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REGULATED RADIO FREQUENCY POWER SUPPLY

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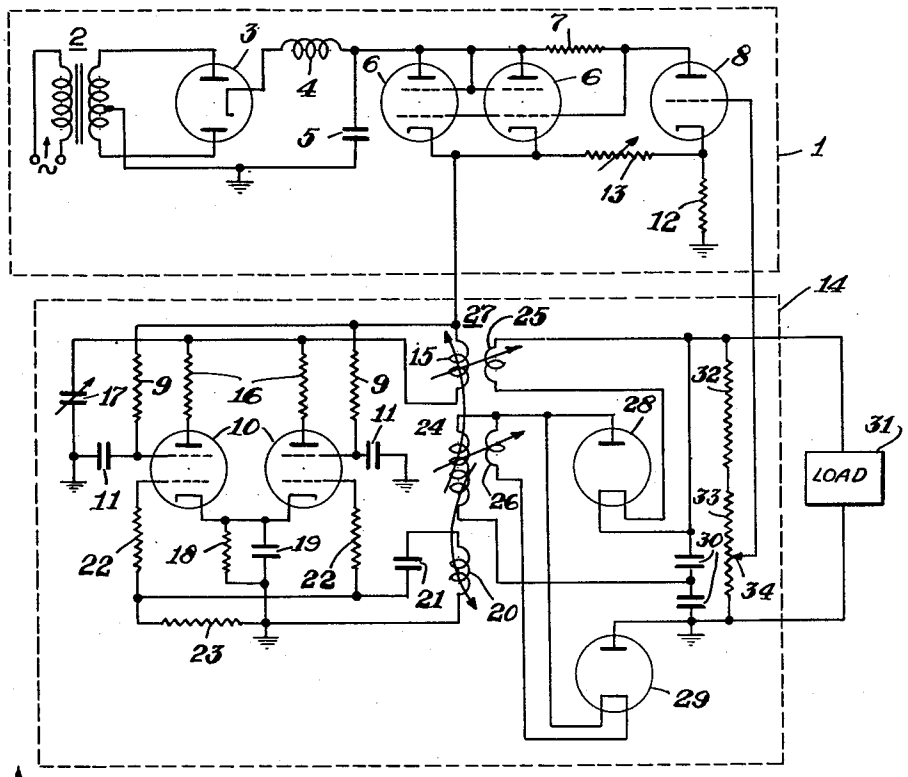
Fig. 1.



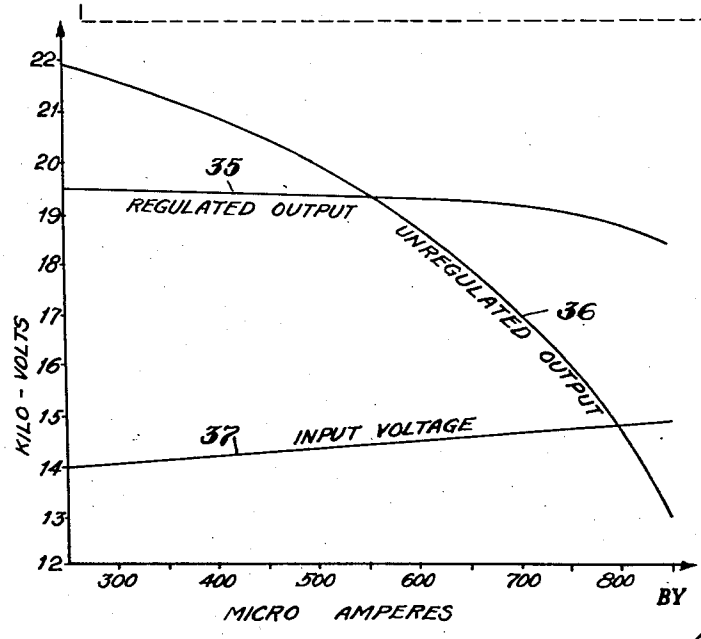


Fig. 2.

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REGULATED RADIO FREQUENCY POWER SUPPLY

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6 Claims. (Cl. 321—18)

1

This invention relates to regulated power supplies, particularly for obtaining voltage regulation of a low current at very high voltages.

A power supply for deriving direct current at high voltage is useful, among other things, for the operation of projection type television kinescopes. Regulation is particularly important if the focusing electrode of a kinescope is supplied by another power supply. In this case it is imperative that the degree of regulation be similar for the two power supplies. Failing this condition defocusing takes place with consequent changes in the average brilliancy of the reproduced picture.

Of course there are other uses to which a high voltage regulated power supply may be put. Accordingly, it is a principal object of my invention to provide a system for automatic voltage regulation which may be applied in a combination of two power supplies, one of which may be, for example, a conventional rectified plate voltage supply, while the other may be of the type which first generates a high voltage radio frequency and then transforms the output to a still higher voltage, from which a direct current is obtained by rectification.

Another object of my invention is to provide a regulated power supply in which the degree of regulation of one of its components is maintained substantially the same as in another component.

Still another object is to provide a regulated power supply system in which the control voltage applied to the grid of a certain voltage regulator tube is derived from the output of a radio frequency power supply unit of the same system.

An important feature of the invention, as I have evolved it, is that the cathode of a certain voltage regulator tube is varied with respect to ground potential by means of a voltage divider which is a component of the plate supply unit.

Another feature of the invention resides in the use of a control voltage for a regulator tube which is derived from an output component of a radio frequency power supply.

My invention will now be described in more detail, reference being made to the accompanying drawings in which:

Fig. 1 shows illustratively a preferred circuit arrangement of a power supply system having improved features such as mentioned above, and

Fig. 2 shows a graph of regulated and unregulated voltages which figure is referred to in pointing out the advantages of my system.

Fig. 1 shows two main components of the power supply system. These components are separately

2

enclosed in broken line rectangles. The first component to be considered is the plate supply 1 which comprises the usual transformer 2 and rectifier tube 3. The output is filtered conventionally by a series inductance 4 and a shunt capacitor 5. This output is delivered first to the plates and screen grids of two amplifier tubes 6 which are connected in parallel. Secondly the output is fed through a resistor 7 to the anode of a regulator tube 8 which may be of triode type if desired. The anode of tube 8 is directly connected to the control grids in the tubes 6. The cathodes of tubes 6 are connected through resistors 9 to the screen grids in two parallel-connected oscillator tubes 10. These screen grids are also coupled to ground through capacitors 11.

The cathode in the regulator tube 8 is connected to ground through a resistor 12 and is also connected to the cathodes of tubes 6 through an adjustable resistor 13. The control grid in the regulator tube 8 derives its control potential from a voltage divider which will be described in connection with the radio frequency power supply unit.

A radio frequency output is obtained from the tubes 10, which tubes constitute principal components of a radio frequency power supply, indicated generally within the broken line rectangle 14. The radio frequency generated results from the use of inductances and capacitances together with a feed-back circuit, as is more or less conventional. In more particular respects, the plate current for tubes 10 is fed from the cathodes in tubes 6 through a transformer winding 15 and thence to resistors 16 which are connected to the anodes in tubes 10. The anode circuit is made resonant by combining with the inductance 15 an adjustable capacitor 17 which is connected between the anode circuit and ground. The cathode circuit for tubes 10 is also given a suitable time constant by virtue of a ground connection including resistor 18 in parallel with a capacitor 19.

The control grids in tubes 10 derive their feedback potential from a transformer winding 20 which is grounded at one end and is coupled to said control grids through a capacitor 21 in series with grid resistors 22. The terminal of capacitor 21 on the other side from the transformer winding 20 is also connected to ground through a resistor 23.

The transformer windings above mentioned are wound for mutual inductive reactance with other windings 24, 25 and 26. The complete transformer is given the reference number 27. The

windings 25 and 26 provide separate sources for the filaments in two rectifier tubes 28 and 29. The winding 24 may be considered the main secondary the output from which is to be rectified in the tubes 28 and 29. At one terminal of the winding 24 is a connection to the anode of tube 28 and to the filament of tube 29. The other terminal of winding 24 is coupled through capacitors 30 both to the filament of tube 28 and the anode of tube 29.

It will be apparent to those skilled in the art that the circuit components for the radio frequency power supply 14 as above described are suitably coordinated for the generation and rectification of a low current of very high voltage. The method of first producing oscillations and then rectifying them is recognized as having many advantages for a high voltage power supply. One of the principal advantages is that power generation can be accomplished with very simple and low cost components. It is true that the rectifier tubes 28 and 29 must be of special design in order to prevent arcing and brush discharge between the electrodes. Such problems as these, however, have been met in the prior art.

The rectified output from the power supply unit 14 may be delivered to any suitable load, generally indicated by the rectangle 31. In shunt with this load, however, I introduce as a featural component of my invention a voltage divider of very high resistance comprising a resistor 32 in series with a potentiometer 33. The tap 34 on the potentiometer is directly connected to the control grid in the voltage regulator tube 8. Adjustment of the tap 34 permits the various conditions of voltage regulation to be met, as will be pointed out presently.

Because of the connection of the cathode in tube 8 to a junction point between two resistors 12 and 13 and because of the fact that these resistors are subject to a variable voltage drop dependent upon the output of current from the tubes 6, it will be observed that this cathode is not maintained at a definite potential above ground. The advantage of this arrangement will also be explained in describing the operation of the system.

The connection of the tap 34 to the potentiometer section 33 of the voltage divider is one which is adjustable in a low voltage range above ground. The voltage at the tap 34 may, therefore, be adjusted satisfactorily for application to the grid of tube 8.

The regulation process of this system may be described as follows:

With a possible decrease in the resistance of the load 31 there is a slight drop of voltage across the load and also across the divider elements 32 and 33. This results in a slightly lower regulating voltage for application to the grid of the regulator tube 8. The plate current of this tube under this condition is decreased and the potential difference between the plate and ground of this tube rises, producing a less negative potential on the grids of tubes 6. This reduces the potential drop across the space paths of the tubes 6 and consequently increases the output potential of the entire plate supply unit 1.

Now the oscillator tubes 10 will give an increased output, due to the higher D. C. potential which is supplied to their anodes and to their screen grids. The increased radio frequency output after rectification in the tubes 28 and 29 will tend to bring back the voltage across the load 31 to the value which it held before the decrease of its resistance.

The voltage regulation as supplied to the grid of tube 8 would not, however, produce ideal results. To improve the regulation further the cathode potential of the regulator tube 8 is preferably altered in the proper direction. This is done simply by obtaining the potential for this cathode from the plate supply unit through resistors 12 and 13.

From the foregoing description of operation it may be seen that the output voltage of the plate supply unit 1 is not held constant, but rather is increased with increasing load current on the radio frequency supply unit 14. The complete operation of the system, therefore, must take into account this rise of potential between the cathode of the triode tube 8 and ground when the load current is increased through the load 31. These effects add up to far better regulation for the load 31.

By adjusting the resistance 13 it is possible to change the degree of regulation until it becomes negative. Beyond this point instability would result. Hence, it is important for satisfactory operation that the adjustment of resistor 13 be kept within workable bounds. However, it has been found experimentally that the effective internal resistance which faces the load 31 can be made slightly negative without producing oscillations. It can also be varied between a slightly negative value and several megohms without reducing efficiency.

Referring now to Fig. 2, I show therein a curve 35 which has been plotted from observations of a regulated power supply built in accordance with the system herein disclosed. In comparison with this curve 35 I also show a curve of unregulated output 36 which was also obtained by the use of a radio frequency power supply lacking the regulating means which are supplied for producing the curve 35. Curve 37 has been plotted to show variations of input voltage as supplied to the anodes of tubes 10. The coordinates of the chart represent kilovolts along a vertical scale and microamperes along a horizontal scale. It will be observed that the voltage regulation between the values of no current and 700 microamperes is as nearly perfect as one could desire, whereas with unregulated power output there is an extreme drop in voltage with an increase in current. The effective internal resistance without the regulator operating was found in one instance to be 15 megohms. By introducing the regulator this dropped to 0.2 megohm. When the resistor 13 was suitably adjusted the effective internal resistance could be still further reduced.

It was also observed in the performance of my improved system that a certain degree of adjustment of the resistor 13 was found desirable to compensate for the ageing of the tubes and other slight variables of operating conditions.

While I have described and illustrated my invention as it might be applied to a specific embodiment of a regulated power supply, it will be understood by those skilled in the art that various changes may be made and other embodiments may be adopted which would also be comprehended within the scope of the invention.

I claim:

1. In a high voltage power supply system of the type which includes a radio frequency generator, and means for rectifying the output therefrom, an electronic D. C. power supply unit having an anodal connection to a source of positive D. C. potential and a floating cathodal connection to the positive electrodes of said generator, regulator means for varying the cathode potential of said

unit, and a control circuit including a potentiometer connected across the output terminals of said rectifying means and an adjustable tap on said potentiometer connected to a control electrode in said regulator means.

2. In combination with a radio frequency generator and rectifier for supplying a very high voltage current to a load, an electronic D. C. power supply unit for feeding a suitable potential to the positive electrodes of said generator, a regulator discharge tube having at least a cathode, an anode and a control grid, a voltage divider connected between the cathodal output terminal of said power supply unit and ground, the cathode of said regulator tube being connected to an intermediate point on said divider, a control electrode in said power supply unit having a resistive connection to its more positive electrodes and a direct connection to the anode of said regulator tube, a potentiometer of relatively high resistance connected in shunt with said load and having an adjustable tap thereon connected to the control grid of said regulator tube.

3. The combination according to claim 2 and including transformer means for feeding output energy from said generator to said rectifier.

4. The combination according to claim 2 and including transformer means and connections

therefrom to said rectifier whereby the output potential of said generator is at least doubled.

5. In a high voltage power supply system, of the type which includes a radio frequency generator and means for rectifying the output from said generator, an electronic circuit for supplying a variable plate potential to said generator, transformer means for raising the output voltage from said generator, means for rectifying said output voltage, a voltage regulator discharge tube suitably connected to said circuit arrangement which supplies plate potential and constituting means for controlling the voltage of said plate potential, and a potentiometer connected across the output circuit of said output rectifying means, said potentiometer having an adjustable tap connected to a control grid in said voltage regulator tube, whereby said tube is caused to deliver a regulatory control voltage to said plate potential supply circuit.

6. The device according to claim 5 and including a voltage divider connected in shunt with said radio frequency generator, an intermediate point along this divider being connected to the cathode of said regulator tube.

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No references cited.