May 7, 1946. L. D. WHITELOCK 2,399,968

RECEIVING APPARATUS FOR COMMUNICATION SYSTEMS

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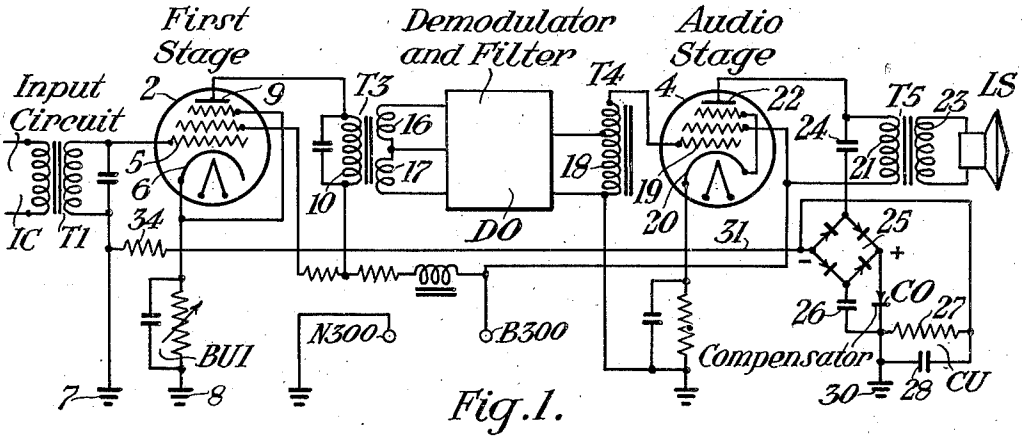

Fig. 1.

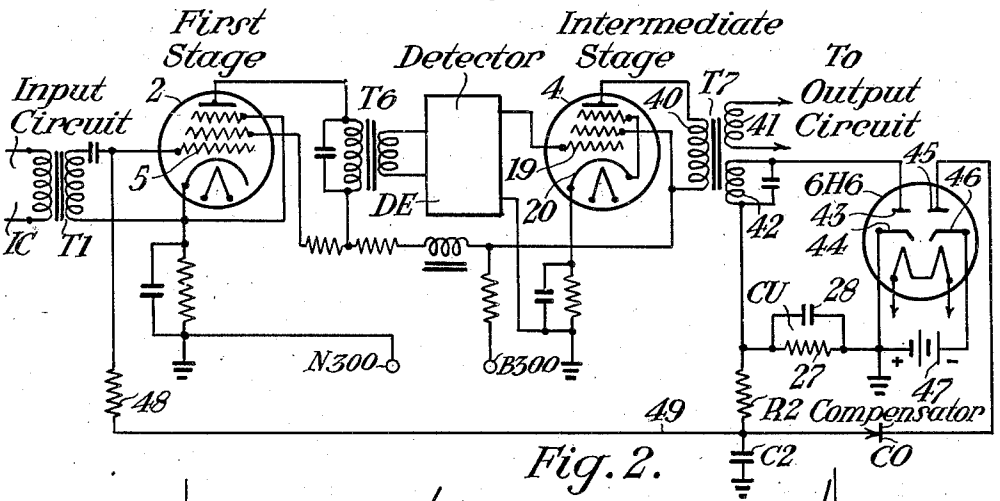

Fig. 2.

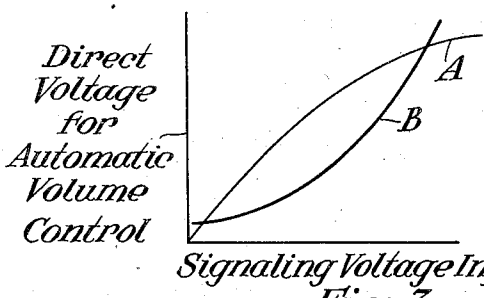

Fig. 3.

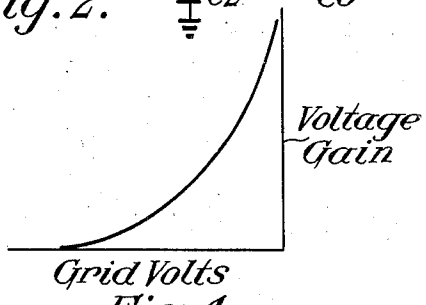

Fig. 4.

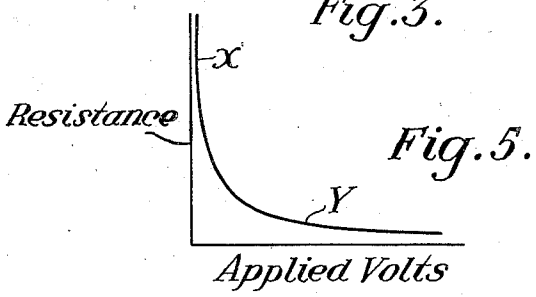

Fig. 5.

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RECEIVING APPARATUS FOR COMMUNICATION SYSTEMS

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2 Claims. (Cl. 250—20)

My invention relates to receiving apparatus for communication systems, and more particularly to receiving apparatus which includes an electron tube amplifier.

Communication systems using electron tube amplifiers in the receiving apparatus frequently require automatic volume control means to control the amplifier gain during periods in which the energy level of the input current exceeds a normal value.

A feature of my invention is the provision of a communication system receiving apparatus incorporating novel and improved means for controlling the amplifier gain of electron tubes used in the receiving apparatus.

Another feature of my invention is the provision of receiving apparatus of the type here involved including a novel automatic volume control means provided with a compensator characterized by a falling resistance when the voltage applied thereto increases and by which compensator the non-linear characteristic of the gain curve of an electron tube is compensated.

Other features, objects and advantages of my invention will appear as the specification progresses.

I shall describe two forms of apparatus embodying my invention and shall then point out the novel features thereof in claims.

In the accompanying drawing, Fig. 1 is a diagrammatic view showing one form of receiving apparatus embodying my invention for use in a communication system employing an oscillating current, such as a carrier telephone current. Fig. 2 is a diagrammatic view showing apparatus embodying my invention suitable for use for radio reception. Figs. 3, 4 and 5 are diagrams of operating characteristics of the apparatus of Figs. 1 and 2. In each of the different views like reference characters are used to designate similar parts.

Receiving apparatus of the type here contemplated frequently employs a rectifier to rectify a portion of the output of a final or a preselected stage of the receiving apparatus for obtaining a variable direct voltage which is used to control the amplifier gain of one or more earlier stages of the apparatus. The saturation of the available automatic volume control voltage obtained by such a circuit is illustrated by curve A of Fig. 3. The curve of Fig. 4 illustrates the change in voltage gain of an amplifier tube with a change in grid bias. It is to be seen from the curve of Fig. 4, that the desired type of curve for automatic volume control voltage where a substantially constant energy level of the output current is to be maintained is that illustrated by curve B of Fig. 3. A comparison of curves A and B of Fig. 3 readily shows why a substantially constant output current may not be maintained by the circuit arrangement heretofore used for obtaining an automatic volume control voltage. To improve the automatic volume control means heretofore used, I interpose a compensator having a falling resistance characteristic of the nature illustrated by the curve of Fig. 5 in the automatic volume control means and by the use of which compensator the non-linearity of the amplifier gain curve of an electron tube is compensated with the result that an automatic volume control voltage of the character illustrated by curve B of Fig. 3 is obtained.

Referring now to Fig. 1, the receiving apparatus includes a first stage of high frequency amplification, a demodulator-filter and one stage of low or audio frequency amplification. The first or high frequency stage of amplification includes an electron tube 2 which as here shown is an indirectly heated cathode tube, the filament of which is constantly heated in the usual manner. A receiving or input circuit indicated by the reference character IC is supplied at some remote station not shown with an oscillating current, such as, for example, a carrier telephone current, and is coupled to the control grid 5 and cathode 6 of tube 2 through a transformer T1, the control grid circuit of tube 2 being completed through a biasing unit BU1 and ground electrodes 7 and 8. Plate circuit voltage is applied to plate 9 and cathode 6 of tube 2 from a source whose terminals are indicated at B300 and N300, and which plate circuit includes winding 10 of a coupling transformer T3 to couple the plate circuit of tube 2 with a demodulator-filter DO, windings 16 and 17 of transformer T3 being connected to the input of demodulator-filter DO. Demodulator-filter DO is shown conventionally since its specific structure forms no part of my invention. It may be of any one of several well-known forms, for example, it may be a balanced demodulator with a band pass filter. It is sufficient for the present application to point out that a modulated carrier current such as a single side band telephone current is mixed with a carrier for demodulation and then applied to a band pass filter so that the voice frequencies only are supplied to winding 18 of a transformer T4. Winding 18 of transformer T4 is in turn connected across control grid 19 and cathode 20 of an electron tube 4 of the audio or low frequency

stage of amplification. Tube 4 as here shown is of the indirectly heated cathode type, the filament of which is constantly heated and the plate 22 of which is supplied with voltage from the B300–N300 current source through a winding 21 of an output transformer T5. A secondary winding 23 of transformer T5 is connected to a loud speaker LS so that the voice frequencies supplied to tube 4 are reproduced at the loud speaker.

An automatic volume control means is connected across the output circuit of tube 4 to be energized by a portion of the alternating current component of the plate circuit current. This means comprises a condenser 24, a full wave rectifier 25, a control unit CU consisting of a resistor 27 and a condenser 28 in multiple, another condenser 26 and a compensator CO. The positive output terminal of rectifier 25 is connected to one terminal of unit CU through the compensator CO, and the same terminal of unit CU is also connected to a ground electrode 30. The other terminal of unit CU and the negative terminal of rectifier 25 are connected to the control grid 5 of tube 2 through a connection including wire 31 and a resistor 34. A portion of the alternating current component of the plate circuit current for tube 4 is rectified by rectifier 25 and the resulting unidirectional current is caused to flow through compensator CO and resistor 27 of unit CU so that condenser 28 is charged at a potential substantially equal to the average voltage drop across resistor 27, the flow of current being in such direction that the positive terminal of unit CU is adjacent the ground electrode 30. Compensator CO is characterized by a falling resistance characteristic. For example, compensator CO may be a copper oxide rectifier element of the type having a falling resistance characteristic of the form illustrated by the curve of Fig. 5. That is to say, such an element has in its low resistance or pass direction a relatively high resistance when low voltages are applied thereto and such resistance falls rapidly in value to a relatively low value as the voltage applied thereto is increased. Compensator CO is interposed between the positive output terminal of rectifier 25 and the corresponding terminal of unit CU, and the parts are so proportioned that a normal predetermined output energy level for the plate circuit of tube 4 impresses a relatively low voltage across compensator CO and unit CU with the result that the resistance of compensator CO is relatively high and is large as compared with the fixed resistance of resistor 27. This means that the major portion of such direct voltage is consumed in a voltage drop through compensator CO. When the energy level of the plate circuit of tube 4 is relatively large, the voltage impressed across compensator CO and unit CU is increased so that the resistance of compensator CO is now relatively low while that of resistor 27 is substantially the same as before. Under this condition the major portion of the direct voltage is consumed by resistor 27, and only a small portion is consumed at compensator CO. Looking at Fig. 5, the compensator CO is arranged to be worked at a point such as X of the curve at the normal output of the amplifier, and is worked at another point such as Y, of its operating curve for an output of large magnitude. The voltage developed across unit CU is applied to the control grid of tube 2 as an automatic volume control voltage, this voltage being applied to the control grid 5 of tube 2 through the connection including resistor 34.

It is to be seen therefore that with the apparatus of Fig. 1 an incoming carrier telephone current of a normal predetermined value is amplified at tube 2, demodulated, further amplified at tube 4 and reproduced at the loud speaker, the output energy level of the amplifier tube 4 being such that substantially no bias voltage is applied through unit CU to the tube 2. As the magnitude of such incoming current increases, the charge created across unit CU is built up along a curve corresponding to curve B of Fig. 3 due to the characteristic of compensator CO. That is, the automatic volume control voltage created across unit CU increases faster than the energy level of the output of the amplifier. Such automatic volume control voltage applied to tube 2 reduces the amplifier gain so that a substantially constant value of output current for the amplifier is obtained. Additional stages of amplification can be of course included in the receiving apparatus if desired and the automatic volume control voltage derived through unit CU applied to such additional stages if desired.

Referring to Fig. 2, I have here shown the essential parts of a radio receiver apparatus. An input circuit IC connected to an antenna or similar device is coupled to the control grid of first stage tube 2 through transformer T1, while the output or plate circuit of tube 2 is coupled through a transformer T6 to a detector shown conventionally at DE. The specific construction of such detector DE is immaterial and may be any one of several well-known arrangements. The output of detector DE is connected across control grid 19 and cathode 20 of tube 4 of a following or intermediate stage of amplification. The plate circuit of tube 4 includes a primary winding 40 of a transformer T7. One secondary winding 41 of transformer T7 is connected to an output circuit not shown, and another secondary winding 42 connected to an automatic volume control means which includes a twin diode rectifier tube 6H6, a control unit CU, a filter comprising a resistor R2 and a condenser C2, and a compensator CO. The portion of the amplified energy passed to winding 42 of transformer T7 is rectified at anode 43 and cathode 44 of tube 6H6 and supplied to unit CU, the resistor 27 of unit CU acting as a load resistance and condenser 28 of the unit being charged at a potential substantially equal to the average voltage drop across resistor 27, the same as in Fig. 1. A battery 47 provides a fixed voltage which is applied to anode 45 and cathode 46 of tube 6H6 through resistor 27 of unit CU, resistor R2 and compensator CO, compensator CO being characterized by a falling resistance the same as in Fig. 1. At the normal voltage of battery 47, compensator CO is operated at point Y of its characteristic curve as illustrated in Fig. 5. When the electromotive force of winding 42 of output transformer T7 becomes large, the rectified current flowing in resistor 27 creates a voltage drop that tends to cause anode 45 to be less positive in potential with respect to cathode 46. This change tends to cause a lower voltage to be applied to compensator CO and hence its resistance rapidly increases with the result that the automatic volume control voltage applied to control grid 5 of tube 2 through a connection including resistor 48 and wire 49 in-

creases in a manner illustrated by curve B of Fig. 3.

It is to be pointed out that the compensator CO of Fig. 2 may be interposed in the connection between winding 42 and anode 43 of tube 6H6, in which case it will govern the automatic volume control voltage by governing the voltage drop across unit CU.

Apparatus embodying my invention has the advantage that as the energy level of the input current increases above a predetermined normal value, the automatic volume control voltage is increased at a faster rate and so the non-linear condition of the amplifier curve of an electron tube is compensated. Also, apparatus embodying my invention tends to increase the initial sensitivity of the automatic volume control circuit and tends to maintain a highly uniform output energy level.

Although I have herein shown and described but two forms of receiving apparatus for communication systems embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In receiving apparatus for use with an oscillating communication current, the combination comprising, a plurality of electron tube amplifier stages arranged in cascade, a grid circuit for the tube of a first one of said stages to receive such communication current, a plate circuit including a source of direct current for the tube of a final one of said stages, a multiple winding transformer having a first winding interposed in said plate circuit, a receiver connected to a second winding of said transformer to receive said communication current as amplified by said stages, a twin diode rectifier tube, a control unit consisting of a first resistor and a condenser in multiple, a compensator characterised by a falling resistance as the applied voltage increases, a battery, a second resistor; said control unit connected to said battery through said second resistor, said compensator and one side of said rectifier tube in series to create a normal voltage drop across said unit; said unit connected to a third winding of said transformer through the other side of said rectifier tube to create across said unit a direct voltage proportional to the amplitude of said communication current, and said control unit and said second resistor in series connected between the grid and cathode of the tube of at least one of said stages to control the amplifier gain of that tube by the resultant voltage thus created across said control unit.

2. In receiving apparatus for use with an oscillating communication current, the combination comprising, a plurality of electron tube amplifier stages arranged in cascade, a grid circuit for the tube of a first one of said stages to receive such communication current, a plate circuit including a source of direct current for the tube of a final one of said stages to reproduce said communication current as amplified by said stages, an output circuit coupled to said plate circuit to receive such amplified communication current, a control unit consisting of a resistor and a condenser in multiple, a rectifier, a compensator characterized by a falling resistance as the applied voltage is increased; circuit means including said control unit, rectifier and compensator coupled to said plate circuit to receive such communication current in multiple with said output circuit to create a voltage across said unit that is amplified proportional to the communication current and is made to vary at a rate that substantially corresponds to the amplifier gain curve of the tube of said first stage, and other circuit means to connect said control unit to the grid circuit of said first stage tube to govern its gain by the voltage thus created across said unit.

LELAND D. WHITELOCK.