

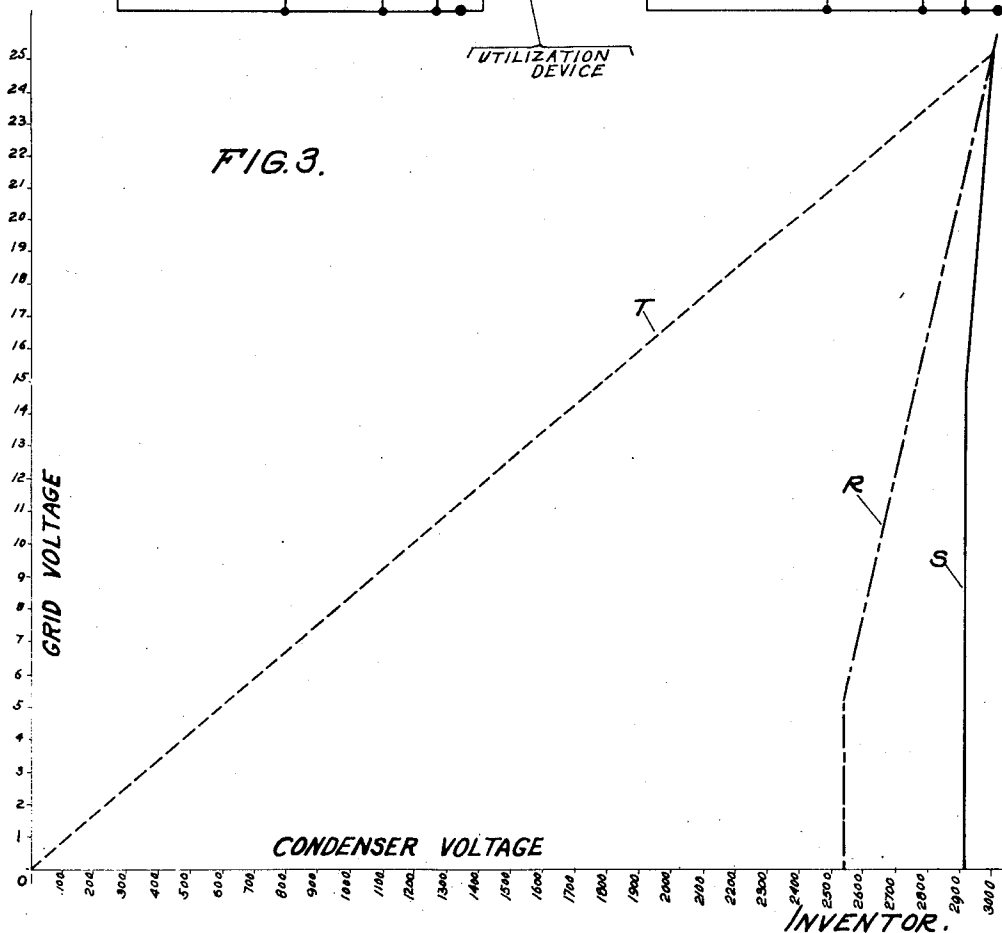
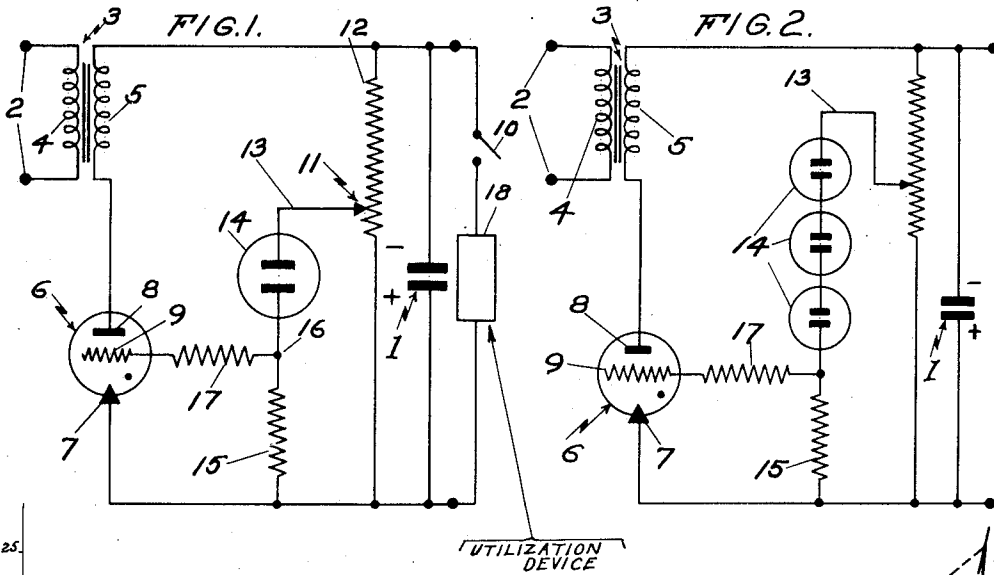
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VOLTAGE REGULATOR

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VOLTAGE REGULATOR

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This invention relates to voltage regulators.

Certain loads are critical as to the voltage applied to them. For example, condensers supplying welding energy for resistance welding are critical as to the voltage applied to such condensers. If excess voltage is applied to such condensers, holes may be burnt out in the work during welding, or the structure around the weld may be materially weakened. In numerous other instances outside the field of welding the application of a constant voltage to a load is desirable. To prevent the application of such excess voltages it has heretofore been customary to utilize voltage regulators. One of the difficulties heretofore encountered in connection with such regulators has been their slowness of response. Frequently when steeply rising voltages were being transmitted to the load these regulators would operate only after a voltage substantially in excess of the desired voltage had been applied to said load. In systems where the load voltage is not critical this excess voltage is usually not material; but in systems where the load voltage is critical such regulators prove unsatisfactory.

An object of this invention is the provision of a voltage regulator which has a substantially instantaneous response so as to be capable of blocking out almost all variations ordinarily encountered in systems of this kind.

Certain types of voltage regulators operate by applying a control voltage derived from the load voltage to a control element, such as, for example, the control grid of a tube governing the supply of load voltage. In these regulators as the load voltage rises the control voltage rises too, and when the load voltage reaches a predetermined value the control becomes sufficiently great to operate the control element. When the control element is the control grid of a tube the control voltage is utilized to apply a bias to the control grid and when the control voltage is sufficiently great further conduction in the tube is prevented by the bias which reaches a cut-off value when the load voltage reaches its predetermined value.

One of the difficulties heretofore encountered in regulators of the general type utilizing a control voltage derived from the load voltage is that the control voltage rises much more gradually than does the load voltage. Coupled with this is the fact that the usual control element does not operate at a precise voltage, but varies in its point of operation. For example, the bias required to cut off conduction in one type of tube may vary several volts. Therefore, when the control voltage rises very gradually in relation

to the load voltage as in prior types of regulators and where the control element does not operate at a precise voltage, it becomes possible for the load voltage to rise substantially above its selected maximum voltage before the control element operates. Thus with such prior types of regulators it has been impossible to prevent the application of substantial excess voltages to the load. Therefore, another object of this invention is the provision of a voltage regulator which is extremely accurate in its operation and will prevent the application of substantially any excess voltage to the load. One of the features of regulators embodying this invention is that the control voltage rises relatively steeply as the load voltage rises. Another feature of this invention is that any desired steepness in the rise of the control voltage may be obtained so as to satisfy the requirements of the particular system in which the voltage regulator is used.

A further object of the present invention is the provision of a simple and relatively inexpensive voltage regulator of the type described.

Other and further objects and advantages of the present invention will become apparent, and the foregoing will be understood in relation to the following exemplifications thereof, reference being had to the drawing in which:

Fig. 1 is a schematic diagram of an electrical system including one form of a voltage regulator embodying my invention;

Fig. 2 is a schematic diagram of a similar electrical system including a modified form of a voltage regulator embodying my invention; and

Fig. 3 is a graph indicating qualitatively rather than quantitatively certain aspects of my invention.

Referring now to Fig. 1, a load which may be critical as to the voltage applied thereto, for example, condenser 1, is adapted to have a voltage applied thereto from a voltage source 2 through a power transformer 3 having its primary 4 connected to the source 2 and one end of its secondary 5 connected directly to one side of condenser 1, the other end of said secondary 5 being connected to the other side of condenser 1 through a controlled electrical space discharge device or tube 6. Tube 6 may be of the gaseous type having a continuously energized cathode 7 connected to the positive side of condenser 1 and having its anode 8 connected to one side of the secondary 5 of power transformer 3. Tube 6 is also provided with a control element or control grid 9. Condenser 1 may be connected through a switch 10 to any suitable utilization device 11

and its discharge may be utilized to supply energy to said utilization device 18, which may be, for example, a welding transformer. It is to be understood that condenser 1 in this system may be critical as to the voltage applied thereto and that excess voltages are to be avoided. To prevent the application of such excess voltages I have provided the following means.

A potentiometer 11 has its resistance 12 arranged across condenser 1, and its moveable arm 13 connected in series with a constant voltage device, such as, for example, a glow tube 14 and a resistance 15 to the positive side of condenser 1. Point 16, intermediate glow tube 14 and resistance 15, is connected in series with a grid resistance 17 to the grid 9 of tube 6. The method of operation of this device is as follows. As the voltage derived from source 2 is applied to condenser 1 through tube 6 the potential drop across condenser 1 and across resistance 12 of potentiometer 11 rises. This rising voltage reaches a value at which the potential drop across the series circuit consisting of glow tube 14 and resistance 15 is equal to the starting voltage of glow tube 14, whereupon tube 14 fires and a potential drop appears across resistance 15. This potential drop is impressed between the grid 9 and cathode 7 of tube 6. At the breakdown voltage of glow tube 14 the potential appearing across resistance 15 preferably is insufficient to cut off conduction in tube 6. When, however, the voltage on condenser 1 continues to rise, the voltage across resistance 15 rises in accordance therewith until it reaches a value sufficient to cut off further conduction in tube 6. By varying the position of arm 13, or if desired, by varying the value of resistance 15, the precise voltage on condenser 1 at which further conduction by tube 6 is prevented may be selected. How this operation produces a steep control voltage will be described hereinafter in connection with Fig. 3.

Referring now to Fig. 2, a modified form of the system disclosed in Fig. 1 is depicted. Instead of a single glow tube 14 a plurality of such tubes in series, to wit, three, are employed. By the use of three such tubes it is apparent that the voltage required to cause conduction in said tubes must be three times as large as the voltage required to cause conduction in the single tube 14 of Fig. 1. As will be more fully understood from the description in connection with Fig. 3 the use of three such tubes results in the production of an even steeper characteristic for the control voltages.

In one system embodying the system illustrated in Fig. 1 the following were the constants used: the maximum voltage to be applied to the condenser 1 was 3000 volts, the glow tubes 14 had a starting voltage of 110 volts, and a constant operating voltage of 105 volts, and in tube 6 a negative bias of 25 volts applied to its grid would prevent further conduction therein. From the foregoing it will be apparent that when a voltage of 110 volts was applied to the series circuit in Fig. 1 consisting of glow tube 14 and impedance 15 tube 14 would fire and thereupon the voltage drop across tube 14 would become constant at 105 volts, while the drop across resistance 15 would be 5 volts. As the voltage drop across condenser 1 increased the voltage drop across resistance 15 also increased until said voltage drop was equal to 25 volts, whereupon the bias applied to the grid 9 was sufficient to prevent further conduction of tube 6. At this time the voltage across condenser 1 would be 3000 volts. The voltage across con-

denser 1 at the time tube 14 fires is approximately 2538 volts.

The foregoing operation is represented by curve R in Fig. 3 in the graph in which the voltage on condenser 1 is plotted along the horizontal line, while the voltage across resistance 15 is plotted on the vertical line. From said graph it will be seen that no drop appears across resistance 15 until the potential on condenser 1 is about 2538 volts, whereupon tube 14 fires and a potential of 5 volts appears across resistance 15. As the voltage on condenser 1 rises from 2538 to 3000 volts the potential across resistance 15 rises from 5 volts to 25 volts.

In the embodiment of Fig. 2 the same constants are employed, except that there are three glow tubes 14 each having a starting voltage of 110 volts and a constant operating voltage drop of 105 volts. Curve S of Fig. 3 represents the operation of this system. Before the glow tube 14 fires, a voltage of 330 volts must be impressed across the series circuit consisting of the three glow tubes 14 and resistance 15. These tubes then fire and the voltage drop across these tubes falls to 315 volts, while a drop of 15 volts appears across resistance 15. At this point, that is when the three glow tubes 14 fire the voltage across condenser 1 is about 2912 volts. As the potential on condenser 1 rises from about 2912 volts to 3000 volts, the voltage across resistance 15 rises from 15 volts to 25 volts.

It will be seen that the rise of curve S is steeper than the rise of curve R. These curves may be contrasted with the curve that would be produced if the control voltage was obtained simply by the use of a voltage divider and the potential derived from said voltage divider were applied to grid 9. Resistance 12 may be used as the voltage divider and the potential derived therefrom between the arm 13 and the point 16, without the intervening tube 14, might be impressed on grid 9. Referring now to curve T which represents this derived voltage, this voltage would be zero when the voltage across condenser 1 is zero and would rise linearly to 25 volts when the voltage across condenser 1 would be 3000 volts.

It will be seen that the control voltage derived from a voltage divider has a relatively gradual rise in relation to the rise of potential across condenser 1, whereas the rise of the control voltage in a system such as in Fig. 1 would be much steeper, and in Fig. 2 even more steep. As is apparent the steeper the slope of the control voltage applied to the grid 9 of tube 6, the more positive the operation of the voltage regulator. It will therefore be seen that the systems illustrated in Figs. 1 and 2 are more positive in their operation and consequently more accurate. It will also be apparent that in order to obtain a steeper control voltage characteristic than that shown in curve S it is only necessary to add more constant voltage tubes in series with the three there illustrated or to use tubes having a larger constant voltage drop.

It will be noted that the glow tubes 14 in effect subtract a constant value of voltage from the potential appearing on the potentiometer arm 13. This means that if the voltage at the arm 13 in Fig. 1, for example, were to change by a value of one volt, the voltage at the point 16 would vary by exactly the same amount. Therefore, insofar as any time variation is concerned the voltage changes at the point 16 are exactly parallel with the voltage changes at the arm 13, differing therefrom by a constant value determined by the drop through the tubes 14. As more and more glow

tubes 14 are added in series, the variation in voltage on the control grid 9 approaches more closely the variation in the voltage applied to the load itself. Thus, in the limiting case in which the series circuit consisting of glow tubes 14 and the impedance 15 is connected across the entire load voltage, a variation of one volt in the load voltage will produce a variation of one volt in the voltage impressed on the control grid 9.

Of course it is to be understood that in place of glow tubes having the constant voltage drop mentioned, other constant voltage devices or other glow tubes having different constant voltage drop values might be employed. Furthermore, while I have illustrated a half-wave rectifier system, it is to be understood that a full-wave rectifier system might be employed in a manner readily understood by those versed in this art from the foregoing description. Likewise a multiphase voltage source might be employed instead of the single phase system here described. A plurality of tubes, such as the gaseous type tube 6, or other rectifying tubes or devices subject to control might be substituted in place of tube 6. In addition, while I have described the load in this instance as being a condenser, other types of loads might be used. Because of the swift and positive operation of voltage regulators of my invention, it becomes feasible to employ them for controlling the voltages across loads where the voltage varies more rapidly than can be taken care of by prior voltage regulators.

Other and further variations within the scope of this invention will occur to those versed in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. An electrical system comprising a load, a voltage source, means for connecting said load to said source, a constant voltage device and an impedance arranged in series and means to impress at least a portion of the voltage across the load on said constant voltage device and said impedance, whereby a control voltage responsive to the voltage across said load appears across said impedance, and means responsive to said control voltage for disconnecting said load from said source when said control voltage reaches a predetermined value.

2. An electrical system comprising a load, a voltage source, means for connecting said load to said source, a glow tube and an impedance arranged in series and means to impress at least a portion of the voltage across the load on said glow tube and said impedance whereby a control voltage responsive to the voltage across said load appears across said impedance, and means responsive to said control voltage for disconnecting said load from said source when said control voltage reaches a predetermined value.

3. An electrical system comprising a load, a voltage source, means for connecting said load to said source, a constant voltage device and an impedance arranged in series and means to impress a voltage responsive to the voltage across the load on said constant voltage device and said impedance, whereby a control voltage responsive to the voltage across said load appears across said impedance, and means responsive to said control voltage for disconnecting said load from said source when said control voltage reaches a predetermined value.

4. An electrical system comprising a load, a voltage source, means for connecting said load to

said source, a circuit for connecting said source to said load including a controlled electrical space discharge device having a control element, a constant voltage device and an impedance arranged in series and means to impress a voltage responsive to the voltage across the load on said constant voltage device and said impedance, whereby a control voltage responsive to the voltage across said load appears across said impedance, said control voltage being impressed upon said control element and being adapted to cut off conduction in said controlled electrical space discharge device when said control voltage reaches a predetermined value to thereby disconnect said source from said load.

5. An electrical system comprising a load, a voltage source, means for connecting said load to said source, a circuit for connecting said source to said load including a controlled electrical space discharge device having a control grid, a constant voltage device and an impedance arranged in series and means to impress at least a portion of the voltage across the load on said constant voltage device and said impedance, whereby a control voltage responsive to the voltage across said load appears across said impedance, said control voltage being impressed upon said control grid and being adapted to cut off conduction in said controlled electrical space discharge device when said control voltage reaches a predetermined value to thereby disconnect said source from said load.

6. An electrical system comprising a condenser, a voltage source, means for charging said condenser from said source, a constant voltage device and an impedance arranged in series and means to impress at least a portion of the voltage across the condenser on said constant voltage device and said impedance, whereby a portion of the voltage on the condenser appears across said impedance, said portion being a control voltage, and means responsive to said control voltage for disconnecting the condenser from said source when said control voltage reaches a predetermined value.

7. An electrical system comprising a condenser, a voltage source, means for charging said condenser from said source, a constant voltage device comprising a glow tube and an impedance arranged in series and means to impress at least a portion of the voltage across the condenser on said constant voltage device and said impedance, whereby a portion of the voltage on the condenser appears across said impedance, said portion being a control voltage, means responsive to said control voltage for disconnecting the condenser from said source when said control voltage reaches a predetermined value, a utilization device and means for discharging said condenser through said device.

8. An electrical system comprising a load, a voltage source, means for connecting said load to said source, means for deriving a voltage from at least a portion of the voltage across said load, means effective when the derived voltage reaches a predetermined value for subtracting a constant voltage from said derived voltage to obtain a control voltage proportionate to and having a value less than said derived voltage by a constant predetermined amount, and means responsive to said control voltage for controlling the flow of current in a portion of said system when said control voltage reaches a predetermined value above its initial value.

9. An electrical system comprising a load, a voltage source, means for connecting said load

to said source, a controlled electrical spaced discharge device having a control element for controlling the flow of current in a portion of said system, a constant voltage device and an impedance arranged in series and means to impress a voltage responsive to the voltage across the load on said constant voltage device and said impedance, whereby a control voltage responsive to the voltage across said load appears across said impedance, said control voltage being impressed upon said control element and being adapted to control conduction in said controlled electrical space discharge device when said control voltage reaches a predetermined value.

10. An electrical system comprising a load, a voltage source, means for connecting said load to said source, a controlled electrical space discharge device having a control grid for controlling the flow of current in a portion of said system, a constant voltage device and an impedance arranged in series and means to impress at least a portion of the voltage across the load on said constant voltage device and said impedance, whereby a control voltage responsive to the voltage across said load appears across said impedance, said control voltage being impressed upon said control grid and being adapted to control conduction in said controlled electrical space discharge device when said control voltage reaches a predetermined value.

11. An electrical system comprising a load, a voltage source, means for connecting said load to said source, means for deriving a voltage from

at least a portion of the voltage across said load, means effective when the derived voltage reaches a predetermined value for obtaining a control voltage proportionate to and having a value less than said derived voltage by a constant predetermined amount, and means responsive to said control voltage for disconnecting said load from said source when said control voltage reaches a predetermined value above its initial value.

12. In combination, a condenser, a source of current for charging said condenser, means for deriving a voltage proportionate to the voltage across said condenser, means for obtaining a control voltage from said proportionate voltage, said control voltage differing from said derived voltage by a predetermined constant value, and means for cutting off the supply of charging current to said condenser when said control voltage reaches a predetermined value above its initial value.

13. In combination, a condenser, a source of current for charging said condenser, means for deriving a voltage continuously proportionate to and substantially less than the voltage across said condenser, means for obtaining a control voltage from said proportionate voltage, said control voltage being less than said proportionate voltage by a predetermined constant value, and means for cutting off the supply of charging current to said condenser when said control voltage reaches a predetermined value above its initial value.

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