J. NIENHOLD.

VACUUM RECTIFIER.

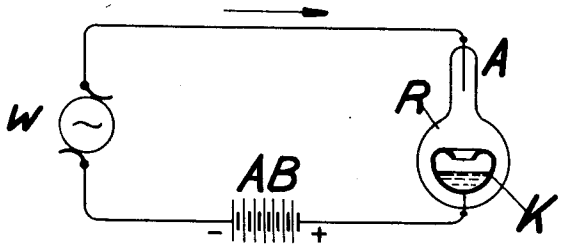
APPLICATION FILED FEB. 21, 1921.

1,434,310.

Patented Oct. 31, 1922.

2 SHEETS—SHEET 1.

Fig. 1.



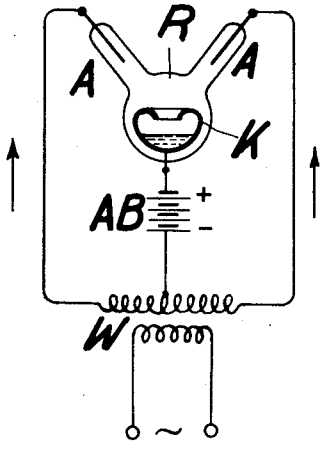


Fig. 2.

Inventor:

Johannes Nienhold

by. A. E. Hall

Attorney.

J. NIENHOLD.

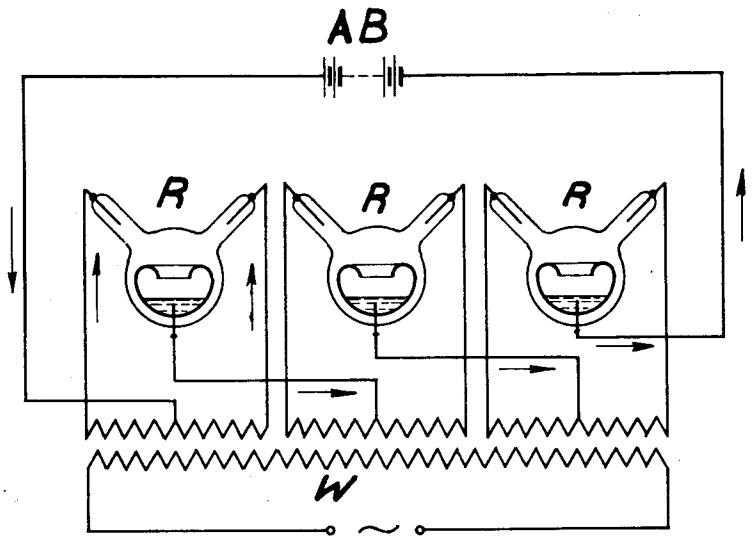
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2 SHEETS—SHEET 2.

Fig. 3.



Inventor:
Johannes Nienhold.
by. A. E. Odell.
Attorney.

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UNITED STATES PATENT OFFICE.

JOHANNES NIENHOLD, OF BERLIN, GERMANY.

VACUUM RECTIFIER.

Application filed February 21, 1921. Serial No. 446,972.

To all whom it may concern:

Be it known that I, JOHANNES NIENHOLD, a citizen of the German Republic, residing at Berlin, Germany, have invented new and useful Improvements in Vacuum Rectifiers (for which I have filed applications in Germany, May 15, 1917; Austria, Dec. 28th, 1917; Hungary, Dec. 28th, 1917; Switzerland, Feb. 25th, 1918; Sweden, Feb. 26th, 1918; Denmark, March 7th, 1918; Norway, March 13th, 1918; Great Britain, May 8th, 1920), of which the following is a specification.

This invention relates to an improved method of and means for rectifying alternating currents whether of high or low frequency.

Particularly it consists in a device for effecting rectification by the formation of a glow-arc discharge of electricity through rarified gas in the path of the current to be rectified. Said device comprises a vessel filled with a rare gas at low pressure, for instance with argon, helium, neon or the like, and having in it a cathode of highly electropositive material and one or more anodes of highly electronegative material. The cathode may advantageously be of alkali material, for example potassium or an alloy thereof; and the anode of copper or constantan. The pressure of the gas in the vessel should be from 0.1 to 20 millimeters of mercury. The voltage between the electrodes should be adjusted to produce a discharge of the glow-arc type; its proper value depending on the kind of gas employed, its pressure, and the material of the electrodes. For instance, 15 volts is a suitable E. M. F. for a rectifying device having an anode of copper or constantan, a cathode of potassium or alloy thereof, and filled with argon at a pressure of 1 millimeter of mercury.

The glow-arc discharge is to be distinguished from the well known glow discharge. Glow discharge rectifiers having an alkali cathode and containing one of the rare gases have already been used for converting alternating into direct current. But their efficiency is low, for they consume in themselves as a potential drop about 100 volts of the E. M. F. to be converted. The glow-arc discharge is also to be distinguished from the well known arc discharge. Arc discharge rectifiers containing a rare gas have also been tried, but their rectifying effect is insignificant. The glow-arc discharge is an electrical discharge issuing as an arc from an incandescent point on the cathode and terminating on the anode surface as a broad non-incandescent glow discharge. The nature of the glow-arc has been described in Marx "Handbuch der Radiologie" 1916.

For a current strength of from 0.1 to 5 amperes a rectifier may be constructed according to this invention with a tube or vessel of ordinary glass; for higher current values it is preferable to use tubes of quartz or the like which will rectify currents up to 100 amperes.

The invention further includes a rectifying system comprising a source of alternating current, a direct current consuming device, a rectifying device such as above described, and connections joining the source, the consuming device and the rectifier in series. If the E. M. F. of the alternating current circuit is not appropriate for such direct connection a transformer may be interposed.

Examples of the invention are illustrated in the accompanying drawings wherein—

Fig. 1 is a diagram of the simplest type of rectifying device and system.

Fig. 2 is a diagram of a system employing a rectifying device with two anodes.

Fig. 3 shows the use of a plurality of rectifying device in series.

In Figure 1 a tube R is connected in series with a consuming battery AB to be charged, in order that the charging current may be taken from an alternating current source W. The current flows in the direction of the arrow. A is the anode and K the cathode of the tube. The latter is formed as a basin which contains, for instance, potassium or other alkali metal. The argon tube above described under an applied alternating voltage of 110 volts would charge at a 5 ampere rate a secondary battery requiring 90 volts for charging.

Figure 2 shows an arrangement in which both half waves of the alternating current supplied are rectified. In this case the tube has two anodes and one cathode. A similar arrangement is appropriate for rectifying two phase alternating currents. For rectifying three phase currents the tube would have three anodes.

Particular care must be taken that a glow discharge is not set up in the opposite direction (i. e., that the tube does not "reverse")

which is specially liable to happen for higher values of the alternating E. M. F. in the circuit (about 300 volts). One means of obviating this consists in giving the cathode as large a surface as possible, and the anode as small a surface is possible. For very high voltages it is better to use tubes in series, as shown in Figure 3, to make certain of avoiding reversal. In this figure R, R, are the reversal rectifying tubes, W is the source of alternating current and AB the direct current consuming device. Further it is desirable to make the anode of a material which is a good conductor of heat (e. g., copper) as the anode is liable to become heated at a particular point, especially when rectifying considerable currents (10–100 amperes) and then a sharp arc starting-point forms upon the anode as well; with the result that an ordinary arc forms and the rectifying effect diminishes to a minimum.

The device can be used for both high and low frequency currents. Naturally the material of the anode or anodes should be so chosen that when the negative half wave of the alternating E. M. F. comes upon them they would have a higher cathode potential drop than the cathode K.

What I claim is:

1. Apparatus for rectifying alternating currents comprising a sealed vessel containing a rare gas at low pressure, a cathode of electropositive material in said vessel, an anode of electronegative material in said vessel, and means applying to said anode and cathode an E. M. F. which produces a glow-arc discharge between them.

2. Apparatus for rectifying alternating currents comprising a sealed vessel containing a rare gas at low pressure, a cathode of electropositive material in said vessel having a large surface, an anode of electronegative material in said vessel having a relatively small surface and means applying to said anode and cathode an E. M. F. which produces a glow-arc discharge between them.

3. Apparatus for rectifying alternating currents comprising a sealed vessel containing a rare gas at low pressure, a cathode of electropositive material in said vessel, a plurality of anodes of electronegative material in said vessel, and means applying to said anodes and cathode an E. M. F. which produces a glow-arc discharge between them.

4. Apparatus for rectifying alternating currents comprising a sealed vessel containing a rare gas at low pressure, a cathode of alkali metal in said vessel, an anode of electronegative material in said vessel, and means applying to said anode and cathode an E. M. F. which produces a glow-arc discharge between them.

5. Apparatus for rectifying alternating currents comprising a sealed vessel containing a rare gas at a pressure of from 0.1 to 20 millimeters of mercury, a cathode of electropositive material in said vessel, an anode of electronegative material in said vessel and means applying to said anode and cathode an E. M. F. which produces a glow-arc discharge between them.

6. Apparatus for rectifying alternating currents comprising a vessel containing a rare gas at a pressure not exceeding 20 millimeters of mercury, a cathode of alkali material in said vessel having a large surface, an anode of copper in said vessel having a relatively small surface and means for applying between said anode and cathode an E. M. F. not exceeding 15 volts.

7. A system of alternating current rectification comprising a source of alternating current, a direct current consuming device, a rectifying tube containing a rare gas and an anode and cathode, and connections joining said source consuming device and rectifying tube in series so as to apply to said anode and cathode an E. M. F. which produces a glow-arc discharge between them.

8. A system of alternating current rectification comprising a source of alternating current, a direct current consuming device, a plurality of rectifying tubes each containing a rare gas and an anode and cathode, and connections joining said source consuming device and rectifying tubes in series so as to apply to said anode and cathode an E. M. F. which produces a glow-arc discharge between them.

In testimony whereof I affix my signature.

JOHANNES NIENHOLD.

Witness:
L. WERNER.