April 27, 1937. B. SPRINGER 2,078,618

DIRECT CURRENT TRANSFORMER

Filed Sept. 29, 1934 4 Sheets-Sheet 1

Fig. 1

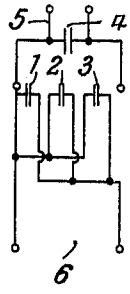



Fig. 2

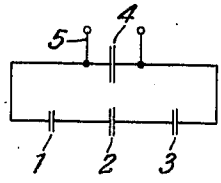



Fig. 3

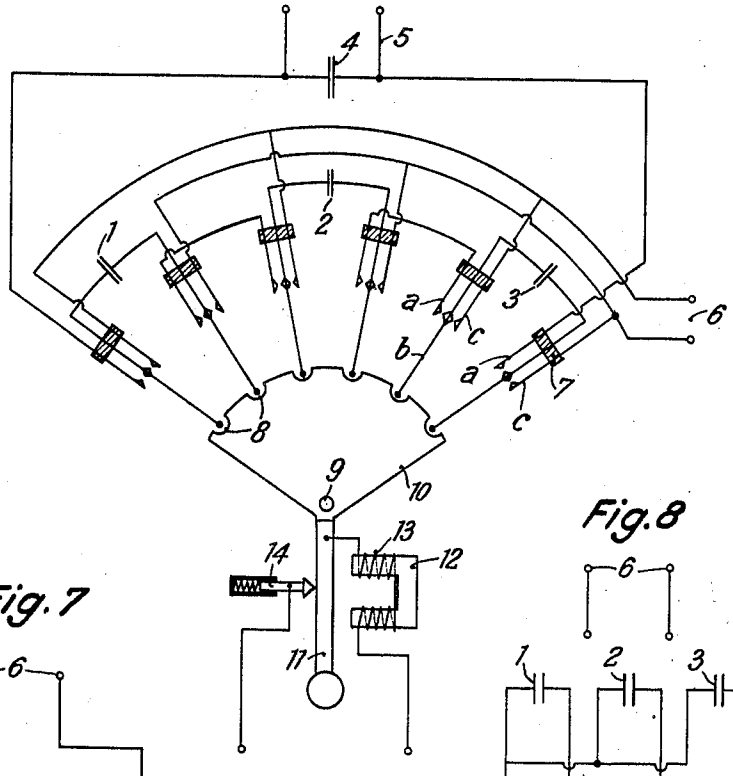



Fig. 7

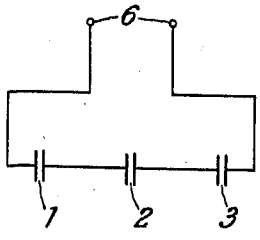
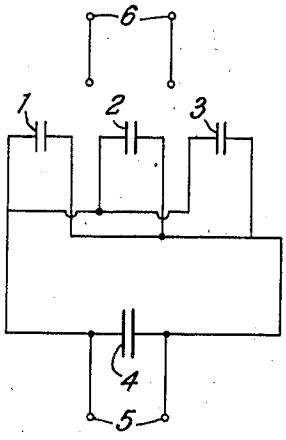



Fig. 8




B. Springer
INVENTOR

By: Glascock Downing & Seebold
Attys.

April 27, 1937. B. SPRINGER 2,078,618

DIRECT CURRENT TRANSFORMER

Filed Sept. 29, 1934 4 Sheets-Sheet 2

Fig. 4

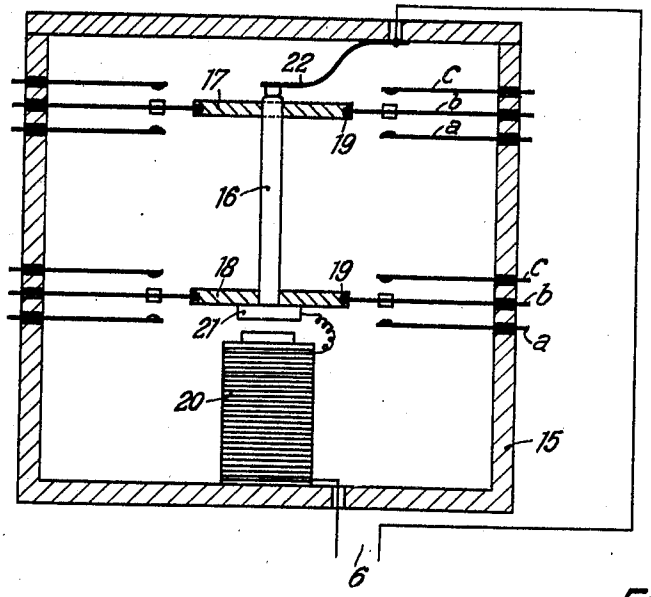



Fig. 5

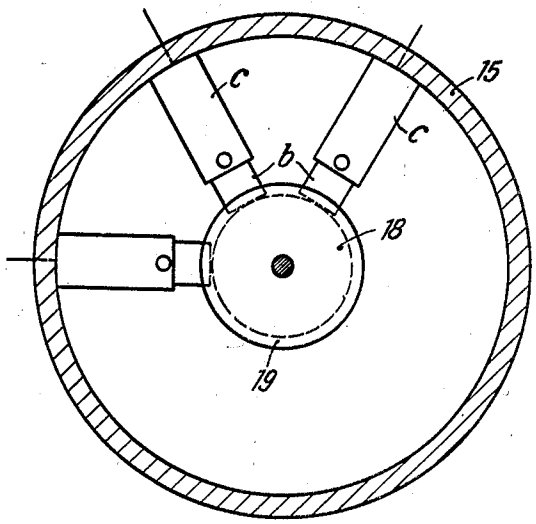
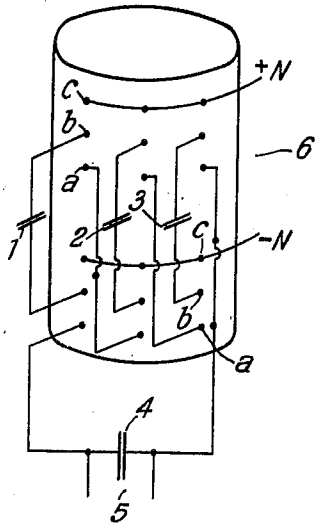



Fig. 6




B. Springer
INVENTOR

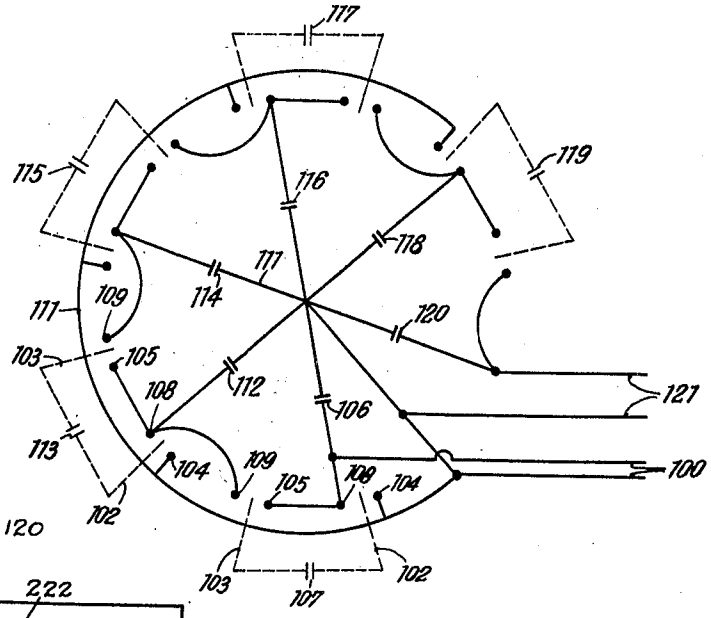
By: Glascock Downing & Seebold
ATTYS.

April 27, 1937. B. SPRINGER 2,078,618

DIRECT CURRENT TRANSFORMER

Filed Sept. 29, 1934 4 Sheets-Sheet 3

Fig. 14



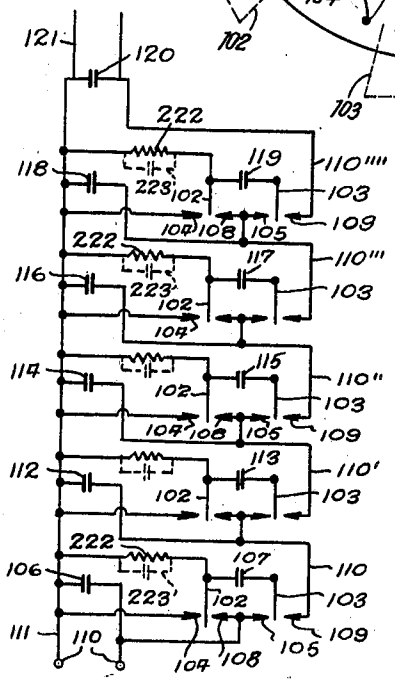




Fig. 9

B. Springer
INVENTOR

By: Glascock Downing & Seebold
Attys.

April 27, 1937. B. SPRINGER 2,078,618

DIRECT CURRENT TRANSFORMER

Filed Sept. 29, 1934 4 Sheets-Sheet 4

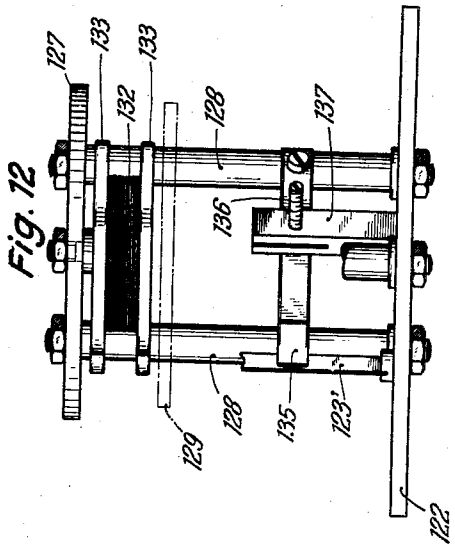



Fig. 12

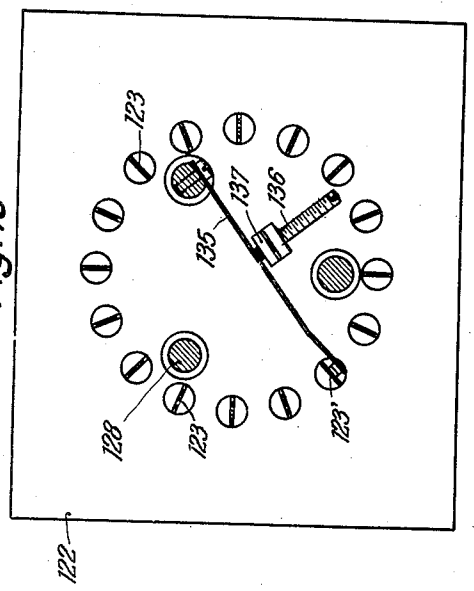



Fig. 13

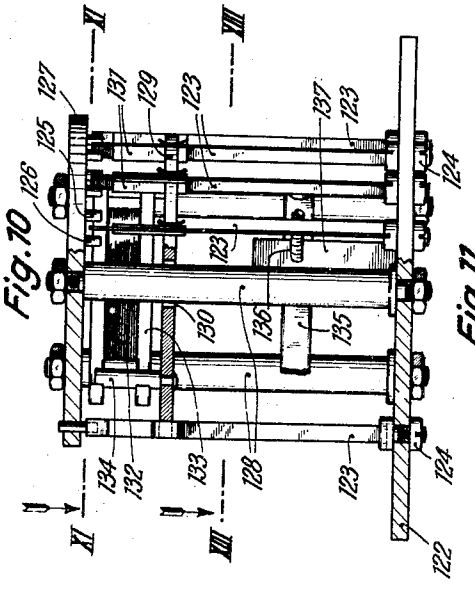



Fig. 10

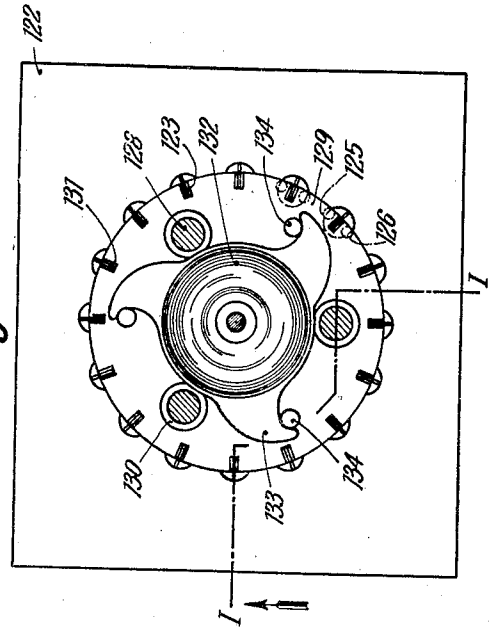



Fig. 11

B. Springer
INVENTOR

By: Glascock Downing & Seebold
Attys.

Patented Apr. 27, 1937

2,078,618

# UNITED STATES PATENT OFFICE

2,078,618

## DIRECT-CURRENT TRANSFORMER

Berthold Springer, Berlin-Schoneberg, Germany

Application September 29, 1934, Serial No. 746,253
In Germany October 2, 1933

22 Claims. (Cl. 171—97)

My invention relates to improvements in direct current transformers and methods for operating such transformers and has for its main object to provide a transformer of this type having improved characteristics and high operating efficiency.

Further objects and advantages of the invention will be apparent from the detailed description hereafter presented in connection with the accompanying drawings.

In accordance with the general method and apparatus forming the subject of the invention, I provide a set of condensers connected with a plurality of movable contact elements, a load or output circuit, and an input circuit carrying the low voltage to be transformed and means for periodically operating said movable contacts for alternately placing the condensers in parallel and in series in such a manner that they are charged in parallel at low voltage from the primary circuit and thereafter discharged in series at high voltage upon the load circuit. I furthermore provide a suitable storage device such as an electric condenser in the load circuit in such a manner that by choosing a sufficient rate of the charging and discharging periods a substantially steady output voltage is obtained.

It has already been proposed to transform direct current of comparatively low voltage into direct current of high voltage by charging a set of condensers with a primary voltage to be transformed, and thereafter discharging the condensers in series. The total secondary voltage thus obtained is equal to the number of condensers used multiplied with the primary voltage.

This method of transformation by means of condensers is superior to the use of rectifiers because it operates practically without loss. Heretofore, direct-current transformers designed on this principle, however, were not suited for use in practice due substantially to the fact that difficulties were encountered in performing the necessary switching operations of the condensers and that the number of switching operations per second should be very high if a continuous output voltage is desired. Moreover, consideration must be given to the voltage applied to the condensers which may amount to several thousands of volts, and to the power consumption of the switching device which should be as low as possible. In addition, switching devices as used heretofore, mostly comprising rotary contact drums, have been found to be quite unsatisfactory due to the fact that after a short period of operation, strips of conducting metal form between the individual metal contacts of the drum, resulting in short-circuits. Moreover, rotary contact drums are not reliable for continuous operation without attendance.

By providing a transformer according to my invention as described, the above-mentioned drawbacks are substantially eliminated and reliable switching of the condensers is insured.

Transformers according to my invention may be used in all cases where a high direct current voltage is required. Thus, high voltage current is required in systems for testing insulators and the like. Heretofore, crank inductors, which are inaccurate and expensive, or large generators, had to be used for obtaining comparatively high voltages. High voltage direct current is also required for operating gas discharge tubes for power and similar purposes. Stepping down of direct current voltage is required, for instance, for charging storage batteries from a supply system having a higher voltage, such as for heating vacuum tubes, etc., in the operation of wireless transmitters or receivers.

I have shown in the accompanying drawings, various types of transformers embodying my invention and diagrams illustrating the operation according to the invention.

In the drawings:

Figures 1 and 2 are diagrams showing, respectively, condensers connected in parallel and in series.

Figure 3 diagrammatically illustrates a direct-current step-up transformer in accordance with the invention.

Figure 4 and Figure 5 show vertical and horizontal cross-sections, respectively of a constructional embodiment of a device according to the invention.

Figure 6 is a diagram illustrating the operation of the device according to Figures 4 and 5.

Figures 7 and 8 show diagrams for step-down transformation in the charging and discharging positions, respectively, of the condensers.

Figure 9 shows a cascade connection of condensers.

Figure 10 shows another form of a switching device according to the invention.

Figure 11 is a section on line XI—XI in Figure 10.

Figure 12 is an elevation showing certain parts of the device according to Figure 10.

Figure 13 is a section on line XIII—XIII in Figure 10.

Figure 14 is a diagram showing connections for devices according to Figures 10 to 13.

Referring to the drawings, Figure 3, items 1, 2 and 3 represent individual condensers of the transformer, it being understood that any number of such condensers may be provided, while item 4 is a collecting condenser for maintaining a steady output voltage. Item 5 indicates a load circuit connected to the collecting condenser 4. As is understood, more than one collecting condenser may be provided, or the collecting condenser may be dispensed with altogether. Item

6 indicates the supply or input circuit carrying the primary voltage to be transformed.

Figure 1 is a diagram showing the three condensers connected in parallel to the circuit 6 in charging position, while Figure 2 shows the condensers connected in series to the collecting condenser 4 in the discharging position. The collecting condenser is thus charged to three times the primary voltage without loss and the high voltage direct current applied to the load circuit 5.

The periodic switching-over of the condensers from one position to the other position is carried out automatically and in rapid succession, such as by means of an arrangement illustrated in Figure 3. In the latter, a plurality of groups of contact elements each comprising three contact springs *a*, *b*, and *c* secured to blocks 7 of insulating material are provided in circular arrangement as shown. The ends of the central movable springs of each group connected to the condensers engage notches 8 of a segmental element 10 fulcrumed at its center 9. The segmental element 10 is made of insulating material or the ends of the springs *b* may be properly insulated. I have furthermore shown means for oscillating the element 10 provided for this purpose with a rocker arm extension 11 which is partly or entirely of magnetic material and carries a balance weight at its extreme end. This arm is alternately attracted and released by an electromagnet 12 whose coil 13 has one end connected to the arm as shown. Item 14 is a spring contact engaging the arm 11 as shown. When the arm 11 is in the central position illustrated, an electric circuit is closed through contact 14, arm 11, and the magnet coil 13, whereby the magnet attracts the arm, thus breaking the circuit of coil 13. The arm now moves into the opposite position, forcing back contact 14 and closing the circuit, whereupon the cycle is repeated in a known manner. When the arm 11 moves to the left, the springs *b* engage the fixed contacts *c* and all condensers 1, 2 and 3 are connected in parallel to the primary or fundamental voltage circuit 6. The connection is now as shown in Figure 1 and the condensers are charged. When the arm 11 moves to the right, the springs *b* engage the contacts *a* and the connection illustrated in Figure 2 is obtained whereby the total voltage of the condensers is applied to the collecting condenser 4 supplying the load with the desired voltage.

Thus, during each oscillation of the segment 10, the collecting condenser is charged afresh at high voltage. The velocity at which the segment oscillates is limited only by the charging period of the condensers which, however, is so short as to be negligible so that any practically attainable frequency of oscillation may be used.

This method of switching has the additional advantage that the movable contact members *b* have to move through short distances only in the notches 8. The collecting condenser 4 and the load circuit 5 are never in conductive connection with the fundamental or primary circuit 6. Short-circuits in the load circuit 5 which frequently occur during tests are harmless and only cause a more intense discharge of the collecting condenser 4.

Referring to Figures 4 and 5 showing a structural embodiment of a switching apparatus according to the invention, the contact springs *a* and *c*, and the movable spring *b* therebetween are arranged one above the other and mounted in the wall and distributed along the circumference of a cylindrical casing 15 of insulating material, such as fibre. Mounted centrally on a shaft 16 between the contacts and movable members are a pair of switching plates 17 and 18 of insulating material, and the movable members *b* are arranged to engage recesses 19 in the two plates 17 and 18 as shown. By these means the shaft 16 is resiliently supported by the movable members *b* and is moved up and down by an electromagnet 20 attracting an armature 21 mounted at the lower end of shaft 16. Item 22 is a contact spring engaging the upper end of shaft 16 which is in the neutral position as shown. One end of the magnet coil 20 is connected to the armature and the remaining end is connected to one pole of the source of input potential to be connected at 6. The other pole of the input source is connected to the spring contact 22. Thus, when the magnet 20 is excited and armature 21 is attracted, the circuit is periodically broken by contact 22 and the shaft 16 together with the movable springs 6 vibrated in a manner similar as described in connection with Figure 3.

Figure 6 shows the diagram of connections for Figures 4 and 5. The projecting ends of the contacts *a*, *c* and the movable members *b* are indicated by black dots. By the vibrating movement of shaft 16, the movable member *b* is alternately caused to engage contacts *a* and *c*, in a similar manner as described for Figure 3, and the condensers 1, 2 and 3 are connected and disconnected as described.

Another advantage of the device illustrated in Figures 4 to 6 is the fact that only small weights have to be moved for performing the switching operation so that a small battery, such as an ordinary flash light battery, may be used for energizing the magnet coil 20. The voltage of the battery is maintained constant by any suitable means to obtain a uniform oscillation and constant charging of the collecting condenser 4. Another reason why the battery may be small is the fact that it is not necessary to start the movable members *b* which will rapidly attain resonance and amplitudes required for engaging the contacts *a* or *c*, respectively.

The method of stepping down direct current voltages is illustrated diagrammatically by Figures 7 and 8. In the position shown in Figure 7, the condensers are connected in series and charged at high voltage, and then, as shown in Figure 8, they are separated from the source of high voltage and connected in parallel. As will be understood, a voltage stepped down at the ratio of 3:1 is available at collecting transformer 4 in the example illustrated. The devices illustrated in Figures 3, 4 and 5 may be used for performing the switching operation but obviously the circuits must be modified as shown in Figures 7 and 8.

The transformer ratio obtained by the means described depends on the number of condensers used. The resultant voltage for three condensers is three times the fundamental voltage in a step-up transformer, or one-third thereof in a step-up or step-down transformer.

It may be desirable to obtain a higher ratio with a given number of condensers to save the condensers and to simplify the system and reduce the initial cost. For this purpose, I have shown a simplified arrangement in Figure 9 based on the cascade principle. When the movable members shown at 102 and 103 move to the left, the condensers 106 and 107 are connected

in parallel and both to the voltage supplied at the input terminals 100 which may be an available supply voltage, for instance 220 volt, to which the condensers are charged. Upon the subsequent movement of movable members 102, 103 to the right, the condensers 106 and 107 are connected in series over contacts 108 and 109, so that a voltage of 440 is applied between the lead 110 connected to contact 109, and the lead 111. The condenser 112 has the same voltage applied to it, and when the movable members again move to the left, the condenser 113 is connected in parallel to condenser 112. When the movable members 102, 103 again move to the right, condensers 112, 113 are connected in series so that the total voltage between the leads 111, 110' is 880 volts in the example above given. In this manner the fundamental voltage is raised to a final voltage of 7040 by connecting the condensers 114 and 115, 116 and 117, and 118 and 119 alternately in parallel and in series, and the collecting condenser 120 to which the load circuit 121 is connected is charged at this voltage. It is understood that on account of the finite charging periods of the condensers, a number of oscillations of the movable members 102, 103 are required before static conditions are attained requiring a few seconds for the starting of the transformer.

It follows that by the novel connection, a thirty-two fold ratio is obtained instead of a ten-fold ratio obtained with the previous methods. For a still higher ratio, a greater number of series-parallel groups may be provided, or three or more condensers may be provided in each group, the final voltage being equal to $m^n$ wherein $m$ is the number of condensers in each group and $n$ represents the number of groups used. For instance, if groups of three condensers are formed, the ratio increases by a cubic law, that is, with five groups of three condensers each the ratio would be 1:243.

The advantages of a system of this type are obvious. Another and very important advantage of the invention is the fact that the number of movable contact members is reduced considerably so that the device becomes more simple and reliable.

Stepping-down may be performed on the same principle. The high voltage to be transformed has only to be connected to wires 121 while the condenser 106 serves the collecting condenser for the load circuit.

The condensers should be adapted to the various voltages in such a manner that the capacity of the condensers decreases as the voltage increases since the higher the voltage and the lower the current intensity, the smaller the capacities required for receiving the voltage impulses.

It is most important for the reliability of the devices described, that no sparks should form between the movable contact members and the cooperating contacts as this would damage the contacts on account of the high number of operations. In the diagram, Figure 9, the contacts 104—108, or 105—109 carry the full voltage, whereas the voltage between the contacts 102—103, 104—108, and 105—109 may never attain amounts at which sparks will form because the condensers transmit only part of their charge to the next steps. It has been found in actual operation, however, that a closing spark occurs between contacts 104 and movable member 102 which is troublesome, particularly at higher voltages. I have found that this closing spark is due to a certain leakage capacity which the condensers 119, 107, 113, 115 possess through their casing which is of the order of some 100 cm. and connected to earth, or wire 111. This leakage capacity is charged when the two condensers 118 and 119 are connected in series, at the full voltage of the respective stage, say, 3520 volts so that upon the subsequent movement of member 102 to the left, there is a great voltage drop between the member and contact 104 which causes a spark to jump.

Sparking is eliminated according to my invention by connecting the movable contact members 102 to earth or to the wire 111 through a high resistance 222. While the contact member 102 moves from contact 108 to contact 104, the leakage capacity is discharged and sparking is prevented. In Figure 9 the leakage capacity of the condenser where it occurs, is indicated in dotted lines at 223.

Referring now to Figures 10 to 14, these show a switching device particularly designed for cascade operation but equally suited for the simple system described previously. Item 122 is a base plate in which are inserted movable contacting members or springs 123 with terminal screws 124 at their lower ends. The free end of each movable member 123 projects between two contact elements 125 and 126 secured to a top plate 127 supported by posts 128, connecting the top and base plates as shown. A disk 129 of insulating material has its peripheral edge connected to the springs 123 as shown. The posts 128 pass through openings of the plate 129, said openings being larger than the diameter of the posts as shown in Figure 11. When disk 129 is rotated, the movable members 123 engage one or the other contacts 125 and 126. The holes 130 for the posts 128 must be wide enough to provide sufficient clearance to insure engagement of the contacts 125 and 126. Tension is exerted on the movable members 123 when the disk 129 is turned but this is limited to the portion of the members which is between base plate 122 and disk 129 while the portions of the members which project from disk 129 are displaced practically without distortion. In order to dampen the projecting portions of member 123, damping plates 131 may be arranged at opposite sides thereof, as shown.

When the disk 129 is oscillated, the movable members 123 alternately engage the contacts 125 and 126. Any suitable means may be provided for oscillating the disk 129. Thus, the disk may be provided with a lug, not shown, which is struck by an oscillating hammer. In the example illustrated, oscillation of disk 129 is effected by an interrupter comprising a magnet coil 132 having core 133 with three extending arms as seen from Figure 11. The armatures consist of three pins 134 mounted upon the disk 129. When the core 133 attracts its three armatures 134, the disk 129 moves closer to one of the contacts, such as 125. When the coil 132 is deenergized, the elastic reaction of the movable contacting members 123 causes the disk 129 to return and the movable members 123 to engage contact 126. A spring 135, as shown in Figure 13, cooperating with a contact spring 123' serves to control the exciter circuit, in a manner similar as described hereinbefore.

The operation is as follows: current at first flows thru coil 132 (see Figures 10 and 13), then thru spring 135 and contact spring 123', and back to the source of energy. While the spring

135 is in contact with spring 123', the exciter circuit is closed. The circuit is broken at the instant when the springs 135 and 123' are separated by the movement of disk 129. Spring 123' swings back and the cycle is repeated. The spring 135 may be adjusted by a set screw 136 mounted upon a bracket 137. The current consumption is very low so that a normal pocket lamp battery will last for more than 1,000 hours.

A condenser is arranged between every two movable contacting members 123, and connected thereto by screws 124. The condensers are not shown and it is understood that they may comprise several individual condensers connected in parallel. The contacts 125 and 126 are connected to each other in the manner illustrated in Figure 9.

It is understood that I am not in any way limited to any particular type of condenser but may use any condensers desired.

I claim:

1. In a direct-current transformer, a primary circuit supplying a voltage to be transformed; a secondary circuit; a set of condensers; a plurality of movable contact members; a pair of cooperating contact elements for each movable member arranged at opposite sides of the movable member; and means for alternately placing said movable members into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when said movable members engage one of their cooperating contacts and that the condensers are connected in series to said secondary circuit when said movable members engage their other cooperating contact.

2. In a direct-current transformer, a load circuit; an equalizing condenser connected across said load circuit; a primary circuit supplying a fundamental voltage to be transformed; a set of condensers; a plurality of movable contact members; a pair of cooperating contact elements for each movable member arranged at opposite sides of said movable members; and means for alternately placing said movable members into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that said condensers are connected in paralel to said primary circuit when said movable members engage one of their cooperating contacts, and that said condensers are connected in series to said load circuit when said movable members engage the other of their cooperating contacts.

3. In a direct-current transformer, a load circuit; a primary circuit supplying the fundamental voltage to be transformed; a plurality of groups of condensers; a plurality of movable contact members; a pair of cooperating contacts for each movable member arranged at opposite sides of the corresponding movable member; means for alternately placing said movable members into engagement with one of their cooperating contacts; further means including circuit connections for connecting the individual condensers of each group in series and across one of the condensers of the succeeding group in one of the contacting positions of said members; and further means for connecting the condensers of each group in parallel in the other contacting position of said movable members, said primary circuit being connected across a condenser of the first group and said load circuit being connected across the last group of condensers.

4. In a direct-current transformer, a load circuit; a primary circuit supplying the fundamental voltage to be transformed; a set of condensers; a plurality of movable contact members; a pair of cooperating contacts for each movable member arranged at opposite sides of the corresponding movable member; means for grounding said movable members through a high resistance; and means for alternately placing said movable members into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when the movable members engage one of their individual contacts, and that the condensers are connected in series to said load circuit when the movable members engage the other of their cooperating contacts.

5. In a direct-current transformer, a load circuit; a primary circuit supplying the fundamental voltage to be transformed; a plurality of condensers; a plurality of movable contact members; a pair of contacts for each movable member arranged at opposite sides of the corresponding movable member; an element operatively connected to said movable members for alternately placing them into engagement with one of their cooperating contacts; and means for imparting oscillating movement to said element, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when said movable members engage one of their cooperating contacts, and that the condensers are connected in series to said load circuit when said movable members engage the other cooperating contact.

6. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a set of condensers; a plurality of movable contact members, a pair of contacts for each movable member arranged at opposite sides of the corresponding movable member; a vibrating element operatively connected to said movable members and being electrically insulated therefrom; and means for imparting vibratory movement to said element for alternately placing said movable members into engagement with their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when said movable members engage one of their cooperating contacts, and that the condensers are connected in series to said load circuit when said movable members engage the other cooperating contact.

7. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a plurality of condensers; a plurality of movable contact members; a pair of juxtaposed contacts for each movable member arranged at opposite sides of the corresponding member and distributed along the arc of a circle; a vibratory element having recesses engaging said movable members; and electromagnetic means for imparting vibrating movement to said element for alternately placing said movable members into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that said condensers are connected in parallel to said primary circuit when said movable

members engage one of their cooperating contacts, and that said condensers are connected in series to said load circuit when said movable members engage their other cooperating contact.

8. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a set of condensers; a plurality of flat contact springs; pairs of cooperating contacts associated with each of said springs arranged at opposite sides of the corresponding spring; an actuating element engaging the free ends of said springs; and electromagnetic means for imparting vibrating movement transversely to said springs for alternately placing said springs into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that said condensers are connected in parallel to said primary circuit when said springs engage one of their cooperating contacts, and that said condensers are connected in series to said load circuit when said springs engage the other cooperating contact.

9. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a set of condensers; a base plate; a plurality of flat contacting springs having one end secured to said base plate; a pair of cooperating contacts for each spring arranged at opposite sides of the corresponding spring; an actuating member firmly connected to said springs; and means for applying rotary vibrating movement to said member for alternately placing said springs into engagement with one of the cooperating contacts, the individual contacts being so connected to said condensers and circuits that the condensers are connected in parallel to said primary circuit when said springs engage one of their cooperating contacts, and that the condensers are connected in series to said load circuit when said springs engage their other cooperating contact.

10. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a set of condensers; a base plate; a plurality of flat contact springs having one end secured to said base plate; a pair of cooperating contacts for each spring arranged at opposite sides of the corresponding spring; a disk having its periphery connected to said springs with the contacting ends of said springs projecting beyond said disk; and means for applying rotary vibrating movement to said disk for alternately placing said springs into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when said springs engage one of the individual contacts in each pair, and that the condensers are connected in series to said load circuit when said springs engage the other individual contact.

11. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a set of condensers; a base plate; a plurality of flat springs having one end secured to said base plate and arranged along a substantially circular curve; a pair of cooperating contacts for each spring arranged at opposite sides of the corresponding spring; a disk having its periphery connected to said springs with the contacting ends of said springs projecting beyond said disk; means for dampening the projecting ends of said springs; and means for applying rotary vibrating movement to said disk for alternately placing said springs into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when said springs engage one of their cooperating contacts and that the condensers are connected in series to said load circuit when said springs engage the other cooperating contact.

12. In a direct-current transformer, a load circuit; a primary circuit carrying the fundamental voltage to be transformed; a set of condensers; a base plate; a plurality of contacting springs having one end secured to said base plate and arranged along a substantially circular curve; a pair of cooperating contacts for each spring arranged at opposite sides of the corresponding spring; a disk having its periphery firmly connected to said springs with the contacting ends of said springs projecting beyond said disk; and electromagnetic vibrating means for applying rotary vibrating movement to said disk for alternately placing said springs into engagement with one of their cooperating contacts, the individual contacts being so connected to said condensers and said circuits that the condensers are connected in parallel to said primary circuit when said springs engage one of their cooperating contacts, and that the condensers are connected in series to said load circuit when said springs engage the other cooperating contact.

13. A direct current transformer comprising a load circuit, an input circuit carrying the fundamental voltage to be transformed, a plurality of groups of condensers, a plurality of switching mechanisms each including a movable contact member, a pair of cooperating stationary contacts for each movable contact member in which pairs the individual contacts are arranged at opposite sides of the corresponding movable contacts, means for alternately placing said movable members into engagement with one of the individual contacts in the corresponding pairs, further means including circuit connections for connecting the individual condensers of each group in series and across one of the condensers of the succeeding group in one of the positions of said contact members, further means for connecting the condensers in each group in parallel in the other contacting position of said movable contact members, said load circuit and said input circuits being each connected across a single condenser of the first of said groups and across all the condensers in series of the last of said groups.

14. A direct current transformer comprising input and output operating circuits, a plurality of electrical condensers, a contacting mechanism having a base, a plurality of leaf springs circumferentially secured to said base, each pair of said springs being connected to the terminals of said condensers, a pair of stationery contacts operatively associated with the free ends of said springs, the individual contacts in each pair being disposed at opposite sides of the corresponding spring, a disc shaped actuating member firmly and circumferentially engaging said springs at a position intermediate said base and the free ends of said springs, and an electro-magnetic actuating device for imparting rotary oscillating movement to said member for alternately placing said springs into engagement with one of the associated stationary contacts, and further means including circuit connections from said stationary contacts to said operating circuits for placing said condensers alternately in parallel and in series

and in connection with said operating circuits by the operation of said actuating member whereby the input direct voltage is transformed to a different voltage by alternate charge and discharge of said condensers.

15. In a direct current transformer as claimed in claim 14 in which said electro-magnetic mechanism comprises a magnet core mounted concentrically to said disc and having a plurality of radial extensions, and a plurality of pin-shaped armatures carried by said disc in operative relation to said core extensions.

16. An energy conversion system comprising a low voltage direct current source; a plurality of low voltage input condensers; a high voltage output condenser; a switching device having contact means for charging said condensers by said source substantially in parallel at a predetermined position of said switching device; further contact means of said switching device for thereafter connecting said condensers in series and discharging them upon said high voltage condenser at a successive position of said switching device while simultaneously disconnecting said input condensers from the low voltage source and means for periodically operating said switching device to obtain a substantially steady output voltage from said high voltage condenser.

17. An energy conversion system comprising a low voltage direct current source; a plurality of low voltage input condensers; a high voltage output condenser; a switching device having contact means for charging said condensers by said source substantially in parallel at a predetermined position of said switching device; further contact means of said switching device for thereafter connecting said condensers in series and discharging them upon said high voltage condenser at a successive position of said switching device while simultaneously disconnecting said input condensers from the low voltage source and means for periodically operating said switching device to obtain a substantially steady output voltage from said high voltage condenser, said last means comprising an electro-mechanical vibrator operating said switching device.

18. An energy conversion system comprising a low voltage direct current source; a plurality of low voltage input condensers; a high voltage output condenser; a plurality of switching members; means for operating said switching members in unison; means including contact means associated with said switching members and circuit connections therefrom to said condensers for charging said input condensers by said source substantially in parallel at one position of said switching members and for thereafter disconnecting said condensers from said source and connecting them to said high voltage condenser in series at a different position of said switching members, said high voltage condenser being disconnected from said input condensers during the charging periods; and means for periodically operating said switching members between alternate positions to obtain a substantially steady output voltage from said high voltage condenser, said last means comprising an electro-mechanical vibrator.

19. An energy conversion device comprising a low voltage direct current source; a plurality of low voltage input condensers; a high voltage output condenser; a plurality of switching members; a common shaft for operating said switching members in unison; a vibrator mechanism actuating said shaft for moving said switching members periodically between two positions; resilient contacts associated with said switching members; and cooperating stationary contacts and circuit connections thereto from said input condensers, said source and said output condenser, whereby at one position of said switching members said input condensers are connected to said low voltage source substantially in parallel and whereby at the other position of said switching members said input condensers are connected in series and discharged upon said high voltage condenser.

20. In combination, a low voltage current source; a plurality of low voltage input condensers; a high voltage storage condenser; an oscillating switching device having contact means and circuit connections therefrom to said input condensers and said source for charging said condensers by said source in parallel in one position of said switching device; further contact means of said switching device and circuit connections therefrom to said input condensers and to said storage condenser for thereafter connecting said condensers in series and discharging them upon said storage condenser at the opposite position of said switching device while disconnecting said input condensers from said source, the frequency of charging and discharging of said condensers and the capacity of said storage condenser being such as to secure a substantially steady high voltage output potential from said storage condenser.

21. An energy transfer system comprising a low voltage direct current circuit; a high voltage direct current circuit; a plurality of low voltage condensers; a high voltage condenser in said high voltage circuit; a switching device having contact means for connecting said condensers to said low voltage circuit in parallel at a predetermined position of said switching device; further contact means of said switching device for thereafter connecting said low voltage condensers in series across said high voltage condenser at a successive position of said switching device while simultaneously disconnecting said low voltage condensers from the low voltage circuit; and means for periodically operating said switching device to secure a substantially steady energy transfer between said low voltage and said high voltage circuits.

22. An energy transfer system comprising a low voltage direct current circuit; a high voltage direct current circuit; a plurality of low voltage condensers; a high voltage condenser in said high voltage circuit; a switching device having contact means for connecting said low voltage condensers in parallel to said low voltage circuit at a predetermined position of said switching device; further contact means of said switching device for thereafter connecting said low voltage condensers in series and across said high voltage condensers at a successive position of said switching device while simultaneously disconnecting said low voltage condensers from said low voltage source; and means for periodically operating said switching device to secure a substantially steady energy transfer between said low voltage and high voltage circuits, said last means comprising an electro-mechanical vibrator operating said switching device.

BERTHOLD SPRINGER.