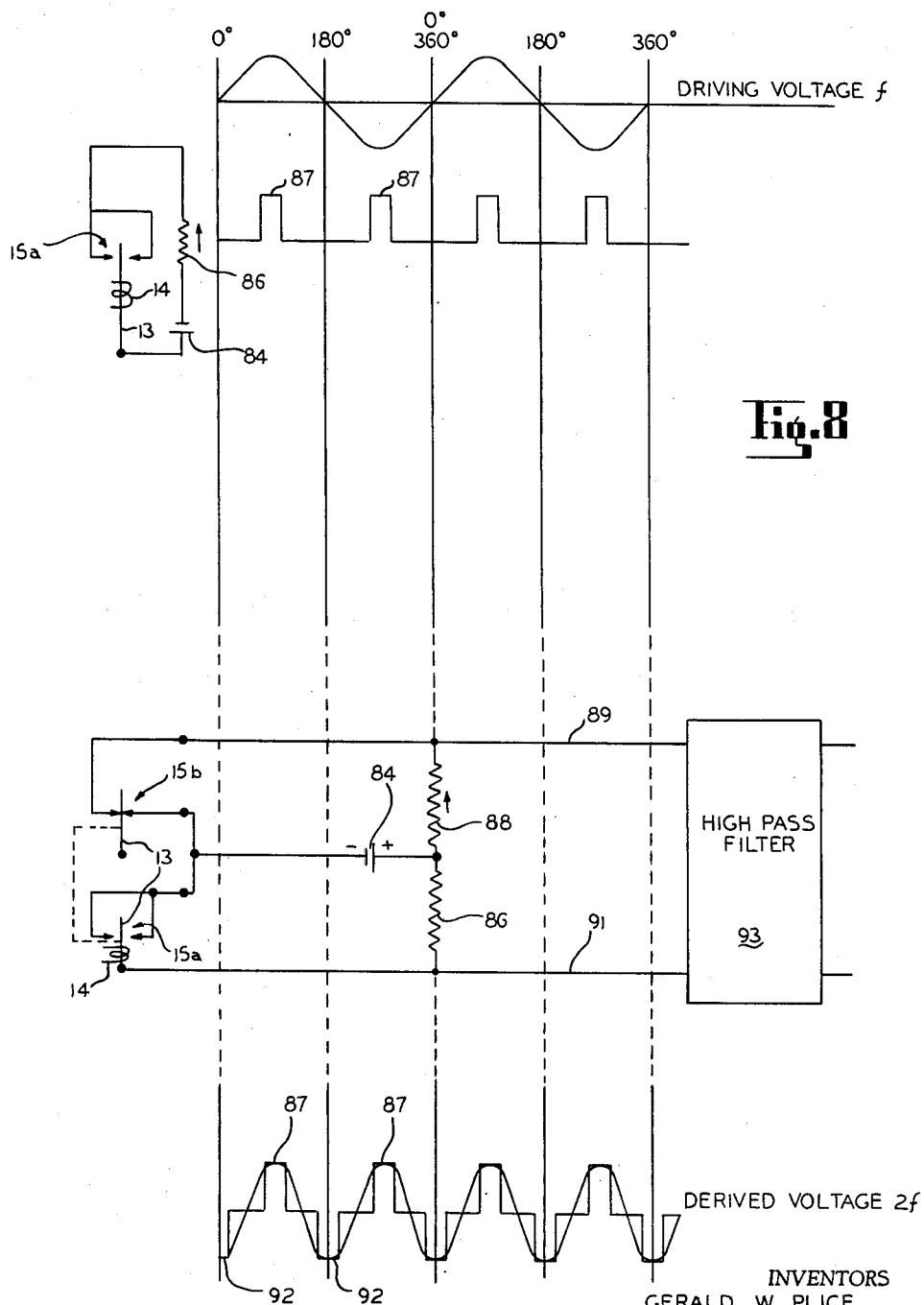


Fig. 8

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HIGH FREQUENCY VIBRATOR OR CHOPPER AND FREQUENCY DOUBLING CIRCUIT DERIVED THEREFROM

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Continuation of abandoned application Ser. No. 731,365, Apr. 28, 1958. This application Nov. 6, 1963, Ser. No. 333,247

5 Claims. (Cl. 321—70)

This application is a continuation of our application Serial No. 731,365, filed April 28, 1958, now abandoned.

This invention relates generally to vibrating devices which can be driven from a high frequency source for interrupting a voltage of small magnitude and subsequently amplifying the same.

This invention represents an improvement over that shown in Plice application Serial No. 565,459, filed February 14, 1956, for High Frequency Vibrator or the Like, now Patent No. 2,831,936 issued April 22, 1958.

According to the present invention the vibrating armature is made of ferrous material, one portion being extremely permeable to magnetic lines of force, and the other portion being non-magnetic such as stainless steel. These two portions are dovetailed together and spot welded at their dovetailing points. The vibrating armature cooperates with auxiliary pole members having pole faces close to the point of dovetailing so as to provide a low reluctance flux path for a driving coil for vibrating the armature in the presence of a permanent magnetic field.

The vibrating assembly is held in a frame having confronting frame portions which effectively provide shielding for a contact or switching assembly operated by the vibrating armature and enclosed within a short-circuiting loop, and shielding for the driving coil and permanent magnetic field, the latter also being enclosed within a second short-circuiting loop. The frame holds the auxiliary pole members in position, so that not only is the drive assembly for the armature effectively shielded electrostatically, but there is also concentration of all magnetic flux so that there can be no extraneous voltages induced in the contact assembly enclosed within the other short-circuiting loop.

The vibrator or chopper according to the present invention is also characterized by performance as a frequency doubler, the vibrating armature described above operating double-pole, double-throw contacts phased ninety electrical degrees apart and having contact time of a duration so as to develop a frequency double that of the driving frequency. The configuration of the frame and the shielding of the driven contacts from the driven armature both magnetically and electrostatically results in a developed frequency at twice the driven frequency and substantially free from transient voltages.

With the foregoing considerations in mind it is a principal object of this invention to provide an improved vibrator or chopper characterized by a construction whereby both electrostatic and magnetic shielding of the contact structure is provided.

Another object is to provide an improved vibrator or chopper having means supported by the confronting frame portions for preventing stray flux from the driving coil for the vibrating armature.

Yet another object is to provide a vibrator or chopper having an armature composed of two ferrous portions, a magnetically permeable portion in close proximity to the driving structure therefor, and a non-magnetic portion, the two being supported by the confronting frame por-

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tions and having means mounted thereon for operating a contact assembly remote from the aforesaid magnetic portion thereof.

Still another object is to provide a vibrating armature consisting of dovetailing ferrous portions, one being magnetic and the other being non-magnetic, the two portions being spot welded, and the non-magnetic portion being employed solely as part of a structure for operating a contact assembly.

Still another object is to provide a vibrator or chopper having a double-pole, double-throw switching assembly capable of deriving a voltage which is twice that of the frequency of the driving voltage across the driving coil for the armature.

Other objects and important features of the invention will be apparent from a study of the specification following taken with the drawings which together describe and illustrate a preferred embodiment of the invention and what is now considered to be the best mode of practicing the principles thereof. Other embodiments may be suggested to those having the benefit of the teachings herein, and such other embodiments are intended to be reserved especially as they fall within the scope and spirit of the subjoined claims.

In the drawings:

FIG. 1 is an elevational view of a vibrator or chopper having the improvements according to the present invention embodied therein;

FIG. 2 is a longitudinal section taken along the line 2—2 of FIG. 1 looking in the direction of the arrows;

FIG. 3 is a longitudinal section taken along the line 3—3 of FIG. 2 looking in the direction of the arrows;

FIG. 4 is an end view of the chopper looking in the direction of the arrows 4—4 of FIG. 1;

FIG. 5 is a vertical sectional view taken along the line 5—5 of FIG. 2 looking in the direction of the arrows;

FIG. 6 is a perspective view showing details of the vibrating armature of the vibrator seen in FIGS. 1 to 5 inclusive, and showing means for mounting same on the frame thereof, and showing also means mounted on the vibrator for actuating the contact assembly seen in FIGS. 1 to 5;

FIG. 7 is an exploded perspective of a portion of the vibrating armature seen in FIG. 6, and showing how the armature consists of a pair of dovetailed portions, one such portion being of a permeable magnetic material, and the other portion being composed of a non-magnetic material; and

FIG. 8 is a schematic diagram illustrating how the vibrator or chopper of FIG. 1 may be connected so as to derive a voltage wave having twice the frequency of the voltage across the driving coil thereof.

Referring now to FIGS. 1 to 7 of the drawings, the improved vibrator or chopper according to the present invention is referred to generally by the reference numeral 10 and consists generally of confronting frame structures 11, 11, a uni-directional magnetic field structure 12, a vibrating armature 13, a driving coil winding 14 therefore, and contact or switching assemblies indicated generally by the reference numeral 15.

The frame structures 11, 11 are symmetrical and are in confronting relationship. Each frame structure 11 consists of a side rail 17 having at one end thereof spaced confronting bosses 18, 19 and 21 for supporting and locating the switching or contact assemblies 15, and centrally disposed confronting bosses 22 and 23 forming a means for supporting the vibrating armature 13. The other end of each frame structure 21 includes spaced confronting end bosses 24 and 26 for positioning the uni-directional magnetic field structure 12.

The magnetic structure 12 consists of a cast piece of

high retentivity magnet material 27, such as Alnico or the like, which is flanked on each side by L-shaped pole pieces 28, 28, the pole pieces 28 being spaced from each other at pole tips 29 as seen in FIG. 1 and FIG. 2 to provide a magnetic gap 31 of high field strength. A spaced plate 32 is maintained between the pole pieces 29, 29 and the cast piece of magnet material 12.

The magnetic assembly thus far described is maintained in position by the frame members 11, 11 and between the confronting bosses 24 and 26 by means of screws 33 and 34 tapped into the respective confronting bosses 24 and 26. It may be noted that the bosses 24 and 26 are separated a slight amount as at 36 to insure good clamping pressure against the magnet structure 12.

Referring now particularly to FIGS. 6 and 7 the vibrating armature 13 is generally in the shape of a T as shown. It consists of a leg portion of highly permeable magnetic material 37 such as soft iron and a non-magnetic portion which may be of non-ferrous material such as brass or a ferrous material such as stainless steel 38 which has very low permeability. For reasons of convenience in manufacture, we prefer to make one portion of soft iron and the other of stainless steel (non-magnetic) as they can be welded together. For example, the permeable portion can be a nickel alloy, and the non-permeable portion can be an aluminum alloy as long as they can be joined by welding, brazing, soldering, riveting, or the like. The permeable portion 37 consists of two armature elements 39, each having a dovetail 41. The non-magnetic portion 38 likewise consists of a pair of flat non-magnetic elements 42, 42 each having a dovetail 43, the two dovetailed ends being connectable as seen in FIGS. 6 and 7 and being joined at their dovetails by spot welding 44.

The two elements 42, 42 of the non-magnetic portion 38 have arms 46 extending laterally therefrom holding therebetween a U-shaped reed 45 having spring arms 48, 48. Each end of the arm 46 has a generally U-shaped contact actuating member 49 at the end thereof with spaced tines 51 holding therebetween insulation means 52. The tine supporting members 49, the insulation means 52 and the reed arms 48 are held together as an assembly by means of a rivet 53. The reed arms 48 are anchored between the central confronting bosses 22 and 23 by means of screws 54 tapped thereinto.

The permeable portion 37 of the vibrating armature 13 extends between the spaced confronting bosses 22 as seen in FIGS. 2 and 5 and into a hollow bobbin 56 of the driving coil 14, which has rectangular end flanges 57 held in position in spaced grooves 58 formed in the side rails 17. The permeable portion 37 extends through the hollow bobbin 56 with its end in close proximity to the magnetic gap 31 at the pole faces 29, 29. The driving coil 14 is connected to leads 59 and 61 to a suitable source of voltage at a desired frequency.

As is known in the art, an alternating voltage across the leads 59, 61 will change the polarity of the armature 13 to cause it to vibrate in the presence of the uni-directional field in the gap 41, the armature 13 being supported during such vibration by the reed arms anchored between the confronting bosses 23, 23.

Means are provided to prevent the occurrence of stray flux from the driving coil 14, in such a fashion as to confine the flux effectively in magnetic portion 39 of armature 13, and to this end the confronting frame portions are milled with a groove 62, preferably of rectangular cross section, see also FIG. 5, to receive a pair of auxiliary pole pieces 63 each such pole piece being in the shape of an L, and having a portion 64 extending toward the vibrating armature 13 as seen more clearly in FIG. 3. The pole pieces 63 are in close proximity to the weldment 44 on armature 13. The pole piece 63 can be staked in position in the slot 62 as seen at 65. We have found that the provision of the auxiliary pole pieces 63 reduces stray flux from the driving coil 14 by providing a low

reluctance path. In addition, the inclusion in the magnetic circuit so improves the efficiency that less power is needed in the driving coil 14, thereby further reducing stray flux.

The vibrating armature 13 is arranged to cause interruption of one or more circuits at the contact assemblies 15. Such contact assembly includes contact arms 66, 67, 68 and 69, contacts 66 and 67 carrying respectively contacts 71 and 72, and contact arms 68 and 69 carrying respectively contacts 73 and 74. The several contact arms are electrically insulated from each other by leaves of insulating material 76. The contact arms 66, 67, 68 and 69 extend beyond the stack seen as at 66a, 67a, 68a, and 69a for connection thereto to any circuit as desired.

The frame portions are held together at the contact assembly just described by means of screws 77 and 78. Screw 77 is tapped into the confronting bosses 19 at the contact end of the frame portions 11, while screw 78 is tapped into the side rail 17 between each contact assembly 15.

As seen in FIG. 3, the insulating material 52 held between the tines 51 engages the contact arms 67 and 68 to alternately open and close the circuits made with the contacts 66 and 69. The insulating material 52 also serves as a low friction bearing surface for the ends of the contact arms 67 and 68.

The position of the outermost contacts 66 and 69 with respect to their cooperating contacts 67 and 68 is adjusted by means of adjusting set screws 79 and 81, each such set screw having insulating material 82 at the end thereof to insulate the contacts from the frame portions 11, 11.

When a driving voltage is impressed across terminals 59 and 61 of driving coil 14, the armature 13 will vibrate synchronously with the driving voltage, causing the contact arms 67 and 68 to vibrate therewith to open and close their cooperating contacts alternately. Appropriate circuitry can be connected to the contact arms 67, 68, 69 and 71 to develop an interrupted voltage as desired.

As seen in FIG. 2, there are a pair of such contact assemblies provided, and one such assembly may be adjusted so as to cooperate with the moving contact arms 67 and 68 so that the assembly will operate upon vibration of the armature 13 with a "make before break" or a "break before make" function as desired. By suitably spacing the magnetic gap 31 with respect to the armature portions 37, 37, the armature 13 can occupy a "null" position with the contacts either closed or opened as desired. It may be noted that with one set of contacts adjusted to "make before break" and the other set adjusted to "break before make" with appropriate circuitry it is possible to develop a voltage having a frequency which is twice the frequency of the voltage impressed across the driving coil 14.

Referring now to FIG. 8, there is shown the driving voltage at frequency "f" impressed across the driving coil 14. The armature 13 is shown within the influence of the driving coil 14 and cooperating with a contact assembly indicated by the reference numeral 15a. The vibrating armature 13 and the contact 15a are connected in circuit with a battery 84 and a load 86, the power derived being indicated by the square wave form 87 at the 90° and 270° points of the driving voltage wave shown. The contact assembly shown at 15a is adjusted for "break before make" operation.

The armature 13 can also be caused to operate a set of contacts 15b adjusted for "make before break" operation and connected in a circuit including the battery 84 and a load circuit 88, the two loads 86 and 88 being connected across the output circuit having leads 89 and 91. The wave form developed will have a frequency twice that of the frequency of the driving coil 14, the switching assembly 15b developing power at the wave forms 92 which are spaced at ninety electrical degrees from the wave forms 87 provided by the contact assembly 15a previously described.

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By any suitable filter, not shown, the wave form may be suitably modified to a sine or other shape as desired, and the output circuit 89 and 91 may be connected in circuit with a high pass filter 93 to filter out all transient voltages of low frequency and sub-harmonics of the frequency of the driving voltage across the coil 14.

While the invention has been described in terms of a preferred embodiment thereof its scope is intended to be limited only by the claims herein appended.

We claim:

1. In a device of the class described, a pair of frame members, a vibratory non-resilient armature extending lengthwise of said frame members and having a non-magnetic portion and a magnetically permeable portion, said non-magnetic portion and said magnetically permeable portion being joined to each other, said frame members being in confronting relationship with means disposed between the ends thereof for supporting said vibratory armature, means forming a uni-directional magnetic field supported by said frame members, a driving coil supported by said frame members between said uni-directional magnetic field means and said armature supporting means for causing vibration of said armature, a pair of spaced pole tips in proximity to the end of the armature adjacent said uni-directional magnetic field for concentrating the flux of said uni-directional magnetic field, a slot formed in each confronting face of said frame members, and an auxiliary pole piece of high permeability supported in each of said slots and contacting said spaced pole tips and extending beyond said driving coil and terminating in pole faces in close proximity to the juncture between said non-magnetic and magnetically permeable portions of said armature to provide a low reluctance path for the flux of said driving coil and to prevent stray flux from being present in the said non-magnetic portion of said armature.

2. In a device of the class described, a pair of frame members, a vibratory non-resilient armature extending lengthwise of said frame members and having a non-magnetic portion and a magnetically permeable portion, said non-magnetic portion and said magnetically permeable portion being joined to each other, said frame members being in confronting relationship with means disposed between the ends thereof for supporting said vibratory armature, means forming a uni-directional magnetic field supported by said frame members, a driving coil supported by said frame between said uni-directional magnetic field means and said armature supporting means for causing vibration of said armature, a pair of spaced pole tips in proximity to the end of the armature adjacent said uni-directional magnetic field for concentrating the flux of said uni-directional magnetic field, auxiliary pole pieces of high permeability supported in said frame member and extending from said spaced pole tips in a plane common to said spaced pole tips and the plane of vibration of said armature, said auxiliary pole pieces extending beyond said driving coil and terminating in pole faces in the aforesaid plane in close proximity to the juncture between said non-magnetic and magnetically permeable portions of said armature, said pole tips and said auxiliary pole pieces providing a low reluctance path for the flux of said driving coil.

3. In a device of the class described, a pair of frame members, a vibratory non-resilient armature extending lengthwise of said frame members and having a non-magnetic portion and a magnetically permeable portion,

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said non-magnetic portion and said magnetically permeable portion being joined to each other, said frame members being in confronting relationship with means disposed between the ends thereof for supporting said vibratory armature, means forming a uni-directional magnetic field supported by said frame members, a driving coil supported by said frame between said uni-directional magnetic field means and said armature supporting means for causing vibration of said armature, a pair of spaced pole tips in proximity to the end of the armature adjacent said uni-directional magnetic field for concentrating the flux of said uni-directional magnetic field, a slot formed in each of said frame members and lying in a plane common to the plane of vibration of said armature, and an auxiliary pole piece of high permeability supported in each of said slots and in contact with said spaced pole tips, said auxiliary pole pieces extending beyond said driving coil and terminating in pole faces lying in the aforesaid plane and in close proximity to the juncture between said non-magnetic and magnetically permeable portions of said armature, said pole tips and said auxiliary pole pieces providing a low reluctance path for the flux of said driving coil and for preventing the occurrence of stray flux in said non-magnetic portion of said armature.

4. In apparatus of the class described for driving an alternating voltage having a frequency which is double the frequency of a known alternating voltage source, a frame supporting means providing a uni-directional magnetic field, a driving coil energized by said known alternating voltage source and supported by said frame, an armature pivotally supported by said frame and extending through said coil and having an end thereof in proximity to said uni-directional field so as to vibrate at the frequency of the voltage impressed across said driving coil, contact operating means supported at the other end of said armature, a double pole-double throw contact assembly operated by said contact operating means, one of said poles and its cooperating contacts being adjusted for "make before break" operation, said cooperating contacts being connected in circuit with a source of energy and a first load device, the other of said poles and its other set of cooperating contacts being adjusted for "break before make" operation, said other pole and said other set of cooperating contacts being connected in a circuit including said source of energy and a second load device, the closed time for each of said contacts and its associated pole being phased 90 electrical degrees apart from the other, the frequency of the alternating voltage across said load devices being twice the frequency of the alternating voltage across said driving coil.

5. The invention as defined in claim 4 wherein said contact operating means is insulated from said armature whereby the fundamental frequency of said driving coil is isolated from said contacts.

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