

[54] **OUTPUT VOLTAGE ADJUSTING CIRCUIT**

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[58] Field of Search**315/207, 311; 321/18; 323/8, 323/22 T, 23, 25**

[56] **References Cited**

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[57] **ABSTRACT**

A circuit connectible to an integrated circuit fixed voltage D.C. regulator for providing an adjustable value of output voltage to a load, especially a load consisting of an incandescent lamp.

5 Claims, 2 Drawing Figures

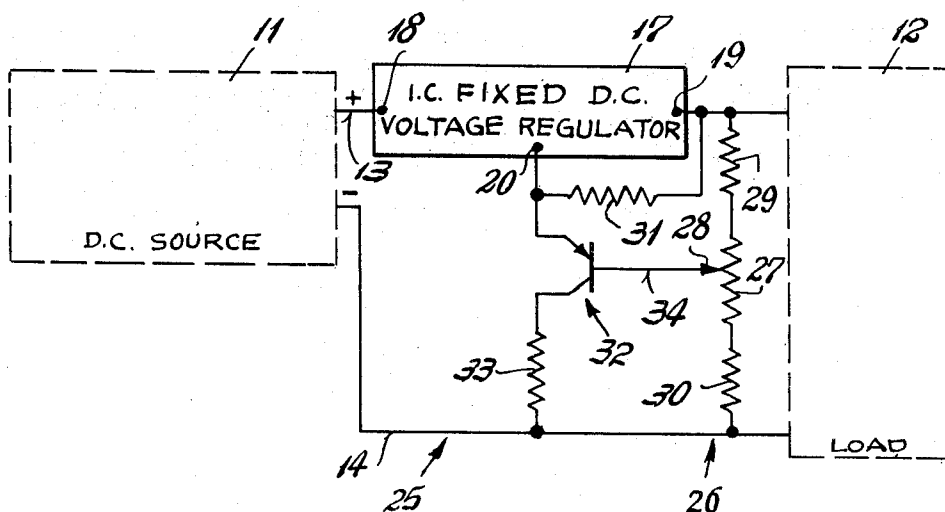


Fig. 1

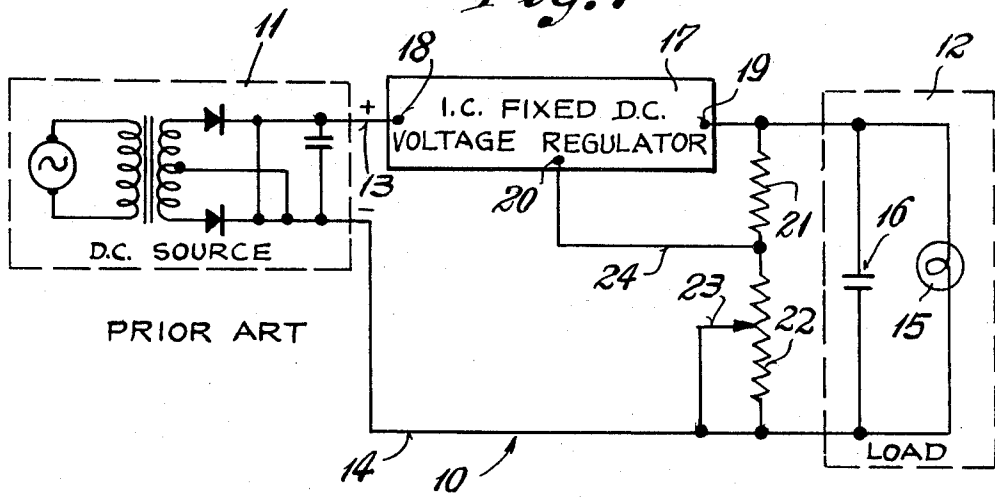
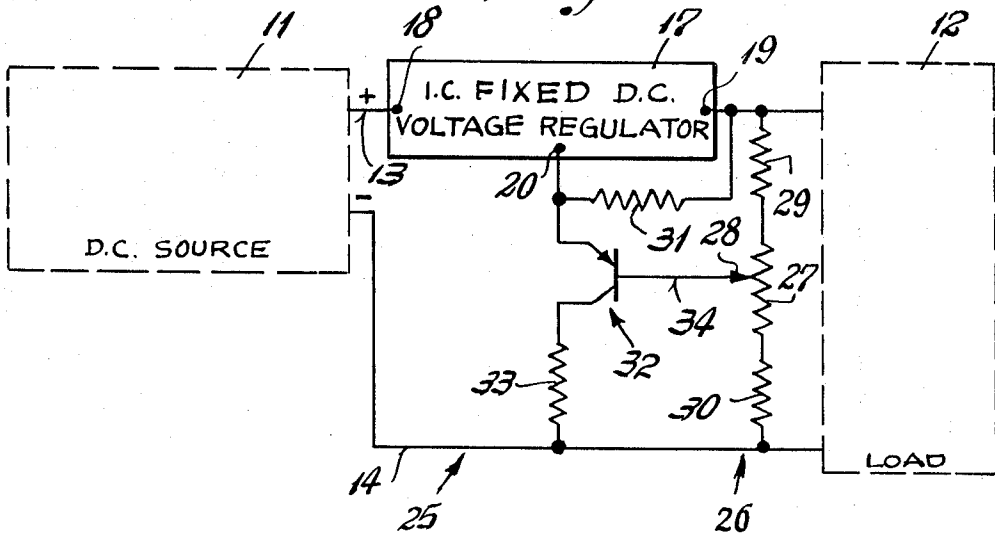


Fig. 2



OUTPUT VOLTAGE ADJUSTING CIRCUIT

In many applications it has been found advantageous to use currently commercially available integrated circuit devices for providing a regulated voltage in a circuit. These regulators have a fixed value of output voltage but if used with an external circuit a voltage may be obtained that is adjustable in value with the value of the fixed voltage being the minimum value in the adjustment range. However, such suggested circuits have sometimes not provided a sufficient range of adjustability and if used to adjust the voltage to an incandescent lamp load for varying the intensity thereof have even been found to be incapable of operating.

It is accordingly an object of the present invention to provide a circuit usable with an IC fixed voltage regulator which enables the regulator to be accurately adjustable over a wide range of output voltages.

Another object of the present invention is to provide an IC fixed voltage regulator with an adjustable circuit that enables the regulator to reliably function with a load that has a low resistance when cold such as a lamp load.

A further object of the invention is to achieve the above objects with a circuit that is reliable in use, relatively inexpensive, easily incorporated with a regulator and significantly less power consuming and heat producing.

The present invention is usable with a commercially available integrated circuit that is formed to provide a fixed value of output voltage such as a type LM309 available from National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California; or μ A7800 series regulator currently commercially available from Fairchild Semiconductor (a division of Fairchild Camera and Instrument Corporation) 313 Fairchild Drive, Mountain View, California. These devices have three terminals designated input, output and common with the voltage from a D.C. source being applied between the input and the common terminals and a fixed or regulated value (such as 5 volts) of D.C. being obtained between the output and the common terminals. It has heretofore been suggested to connect a resistance network between the output terminal and the negative side of the input source with one portion of the network being connected between the output and the common terminals and the other portion being variable and connected between the common terminal and the negative side in order to obtain an adjustable value of voltage greater than that produced by the regulator across the resistance network.

In accordance with the present invention, there is also provided a resistance network which has the form of a potential divider connected in parallel across the output and negative side together with a shunt path. The divider includes an adjustable resistance having a tap such that by varying the tap the resistance portions on each side thereof may be relatively varied and in doing so varying the output of the regulator by altering the relative resistances in the two portions. However, connected across the divider and to the common terminal is a shunt path having a transistor whose emitter collector path is connected to the common terminal and with its base being connected to the tap. Accordingly, with the present invention, variation of the output voltage is achieved by varying the current in the potential divider as opposed to the concept of varying

the relative resistances with constant current as in the heretofore suggested circuit.

Other features and advantages will hereinafter appear.

Referring to the drawing:

FIG. 1 is a diagrammatic and schematic illustration of a prior art adjustable voltage regulator using a semiconductor I.C. fixed D.C. voltage regulator.

FIG. 2 is a diagrammatic and schematic illustration showing the adjustable voltage circuit of the present invention interconnected with the same voltage regulator.

Referring to FIG. 1 the adjustable voltage regulator that is heretofore known is indicated by the reference numeral 10 and is connected between a source of direct current 11 and a load 12. The source 11 is diagrammatically shown as being obtained by rectification from an A.C. source to provide a positive voltage on a lead 13 and a negative or ground potential on a lead 14. The load 12 is also diagrammatically shown as including an incandescent lamp 15 and a capacitor 16. It will be appreciated that insofar as the circuit of the present invention is concerned that other and different loads may be used and that similarly other sources of direct current may be also employed.

The adjustable voltage regulator 10 includes an I.C. fixed D.C. voltage regulator 17 having an input terminal 18, an output terminal 19 and a common terminal 20 with such a regulator being of the type illustrated previously and being basically an adjustable current device. Connected to the output terminal 19 is a resistance network consisting of a fixed resistance 21 and an adjustable resistance 22 having a tap 23. A load 12, as shown, is connected to the output terminal 19 and also to the ground lead 14 which is effectively connected to the tap 23. A lead 24 connects the common terminal 20 to a junction between the resistances 21 and 22.

It will be understood that as the tap 23 is moved along resistance 22 towards the resistor 21 that the output voltage to the load approaches five volts while if the tap 23 is moved in reverse direction and more resistance is inserted in the potential divider the value of the output voltage increases.

Shown in FIG. 2 is the adjustable voltage regulator circuit of the present invention, indicated by the reference numeral 25, and connected to the D.C. source 11 and the load 12. The regulator circuit 25 includes the fixed D.C. voltage regulator 17 having its input terminal 18 connected to the plus side 13 of the source 11 and its output terminal 19 connected to the load 12. Its common terminal 20 is also indicated with identical parts in the two circuits bearing the same reference character. Connected between the output terminal 19 and the ground 14 is a potential divider 26 that includes an adjustable resistance 27 having a tap 28, a resistor 29 connected between the resistance 27 and the output terminal 19 and a resistor 30 connected between the ground lead 14 and the resistance 27. Through two fixed resistors have been shown, if desired, they may be incorporated into the resistance 27 to increase the range of output voltage to the regulator.

Connected in parallel with the potential divider 26 across the output terminal 19 and the ground lead 14 is

a shunt path that includes a resistor 31 connected between the output terminal 19 and the emitter collector path of a transistor 32 with the path being connected to the ground lead 14 through a resistance 33. A lead 34 connects the tap 28 to the base of the transistor 32. The common terminal 20 is connected to the emitter of transistor 32.

In the operation of the prior art circuit shown in FIG. 1, the D.C. source is selected to provide a voltage that is at least two volts or so higher than the desired maximum output voltage. Assuming a condition where it is desired to provide a maximum output voltage that is variable in a range of from 5 to 57½ volts, the value of the quiescent current which flows from the common terminal 20 through the resistance 22 to lead 14 amounts to perhaps 5 milliamps. The value of resistance 21 is selected at 300 ohms which with 5 volts thereacross produces a current of 16 milliamps. (called I21) as it flows through resistance 21. The variable resistance 22 thus has a current flow of 16 and 5 or 21 milliamps. which in order to produce a voltage drop of 52½ volts requires the resistance 22 to have a maximum value of 2½ ohms. With these values the maximum wattage of the resistor 22 is about 1.1 watts.

This circuit has the value of resistor 21 (300 ohms) selected such that it is capable of permitting sufficient initializing current to flow from the common to the output to start the regulator operating (as it is basically a current gain device) even with an incandescent lamp load 15. Any higher value of resistor 21 could prevent sufficient initializing current from flowing. However, in view of the current I21 being only about three times the quiescent current, a change of even 1 milliamp. in the quiescent current is capable of causing a change of 2 ½ volts in the output voltage and this in many instances, has been found undesirable.

To overcome this defect caused by the change in the value of the quiescent current, one typical approach is to make the current I21 have a value of about 10 times the quiescent current and in such an instance I21 would be 50 milliamps. which is achieved by changing the value of resistance 21 to 100 ohms. The current through the variable resistance 22 will thus be 55 milliamps. (50 + 5) and the value of the resistance 22 is about 1K ohms in order to produce a 55 volt drop thereacross. However, the power dissipated by this amount of current through the variable resistance 22 closely approaches 3 watts (55 milliamps. times 55 volts) and in many instances has rendered such a circuit undesirable as too much heat is produced, too costly a resistor 22 is required and too much regulator output current is required.

In order to overcome the above defects the circuit of the present invention has the resistor 31 equal approximately 300 ohms which is of a sufficiently low value to enable starting of the regulator but yet limits the current therethrough to 16 milliamps. The current to the emitter of the transistor is thus 16 milliamps. plus 5 milliamps. quiescent current which assuming the transistor has a current gain of 100 to 1 (a type 2N2907 for example) causes 0.21 milliamps. to flow through it from its emitter to the base and then through the tap 28 to the ground 14. In order to minimize output voltage changes caused by changes in the value of the quiescent current, (which are reflected in a change of the current

flowing to the tap 28) the value of current from the output terminal 19 through the divider 26 is made to be 2.1 milliamps. (i.e. 10 times 0.21). As there is about a 4.5 voltage drop across the resistor 29 it may have a value of 2.15K ohms to produce this current.

In order to produce the output voltage range of 4.5 to 57 volts, the drop across the variable resistor will be about 52 volts and hence its value will be 23K ohms as 2.31 milliamps. of current is flowing therethrough. The wattage loss in the resistor 27 is thus 52 volts × 2.31 milliamps. or only about 120 milliwatts.

The reason for there being a 4.5 volt drop across the resistance 29 is to provide a half volt voltage difference between the emitter and base of transistor 32 such that it is caused to be fully conducting as soon as the output voltage appears at the output terminal 19. The value of resistor 33, which is basically a power dissipating resistor and is used to decrease the voltage drop across the transistor emitter base path and thus may, for example, have a value which produces a 10 volt drop thereacross.

It will be seen from a consideration of the two circuits that the prior art circuit is basically a constant current circuit and the value of the output voltage is changed by varying the total resistance in the potential divider 21. Thus, as the tap 23 approaches the resistor 21 the output voltage decreases while as it approaches the ground 14 the output voltage is made to increase. On the other hand, the present invention circuit is basically a constant voltage circuit and the value of the current in the path is made to change as the value of the resistance across the constant voltage is changed. Thus, for the maximum output voltage, the tap 28 is positioned on the resistance 27 at the junction with the resistor 29 while for a minimum output voltage it is positioned on resistor 27 toward the resistance 30 or the ground lead 14. In both instances the value of the voltage between the tap 28 and the output terminal 19 is 4.5 volts by reason of the transistor 32 being connected as in an emitter follower connection with the emitter being maintained at 5 volts and the voltage at the tap being approximately one-half a volt less due to the diode drop in the transistor. Thus, the value of current flowing through the potential divider is thus substantially changed in view of the change in the resistance between the maximum and minimum positions but still even with the maximum output voltage of perhaps around 57 volts, there is still only a small current flow in the potential divider 26 and thus only very small power dissipation in the variable resistance 27.

Accordingly, it will be understood there has been disclosed an adjustable voltage regulating circuit which utilizes a fixed D.C. voltage regulator of the integrated circuit type that normally functions as a current gain device. The circuit utilizes only a limited amount of output power and has low power dissipation by reason of the use of a shunt path connected in parallel across a potential divider with the output of the potential divider being the output of the circuit. Thus, the shunt path enables sufficient initializing current to flow to begin operation of the regulator even with an incandescent lamp load while at the same time carrying a substantial flow of current including the quiescent current to the ground lead independently of the potential divider.

Variations and modifications may be made within the scope of the claims and portions of the improvements may be used without others.

We claim:

1. An adjustable D.C. voltage regulating circuit connectible to a D.C. input source for providing an output voltage adjustable in value comprising a semiconductor voltage regulator means having an input, output and common terminals and having the input terminal being connectible to the positive input source to provide a constant value of voltage between the common and the output terminals with the common terminal being negative with respect to the output terminal and with a quiescent current normally flowing from the common terminal, a potential divider connected between the output terminal and the ground of the source and across which the desired value of output voltage appears, said divider including an adjustable resistance having a tap with a first portion being connected between the output terminal and the tap and a second portion being connected between the tap and the ground, a shunt path connected between the common terminal and the ground and means for maintaining a selected value of voltage across the first portion of the

divider.

2. The invention as defined in claim 1 in which the shunt path includes a transistor having an emitter collector path with the emitter being connected to the common terminal and with the emitter collector path being connected between the said common terminal and the ground.

3. The invention as defined in claim 2 in which there are means for causing the transistor to be conducting during the flow of quiescent current and the shunt path carries substantially all of the quiescent current.

4. The invention as defined in claim 1 in which the shunt path has a transistor connected as in an emitting follower connection, means for placing a fixed value of voltage from the output terminal at the emitter and in which the selected value of voltage is the fixed value less the diode voltage drop between the base and emitter of the transistor.

5. The invention as defined in claim 1 in which the last named means includes a transistor, a connection between the tap and the base of the transistor and a resistor connected between the output terminal and the emitter of the transistor.

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