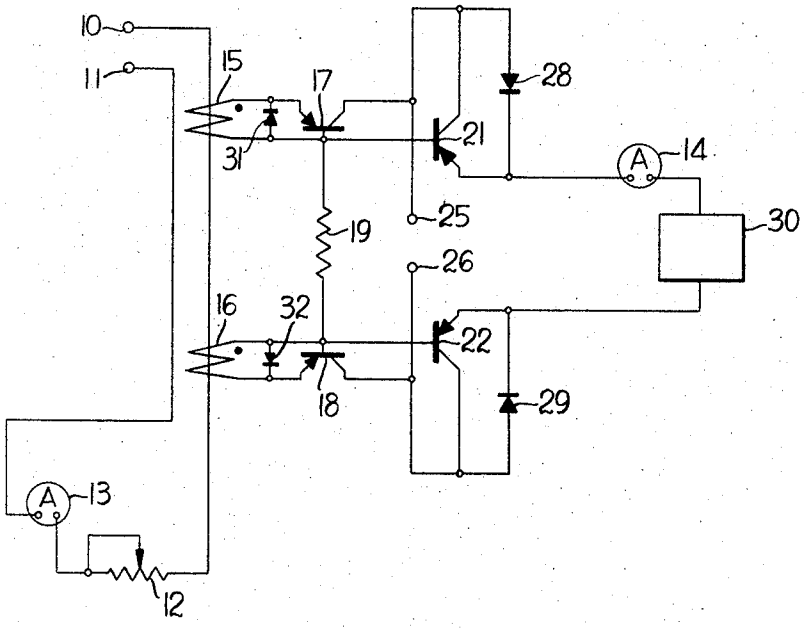
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MEANS FOR PROVIDING A CONSTANT CURRENT SOURCE

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MEANS FOR PROVIDING A CONSTANT CURRENT SOURCE

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ABSTRACT OF THE DISCLOSURE

An alternating electrical source is connected to supply current through a load having a controlled resistance and an ammeter. A pair of current transformers are connected to provide an output current proportional to the current in the electrical power system. A first pair of transistors in a common base configuration are connected to the current transformers to be turned on during opposite half cycle of the alternating electrical source. The outputs of these transistors are amplified by a second pair of common collector connected transistors. The output of the second pair of transistors is applied across the load circuit including a load and an ammeter connected between the emitters. A power source is connected between the collectors and diodes are connected across the emitter-collector circuits of the second pair of transistors.

This invention relates to constant current producing devices, particularly to means for providing a constant current source for testing, measuring, operating or sampling devices having a widely varying impedance characteristic.

In many instances it is desirable to have a constant current source for testing of current sensitive devices. A constant current source can be defined as a source that produces a constant current over a wide range of load power requirements with a voltage varying as a function of power consumption. Devices such as static relays, static tripping devices, circuit breakers responsive to overcurrent, or other similar devices that respond to current may require a constant current source for testing under conditions simulating actual operation.

These devices generally require accurate testing and calibration before they are put into practical application. While current transformers can be utilized for providing a constant current output from an electrical source, this is not desirable because the accuracy and relatively high current requirements of most devices necessitate relatively expensive current transformers.

With this invention means are provided for furnishing a constant current source from any alternating current source. The constant current is produced at a desired current level while using current transformers that operate at low power levels. As a result relatively inexpensive current transformers may be used. Semiconductor devices such as transistors are utilized to amplify the current from these inexpensive transformers and provide an amplified current output having constant current source characteristics.

The amplification is accomplished with two or more stages. The first stage preferably comprises two transistors, one for the positive and one for the negative portions of the alternating current, each connected in a common base configuration to provide a low impedance input for receiving the low impedance current transformer outputs. The second stage amplifies the current output of the first stage to provide a relatively high current source of low impedance that has the characteristics of a constant current source. The second stage may provide for several stages of amplification, if necessary.

The objects of this invention are: to provide a new and

improved circuit for furnishing a constant current source; to provide a constant current source for purposes of testing or operating equipment with components that are relatively inexpensive; and to provide a constant current source for sampling an auxiliary alternating power source as a function of the level of the constant current source.

Advantages and other objects of this invention will be apparent from the following detailed description.

The figure is a schematic drawing of an embodiment of a constant current producing circuit according to this invention.

Referring to the figure, alternating current is supplied from a source across terminals **10** and **11** to provide a source of power for the circuit. This current flows through a variable or calibrated load **12**. An ammeter **13** may be included in the power circuit that could be used in conjunction with an ammeter **14** that may be included in the output circuit for purposes of comparing the input and output currents of the constant current circuit or for calibrating and adjusting the system or connected equipment that is being tested. Once the circuit has been calibrated, either ammeter in some instances, or both ammeters in other instances, may no longer be necessary. If a greater degree of accuracy is required various types of known temperature compensation circuits and components may be incorporated into the circuitry to assure the desired response.

Means are provided to provide a low impedance current source in response to the current flow through load **12**. To provide isolation from the source across terminals **10** and **11**, it is desirable to use current transformers such as current transformers **15** and **16** to provide the low impedance current. Current transformers **15** and **16** are connected to produce a low impedance constant current varying as a function of current through load **12** at their secondary windings. The current transformers should preferably be matched but do not have to be accurately calibrated in respect to their current ratios, and their output currents can be of low magnitude. In some applications the current transformers could probably be constructed without an iron core. These factors make the requirements of the current transformers noncritical and cheaper transformers may be used.

A first amplifying means is provided and comprises transistors **17** and **18** connected to the current transformers to be alternately turned on by the alternating current source at terminals **10** and **11**. Transistors **17** and **18** are connected in a common base configuration to provide a low impedance input for the secondary windings of the current transformers. The output across the base and collector of transistors **17** and **18** has substantially the same current level as the input but has a relatively high impedance. A resistor **19** is connected between the bases of the two transistors to prevent thermal runaway of power transistors **21** and **22**.

Diodes **31** and **32** are desirable in most applications to protect transistors **17** and **18**, respectively, during the half cycle that they are turned off.

The outputs of transistors **17** and **18** are applied as inputs to a second amplifying means that may include several stages of amplification if necessary. The second amplifying stage comprises transistors **21** and **22** which are preferably connected in a common collector configuration to amplify the input current from transistors **17** and **18** to provide an increased current at a low impedance. A second power source provides power for the second amplifying stage at terminals **25** and **26**.

The second power source at terminals **25** and **26** provides a carrier current. Because of the amplifying characteristics of transistors **17** and **21** during one half cycle and transistors **18** and **22** during the other half cycle, a full cycle constant current appears across a load **30** that

is a function of the primary current flowing in current transformers **15** and **16**, a function of the current transfer characteristic of current transformers **15** and **16** and transistors **17** and **18**, and a function of the current amplification factor of transistors **21** and **22**. As mentioned, ammeter **14** can be used to measure the current output.

Diodes **28** and **29** are connected to provide a current path past the turned off transistor. When transistor **21** is turned on the current path is from terminal **25** of the source through transistor **21**, through ammeter **14** and load **30**, and through diode **29** to terminal **26** of the source.

Similarly, current flows through transistor **22** and diode **28** when transistor **22** is turned on.

If the power source across terminals **25** and **26** and the power source across terminals **10** and **11** are of the same frequency they are preferably in phase. This can easily be provided in a typical application of this circuit by utilizing a common source, such as **60** c.p.s. alternating current, for the two power sources.

If desired, the power source across terminals **25** and **26** may be a high frequency source, preferably having a square wave form. With a high frequency source this circuit can be used to provide a sampling of the high frequency source as a function of the current in the source across terminals **10** and **11**. Generally, the frequency of the second source should be at least approximately ten times the frequency of the first source. With this frequency relationship, no particular phase relationship between the two power sources is necessary.

In describing the invention, the preferred embodiment has been shown and described, but it is obvious to one skilled in the art that there are many variations, combinations, alterations, and modifications that may be made without departing from the spirit of the invention or from the scope of the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A circuit for providing a constant current output through a load with said output derived from a power system comprising:

first and second current means responsive to the current of the power system for providing a low impedance output having a current varying as a function of the current of the power system;

a first pair of amplifying stages each having a low impedance input and each connected to receive the output of the first and second current means, respectively, as an input said first pair of amplifying stages each connected to provide a high impedance output having a current varying as a function of the current of the power system;

an electrical source;

a second pair of amplifying stages each connected to receive the output of a different one of said first pair of amplifying stages as an input and each having an output circuit with said output circuits connected in series with each other, in series with the source, and in series with the load.

2. A circuit for providing a constant current output through a load with said output derived from a power system comprising:

first and second current transformers coupled to the power system;

a pair of transistors each connected to receive the output of the first and second transformers respectively, said pair of transistors each connected in a common base configuration and connected to be alternately turned on by the outputs of the transformers;

an electrical source;

a pair of amplifying stages each connected to receive the output of a different one of said pair of transistors as an input, each of said pair of amplifying stages connected to provide the constant current output and each having an output circuit with said output circuits connected in series with each other, in series with the source, and in series with the load.

3. A circuit for providing a constant current output derived from a power system including a first alternating source comprising:

first and second current transformers coupled to the power system;

amplifying means for providing a low impedance input comprising

a pair of amplifying stages each connected to receive the output of the first and second transformers, respectively, as an input, said first pair of amplifying stages each connected to provide a current output varying as a function of the current of the first source;

a pair of transistors each connected to receive the output of a different one of said pair of amplifying stages as an input, each of said pair of transistors connected in a common collector configuration to provide the constant current output between their emitters; and

a second alternating current source connected between the collectors of the pair of transistors.

4. A circuit according to claim **3** also comprising:

bypassing means connected to the transistors for providing a current path past the transistor that is turned off.

5. A circuit according to claim **4** wherein the bypassing means comprises a diode connected across the emitter-collector circuits of each transistor.

6. A circuit for providing a constant current output derived from an electrical power system across a first and second output terminal, said circuit comprising:

first and second current transformers coupled to the power system;

a first pair of transistors each connected to receive the output of the first and second transformers respectively, said first pair of transistors each connected in a common base configuration and connected to be alternately turned on by the outputs of the transformers;

a second pair of transistors each connected to receive the output of a different one of said first pair of transistors as an input, each of said second pair of transistors connected in a common collector configuration;

an alternating current source connected between the collectors of the second pair of transistors; and

a first output terminal connected to the emitter of one of the second pair of transistors and a second output terminal connected to the emitter of the other of said second pair of transistors.

7. A circuit according to claim **6** also comprising:

a pair of diodes each connected across the emitter-collector circuit of a different one of the second pair of transistors, said diodes connected to bypass current past its associated transistor when its associated transistor is turned off.

8. A circuit for providing an adjustable constant current output across a first and second output terminal comprising:

a first source of alternating current;

a first load having an adjustable resistance connected to the first source of alternating current;

a first current transformer coupled to a line of the first source for producing a constant current output;

a second current transformer coupled to a line of the first source for producing a constant current output;

a first and second transistor each having a base, emitter, and collector;

said emitter of the first transistor connected to the first terminal of the first transformer, said base of the first transistor connected to the second terminal of the first transformer, said base of the second transistor connected to the first terminal of the second

transformer, and said emitter of the second transistor connected to the second terminal of the second transformer;

a third and fourth transistor each having a base, emitter, and collector;

said base of the third transistor connected to the base of the first transistor, said base of the fourth transistor connected to the base of the second transistor, said collector of the third transistor connected to the collector of the first transistor, and said collector of the fourth transistor connected to the collector of the second transistor;

a second alternating current source having two terminals with one terminal connected to the collector of the third transistor and the other terminal connected to the collector of the fourth transistor;

said first output terminal connected to the emitter of the third transistor and said second output terminal connected to the emitter of the fourth transistor;

a first diode having an anode and a cathode, said anode connected to the collector of the third transistor and said cathode connected to the emitter of the third transistor; and

a second diode having an anode and cathode, said anode connected to the collector of the fourth transistor and said cathode connected to the emitter of the fourth transistor.

9. A circuit according to claim **3** wherein the second alternating source is in phase with the first alternating source.

10. A circuit according to claim **5** also comprising a pair of diodes each connected across the emitter-collector circuits of a different one of the second pair of transistors, said diodes connected to bypass current past its associated transistor when it associated transistor is turned off, wherein the second alternating source has a high frequency relative to the frequency of the first alternating source.

11. A circuit for providing an adjustable constant current output across a first and second output terminal comprising:

a first source of alternating current;

a first load having an adjustable resistance connected to the first source of alternating current;

a first current transformer coupled to a line of the first source having a first and second output terminal;

a second current transformer coupled to a line of the first source having a first and second output terminal, said first output terminals of said current transformers connected to produce outputs in phase with each other;

a first and second transistor connected to be turned on alternately in response to half cycles of the first source and each producing an output, said first transistor connected in a common base configuration to receive the output of the first transformer as an input, and said second transistor connected in a common base configuration to receive the output of the second transformer as an input;

a third and fourth transistor each having an output terminal, said third transistor connected in a common collector configuration to receive the output of the first transistor as an input, and said fourth transistor connected in a common collector configuration to receive the output of the first transformer as an input;

a second alternating current source connected to provide power for the third and fourth transistor output circuits;

said first output terminal connected to the emitter of the third transistor and said second output terminal connected to the emitter of the fourth transistor;

first bypassing means connected to the third transistor for shunting current past the third transistor when the third transistor is turned off; and

second bypassing means connected to the fourth transistor for shunting current past the fourth transistor when the fourth transistor is turned off.

12. A circuit according to claim **11** wherein the second alternating source has the same frequency and is in phase with the first alternating source.

13. A circuit according to claim **11** wherein the second alternating source has a high frequency relative to the first alternating source.

14. A circuit according to claim **12** wherein said second alternating source has a frequency greater than approximately ten times the frequency of the first alternating source.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,344,339 September 26, 1967

John Baude

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 49, after "input" insert a comma; column 5, line 35, for "it" read -- its --; column 6, line 16, for "first transformer" read -- second transistor --.

Signed and sealed this 19th day of November 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents