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AUTOMATIC GAIN CONTROL CIRCUIT

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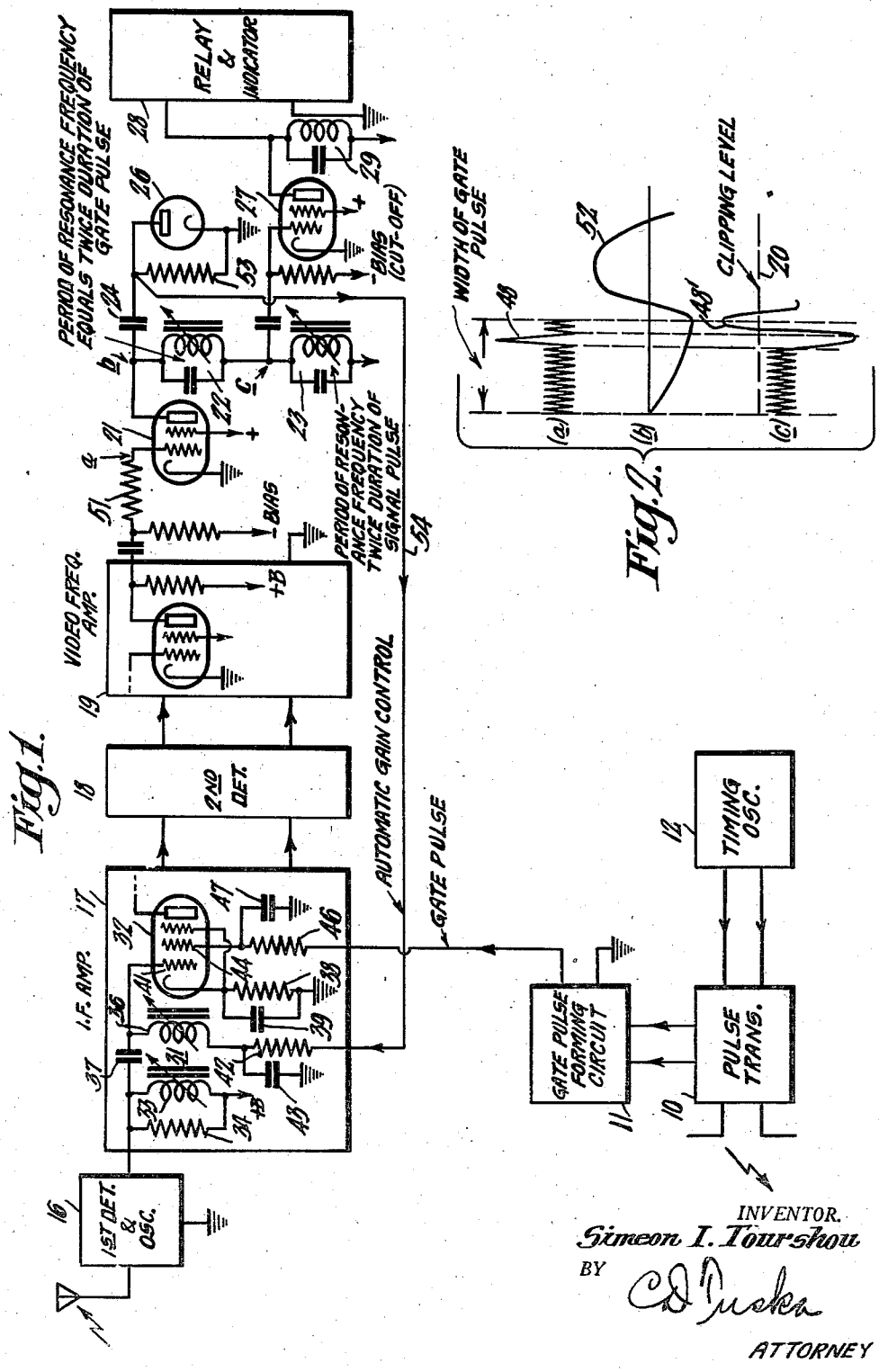


Fig. 1.

Fig. 2.

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AUTOMATIC GAIN CONTROL CIRCUIT

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6 Claims. (Cl. 250—20)

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My invention relates to automatic gain control circuits, particularly as applied to gated radio pulse receivers.

The invention will be described with reference to a gated pulse-echo radar system that is designed to actuate a warning device if an object moves into a certain region or area. A radar system of this kind is described and claimed in copending application Serial No. 515,496, filed December 24, 1943, jointly by Simeon I. Tourshou and Robert Trachtenberg, and entitled Radio pulse echo system, now Patent 2,432,180, issued December 9, 1947. The said region is determined by the timing and duration of a gating pulse that "opens up" a normally blocked receiver. In order that the warning device shall be actuated only by reflected signal pulses and not by noise pulses, it is desirable to hold the noise pulses at a predetermined amplitude level at the receiver output circuit whereby only the higher amplitude signal pulses will pass through a clipping tube to a relay that operates the warning device.

It has been found that a conventional type automatic gain control circuit does not receive sufficient energy from the noise for satisfactory operation when the duration of the gating pulse is short compared with the signal pulse repetition rate as is the case in the warning system being described.

An object of the invention, therefore, is to provide an improved automatic gain control circuit for a radar receiver that is rendered effective to pass signal periodically and only a small percentage of the total time.

Another object of the invention is to provide an improved automatic gain control system for a radio receiver.

Still another object of the invention is to provide an improved automatic gain control circuit for a gated radar receiver.

In accordance with the present invention the output of the video frequency amplifier of the receiver is applied to two parallel tuned circuits which are connected in series with each other. One of the tuned circuits is tuned to resonate at a comparatively low frequency determined by the width or duration of the gating pulse so that this tuned circuit integrates the noise pulses. The integrated signal thus obtained is applied to the diode of the automatic gain control circuit.

The other tuned circuit is tuned to a higher frequency determined by the width or duration of the signal pulse. The signal appearing thereacross is applied through a clipping tube to a relay and warning indicator circuit. Since the

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noise level is held substantially constant by the gain control circuit, the clipping level of the clipping tube can be set so that substantially only the signal pulses are passed on to the warning circuit relay, thus avoiding false operation.

The invention will be better understood from the following description taken in connection with the accompanying drawing in which

Figure 1 is a block and circuit diagram of a radar system embodying the invention and Figure 2 is a group of graphs that are referred to in explaining the operation of the circuit shown in Fig. 1.

Figure 1 shows a pulse-echo radar system comprising a radio pulse transmitter 10, a gate pulse forming circuit 11 and a timing oscillator 12 that controls the timing of the transmitted radio pulse and the gate pulse.

The receiver of the system is of the superheterodyne type and includes a first detector and tuning oscillator indicated at 16, an I.-F. amplifier 17, a second detector 18, and a video frequency amplifier 19. The output of the amplifier 19 (consisting of a signal pulse 48 and noise as indicated at graph *a* in Fig. 2) is applied to an amplifier tube 21 that has in its anode circuit a noise integrating tuned circuit 22 that is resonant at a comparatively low frequency and a signal supplying tuned circuit 23 that is resonant at a higher frequency.

The integrated noise energy from the tuned circuit 22 (indicated at graph *b* in Fig. 2) is applied through a coupling capacitor 24 to a diode 26 comprising part of the automatic gain control circuit which will be described more fully hereinafter.

The signal pulse 48' and the accompanying noise (indicated at graph *c* in Fig. 2) from the tuned circuit 23 are applied to a vacuum tube 27 that is biased beyond cut-off sufficiently to pass only the signal pulses 48' as indicated by the dotted line 20 at graph *c* of Fig. 2. The signal pulses 48' passed by the tube 27 are supplied to a suitable relay, such as a Thyratron, for operating a warning indicator such as a light or a bell as indicated at 28. The anode voltage for the tube 27 may be applied through a resonant circuit 29 tuned to the same frequency as the tuned circuit 23.

Referring more specifically to the I.-F. amplifier 17, which is conventional in design, it may consist of several stages similar to the one illustrated which includes a tuned coupling circuit 31 and a pentode 32. The coupling circuit 31 comprises a tunable inductance coil 33, shunted by a

damping resistor 34, a tunable inductance coil 36, and a coupling capacitor 37.

The pentode 32 is provided with a negative operating bias for the control grid by means of a cathode resistor 38 and a shunt capacitor 39. Gain control bias is applied to the control grid 41 of pentode 32 from the automatic gain control circuit through a filter resistor 42 and the coupling coil 36. A filter capacitor 43 is connected between ground and the junction point of resistor 42 and coil 36.

A positive gate pulse from the circuit 11 is applied to the screen grid 44 of the pentode 32 through a filter resistor 46. A filter capacitor is shown at 47. Since the only voltage applied to the screen grid 44 is the gate pulse voltage, the pentode 32 will pass signal only while the gate pulse is on the screen grid. This feature is claimed in the above-identified Tourshou and Trachtenberg application. If a reflected signal pulse is received during this gating period, it will appear in the output of the video frequency amplifier 19 as indicated at 48 in graph *a* of Fig. 2.

Referring more in detail to the automatic gain control and associated circuit, the last video frequency amplifier stage 21 is resistance-capacity coupled to the preceding stage and is provided with a grid current limiting resistor 51.

The tuned circuit 22 preferably is tuned so that its resonant period is equal to twice the duration of the gate pulse whereby the applied energy (graph *a* of Fig. 2) is integrated to produce the voltage wave 52 shown in graph *b* of Fig. 2. The wave 52 is rectified by the diode 26 thus placing a direct-current charge on the capacitor 24 which charge leaks off slowly through a leak resistor 53. As a result, the upper end of resistor 53 has a negative voltage with respect to ground that increases in amplitude with respect to ground in response to any increase in the amplitude of the noise signal. This negative voltage is applied as a gain control voltage over a conductor 54 to the control grid 41 of the I.-F. amplifier tube 32 whereby the noise level is held substantially constant at the output of the amplifier tube 21. It may be noted that the signal pulse 48 will have practically no effect on the gain control because it is of short duration compared with the gate pulse duration and, therefore, has small energy content as compared with that of the noise passed during the gate period.

It may be noted that the ration of gate pulse duration to signal pulse duration preferably should be about 10 or 15 to 1 or more for best operation of the invention.

The video frequency output signal shown at graph *a* (Fig. 2) also feeds through the capacitor of the tuned circuit 22 to energize the tuned circuit 23 which preferably is tuned to have a resonant period of a duration twice the duration of the signal pulse 48. Therefore, the signal pulse 48 appears across the tuned circuit 23 as a damped sine wave as shown in graph *c* (Fig. 2), and the positive half cycle 48' is passed through the clipping tube 27 to the exclusion of the noise whereby false operation of the warning indicator is avoided. It should be understood that the clipping tube 27 may be adjusted to function as an amplifier tube without any clipping action if the relay and indicator circuit 28 is adjusted to respond only to signal that exceeds the noise voltage level.

I claim as my invention:

1. In a radio receiver wherein the receiver output energy comprises a received signal and accompanying noise, and wherein the duration of the received signal is short compared with that of the noise, means for receiving and demodulating the received signal to obtain a video frequency signal, said receiving means including an amplifier, a pair of parallel resonant circuits which are connected in series with each other and which are tuned to resonate at compartively low and comparatively high frequencies, respectively, means for applying said video frequency signal and the accompanying noise signal across said resonant circuits in series whereby integrated noise voltage appears across the circuit tuned to the low frequency and whereby the received signal accompanied by noise appears across the circuit tuned to the high frequency, means for controlling the gain of said amplifier in accordance with the amplitude of said integrated noise voltage to hold the noise output substantially constant, and means for applying the signal appearing across the high frequency tuned circuit to a utilization device.

2. In a radio pulse receiver wherein the receiver is operative to pass signals only during periodic gating periods which are a small percentage of the total time, means for receiving and demodulating reflected pulses accompanied by noise to obtain a video frequency signal, said receiving means including an amplifier, a pair of parallel resonant circuits which are connected in series with each other and which are tuned to resonate at comparatively low and comparatively high frequencies, respectively, means for applying said video frequency signal across said resonant circuits in series whereby integrated noise voltage appears across the circuit tuned to the low frequency and whereby the signal pulse accompanied by noise appears across the circuit tuned to the high frequency, means for controlling the gain of said amplifier in accordance with the amplitude of said integrated noise voltage to hold the noise output substantially constant, a pulse-reception indicator, and means for applying the signal appearing across the high frequency tuned circuit to said indicator.

3. In a radio pulse receiver wherein the receiver is operative to pass signals only during periodic gating periods which are a small percentage of the total time, means for receiving and demodulating reflected pulses accompanied by noise to obtain a video frequency signal, said receiving means including an amplifier, a pair of parallel resonant circuits which are connected in series with each other and which are tuned to resonate at comparatively low and comparatively high frequencies, respectively, means for applying said video frequency signal across said resonant circuits in series whereby integrated noise voltage appears across the circuit tuned to the low frequency and whereby the signal pulse accompanied by noise appears across the circuit tuned to the high frequency, means for rectifying said integrated noise voltage thereby producing an automatic gain control voltage, means for applying said gain control voltage to said amplifier in negative feed-back relation to hold the noise output level substantially constant, a pulse-reception indicator, and means for applying the signal pulse appearing across the high frequency tuned circuit to said indicator.

4. In a radio pulse receiver wherein the receiver is operative to pass signals only during periodic gating periods which are a small percentage of the total time, means for receiving and demodulating reflected pulses accompanied by noise to obtain a video frequency signal, said receiving means including an amplifier, a pair of parallel resonant

circuits which are connected in series with each other and which are tuned to resonate at comparatively low and comparatively high frequencies, respectively, means for applying said video frequency signal across said resonant circuits in series whereby integrated noise voltage appears across the circuit tuned to the low frequency and whereby the signal pulse accompanied by noise appears across the circuit tuned to the high frequency, means for rectifying said integrated noise voltage and thereby producing an automatic gain control voltage, means for applying said gain control voltage to said amplifier in negative feed-back relation to hold the noise output level substantially constant, a clipping circuit and a pulse-reception indicator, and means for applying the signal appearing across the high frequency tuned circuit to said indicator through said clipping circuit, the clipping level of said clipping circuit being set at a level to pass a received signal pulse substantially to the exclusion of the accompanying noise.

5. In a radio pulse receiver wherein the receiver is operative to pass signals only during periodic gating periods which are a small percentage of the total time, means for receiving and demodulating reflected pulses accompanied by noise to obtain a video frequency signal, said receiving means including an amplifier, a pair of parallel resonant circuits which are connected in series with each other and which are tuned to resonate at comparatively low and comparatively high frequencies, respectively, said low frequency having a period substantially equal to twice the duration of said gating period and said high frequency having a period substantially equal to twice the duration of said signal pulse, means for applying said video frequency signal across said resonant circuits in series whereby integrated noise voltage appears across the circuit tuned to the low frequency and whereby the signal pulse accompanied by noise appears across the circuit tuned to the high frequency, means for deriving an automatic gain control voltage from said integrated noise voltage, and means for applying said gain control voltage to said amplifier in negative feedback relation to hold the noise output level substantially constant.

6. In a pulse-echo receiver wherein the receiver is operative to pass signals only during periodic gating periods which are a small percentage of the total time, means for receiving and demodulating reflected pulses accompanied by noise to obtain a video frequency signal, said receiving means including an amplifier, a pair of parallel resonant circuits which are connected in series with each other and which are tuned to resonate at comparatively low and comparatively high frequencies, respectively, said low frequency having a period substantially equal to twice the duration of said gating period and said high frequency having a period substantially equal to twice the duration of said signal pulse, means for applying said video frequency signal across said resonant circuits in series whereby integrated noise voltage appears across the circuit tuned to the low frequency and whereby the signal pulse accompanied by noise appears across the circuit tuned to the high frequency, means for deriving an automatic gain control voltage from said integrated noise voltage, means for applying said gain control voltage to said amplifier in negative feed-back relation to hold the noise output level substantially constant, a warning indicator, and means for applying the signal appearing across the high frequency tuned circuit to said indicator.

SIMEON I. TOURSHOU.

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