

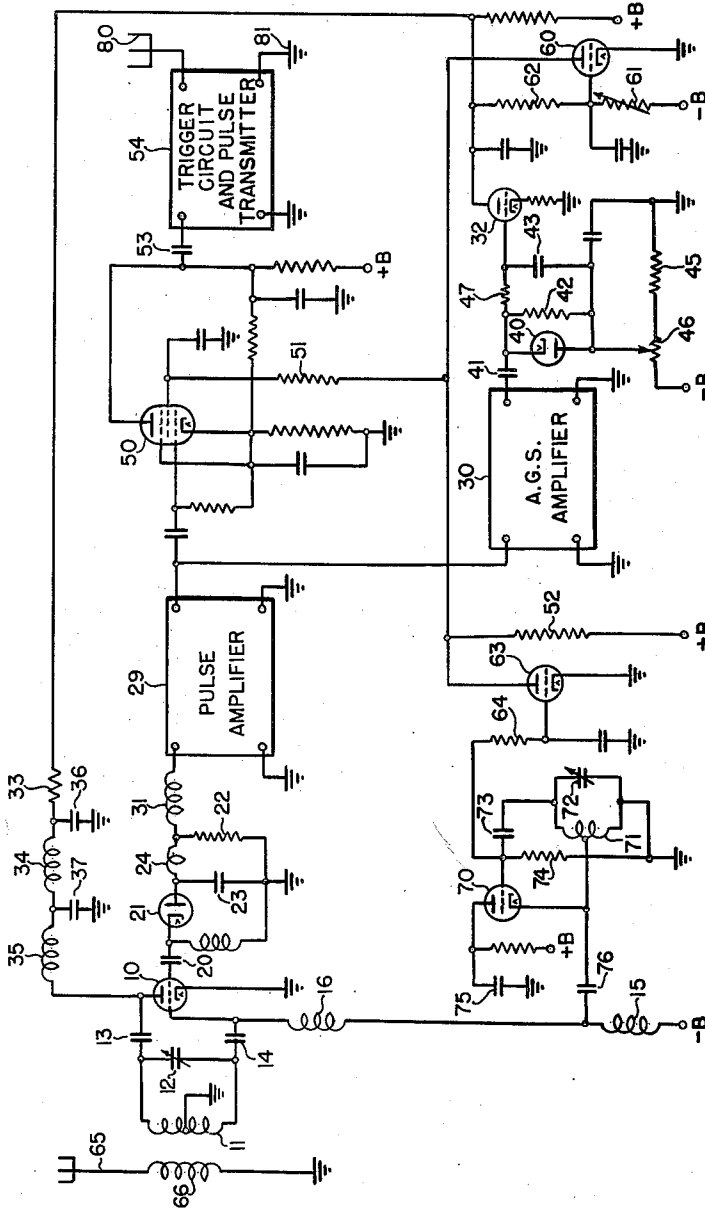
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WAVE-SIGNAL RECEIVER

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WAVE-SIGNAL RECEIVER

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ber 9, 1945, Serial No. 627,732

6 Claims. (Cl. 250—20)

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This invention is directed to a wave-signal receiver of the superregenerative type including an arrangement for effectively disabling the receiver in response to an abnormal variation of a predetermined operating condition thereof. This application is a division of application Serial No. 558,531, filed October 13, 1944, now abandoned, in the name of Jasper J. Okrent and assigned to the same assignee as the present invention.

A superregenerative receiver comprises a regenerative circuit in which the degree of regeneration provided is such as to support oscillations, but the generated oscillations are periodically suppressed by an applied periodic quench signal. The superregenerative receiver has numerous applications, one of which will be particularly described.

Consider, as an example, a wave-signal transponder system which includes a superregenerative receiver. The term "wave-signal transponder system" is here used to designate a wave-signal translating system having a receiver portion and a transmitter portion arranged to transmit a reply signal in response to a received interrogating signal, each such signal preferably comprising a pulse-modulated radiant-energy signal. Usually, the transmitter is triggered, or set into operation, under the control of the receiver through an amplitude-selective circuit. To obtain optimum sensitivity of the transponder system, a gain-control arrangement is used to stabilize the receiver gain to a compromise value between that corresponding to maximum receiver sensitivity and that which is necessary to assure freedom from triggering the transmitter on the quiescent signal output of the receiver.

An operating limitation of the superregenerative receiver which may prove to be undesirable in such an installation concerns its quench-signal source. Under certain unavoidable conditions, notably as a result of a defective tube, the quench-signal supply may become disabled. Depending upon the adjustment of the superregenerative circuit, the loss of quench signal may provoke self-quenching of the receiver circuit, a condition in which the regenerative circuit periodically oscillates freely, the oscillations being quenched by self-blocking in the oscillatory circuit. For the most part, self-quenching represents an uncontrolled operating state and may therefore be objectionable.

It is an object of the invention, therefore, to provide a wave-signal receiver of the superregenerative type having a quench-signal source and

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which avoids the aforementioned limitation of prior art arrangements through an arrangement for effectively disabling the receiver in response to an abnormal variation of a predetermined operating condition of its quench-signal supply.

It is a specific object of the invention to provide a wave-signal receiver of the superregenerative type having a quench-signal source and including an improved arrangement for effectively disabling the receiver in response to a failure of its quench-signal source.

In accordance with the invention, a wave-signal receiver of the superregenerative type including an arrangement for effectively disabling the receiver in response to an abnormal variation of a predetermined operating condition thereof comprises means for supplying to the receiver a periodic quench signal for controlling superregeneration and having amplitude levels within a predetermined range of values during normal operating conditions, but having abnormal amplitude levels outside of this range of values in response to an abnormal variation of the aforesaid operating conditions. The receiver also includes a control system responsive primarily only to these abnormal amplitude levels of the quench signal for deriving a control effect and means for utilizing the control effect effectively to disable the receiver.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

Referring now more particularly to the drawing, the transponder system there represented includes a superregenerative receiver, in accordance with the present invention, and an associated wave-signal transmitter. This system is substantially the same as that disclosed in Fig. 2 of the above-mentioned copending application Serial No. 558,531, corresponding components thereof being designated by similar reference characters. In the following discussion, the system as a whole will be considered as a radio beacon adapted to transmit direction-finding information to inquiring aircraft.

As illustrated, the receiver portion of the beacon comprises a superregenerative circuit including a triode vacuum tube 10 having anode, cathode and control electrodes. In the oscillatory circuit of tube 10 is a resonant circuit provided by the parallel combination of an inductor 11 and an adjustable condenser 12. The resonant cir-

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cuit is coupled to the anode and control electrodes of tube 10 by way of condensers 13 and 14, respectively. Regeneration is obtained in a conventional manner by coupling the cathode of tube 10 to a tap of inductor 11. An operating bias potential is applied to the control electrode of tube 10 from a source indicated -B through signal-frequency chokes 15 and 16. A source of space current is applied to the tube in a manner to be pointed out hereinafter.

There also is associated with the oscillatory circuit of tube 10 means for supplying thereto a periodic quench signal for providing and controlling superregeneration. This means comprises an oscillation generator including a vacuum tube 70 arranged in an oscillatory circuit of the Hartley type. The oscillator has a frequency-determining circuit including an inductor 71 and an adjustable condenser 72, coupled to the control electrode of tube 70 through a condenser 73 and grid resistor 74. The anode of tube 70 is effectively connected with the frequency-determining circuit by means of a condenser 75, while the cathode thereof is directly coupled to a tap on inductor 71. A source of space current, indicated +B, is applied to the anode of the tube and the quench-signal output is derived in the cathode circuit for application to oscillator 10 through a condenser 76 and choke 16. As is well understood in the art, the oscillator is self-biasing through means comprising condenser 73 and its grid resistor 74.

The quench signal supplied by oscillator 70 may have a sinusoidal or other suitable wave form, but has a frequency which is low with reference to the operating frequency of oscillator 10. Also, the quench frequency is high in comparison with the pulse-repetition frequencies of interrogating signals to be received by the beacon, preferably, being so high that the quench period is equal to or less than the pulse duration of a received signal. Chokes 15 and 16 are selected to isolate the oscillations generated in the receiver circuit from the bias potential -B and from the quench-signal oscillator.

A condenser 20 couples a diode detector 21 to the described superregenerative circuit. The load circuit of the diode includes a signal-frequency choke 24 and a resistor 22, by-passed by a condenser 23.

The receiver also comprises a gain-stabilization channel, which includes a pulse amplifier 29 of one or more stages, coupled to the load circuit of diode 21 through a signal-frequency choke 31. Following the pulse amplifier 29 in this channel is an automatic gain-stabilization or A. G. S. amplifier 30 of one or more stages. The A. G. S. amplifier may include selector circuits arranged to select a portion of the detected signal output of the receiver for utilization in stabilizing the receiver gain.

There is coupled to the output circuit of A. G. S. amplifier 30 means for deriving from the gain-stabilization channel a control signal having amplitude levels determined by the gain characteristic of the receiver. This means comprises an A. G. S. rectifier, including a diode rectifier 40, coupled to the output circuit of A. G. S. amplifier 30 through a condenser 41. The load circuit of diode 40 is provided by a resistor 42, a filter resistor 47 and a by-pass condenser 43. The rectifier circuit has a fast charging time constant and a slow discharge time constant so as to peak rectify the applied signal output of amplifier 30.

In stabilizing the gain of the receiver the mag-

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nitude of the anode-cathode excitation potential of tube 10 is adjusted by the gain-stabilization arrangement. To this end, the signal output of rectifier 40, as obtained across its load resistor 42, is applied with positive polarity to the input circuit of an amplifier including a vacuum tube 32. An adjustably fixed component of bias potential is obtained from a bleeder network provided by a resistor 45 and a voltage divider 46 connected in circuit with a suitable potential source indicated -B. This bias potential is applied to the input circuit of tube 32 through resistor 42. The magnitude of this bias potential is selected of such value that, in the absence of a control signal from A. G. S. rectifier 40, tube 32 is biased substantially to anode current cutoff. A source of space current, indicated +B, is coupled to the anode of tube 32. A unidirectional potential, having a magnitude determined by the conductive state of tube 32, is derived from the anode-cathode circuit thereof and is utilized as the anode-cathode excitation potential for receiver tube 10. For this purpose, the anodes of tubes 32 and 10 are coupled through a resistor 33 and a filter provided by series inductors 34 and 35 and shunt condensers 36 and 37. This arrangement provides a source of space current for tube 10.

An antenna-ground system 65, including an inductor 66 inductively coupled with resonant circuit 11, 12, applies received signals to the receiver for translation therethrough.

The receiver also has means for applying received wave signals translated therethrough to a utilizing circuit. This means comprises a repeater, including a vacuum tube 50, having an input circuit coupled to the output circuit of pulse amplifier 29. A source of space current, indicated +B, is coupled to the anode electrode of tube 50. During normal operating conditions, a screen voltage of sufficient magnitude to operate tube 50 substantially above anode current cutoff is applied through a bleeder network of resistors 51 and 52 coupled to a potential source +B. The output circuit of repeater 50 is connected through a condenser 53 to a suitable utilizing circuit 54.

The utilizing circuit 54, represented in block form, includes a pulse transmitter which is normally in a quiescent state but which may be set into operation through an associated amplitude-selective trigger circuit to transmit a single pulse of a reply signal. The output circuit of unit 54 is coupled to an antenna system 80, 81 for radiating the reply signal, and its input circuit is coupled through repeater 50 to the output circuit of pulse amplifier 29, as indicated hereinabove. By virtue of the interconnection between pulse amplifier 29 and unit 54, the operation of the transmitter is controlled by the superregenerative receiver.

The receiver illustrated also comprises a control system for effectively disabling the receiver in response to an abnormal variation of a predetermined operating condition thereof. This system constitutes means responsive to abnormal amplitude levels of the quench signal for deriving a control effect, and includes an electron-discharge device shown as a triode amplifier including a vacuum tube 63. The input circuit of tube 63 is coupled through a resistor 64 to the self-biasing arrangement of the quench-signal generator, so as to be biased substantially to anode current cutoff thereby during normal operating conditions of the quench-signal generator. Abnormal variations of the operating

conditions of the quench-signal generator are effective to render tube 63 conductive, so that a control voltage is derived at its anode electrode. The output circuit of tube 63 is connected in shunt relation to resistor 51 and the screen electrode of repeater 50 with respect to ground.

Finally, the receiver is shown as having additional amplitude-selective means, responsive to abnormal amplitude levels of the control signal derived by A. G. S. rectifier 40, for effectively disabling the receiver. This last-named means comprises a second electron-discharge vacuum-tube device or triode amplifier 60 also having its anode-cathode circuit connected in shunt relation to resistor 51 and the screen electrode of repeater 50 with respect to ground. Tube 60 is normally biased to anode current cutoff by a suitable bias potential -B coupled to the input circuit thereof through a variable resistor 61. A resistor 62 couples the input circuit of tube 60 to the output circuit of amplifier 32 in order that tube 60 may be rendered conductive in response to abnormal amplitude levels of the control signal derived from A. G. S. rectifier 40. That is, tube 60 is rendered conductive in response to an abnormal variation in the gain condition of the A. G. S. system.

In operation, the circuit of receiver tube 10 is initially adjusted for sustained oscillations. During quiescent operating conditions when no signal is intercepted by antenna system 65, oscillations are periodically produced by oscillator 10 under the control of the quench voltage supplied by oscillator 70. These oscillations are initiated by the low amplitude noise signal and similar disturbances inherent in the receiver circuit and produce in the output circuit of detector 21 a quiescent signal output. In response to this quiescent signal output, the gain-stabilization system produces in the load circuit of rectifier 40 a control signal having amplitude levels determined by the gain characteristic of the receiver and included within a given range of values during normal operating conditions thereof.

This output signal of the A. G. S. rectifier 40 is applied with positive polarity to the input circuit of vacuum tube 32 and, in conjunction with the biasing arrangement thereof, determines the conductivity of the tube and consequently the magnitude of the unidirectional potential obtained therefrom and applied to the anode-cathode circuit of oscillator 10. The circuit adjustments are such that, under normal conditions of operation, the excitation potential thus applied to oscillator 10 has that value which is required to establish optimum sensitivity of the receiver. The gain-stabilization system controls the receiver gain to maintain such optimum condition through appropriate variations of the anode-cathode excitation potential of tube 10.

The anode-cathode potential applied through the resistor 33 and filter elements 34 and 35 to receiver tube 10 is likewise applied to tube 60, and under normal operating conditions the latter remains at anode current cutoff. With tube 60 in a nonconductive state and the quench signal circuits operating normally as discussed hereinbelow, normal operating potentials are established for repeater 50, rendering the repeater conductive to translate the signal output of pulse amplifier 29 to utilizing circuit 54.

For the assumed normal operating conditions of the receiver, control tube 63, as well as tube 60, is biased to anode current cutoff. With both control tube 63 and tube 60 in a nonconductive

state, repeater 50 is enabled to connect pulse amplifier 29 to utilizing circuit 54. Therefore, the quiescent signal output of the receiver is also applied to its utilizing circuit 54. However, during normal operating conditions the controlled amplitude of the quiescent signal output is insufficient to excite the trigger circuit of unit 54 and trigger its associated transmitter.

Assume now, that an aircraft desiring direction-finding information from the beacon transmits thereto a pulse-modulated interrogating signal. This signal will, in general, have a high intensity with reference to the noise signal of the receiver circuit, wherefore oscillations generated in the receiver in any quench cycle occurring within the duration of the received pulse have a relatively high amplitude. During intervals which intervene between pulses of the received signal, the signal output of detector 21 comprises the quiescent signal output mentioned above. Hence, in response to the received interrogating signal, the output signal of detector 21 has high amplitude and low amplitude signal components, the former representing the modulation of the received signal. This signal output is translated through the gain-stabilization channel for the purpose of maintaining the desired receiver gain, in the manner indicated. This output signal is likewise applied through pulse amplifier 29 and repeater 50 to unit 54. The first high-amplitude signal component derived from each received pulse of the interrogating signal causes the trigger circuit of unit 54 to excite its associated transmitter for the transmission of a reply signal. Therefore, in response to a received interrogating signal, the beacon transmits a pulse-modulated reply signal having the same pulse-repetition frequency as the received signal and having a pulse duration determined by the adjustments of unit 54. The inquiring aircraft is able to obtain the desired bearing indication or other direction-finding information from such transmitted reply signal.

Coming now to a consideration of the function of the control tube 63, this tube is adapted effectively to disable the receiver in response to an abnormal variation in the operating condition of its quench-signal generator 70. During intervals in which this generator functions properly, the quench-signal output and the self-generated operating bias have amplitude levels within predetermined ranges of values. However, when the oscillator fails, the amplitude levels of the quench signal and the self-bias potential have abnormal values outside of their normal ranges of values, specifically, each falls to zero. The loss of bias potential renders tube 63 conductive, thereby deriving a control effect from abnormal amplitude levels of the quench signal. As tube 63 conducts, the screen voltage of repeater 50 is reduced to a value which effectively drives the repeater to anode current cutoff, effectively disabling the receiver by disassociating its utilizing circuit 54 therefrom. Thus, under the control of control tube 63, the circuits associated with tube 50 constitute means for utilizing the control effect derived from abnormal amplitude levels of the quench signal effectively to disable the receiver.

Repeater 50 conveniently may serve an additional purpose in the circuits illustrated, as will be pointed out in connection with the function of tube 60. Let it now be assumed that a failure has occurred in the gain-stabilization system, as may be occasioned through a defective tube. Upon such failure, the signal derived from A. G. S.

rectifier 40 has an abnormal amplitude level outside of its normal range of values. Usually, a failure in the gain-stabilization channel causes the signal output of A. G. S. rectifier 40 to fall to zero. Thereupon, tube 32 is biased to anode current cutoff through its biasing circuit including voltage divider 46, raising the anode-cathode potential of tube 10 to an abnormally high level. As a result, the amplitude level of the quiescent signal output of the receiver may increase sufficiently to trigger the transmitter of unit 54. However, a corresponding potential increase occurs in the input circuit of tube 60, rendering this tube conductive to establish a substantial shunt around resistor 51 and the screen electrode of repeater 50. Unit 54 is thereby effectively dissociated from the receiver in the manner already described. By isolating unit 54, any increase in the amplitude of the receiver quiescent signal output which may follow a failure in the gain-stabilization system has no undesirable effect on the transmitter of unit 54. Therefore, false firing of the transmitter is obviated. Thus, repeater 50 serves for effectively disabling the receiver in response to abnormal amplitude levels of at least one of the signal outputs of the quench generator and the gain-stabilization system. The control arrangement for disabling the receiver in response to a failure causing an abnormal operating condition of the gain-control system is particularly described in the above-mentioned copending application Serial No. 558,531.

It will be understood that control tube 63 and tube 60 may, if desired, be utilized to bias receiver tube 10 to anode current cutoff in the event of a quench signal or A. G. S. failure. While this result may obviously be obtained with the described control arrangement, it may be more desirable in particular installations to utilize a modified form of control arrangement particularly described in copending application Serial No. 558,532, now Patent No. 2,467,564, issued April 19, 1949, filed concurrently with the application Serial No. 558,531 mentioned above, in the name of Jasper J. Okrent, and assigned to the same assignee as the present invention.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A wave-signal receiver of the superregenerative type including an arrangement for effectively disabling said receiver in response to an abnormal variation of a predetermined operating condition thereof comprising, means for supplying to said receiver a periodic quench signal for controlling superregeneration and having amplitude levels within a predetermined range of values during normal operating conditions thereof but having abnormal amplitude levels outside of said range of values in response to an abnormal variation of said operating conditions, a control system responsive primarily only to said abnormal amplitude levels of said quench signal for deriving a control effect, and means for utilizing said control effect effectively to disable said receiver.

2. A wave-signal receiver of the superregenerative type including an arrangement for effectively disabling said receiver in response to an

abnormal variation of a predetermined operating condition thereof comprising, means for supplying to said receiver a periodic quench signal for controlling superregeneration and having amplitude levels within a predetermined range of values during normal operating conditions thereof but having abnormal amplitude levels outside of said range of values in response to an abnormal variation of said operating conditions, a control system including an electron-discharge device biased substantially to anode current cutoff during normal operating conditions of said quench-signal supplying means but responsive to said abnormal amplitude levels of said quench signal for deriving a control effect, and means for utilizing said control effect effectively to disable said receiver.

3. A wave-signal receiver of the superregenerative type including an arrangement for effectively disabling said receiver in response to an abnormal variation of a predetermined operating condition thereof comprising, means for supplying to said receiver a periodic quench signal for controlling superregeneration and having amplitude levels within a predetermined range of values during normal operating conditions thereof but having abnormal amplitude levels outside of said range of values in response to an abnormal variation of said operating conditions, a control system including an electron-discharge device biased substantially to anode current cutoff by said quench-signal supply means during normal operating conditions thereof but responsive to said abnormal amplitude levels of said quench signal for deriving a control effect, and means for utilizing said control effect effectively to disable said receiver.

4. A wave-signal receiver of the superregenerative type including an arrangement for effectively disabling said receiver in response to an abnormal variation of a predetermined operating condition thereof comprising, means for supplying to said receiver a periodic quench signal for controlling superregeneration and having amplitude levels within a predetermined range of values during normal operating conditions thereof but having abnormal amplitude levels outside of said range of values in response to an abnormal variation of said operating conditions, a control system including an electron-discharge device biased substantially to anode current cutoff by said quench-signal supply means during normal operating conditions thereof but responsive to said abnormal amplitude levels of said quench signal for deriving a control voltage, means including a vacuum-tube repeater operated substantially above anode current cutoff during normal operating conditions of said receiver for applying signals translated therethrough to a utilizing circuit, and means responsive to said control voltage for biasing said repeater to anode current cutoff, thereby effectively to disable said receiver.

5. A wave signal receiver of the superregenerative type including an arrangement for effectively disabling said receiver in response to an abnormal variation of a predetermined operating condition thereof comprising, a vacuum-tube oscillation generator for supplying to said receiver a periodic quench signal for controlling superregeneration and including self-biasing means effective to provide an operating bias potential for said generator having amplitude levels within a predetermined range of values during normal operating conditions thereof but having abnormal amplitude levels outside of said range

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of values in response to an abnormal variation of said operating conditions, a control system responsive to said abnormal amplitude levels of said operating bias potential for deriving a control effect, and means for utilizing said control effect effectively to disable said receiver. 5

6. A wave-signal receiver of the superregenerative type including an arrangement for effectively disabling said receiver in response to an abnormal variation of a predetermined operating condition thereof comprising, a vacuum-tube oscillation generator for supplying to said receiver a periodic quench signal for controlling superregeneration and including self-biasing means effective to provide an operating bias potential for said generator having amplitude levels within a predetermined range of values during normal operating conditions thereof but having abnormal amplitude levels outside of said range 10 15

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of values in response to an abnormal variation of said operating conditions, electron-discharge means biased substantially to anode current cut-off by said self-biasing means of said generator during said normal operating conditions but responsive to said abnormal amplitude levels of said operating bias potential for deriving a control effect, and means for utilizing said control effect effectively to disable said receiver.

JASPER J. OKRENT.

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The following references are of record in the file of this patent:

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