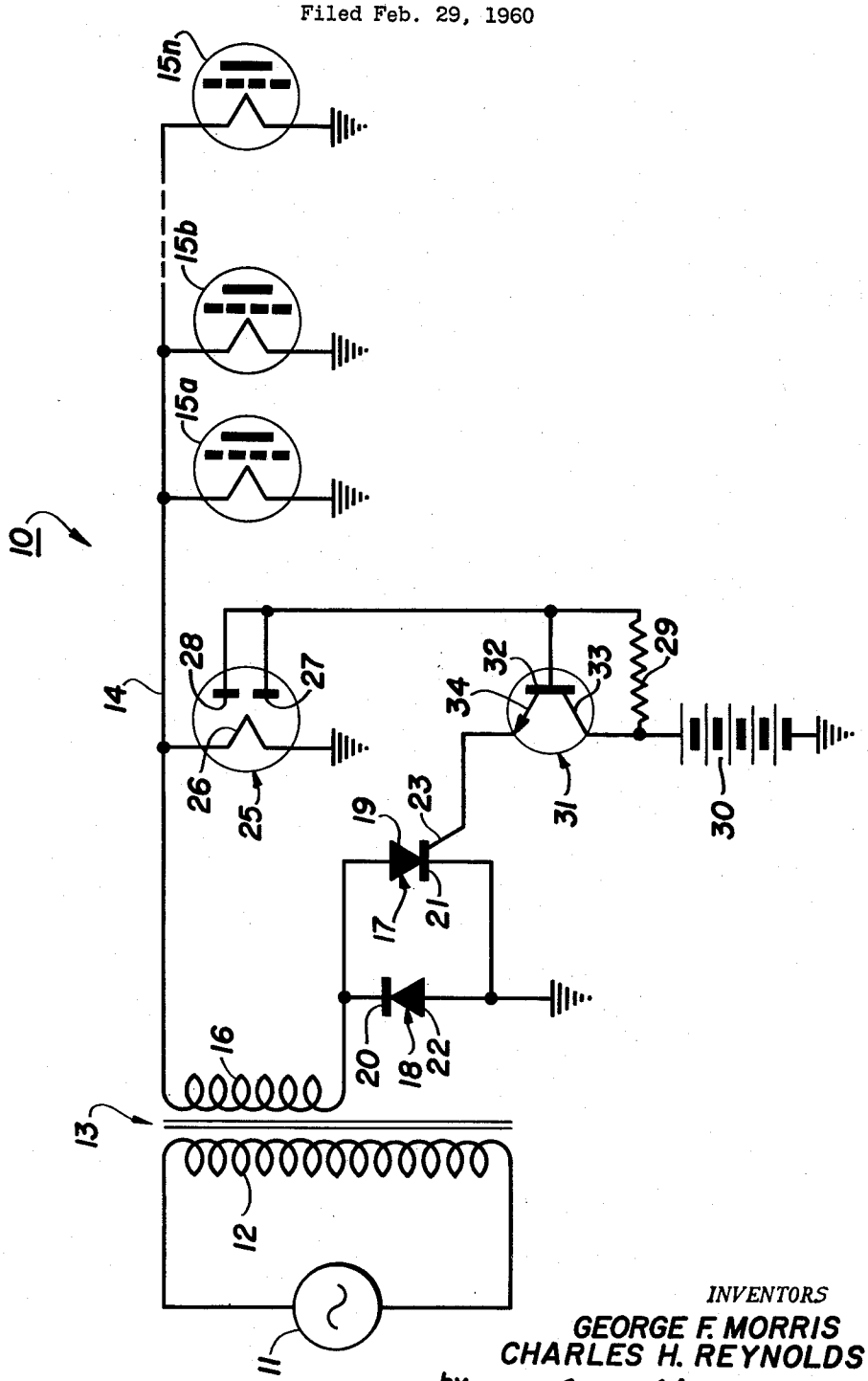
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R.M.S. VOLTAGE REGULATOR

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R.M.S. VOLTAGE REGULATOR

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The present invention relates generally to a new and improved voltage regulating circuit and is more particularly concerned with a circuit having a regulated R.M.S. output voltage while employing only very small, light components arranged to conserve power and to provide very fast response to variations in the amplitude of the input voltage.

In a number of applications, for example, in controlling the filament temperatures of one or more tubes connected across an A.C. line, it is desirable to maintain substantially constant R.M.S. voltage. Prior to the present invention, it has been customary to use ballast tubes or magnetic amplifiers to effect the desired control. However, neither of these devices is entirely satisfactory, since the ballast tubes are wasteful of power while the use of a magnetic amplifier requires a heavy, space consuming device usually of a size commensurate with that of the transformer whose output voltage is being regulated. The primary object of the present invention is, therefore, to provide a new and improved voltage regulating circuit which avoids all of the aforementioned disadvantages of prior art circuits.

The invention has for another object the provision of a voltage regulating circuit of the character described above employing only very small, light and inexpensive components.

A further object of the invention is to provide a circuit delivering a regulated R.M.S. output voltage from an A.C. input subject to voltage excursions with the circuit being characterized by a very fast response to the input voltage variations.

In accordance with the present invention the foregoing and other objects are realized by the provision of a circuit for providing a regualted R.M.S. voltage output in response to an A.C. input signal which may vary in amplitude. The circuit includes an input transformer having its primary excited by the A.C. input signal and having its secondary regulated to provide nearly constant R.M.S. output voltage. To provide the regulation the transformer secondary circuit includes a silicon controlled rectifier which effectively deletes a portion of the secondary signal. The amount of signal deleted is controlled by applying to the gate electrode of the controlled rectifier a control voltage developed by an R.M.S. sensing device connected across the output. The latter sensing device, which preferably comprises a temperature limited diode, is sensitive to small changes in R.M.S. voltage applied across its filament and it functions to develop a D.C. control signal which is amplified and supplied to the gate electrode of the controlled rectifier. Thus, if the output voltage tends to increase, the sensing device and its associated amplifier apply a signal to the gate electrode which causes the controlled rectifier to delete a greater portion of the secondary voltage. A decrease in the output voltage, on the other hand, causes the control rectifier to delete a smaller portion of the secondary voltage. Through the circuit described, the R.M.S. output voltage can be maintained substantially constant despite very wide variations in the input voltage.

The invention, both as to its organization and manner of operation together with further objects and advantages, will be understood by reference to the following description taken in conjunction with the accompanying drawing wherein the single FIGURE illustrates a regulating

circuit **10** characterized by the features of the present invention. This circuit is excited by A.C. input signals supplied from a suitable source **11** across the primary winding **12** of a conventional input transformer **13**. The A.C. input signal is sinusoidal in form but is not regulated in amplitude and, hence, may be subject to appreciable voltage excursions. It is the purpose of the circuit **10** to provide a substantially constant R.M.S. output voltage appearing between the output lead **14** and ground despite these variations in the amplitude of the input signal. As was indicated previously, one possible use for the circuit **10** might be for supplying nearly constant R.M.S. filament voltage to one or more tubes connected across the output. Any desired number of such tubes may be employed as indicated by the reference numerals **15***a*, **15***b* . . . **15***n* with the filaments of all of the tubes being connected across the output of the circuit **10** between lead **14** and ground.

The lead **14** is connected to one side of the secondary winding **16** of the transformer **13** with the other side of this winding being connected to ground through a silicon controlled rectifier **17** connected across a diode or dry rectifying means **18**. The silicon controlled rectifier, which may be of Type C–35 manufactured by General Electric Company, is poled oppositely to the diode **18**. More specifically, the anode **19** of the controlled rectifier and the cathode **20** of the diode **18** are connected directly together and to the lower end of the secondary winding **16** while the cathode **21** of the controlled rectifier is connected directly to the anode **22** of the diode **18** and to ground. The diode **18** conducts on the negative half cycles of the signal appearing across the secondary winding **16**, and since its forward resistance is very low the lower end of the secondary winding is effectively at ground potential during the negative half cycles. The negative half cycles, of course, have no effect on the controlled rectifier **17**. On the positive half cycles the diode **18** is effectively an open circuit since its back resistance is very high. The positive half cycles cause the controlled rectifier **17** to conduct only when the potential existing between the gate **23** and cathode **21** is sufficient to cause breakdown. Until the controlled rectifier conducts, it offers a very high resistance to the A.C. signal and, as a consequence, substantially all of the voltage is dropped thereacross and is deleted from the output. As soon as the controlled rectifier begins to conduct its very low forward resistance effectively grounds the lower end of the secondary winding and, hence, causes the remaining portion of the positive half cycle to appear across the output. Thus, the output between lead **14** and ground comprises the negative half cycles of the secondary voltage and a portion of the positive half cycles delayed by the time required for the controlled rectifier **17** to fire. As is well known, the breakdown voltage of the controlled rectifier is a function of the potential of the gate electrode **23**. Thus, by controlling the potential of the gate electrode, it is possible to control the firing time of the controlled rectifier and, hence, to control the R.M.S. level of the output voltage.

The gate electrode potential is controlled, in accordance with the present invention, by employing an R.M.S. sensing device to detect variations in the R.M.S. voltage appearing between lead **14** and ground and by utilizing the output of this device to alter the potential on the gate electrode in order to compensate for any such variations. More specifically, the R.M.S. sensing device preferably comprises a temperature limited diode **25**, for example, a Sylvania 6352 type diode, having a directly heated cathode **26** connected directly across the line **14** and ground. The plates **27** and **28** of the diode **25** are connected directly together and through a load resistor **29** to the positive terminal of a source **30** of D.C. voltage. Small variations in the R.M.S. voltage appearing across the

cathode of the sensing device **25** cause marked changes in the plate current flowing through resistor **29**. Thus, as the R.M.S. voltage across the cathode **26** increases the plate current flowing through the resistor **29** also increases to produce a decrease in the potential at the plates **27** and **28**. The signal appearing across the load resistor **29** is amplified by a conventional emitter follower circuit including a transistor **31** and the amplified signal is applied to the gate electrode **23**. More specifically, the resistor **29** is connected between the base **32** and the collector **33** of the transistor **31** in order to provide input drive for the emitter follower. The output of the emitter follower is, of course, derived from the emitter **34** of the transistor **31**.

Turning now to the operation of the circuit **10** described above, it will be recognized that any increase in the R.M.S. level of the output voltage between lead **14** and ground is accompanied by an increase in plate current of the diode **25** which, in turn, causes a decrease in the potential of the base **32**. The emitter **34** and the gate electrode **23** are thus driven negatively with the result that the firing of the controlled rectifier **17** is delayed. More specifically, the decrease in potential of the gate electrode **23** delays the firing of the controlled rectifier since the firing point is not reached until a later point of the input voltage waveform. As a consequence, the latter rectifier does not fire until a later time in the positive going portion of the cycle. Thus, a greater portion of the positive cycle is deleted so that the R.M.S. level of the output voltage is driven back to the desired level. Any tendency for a decrease in the R.M.S. voltage across the cathode **26**, of course, drives the potential of the plates **27** and **28** and the base **32** in a positive direction thus increasing the potential of the gate electrode **23** and causing the controlled rectifier to fire earlier in the positive going portion of the cycle. Thus, under the latter conditions the R.M.S. output voltage is increased to the desired output level. It has been found that the circuit described is able to provide negligible changes in R.M.S. output voltage for input changes as great as thirty percent above or below the nominal input level. Moreover, since the sensing device **25**, the transistor **31** and the controlled rectifier **17** respond very quickly to changes in applied signals, the overall response time of the circuit **10** to changes in the level of the input signal is very fast.

In view of the foregoing discussion it will be observed that the circuit described is effective to accomplish all of the enumerated objects of the invention. While a particular embodiment of the invention has been shown, it will be understood, of course, that the invention is not limited thereto since many modifications may be made and it is, therefore, contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

A circuit for providing a regulated R.M.S. output voltage, said circuit comprising an input transformer having a primary circuit excited by A.C. input signals subject to voltage variations and also having a secondary winding for supplying drive signals to a secondary circuit, a pair of output terminals in said secondary circuit, a controlled rectifier connected in said secondary circuit between one of said terminals and one side of said secondary winding and having a gate electrode and first and second terminal electrodes, rectifying means connected across said terminal electrodes and poled oppositely to said controlled rectifier so that the rectifying means is poled for conduction during one half cycle of the signal appearing across the secondary winding while the controlled rectifier is poled for conduction during the other half cycle whenever the voltage existing across said terminal electrodes becomes sufficient to break down the rectifier, the R.M.S. voltage appearing across said pair of output terminals being inversely proportional to the time required for firing said controlled rectifier during said other half cycle, a voltage sensing device comprising an electron discharge device having a cathode and an anode, said cathode being connected across said terminals and said anode being connected to a voltage source to develop a temperature limited D.C. control signal in the cathode-anode circuit varying with changes in the R.M.S. voltage appearing across said cathode, and means for supplying said control signal to said gate electrode to alter the firing time of the controlled rectifier and, hence, to control the R.M.S. voltage appearing across said output terminals.

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