Mar. 6, 1923. 1,447,773.

L. ESPENSCHIED ET AL.

RADIOTRANSMISSION CONTROL SYSTEM.

FILED SEPT. 15, 1921.

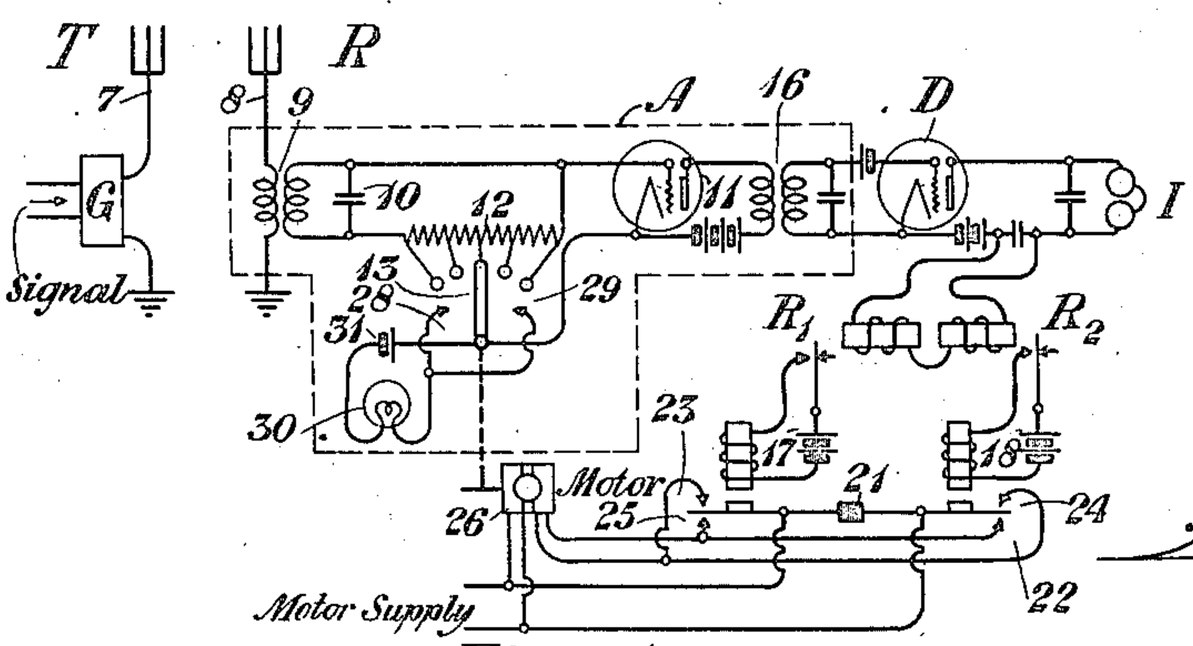

Fig. 1

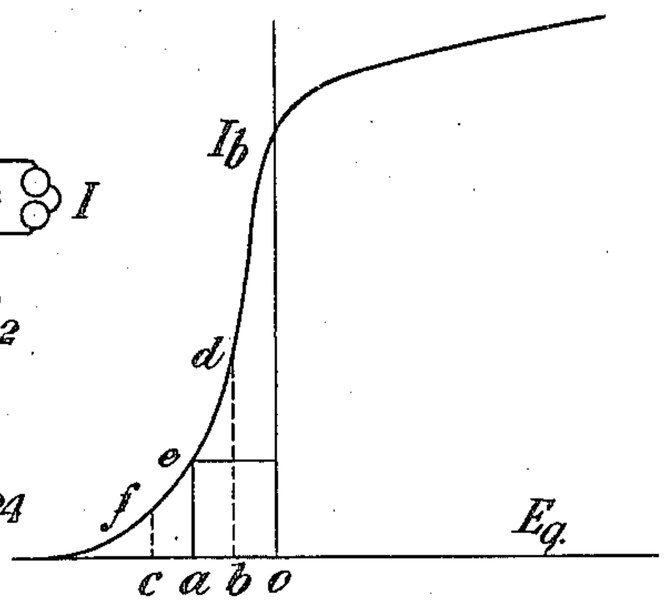

Fig. 2

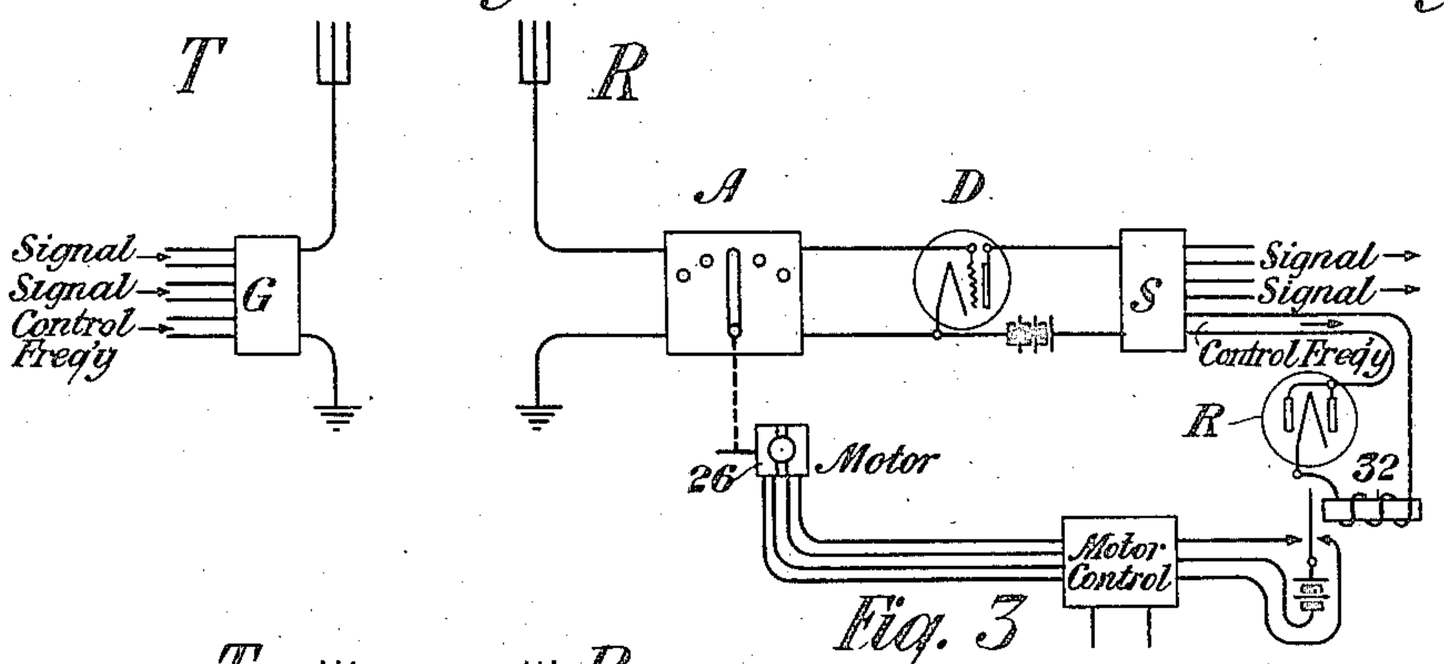

Fig. 3

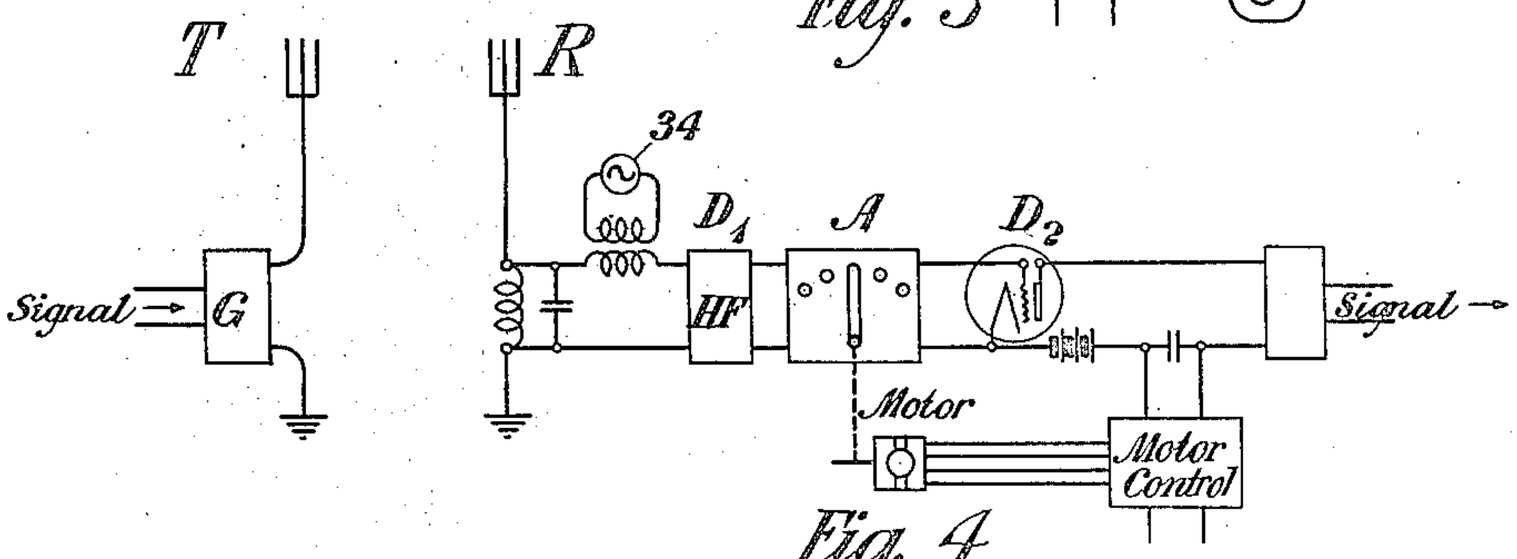

Fig. 4

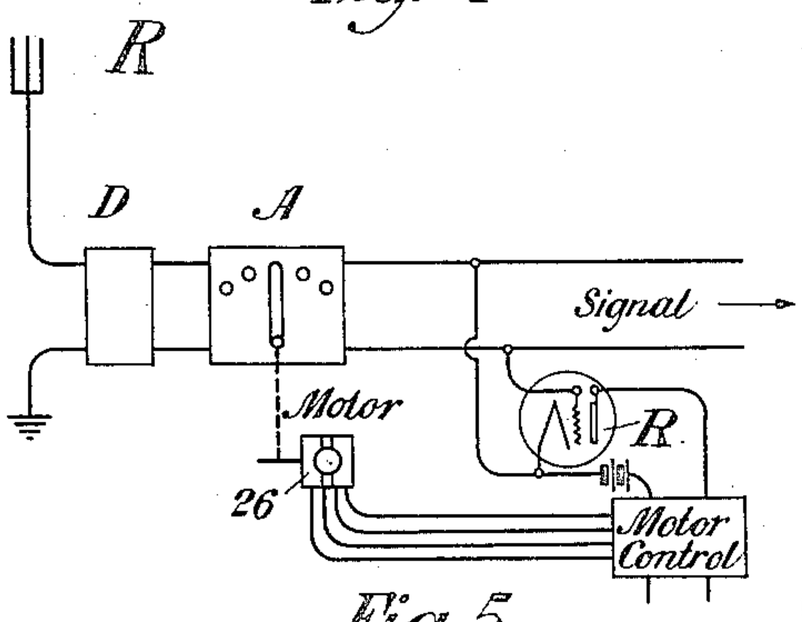

Fig. 5

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UNITED STATES PATENT OFFICE.

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RADIO TRANSMISSION CONTROL SYSTEM.

Application filed September 15, 1921. Serial No. 500,881.

To all whom it may concern:

Be it known that we, LLOYD ESPENSCHIED and RALPH BOWN, residing at Queens and East Orange, in the counties of Queens and Essex and States of New York and New Jersey, respectively, have invented certain Improvements in Radio Transmission Control Systems, of which the following is a specification.

This invention relates to radio signaling, and more particularly to the control of the level of transmission in such signaling. While it will be described as applied especially to radio telephony, for the reason that the need is greatest in that field, it is to be understood that it may be applied equally well to telegraphy, or the transmission of any other signals. Its object is particularly to improve the constancy of transmission characteristics in radio communication.

In radio signaling, there are present to an enormous extent, variations in the transmission characteristics which render it difficult to obtain satisfactory signal conditions and which result, among other things, in large fluctuations in the volume of a telephone or other message being transmitted. These variations may be due to such well-known phenomena as "fading away" or to differences in day and night signaling. Or again, they may be due to changes in the apparatus, either at the sending or receiving stations. If, in long distance radio transmission, repeater stations are used, further possibilities for variations enter. These variations may be sudden or slow, depending on their origin, but in any case detract materially from the effectiveness of radio communication.

In our invention we propose to overcome the effect of these variations by providing compensating means, preferably automatic, and in general, to accomplish this we virtually set aside a signal channel which may be considered as a "pilot" channel over which shall come information as to the transmission character of the ether path through which the signals come. The particular apparatus used to illustrate the invention will be better understood from the following description and the accompanying drawing, in which Figure 1 shows a radio transmission system comprising a transmitting station and a receiving station, the latter showing the invention; Fig. 2 is a curve showing the characteristic of the detector which may be used in connection with Fig. 1; Figs. 3, 4 and 5 are modified forms of circuits showing further applications of the invention.

Referring to Fig. 1, at the station T there is located any suitable generator G of high frequency oscillations, which are to be impressed on the radiating antenna 7. These high frequency oscillations are modified in any appropriate manner with the message or signal to be transmitted. At the receiving station R there is shown a receiving antenna 8, including the primary of a transformer 9. A secondary of this transformer, by means of the condenser 10, may be tuned to the carrier frequency. Across the terminals of the condenser 10 there is shown an amplifier 11, which may be of the well-known three-element vacuum tube type, and the intensity of the high frequency signal impressed on the input of this amplifier may be varied by means of a potentiometer comprising a resistance 12 and swinging arm 13, which makes contact with any one of a number of points of the resistance 12. The output of the amplifier 11, through a transformer 16, is impressed on a detector D, which, for purposes of illustration, has been shown as a vacuum tube detector although we wish it to be understood that many other forms of detectors are suitable. The low frequency output or signal may then be heard in some indicating device, such as the telephones T.

One of the properties of a detector of this type as well as of others is that the direct current component varies with the intensity of the impressed high frequency impulses. This is shown, for example, in Fig. 2, in which the space current flowing from plate to filament is plotted against the voltage impressed on the grid. If the normal operation of the detector is given by the point *a* in Fig. 2, the space current flowing will be equal to *ae*. If high frequency oscillations of amplitude *ab* are now impressed upon the grid, it will be seen that as the grid becomes positive, the increase in current through the tube is larger than the corresponding de-

crease when the grid becomes more negative. Consequently, the direct current component flowing through the tube is larger during the reception of signals than when no signals are received, and this increase above the normal space current will be dependent upon the amplitude of the high frequency input. We make use of this phenomenon to indicate the magnitude of the high frequency waves falling on the receiving antenna. If, for any reason, the attenuation of the waves passing through the ether is increased, the amplitude of the waves is correspondingly decreased, and the departure of the space current from the normal value *ae* of Fig. 2 is comparatively small. Use may be made of this fact to increase the gain due to the amplifier 11, and it is our purpose to adjust this gain automatically to such an extent that the intensity of the signal received in the indicator I remains substantially constant. We accomplish this by placing in the output circuit of the detector D to relays R_1 and R_2, through which the direct current component of the detector flows. The relay R_1 is shown as a lower limit relay and relay R_2 is shown as an upper limit relay. These relays control respectively, the circuits 17 and 18, each containing a relay. Mounted adjacent to these last relays is a switch mechanism consisting of a rocking member 21, which, when tilted in one direction, will make contact with points 22 and 23, and when tilted in the other direction, will make contact with points 24 and 25. The tilting member 21 is made up of two conductors separated by an insulating block and to these two conductors are connected, respectively, the supply terminals from a suitable source of electric power. The contacts 22 to 25 are connected to a motor 26, which, in turn, by any appropriate mechanism, may be used to rotate the arm 13 in the one direction or the other.

The operation of the circuit is as follows: incoming messages are amplified by the amplifier 11 to an extent depending upon the setting of the arm 13 on the potentiometer or gain control. The amplified output impressed on the detector D will produce a signal in the indicator I of a certain volume. The space current through the relays R_1 and R_2 is such that for normal volume neither of the local circuits 17 and 18 is closed. If, however, the attenuation in transmission is such that the signals arriving at the detector D are weak, the space current will be relatively small and the lower limit relay R_1 will permit the closing of the circuit 17. This circuit, operating upon the rocking member 21, will connect the motor supply through the contacts 22 and 23, causing the motor 26 to turn in such a direction as to step up the arm 13, thereby increasing the gain of the amplifier 11. This stepping up of the gain will continue until the increase in the direct current component through the relay R_1 is sufficient to open the circuit 17. In case the intensity of the signals becomes too high, the space current through the relay R_2 will be sufficient to close the local circuit 18, which will then tilt the member 21 in a direction to make contact with the points 24 and 25, thereby reversing the connections to the motor 26. This will result in a stepping down of the gain of the amplifier until the volume of the signal at the indicator I is restored to normal. We have thus provided a system which will automatically adjust itself for variations in the transmission characteristics of the system as a whole in such a manner as to maintain a uniform transmission level, and in this we have virtually made use of the carrier oscillations of the message as a "pilot" to indicate the state or condition of the ether through which the waves have been transmitted.

Under extreme conditions of variation it may be that the potentiometer arm 13 may be moved to one extreme limit or the other of the potentiometer 12, and for such cases it is frequently desirable to have notification through some alarm system. For the purposes of illustration we have shown such an alarm system in Fig. 1, consisting of two contact points 28 and 29 in parallel with each other and in series with a lamp 30, and battery 31 which then connects with the arm 13. The contacts 28 and 29 would be so adjusted in position that the arm 13 makes contact with the one or the other upon reaching one extreme position or the other. While we have shown the indicator as consisting of a lamp 30, it is obvious that this may be any other suitable alarm device, such as a bell.

We have described the detector D as being one in which there is an increase in the direct current component during the reception of high frequency signals. Such detectors may, however, work in the opposite direction, this depending upon the curvature of the characteristic. In the case of a vacuum tube detector, it is usual to operate it on the lower curve, as shown in Fig. 2. If, however, it should be operated on the upper curve of this characteristic, it is apparent that there would then be a decrease in the direct current component, this decrease being greater as the intensity of the signal increased. In this event, it would obviously be necessary to reverse the connections for the motor 26.

One of the advantages of using the change in the direct current component flowing through the particular detector described, as well as other detectors, is that the power available from this source is in general greater than that of the low frequency signal obtained from detection. Also this change in direct component is not subject to as

great fluctuations as the message current and therefore apparatus controlled by such change in direct current component is more certain in operation.

A modification of the method used in Fig. 1 is shown in Fig. 3. In this case, instead of using the carrier frequency as a pilot to indicate the condition of the ether, we propose to modulate the carrier frequency with some suitable lower frequency, thus setting aside a signal channel for pilot purposes. The intensity of this special signal, when received, may be used to control the amplification. In Fig. 3, T again represents the transmitting station with the antenna of which is associated a generator G. The high frequency oscillations may be modulated with respect to one or more signal frequencies or multiplex purposes, as is well understood in the art, and at the same time is modulated with some control frequency. The receiving station R includes an amplifying and gain control mechanism shown conventionally at A, this including, for example, the portion of the circuit included in the dotted lines and indicated A in Fig. 1. The amplified output is impressed on a detector D in the output circuit of which may be connected appropriate networks S for separating the plurality of signals from each other and from the control frequency. The control frequency may be passed to a rectifier R in series with which is a relay 32, which, through its front and back contacts, is adapted to control the motor 26, this in turn operating the gain control in the one direction or the other as described in connection with Fig. 1.

The control frequency may obviously be varied over a wide range but in general it will be desirable to have this outside the frequency ranges of the signals to be transmitted. If, for example, one of these signals is a telephone signal and the other is a telegraph signal, it would be convenient to give the control frequency some value, such as 5,000. In this modification, the control frequency becomes the pilot channel to indicate the condition of transmission and operates to step up or step down the gain control in accordance with the conditions it may have encountered in arriving at the station R.

Fig. 4 shows a further modification of the invention, in which the high frequency message received at the station R is stepped down by the detector D_1 to some intermediate frequency lower than the carrier frequency and, in general, higher than the speech frequencies, this latter being accomplished by impressing in series on the input of the detector D_1 the received high frequency and locally generated oscillations from a generator 34. The output from the high frequency detector D_1 may then be impressed upon an amplifier A with gain control of the same form as indicated at A in Fig. 1. The amplified output may then be impressed on the low frequency detector D_2 and, through a motor control mechanism of the form shown in Fig. 1, may be used to control the motor which, in turn, operates the gain control.

It is possible to receive the incoming high frequency message directly on a detector and follow this by amplification, as illustrated in Fig. 5. In this case, there is shown bridged across the output of the amplifier which goes directly to the indicator a circuit containing a rectifier R, the output of which, through a motor control device, is able to control the motor 26 in a manner heretofore described. If the volume of transmission level of the signal passing to the indicator I is below normal, there will be a corresponding decrease in the output of the rectifier R, which will then operate the amplifier A. If, however, the incoming waves are of high amplitude, the increased output of the rectifier R will operate in a compensatory manner on the amplifier A.

In using the term "detector" herein, it is to be taken in a broad sense, as including any device which upon reception of high frequency signals will produce a rectified effect, either electrical or mechanical. It may, for example, be a thermo-junction detector or a hot wire detector in both of which cases a direct current component is produced, dependent on the amplitude of the received high frequency waves. On the other hand the detector may be a hot wire device in which the average change in dimensions depends on the average amplitude of the high frequency waves, and as the mechanical rectified effect varies it may be used to open or close auxiliary circuits to control the amplifier gain in a manner described in connection with various figures. Again, it may consist of a dynamometer of well known forms such as that shown in patent to Fessenden, 706,735 of August 12, 1902, the rectified effect being here a mechanical effect which may be used to open and close a circuit. Such a device may obviously be attached to the receiving circuit either ahead of or after the amplifier.

We would not, however, place too much emphasis on the nature of the detecting device but rather on the designation of a radio signal channel to give information as to the transmission character of the signal path. Any means, then, which will indicate the intensity of the incoming waves and control the amplifier gain may be used.

While the invention has been described as operating at the receiver on that receiver, other methods of raising or lowering the transmission level may be used. For example, in case of two-way signaling in which

there is a transmitting and a receiving equipment at each station a low volume at a receiver, indicating poor transmission, could be used also to cause the output of more energy from the transmitter at that station, thus raising the transmission level for the return message.

The variations which we have described are for illustrative purposes only. It is to be understood that many other variations may be made in the circuit arrangements, or in the details of the motor control and gain control, all of which variations may be made without departing from the spirit or scope of this invention as indicated in the following claims.

What is claimed is:

1. In radio signaling, the method of maintaining a uniform transmission level, which consists in varying the amplification of the receiver to compensate for transmission variations.

2. In a radio signaling system, the method of maintaining a uniform transmission level which consists in using a radio signal channel as a pilot to indicate the transmission character of the transmitting medium and causing this indication to operate on the terminal station apparatus to increase or decrease the power accordingly.

3. In a radio signaling system comprising a detector, the method of maintaining a uniform transmission level, which consists in causing the change in average current through the detector to vary the amplification of the signal.

4. In radio signaling, the method of maintaining a uniform transmission level, which consists in amplifying the incoming signal, impressing the amplified signals on a detector, and causing the variations in average detector currents due to transmission changes to vary the amplification accordingly.

5. In a radio receiving system, means for adjusting the transmission level of the received signal, said means being responsive to changes in the transmission character of the transmitting ether medium.

6. In a radio receiving circuit comprising a detector, means associated therewith responsive to the intensity of the incoming signal for maintaining a unform transmission level for the signals.

7. In a radio receiving circuit comprising a detector and an amplifier, means associated therewith responsive to the intensity of the incoming signal for changing the gain of the amplifier.

8. In a radio receiving circuit comprising a detector and an amplifier, means associated therewith responsive to changes in the transmitting character of the transmitting ether medium and adapted to maintain uniform transmission level.

9. In a radio receiving circuit comprising a detector and an amplifier, means associated therewith responsive to the detector for changing the gain of the amplifier.

10. In a radio receiving circuit comprising a detector and an amplifier, means associated therewith responsive to the changes in the direct current component of the detector for changing the gain of the amplifier.

11. In a radio receiving circuit comprising an amplifier and a vacuum tube detector, means responsive to the average space current through the detector for changing the amplification of the amplifier.

12. In a radio receiving circuit comprising an amplifier and gain control therefor, and a vacuum tube detector, means responsive to the average space current through the detector for changing the gain control in accordance with variations in the transmission level.

In testimony whereof, we have signed our names to this specification this 13th day of September, 1921.

LLOYD ESPENSCHIED.
RALPH BOWN.