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[54] AVC SYSTEM

[72] Inventor: **Richard H. Campbell, Rockford, Ill.**

[73] Assignee: **Webster Electric Company, Inc., Racine, Wis.**

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[58] **Field of Search** 330/29, 145, 134, 138, 141; 325/319, 404, 410, 413

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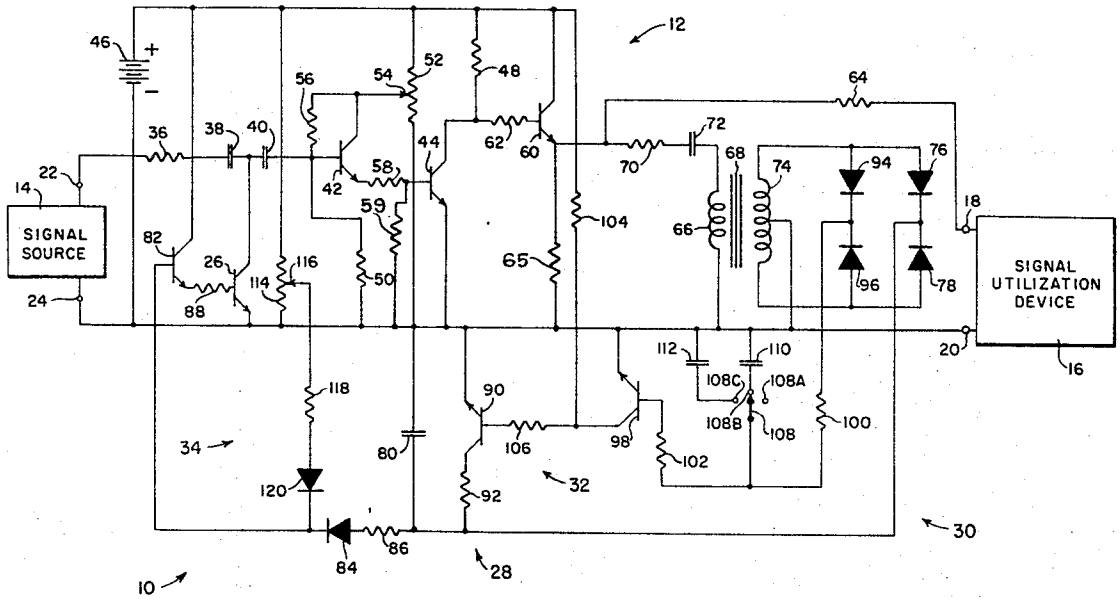
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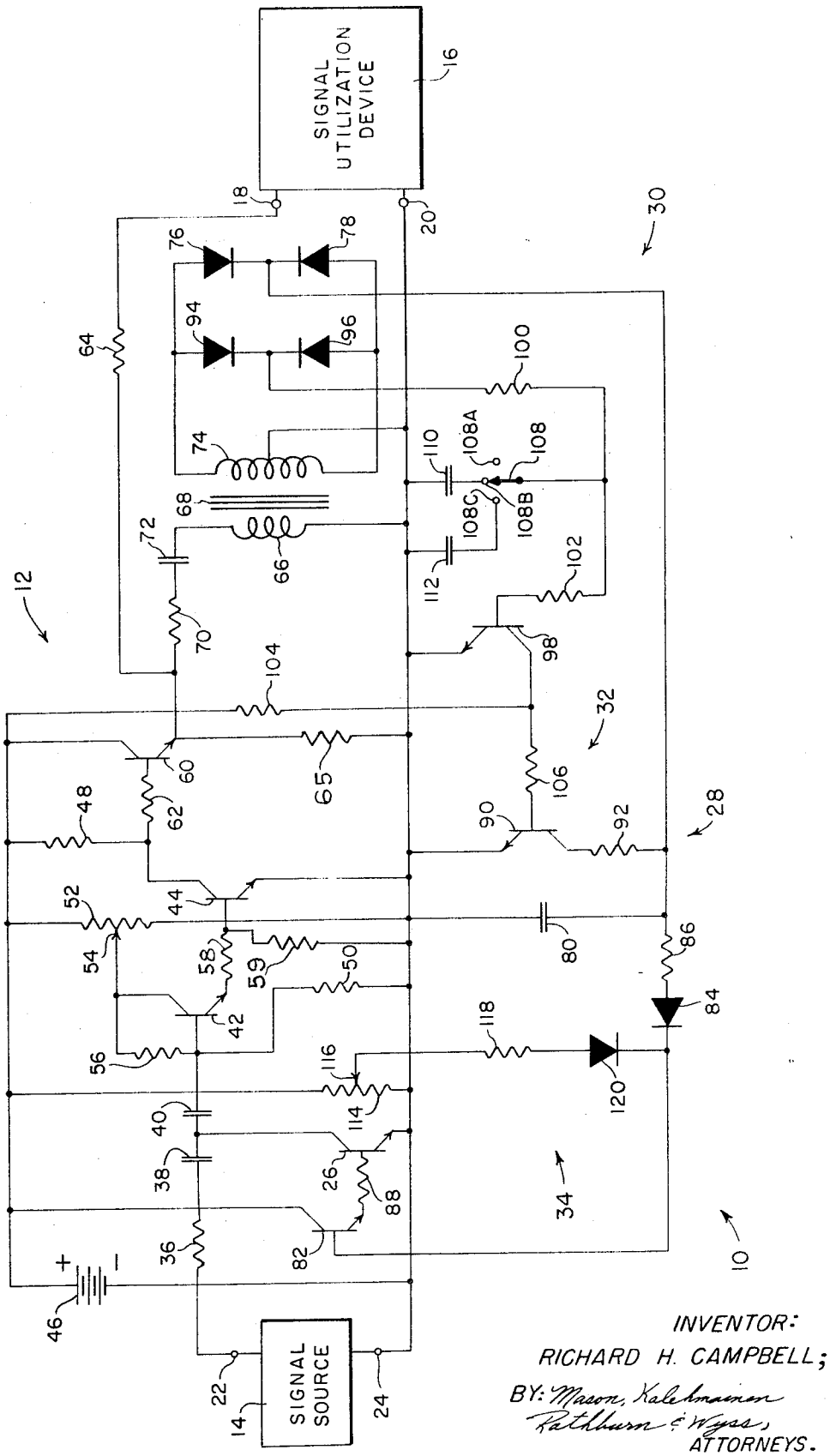
Primary Examiner—Roy Lake
Assistant Examiner—James B. Mullins
Attorney—Mason, Kolehmainen, Rathburn & Wyss

[57] **ABSTRACT**

An audio amplifier is provided with an automatic volume control system including an unpolarized junction transistor coupled in shunt with the amplifier input terminals and serving as a bidirectional variable resistance shunt having a resistance level controlled in accordance with an AVC operating signal appearing upon a capacitor charged by a detecting circuit in accordance with the amplifier output signal amplitude. Release time of the AVC system is determined by a variable resistance device connected in a capacitor discharge path, and the device is controlled to have decreasing resistance as amplifier output signals decrease. Sensitivity of the amplifier is controlled by an adjustable circuit providing a residual, nonvarying signal component to the control electrode of the unpolarized transistor to establish a maximum resistance level.

11 Claims, 1 Drawing Figure





INVENTOR:
RICHARD H. CAMPBELL;
BY: Mason, Kalehmainen
Fathburn & Wyss,
ATTORNEYS.

AVC SYSTEM

The present invention relates to automatic volume control, or "AVC," systems for use with amplifiers.

Many types of AVC systems have been devised in order to maintain the output signals of an amplifier at a relatively constant amplitude notwithstanding variations in input signal strength. Feedback circuits have been used in order to attempt to reduce the gain of one or more amplifier stages in response to increases in amplifier output signal amplitude. However, regulation of the gain of a transistor amplifier gives a limited range of control and tends to cause distortion in the amplified signal due to the small operating range of a given amplifier transistor. In addition, attempts to increase the sensitivity or reduce the response or attack time of known AVC systems result in undesirable distortion due to the presence of AC transient components of the feedback signal. Another problem with known arrangements is that changes in the input and/or output impedance of the amplifier may be introduced by regulation of the gain of one or more amplifier stages.

Important objects of the present invention are to provide a new and improved AVC system; to provide a system which may have wide application but which is particularly useful with audio amplifiers such as may be used in intercom and telephone systems and with other amplifiers such as RF amplifiers where distortion is undesirable; to provide an improved AVC control using an unpolarized transistor as a nonrectifying bidirectional variable resistance element in shunt with amplifier input terminals; to provide an AVC system with fast response time and with variable release time, and to provide a novel sensitivity control for use in conjunction with an amplifier.

In brief, the present invention provides an AVC system for use with an amplifier having a pair of input terminals and a pair of output terminals. The AVC system includes a detecting circuit including rectifying means and a capacitor coupled to the amplifier output terminals for developing a DC potential serving as an AVC operating signal having a magnitude substantially proportional to the amplifier output signal amplitude.

In accordance with one aspect of the invention, an unpolarized junction transistor has its output electrodes connected to shunt the amplifier input signals and has its control electrode coupled to the AVC capacitor to the end that its resistance is varied substantially in accordance with the amplifier output signal magnitude. The release time of the AVC system is determined by providing a variable resistance discharge path for the capacitor, the resistance of which is determined in accordance with amplifier output signal amplitude to the end that the discharge rate is increased in the absence of amplifier output signals. The sensitivity of the amplifier is adjusted by means of a fixed DC component applied to the unpolarized transistor to provide a maximum resistance level.

The present invention together with the above and other objects and advantages will appear from the following detailed description of an embodiment of the invention shown in the single FIGURE of the accompanying drawing, which FIGURE is a schematic diagram of an amplifier provided with an AVC system constructed in accordance with the present invention.

Referring now more specifically to the drawing, there is illustrated an automatic volume control or AVC system constructed in accordance with the principles of the present invention and designated as a whole by the reference numeral **10**. The system **10** is illustrated as used with an audio amplifier generally designated as **12** serving to amplify signals from a signal source **14** and to provide amplified signals to a signal utilization device **16**.

The AVC system **10** serves to maintain the amplifier output signals appearing at amplifier output terminals **18** and **20** at a generally constant amplitude regardless of substantial variations in the amplifier input signals applied to a pair of amplifier input terminals **22** and **24**. In accordance with an important feature of the present invention, the application of input signals from the input terminals **22** and **24** to the amplifier **12** is controlled in accordance with amplifier output signal magnitude by means of a transistor **26** used as a variable resistance device. A control circuit designated as a whole by the reference numeral **28** operates to control the resistance level of the transistor **26** and includes an output level detecting circuit generally designated as **30**, a release time control circuit generally designated as **32** and a sensitivity control circuit generally designated as **34**.

The amplifier **12** is an audio frequency amplifier suitable for use in voice and/or music signal amplification, and may be used in intercom systems, telephone systems, and the like. For example, the signal source **14** might comprise a microphone or other transducer, while the signal utilization device **16** might comprise a power amplification stage or the like. However, it should be understood that the AVC system of the present invention may be used with a wide variety of types of amplifiers.

In the illustrated arrangement the amplifier input signal is coupled through a resistor **36** and a pair of DC isolating capacitors **38** and **40** to the first stage of amplifier **12** including a pair of transistors **42** and **44** connected in a Darlington configuration to provide a high input impedance, a low output impedance and a high gain. The operating potential for operation of transistors **42** and **44** is obtained from any suitable DC source such as the illustrated battery **46**. Resistor **48** and variable resistor **52** including a movable tap **54** are coupled between the battery and electrodes of the transistors **42** and **44**. Resistors **50** and **56** form a voltage divider furnishing base bias to transistor **44** via transistor **42** and a resistor **58**. Resistor **58** couples the signal from the emitter electrode of transistor **42** to the base electrode of transistor **44**, and serves as an over-signal protective limiter. Resistor **59** coupled from the base of transistor **44** to ground serves to reduce distortion.

In order to provide a low impedance output for driving the AVC system **10** of the present invention, there is provided an emitter follower stage including a transistor **60** having a base electrode coupled by an over-signal protection resistor **62** to the collector electrode of the transistor **44**. The amplifier output signal is coupled to the amplifier output terminal **18** through a resistor **64** acting in conjunction with an emitter resistor **65** to provide the desired output impedance.

In accordance with an important feature of the present invention, the transistor **26** is connected in shunt with the amplifier input terminals and serves as a variable resistance, the value of which is controlled in accordance with an AVC operating signal or potential corresponding to the amplifier output signal amplitude. The transistor **26** comprises a silicon junction transistor, and it has been found that when such a transistor is not polarized by a DC potential applied across its collector and emitter electrodes, the transistor may be used as a bidirectional variable resistance device, the resistance of which is determined by the voltage applied to the base electrode of the transistor. Consequently, in the novel AVC system **10** of the present invention the transistor **26** is used as a bidirectional variable resistance shunt of the amplifier input signal, and produces substantially no rectification of the signal and therefore does not cause significant distortion.

More specifically, it has been found that any ordinarily available high gain silicon junction transistor, such as for example types 2N5249, 2N2219 and 2N5210, may be connected in shunt, in the absence of a DC polarization potential applied across the collector and emitter electrodes, to a relatively small AC signal such as, for example, a signal in the approximate range of 0.02 to 0.03 volts or so. When so connected, the transistor serves as a variable resistance when the base electrode is supplied with an adjustable positive potential.

In the illustrated embodiment of the invention, this function is accomplished by connecting the emitter electrode of the transistor **26** to the common amplifier input terminal **24** and by coupling the collector electrode of the transistor **26** to the amplifier input terminal **22** through the resistor **36**, which resistor has a sufficiently high value to limit the AC signals ap-

plied across the transistor **26** to a desired maximum value such as about 0.03 volts or so. Capacitors **38** and **40** are each connected to one side of the point of connection of the collector electrode of the transistor **26**, and serve to prevent the application of any polarizing DC voltage to the transistor. The base electrode of the transistor **26** is supplied in accordance with the present invention with a positive potential the magnitude of which determines the bidirectional resistance exhibited across the collector and emitter electrodes of the transistor **26**.

Referring now more specifically to the output level detecting circuit **30** of the AVC system **10**, amplifier output signals are coupled through the primary winding **66** of an AVC transformer **68** by way of a resistor **70** and a DC blocking capacitor **72**. A secondary winding **74** of the AVC transformer **68** is coupled to a first full wave rectifier network including a pair of diodes **76** and **78**. When amplifier output signals are present, an AVC capacitor **80** is supplied with a DC charging current by means of the diodes **76** and **78** and is charged to a potential level having a value substantially proportional to the amplitude of amplifier output signals.

Resistor **36** and transistor **26** serve as a variable AC voltage divider determining the proportion of the signal voltage applied across the input terminals **22** and **24** appearing at the base electrode of the transistor **42**. During operation of the AVC system **10**, the resistance value of the input signal shunt path provided by the transistor **26** is determined in accordance with the AVC operating potential or DC potential existing across the AVC capacitor **80**. In order to increase the operating speed of the system, it is desireable for the capacitor **80** to have a low value. In order to make this possible and in order to greatly decrease the loading of the capacitor **80** in operation without the introduction of substantial distortion, there is provided an additional transistor **82** having its base electrode coupled to the capacitor **80** by means of a diode **84** and a resistor **86**. The emitter electrode of the transistor **82** is coupled to the base electrode of the transistor **26** by means of a resistor **88**. Due to the interposition of the isolation transistor **82**, during the operation of the system the current drain on the capacitor **80** due to operation of the transistor **26** is very small.

In order to discharge the AVC capacitor **80** when amplifier output signals decrease, the release time control circuit **32** of the present invention is provided. Since the circuit including transistors **82** and **26** draws only a very small amount of current in operation, a discharge path must be provided for discharge of the AVC capacitor **80** thereby to release the AVC system when input signals decrease or cease. During active operation of the system **10**, this discharge path should have a very high resistance in order to prevent the application of an AC signal ripple to the transistors **82** and **26** and the resulting low frequency distortion of the audio signal. However, the use of a very high fixed resistance path will delay the discharge of the capacitor **80** to such an extent that the release time of the AVC system **10** is much greater than desirable.

In accordance with a feature of the present invention the discharge path for the AVC capacitor **80** is constituted by a variable resistance device in the form of a transistor **90**, the resistance of which is relatively large during active operation of the system **10** and is decreased in the absence of amplifier output signals. More specifically, the output electrodes or emitter and collector electrodes of the transistor **90** are connected in series with a limiting resistor **92** and across the terminals of the AVC capacitor **80**.

In order to control the resistance level of the discharge path of capacitor **80**, there is provided a second rectifier network including diodes **94** and **96** driven from the secondary winding **74** of the AVC transformer **68** and coupled to the base electrode of a transistor **98** through a pair of resistors **100** and **102**. In the normal, nonconductive condition of transistor **98**, the capacitor discharge transistor **90** is rendered relatively conductive by means of a bias potential applied to its base electrode through a pair of resistors **104** and **106**. However, when output signals are present, a positive voltage is applied to the base electrode of transistor **98** and transistor **98** is rendered conductive. As a result, the potential of the base electrode of the transistor **90** is reduced and transistor **90** is rendered relatively nonconductive. Thus, when amplifier output signals are present, the discharge path for the AVC capacitor **80** exhibits a very high resistance characteristic permitting the AVC system **10** to operate. Conversely, in the absence of output signals the AVC capacitor **80** is rapidly discharged through the discharge path including the resistor **92** and the emitter and collector electrodes of the transistor **90**.

It may be desirable to vary the AVC release time for different applications between very small periods in the order of milliseconds to a period of seconds as required. For this purpose there is provided a switch **108** having selectively closable switch contacts **108***a*, **108***b* and **108***c* which in the illustrated arrangement correspond respectively to fast, medium and slow release positions. In the medium and slow release time positions, wherein switch contacts **108***b* and **108***c* are closed, capacitor **110** or capacitor **112** is introduced into the base electrode circuit of transistor **98** thereby to provide the desired time delay.

In accordance with another feature of the present invention, the variable resistance transistor **26** is used not only for an AVC control but also in a circuit to control the sensitivity of the amplifier **12**. Referring now more specifically to the sensitivity control circuit **34**, there is provided a voltage divider in the form of a variable resistor **114** having an adjustable tap **116** coupled through a resistor **118** and diode **120** to the base electrode of the transistor **82** for controlling the resistance condition of the transistor **26**. The setting of the tap **116** to a position corresponding to a desired positive DC voltage serves to apply a residual DC signal to the transistor **82** to establish a maximum resistance level of the transistor **26**. Consequently, the sensitivity of the amplifier **12** is controlled by establishing the proportion of the input signal which will be applied to the amplifier in the absence of, or previous to, operation of the AVC system **10**.

Considering now the operation of the amplifier **12** equipped with the novel AVC system **10** of the present invention, in the absence of amplifier input signals provided by the signal source **14** to the amplifier input terminals **22** and **24**, no output signals appear at the amplifier output terminals **18** and **20** and the AVC system **10** is in an inactive condition. When an input signal of, for example, increasing magnitude is received, it is amplified by the amplifier **12** including transistors **42**, **44** and **60** and applied to the signal utilization device **16** through the amplifier output terminals **18** and **20**. The sensitivity of the amplifier is determined by the residual resistance level of the input signal shunt transistor **26**. This resistance level is determined by setting of the tap **116** of the variable resistance **114**.

As the amplifier output signals approach a desired amplitude level, the AVC system **10** commences to operate. More specifically, output signals are coupled through the AVC transformer **68** to the rectifier networks comprising respectively diodes **76** and **78** and diodes **94** and **96**. The current supplied by diodes **94** and **96** operates the release time control circuit **32** to the end that the discharge path through the transistor **90** for the AVC capacitor **80** assumes a high resistance characteristic. The current supplied by the diodes **76** and **78** charges the AVC capacitor **80** so that there is created an AVC operating potential. When the positive value of this potential increases above the positive potential supplied by the sensitivity control circuit **34**, the resistance of the transistor **26** is decreased from its initial maximum value thereby to reduce the proportion of the input signal which is applied to the amplifier **12**. The diodes **84** and **120** serve to isolate the AVC system and the sensitivity control circuit **34** from one another and to couple each to the transistor **82**.

When the input signals provided by the signal source **14** decrease or are discontinued, the resistance provided by the transistor **26** returns to its initial maximum level. More specifically, in the absence of output signals coupled through the

AVC transformer 68, the transistor 90 in the AVC capacitor discharge path is returned to its conductive condition due to the absence of base current supplied to the transistor 98. Thus the AVC capacitor 80 is able to discharge relatively rapidly through the discharge path provided by the resistor 92 and the transistor 90. The duration of the release time is varied as desired by the introduction of capacitance into the base circuit of the transistor 98 by means of operation of the switch 108.

Although the present invention has been described with reference to a particular embodiment thereof, many changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the present invention as defined in the appended claims.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. An AVC system for use with an amplifier having a pair of input terminals through which are received input signals for the amplifier and a pair of output terminals through which output signals are supplied to a signal utilization device, said system comprising:

detecting circuit means coupled to the amplifier output terminals for developing an AVC operating potential substantially in accordance with the magnitude of said output signals, said detecting circuit means including rectifier means coupled to said output terminals for providing a DC voltage having a value determined by the magnitude of the output signals and a control capacitor coupled to said rectifier means;

a variable resistance device connected in shunt with the amplifier input terminals, and comprising a first transistor having a first control electrode and having first and second output electrodes, said first output electrode being coupled to one of said input terminals and said second output electrode being coupled to the outer of said input terminals;

unpolarizing means for preventing the application of a polarizing DC potential to said first output electrode;

coupling means coupling the first control electrode of said first transistor to said detecting circuit means for operation of the first transistor at a resistance level determined by said AVC operating potential, said coupling means including a second transistor having a second control electrode coupled to said detecting circuit means for receiving said AVC operating potential from said detecting circuit means and third and fourth output electrodes one of which said third and fourth output electrodes being coupled to said first control electrode so that said second transistor controls the resistance level of said first transistor; and

a discharge path for said control capacitor to discharge said control capacitor following the termination of amplifier output signals above a predetermined magnitude, said discharge path including a third transistor and circuit means connected between the amplifier output terminals and said third transistor for decreasing the resistance of said third transistor in response to the decreasing of the magnitude of said output signals below the predetermined magnitude, said circuit means including additional rectifying means for providing a DC signal substantially proportional to the amplifier output signal and a fourth transistor having a third control electrode coupled to said additional rectifying means and having a fifth output electrode coupled to said third transistor.

2. The AVC system of claim 1 wherein said circuit means further includes manually adjustable means coupled to said third control electrode of said fourth transistor for selectively varying the release time of said AVC system.

3. The AVC system of claim 1, said detecting circuit means further comprising a transformer coupled between said amplifier output terminals and said rectifier means.

4. The AVC system of claim 3, said rectifier means comprising full-wave rectifier means, and said control capacitor having a relatively small capacitance value.

5. An AVC system for use with an amplifier having a pair of input terminals through which are received input signals for the amplifier and a pair of output terminals through which output signals are supplied to a signal utilization device, said system comprising:

detecting circuit means coupled to the amplifier output terminals for developing an AVC operating potential substantially in accordance with the magnitude of said output signals;

a variable resistance device connected in shunt with the amplifier input terminals, and comprising a first transistor having a first control electrode and having first and second output electrodes, said first output electrode being coupled to one of said input terminals and said second output electrode being coupled to the other of said input terminals;

unpolarizing means for preventing the application of a polarizing DC potential to said first output electrode;

coupling means coupling the first control electrode of said first transistor to said detecting circuit means for operation of the first transistor at a resistance level determined by said AVC operating potential, said coupling means including a second transistor having a second control electrode coupled to said detecting circuit means for receiving said AVC operating potential from said detecting circuit means and third and fourth output electrodes one of which said third and fourth output electrodes being coupled to said first control electrode so that said second transistor controls the resistance level of said first transistor; and

a sensitivity control coupled to said second transistor to control the maximum resistance level of said first transistor and comprising a source of DC potential coupled to said second control electrode through a variable resistor.

6. The AVC system of claim 5, said unpolarizing preventing means comprising first and second capacitors, said first capacitor being coupled between said first output electrode and said one input terminal and said second capacitor being coupled between said first output electrode and a first amplifier stage of said amplifier.

7. The AVC system of claim 5, said first transistor comprising a silicon junction transistor.

8. An amplifier AVC system for use with an amplifier having an amplifier output to supply amplifier output signals, said system comprising in combination;

a capacitor

a control means coupled between the capacitor and the amplifier for exercising a control function with respect to the amplifier in accordance with the voltage across the capacitor;

means including a discharge transistor having first and second output electrodes and a first control electrode, said first and second output electrodes coupled across the capacitor to form a capacitor discharge circuit;

first rectifier means coupled between the amplifier output and the capacitor for charging the capacitor upon an increase in amplifier output signal magnitude;

a control transistor having third and fourth output electrodes and a second control electrode, said third output electrode being coupled to said first control electrode of said discharge transistor; and

second rectifier means coupled between the amplifier output and said second control electrode of said control transistor for decreasing the resistance of said capacitor discharge circuit upon a decrease in amplifier output signal magnitude.

9. The AVC system of claim 8, further comprising manually adjustable means coupled to said second control electrode of said control transistor for selectively varying the release time of said AVC system.

10. The AVC system of claim 9 wherein said manually adjustable means is a plurality of delay capacitors any one of which is connectable between said second rectifier means and said second control electrode.

11. The amplifier AVC system of claim 8, said control means including a shunt transistor having fifth and sixth output electrodes coupled between a pair of input terminals of said amplifier.

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