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2,897,432

ELECTRICAL SIGNAL REGULATOR

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FIG.1. PRIOR ART

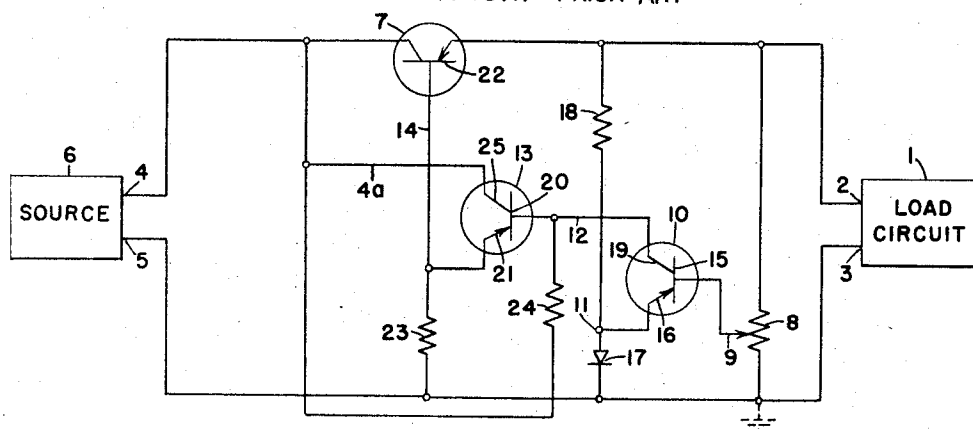


FIG. 2a.

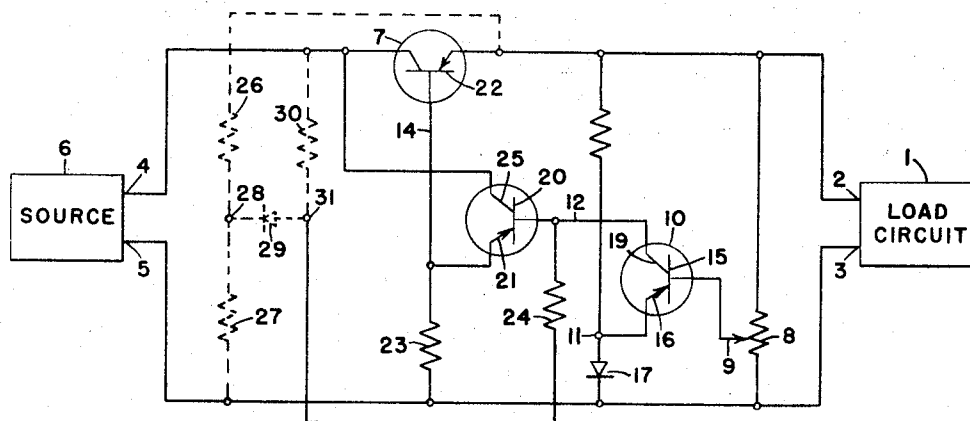
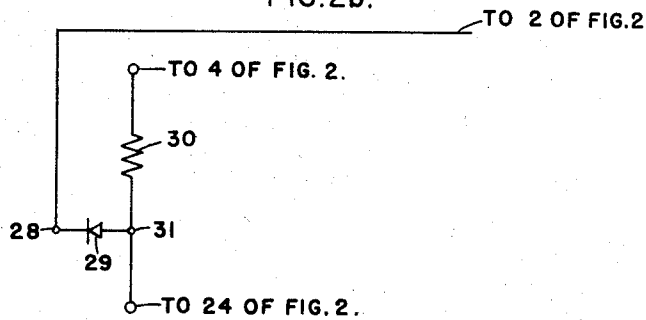


FIG. 2b.



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ELECTRICAL SIGNAL REGULATOR

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8 Claims. (Cl. 323—22)

My invention relates to regulating devices and more particularly to electrical signal regulators.

It is oftentimes desirable to control the voltage supplied from a source to a load circuit to within predetermined levels irrespective of variations in source and the load circuit. Where the power to be supplied to a load circuit is obtained from a source of poor regulation, it is common to employ a voltage regulator between the source and the load circuit to maintain the voltage at the load circuit substantially constant. Previous regulators of this type have suffered from certain shortcomings, notably the inability to provide adequate regulation of output voltage for variations in the source.

It is therefore an object of my invention to provide an improved signal processing arrangement.

It is another object of my invention to provide a new and improved signal regulator capable of satisfactory performance over wide operation conditions.

It is a further object of my invention to provide an improved voltage regulating arrangement.

It is a further object of my invention to provide an improved electrical signal regulator.

Briefly, prior art regulating arrangements compare a portion of the output voltage with a reference voltage to derive a control signal and then amplify the control signal to a suitable level for operating a variable impedance connected between a voltage source and the load circuit. Where transistor circuits are employed for the comparison and amplifying function, regulation deteriorates because transistor circuits are more sensitive to variations in the supply voltage. In accordance with the present invention, an arrangement is provided for supplying a stabilized collector voltage to obtain improved transistor stage operation.

For a better understanding of my invention, reference is made to the following description taken in connection with the accompanying drawings and the appended claims wherein Fig. 1 illustrates in circuit diagram form a prior art transistorized regulating arrangement; Figs. 2a and 2b illustrate in circuit diagram form a transistorized embodiment of the present invention.

Referring now to Fig. 1 there is shown an output or load circuit 1 having its input terminals 2 and 3 connected through a circuit arrangement, to be described, to the output terminals 4 and 5 of a source of unregulated unidirectional or undulating voltage 6. In order to maintain a substantially constant voltage across terminals 2 and 3 which is independent of variations in the load circuit 1 impedance and the source 6 voltage, a signal regulating arrangement is provided. This regulating arrangement comprises a variable impedance 7, placed between the source output terminal 4 and the load input terminal 2 which is made responsive to variations in the voltage developed across the load sensing resistor 8 in a manner to cause the voltage developed across resistor 8 to be kept constant. To accomplish this, a portion of the voltage developed across the load sensing resistor 8 is selected

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amplifier circuit 10. The comparator and amplifier compares the voltage signal selected by the movable tap 9 with a fixed reference voltage signal provided at the junction point 11 in a manner to be described shortly.

5 The result of this amplitude comparison is a control signal which is applied over lead 12 to the amplifying stage 13. Upon amplification in stage 13, an amplified control signal is supplied over lead 14 to the variable impedance device 7 causing the impedance device 7 to change in the proper direction to maintain the voltage developed across resistor 8 constant.

10 Transistor stage 10, operating as a comparator and amplifier, has its base electrode 15 connected through the movable tap 9 to a point on the sensing resistor 8. Emitter electrode 16 is connected to the junction 11 of a constant voltage reference element 17 and the reference load resistor 18. The reference element may comprise, for example, a zener silicon diode. The collector electrode 19 is connected by lead 12 to the base electrode 20 of the transistor amplifier 13. The emitter electrode 21 is connected directly to the base electrode 22 of the transistor regulating device 7 and by a load resistor 23 to ground. Transistor 7 has its collector electrode connected to terminal 4 and its emitter electrode connected to terminal 2. Collector voltage for the transistors 13 and 10 are supplied from terminal 4 over lead 4a to the collector electrode 25 and from terminal 4 by means of a load resistor 24 to the collector electrode 19. Load resistor 24 also supplies an operating voltage for the base electrode 20 of transistor 13.

25 The operation of the regulating arrangement can be described as follows. If the output voltage developed across terminals 2 and 3 becomes more negative with respect to its normal operating level, transistor 10 operates to compare this more negative-going signal with the reference voltage available between junction 11 and ground to provide a less negative signal on lead 12. The amplifying stage 13 responds to the less negative signal applied to its base electrode to provide a less negative signal on the output lead 14. The regulating arrangement responds to this less negative signal to increase the effective impedance between terminals 4 and 2 and thereby return the output voltage back to its normal operating level. In a similar manner, if the output voltage developed across terminals 2 and 3 should become less negative, transistor stage 10 operates to provide a more negative voltage on lead 12 and transistor 13 operates in response to the latter to provide a more negative voltage at the output lead 14. Regulating arrangement 7 responds to the more negative voltage to reduce the effective impedance between terminals 2 and 4 and therefore return the output voltage developed across 2 and 3 back to its normal operating level. It should be noted that the output voltage variations across terminals 2 may be realized because of variations in load circuit or in the source itself as reflected across the sensing resistor 8. It should be noted that variations in the source voltage across terminals 4 and 5 result in these variations being applied to the collector electrode 19 of transistor 10 and to base electrode 21 of transistor 13 through the load resistor 24, and also to the collector electrode 25 of transistor 13. For a predetermined setting of the movable tap 9 on the sensing resistor 8, the regulating arrangement shown will provide proper regulation within given tolerances for a given range of load circuit variations. However, any variations in the voltage of source 6 will modify the regulating function being achieved since the source voltage variations appear at the collector electrodes of the transistors 10 and 13. While the regulating arrangement will compensate to a certain degree for these undesirable source variations, it does not do so completely and adequately.

In accordance with one embodiment of the invention to be described shortly, the shortcomings of this prior art arrangement are corrected by providing more stabilized voltages for operation of the transistors 10 and 13. Before explaining the details of the present invention, it is desirable to note the existence of certain voltage conditions within the circuit arrangement of Fig. 1. For example in a particular embodiment the zener diode 17 provided a constant nine volt reference across its terminals. The voltage available at lead 2 was a regulated 20 volts negative while the voltage at terminal 4 was an unregulated 35 volts negative. It is inherent in transistor circuit operation that the emitter and base operate with small voltage differences, in the order of $\frac{1}{10}$ volt or so. Accordingly the voltage developed at the emitter electrode of transistor stage 7 is substantially equal to that available on lead 12 and corresponds to the collector voltage for transistor stage 10. In view of this, the voltage required for proper operation of the collector 19 through the dropping resistor 24 must be larger than that available at the emitter of regulator 7 which corresponds to the output voltage available on lead 2 with respect to ground. This accounts for the collector 19 being connected through the load resistor 24 to the unregulated high voltage side of the regulator corresponding to terminal 4.

In accordance with the present invention, the source of unregulated voltage for the collector electrode 19 of transistor stage 10 and the base electrode 20 of transistor stage 13 is replaced with a stabilized voltage source. This stabilized voltage is achieved as follows. A resistance divider comprising resistors 26 and 27 is connected between the output terminal 2 and ground. The junction 28 therefore provides a regulated voltage which in a particular embodiment was found to be 16 volts. Since, as previously described, the voltage required to be applied through the load resistor 24 to transistors 10 and 13 was to be of the order of 25 volts, the following arrangement is provided. A zener silicon diode or reference signal source 29 is connected between terminal 28 and the high voltage unregulated terminal 4 through the load resistor 30. Since the reference diode 29 develops a fixed potential of 9 volts across its terminals, the voltage available at junction 31 is the sum of the voltages developed at junction 28 and across the reference source 29 or 25 volts. Since junction 28 is a point of regulated voltage available from terminal 2 and the reference source 29 develops a constant voltage drop of 9 volts thereacross, the voltage at terminal 31 is a stabilized or regulated voltage of 25 volts. By providing this stabilized voltage for the collector electrode 19 and the base electrode 20, the shortcomings previously pointed out are eliminated. The regulating arrangement of Fig. 2 results in improved regulation over wider limits of source voltage variation. For example, a prior art arrangement such as shown in Fig. 1 requires the input voltage to be maintained constant to within $\pm 7\frac{1}{2}\%$ in order to realize no more than a $\pm \frac{1}{2}\%$ output voltage variation. By the simple application of the present invention, the same constancy of output voltage could be maintained with as much as a $\pm 30\%$ variation in the input voltage.

Depending upon the particular reference voltage source 29 selected, the present arrangement is capable of further modification. For example, if the reference source 29 is selected to provide an output voltage across its terminals other than 9, for example 5 volts, then the low voltage side of the source 29, namely junction 28, may be connected directly to the terminal 2 as shown in Fig. 2b. In the original discussion with respect to Fig. 2, the use of a divider comprising resistors 26 and 27 was prompted by the fact that the reference source 29 selected was one which developed 9 volts across its output terminals. Obviously, other voltage values and polarities may be as readily accommodated.

While a specific embodiment has been shown and de-

scribed, it will of course be understood that various modifications may yet be devised by those skilled in the art which will embody the principles of the invention and found in the true spirit and scope thereof.

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

1. In combination, an input signal source, a load circuit, an adjustable impedance means for regulating the amount of said signal being applied from said source to said load circuit connected in series between an output terminal of said input signal source and an input terminal of said load circuit, a reference signal source, a source of a further signal having an amplitude determined by the amount of said input signal applied to said load circuit, a first transistor stage for comparing the amplitudes of said reference and further signals to derive a control signal, a second transistor stage for amplifying said control signal, said impedance means responsive to said amplified control signal for adjusting the amount of said input signal applied to said load circuit, means for energizing said transistor stages comprising means responsive to the input signal available on said input terminal for providing an amplitude regulated signal, and means responsive to the regulated input signal available on said input terminal and said amplitude regulated signal for supplying a regulated signal of amplitude greater than that available on said input terminal.

2. In combination, a source of unregulated voltage, a load circuit coupled to said source, an adjustable impedance means for regulating the amplitude of voltage being coupled from said source to said load circuit, said impedance means connected in series between an output terminal of said source and an input terminal of said load circuit, a reference signal source, a further source of a signal having an amplitude determined by the amplitude of said voltage developed in said load circuit, a first transistor stage for comparing the amplitudes of said reference and further signals to derive a control signal, a second transistor stage for amplifying said control signal, said impedance means responsive to said amplified control signal for adjusting the amplitude of voltage being coupled to said load circuit, means for energizing said transistor stages comprising means responsive to the unregulated voltage available on said input terminal for supplying an amplitude regulated signal, and means responsive to the regulated voltage available on said input terminal and said amplitude regulated signal for energizing said transistor stages with a further amplitude regulated signal.

3. In combination, a source of unregulated voltage, a load circuit coupled to said source, an adjustable impedance means for regulating the amplitude of voltage being coupled from said source to said load circuit, said impedance means connected in series between an output terminal of said source and an input terminal of said load circuit, a reference signal source, a further source of a signal having an amplitude determined by the amplitude of said voltage developed in said load circuit, a first transistor stage for comparing the amplitudes of said reference and further signals to derive a control signal, a second transistor stage for amplifying said control signal, said impedance means responsive to said amplified control signal for adjusting the amplitude of voltage being coupled to said load circuit, means for energizing said transistor stages comprising a zener diode responsive to the unregulated voltage available on said input terminal for providing a first amplitude regulated voltage, said last-named means responsive to the regulated voltage available on said input terminal and said first regulated voltage for energizing said transistor stages with a second amplitude regulated signal.

4. In combination, a source of unregulated voltage comprising an output terminal, a load circuit comprising an input terminal, an adjustable impedance device con-

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nected between said terminals, a source of reference voltage, a first transistor circuit comprising a collector electrode responsive to the relative amplitudes of said reference voltage and the voltage developed across said load circuit for providing a control signal, a second transistor circuit having a base electrode connected to said collector electrode for amplifying said control signal, means responsive to said amplified control signal for adjusting the impedance of said device to provide a regulated voltage on said input terminal, means for energizing said transistor circuits comprising a first resistance network connected to said input terminal for supplying a first regulated voltage, a second resistance network connected to said output terminal for supplying a second unregulated voltage, and a zener diode connected between said first and second networks and to said base and collector electrodes for energizing said transistor circuits with a regulated voltage.

5. In combination, a source of unregulated voltage comprising an output terminal, a load circuit comprising an input terminal, an adjustable impedance device connected between said terminals, a source of reference voltage, a transistor circuit responsive to the relative amplitudes of said reference voltage and the voltage developed across said load circuit for adjusting the impedance of said device to provide a regulated voltage on said input terminal, means for energizing said transistor circuit comprising a first resistance network connected to said input terminal for supplying a first regulated voltage, a second resistance network connected to said output terminal for supplying a second unregulated voltage, and a constant voltage device connected between said first and second networks and to said transistor circuit for energizing said transistor circuit with a regulated voltage having an amplitude smaller than said first voltage but greater than said second voltage.

6. In combination, a source of unregulated voltage comprising an output terminal, a load circuit comprising an input terminal, an adjustable impedance device connected between said terminals, a source of reference voltage, a transistor circuit responsive to the relative amplitudes of said reference voltage and the voltage developed across said load circuit for adjusting the impedance of

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said device to provide a regulated voltage on said input terminal, means for energizing said transistor circuit comprising a first resistance network connected to said input terminal for supplying a first regulated voltage, a second resistance network connected to said output terminal for supplying a second unregulated voltage, and a zener diode connected between said first and second networks and to said transistor circuit for energizing said transistor circuit.

7. In combination, a source of unregulated voltage comprising a pair of output terminals, a load circuit comprising an input terminal, an adjustable impedance device connected between said input and output terminals, a source of reference voltage, a transistor circuit responsive to the relative amplitudes of said reference voltage and the voltage developed across said load circuit for adjusting the impedance of said device to provide a regulated voltage on said input terminal, means for energizing said transistor circuit comprising a first resistance network connected between said input terminal and one of said output terminals for supplying a first regulated voltage, a zener diode and a resistor connected in series between said other output terminal and an intermediate point in said first network, and means for applying the voltage developed at the junction between said resistor and diode to said transistor circuit for energizing the latter.

8. In combination, a source of unregulated voltage comprising an output terminal, a load circuit comprising an input terminal, an adjustable impedance device connected between said terminals, a source of reference voltage, a transistor circuit responsive to the relative amplitudes of said reference voltage and the voltage developed across said load circuit for adjusting the impedance of said device to provide a regulated voltage on said input terminal, means for energizing said transistor circuit comprising means coupled to said input terminal for supplying a first regulated voltage, means coupled to said output terminal for supplying a second unregulated voltage, means for regulating said second voltage, means for combining said first and second regulated voltages and means for energizing said transistor circuit with said combined regulated voltages.

No references cited.