

July 14, 1936.

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2,047,463

HIGH TENSION GENERATOR

Filed May 24, 1934

2 Sheets-Sheet 1

Fig. 1

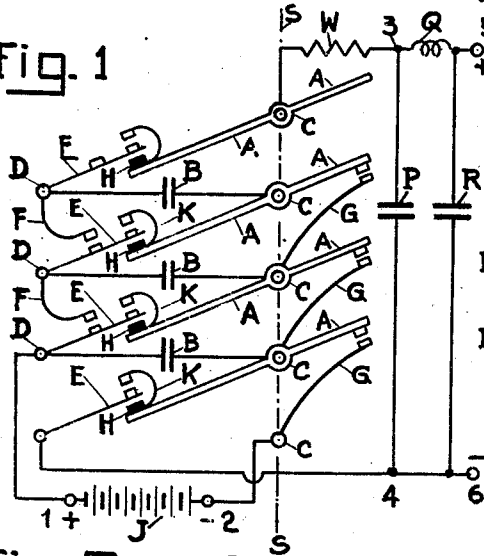


Fig. 4

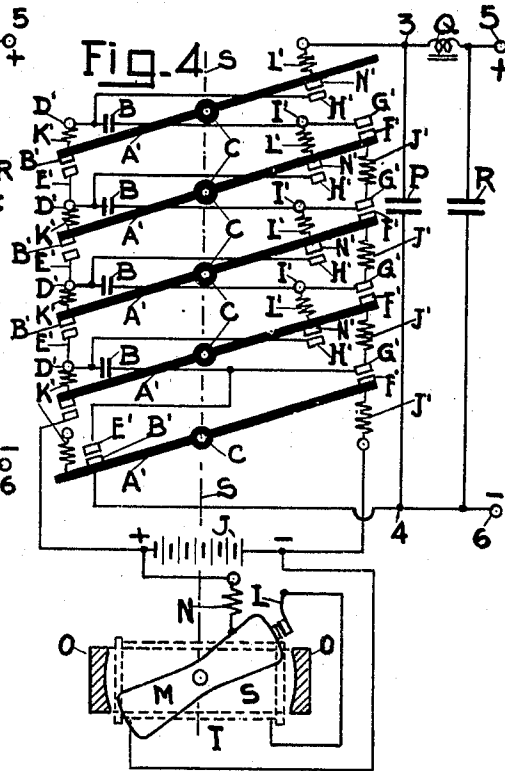


Fig. 2a

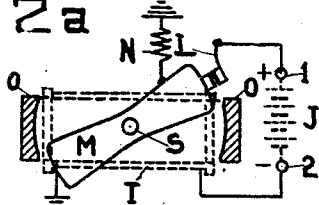


Fig. 2b

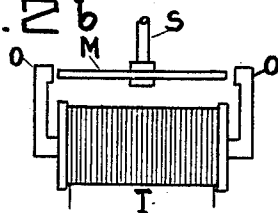
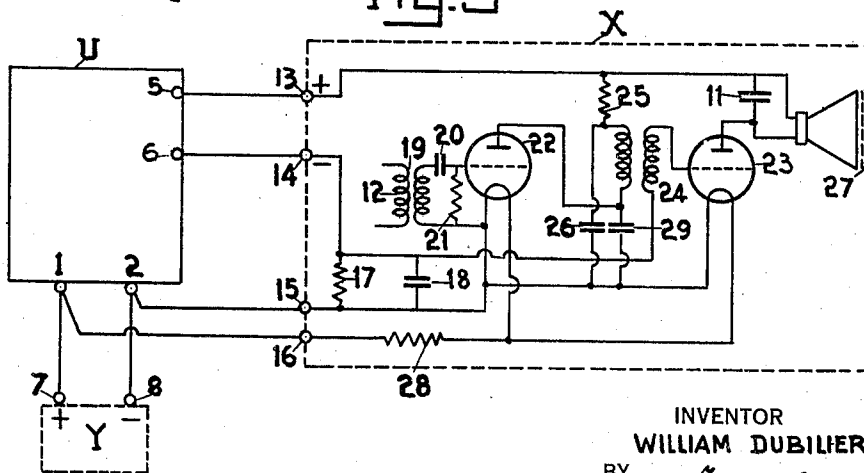


Fig. 3



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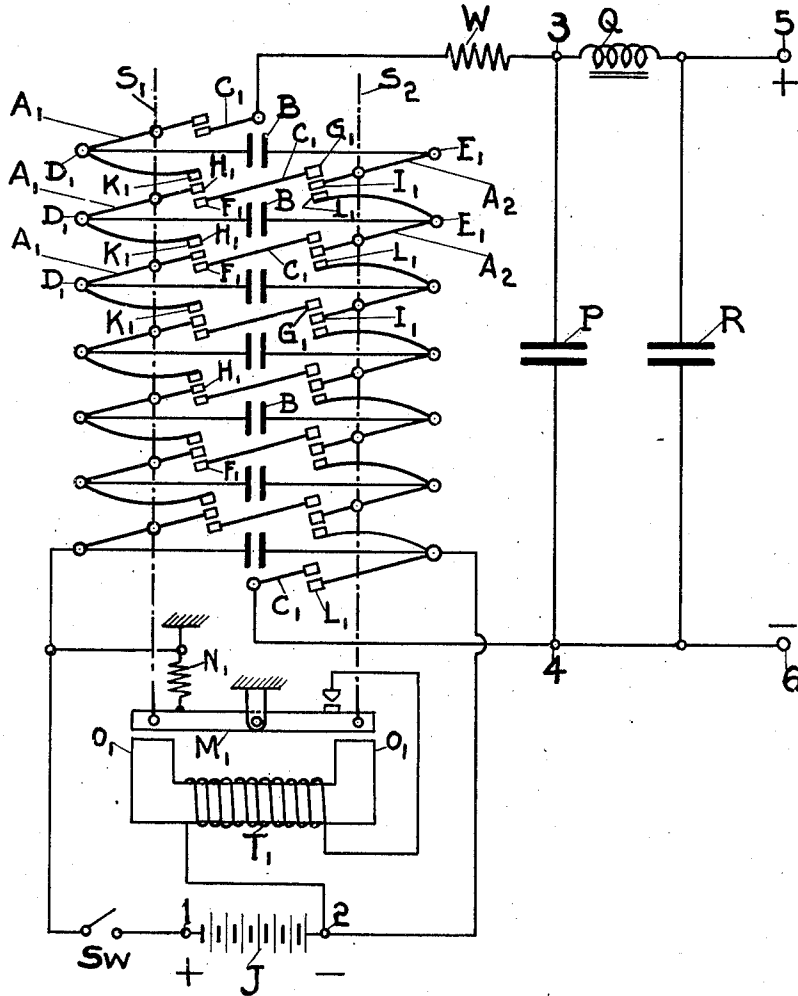
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2 Sheets-Sheet 2

Fig. 5



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2,047,463

HIGH TENSION GENERATOR

William Dubiller, New Rochelle, N. Y.

Application May 24, 1934, Serial No. 727,238
In Great Britain April 24, 1934

8 Claims. (Cl. 171-97)

The invention relates to apparatus and methods for operating such apparatus for the conversion of electrical energy from a low voltage supply source into a high voltage steady or direct current; and to the combination of such apparatus with a consuming device which requires to be energized either wholly or in part by a high voltage supply, such for example as a radio receiver, gaseous discharge devices, and similar apparatus.

In operating radio receiving or transmitting apparatus and portable stations in motor cars, motor boats and other mobile transport, it has been customary to utilize the so-called ignition or starter storage battery already available, which is usually of low voltage, from 6 to 12 volts, and which was essential also for heating the filaments of the valves in the radio apparatus. To obtain the high potential or anode supply for the valves either a small motor generator was utilized or a small transformer with a vibrating interrupter in its primary circuit and rectifiers connected across the secondary with smoothing devices for obtaining the desired high voltage direct current potential. These methods for obtaining the high potential supply are usually of very low efficiency, expensive, and, where the transformer and interrupting device are used, very unreliable in operation after a comparatively short period. Due to their inefficiency, considerable power is drained from the battery or low voltage supply, which thereby requires frequent re-charging and other attention.

Accordingly, a main object of my invention is the provision of a novel energy conversion device especially adapted for converting low voltage direct current into high voltage direct current which is simple in construction, reliable in operation and which is of great durability electrically and of high efficiency as compared to devices heretofore known in the art.

Furthermore, where formerly interrupters were utilized in the primary of the transformer, they have developed considerable trouble after short periods due to well-known reasons, such as sparking, wear of the contacts and other similar defects. These amongst others, are serious handicaps in the use of portable radio receiving and transmitting apparatus.

The aforementioned disadvantages and defects of converting systems known in the art using interrupting devices are due mostly to the fact that the entire current passes across the interrupting or vibrating contacts inserted in the primary of the transformer.

Accordingly it is a further object of my inven-

tion to provide means for novel energy conversion system especially for converting low voltage direct current into high voltage direct current in which the primary current passes through a large number of contact devices, thus greatly minimizing the tendency of arcing between the contacts and increasing the reliability and durability of the converter.

The object of the invention is to simplify the anode or high potential supply and to obtain the same from a low potential supply with very much greater reliability, thus enabling the use of either a smaller storage battery or longer periods of use with the same battery.

It is well-known that a condenser will store up electrical energy as an electric charge and if of efficient construction will act as a supply source of high efficiency; that is, it will store up and give up electrical energy at very high efficiencies.

The main cause for the excessive sparking at the interrupter contacts in devices heretofore known in the art is due primarily to the comparatively high inductance of the transformer or interrupter coil whereby a high voltage is induced when the contacts are interrupted due to the self-inductance of the circuit, resulting in an excessive spark, as is well known.

Accordingly it is a further object of my invention to provide a new energy conversion system in particular for producing high voltage direct current from low voltage direct current in which substantially no self-inductance is used, resulting in a substantial suppression of objectionable sparks or arcs produced between the contacts.

A more specific object of my invention is the provision of a plurality of low voltage energy storing devices and one or more high voltage storing devices, such as electrical condensers, and means for periodically charging the low voltage condensers in parallel and consecutively discharging them in series upon the high voltage condenser in such a manner that by rapid periodic repeating of the process of charging and discharging a substantially steady high potential charge is available at the terminals of the high voltage condenser which may be used for supplying a consuming device such as a radio receiver and the like.

The invention consists of the arrangement of a number of condensers, of sufficient capacity to supply the desired high potential currents in combination with means whereby they can be charged in parallel from the low voltage source and discharged in series in a simple manner.

It consists also in the mechanism whereby such

charging and discharging can be carried out with the minimum of switching apparatus and with apparatus of a robust and reliable form not readily liable to damage by sparking at the contacts, etc. during prolonged operation.

It consists also in the combination of the said switching means with a reservoir condenser or condensers and smoothing circuits for filtering out irregularities in the high voltage supply; and in the combination of the said apparatus with the consuming device, such for example as a radio receiver.

These and further objects and aspects of my invention will be better understood from the following detailed description taken with reference to the accompanying drawings wherein I have illustrated some forms of practical embodiment of the invention. The description is to be regarded as being illustrative only of the broad inventive concept which, as will become obvious, is susceptible of various modifications and variations coming within the broad scope and spirit of the invention as expressed in the appended claims.

In the diagrams, in which similar reference characters identify similar parts throughout;

Figure 1 indicates in diagrammatic form one example of the means for charging and discharging the condensers forming the basis of this invention.

Figures 2a and 2b detail a portion of the switching means described in connection with Figure 1.

Figure 3 indicates by way of example only the combination of a radio receiving apparatus (indicated in diagrammatic form only) with converting apparatus forming the subject of this invention; and

Figures 4 and 5 show modifications of a conversion system in accordance with the invention.

In one method of carrying the invention into effect a shaft S, insulated if necessary, has mounted upon it the desired number of switch arms A, Figure 1. Low voltage condensers B of the desired capacity (as determined by considerations of the high voltage energy required by the consuming device) are connected across the points C and D and small spring switch contacts E, F and G are connected to the different points of the condensers B as indicated. One end of the switch arm A is so arranged with an insulated button H and a U-shaped contact K so that when the movement of the arm around the center-point C as by rotation of the shaft S is in one direction (shown as clockwise in the diagram), insulated button H will press spring contact E upward until it makes contact with the contact point F, and at the same time the other end of switch arm A will make contact with spring contact point G connected to the other terminal of the condensers. It will thus be seen that in this position all the condensers are connected in parallel, and thus at the same time the two terminals of all the condensers are automatically connected to the source of supply J, which may be a 6 volt storage battery for example, and each condenser then becomes charged to this voltage.

The switch arm is now moved in the opposite direction; when all the previous contacts are first broken and then contact K is made with contact E, thus connecting all the condensers in series. At the same time the last switch arm is so arranged as to connect the output circuit 3, 4, to the last condenser, as indicated, and a high po-

tential is thus obtained at these points depending upon the number of condensers charged in parallel and connected in series.

The illustration is merely descriptive and the apparatus can consist of as many switch points and condensers as desired, depending upon the voltage required. It is evident also that the rate at which the switch arms A charge and discharge will govern the capacity of the condensers to be charged in parallel so as to furnish the desired energy. It is desirable, therefore, to construct the switch arms and contacts of small parts as light as possible consistent with mechanical durability and reliability of service.

One convenient way of embodying the construction is to have a small bi-polar electro-magnet with an armature which is mechanically associated with the shaft S for the switch arms and held in position by a small spring. If a current is passed through the windings of the electro-magnet T (Figures 2a and 2b) its poles O—O are energized and attract the armature M in well-known manner against the action of the spring N, so performing the operations described above. On one side may be placed a brush or other contact as shown at L, or alternatively a simple switching device as used in telephone apparatus for maintaining the current on and off for definite periods may be employed.

The electro-magnetic vibrating mechanism as shown for operating the switch arms A may be operated from a separate battery or from the supply source J as shown in the drawings. For this purpose one pole of the battery J is shown to be connected to the spring contact L of the vibrator while the other pole is connected to one terminal of the electro-magnet. The remaining terminal of the electro-magnet as well as the spring N of the armature M are shown to be grounded, thus completing the electrical circuit.

It is understood that any other actuating mechanism may be provided in place of the vibrating device as shown, such as a rotating contact arrangement and the like designed and operated for charging the condensers B in parallel and consecutively discharging them in series upon the output circuit or storage condenser P in rapid periodic succession in the same manner as described in connection with Figure 1.

Across the high potential output circuit 3, 4, is placed another condenser P which is used as a storage reservoir and which helps to give a smoother high voltage output. If necessary a smoothing choke Q and a further condenser R can be connected in well-known manner as shown in Figure 1. I have furthermore shown the negative pole 4 of the output circuit isolated from the low voltage source at 2 by an additional contact arm A, as shown in the drawings, by the connection of the negative or right-hand terminal of the lowermost condenser through the switch arm A, contacts K and E, to the point 4 of the output circuit in such a manner that both output leads are disconnected from the input during the charging period of the condensers B by the contacts K and E of the lowermost and uppermost switching arms, respectively. In this manner any undesired reaction of the high voltage output on the input circuit is substantially eliminated. Thus, during the discharging periods; that is, when the switch arms A have swung in the anti-clockwise direction the output circuit is connected to the condenser series by the closing of the contacts K and E of the lowermost and uppermost switch arms.

The illustration and example cited above is one way of carrying out the invention. Other simplified structures can be utilized, and the dimensions of the springs, contacts, insulating points, moving arms, will be governed by the potential of the supply available and the output required. If necessary, a small motor or cam device can be used and the contact springs may be long and the insulated buttons large if higher potentials and heavier currents are required.

Referring to Figure 4, this shows a modified arrangement for performing the necessary switching operations for charging and discharging the condensers B in accordance with the invention. While according to Figure 1 the switching arms A consist of conductive material, in the arrangement according to Figure 2 switching arms A' or similar switching members are made of insulating material carrying metallic contacts B', N', F' arranged as shown in the drawings. I have furthermore shown cooperating stationary contacts E', H' and G' mounted opposite the contacts B', N', and F', respectively. Reference characters D' and I' represent the terminals of the condensers B.

Regarding one of the switch arms A' and its coordinated condenser B, the connections are as follows: Switch contact B' is furthermore connected to condenser terminal D' through a resilient conductor, such as a coil spring K' or the like. The cooperating stationary contact E' is connected to the terminal D' of the preceding condenser, as shown. Switch contact N' is connected to the terminal I' of the succeeding condenser through a coil spring L' and its cooperating stationary contact H' is connected to the left-hand or positive terminal (D') of the condenser as shown. Switch contact F' is shown to be connected to stationary contact G' of the preceding switch arm through a spring J' and its cooperating stationary contact G' is connected to the terminal I' of the succeeding condenser. Contacts B' and E' of the lower switch arm and contacts H' and N' of the upper switch arm serve to disconnect the output leads from the input circuit during the discharging periods in the manner similar as described in Figure 1.

I have furthermore shown a vibrating device similar as described by Figures 2a and 2b for operating the switch arms A' and energized directly from the lower voltage source J. Otherwise, the operation and circuit arrangements are similar to the arrangements described by Figure 1.

Referring to Figure 5 of the drawings, this shows another way of practicing my invention comprising a plurality of condensers B and a pair of insulating operating members indicated at S₁ and S₂, such as insulating rods, operating a pair of sets of switching arms or springs as shown at A₁ and A₂. The insulating rods S₁ and S₂ are shown to be operated by the armature M₁ of an electromagnetic vibrator having poles O₁ and an operating winding T₁. The contact springs A₁ and A₂ are provided with contacts H₁ and I₁, respectively, cooperating with upper and lower stationary contacts K₁, F₁ and G₁, L₁ respectively, as seen from the drawings. The condenser terminals are shown at D₁ and E₁ directly connected to the left-hand and right-hand switch or spring contacts A₁ and A₂, respectively. Condenser terminal D₁ is furthermore connected to the upper contact H₁ of the preceding spring switch A₁ and the other terminal of the condenser E₁ is connected to the lower contact L₁ of the succeeding switch arm A₂. Stationary contacts F₁ and G₁

cooperating with the switch arms A₁ and A₂ are connected as by means of a connection shown at C₁. Alternatively, contacts F₁ and G₁ and the connection C₁ may consist of a single solid piece, as is understood.

The operation of this device is similar to the arrangements previously described. By vibration of the armature M₁ it is seen that the operating rods S₁ and S₂ will alternately move up and down, thus performing the necessary connections for successively placing the condensers B in parallel and in series. Thus in one position, if the rod S₂ moves downward and the rod S₁ moves upward, it is seen that contacts I₁ and L₁, on the one hand, and contacts H₁ and K₁, on the other hand, will be closed thus connecting all the condensers in parallel to the primary current source J. In the other position; that is, when rod S₂ moves upward and rod S₁ moves downward, the contacts are broken and contacts I₁ 20 and G₁ on the one hand and contacts H₁ and F₁ on the other hand will be closed, thus placing the condensers in series. At the same time the output circuit will be connected to the ends of the condenser series in a manner similar as described by the previous figures. I have furthermore shown the vibrating magnet to be supplied directly from the primary current source J. The primary circuit may be opened and closed as by means of a switch sw to set the apparatus into 30 operation. N₁ represents a spring for the vibrating armature M₁ and the remaining elements and their function are substantially equal to the previous arrangements shown by Figures 1 and 4 as will be readily understood.

While moving contacts and switches have been described which may appear similar in structure to those heretofore used, it is important to point out that this invention enables much lighter and smaller parts to be employed for the following reason. When the condensers are charged in parallel and the contacts broken, no difference of potential exists between the contacts and therefore no sparking occurs or should occur if the apparatus is properly adjusted. When the condensers are connected in series again connections are being made through which no current should flow for all practical purposes. It may be advisable under certain conditions to insert a resistance W between one of the terminals and the reservoir condenser to ensure smoother operation if the reservoir condenser P is being drained heavily.

In Figure 3 is given a diagrammatic representation of one manner in which the invention may be applied to the operation of a radio receiver, as for example a radio receiver installed in a motor car. In this diagram the low voltage source, which may be, for example, the storage battery of the said motor car, is indicated at Y. The box U represents an enclosure containing an apparatus constructed in accordance with the invention, as for example that illustrated in Figures 1, 2a and 2b, and 4 wherein 5 and 6 represent the output terminals of this device. The enclosure X represents the radio receiver proper and for the purpose of illustration this is shown as containing two valves 22 and 23 only, although in the majority of such receivers more than two valves would be employed. In the diagram, the low frequency portion of the receiver only is shown, the valve 22 being indicated as a detector valve and the valve 23 as an audio frequency amplifier valve for operating a loud speaker 27. The terminals 1 and 2 of the box U containing the

apparatus constructed in accordance with this invention are connected to the terminals 7 and 8 of the storage battery Y and are also connected to the terminals 15 and 16 for supplying the low tension connection for heating the filament or cathodes of the valves 22 and 23 in the radio receiver. A resistance 28 may be inserted in series with this filament circuit if desired to limit the current flow through these filaments, or alternatively two or more of the valve filaments may be connected in series as may be most convenient depending upon the voltage of the storage battery Y. The terminals 5, 6 forming the high voltage output terminals of U, are connected to the corresponding terminals 13, 14 in the radio receiver X and the terminal 13 being the positive high voltage terminal is connected directly to the loud speaker 27 and also through a voltage drop resistance 25 and primary winding of transformer 24 to the anode of the valve 22. Corresponding connections may also be made to the other valves in the radio receiver either directly to the positive connection 13 or through various voltage dropping or de-coupling resistances as may be required, depending upon the design of the valves and of the particular radio receiver in which they are employed. The radio frequency side of the receiver or the intermediate frequency side in case of a superheterodyne receiver would be connected to the coil 12 and is shown in the diagram as coupled through the transformer 19 to the grid condenser 20 and the grid leak 21 of the detector valve 22, but it is to be understood that this arrangement is diagrammatic only and may be varied as desired. The condenser 26 forms a de-coupling condenser in conjunction with the resistance 25, while a second condenser 29 may be used to form a radio frequency bypass from the anode of the valve if desired. The secondary winding of the transformer 24 is shown returned directly to the terminal 14 which is the negative terminal of the high voltage supply given by the apparatus U. The resistance 17 is connected between this terminal and terminal 15 which is the negative terminal of the storage battery supply from Y. The condenser 18 is shunted across this resistance to prevent undesirable reactions between the various valves in the receiver and degeneration of the signals by valve 23. Other tapings on this resistance 17 can be utilized for different grid bias voltages to other valves in the radio receiver. The resistance 17 serves to provide automatic means of furnishing grid bias voltage to the valves in the radio receiver, and when it is used the connection between the reservoir condenser P, Figure 1, and the negative terminal of the storage battery must be removed and replaced by a switch contact on an arm A similar to the other contacts in order to prevent short-circuiting of this resistance 17.

This has been shown in Figure 1 by connecting the negative or right-hand terminal of the lowermost condenser B through the contact arm A and spring contact G to the negative pole of the supply source J in place of a direct connection from B to the source J. Thus, the contacts G, K and E of the lowermost switch arm serve on the one hand to disconnect the output circuit from the input during the charging periods, and on the other hand to disconnect the battery I during the discharging periods. In this manner a short circuiting of the biasing resistance 17 is prevented. Alternatively, indirectly heated cathodes may be used for the vacuum tubes 22 and 23 for prevent-

ing short circuiting of the biasing resistance 17, in which case the disconnecting switches may be dispensed with, as is readily understood.

Various other combinations of the apparatus U which forms the source of the high voltage direct current and the utilizing apparatus X may also be arranged, while the apparatus X may take a variety of other forms than the radio receiver shown in the diagram, without departing from the spirit of the invention.

The invention may be applied to other devices, such for example as the operation of X-ray tubes where a direct current potential is preferable, and in this manner can be obtained without the use of large transformers and expensive rectifiers to furnish the high voltages. As a further example the apparatus may be applied for use in the illumination of gas discharge tubes and electric signs and the like where high potentials are required, and can thus be furnished in a simple safe and inexpensive manner from existing low voltage supply sources, such as direct current electric power mains or batteries.

I claim:

1. An energy conversion apparatus comprising a low voltage circuit; a plurality of pairs of switching devices, corresponding devices of each pair being connected in series and to one terminal of said circuit; a plurality of electrical condensers each connected with one of said pairs of switching devices, whereby said condensers are connected in parallel across said circuit when said devices are in current passing condition; common control means for operating said devices in unison; a high voltage circuit; and a set of further switching devices connected to said condensers and to said high voltage circuit, said last mentioned switching devices being also operated by said control means for connecting said condensers in series across said high voltage circuit when said first devices are in current interrupting condition.

2. An energy conversion apparatus comprising a low voltage circuit; a plurality of pairs of switching devices, corresponding devices of each pair being connected in series and to one terminal of said circuit; a plurality of electrical condensers each connected with one of said pairs of switching devices, whereby said condensers are connected in parallel across said circuit when said devices are in current passing condition; common control means for operating said devices in unison; a high voltage circuit; a set of further switching devices connected to said condensers and to said high voltage circuit, said last mentioned switching devices being also operated by said control means for connecting said condensers in series across said high voltage circuit when said first devices are in current interrupting condition; and means for periodically operating said control means at such a rate as to secure a substantially steady energy transfer between said low voltage and high voltage circuits.

3. An energy conversion apparatus comprising a low voltage circuit; a plurality of pairs of switching devices, corresponding devices of each pair being connected in series and to one terminal of said circuit; a plurality of electrical low voltage condensers each connected with one pair of said switching devices, whereby said condensers are connected in parallel across said circuit when said devices are in current passing condition; common control means for operating said devices in unison; a high voltage condenser and a circuit connected thereto; and a set of further

switching devices connected to said low voltage condensers and to said high voltage condenser, said last mentioned switching devices being also operated by said control means for connecting
 5 said condensers in series across said high voltage condenser when said first devices are in current interrupting condition.

4. An energy conversion apparatus comprising a low voltage circuit; a plurality of pairs of switching devices, corresponding devices of each pair being connected in series and to one terminal of said circuit; a plurality of electrical low voltage condensers each connected with one pair of said switching devices, whereby said condensers are connected in parallel across said circuit
 15 when said devices are in current passing condition; common control means for operating said devices in unison; a high voltage condenser and a circuit connected thereto; a set of further switching devices connected to said low voltage condensers and to said high voltage condenser, said last mentioned switching devices being also
 20 operated by said control means for connecting said condensers in series across said high voltage condenser when said first devices are in current interrupting condition; and means for periodically operating said control means at such a rate as to secure a substantially steady energy transfer between said low voltage and high voltage circuits.

5. An energy conversion apparatus comprising a low voltage circuit; a plurality of rocking switching members; a pair of first contacts carried by each of said switching members; cooperating stationary contacts for said contacts and circuit connections therebetween and said low voltage circuit, whereby corresponding contacts of said switching members are connected in series and to one terminal of said circuit in one position of said switching members; a plurality of electrical condensers each with one of said switching members, whereby said condensers are connected in parallel when said contacts are in closed position; a high voltage circuit; further
 45 contacts associated with each of said switching members and cooperating stationary contacts therefor; and circuit connections between said last mentioned contacts, said low voltage condensers and said high voltage circuit, whereby
 50 said condensers are disconnected from said low voltage circuit and connected in series across said high voltage circuit in another position of said switching members.

6. An energy conversion apparatus comprising
 55 a low voltage circuit; a plurality of rocking switching members; a pair of contacts carried by each of said switching members; cooperating stationary contacts for said contacts and circuit connections therebetween and said low voltage circuit, whereby corresponding contacts of said
 60 switching members are connected in series and

to one terminal of said low voltage circuit in a predetermined position of said switching members, a plurality of low voltage condensers each connected to one of said switching members, whereby said condensers are connected in parallel across said circuit when said contacts are in closed position; a high voltage condenser and a circuit connected thereto; further contacts associated with said switching members and cooperating contacts therefor; and circuit connections between said last mentioned contacts, said low voltage condensers and said high voltage condenser, whereby said low voltage condensers are disconnected from said low voltage circuit and connected in series across said high voltage
 15 condenser in another position of said switching members, and means for periodically operating said switch members for securing steady energy transfer between said low voltage and high voltage circuits.

7. An energy conversion apparatus comprising a plurality of low voltage condensers; a low voltage direct current circuit; a high voltage direct current circuit; a first set of switching devices connected between each two successive plates of like polarity of said condensers and said low voltage circuit; control means for closing said switching devices in unison to connect said low voltage condensers in parallel across said low voltage circuit; a further set of switching devices connected
 30 between each of said condensers and said high voltage circuit, said last mentioned switching devices being operatively associated with said control means, for connecting said condensers in series across said high voltage circuit upon interruption of the first mentioned switching devices.

8. An energy conversion apparatus comprising a plurality of low voltage condensers, a low voltage direct current circuit; a high voltage condenser and a direct current circuit connected thereto; a first set of switching devices connected between each two successive plates of like polarity of said low voltage condensers and said low voltage circuit; control means for closing said devices in unison to connect said low voltage
 45 condensers in parallel across said low voltage circuit; a further set of switching devices connected to each of said low voltage condensers and said high voltage condenser operable by said control means for connecting said low voltage condensers in series across said high voltage condenser upon interruption of said first switching devices; and means for periodically operating
 50 said control means for alternately connecting said low voltage condensers in parallel to said low voltage circuit, and in series across said high voltage condenser, respectively, at such a rate as to secure substantially steady energy transfer between said low voltage and high voltage circuits.

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