May 9, 1933. A. NYMAN 1,907,859

RECTIFYING AND FILTERING APPARATUS

Filed March 17, 1926

Fig. 1

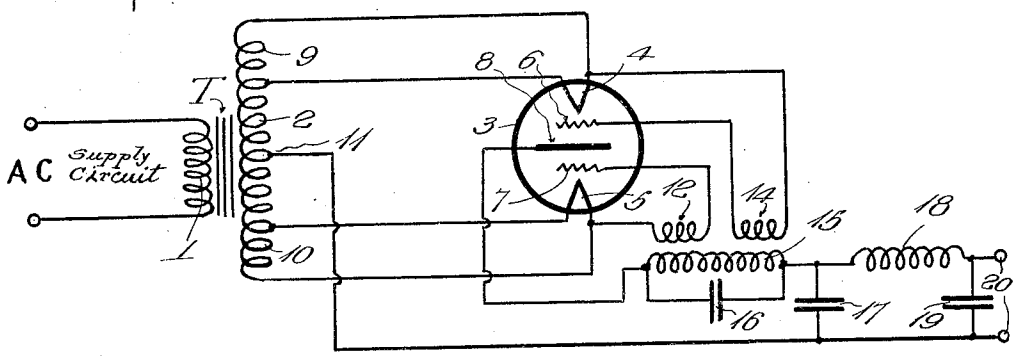


Fig. 2

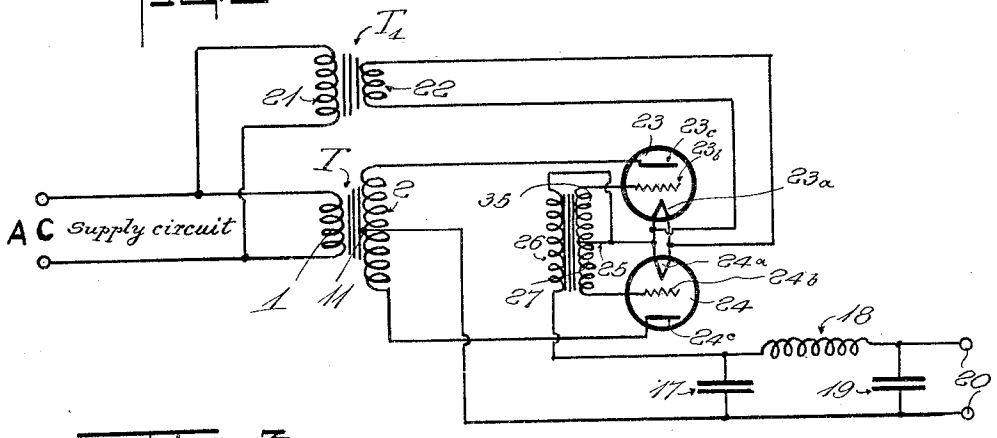
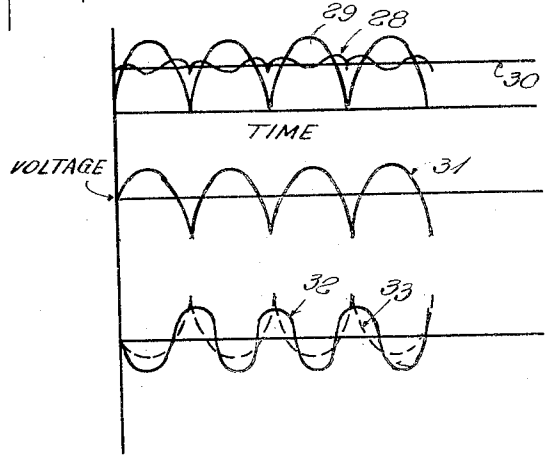


Fig. 3



INVENTOR
Alexander Nyman
BY
William F. Nickel
ATTORNEY

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UNITED STATES PATENT OFFICE

ALEXANDER NYMAN, OF NEW YORK, N. Y., ASSIGNOR TO DUBILIER CONDENSER CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

RECTIFYING AND FILTERING APPARATUS

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My invention relates broadly to rectifying apparatus and more particularly to an electron tube system for supplying uni-directional current to the circuits of electron tube amplifying systems.

One of the objects of my invention is to provide means for rectifying alternating current for supplying power to the circuits of electron tubes of an amplifying system with a method and means for suppressing the hum of the alternating current in the electron tube circuits.

Another object of my invention is to provide a system for rectifying alternating current for supplying power to the circuits of a plurality of electron tubes constituting an amplifying system having means for deriving a harmonic frequency from the supply frequency and combining the effects of the harmonic frequency for smoothing out the rectified current which is supplied to the circuits of the electron tube amplifying system.

Still another object of my invention is to provide a system for rectifying alternating current for energizing the circuits of an electron tube amplifying system in which an electron tube rectifying circuit is provided with circuit connections for developing a harmonic frequency from the supply frequency and opposing the disturbing effects of alternating current inherent with the supply frequency by the harmonic frequency thus developed for smoothing out the rectified energy which is supplied to the circuits of the electron amplification system.

Still another object of my invention is to provide a circuit arrangement for rectifying alternating current having means for smoothing out the rectified current independent of filter circuits as heretofore required.

A further object of my invention is to provide an electron tube system for rectifying alternating current and supplying the rectified current to a load circuit through a relatively small filter, auxiliary means being interposed in the electron tube system for smoothing out the rectified current independently of the filter circuit.

My invention will be more fully understood from the following specification by reference to the accompanying drawing, wherein:

Figure 1 illustrates diagrammatically the connections of an electron tube rectifying system embodying the principles of my invention; Fig. 2 illustrates a modified arrangement of electron tube circuit operating in accordance with my invention; and Fig. 3 illustrates the characteristics of the several currents existent in the electron tube rectifying system showing the characteristic of the resultant direct current supply which is impressed upon a load circuit.

Heretofore in the art in the operation of sensitive electron tube amplifiers from energy supplied from an alternating current source such as a residence lighting circuit it has been difficult to suppress the hum of the alternating current in the reproducing system which connects with the amplifying apparatus. It has been necessary to employ relatively large filter circuits in connection with the rectifier system and such filters introduce complications in manufacture and assembly of the apparatus and incur an undesirable expense. By my invention I provide an electron tube amplifying system having means independent of a filter circuit for smoothing out the rectified current preparatory to the delivery of the rectified current to the load circuit. I have found that by deriving a harmonic frequency with respect to the frequency of the alternating current source and opposing the effects of the alternating current source with the effects of the harmonic frequency that a resulting direct current supply may be obtained substantially free from disturbing

ripples. By reason of the auxiliary system for smoothing out the rectified current, the filter circuit used with the rectifying apparatus may be relatively small thereby reducing the manufacturing and assembly cost at the same time that a smooth direct current supply is obtained.

Referring to the drawing in more detail, a transformer system for the rectifying apparatus is designated at T having a primary winding 1 which connects with an alternating current supply circuit with a secondary winding consisting of sections 2, 9 and 10. An electron tube 3 having filament electrodes 4 and 5 and independent grid electrodes 6 and 7 with a common plate electrode 8 is provided and arranged in the rectifier circuit as shown for double wave rectification. The filament electrode 4 is heated from the section 9 of the secondary winding of the transformer, while filament 5 is heated from section 10 of the secondary winding of the transformer. A midtap connection 11 is taken from section 2 of the secondary winding to the output circuit. In circuit with each of the grid electrodes, I provide independent windings 12 and 14 which are coupled to a tuned circuit constituted by inductance 15 and capacity 16. The circuit 15—16 is tuned to a harmonic of the supply frequency. I have found as a result of practical work that the adjustment of circuit 15—16 to the second harmonic of the supply frequency permits the several currents existent in the rectifying system to be smoothed out to a constant characteristic. That is to say, assuming the supply frequency to be 60 cycles, the circuit 15—16 would be tuned to 120 cycles. The voltage developed in circuit 15—16 is impressed upon the grid electrodes 6 and 7 of the electron tube system for opposing any tendency of periodic disturbances arising from the initial alternating current supply. The rectified current thus smoothed out is supplied to a small filter circuit constituted by shunt condensers 17 and 19 and reactance 18 for delivering smooth direct current to terminals 20 of the rectifying apparatus.

In Figure 2 I have shown a rectifying system employing two three electrode electron tubes 23 and 24. Electron tube 23 includes filament electrode 23*a*, grid electrode 23*b* and plate electrode 23*c*. Electron tube 24 includes filament electrode 24*a*, grid electrode 24*b* and plate electrode 24*c*. The input circuits of the two tubes include windings 27 and 35 which are coupled through winding 26 with the load circuit from a mid connection 25 between the windings 27 and 35. The filaments of each of the tubes are heated from current derived from auxiliary transformer T_1, having its primary winding 21 connected to the alternating current supply circuit and its secondary winding 22 connected with the filament electrodes 23*a* and 24*a*. By means of the coupled system 35—27—26, a potential difference may be derived between the required D. C. voltage and the rectified voltage for securing a more uniform and complete smoothing out of the effects of the alternating current supply.

In Fig. 3, I have shown a set of curves representing the characteristics of the currents existing in the rectifying system. Curve 29 represents the voltage at the tube terminals. Curve 31 represents the ripple voltage between 8 and 11 which is to be filtered. The voltage applied to the grids of the electron tube system of Fig. 1 is represented by curve 32. The voltage applied to the grids of the tubes in Fig. 2 is designated by curve 33. The application of the potential to the grid acts on the electronic stream to impede it in greater or lesser extent, depending on the voltage applied; thus the resistance of the electronic tube will vary according to the voltage applied to the grid. Since there is a direct current flowing from the plate to the filament, this current will be causing a voltage drop through the tube which will be affected by the grid potential, thus if the impedance of the tube were constant, the voltage between the plate and the center point of the transformer would be according to curve 29, with a ripple represented by curve 31. By introducing a grid potential similar to 32 on the two grids, a resistance is introduced in the tube of such a magnitude that the curve 29 is changed to curve 28. In Fig. 2, however, the voltage applied to the grid would be represented by curve 33, and the result would be that the curve 29 would be smoothed further yet, almost equal to straight line 30, leaving very little to be done by the filters. Curve 28 is the final characteristic before filtering the circuit of Fig. 1; curve 30 is the final characteristic before filtering of the circuit of Fig. 2.

It will be understood that other harmonics than the second harmonic may be derived and utilized in the function of smoothing out the rectified current. It will be observed that by reason of the auxiliary smoothing out operation in combining the effects of the harmonic frequency and the frequency of the initial alternating current supply that the size of the filter system 17—18—19 may be considerably reduced. In the circuit of Fig. 2 harmonic frequencies are suppressed. The voltage applied in the circuit of Fig. 2 is represented by 33; this voltage is not introduced by means of any tuned circuit, nor is it representative of any special harmonics; it is simply the difference between the required D. C. voltage and the rectified volt-

age as obtained on the usual two-way rectifier tube.

While I have described the circuit arrangement of my invention in certain particular embodiments, I desire that it be understood that my invention may be carried out in several modified arrangements without departing from the spirit of my invention, and no limitations upon the invention are intended other than those imposed by the scope of the appended claims.

What I claim and desire to secure by Letters Patent of the United States is as follows:

1. In a system for rectifying alternating current the combination with a source of alternating current of an electron tube system including plate, filament and grid electrodes, the latter being connected to cooperate with the filament and plates electrodes, and a circuit tuned to a harmonic of the frequency of said source and connected to influence said grids for establishing a potential in opposition to the normal voltage variations for securing a substantially smooth rectified current.

2. In a system for rectifying alternating current, the combination with a source of alternating current of an electron tube system, plate, filament and grid electrodes constituting said electron tube system, connections between said source of alternating current and said filament and plate electrodes for rectifying the alternating current, an output circuit, and means connecting said grid and filament electrodes with said output circuit for deriving a harmonic of the frequency of said alternating current source and opposing the effects thereof for smoothing out the rectified current.

3. In a system for rectifying alternating current the combination with a source of alternating current, of an electron tube system including grid, filament and plate electrodes, circuits for connecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, said circuits connecting said grid and filament electrodes, and said output circuit being mutually coupled for developing a harmonic of the frequency of said alternating current source for opposing the effects thereof and smoothing out the rectified current.

4. In a system for rectifying alternating current, the combination with a source of alternating current of an electron tube system including grid, filament and plate electrodes, individual circuits interconnecting said grid and filament electrodes, an output circuit interconnecting said plate and filament electrodes, and means interposed between said output circuit and said first-named circuits for deriving a harmonic of the frequency of said source and opposing the effects thereof for smoothing out the rectified current.

5. In a system for rectifying alternating current, the combination with a source of alternating current of an electron tube system including an anode, and a plurality of sets of grid and filament electrodes, independent circuits interconnecting said grid and filament electrodes, an output circuit, connections between said plate electrode and said output circuit, and a tuned circuit interposed in said output circuit and coupled with said independent circuits, said tuned circuit being arranged to develop a harmonic of the frequency of said source for opposing the effects thereof and smoothing out the rectified current.

6. In a system for rectifying alternating current the combination with a source of alternating current of an electron tube system including grid, filament and plate electrodes, a pair of independent circuits interconnecting said grid and filament electrodes, an output circuit, connections between said output circuit and said plate electrodes, a tuned circuit interposed in series with said output circuit, and coupled with said independent circuits, said tuned circuit being resonant to the second harmonic of said alternating current source for opposing the effects of said source and smoothing out the rectified current.

7. A system for rectifying alternating current comprising an electron tube system having an anode, a cathode and a control electrode, means for supplying alternating current to the input of said system, an output circuit for the rectifying system, means connected to the output circuit of said system and adapted to generate a harmonic of the frequency of said alternating current supply, and means for impressing said harmonic upon the control electrode in such manner as to oppose the disturbing effects of said alternating current and for smoothing out the rectified current.

8. In a system for rectifying alternating current the combination with a source of alternating current, of an electron tube system including grid, filament and plate electrodes, a pair of input circuits interconnecting said electrodes, an output circuit interconnecting said plate and filament electrodes, said input and output circuits being mutually coupled for combining the effects of the difference between the required direct current voltage and the rectified voltage for smoothing out the rectified current.

9. In combination, an alternating current input circuit, an output circuit, a full-wave rectifier system adapted to be energized by alternating current from said input circuit and deliver rectified current to said output circuit, said system comprising a cathode, a plurality of anodes and a plurality of con-

trol electrodes associated with said anodes respectively, and means in said output circuit responsive to variations of current therein for impressing between said control electrodes a potential corresponding to said variations in a direction to reduce said variations.

10. In a rectifying system having a rectifier energized from a source of periodically varying current, said rectifier having means for controlling the rectification of said current, the method of neutralizing disturbing ripples in the output circuit of the system which comprises impressing upon the control means of said rectifier a current having a frequency which is an harmonic of the frequency of said periodically varying current.

In testimony whereof I affix my signature.

ALEXANDER NYMAN.