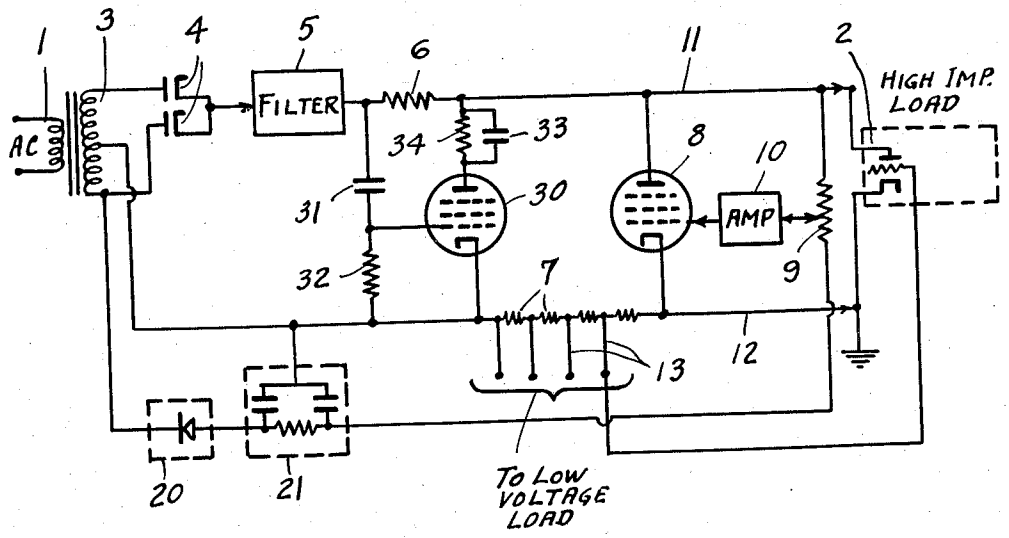
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VOLTAGE REGULATORS

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INVENTORS.
BEVITT J. NORRIS.
MELVIN L. McCREA.
BY
Lockwood, Galt, Woodard & Smith.
ATTORNEYS.

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VOLTAGE REGULATORS

Bevitt J. Norris and Melvin L. McCrea, Fort Wayne, Ind., assignors to International Telephone and Telegraph Corporation

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This invention relates to voltage regulators and is particularly directed to regulators for power supplies requiring both high voltage and low voltage sources.

It is desirable in many industrial applications of radio tubes to regulate both the plate voltage and the grid bias of the amplifier tubes. It is also desirable to supply both low and high voltages for the amplifiers from the same primary source. Prior methods for providing high-current biases require a separate high-current supply, including a separate transformer or transformer winding, and rectifier circuit. Methods of obtaining the bias voltage directly from the high voltage circuits usually are electrically inefficient and do not provide electronic ripple reduction necessary for a good bias source.

The object of this invention is a regulated voltage source for both high and low voltage loads which is electrically efficient, which eliminates the necessity for separate transformers or transformer windings for the two loads, and which eliminates undesired ripple to both the high and low voltage loads.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawing in which the single figure is a circuit diagram of said embodiment.

The primary power source **1** is a source of alternating current which is rectified and adapted for efficient use with both high and low voltage loads, such as the amplifier tube **2** which requires both a B+ anode voltage as well as a grid bias voltage. The secondary **3** of the usual transformer is connected to the full wave rectifiers **4**. The rectified power is filtered at **5** and is passed through the regulator resistor **6** to the load **2**. The regulating resistor **6** is in series in the positive side of the line, while the low-value biasing resistors **7** are in the grounded side of the line. Shunted across the line adjacent the load is the grid-controlled regulator tube **8**, the control grid of which is changed in potential in the proper phase with respect to changes of voltage at the load to complement the load current and hold the total drain on the source constant. This grid voltage is an amplified sample of the load voltage; that is, one end of potentiometer **9** is connected to the positive side **11** of the line and an adjustable sample thereof is amplified in amplifier **10**, and applied to the regulator control grid. The opposite end of potentiometer **9** is connected, not to the opposite side **12** of the direct current supply line, but to a source of voltage which is closely analogous to the alternating current supply line voltage, and which will more fully hereinafter be described.

In the operation of the circuit thus far disclosed, if the load current changes, with a corresponding change in voltage of the positive line **11**, the amplified sample at the grid of regulator tube **8** increases or decreases in a direction opposite to the load change so that the total current through regulator resistor **6** remains substantially constant. If, for example, the load voltage supplied on line **11** is 250 volts and the load current is, say, 130 milliamperes, the shunt regulator tube **8** would be adjusted to draw, say, 60 milliamperes, making a total of 190 milliamperes drawn by the load and its shunt through resistor **6**.

According to an important feature of this invention, this entire 190 milliamperes flows through biasing resistors **7** in series in the grounded side **12** of the line. The ohmic values of the resistors **7** are low and are tapped as at **13** to yield desired biasing potentials for the tube or tubes comprising the load. Should the load tube be of the type above suggested, the taps **12** would preferably yield biasing potentials from about —1.5 to —12.5 volts. Because of the high gain of the regulator amplifier **10**, the output impedance of lines **11** and **12**, as viewed from the load, is very low. This feature is of importance to the proper functioning of tubes in many industrial applications.

Since the actual output voltage to the load is often not critical, no attempt need be made to hold this voltage at an exact level, such as +250 volts. In fact, the circuit, according to this invention, is so designed as to permit a certain amount of shift in the direct current line voltage. That is, fluctuations in the alternating current line voltage result in corresponding changes in the voltage output from the high voltage rectifier **4** and filter **5**. This change is reflected through resistor **6** and causes a change in the value of the output voltage. Now, if an attempt were made to compensate for these line voltage changes by adjusting the current through regulator tube **8**, it is possible that the regulating range of tube **8** could be exceeded. If, for instance, the line voltage decreased sufficiently, the current through regulator **8** could be cut off completely in the attempt of the sampling circuit to maintain a constant output voltage. If, at the same time, the load current increased momentarily there could be no further adjustment by regulator **8**. This would result in an apparent high source impedance for the B+ voltage, and could seriously impair the performance of the load equipment.

To eliminate this possibility, the low side of voltage sampling divider **9** is coupled to one of the output terminals of transformer **3**. This terminal is connected through the rectifier **20** and filter **21** to the lower end of sampling divider **9**. Rectifier **20** may, if desired, be of the solid semi-conductor type and the filter **21** may be of the conventional series-resistance shunt-capacity type. Since the current through filters **21** is not regulated, it varies with alternating current line voltage. As a result, when the alternating current line voltage drops, the voltage at the top of the sampling divider becomes less positive, the output of the winding **3** decreases, and the voltage at the bottom of the sampling divider becomes less negative. As a result, the signal voltage change at the grid of regulator **8** is negligible and the current through regulator tube **8** changes but slightly. If the nominal voltage of the output of filter **21** were —250 volts in the example mentioned, and the voltage of line **11** were +250 volts, the percentage change in the B+ voltage at the load and in the reference voltage would be exactly equal, and the output voltage would vary directly with line voltage. Such line voltage variations at the load are often of no importance. Where the anode of the industrial tube **2** varies with the line voltage, correspondeing bias voltage follows, and the overall operation of the tube **2** remains unchanged.

As explained above, fluctuations of load current are compensated by corresponding but opposite changes in current through regulator tube **8**. As a result, the total current supplied by transformer winding **3** is essentially constant. This constant current provides a means of

obtaining a high current bias voltage across resistor 7 in the negative line.

Because the impedance of the bias source is higher than the source impedance of the regulator circuits, the ripple content of the current at the output of the filter is developed almost entirely across the series resistors 6 and 7. The resulting ripple across the bias supply is sufficient to insert objectionable ripple into the output of the load tube 2. According to this invention, tube 30 is connected as a ripple filter to remove this undesired ripple voltage from the bias supply. The anode-cathode space of regulator 30 is connected between the load-end of resistance 6 and the source-end of resistance 7. The ripple voltage at the output of filter 5 is sampled through coupling condenser 31 and applied to the control grid of regulator 30. Grid resistor 32 is so proportioned with respect to the capacity of condenser 31 and to the ripple frequency that the signal applied to the grid regulator 30 is proportional to the amplitude of the ripple. As the ripple amplitude increases, the current through regulator 30 increases. This causes a corresponding increase in the current through resistance 6. Conversely, as the ripple amplitude decreases, the current through resistance 6 and tube 30 decreases, and as a result the voltage at the output of resistance 6 and across the bias supply resistor 7 remains constant even though there may be considerable ripple at the output of filter 5. Resistor 34 serves to drop the voltage at the plate of tube 30 and maintain the plate dissipation within tube ratings. Condenser 33 serves as a ripple signal bypass for anode resistor 34.

Accordingly, the regulator circuit of this invention provides a constant drain on the source with varying load current drain, offers an efficient bias voltage source, insures corresponding bias and load voltage changes with changing line voltage, effectively eliminates ripple voltages from the bias source, and provides a low impedance direct current voltage source for the load.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of our invention.

What is claimed is:

1. In combination in a regulated power supply; an alternating current source, including a rectifier and a filter; a regulating resistor, a high impedance load and a bias resistor connected in series across the power source, a bias grid-controlled regulator tube shunted across said load immediately adjacent said load, a second grid-controlled regulator tube connected between the load end of said regulating resistor and the source end of said bias resistor, means for sampling voltages at said load and at said source and for combining the sampled voltages, and means for applying the combined sampled voltages to the grid of said first regulator tube.

2. In combination, a high potential line and a low potential line for connecting a load and an unregulated power source, a regulator resistor in the high line, a bias resistor in the low line, first and second grid-controlled regulator tubes connected between the load-end of the regulator resistor and, respectively, opposite ends of said bias resistor, a coupling between the source-end of said regulator resistor and the grid of the first tube, and a coupling between the load-end of the regulator resistor and the grid of the second tube.

3. In the combination of elements for connecting an unregulated source to a load, impedance means in the lines between the source and load, a variable shunt device connected across the load-end of the line, means for sampling the voltage at load-end of the line, means for sampling the voltage at the source-end of the line, means for combining the two sample voltages, means for varying the impedance of the shunt device in response to the combined voltages, a bias resistor in series with one of said lines between said source and the parallel connected load and shunt, and taps on said resistor for supplying low voltage potentials to said load.

4. A system of the character described comprising a transformer having a center tapped secondary, output terminals, a full-wave rectifying and filtering circuit coupling said secondary to said terminals, a regulating resistor connected in series with the other of said terminals, a first regulator tube connected in shunt with said terminals, said tube having a control grid, a sampling potentiometer coupled to said control grid, a rectifier coupled in series with said potentiometer, said series connected potentiometer and rectifier being coupled in series between said one of said terminals and said secondary, a second regulator tube coupled between the load-end of said regulating resistor and the source-end of said biasing resistor, said second tube having a control grid, and a coupling between the source-ends of both regulating and biasing resistors and the second tube grid.

5. A system of the character described comprising a transformer having a center tapped secondary, output terminals, a full-wave rectifying and filtering circuit coupling said secondary to said terminals, a regulating resistor connected in series with one of said terminals, a biasing resistor connected in series with the other of said terminals, a first regulator tube connected in shunt with said terminals, said tube having a control grid, and a sampling potentiometer coupled to said control grid, a rectifier coupled in series with said potentiometer, said series connected potentiometer and rectifier being coupled in series between said one of said terminals and said secondary.

6. A system of the character described comprising a source of alternating current voltage, a full-wave rectifier coupled to said source and having two output terminals, a regulating resistor in series with one of said terminals and said full-wave rectifier, a grid-controlled tube in shunt with said terminals, a half-wave rectifier coupled to said source, and a sampling resistor in series with said half-wave rectifier and said one terminal, said sampling resistor being coupled to the grid of said tube.

7. The system of claim 6 and including a biasing resistor in series with the other terminal and said full-wave rectifier.

8. The system of claim 6 and including a ripple filter coupled between the load-end of said regulating resistor and the other terminal.

9. A system of the character described comprising a source of alternating current voltage, a full-wave rectifier coupled to said source and having two output terminals, a regulating resistor in series with one of said terminals and said full-wave rectifier, a variable shunt device coupled across said terminals, means for varying the impedance of said shunt device, a half-wave rectifier coupled to said source, and a sampling resistor in series with said half-wave rectifier and said one terminal, said sampling resistor being coupled to said means.

10. The system of claim 9 and including a biasing resistor in series with the other terminal and said full-wave rectifier.

11. The system of claim 9 and including a ripple filter coupled between the load-end of said regulating resistor and the other terminal.

12. A system of the character described comprising a source of alternating current voltage, a full-wave rectifier coupled to said source, two output terminals adapted to be connected to a load, a regulating resistor in series with one of said terminals and said full-wave rectifier, a biasing resistor in series with the other of said terminals and said full-wave rectifier, and a ripple filter coupled between the load-end of said regulating resistor and the source-end of said biasing resistor.

13. A system of the character described comprising a source of voltage, first and second lines coupled to said source, first fixed impedance means in series with the

first line, a variable impedance shunt device coupled across said lines, means for varying the impedance of said shunt device, a third line coupled to said source, and second impedance means coupled in series between said third and first lines, said impedance-varying means being coupled to said second means for controlling the impedance of said shunt device.

14. The system of claim 13 and including a third impedance means in series with the second line arranged to provide a biasing voltage.

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