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CONSTANT OUTPUT AMPLIFIER

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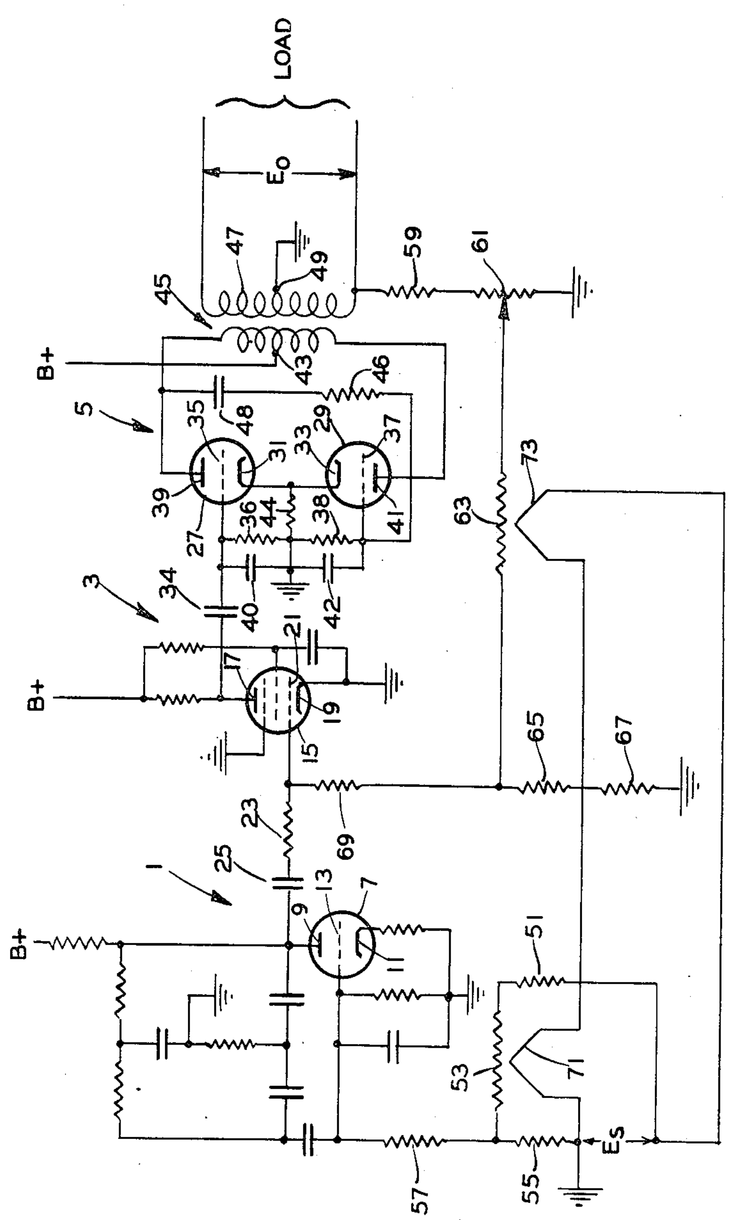

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CONSTANT OUTPUT AMPLIFIER

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The invention relates to amplifier circuits and more particularly to amplifiers having a regulated output.

In circuits where a substantially constant A. C. voltage is required, it is usually necessary to use a local oscillator of the Wein bridge type wherein the output is held substantially constant by means of a negative feedback circuit controlled by a current sensitive resistor. To maintain a substantially constant voltage, the current sensitive resistor must be held at a constant ambient temperature and the resistor is installed in an oven having a temperature regulator. This arrangement is satisfactory where the ambient temperature surrounding the oven is also substantially constant, but when the ambient temperature varies over a wide range, then the oven temperature varies also and the output of the local oscillator cannot be maintained constant.

Since the frequency of the output voltage of the local oscillator is not determined by the frequency of the line voltage energizing the oscillator, the frequency of the oscillator output may vary relative to the frequency of the line voltage. This is objectionable or impractical where the two frequencies are used to operate a device, such as a two-phase motor, where one phase is energized by the line voltage and the other phase is energized by the output of the oscillator. One remedy is to provide a local oscillator capable of supplying all the power necessary to operate a single frequency type circuit, but where considerable power is required, the size and weight of the oscillator is impractical.

One object of the present invention is to provide a novel amplifier having its input supplied by a conveniently available line voltage or local power supply and having an output of the same frequency as the line voltage or local power supply.

Another object is to provide an amplifier having a predetermined output which is maintained substantially constant irrespective of variations in line voltage, circuit constants, and output load.

Another object is to provide an amplifier wherein the output is maintained substantially constant even with wide variations in ambient temperature.

The foregoing and other objects and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description which follows, taken together with the accompanying drawing wherein one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawing is for the purpose of illustration and description only, and is not intended as a definition of the limits of the invention.

The invention contemplates an amplifier having an input and an output and adapted to have its input supplied from a fluctuating alternating power source. A current sensitive resistor is connected to the input and has a negative temperature coefficient of resistance. A feedback circuit is connected to the output and includes a current sensitive resistor having a negative temperature coefficient of resistance. The relative characteristics of the resistors are such that a change in the voltage of the power source effects a change in the voltage at the input, and a corresponding change in the feedback voltage, so that the output of the amplifier remains substantially constant irrespective of fluctuations of the power source.

The single figure of the drawing is a schematic wiring diagram of a novel amplifier constructed according to the invention.

Referring now to the drawing for a more detailed description of the novel amplifier constructed according to the invention, the amplifier is shown as having three stages of amplification **1, 3, 5**. The first stage **1** of the amplifier includes a triode **7** having an anode **9**, a cathode **11**, and a grid **13**, connected in a conventional bridge-T circuit to eliminate harmonics of the desired frequency.

The second stage **3** of the amplifier includes a pentode **15** having an anode **17**, a cathode **19**, and a control grid **21**, the latter being connected through a resistor **23** and a condenser **25** to the anode **9** of triode **7**. The output stage **5** of the amplifier comprises a pair of triodes **27, 29** connected in push-pull fashion and having cathodes **31, 33**, grids **35, 37**, and plates **39, 41**. Grid **35** is connected to the anode **17** of pentode **15** through a condenser **34**, and grids **35, 37** are connected to ground by resistors **36, 38** and considers **40, 42** in parallel. Cathodes **31, 33** are connected together and to ground through a common cathode resistor **44**. Plates **39, 41** are connected to the primary winding **43** of an output transformer **45**. Grid **37** is connected by a resistor **46** and a condenser **48** to plate **39** of tube **27** whereby grid **37** is provided with a voltage 180° out of phase with the voltage applied to grid **35** of tube **27** and of substantially the same amplitude.

A center tapped secondary winding **47** of transformer **45** is connected to a load L of any suitable kind and the center tap **49** is grounded. The amplifier described above is of conventional design and any other suitable amplifier may be used instead.

The amplifier has its input supplied from an alternating power source E_s through resistors **51, 53, 55** connected in series with one another to the power source. Grid **13** of triode **7** in the first amplifier stage is connected through a resistor **57** to the junction of resistors **53, 55** so that the voltage across resistor **55** is coupled to the grid.

A portion of the output of the third amplifier stage is fed back to the input of the second stage through a circuit connecting secondary winding **47** of transformer **45** to control grid **21** of pentode **15** and comprising a resistor **59**, a potentiometer **61**, and resistors **63, 65, 67, 69**. The feedback voltage across resistors **65, 67, 69** is 180° out of phase with the voltage at the output of the first amplifier stage at resistor **23**, and the output of the first amplifier stage and the feedback voltage are combined algebraically and applied to the control grid **21** of pentode **15**. The magnitude of the output voltage across secondary winding **47** of transformer **45** may be adjusted to any desired value by adjusting the feedback voltage by means of potentiometer **61**.

Resistors **53, 63** and **67** preferably have negative temperature coefficients, and reistors **53, 63** preferably are equally sensitive to changes in ambient temperature so that their resistances change proportionally with equal changes in temperature. Resistor **67** preferably is current insensitive, that is, a change in current flow through the resistor has no effect on its resistance. Resistors **53** and **63** are current sensitive, that is, a small change in current flow through the resistors causes a substantial change in their resistances. Resistors **53, 63** preferably are enclosed within a single envelope and are heated by heaters **71, 73** closely associated with the resistors within the envelope. Heaters **71, 73** are connected in series across power source E_s. Various types of negative temperature coefficient resistors are available commercially, certain of these types being current sensitive and other of these types being current insensitive. Representative constructions of current sensitive negative temperature coefficient resistors and of current insensitive negative temperature coefficient resistors are described, for example, in U. S. Patent No. 2,332,073 to C. A. W. Grierson, granted October 19, 1943.

An increase in voltage E_s produces increased current through heaters **71**, **73** so that the ambient temperature of the associated resistors **53**, **63** increases and their resistances decrease. The increase in voltage E_s also increases current flow through the circuit including resistors **51**, **53**, **55** and this increased current flow through resistor **53** further decreases its resistance. The combined effect of the change in ambient temperature of resistor **53** and the increased current flow therethrough results in increased voltage across resistor **55** which is applied to grid **13** of tube **7** through resistor **57**. The voltage at the output of the first amplifier stage increases accordingly. Thus, an increase in voltage E_s produces an increased voltage at the output of the first amplifier stage, and this is then conveniently balanced out by feedback means about to be described.

The increase in ambient temperature of resistor **63**, caused by the increased heater current, decreases its resistance and current flow increases in the circuit including resistors **63**, **65**, **67** and a portion of potentiometer **61**. The voltage across resistors **65**, **67** increases accordingly. Since the output of the first amplifier stage and the feedback voltage across resistors **65**, **67**, **69** are subtracted from one another, the increased output of the first amplifier stage is substantially offset by the increased feedback voltage across resistors **65**, **67**, **69** so that the input to the second amplifier stage is substantially constant.

Likewise, a decrease in voltage E_s produces a decreased voltage at the output of the first amplifier stage and a corresponding decreased voltage across resistors **65**, **67**, **69**. The decreased output of the first amplifier stage is substantially offset by the decreased voltage across resistors **65**, **67**, **69** so that the input to the second amplifier stage is substantially constant with a decrease in E_s.

If the output E_o across transformer **45** should increase instantaneously, then current flow increases through the circuit including resistor **59**, potentiometer **61**, and resistors **63**, **65**, **67**. This increased current flow through resistor **63** decreases its resistance, and the feedback voltage across resistors **65**, **67**, **69** increases whereby the input to the second amplifier stage **3** decreases and the output voltage E_o returns to the desired value.

If the output E_o across transformer **45** should decrease instantaneously, the current flow decreases through the circuit including resistor **59**, potentiometer **61**, and resistors **63**, **65**, **67**. This decreased current flow through resistor **63** increases its resistance and the feedback voltage across resistors **65**, **67**, **69** decreases whereby the input to the second amplifier stage **3** increases and the output voltage E_o returns to the desired value.

If the gain of one or the other stages of amplification changes due to a change in the B power supply or the μ of one or more of the tubes, then as the voltage at the output of the first amplifier stage changes, the feedback voltage changes in substantially the same proportion so that the output E_o across transformer **45** is substantially constant.

Wide variations in ambient temperature surrounding the tube containing resistors **53**, **63** results in a change in resistance of resistors **53**, **63**, but the change in voltage at the output of the first amplifier stage resulting from the change in resistance of resistor **53** is offset by the change in feedback voltage as a result of change in resistance of resistor **63** so that E_o across secondary transformer **45** remains substantially constant even with wide variations in ambient temperature.

For example, if the ambient temperature rises and the resistance of resistor **53** decreases, the voltage at the input of the first amplifier stage increases accordingly. Likewise, the resistance of resistor **63** decreases and the feedback voltage increases. The increased voltage at the output of the first amplifier stage corresponds to the increased feedback voltage, and since the two voltages are added algebraically, the input to the second amplifier stage **3** remains substantially the same.

Also, when the ambient temperature falls, then the decrease in the output of the first amplifier stage is offset by the decrease in the feedback voltage and the output voltage E_o remains substantially constant. Any residual change in output voltage E_o due to change in ambient temperature is compensated by resistor **67** which is selected to compensate for any differences in the negative temperature coefficient characteristics of resistors **53**, **63**.

The amplifier described herein provides an output voltage E_o which may be adjusted within limits to any desired value and which is maintained substantially constant irrespective of variations in line voltage, circuit constants, output load, and wide variations in ambient temperature. Also, the output voltage E_o has the same frequency as the local power supply so that the amplifier may be used to energize a device such as a two phase motor where one phase is energized by the line voltage and the other phase is energized by the output of the amplifier.

Although but one embodiment of the invention has been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. Various changes can be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art.

I claim:

1. In an amplifier having an output and having an input adapted to receive an A. C. input signal of varying amplitude, means for deriving a first A. C. signal from said input signal including a current-sensitive first resistance element having a negative temperature coefficient of resistance and electrically coupled in circuit between the source of input signals and said amplifier input to vary the amplitude of said first signal as a direct function of said input signal, means including a negative feedback circuit coupled to said amplifier output for developing a second A. C. signal of the same frequency as said first signal but substantially 180° out of phase therewith, said feedback circuit including a second resistance element having a negative temperature coefficient of resistance, means for additionally modifying the amplitude of said first signal as a function of said input signal and for modifying the amplitude of said second signal as a function of said input signal so that the amplitudes of said modified first and second signals vary directly by substantially equal amounts in response to variation in the amplitude of said input signal, said modifying means including heater means for indirectly heating the resistance of said first and second elements as a function of said input signal, means for algebraically adding said modified first and second signals to produce a resultant A. C. signal having a substantially constant magnitude corresponding to the difference in the amplitudes of said modified first and second signals, and means for amplifying said resultant signal to develop an amplified resultant signal at said amplifier output.

2. In an amplifier having an output and having an input adapted to receive an A. C. input signal of varying amplitude, means for deriving a first A. C. signal from said input signal including a current-sensitive first resistance element having a negative temperature coefficient of resistance and electrically coupled in circuit between the source of input signals and said amplifier input to vary the amplitude of said first signal as a direct function of said input signal, means including a negative feedback circuit coupled to said amplifier output for developing a

second A. C. signal of the same frequency as said first signal but substantially 180° out of phase therewith, said feedback circuit including a second resistance element having a negative temperature coefficient of resistance, means for additionally modifying the amplitude of said first signal as a function of said input signal and for modifying the amplitude of said second signal as a function of said input signal so that the amplitudes of said modified first and second signals vary directly by substantially equal amounts in response to variation in the amplitude of said input signal, said modifying means including heater means for indirectly heating the resistance of said first and second elements as a function of said input signal, means for algebraically adding said modified first and second signals to produce a resultant A. C. signal having a substantially constant amplitude corresponding to the difference in the amplitudes of said modified first and second signals, said first and second resistance elements being substantially equally responsive to changes in ambient temperature to change the amplitudes of said modified first and second signals by substantially equal amounts, whereby the amplitude of said resultant signal is substantially unaffected by changes in ambient temperature, and means for amplifying said resultant signal to develop an amplified resultant signal at said amplifier output.

3. In a constant-output amplifier having an output circuit and having an input circuit including a pair of terminals adapted to be coupled to a source of fluctuating A. C. voltage of predetermined frequency to receive an input signal therefrom, a plurality of amplifying stages for developing an amplified signal in said output circuit, means for producing a first A. C. signal of said predetermined frequency including the first amplifying stage and a current-sensitive first resistance element having a negative temperature coefficient of resistance and coupled in circuit between said input terminals and the input to said first amplifying stage to vary the amplitude of said first signal as a direct function of said input signal, means including a negative feedback circuit coupled between said output circuit and the input to the second stage for developing a second A. C. signal of said predetermined frequency but substantially 180° out of phase therewith,

said feedback circuit including a second current-sensitive resistance element having a negative temperature coefficient of resistance to vary the amplitude of said second signal as a direct function of said amplified signal, a common envelope enclosing said first and second resistance elements so that said elements are subjected to substantially the same ambient temperature, means for additionally modifying the amplitude of said first signal as a function of said input signal and for additionally modifying the amplitude of said second signal as a function of said input signal so that the amplitudes of said modified first and second signals vary directly by substantially equal amounts in response to variation in the amplitude of said input signal, said modifying means including heater means inside said envelope for indirectly heating said resistance elements as a function of said input signal, a circuit for energizing said heater means coupled to said pair of terminals, means for algebraically adding said modified first and second signals to develop a resultant A. C. signal of said predetermined frequency at the input of said second stage, the amplitude of said resultant signal being substantially constant and corresponding to the difference in the amplitudes of said modified first and second signals, said first and second resistance elements being substantially equally responsive to changes in ambient temperature so that the resistances of said elements change proportionally to change the amplitudes of said modified first and second signals by substantially equal amounts when changes in ambient temperature occur, whereby said amplified signal is substantially unaffected by changes in ambient temperature.

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