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TRANSMISSION CONTROL IN SIGNALING SYSTEMS

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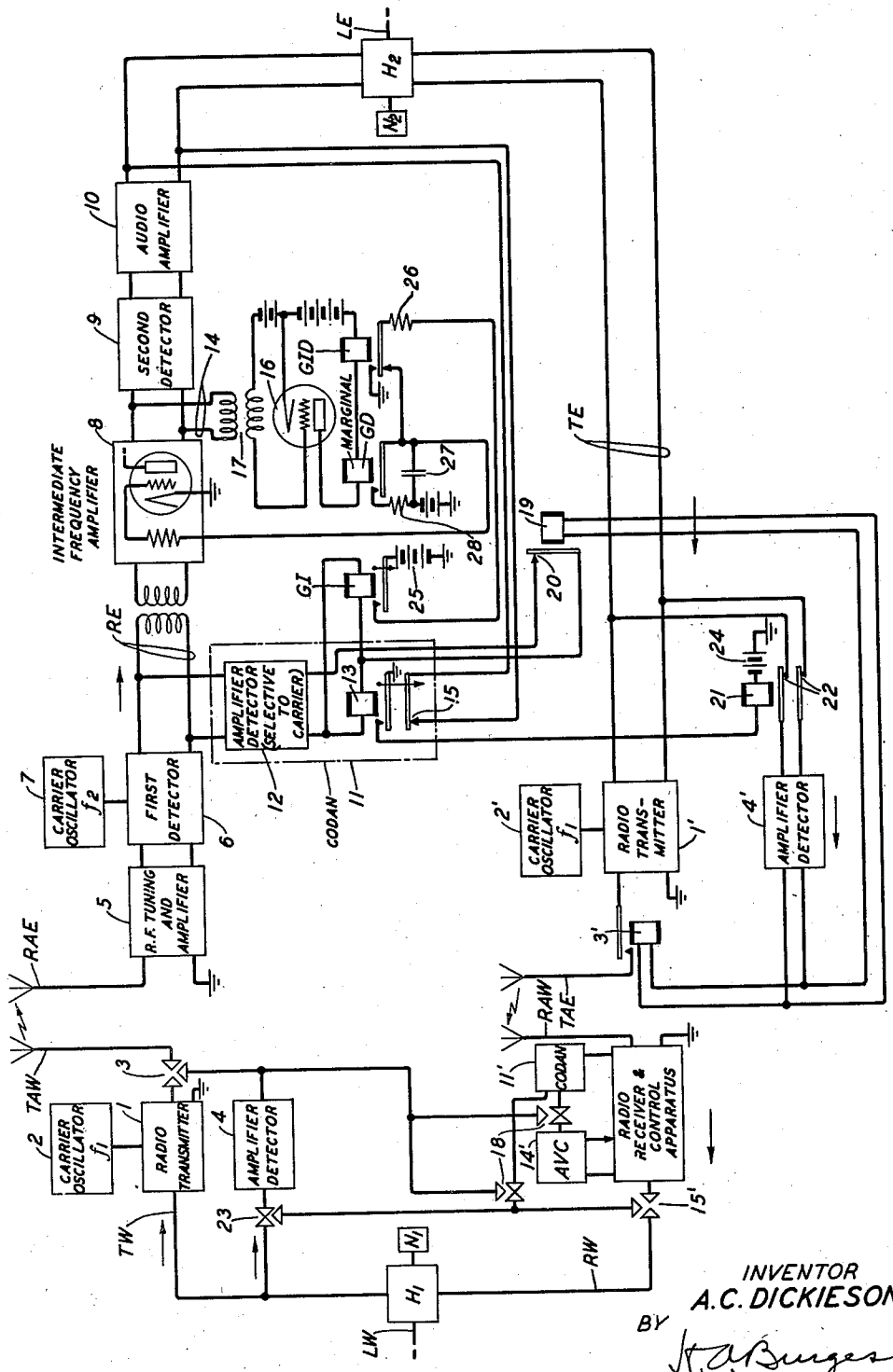

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TRANSMISSION CONTROL IN SIGNALING SYSTEMS

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The invention relates to signal wave transmission systems and particularly to wave-operated switching circuits for controlling signal transmission in such systems.

The invention has particular reference to carrier wave signaling systems of the type in which carrier energy, or special control energy other than the carrier, is applied to the transmitter only during periods of signal transmission, and in which the gain of the receiver is automatically controlled by the received carrier or other control energy.

In systems of the above type, every time the carrier or control energy is applied, the receiver gain changes from a maximum value as limited by the manual control to a value determined by the carrier amplitude. To allow for correction for fading, the range of gain needs to be at least 10 decibels, and may be as much as 50 to 60 decibels. That is, every time the carrier is applied during the gain adjusting interval, the gain is considerably higher than it should be finally, with consequent high noise and speech distortion. For control current operation where nearly every word means a new application of carrier, these transient effects will be quite troublesome.

So-called "Codan" (carrier-operated detector anti-noise) circuits have heretofore been used with the receiving circuits in such systems, to prevent the reception of interference (static) which, during periods of no signal (no carrier) when automatic gain control receivers are at maximum sensitivity, may be of sufficient amplitude to annoy the receiving subscriber and to falsely operate the voice-operated switching circuits for controlling the application of carrier by the transmitter at the terminal. The codan circuit accomplishes this by disabling the output of the receiver at each station during periods of no signal transmission and removing the disability when signal transmission is taking place.

The fundamental requirements of a codan are (1) that it operates on the weakest carrier that will give a commercial circuit with the static and set noise present and (2) that it should not operate on the strongest static through which a commercial circuit could be given with the circuit elements involved. The attaining of these requirements is made difficult in present-day radio receivers because the codan is controlled from a point in the receiving circuit where the signal-to-noise ratio (noise considered with carrier off) is made to approach unity, no matter how large that ratio may be at the receiving antenna, due to the action of the preceding automatic gain control. This difficulty has been minimized in the past by the use of a manual gain control to add a loss inside the circuit, the gain of which is being adjusted, to limit the maximum gain of the receiver, and thus effectively to prevent the automatic gain control from operating in the region where the static falls. This method is not particularly suitable at an attended station because of the wide variations in conditions requiring quick adjustments in gain, and, of course, is not feasible for an unattended station.

An object of the present invention is to reduce in systems of the above type signal distortion at the receiver due to the removal and reapplication of the carrier or other control energy.

Another object is to provide a receiver gain of an optimum value when the carrier or control energy is removed and to quickly readjust the gain to the proper value when carrier or control energy is again applied, if a re-adjustment is necessary.

These objects are attained in accordance with the invention by so arranging the codan in the receiving circuit that it is controlled by the received carrier or control energy prior to its regulation in level by the automatic gain control and to make the gain regulation neutral, that is, to maintain the receiver gain at the last established value when the reception of carrier or control energy ceases until the carrier is again received and then to quickly readjust the gain to the optimum value for signal reception.

Other objects and features of the invention will be brought out in the following detailed description when read in connection with the accompanying drawing, the single figure of which shows diagrammatically (and in part schematically) a two-way radio telephone system embodying the invention.

The west terminal of the system in the drawing is shown diagrammatically. This portion is not an actual circuit diagram but rather a single line layout, each line indicating a two-wire transmission path. A break in a path, represented by separated arrowheads, indicates that the path is normally disabled at that point, and an arrow pointing toward such a break from a control device (amplifier-detector) indicates that the path will be made operative by operation of the control device. A make in the path, represented by contacting arrowheads, indicates that the path is operative at that point, and an arrow pointed towards the contacting arrowheads from

a control device (amplifier-detector) indicates that the path will be disabled at that point by operation of the control device. An arrow pointing from one box representing a control device (automatic gain control or codan) to another box representing other apparatus indicates that the former device controls in some manner the adjustment or rearrangement of the latter apparatus.

The east terminal of the system employing apparatus identical with that at the west terminal is shown by a circuit diagram in which the component parts of the apparatus and circuits particularly pertaining to the invention are shown in greater detail.

The system of the drawing is a two-way radio telephone system for transmitting telephone signals in opposite directions between a west two-way telephone line LW and an east two-way telephone line LE.

The west terminal of the radio telephone system comprises the transmitting circuit TW including a transmitting antenna TAW, and a receiving circuit RW including a receiving antenna RAW, the input of the circuit TW and the output of the circuit RW being coupled in conjugate relation with each other and in energy transmitting relation with the telephone line LW by the hybrid coil connection H_1 and balancing network N_1 in well-known manner.

Similarly, the east terminal of the radio telephone system comprises a transmitting circuit TE including the transmitting antenna TAE, and the receiving circuit RE including the receiving antenna RAE, the input of the circuit TE and the output of the circuit RE being coupled in conjugate relation with each other and in energy transmitting relation with the telephone line LE by the hybrid coil H_2 and associated balancing network N_2.

The transmitting circuit TW at the west terminal comprises the usual transmission apparatus including the radio transmitter **1** and associated carrier oscillator **2**. In the absence of speech wave transmission therein, the circuit TW is arranged in any suitable manner, as indicated by the normal open circuit **3** between transmitter **1** and transmitting antenna TAW, to prevent the radiation of carrier oscillations to the east terminal station. When speech wave signals are received in the transmitting circuit TW from the line LW, a portion thereof is impressed on the input of the wave-operated control device (amplifier-detector) **4** bridged across the circuit TW in front of the radio transmitter **1**, and causes the operation of that device to remove the disability in the circuit TW at the point **3**, thereby allowing one or both of the signal side bands, as well as the unmodulated carrier component, to be radiated by the transmitting antenna TAW to the east terminal of the system.

The receiving circuit RE in the east terminal of the system comprises the usual transmission apparatus including the radio frequency tuning and amplifier means **5**, a first detector **6** and associated carrier oscillator **7**, the intermediate frequency amplifier **8**, the second detector **9** and the audio amplifier **10**.

Associated with the receiving circuit RE of the east terminal is the codan circuit **11**. As indicated, it comprises the amplifier-detector circuit **12**, selective to a beat frequency, i. e., the difference between the two carrier frequencies f_1 and f_2, respectively generated by the carrier oscillator **2** at the west terminal and the carrier oscillator **7** at the east terminal, having its input connected across the receiving circuit RE at a point between the first detector **6** and the intermediate frequency amplifier **8**, the mechanical relay **13** adapted to be operated by detected current in the output of the amplifier-detector **12**, and the normally closed short-circuiting connection **15** across the receiving circuit RE in the output of the audio amplifier **10** adapted to be opened by operation of relay **13**.

Also, connected across the receiving circuit RE at the east terminal at a point between the output of the intermediate frequency amplifier **8** and the input of the second detector **9** is the input of the backward-acting portion **14** of an automatic gain control circuit for the intermediate amplifier **8**, comprising the three-electrode vacuum tube detector **16** having its input connected across the receiving circuit RE by input transformer **17**, a "gain decrease" relay GD and a "gain increase disabler" relay GID controlled by the detected carrier current in the output of detector **16**, and associated circuits controlled by operation of these relays. The automatic gain control circuit also comprises a forward-acting portion including the amplifier-detector **12** common also to the codan circuit **11**, the "gain increase" relay GI controlled by the detected carrier current, and an associated circuit controlled by operation of relay GI. This automatic gain control circuit is provided for regulating the gain of the receiving circuit RE to compensate for variations in received signal volume, in a manner which will be described in detail later in connection with the description of operation of the complete system.

The transmitting circuit TE at the east terminal of the system contains transmission and control apparatus similar to that used in the transmitting circuit TW at the west terminal of the system, as indicated by the use of similar characters for identifying corresponding pieces of apparatus, except that in the circuit TE the characters are followed by a prime (') mark. The frequencies of the carrier oscillators, **2**, **2'** in the transmitting circuits at the two terminals are indicated as being the same, f_1, but may be different frequencies. Also, the receiving circuit RW at the west terminal of the system contains transmission and control apparatus similar to that used in the receiving circuit RE at the east terminal including a codan circuit and an automatic gain control circuit as described above, as indicated by the use of the same characters for identifying corresponding pieces of apparatus, except that in the circuit RW the characters are followed by a prime (') mark.

For the purpose of giving exclusive control of the switching apparatus at both terminals to the particular subscriber associated with the telephone line LW or LE, who first starts to talk, additional switching apparatus is provided at both terminals as follows:

Operation of the control circuit (amplifier-detector) **4** at the west terminal in response to telephone signals in the circuit TW, in addition to rendering the latter circuit operative at the point **3** to transmit signal side bands and unmodulated carrier component to the transmitting antenna to be radiated, also disables the normally operative output of the codan circuit **11'** and a portion (gain increase) of the automatic gain control circuit **14'** at the points **18**, as indicated. Similarly, operation of the control circuit **4'** at the east terminal in response to

telephone signals in the transmitting circuit TE, disables the codan circuit 11 in its output and the gain increase action of the automatic gain control circuit 14, for example, by causing the operation of a relay 19 to break the connection between the output of the common amplifier-detector 12 and the codan relay 13 and the "gain increase" relay GI at the point 20, as indicated.

Also, operation of the amplifier-detector 12 at the east terminal, if its output is operative, causes the operation of the control relay 13 to disable the amplifier-detector 4' in its input, for example, by closing an energizing circuit for a relay 21 to cause the operation of the latter to produce an open circuit in the input to amplifier 4' at the points 22. Similarly, operation of the codan circuit 11' at the west terminal, when its output is operative, causes the input of the amplifier-detector 4 associated with the transmitting circuit TW at the same terminal to be disabled at the point 23, as indicated.

However, if the frequencies of the carrier oscillators associated with the transmitting circuit at the two terminals of the system are different so that different radio frequencies are transmitted for the two directions of transmission, some or all of the above-described controls may be eliminated.

The system of the invention, as shown in the drawing, operates as follows:

When no speech signals are being received by the radio telephone system from the west telephone line LW associated with the west radio terminal or from the east telephone line LE associated with the east radio terminal, the control circuits at the two radio terminals are in the condition indicated in the figure, with both transmitting circuits TW and TE disabled in their outputs at the points 3 and 3' respectively, so that no carrier waves may be radiated to the other terminal, and with the receiving circuits RE and RW blocked in their outputs at the points 15 and 15', respectively. The normal blocking of the outputs of the receiving circuits prevents, when signals are not being transmitted, noise currents from being transmitted through the associated line to the telephone subscriber associated with each terminal, and being fed back through the transmitting circuit at the terminal to the switching apparatus for controlling the transmission of carrier from that terminal. In the absence of received carrier, the automatic gain control relays at each terminal are unoperated, and the gain of each receiving circuit RE, RW is set substantially at the value last established when carrier was removed, which value may be sufficient to make the noise currents present, if allowed to go through, of sufficient amplitude to annoy the subscriber associated with the receiving line LE or LW and to cause false operation of the carrier transmitting apparatus associated with the transmitting circuit at the same terminal.

Now, let it be supposed that speech waves are being received in the transmitting circuit TW of the west radio terminal from a subscriber associated with telephone line LW and speech waves are not being simultaneously received in the transmitting circuit TE of the east radio terminal from the telephone line LE associated with the east subscriber. The main portion of the speech waves in the circuit TW will be impressed upon the input of the radio transmitter 1 and will modulate therein the carrier frequency from the associated carrier oscillator 2 in well-known manner. Simultaneously, a portion of the speech waves in the input of the radio transmitter 1 controls the device 4 to remove the disability at the point 3 in the output of the radio transmitter 1 so as to allow the side-band energy as well as the unmodulated carrier component to be radiated by the transmitting antenna TAW to the east terminal of the system, and to disable the codan 11' and the gain increase portion of the automatic gain control 14' retaining the gain of the receiving circuit RW at the west terminal substantially at the last established value while signal transmission from the west terminal continues in the manner previously described.

At the east terminal of the system the radiated energy will be picked up by the receiving antenna RAE and will be selected and amplified by the radio frequency tuning and amplifying means 5 in the input of the receiving circuit RE. The resulting amplified energy is impressed on the first detector 6 in which it will be combined with the local carrier f_2 supplied from the carrier oscillator 7 to produce waves of intermediate frequency. A combination carrier component in the output of detector 6 will be selected by the amplifier-detector 12 and will control the operation of the codan and the "gain increase" portion of the automatic gain control circuit in the manner to be described later.

The remaining portion of the waves of intermediate frequency in the output of detector 6 will be amplified by the intermediate frequency amplifier 8, the gain of which is controlled by selected carrier waves in the input and output of the amplifier by the automatic gain control circuit in the manner to be described later, and then will enter the second detector 9 in which the speech signal waves will be demodulated in well-known manner. The speech waves will then be amplified by the audio amplifier 10.

A portion of the waves in the output of the first detector 6, i. e., a combination product of the carrier frequency f_1 generated by the carrier oscillator 2 at the west terminal and the carrier frequency f_2 generated by the local oscillator at the east terminal, will be selected in the common input of the codan circuit 11 and the forward-acting portion of the automatic gain control, connected across the output of the detector, and will be amplified and detected by amplifier-detector 12. The detected current will energize the windings of the codan relay 13 and the "gain increase" relay GI connected in parallel across the output of the device 12, causing their operation.

Relay 13 will operate to open the short-circuiting connection 15 across the receiving circuit RE in the output of audio amplifier 10, thereby allowing the speech signal waves in the output thereof to be transmitted from the output of the circuit TE through the hybrid coil H_2 to the line LE over which they will be transmitted to the east subscriber. The operation of relay 13 also closes an energizing circuit for the winding of relay 21 from battery 24, causing the operation of the latter relay to open the input circuit of amplifier-detector 4' at the points 22 for the purpose referred to previously.

The gain increase relay GI operates simultaneously with relay 13, to close its armature and contact applying a positive voltage from battery 25, through the charging resistance 26 and the normally closed armature and back contact of the gain increase disabler relay GID, to the regulating condenser 27 in the grid circuit of the intermediate frequency amplifier 8 causing the

gain of the latter amplifier to increase as the charge on condenser 27 increases. The carrier waves, as long as they continue to arrive, will hold the relay GI operated and for a desired hangover interval after the reception of carrier waves ceases.

The gain of the intermediate frequency amplifier 8 will continue to be increased by the charging of condenser 27 in response to the operation of relay GI until the amplified waves in the output of that amplifier reach the desired average level when the detected current in the output of detector 16 connected across the output of amplifier 8 is sufficient to cause operation of the gain increase disabler relay GID in the output circuit of the detector.

The resultant operation of the relay GID breaks its armature and back contact disabling the charging circuit for condenser 27 from battery 25 through resistance 26, thereby preventing any further increase in the gain of the intermediate frequency amplifier 8 due to the continued operation of the gain increase relay GI.

If the output level of amplifier 8 remains at the desired value, the gain thereof will be stabilized at a value corresponding to the charge on condenser 27 at the time relay GID operated. If, however, the output level of amplifier 8 increases about 1 decibel, the marginal gain decrease relay GD will be operated by the detected current in the output of detector 16 to push the gain of amplifier 8 down in the following manner.

The relay GI operates to connect the rather low discharge resistance 28 in parallel with the regulating condenser 27 in the grid circuit of the intermediate amplifier tube 8 causing the gain of the latter to start to decrease as the condenser 27 discharges through resistance 28. The level of the waves in the output of the intermediate frequency amplifier 8 will decrease in accordance with the decrease in gain until the detected current in the output of detector 16 is reduced to the point where the gain decrease relay GD releases. The relay GD is designed to have little, if any, hangover in operation. The relays GD and GID are relatively designed so that the level at which the gain decrease relay GD releases is not sufficiently low to cause the release of the gain increase disabler relay GID. When the gain decrease relay GD releases, the resistance 28 is disconnected from in parallel with the regulating condenser 27 and the gain of the intermediate frequency amplifier 8 is stabilized at the value corresponding to the charge on regulating condenser 27 until such time as the level of the waves in the output of amplifier 8 is reduced to the point where the gain increase disabler relay GID releases. The latter relay preferably has no hangover in operation. The release of relay GID reconnects the charging resistance 26 to regulating condenser 27 so that the operation of the gain increase relay GI in response to the received carrier will cause the gain of the intermediate frequency amplifier 8 to be increased in the manner previously described.

If at any time the reception of carrier waves ceases with cessation in speech transmission at the transmitting terminal, each of the gain control relays which may be operated at the receiving terminal will release so that the gain control circuits are in the condition indicated in the drawing, and the gain of amplifier 8 will remain substantially at the value last established corresponding to the charge on condenser 27 when carrier was removed, although there will be a slight drift to low gain as the charge slowly leaks off the condenser. The relay GI and 13 are arranged to have a short hangover in operation, provided, for example, by designing them to be slow-releasing to the required degree, so that their release will not result in signal clipping. The release of the codan relay 13 will cause the short-circuiting connection 15 to be reapplied across the output of amplifier 10.

By suitable selection of the constants of the circuit associated with the gain increase and decrease relays, i. e., the values of condenser 27, resistances 26 and 28, and battery 25, the rates of gain increase and decrease may be made fast enought to follow fading, but not fast enough to follow the speech envelope.

The sensitivities of the codan circuit and that of the gain increaser circuit operated therethrough are made exactly the same so that the above-mentioned fundamental requirements for the ideal codan circuit are obtained both for it and the gain increaser circuit of the automatic gain control, i. e., both will operate on the weakest usable carrier and will not operate on the strongest static that can be over-ridden. It will be noted also that all of the gain regulation of the receiving circuit is done beyond the point where the codan circuit is bridged, that is, in the intermediate frequency amplifier, so that the signal to noise ratio at the input of the codan is a maximum. Improved operation from a noise standpoint is thus attained.

Various modifications of the circuits which have been illustrated and described which are within the spirit and scope of the invention will be apparent to persons skilled in the art; for example, as indicated above, control energy other than the carrier sent out from the transmitting terminal may be used to control the codan and automatic gain control circuits at the receiver; carrier energy may be used for adjusting receiver gain and control energy of another frequency transmitted during signal transmission for codan operation, or vice versa; the codan circuit may be bridged at some point in front of the point of gain regulation other than the output of the first detector, for example, across the receiving antenna; at least a portion of the gain regulation of the receiver may be made in the audio amplifier; the gain increase relay may be controlled from a different amplifier-detector than used for controlling the codan relay, and it may be connected to the receiving circuit at a different point than the codan amplifier-detector; or the codan function and the gain increase function may be accomplished by a single relay employing two sets of contacts.

What is claimed is:

1. A terminal station for a two-way signaling system including a two-way transmission medium, comprising a circuit for transmitting signals to said medium and a circuit for receiving signals therefrom, transmission apparatus connected to the output of said receiving circuit, means normally disabling said receiving circuit near its output, automatic gain regulating means in said receiving circuit, switching means connected to said receiving circuit in front of the point of gain regulation therein, responsive to impressed control energy of distinctive frequency when signals are being received at the terminal station from said medium to remove the disability from said receiving circuit, and means responsive to signal transmission in said trans-

mitting circuit to disable said switching means, and to prevent change in the gain of said receiving circuit until said signal transmission ceases.

2. A two-way telephone system comprising two stations connected by a two-way transmission medium subject to static, each station comprising a transmitting circuit and a receiving circuit connected to said medium, a subscriber's circuit coupled to the output of said receiving circuit and the input of said transmitting circuit, means normally disabling the output of said receiving circuit to prevent the transmission of static energy to said subscriber's circuit and said transmitting circuit in the absence of received telephone signal energy, means responsive to the initiation of signals in said transmitting circuit for sending out over said medium to the other station said signals and control energy of distinctive frequency, means responsive to the control energy of distinctive frequency received from the other station to automatically regulate the gain of said receiving circuit in accordance with the volume level of the received control energy, switching means connected to said receiving circuit in front of the point of gain regulation therein, selectively responsive to the received control energy to remove the disability from the output of said receiving circuit, means to maintain the gain of the receiving circuit at the last established value when the reception of said control energy ceases, and means responsive to the initiation of signals in said transmitting circuit to disable the switching means connected to said receiving circuit and to substantially prevent change in the gain of the receiving circuit during signal transmission from the station.

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