

April 1, 1941.

O. KILTIE

2,237,003

VIBRATOR CURRENT-CONVERTING SYSTEM

Filed June 14, 1940

FIG. 1.

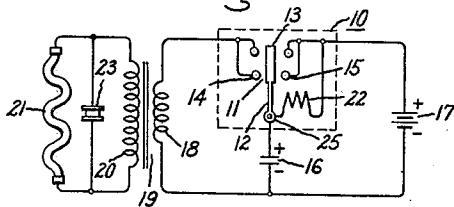


FIG. 3.

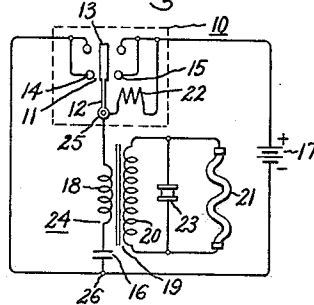


FIG. 4.

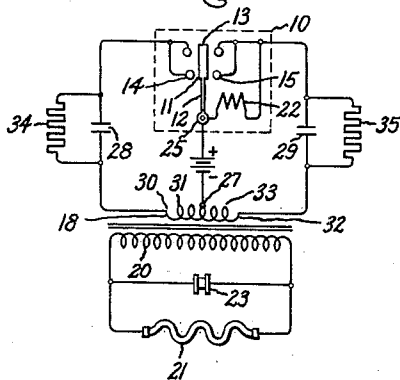


FIG. 5.

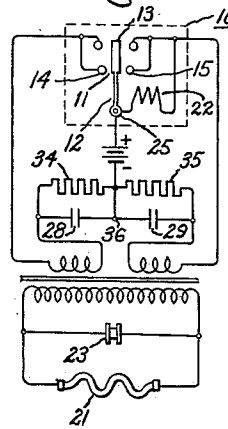


FIG. 6.

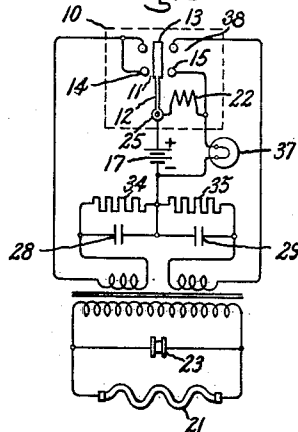
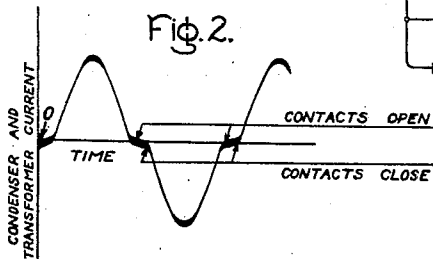


FIG. 2.



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UNITED STATES PATENT OFFICE

2,237,003

VIBRATOR CURRENT-CONVERTING SYSTEM

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Application June 14, 1940, Serial No. 340,548

18 Claims. (Cl. 175—365)

This application is a continuation-in-part of my application, Serial No. 184,616, filed January 12, 1938, for Vibrator current-converting systems.

My invention relates to vibrator systems for converting direct current into alternating current. The invention relates particularly to systems of this character applied to the operating of neon tube signs on automobiles, trucks, buses or other vehicles, and supplied with power from the vehicle starting and lighting battery.

In the employment of vibrator systems for the above-mentioned purpose the difficulty has been encountered that to provide the relatively high power at high voltage required for the neon tubes a large current load is imposed on the vehicle battery in addition to its usual load. High efficiency in the vibrator system is therefore required. At the same time, for practical uses, it is required that the vibrator system be simple and of low cost.

It is an object of my present invention to provide a simple and low cost vibrator system, for converting direct current into alternating current, which is of such character that by its use the current taken from the battery for the extra lighting load is substantially less than that required by vibrator systems heretofore commonly employed, to illuminate the same neon tubes to the same intensity.

A further difficulty encountered in vibrator systems commonly employed heretofore for converting direct current into alternating current resides in sparking at the vibrator contacts, which causes pitting and burning of the contact surfaces and consequent greatly shortened life of the vibrator apparatus, particularly in the severe current load conditions under which the vibrator is called upon to operate in neon sign lighting for vehicles. The objectionable sparking at the vibrator contacts is in general due to such arrangement of the vibrator system that at the moment of break of the vibrator contacts a relatively large current is flowing therethrough. This large current is broken when the contacts open, thereby producing a destructive arc. Vibrator systems heretofore proposed to avoid the sparking difficulty due to the breaking of a large current at the vibrator contacts have been complicated and expensive.

It is a further object of my present invention to provide a simple and low cost vibrator system for converting direct into alternating current so arranged that no large current is broken at the opening of the vibrator contacts, thereby to cause a destructive arc.

It is a further and particular object of my present invention to provide a simple and low cost vibrator system for converting direct to alternating current so arranged that the current through the vibrator is reduced to zero a substantial time period before the opening of the contacts, whereby the breaking of any current whatever at the contacts is prevented.

In carrying my invention into effect I provide a vibratory switch including a resiliently mounted movable contact adapted to make and break engagement with fixed contacts on either side thereof, at least one capacitor adapted to be charged periodically through the vibrating switch from the direct current source or battery, an output transformer the secondary of which is connected to the lamp load and the primary of which is adapted to be energized periodically through the vibratory switch from the capacitor, and an actuating winding for the vibrator adapted to be energized from the direct current source and so arranged as to be short-circuited periodically by the vibrator.

In vibrator systems of the type to which my present invention is directed, the primary winding of the output transformer and the capacitor which is periodically charged from the direct current source constitute elements of a series circuit in the vibrator system. In accordance with my present invention the reactances of this series circuit are so chosen, and the vibratory switch is so proportioned and arranged, that the natural vibration frequency of the vibratory switch bears such a relation to the frequency to which the series circuit is tuned that the current at break of the contacts is so small that no destructive arc forms, or the current at break is even reduced to zero. Preferably this natural vibration frequency of the vibratory switch is smaller by a predetermined, preferably small amount, than the oscillation frequency of the series circuit including the above mentioned capacitor and primary winding.

It is a further feature of my invention that in order to permit a large current to flow in the actuating winding of the vibrator at starting and to reduce the actuating current after normal operation of the vibrator is initiated, a resistance element is provided in the actuating winding circuit which is of low cold resistance and which is so arranged as to have a high resistance when heated.

If desired, for protection of the relatively high voltage output circuit including the secondary of the output transformer connected to the neon

lamp or other similar load, a resistance element preferably having a negative voltage resistance characteristic may be connected across the output circuit.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing, in which Fig. 1 is a diagrammatic representation of a current converting system including a single capacitor for energizing an output circuit winding, in which my invention has been embodied; Fig. 2 shows a characteristic curve illustrating the operation of my invention; Fig. 3 represents an embodiment similar to Fig. 1 but so arranged that the output circuit winding is energized by both the charge and discharge currents of the capacitor; Figs. 4 and 5 represent embodiments in which two capacitors for energizing output circuit windings are employed; and Fig. 6 represents a modification of Fig. 5 wherein a resistor of suitable thermal characteristics for producing a high starting current for the vibrator is provided.

In Fig. 1, the numeral 10 designates a vibratory switch comprising a vibratory element 11 which includes a resilient or reed portion 12 and a movable contact 13 mounted thereon, and fixed contacts 14 and 15 on either side of the movable contact. Extra sets of contacts in parallel with contacts 13, 14 and 15 respectively may be provided, as shown, if desired. A capacitor 16 is connected between the vibratory element 11 and one terminal of a direct current source 17 which in the present embodiment is the starting and lighting battery of a truck or similar vehicle. The capacitor 16 should be of the alternating current type, i. e., it should be of the non-polarized type. It is to be understood, however, that I do not wish to be limited to the use of capacitors of this type only.

The other terminal of current source 17 is connected to one of the fixed contacts, as 15. The primary winding 18 of an output transformer 19 is connected between the other fixed contact 14 and that terminal of capacitor 16 which is connected to source 17. The terminals of the secondary 20 of transformer 19 are connected to a load which in the present embodiment is a neon lighting tube 21. An actuating winding 22 for the vibratory element 11 is connected between the vibrating element and that one of the fixed contacts 15 to which direct current source 17 is connected. Winding 22 should be of low resistance and with sufficient turns to exert a relatively large moving force on reed 12. I have found 600 turns of No. 29 enameled wire, having 6.5 ohms resistance, to be suitable. A resistor 23 having a negative voltage resistance characteristic may be connected across the secondary winding 20.

The reactances of the series circuit including primary winding 18 and capacitor 16 are so chosen and the vibratory element 11 of the switch 10 is so proportioned and arranged that the natural reed frequency or vibration frequency of the vibratory element 11 is such that the current at break of the switch 10 is not sufficient to cause a destructive arc. This natural vibration frequency may be somewhat higher, or equal to, the tuning frequency of the series circuit but is preferably less by a predetermined amount than the

tuning frequency of the series circuit. To assist in tuning the series circuit to a predetermined frequency a reactance may be added therein such as an inductance (not shown) in series with winding 18.

In operation of the system illustrated in Fig. 1, the actuating winding 22 is supplied with driving current from source 17 when the vibratory element 11 is in its intermediate position. Movable contact 13 is thereby caused to engage fixed contact 15 whereupon a charging current flows into capacitor 16 through the switch. The engagement of contact 13 with contact 15 causes winding 22 to be short-circuited. The resilient member 12 then causes the movable contact to break engagement with fixed contact 15 and to swing across into engagement with the other fixed contact 14, whereupon condenser 16 discharges, and energizes primary winding 18, through the contacts 13 and 14. The short circuit being thereby removed from actuating winding 22 the latter again causes the movable contact to engage fixed contact 15. This operation is repeated to produce continued vibration of the switch 10.

I have discovered that in my vibrator system as above described wherein the natural vibration frequency of vibrator 10 is slightly greater than, or equal to, the tuning frequency of the series circuit, including capacitor 16 and winding 18, no large current is broken at the contacts and no destructive arc occurs.

I have further discovered that by so constructing the apparatus the natural vibration frequency of the vibratory element 11 is less by a predetermined amount than the frequency to which the above-described series circuit tunes, no current is broken at the contacts. I have found that under these conditions the current through the switch 10 at the closed contact periods is reduced to zero before the contacts open, as shown in the current curve illustrated in Fig. 2. Sparking at the contacts is therefore eliminated. It will be noted from Fig. 2 that the output voltage wave is substantially sinusoidal, whereas in conventional vibrator rectifiers the wave is flat topped.

As an example of a vibrator rectifier in accordance with my invention capacitor 16 may have such capacity and the inductive portion, including primary 18, of the series circuit may have such inductance, that this circuit tunes at 115 cycles per second. The vibrator is then preferably to be so constructed that the vibrating reed frequency, or natural vibration frequency, of the vibrator is 95 to 105 cycles per second. In a practical application in which the natural vibration frequency of the vibrator has this latter value, a capacitor 16 of 3700 m. f. d. having a .375 ohm reactance at 115 cycles may be used and with this a transformer 19 having 14 turns in the primary, a net core cross-section of .82 square inch and magnetic shunts between primary 18 and secondary 20. As a further example, a capacitor of 5000 m. f. d. having a .310 ohm reactance at 103 cycles may be used with the above-described transformer. The series circuit then oscillates at approximately 103 cycles per second. The vibrator is then to be arranged and proportioned for a natural vibrating frequency of approximately 90 cycles.

Other arrangements of the series circuit constants and the natural vibration frequency of the vibrator may be utilized, to cause the frequencies to assume the desired relation in accordance with my present invention. It is desirable to so ar-

range the system that the vibrating reed frequency or natural vibration frequency of the vibrator 10 is relatively low in order to reduce the mechanical wear of the contacts and the fatigue of the resilient or reed portion of the vibrator.

Fig. 3, which illustrates what I now consider to be the preferred form of my invention, is similar in general to the system of Fig. 1 but differs therefrom in that in Fig. 3 the primary 18 of the output transformer 19 is included with capacitor 16 in a series connection 24 one terminal 25 of which is connected, as through the resilient or reed member 12, to the movable contact 13 of vibrator 10, and the other terminal 26 of which is connected to one terminal of source 17 and to that one of the fixed contacts 14, on the opposite side of movable contact 13 from the battery. The same frequency relations between the series circuit, including the capacitor 16 and primary winding 18 of transformer 19, and the vibrator 10 are provided as described hereinabove in connection with Fig. 1.

Operation of the system of Fig. 3 is similar to that of the system of Fig. 1, but with the important difference that in the system of Fig. 3 the charging current flowing into capacitor 16 from source 17 upon engagement of movable contact 13 with fixed contact 15 flows also through primary winding 18 of transformer 19. In the system of Fig. 3 the output circuit is therefore energized not only during the discharge period of the capacitor 16 but during the charging period also, with consequent better utilization of the energizing current. Sparking at the contacts in the system of Fig. 3 is prevented because of the relation between the natural vibration frequency of the vibrator 10 and the frequency to which the series circuit is tuned, in the same manner as set forth above in connection with Fig. 1.

A resistor 23 having a negative voltage-resistance characteristic may be employed in the system of Fig. 3 also. A suitable resistor for this purpose is shown in U. S. Patent No. 1,822,742, September 8, 1931. A resistor of this type is preferably connected across the output transformer secondary in case a low reactance transformer is employed having no shunts between windings, since under these conditions the open circuit voltage on the secondary would otherwise rise to a very high value. In a practical application of the system shown in Fig. 3 I have employed, for example, a circuit having a 6000 volt rating. A resistor of the above-described type should therefore be provided across the transformer secondary having a resistance equivalent to a volt-ampere test of .008 milliamperes at 1500 volts D. C., .074 milliamperes at 4000 volts, and .44 milliamperes at 5000 volts, this being the range of protection preferred if a protective resistor of the above-described type is employed.

The system illustrated in Fig. 4 differs from the system previously described herein in that the direct current source or battery 17 is connected between the vibrating element, carrying the movable contact 13, and an intermediate terminal 27 of the primary winding 18 of the output transformer. Further, instead of a single capacitor, in Fig. 4 two capacitors 28 and 29 are provided, connected respectively between the end terminal 30 of primary winding section 31 and fixed contact 14, and between end terminal 32 of primary winding section 33 and fixed contact 15. Capacitors 28 and 29 are respectively shunted by resistors 34 and 35. The reactances of the two series circuits, one including primary section 31

and capacitor 28 and the other including primary section 33 and capacitor 29 are so chosen and the vibrator 10 is so proportioned and arranged that the natural vibration frequency of the vibration bears the relation to the oscillation frequency of these series circuits explained in connection with Fig. 1.

In operation of the system of Fig. 4, assuming movable contact 13 closed on fixed contact 15 by a small current in actuating coil 22 from source 17 through resistor 35, capacitor 29 becomes charged from source 17 and the charging current into this capacitor energizes primary winding section 33. Because of the effect of the above-described frequency relation between the oscillation frequency of the series circuits and the vibrator natural frequency the main or charging current through the vibrator contacts 13 and 15 will have dropped to a low value before the contacts open, only the small current through resistor 35 continuing to flow. Therefore at break of contacts 13 and 15 only this small current through resistor 35 remains to be broken. When, on the swing of movable contact 13 toward fixed contact 14, engagement is made between movable contact 13 and this other fixed contact, charging current flows into capacitor 28 and energizes the other primary winding section 31. Contacts 13 and 15 having opened when the movable contact 13 was swung toward contact 14, capacitor 29 discharges through its shunt resistor 35 and is therefore ready for repetition of the above-described cycle when the movable contact 13 swings again toward fixed contact 15 into engagement with the latter contact. As contacts 13 and 14 open at the initiation of the swing of contact 13 toward contact 15, capacitor 28 discharges similarly through its shunt resistor 34. The foregoing operation is repeated and alternating voltages are induced in the output transformer.

In the system illustrated in Fig. 5 the construction and operation are essentially the same as in Fig. 4. In Fig. 5, however, the circuits are so arranged that the capacitors may be assembled easily into one container, and the shunt resistors 34 and 35 may be constructed as a single unit with a mid-tap 36, with resulting considerable saving in cost.

The system illustrated in Fig. 6 is identical in construction and operation with the system illustrated in Fig. 5 except that in Fig. 6 a resistor 37 is provided in circuit with actuating winding 22 having a low cold resistance and of such characteristics and so arranged that upon initiation of vibration of the vibrator the resistance of the resistor 37 rises, due to the vibrator actuating current flowing therethrough, to a desired high value. A large starting current is thus provided which is immediately reduced to the desired operating value. To accomplish this purpose movable contact 13 and fixed contact 15 are connected to opposite extremities of the actuating winding 22, and the battery 17 is connected across the actuating winding 22 through the resistor 37. An auxiliary fixed contact 38, on the same side of movable contact 13 as fixed contact 15, is then provided to connect source 17 periodically to capacitor 29, as hereinbefore described in connection with Fig. 4. An incandescent lamp of suitable character may be utilized as resistor 37.

The vibrator circuits to which my present invention is directed have been described as applied to the energizing of neon lighting apparatus from the batteries of automotive vehicles.

It will be apparent, however, that the invention is capable of many other uses, particularly for low watt current converters for car radio and similar applications.

In the systems hereinabove described for converting direct current to alternating current the switch means utilized for charging and discharging the capacitor or capacitors is constituted by a vibratory switch. The arrangement is such that the frequency to which the series circuit is tuned is greater than the operating frequency of the vibratory switch, i. e., the series resonant circuit frequency is greater than the frequency at which voltage is applied, from the direct current source, to the series circuit by the vibratory switch.

It is to be understood, however, that other switch means than the vibratory switch may be utilized for the same purpose as the latter switch.

For example, in the several circuits illustrated in the drawing, the vibratory switch may be replaced by a commutator device driven by a motor maintained in any usual manner at a desired speed, the arrangement being such that the frequency to which the series circuit is tuned is greater by a predetermined amount than the frequency at which voltage is applied, from the direct current source, to the series circuit by the commutator device.

The vibratory switch may also be replaced by a switch means in the form of a motor driven vibrator device, in which fixed contacts are arranged to be engaged by a movable contact element actuated by suitable cam or other means driven by the motor, the arrangement being such that the frequency to which the series circuit is tuned is greater by a predetermined amount than the frequency at which voltage is applied, from the direct current source, to the series circuit by the motor driven vibrator device.

My invention has been described herein in particular embodiments for purposes of illustration. It is to be understood, however, that the invention is susceptible of various changes and modifications and that by the appended claims I intend to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an electric system for converting direct current into alternating current, a vibratory switch including a resiliently mounted movable contact adapted alternately to engage fixed contacts on either side thereof during periods of energization of said switch and to be out of engagement with said contacts during periods of deenergization of said switch, a capacitor, an output transformer, a source of direct current adapted to charge said capacitor through said switch, said capacitor being connected between said movable contact and one of said fixed contacts and being in series with and adapted to energize a primary winding of said transformer through said switch, and a winding for actuating said switch connected between said movable contact and the other of said fixed contacts and in series with said direct current source, the reactances of the series circuit including said capacitor and said primary winding being such and said vibratory switch being so proportioned and arranged that the natural vibration frequency of said switch is less by a predetermined amount than the frequency to which said circuit is tuned.

2. In an electric system for converting direct

current into alternating current, a vibratory switch including a movable contact and fixed contacts on either side thereof, means to mount said movable contact resiliently whereby said movable contact is adapted alternately to engage one and the other of said fixed contacts, an output transformer, a capacitor connected between said movable contact and one of said fixed contacts, a series circuit including said capacitor and a primary winding of said transformer, a source of direct current adapted to charge said capacitor, and means for actuating said movable contact including a winding energized from said direct current source, the reactances of said circuit including said primary winding and said capacitor being such that said series circuit is tuned to a predetermined frequency, said resilient means and said movable contact mounted thereon being so arranged and proportioned that said vibratory switch has a predetermined natural frequency of vibration, said last-named frequency being substantially less than said first-named frequency.

3. In a vibrator system comprising a vibratory element, a direct current source, means to actuate said vibratory element, a capacitor adapted to be charged through said vibrator from said source, and an output transformer having a primary in series with said capacitor and adapted to be energized by current from said capacitor through said vibrator, the method of operation which includes so tuning the series circuit comprising said capacitor and said primary and so proportioning and arranging said vibratory element that the frequency to which said series circuit is tuned is greater by a predetermined amount than the natural vibration frequency of said vibratory element.

4. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, said movable contact being adapted alternately to engage said fixed contacts during periods of energization of said switch and to be out of engagement with said fixed contacts during periods of deenergization of said switch, a capacitor, a source of direct current, an output transformer having a primary winding in series with said capacitor, means to connect the opposite terminals respectively of the series connection constituted by said primary winding and capacitor to said movable contact and to one of said fixed contacts, means to connect the opposite terminals of said source respectively to the other of said fixed contacts and to that terminal of said series connection which is connected to said one of said fixed contacts, and an actuating winding for said vibratory element connected between said series connection and said other of said fixed contacts, the reactances of said series connection including said capacitor and said primary winding being such and said vibratory element being so proportioned and arranged that the natural vibration frequency of said vibratory element is less by a predetermined amount than the frequency to which said series connection is tuned.

5. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, a capacitor, a source of direct current, an output transformer having a primary winding in series with said capacitor, means to connect the opposite terminals respectively of the series

connection including said primary winding and capacitor to said movable contact and to one of said fixed contacts, means to connect the opposite terminals of said source respectively to the other of said fixed contacts and to that terminal of said series connection which is connected to said one of said fixed contacts, and means including a winding energized from said source to actuate said vibratory element, the reactances of the circuit including said primary winding and capacitor being such and said vibratory element being so proportioned and arranged that the natural vibration frequency of said vibratory element is less by a predetermined amount than the frequency to which the circuit including said primary winding and said capacitor are tuned.

6. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, a source of direct current, an output transformer having a primary winding, means to connect said source between said movable contact and an intermediate point of said winding, a capacitor shunted by a resistor and connected between one extremity of said winding and one of said fixed contacts, a second capacitor shunted by a resistor and connected between the other extremity of said winding and the other of said fixed contacts, and an actuating winding for said vibratory element connected between said movable contact and one of said fixed contacts.

7. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, a source of direct current, an output transformer including a primary winding having two sections, means to connect said source between said movable contact and one extremity of each of said sections, a capacitor shunted by a resistor and connected between one of said fixed contacts and the other extremity of one of said sections, a second capacitor shunted by a resistor and connected between the other of said fixed contacts and the other extremity of the other of said sections, and means including a winding energized from said source to actuate said vibratory element, the reactances of each of the circuits including respectively one of said sections and the corresponding one of said capacitors being such and said vibratory element being so proportioned and arranged that the natural vibration frequency of said vibratory element is less by a predetermined amount than the frequency to which said circuits including respectively one of said sections and the corresponding capacitor are tuned.

8. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, said movable contact being adapted alternately to engage said fixed contacts during periods of energization of said switch and to be out of engagement with said fixed contacts during periods of deenergization of said switch, a pair of capacitors each shunted by a resistor, an output transformer having a pair of primary windings, one of said windings being connected between one terminal of one of said capacitors and one of said fixed contacts and the other of said windings being connected between one terminal of the other of said capacitors and the other of said fixed contacts, a direct current

source connected between said movable contact and the other terminals of said capacitors, and an actuating winding for said vibratory element connected between said movable contact and one of said fixed contacts.

9. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, a pair of capacitors each shunted by a resistor, an output transformer having a pair of primary windings, one of said windings being connected between one terminal of one of said capacitors and one of said fixed contacts and the other of said windings being connected between one terminal of the other of said capacitors and the other of said fixed contacts, a direct current source connected between said movable contact and the other terminals of said capacitors, and means including a winding energized from said source to actuate said vibratory element, the reactances of each of the circuits including respectively one of said primary windings and the corresponding one of said capacitors being such and said vibratory element being so proportioned and arranged that the natural vibration frequency of said vibratory element is less by a predetermined amount than the frequency to which said circuits including respectively one of said primary windings and the corresponding capacitor are tuned.

10. In a vibrator system for converting direct current into alternating current, a vibratory switch, a direct current source, a capacitor adapted to be charged from said source through said switch, an output winding adapted to be energized by current from said capacitor through said switch, a winding energized from said source to actuate said switch, and a resistor connected across said capacitor and in series with said source and said last-named winding, said resistor having a low cold resistance and being so arranged as to have a high resistance when heated after normal operation of said switch has been initiated.

11. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, a pair of capacitors each shunted by a resistor, an output transformer having a pair of primary windings, one of said windings being connected between one terminal of one of said capacitors and one of said fixed contacts and the other of said windings being connected between one terminal of the other of said capacitors and the other of said fixed contacts, a direct current source connected between said movable contact and the other terminals of said capacitors, and means to vibrate said element including in series with said source a second fixed contact on one side of said movable contact, an actuating winding, and a resistor having a low cold resistance and being so arranged as to have a high resistance when heated after normal operation of said switch has been initiated.

12. In an electric system for converting direct current into alternating current, a vibratory switch including a movable contact and fixed contacts on either side thereof, means to mount said movable contact resiliently whereby said movable contact is adapted alternately to engage one and the other of said fixed contacts, an output transformer, a capacitor connected between

said movable contact and one of said fixed contacts, a series circuit including said capacitor and a primary winding of said transformer, a source of direct current adapted to charge said capacitor, and means for actuating said movable contact including a winding energized from said direct current source, the reactances of said circuit including said primary winding and said capacitor being such that said series circuit is tuned to a predetermined frequency, said resilient means and said movable contact mounted thereon being so arranged and proportioned that said vibratory switch has a predetermined natural frequency of vibration, said last-named frequency bearing such relation to said first-named frequency that no destructive arc occurs at said contacts when said switch opens.

13. In a vibrator system comprising a vibratory switch, a direct current source, means to actuate said vibratory switch, a capacitor adapted to be charged through said vibrator from said source, and an output circuit including inductance in series with said capacitor and adapted to be energized by current from said capacitor through said vibrator, the method of operation which includes so tuning the series circuit comprising said capacitor and said inductance and so proportioning and arranging said vibratory switch that the frequency to which said series circuit is tuned is greater by a predetermined amount than the natural vibration frequency of said vibratory switch.

14. In an electric system for converting direct current into alternating current, a vibratory switch including a resiliently mounted movable contact adapted alternately to engage fixed contacts on either side thereof, a capacitor, an output circuit including inductance, a source of direct current adapted to charge said capacitor through said switch, said capacitor being connected between said movable contact and one of said fixed contacts and being adapted to energize said inductance through said switch, and a winding for actuating said switch connected between said movable contact and the other of said fixed contacts and in series with said direct current source, the reactances of the series circuit including said capacitor and said inductance being such and said vibratory switch being so proportioned and arranged that the natural vibration frequency of said switch is less by a predetermined amount than the frequency to which said circuit is tuned.

15. In an electric system for converting direct current into alternating current, a vibratory switch including a movable contact and fixed contacts on either side thereof, means to mount said movable contact resiliently whereby said movable contact is adapted alternately to engage one and the other of said fixed contacts, an output circuit including inductance, a capacitor connected between said movable contact and one of said fixed contacts, a series circuit including said capacitor and said inductance, a source of direct current adapted to charge said capacitor, and means for actuating said movable contact including a winding energized from said direct current source, the reactances of said circuit including inductance and said capacitor being such that said series circuit is tuned to a predetermined frequency, said resilient means

and said movable contact mounted thereon being so arranged and proportioned that said vibratory switch has a predetermined natural frequency of vibration, said last-named frequency being substantially less than said first-named frequency.

16. In a vibrator system for converting direct current into alternating current, a vibratory element including a movable contact, a pair of fixed contacts one on either side of said movable contact, a capacitor, a source of direct current, an output circuit including inductance in series with said capacitor, means to connect the opposite terminals respectively of the series connection including said inductance and capacitor to said movable contact and to one of said fixed contacts, means to connect the opposite terminals of said source respectively to the other of said fixed contacts and to that terminal of said series connection which is connected to said one of said fixed contacts, and means including a winding energized from said source to actuate said vibratory element, the reactances of the circuit including said inductance and capacitor being such and said vibratory element being so proportioned and arranged that the natural vibration frequency of said vibratory element is less by a predetermined amount than the frequency to which the circuit including said inductance and said capacitor are tuned, the reactance of the series circuit including said capacitor and said inductance being such and said vibratory element being so proportioned and arranged that the natural vibration frequency of said vibratory element is less by a predetermined amount than the frequency to which said circuit is tuned.

17. In a system for converting direct current into alternating current comprising a switch means, a direct current source, a capacitor, actuating means for said switch means to supply charging current periodically to said capacitor from said source, and an output circuit including inductance in series with said capacitor and adapted to be energized by current from said capacitor through said switch means, the method of operation which includes so tuning the series circuit comprising said capacitor and said inductance and so proportioning and arranging said switch means and actuating means that the frequency to which said series circuit is tuned is greater by a predetermined amount than the frequency at which voltage is applied from the direct current source to the series circuit by said switch means.

18. In a system for converting direct current into alternating current, a switch means, a direct current source, a capacitor, actuating means for said switch means to supply charging current periodically to said capacitor from said source, and an output circuit including inductance in series with said capacitor and adapted to be energized by current from said capacitor through said switch means, the reactances of the series circuit including said capacitor and inductance being such and said switch means and actuating means being so proportioned and arranged that the frequency to which said series circuit is tuned is greater by a predetermined amount than the frequency at which voltage is applied from the direct current source to the series circuit by said switch means.

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