

Aug. 7, 1962

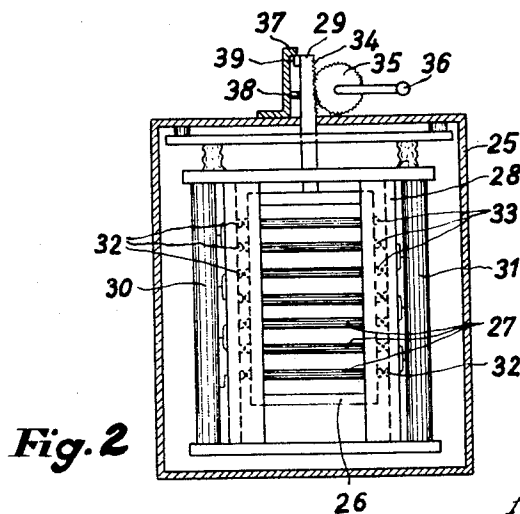
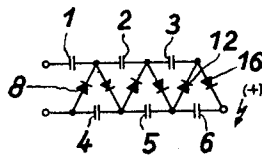
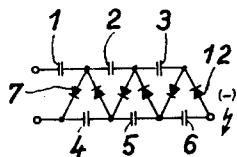
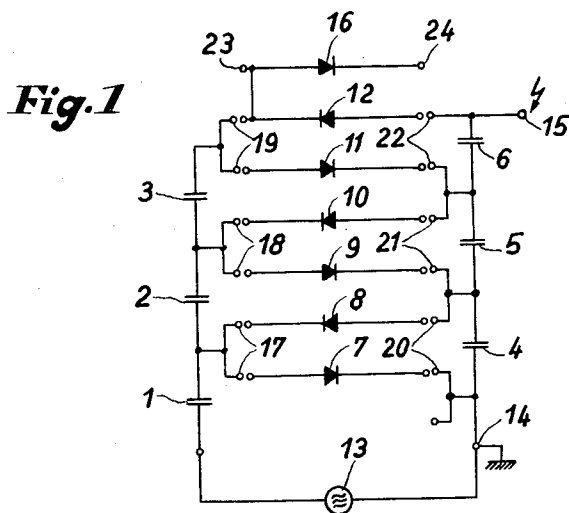
S. PANZER

3,048,766

HIGH DIRECT VOLTAGE GENERATING UNITS

Filed March 7, 1960

4 Sheets-Sheet 1



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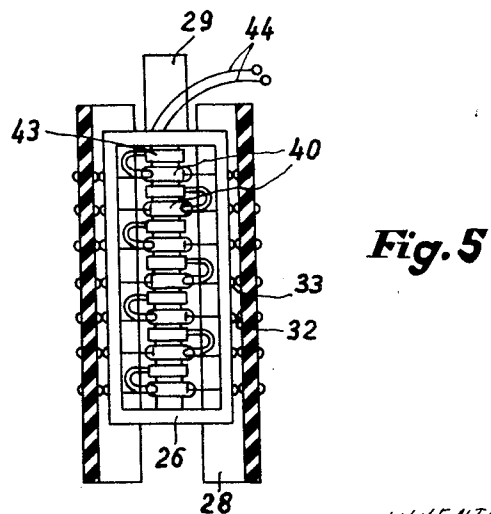
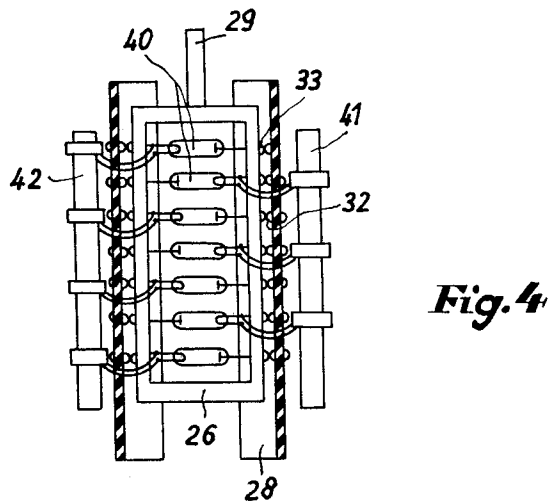
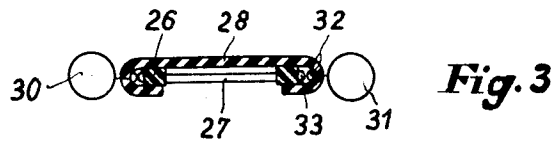
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4 Sheets-Sheet 2



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HIGH DIRECT VOLTAGE GENERATING UNITS

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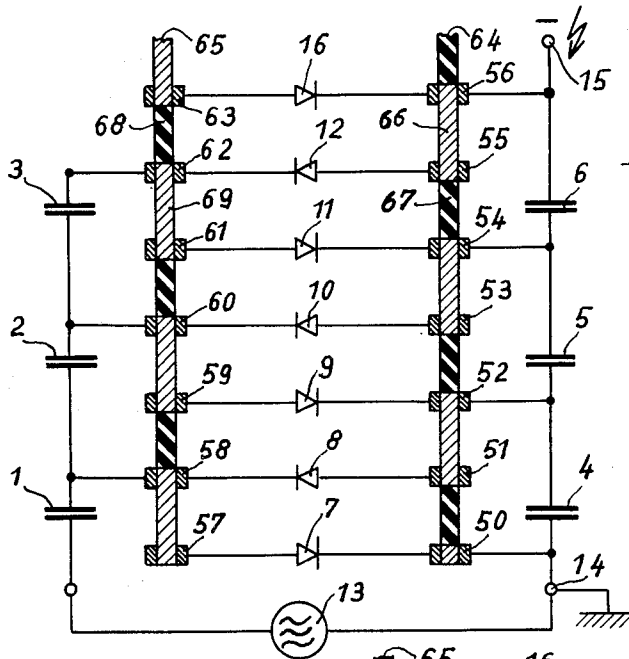


Fig. 6a

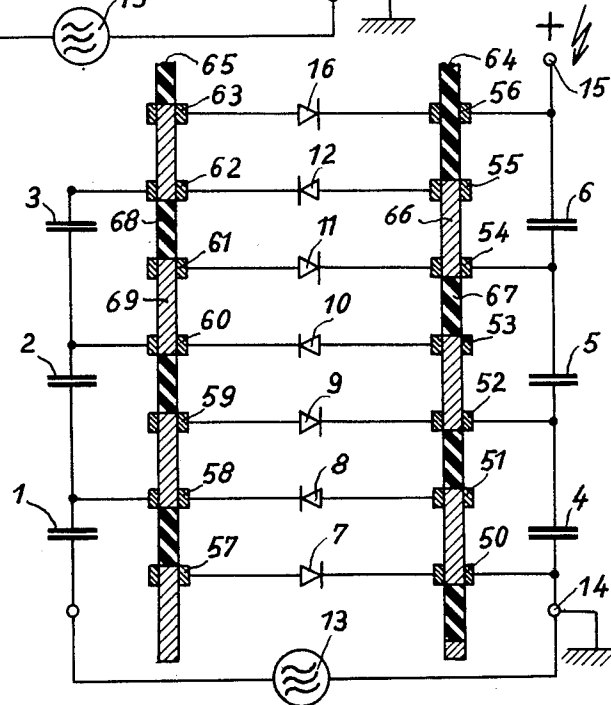


Fig. 6b

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HIGH DIRECT VOLTAGE GENERATING UNITS

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4 Sheets-Sheet 4

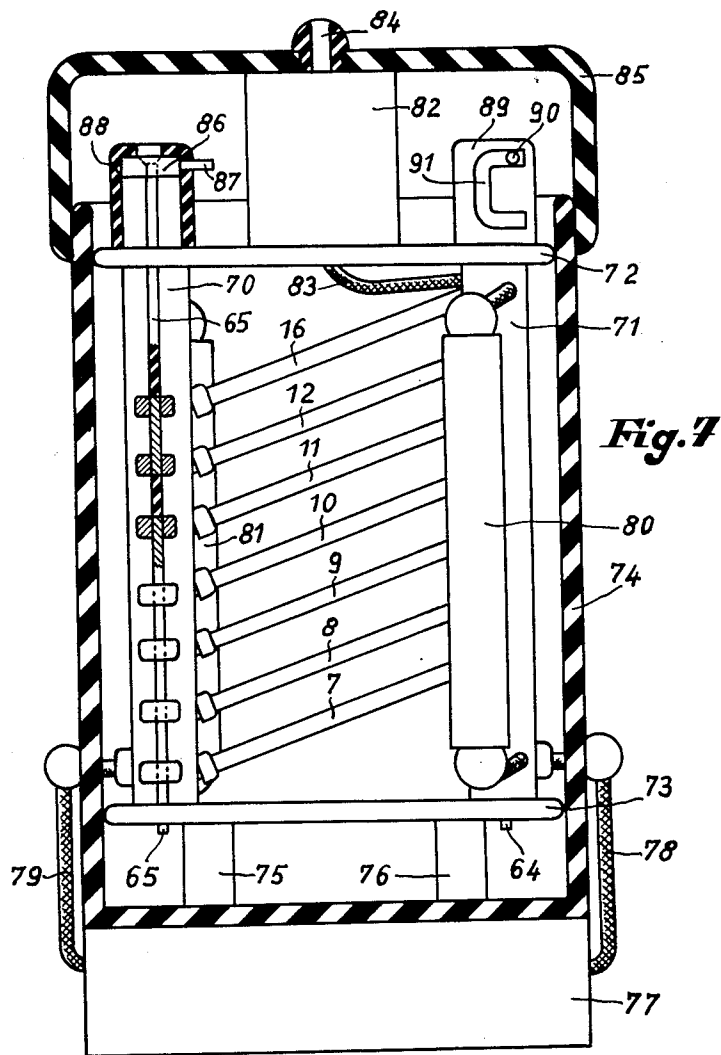


Fig. 7

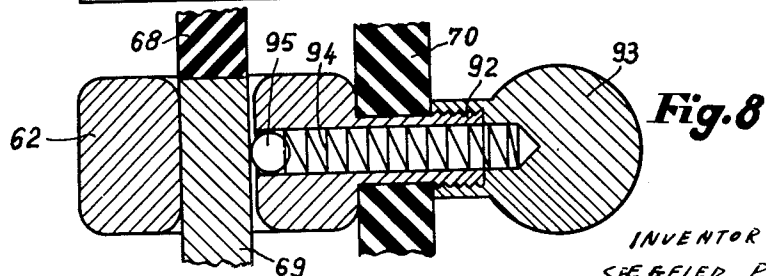


Fig. 8

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3,048,766

HIGH DIRECT VOLTAGE GENERATING UNITS
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Filed Mar. 7, 1960, Ser. No. 12,983

Claims priority, application Germany Mar. 6, 1959

13 Claims. (Cl. 321—15)

This invention relates to voltage multipliers and, more particularly, to a voltage multiplier comprising cascaded doubler circuits in which the polarity of the output voltage is easily reversible.

Voltage multipliers in which an alternating input voltage is converted to a high direct voltage by cascaded doubler stages are known to the art. When such units are used as a source of direct voltage, it frequently becomes necessary to reverse the polarity of the output in accordance with the requirements of the application. Such polarity reversal is not feasible with the units of the prior art.

For example, in the usual high voltage unit, the multiplier circuit components are housed within a tank filled with oil or compressed gas. The high voltage output is supplied at a single terminal post insulated for the application intended. Disassembly of such units and reversal of the polarity of each rectifier element therein for the purpose of reversing the polarity of the output terminal is not only beyond the scope of most users but is obviously impractical.

Providing two output terminals, each of which is insulated to the voltages encountered in operation, in order to allow selection of output polarity entails considerable expense and practical difficulties since the alternating voltage has to be supplied at the high direct voltage. It is, therefore, the primary object of this invention to provide a high voltage unit of the multiplier type in which the polarity of the output voltage can be rapidly and easily reversed with respect to ground.

In accordance with this object, there is provided, in a preferred embodiment of this invention, a multiplier circuit comprising n ($n=1, 2, 3, 4 \dots$) cascaded doubler stages. A plurality of $2n+1$ rectifiers are provided in stacked array of alternate poling. A first $2n$ adjacent rectifiers are coupled to the capacitors of the doubler stages to form said cascade network and to give a first output polarity, whereby the last ($2n+1$) rectifier is not coupled into the multiplier circuit. When it is desired to reverse the output polarity a second $2n$ adjacent rectifiers are coupled to the capacitors of the doubler stages. Said second $2n$ adjacent rectifiers include the last ($2n+1$) rectifier in said network, while the first rectifier is disconnected therefrom. In coupling said second $2n$ adjacent rectifiers to the capacitors each rectifier is displaced by an oppositely poled rectifier, whereby the polarity of each rectifier is effectively reversed in simple manner.

The switching effect can be carried out, for example, by a purely mechanical displacement of the rectifier array in relation to said capacitors. This displacement at the same time changes the polarity of all the cascade rectifiers, and thus produces a rapid reversal of the poles in the high voltage unit.

In the case of purely mechanical displacement of all the rectifiers it is advisable to electrically couple the terminals of two last rectifiers at the high voltage end of the cascade, diametrically opposite to the high voltage terminal.

A high voltage unit of simple design and easy to service is produced by virtue of the fact that all the rectifiers (spaced apart from each other by a suitable insulating distance) are mounted on a frame which is capable of displacement in relation to the contacts associated with the

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cascade condensers. A guide frame of insulating material is provided for the purpose of affording guidance to the frame on which the rectifiers are lodged, the guide frame also serving as a support for the contacts of the cascade condensers. These contacts are mounted opposite to rectifier contacts carried on the displacement frame. It is, furthermore, helpful to spring-load all of the contacts.

In the case of those high voltage units where the components of the cascade are housed in an oil-filled tank, it is advisable to provide an extension projecting out of the oil tank for the frame supporting the rectifiers, on the side of the ground. Furthermore, devices are provided to engage with the said extension and serve the purpose of shifting the frame about.

For the purpose of displacing the rectifiers in relation to the contacts associated with the cascade condensers, to produce a switching effect, it is advantageous to employ an arrangement whereby a switch is coupled to each condenser contact, the switch serving the purpose of selective coupling of the condenser contact to two contacts which are associated with two rectifiers which are consecutive in the switching order. If the arrangement is so devised that all the switches are actuated simultaneously, the high voltage unit can be rapidly reversed in polarity in a simple manner.

It is advisable to couple the cascade rectifiers and condensers with two rows of ring-shaped contacts, and to design the switches in the form of two rods capable of being shifted in an axial direction and sliding along in these contacts, each of these rods being composed of a number of insulating and conductive segments alternating in that sequence. Each conductive segment is of a length corresponding to the distance between two consecutive contacts.

In the case of high voltage units wherein the cascade components are lodged inside an oil tank, it is advisable to provide two insulator parts coupled with the displaceable rods, these parts projecting outside of the oil tank and connected with members which serve to shift the two rods axially by a distance corresponding to the distance between consecutive contacts.

To prevent any possible defective functioning, it is advantageous, regardless of the type of design adopted in any specific case for the high voltage unit, to couple with the unit's connector and disconnecter the actuating members which serve the purpose of polarity reversal, in such a manner that it becomes possible to reverse the polarity of the high voltage only when the unit is disconnected.

The new high voltage unit can be designed to incorporate dry rectifiers or rectifier tubes. In the latter instance, care must be exercised only to assure that filament voltages are supplied to the tubes in any possible switch position of the rectifiers.

The invention will be more clearly understood by reference to the following description taken in conjunction with the accompanying drawings, of which:

FIG. 1 is a schematic diagram of a multiplier circuit in accordance with this invention.

FIG. 1a is a schematic diagram of the circuit of FIG. 1 coupled for one output polarity.

FIG. 1b is a schematic diagram of the circuit of FIG. 1 coupled for output polarity reversed from that illustrated by FIG. 1a.

FIG. 2 is a partially sectioned elevation view of a multiplier using rod-shaped dry rectifiers.

FIG. 3 is a section view of a component of the system shown in FIG. 2.

FIG. 4 is a partially sectioned view of a multiplier employing diodes.

FIG. 5 is a partially sectioned elevation view of another embodiment of this invention employing diodes.

FIG. 6 is a schematic view of another embodiment of

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this invention in which FIG. 6a shows the circuit arrangement for one output polarity and FIG. 6b shows the circuit arrangement for the opposite output polarity.

FIG. 7 is a partially sectioned elevation view of still another embodiment of this invention; and

FIG. 8 is a sectioned view of a component of the unit shown in FIG. 7.

The multiplier shown in FIGS. 1, 1a and 1b comprises condensers 1, 2, 3, 4, 5 and 6 and rectifiers 7, 8, 9, 10, 11 and 12 coupled in the conventional multiplier circuit of cascaded doublers. A high frequency (e.g. 100 kilocycles) source 13 supplies the alternating charging voltage. At 14 the cascade is grounded, while at 15 a negative high voltage of, say 100 kv. can be tapped.

Pursuant to the invention, an additional rectifier 16 is provided, mounted at one end of the cascade and reversed in polarity, with respect to the last rectifier 12 in the rectifier array.

FIG. 1 exhibits an arrangement where all of the rectifiers 7 to 12 and 16 can be jointly displaced in relation to the contacts 17, 18, 19, 20, 21 and 22 associated with cascaded condensers 1 to 6.

The terminals of rectifiers 12 and 16 are electrically coupled on the side of the cascade opposite to the high voltage terminal 15.

If the rectifiers 7 to 12 and 16, as shown in FIG. 1, are shifted downward far enough for the contacts 23 and 24 belonging to rectifier 16 to couple the upper contacts 19 and 22, it can be readily seen that, in such an event, all of the cascade rectifiers will have been reversed in polarity. Here rectifier 7 has been displaced downward by one contact distance, so that it has been tripped out of the cascade.

As becomes apparent on viewing the illustration exhibited in FIG. 1a, the cascade shown in FIG. 1 supplies a negative high voltage so long as the additional rectifier 16 is not switched in. However, once the rectifier in question is switched in, the result is a circuit as displayed in FIG. 1b which supplies a positive high voltage.

FIG. 2 illustrates a type of design of a high voltage unit devised pursuant to the invention. The rod-shaped rectifiers 27 are here mounted on a frame 26, separated by a suitable insulating distance. This frame is mounted in a manner to render it displaceable with the guiding frame 28 and is provided with an extension 29 in the shape of a rod at the grounded end. This extension projects from the tank 25 in which the entire rectifier cascade is lodged.

The cascade condensers are lodged in tubes 30 and 31, and, as can be readily seen from FIG. 3, they are coupled to contacts 32 mounted on the guide frame 28. These contacts 32 face the contacts 33 mounted on the frame 26, the latter contacts being coupled to the rectifiers 27. Contacts 32 and 33 are spring loaded to ensure proper contact pressure.

The rod 29 is provided with teeth 34 which mesh with a toothed gear 35. A lever 36 is rigidly coupled with this toothed gear. The frame 26 is shifted up and down by shifting this lever, and the limits of this travel are defined by the stops 37 and 38.

If, as shown in FIG. 2, the lug 39 secured to the rod 29, runs up against 37, the cascade supplies a high voltage which is positive in relation to the ground. If, on the other hand, by operating the lever 36 in a counter-clockwise direction, the frame travels downward, the lug 39 and 38 run up against each other. In this position a negative high voltage output is able to issue from the cascade.

FIG. 4 displays a portion of a high voltage unit which incorporates rectifier tubes. Here the same reference numbers are used to identify like components as used in FIG. 2.

In the case of the high voltage unit shown here, rectifier tubes 40 are mounted on the frame 26. The currents required for the heating of these tubes are supplied by

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the insulator transformers 41 and 42 which are mounted outside of the guide frames 28. It is necessary in this case to have flexible leads for the supply of the filament currents.

FIG. 5 shows a portion of another high voltage unit similarly equipped with rectifier tubes 40. In the case of this unit, an insulating transformer which supplies the filament currents is securely coupled with the frame 26 on which are mounted the tubes 40. This transformer is thus shifted upward and downward together with the frame 26. It is only necessary, in this case, to provide flexible leads 44 for the supply of primary current to the insulating transformer 43.

To achieve a further simplification of a high voltage unit comprising rectifier tubes, it might be advantageous to devise the traveling frame 26 in such a manner that it forms part of the insulating transformer which serves the purpose of supplying filament currents.

In the case of the type of design exemplified in FIGS. 6a and 6b, the cascade condensers 1 to 6, and the rectifiers 7 to 12 and 16 are coupled with two rows of annular contacts 50 to 56 and 57 to 63. Two rods 64 and 65, which are axially displaceable, slide in these annular contacts. Each of the two rods consists of a number of segments which are insulating and conductive in alternating order.

In FIG. 6a the two rods 64 and 65 are shown in the position to generate a negative high voltage output at the terminal 15. In this instance, by way of example, contacts 55, 56 and 61, 62 are interconnected by way of the conductive segments 66 and 69 respectively while contacts 54, 55 and 62, 63 are separated from each other by the insulator segments 67 and 68 respectively. With the rods 64 and 65 in the position shown in FIG. 6a, the same circuit as shown in FIG. 1a is obtained.

FIG. 6b illustrates an example of a design identical with that shown in FIG. 6a, but in this case the two rods 64 and 65 are displaced downward by an interval of two contacts (e.g. 62, 63). Consequently, the contacts 54, 55 and 60, 61 are now interconnected by way of the conductive segments 66 and 69 respectively, while contacts 53, 54 and 61, 62 are separated from each other by way of the insulating segments 67 and 68 respectively. As can be readily seen, the additional rectifier 16 is now switched into the cascade, while rectifier 7 is disconnected. Thus, the resultant circuit is identical with the one in FIG. 1b, so that a positive high voltage is generated at 15.

In the case of the high voltage unit shown in FIG. 7, the rectifiers 7 to 12 and 16 are mounted between two semi-circular insulator plates 70 and 71. These plates are lodged between two base plates 72 and 73 which are also made of insulating material. The entire cascade is submerged in an oil-filled tank 74, and spacers 75 and 76 brace the cascade against the bottom of the tank. The oil tank 74 is also made of insulating material.

The high frequency transmitter 77 which is connected with the cascade across leads 78 and 79, is mounted underneath the oil-filled tank 74.

A tube 80 containing the cascade condensers 4 to 6 is secured to the plate 71 made of insulating material. Another tube 81 which embraces the cascade condensers 1 to 3 is connected with the insulating plate 70. At 82 is mounted the protective resistance which is connected with the cascade by means of the line 83. This resistance is also coupled with the high voltage terminal 84 which is mounted on the movable tank lid 85.

The two rods which serve the purpose of reversing the high voltage polarity, namely 65 and 64, are lodged between the insulator plates 72 and 73. The upper end of the rod 65 is connected with a member made of insulating material (86) which supports a lever 87. This lever slides inside a groove which is machined in the insulating stock hood 88. The form of the groove can be observed on the insulating stock hood 89 which serves the purpose of accommodating the lever 90 which is con-

nected with the rod 64. This lever travels in the U-shaped slot 91.

Once the tank lid 85 has been removed, the two rods 65 and 64 may be shifted downward by an appropriate movement of the two levers 87 and 90, which causes a reversal of the polarity of the high voltage. The two levers, 87 and 90 can be locked in the U-shaped slot both in the upper and in the lower position.

The contacts found useful in connection with the multiplier shown in FIGS. 7 and 6 are shown in detail in FIG. 8 which shows contact 62 secured to the insulator plate 70. As can be seen by viewing this figure, the annular contact 62 is carried on an extension 92 provided with a threaded portion. This extension passes through a suitable bore in the insulator plate 70. A sphere 93 is screwed onto the extension 92. Both the sphere 93 and the extension 92 are provided with a recess which has a helical spring 94 lodged inside of it. By means of this spring a metal sphere 95 is impelled in the direction of the rod 65 so that a firm contact is at all times maintained between 62 and 69.

All contacts, from 50 to 63 are devised in the shape displayed under FIG. 8.

This invention may be variously modified and embodied within the scope of the subjoined claims.

What is claimed is:

1. A voltage multiplier for the conversion of an alternating input voltage into a direct voltage of high amplitude by a cascaded network of n doubler stages including rectifiers and condensers, comprising $2n+1$ rectifiers arranged in an array of alternately poled rectifiers, means for coupling a first $2n$ adjacent rectifiers to said condensers to form said cascade network, and means for selectively coupling a second $2n$ adjacent rectifiers to said condensers to reverse the polarity of said direct voltage, said second $2n$ adjacent rectifiers including the rectifier in said array which is not included in said first $2n$ adjacent rectifiers.

2. A multiplier in accordance with claim 1 in which said selective coupling means comprises means for mechanically displacing the rectifier array in relation to said condensers.

3. A multiplier in accordance with claim 1 in which said selective coupling means comprises a switch coupled to each of said condensers, said switch serving the purpose of selective coupling of the condenser to two rectifiers adjacent each other in the rectifier array.

4. A multiplier in accordance with claim 2 in which the two terminals of the last two rectifiers on the high-voltage end of the array are electrically connected, said terminals lying opposite to the high-voltage terminal.

5. A multiplier in accordance with claim 2 in which the rectifiers comprising the array are mounted on a dis-

placeable frame with a suitable insulating distance between them, said frame being displaceable in relation to the contacts associated with the cascade condensers.

6. A multiplier in accordance with claim 5 which includes electrical contacts for each of the cascaded condensers, said contacts being mounted on a guide frame opposite the rectifier contacts mounted on said displaceable frame, said guide frame being adapted to guide said displaceable frame.

7. A multiplier in accordance with claim 2 in which each of said rectifiers comprises a rectifier tube and which includes a filament transformer to supply filament current to said tubes, said transformer mounted on said displaceable frame.

8. A multiplier in accordance with claim 7 in which the sliding frame forms a portion of the filament transformer.

9. A multiplier in accordance with claim 3 which includes two rows of ring-shaped contacts, said rectifiers and condensers of the cascade being coupled to said contacts, and in which said switches comprise a first and second rod each of said rods being axially displaceable in said contacts, each of said rods being composed of a number of segments which are alternately insulating and conductive.

10. A multiplier in accordance with claim 9 in which each of said conductive segments is of a length equivalent to the distance between two consecutive contacts.

11. A multiplier in accordance with claim 10 in which each of said contacts is spring loaded.

12. A multiplier in accordance with claim 2 in which said cascade is housed in an oil-filled tank, and which includes an extension from said frame which projects from the tank, and a member engaging said extension to move the frame.

13. A multiplier in accordance with claim 9 in which the cascade components are housed in an oil-filled tank, and which includes a first and second insulator coupled respectively to said first and second rod, said insulators projecting out of the oil tank, and means to move said insulators axially to move two rods over a distance of travel equivalent to the space separating two successive contacts.

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