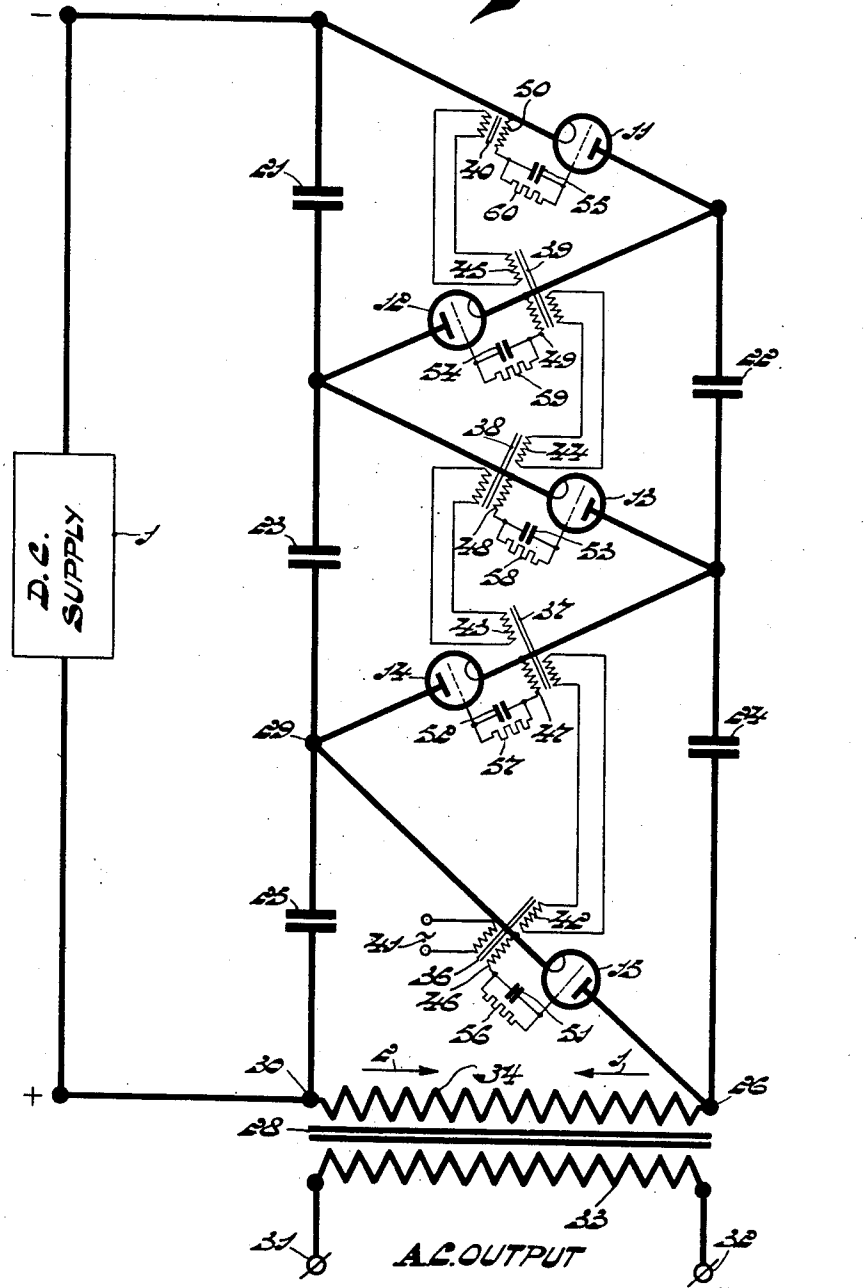
Oct. 29, 1940. A. BOUWERS 2,219,292

VOLTAGE CONVERTER

Filed Dec. 13, 1938 2 Sheets-Sheet 1

Fig. 1



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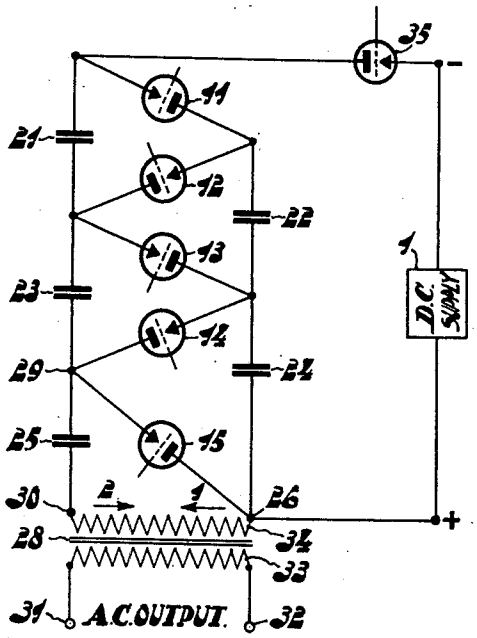


Fig. 2.

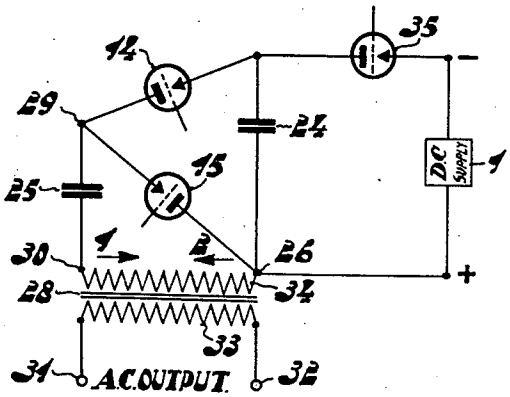


Fig. 3.

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VOLTAGE CONVERTER

Albert Bouwers, Eindhoven, Netherlands, assignor, by mesne assignments, to Hartford National Bank and Trust Company, Hartford, Conn., as trustee

Application December 13, 1938, Serial No. 245,514
In Germany December 14, 1937

6 Claims. (Cl. 175—363)

My invention relates to a device for converting direct voltage into alternating voltage of lower value.

As is well known D. C. transmission is particularly advantageous because there are substantially smaller transmission losses than in the transmission of alternating current energy. However, in such cases it is necessary to provide devices for converting the high direct voltage transmitted into low alternating voltage, and for this purpose numerous devices, such as rotary converters, are used. Such devices are expensive and complicated and have all of the disadvantages of rotating machinery.

The main object of my invention is to provide a simple, inexpensive, and reliable device for converting a high direct voltage, for instance of 500,000 volts, into a lower alternating voltage.

A further object is to provide a device which is small in size and efficient in operation.

Further objects and advantages of my invention will appear as the description progresses.

In my U. S. Patent 1,974,328 I have described a voltage multiplier for changing alternating voltage into a direct voltage of higher value by means of a circuit arrangement comprising any desired number of cascade connected groups consisting of condensers and gaseous discharge tubes.

My present invention is based on the recognition that, conversely, by using circuit arrangements which are in some respects similar to the above it is possible to produce a low alternating voltage from a high direct voltage.

In accordance with the invention I use a device whose circuit arrangement comprises a series connection of controlled discharge tubes, preferably grid-controlled tubes, which are arranged in the same manner and can be extinguished, and of which each two succeeding tubes are bridged by a condenser. One terminal of the direct current supply is directly connected to one end of this series connection, whereas the other terminal of the supply is connected to a "service impedance" which is connected in series with another condenser across the last discharge tube at the other end of the series connection.

I so control the discharge tubes that at any instant every other tube is conductive and the remaining tubes nonconductive. In other words if the tubes are consecutively numbered from one end of the series connection, all the even-numbered tubes should be conductive while the odd-numbered tubes are non-conductive, and vice versa. The operation of this control will be more clearly set out hereinafter.

The term "service impedance" as used herein and in the claims is to be understood to mean a resistance, coil, transformer winding or the like from which the alternating voltage output is to be taken.

By the term "gaseous discharge tube" is meant a tube which has a filling of one or more gases, one or more vapors, or a mixture of one or more gases and vapors.

In order that the invention can be clearly understood and readily carried into effect I shall describe the same in more detail with reference to the accompanying drawings in which

Figure 1 shows a schematic circuit diagram of a device according to the invention,

Fig. 2 is a schematic circuit diagram of a device according to another embodiment of the invention, and

Fig. 3 is a schematic circuit diagram of a simpler device according to the invention.

The device illustrated in Figure 1 comprises five grid-control gaseous discharge tubes 11 to 15 connected in series between the negative terminal of a D. C. supply 1 and a point 26. Connected one across each two succeeding tubes 11 to 15 are four condensers 21 to 24. A fifth condenser 25 has one terminal connected to a point 29 between tubes 14 and 15 and its other terminal connected to a point 30 which is usually grounded and is connected to the positive terminal of the D. C. supply 1. The device also comprises a "service impedance" in the form of a transformer 28 having a primary winding 34 connected across points 26 and 30 and a secondary winding 33 having terminals 31 and 32 from which a low alternating or pulsating voltage is taken off.

In controlling the conductivity of the discharge tubes the grids of the various tubes should receive during operation a potential whose value depends on the voltage stage including the tube. Consequently the various potential levels required for the control are preferably taken through condensers from a preceding discharge valve. A suitable arrangement for applying voltages to the grids of tubes 11 to 15 is illustrated in Figure 1 in which the grid transformer 36 of tube 15 is connected to an A. C. supply-source 41 and the succeeding grid-transformers 37 to 40 are supplied with A. C. from separate secondaries 42 to 45 of the preceding grid-transformer. The secondaries 46 to 50 are connected to the grid-condensers 51 to 55, which are bridged by the leak-

resistances 56 to 60 respectively. The arrangement is such, that the phase of the A. C. grid-voltage of each succeeding tube is opposite with regard to the A. C. grid-voltage of the preceding tube. The grid-condensers bridged by the leak-resistances are charged over the grids of the tubes during the positive phase and discharged over the leak-resistances during the negative phase. As a result the grids of all the tubes are negative somewhat longer than they are positive, so that all the grids are negative for a short time and short-circuiting of the D. C. supply 1 is not to be feared.

In operation the series-connected condensers 21, 23 and 25 receive a part of the total voltage of supply 1 in accordance with their capacity. When the odd-numbered tubes 11, 13 and 15 are allowed to ignite through the above-described grid-control, these condensers are partly discharged in the direction of arrow 1. More particularly, condenser 21 discharges through a circuit which may be traced through tube 11, condensers 22 and 24, winding 34 and condensers 25 and 23; condenser 23 discharges through a circuit which may be traced through tube 13, condenser 24, winding 34 and condenser 25; and condenser 25 discharges through a circuit which may be traced through tube 15 and winding 34. Thus the electron current produced as a result of the discharge of condensers 21, 23 and 25 flows in the direction of arrow 1.

After a short time the odd-numbered tubes 11, 13 and 15 are made non-conductive and even-numbered tubes 12 and 14 are made conductive. As a result condenser 22 discharges through a circuit which may be traced through tube 12, condensers 23 and 35, winding 34, and condenser 24; and condenser 24 discharges through a circuit which may be traced through tube 14, condenser 25 and winding 34. As a result an electron current produced by the discharge of condensers 22 and 24 flows through winding 34 in the direction of arrow 2.

After a short time the tubes 12 and 14 are made non-conductive and tubes 11, 13 and 15 are made conductive and current again flows in the direction of arrow 1. Thus, by periodically controlling the grids of the tubes, there is set up across the terminals of winding 34, and also across terminals 31 and 32, an alternating voltage whose frequency is determined by the periodic application of voltage to the grids. Furthermore the reduction in the voltage depends upon the number of stages used, and in the case illustrated the voltage across winding 34 is about one-fifth of the D. C. supply voltage.

Since a short circuit of the direct voltage through the series-connected discharge tubes 11 to 15 must be avoided, I prefer to use discharge tubes having extinguishing grids, which are known per se, or controlled vacuum-electron tubes whose grids extinguish and block the discharge paths when a negative voltage is applied thereto.

It is of course possible to replace each of the condensers of Figure 1 by a plurality of condensers in order to attain a higher capacity, or to use for each tube a plurality connected in parallel to provide a larger current path.

In Figure 1 the positive terminal of the D. C. supply 1 is connected to the point 30, and as a result the charging current of the condensers 21, 23 and 25 does not flow through the winding 34 and is consequently not used for the conversion. For this reason it is more advantageous to connect the positive terminal of the supply 1 to the point 26. Such a connection is shown in Figure 2 which is similar to Figure 1 and has similar parts indicated by the same reference numeral. With such a connection it is necessary to include in one of the supply conductors a controlled discharge tube 35 which is blocked when the odd-numbered tubes 11, 13 and 15 are conductive and vice versa. In other words if all the tubes are consecutively numbered from one end of the connection, e. g., beginning with tube 35, all the even-numbered tubes would be conductive while the odd-numbered tubes are non-conductive and vice versa. This is necessary as otherwise, due to charging of the condensers 22 and 24 from the D. C. supply, a charging potential arises again which does not flow through the winding 34 and would consequently constitute a loss current. In Figure 2 both the charging currents and the discharging currents of all the condensers flow through the winding 34 so that a maximum efficiency is obtained. Furthermore, the use of the tube 35 increases the number of voltage stages (cascades), as will be more clearly set out hereinafter.

The tube 35 may also be used if the positive terminal of the direct voltage is connected to point 30 as in Figure 1, but in such a case the loss current through condensers 21, 23 and 25 is tolerated. Such an arrangement is shown in Fig. 3.

Fig. 3, which shows a three-stage circuit arrangement, is similar to the arrangement of Figure 2 with certain parts removed, and has similar parts designated by the same reference numerals. The negative terminal of the supply contains the gaseous discharge tube 35 which is so controlled that it becomes conductive simultaneously with the discharge tube 15. As a result of this condenser 24 is charged, but this charging current does not flow through winding 34. After a short time the tubes 35 and 15 are made non-conductive and tube 14 is made conductive whereupon condenser 24 charges condenser 25 through winding 34 in the direction of arrow 1. When tube 15 is again made conductive the electron current flows from condenser 25 through tube 15 and winding 34 in the direction of arrow 2. As a result of this action an alternating voltage is produced between points 31 and 32. It will be understood that in this case the alternating voltage is reduced to about one-third of the direct voltage.

With reference to Fig. 3 it will be appreciated that the circuit arrangement shown in Fig. 1 comprises five voltage stages, and as the condenser 21 is always connected to the D. C. supply it cannot be discharged and does not participate in the conversion. For this reason this condenser can be dispensed and then an arrangement similar to that shown in Fig. 3 is obtained, namely one in which one of the D. C. supply leads is connected to the cascade arrangement through a discharge tube; the number of stages being the same viz. five as before.

If in a five-stage device such as shown in Figure 1 a direct voltage of about 500,000 volts is to be converted into an alternating current voltage of 100,000 volts so as to supply about 1,000 kilowatts, the five stages may, for instance, be chosen so that there is a 100,000 volt drop in each stage. Assuming that the condensers are only partly discharged, for instance each is discharged only about 10 per cent (which reduces the losses and increases the efficiency of the device) each con-

denser would be given a capacity of about 2 microfarads.

While I have described my invention in connection with specific examples and certain applications, I do not wish to be limited thereto but desire the appended claims to be construed as broadly as is permissible in view of the prior art.

What I claim is:

1. A device for producing alternating voltage from a supply of comparatively high direct voltage comprising a plurality of discharge tubes connected in the same manner in a series connection having one end connected to one terminal of the supply, a condenser connected across each two succeeding tubes, a service impedance and a condenser connected in series across the last tube of the series connection, a point of said service impedance being connected to the other terminal of the supply, means to periodically make all the even-numbered tubes conductive while at the same time making all the odd-numbered tubes non-conductive and vice versa, and a load connected to said service impedance.

2. A device for producing alternating voltage from a supply of comparatively high direct voltage comprising a plurality of discharge tubes preferably gaseous discharge tubes, each having a control grid, said tubes being connected in a series connection having one end connected to one terminal of the supply, a condenser connected across each two succeeding tubes, a service impedance and a condenser connected in series across the last tube of the series connection a point of said service impedance being connected to the other terminal of the supply, means to periodically make all the even-numbered tubes conductive while at the same time making all the odd-numbered tubes non-conductive and vice versa, and a load connected to said service impedance.

3. A device for producing alternating voltage from a supply of comparatively high direct voltage comprising a plurality of discharge tubes connected in the same manner in a series connection, a discharge tube connected in the same manner between one end of said series connection and one terminal of the supply, a condenser connected across each pair of succeeding tubes in the series connection, a service impedance and a condenser connected in series across the last tube of the series connection, a point of said service impedance being connected to the other terminal of the supply, means to periodically make all the even-numbered tubes conductive while at the same time making all the odd-numbered tubes non-conductive and vice versa, and a load connected to said service impedance.

4. A device for producing alternating voltage from a supply of comparatively high direct voltage comprising a plurality of discharge tubes preferably gaseous discharge tubes each having a control grid connected in the same manner in a series connection, a condenser connected across each pair of succeeding tubes, a service impedance and a condenser connected in series across the last tube of the series connection, a discharge tube preferably a gaseous discharge tube, having a control grid and connected in the same manner between one terminal of the series connection and the supply and a connection between the other terminal of the series connection and the other terminal of the supply, means to periodically make all the even-numbered tubes conductive while at the same time making all the odd-numbered tubes non-conductive and vice versa, and a load connected to said service impedance.

5. A device for producing low alternating voltage from a supply of comparatively high direct voltage comprising a plurality of discharge tubes preferably gaseous discharge tubes each having a cathode and an anode and a control grid, said tubes being connected in the same manner in a series connection and having one terminal connected to one terminal of the supply, a condenser connected across each pair of succeeding tubes, a service impedance and a condenser connected in series across the last tube of the series connection, a connection between the other terminal of the supply and a point between said service impedance and last condenser, means to periodically make all the even-numbered tubes conductive while at the same time making all the odd-numbered tubes non-conductive and vice versa, and a load connected to said service impedance.

6. A device for producing alternating voltage from a supply of comparatively high direct voltage, comprising a plurality of discharge tubes preferably gaseous discharge tubes having a control grid, said tubes being connected in the same manner in a series connection, a discharge tube preferably a gaseous discharge tube having a control grid, said latter discharge tube being connected in the same manner between the first tube of the series connection and a terminal of the supply, a condenser connected across each pair of succeeding tubes of the series connection, a service impedance and a condenser connected in series across the last tube of the series connection, a point between said service impedance and the last tube of the series connection being connected to the other terminal of the supply, means to periodically make all the odd-numbered tubes conductive while making all the even-numbered tubes non-conductive and vice versa, and a load connected to said service impedance.

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