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Feb. 18, 1969 JAMES E. WEBB 3,428,910
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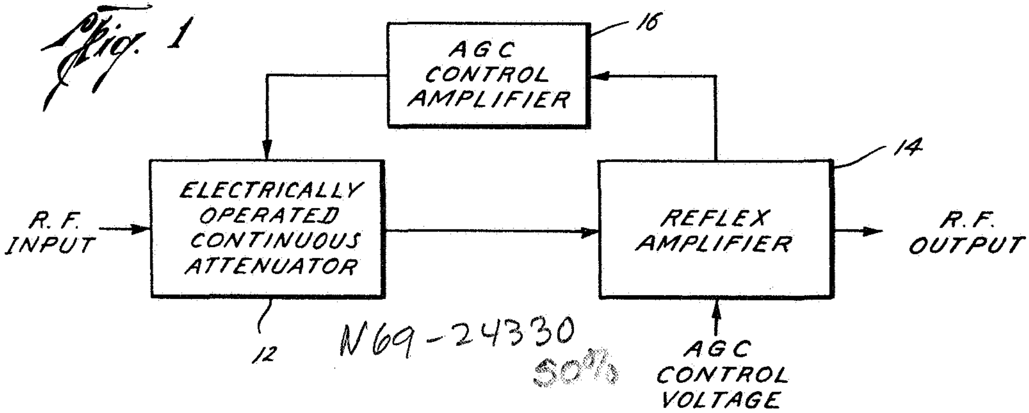
AUTOMATIC GAIN CONTROL SYSTEM
Filed Dec. 23, 1965

Fig. 1



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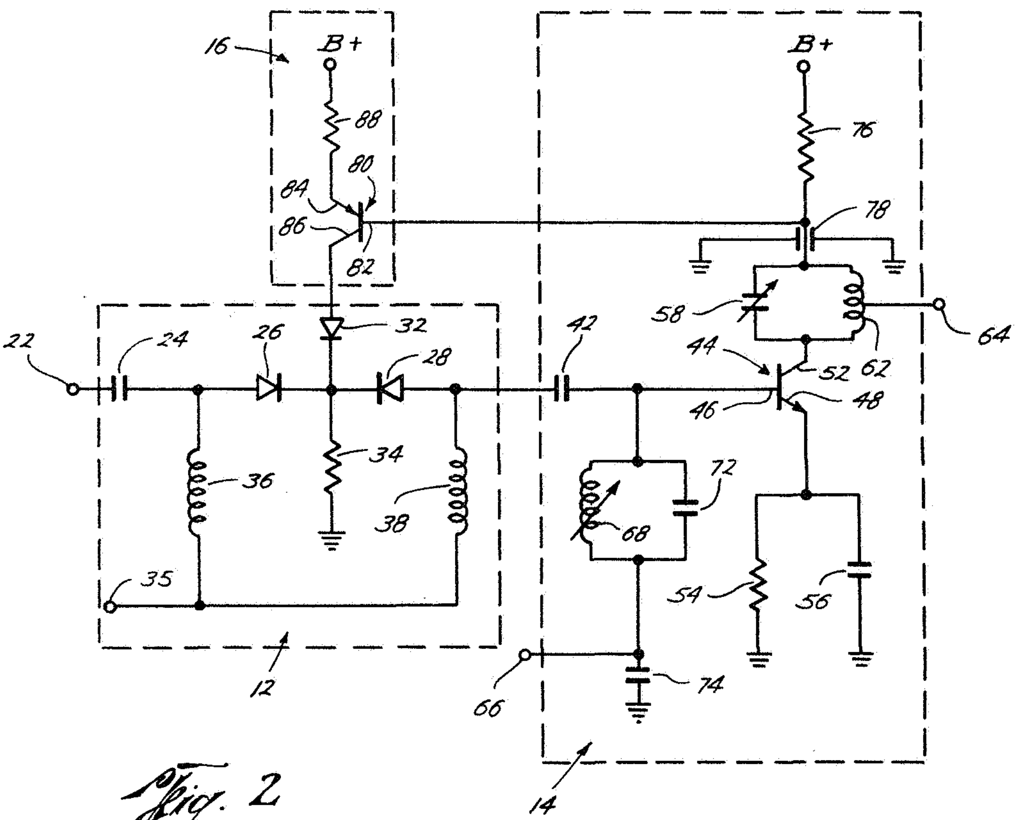

Fig. 2

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Include Figs 1 & 2

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AUTOMATIC GAIN CONTROL SYSTEM

James E. Webb, Administrator of the National Aeronautics and Space Administration with respect to an invention of Stanley H. Black, Phoenix, Ariz.

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Int. Cl. H03g 3/30; H03f 1/30

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; USC 2457).

The invention relates in general to automatic gain control systems and, more particularly, to a system for providing a relatively constant output signal level using an electrically controlled attenuator.

In a receiver system which must be able to handle a wide range of input signal levels, a form of automatic gain control must be employed to prevent overload of the final output stage. Heretofore, a conventional type of automatic gain control system utilized a diode detector to develop a unidirectional control voltage whose amplitude was proportional to the receiver system output level. This unidirectional control voltage was fed back to one or more earlier stages of the receiver system so as to reduce the gain of these earlier stages, thus causing the output level to remain substantially constant. When extremely large input signals were present, however, distortion in the gain control stage of the automatic gain control system caused reduced handling capability. Utilizing presently available transistors, the maximum undistorted input signal was limited to no more than 10 to 50 millivolts, R.M.S.

In order to overcome the attendant disadvantages of prior art automatic gain control systems and to provide an automatic gain control system, which is capable of handling input signals in the order of 1,000 millivolts R.M.S., the system of the present invention utilizes an electrically operated continuous attenuator, which is controlled by an automatic gain control amplifier. Input radio-frequency (R.F.) signals are fed into the attenuator. The attenuated R.F. signal is fed into a reflex amplifier together with a direct current (D.C.) control voltage from the output stage of a receiver system. The reflex amplifier amplifies the attenuated input R.F. signal and feeds it to the next stage of the receiver system. The D.C. control voltage is fed into an automatic gain control (AGC) amplifier. The output of the AGC control amplifier is used to vary the amount of attenuation of the electrically operated continuous amplifier.

More particularly, according to a preferred embodiment of the invention, input R.F. signals are fed into the electrically operated continuous attenuator formed of three diodes, whose cathodes are joined together and connected through a resistor to ground. The anodes of the first and second diode are biased by means of a D.C. control voltage, which are coupled thereto through an inductor. The R.F. signal is coupled to the anode of the first diode and the attenuated R.F. signal is taken off the anode of the second diode and coupled through a coupling capacitor to the base of a transistor of the reflex amplifier. The AGC control voltage is also connected to the base of the reflex amplifier transistor through an input L-C network. The AGC control voltage and the R.F. signal are amplified by the reflex amplifier and the R.F. output is taken off of an inductance in an output L-C network connected to the collector of the reflex amplifier transistor. Further, the AGC control voltage is fed back through the output L-C network to the base of an AGC control amplifier transistor. The collector of the control amplifier transistor is connected to the anode of the third diode of the electrically operated attenuator. As the amplified D.C. control voltage is varied, the attenuation is varied thus causing the input R.F. signal to the attenuator to be corrected.

The advantage of this invention, both as to its construction and mode of operation, will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like parts throughout the figures, and wherein:

FIG. 1 is a block diagram of the automatic gain control system of this invention; and

FIG. 2 is a circuit diagram of a preferred embodiment of the block diagram system of FIG. 1.

Referring now to the drawings, there is shown in FIG. 1 a block diagram of the automatic gain control system wherein R.F. input signals, which are to be controlled, are coupled to the input terminal of an electrically operated continuous attenuator **12**. The output of the attenuator is fed to the R.F. input terminal of a reflex amplifier **14**. A unidirectional AGC control voltage, proportional to the amplitude of the signal present in the last amplifier of a receiver system in which the automatic gain control system is to be utilized, is fed into the D.C. input terminal of the reflex amplifier **14**. The R.F. output signal is taken from the R.F. output terminal of the reflex amplifier. The amplified D.C. signal is coupled from the D.C. output terminal of the reflex amplifier to an AGC control amplifier **16**. The amplified D.C. control voltage is fed from the control amplifier **16** back to the attenuator **12**. The system operates in such a manner as to keep R.F. output voltage of the last stage relative constant by causing more or less attenuation to be inserted by the electrically operated continuous attenuator **12**.

Referring now to FIG. 2, there is shown a preferred embodiment of a circuit utilized in the automatic gain control system of FIG. 1. R.F. input signals, which are to be controlled, are applied to an input terminal **22** which is coupled to one side of a coupling capacitor **24** of the electrically operated continuous attenuator **12**. The electrically operated continuous attenuator is formed of a first diode **26**, a second diode **28**, and a third diode **32**. The other side of the capacitor **24** is coupled to the anode of diode **26**. The cathodes of each of the diodes are coupled through a resistor **34** to ground. The diodes **26** and **28** are biased by means of a positive D.C. control voltage connected to a terminal **35**. The terminal **35** is coupled to the anodes of diodes **26** and **28** through a pair of inductors **36**, **38**, respectively, which form R.F. chokes.

The attenuated R.F. signal is coupled from the anode of diode **28** to one side of a coupling capacitor **42**. The other side of the capacitor **42** is connected to a transistor **44** of the reflex amplifier **14** at the base **46** of the transistor **44**. The transistor **44** further comprises an emitter **48** and a collector **52**. The emitter **48** is coupled to ground through a first path comprising a biasing resistor **54** and a second path comprising an R.F. by-pass capacitor **56**. The collector **52** of the transistor **44** is connected to one side of an output L-C circuit formed of a capacitor **58** and an inductor **62** connected in parallel. Output R.F. signals are taken off of a terminal **64**, which is connected to the inductor **62**.

Input AGC control voltage to the reflex amplifier are coupled from a terminal **66** to the base **46** of transistor **44** through an input L-C circuit formed by an inductor **68** and a capacitor **72** connected in parallel. The terminal **66** is further connected through an R.F. shunting capacitor **74** to ground.

The other side of the output L-C circuit is connected to a source of positive reference voltage through a D.C. output resistor **76**. Further, a feed-through capacitor **78** is connected to the lead at the other side of the output L-C circuit so as to prevent R.F. signals from passing to the resistor **76**. The junction of the output L-C circuit and the resistor **76** is connected to a control transistor **80** of the AGC control amplifier **16** at a base **82** of the transistor **80**. The control transistor **80** further comprises an emitter **84** and a collector **86**. The emitter **84** is connected through a biasing resistor **88** to a source of positive reference voltage and the collector **86** is connected to the anode of the third diode **32**.

With the foregoing in mind, operation of the circuit of FIG. 2 is as follows:

In the no-signal condition, the AGC control voltage applied to the terminal **66** is of such value as to allow only a small amount of current to flow in the collector circuit of transistor **44**. The resulting voltage drop across the D.C. output resistor **76** is, therefore, not sufficient to turn on control transistor **80**. Thus, the diode **32** is effectively an open circuit. In addition, a positive bias voltage is applied to the terminal **35**, forward-biasing the diode **26** and the diode **28**. This causes a current flow through both diodes **26** and **28** through the resistor **34**. Therefore, it can be seen that in the no-signal condition, diodes **26** and **28** are turned on while diode **32** is effectively turned off, resulting in minimum attenuation.

When an input R.F. signal is applied to the terminal **22** and coupled to the attenuator **12** at the anode of diode **26**, the attenuated R.F. signal is coupled from the anode of diode **28** to the base **46** of transistor **44** where it is amplified. This amplified R.F. signal is fed to the output L-C circuit. The amplified R.F. signals are taken off the inductor **62** at the terminal **64**, the terminal **64** being connected to the next stage of a receiver system. As stronger R.F. signals are passed through the system, the positive AGC voltage applied to terminal **66** increases the collector current through transistor **44**. The resulting voltage drop across resistor **76** eventually succeeds in turning on transistor **80** which results in current flow through the diode **32**. As current flows through the diode **32**, the voltage drop across resistor **34** increases to the point where it exceeds the bias voltage applied to terminal **35**. This condition results in effectively back-biasing diodes **26** and **28**. Therefore, with a strong input R.F. signal condition, the diodes **26** and **28** are turned off and diode **32** turned on, resulting in a maximum attenuation. As can be readily seen, the system operates in such a manner as to keep the R.F. output voltage of the last stage of the receiver system relative constant by causing more or less attenuation to be inserted by the electrically operated continuous attenuator **12**.

Additional gain control variation is also provided by the system because the R.F. gain of the reflex amplifier **14** varies with the D.C. control voltage applied to the terminal **66**. This additional gain control variation is obtained because the voltage drop which results from the AGC voltage across resistor **76** causes a reduction of the available collector voltage for the transistor **44**.

* * * * *

an output terminal, means coupling said D.C. output terminal of said reflex amplifier to said input terminal of said AGC control amplifier, and means coupling said output terminal of said control amplifier to said attenuation control terminal of said attenuator network for varying the attenuation level of said attenuator network, said attenuator network comprising:

a first diode, a second diode, and a third diode, biasing means coupled to the anode of said first diode and the anode of said second diode, means coupling said R.F. input signal to said anode of said first diode, means coupling the anode of said second diode to said R.F. input terminal of said reflex amplifier; and means coupling said anode of said third diode to said output terminal of said control amplifier.

2. An automatic gain control system in accordance with claim **1** wherein said AGC control amplifier comprises:

a transistor having a base, an emitter, and a collector, means coupling said D.C. output terminal of said reflex amplifier to the base of said control amplifier transistor, means coupling the emitter of said control amplifier transistor to a source of reference potential, and means coupling the collector of said control amplifier transistor to said anode of said third diode.

3. An automatic gain control system in accordance with claim **2** wherein said reflex amplifier comprises:

a transistor having a base, emitter, and collector, means coupling the anode of said second diode to the base of said reflex amplifier transistor and an R.F. output L-C circuit comprising an inductor and capacitor connected in parallel, means coupling the collector of said reflex amplifier transistor to one side of said parallel L-C network, and means coupling said R.F. output terminal to said inductor of said L-C network.

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U.S. Cl. X.R.

330—145

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AWARDS ABSTRACT

NASA Case ~~No. 5307~~

AUTOMATIC GAIN CONTROL SYSTEM

The instant invention is directed to an automatic gain control system having an electrically operated continuous attenuator for varying an R.F. input signal in accordance with the output of the last stage of a receiver system. The system provides a simple means for controlling the attenuation of a diode network so that the R.F. signal will be attenuated and a relative constant amplitude provided at the output stage of the receiver system.

The system shown in block diagram format in FIG. 1 comprises an electrically operated continuous continuator 12 into which R.F. input signals, which are to be controlled, are coupled. The attenuated R.F. output signal is fed into a reflex amplifier and the amplified R.F. signal is coupled from the reflex amplifier to the next stage of the R.F. system. Further, an AGC control voltage from the last stage of a receiver system is also fed into the reflex amplifier. The amplified AGC voltage is coupled to the input of an AGC control amplifier, and the output thereof fed to the attenuator 12 to vary the attenuation thereof.

The novelty of the ~~invention appears to be~~ in providing an AGC control amplifier, which varies the attenuation of an attenuator network so that the input R.F. signal may be reduced to the extent necessary to keep the output signal of the system relatively constant.

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~~HSHertz:ln~~ 11-18-65