April 26, 1949. L. J. HEATON-ARMSTRONG 2,468,066

ELECTRONIC AMPLIFIER

Filed Nov. 11, 1944

FIG. 1.

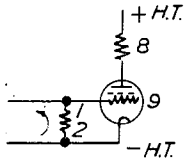


FIG. 2.

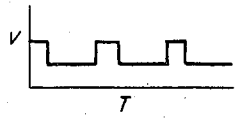


FIG. 5.

FIG. 4.

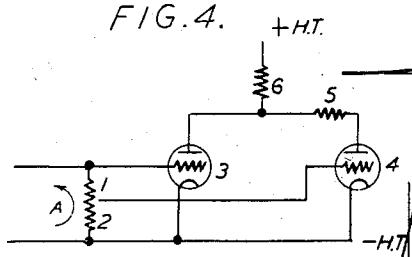
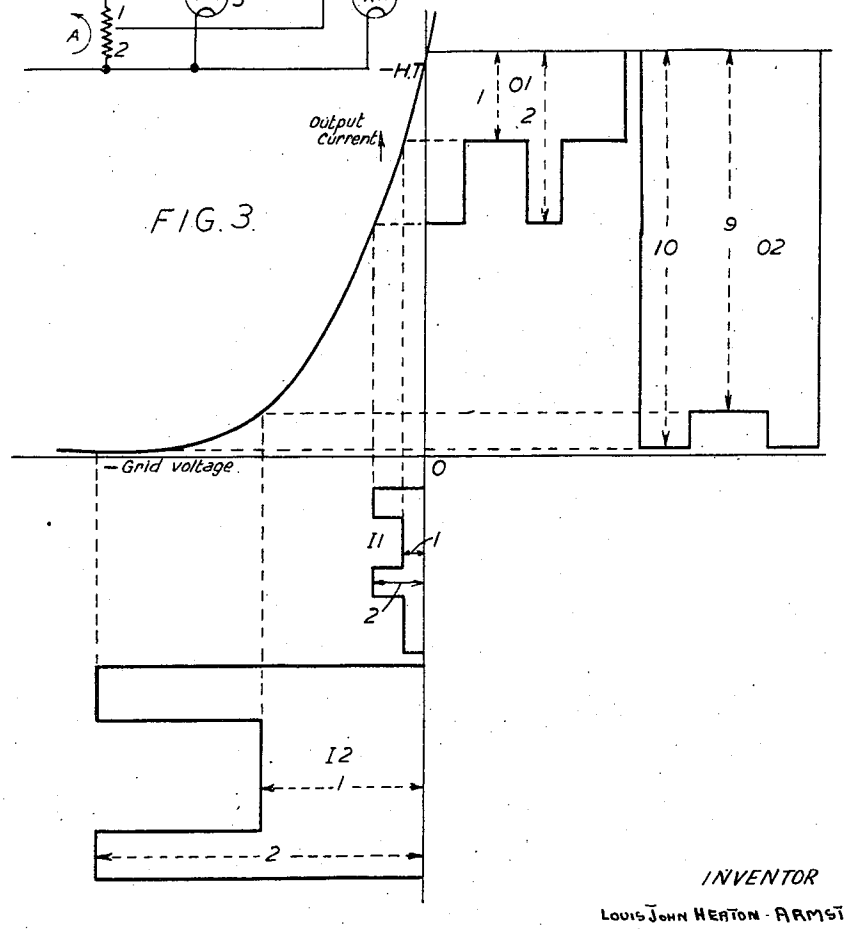


FIG. 3.



INVENTOR

LOUIS JOHN HEATON-ARMSTRONG

BY

Robert Harding Jr.

ATTORNEY

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ELECTRONIC AMPLIFIER

Louis John Heaton-Armstrong, London, England, assignor, by mesne assignments, to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

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3 Claims. (Cl. 179—171)

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The present invention relates to radio receivers for use in radio navigational systems of the kind employing complementary signals, for example A and N of equal strengths on respective sides of a desired path, for example an approach path or a glide path for aircraft so as to produce on said path a continuous dash or no signal. The invention is particularly, though not solely, applicable to equipments in which an aural indication is given, for example by means of head phones.

The complementary signals received by a receiver on the path produce in the output of the receiver a current or voltage of constant amplitude which is normally used to give a continuous dash in the earphones or a zero indication or no signal on visual indicating apparatus. When the receiver is "off course," that is, off the said path there is a difference between the amplitudes of the dot and dash signals received and the louder or greater of the two (or the smaller) indicates on which side of the path the receiver is located. When the receiver is at a great distance from the transmitters radiating the fields modulated in the complementary signal manner, for a specified degree off course, the difference in amplitudes of the dot and dash signals is small and the nearer the receiver is to the transmitter the greater does this difference become, but as the receiver approaches the path the difference diminishes until when on the path equality of amplitudes of the signals is attained. These facts will be evident from a study of the two directive field distributions overlapping along the path since the lines of equal field strengths are closer together nearer the origins of the distributions than further afield. Thus the least departure from the equi-signal path the nearer the receiver approaches the origins, the greater is the difference in amplitude between the dot and dash signals.

One object of the invention is to provide receiving arrangements in the output of which the signal changes are less violent than they would otherwise be when the aeroplane is near the transmitter so that the pilot does not have to try to keep the aeroplane within impossibly narrow limits when about to land.

Another object is to enable the best conditions

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for the observer and for the electrical operation of the system to be fulfilled.

Now it has been found in practice that when the receiver is moved from the equi-signal zone to a point where the ratio of the signal amplitudes is 95:100 the human ear can distinguish this ratio more easily than any other. It is the ratio where the average human ear distinguishes that the equi-signal is no longer being received and that A—N or such complementary signals are being received. Electrically, however, it is desirable that when the observer hears this ratio the actual signal should be changing by a greater ratio say 80:100 as interfering signals or reflections are then of less account. More specifically the object of this invention is to provide arrangements by which this difference in amplitude of the signals is reduced or the ratio of the amplitudes is reduced in the output of the receiver, for application to a pair of headphones or other indicating instrument.

According to the present invention, a radio receiver for use in a radio navigational system of the kind hereinbefore specified comprises means for making the receiver output dot-dash signal amplitude ratio optimum for aural or visual observation irrespective of the input amplitude ratio.

In carrying out the invention any known type of compressor amplifier may be used in which the amplification is non-linearly inversely proportional to the amplitudes of the input signals.

In one specific way of carrying out the invention, which will be more fully described hereinafter, the amplifier of the receiver is a non-linear amplifier, that is, an amplifier so designed that the overall characteristic curve, namely output current versus input voltage, has a decreasing slope as the negative input grid voltage is increased whereas in the normal type of amplifier the slopes of the main portion of the characteristic curve is constant. In one practical embodiment this desired characteristic is obtained by the combination of two electron discharge devices whose individual characteristics are suitably adjusted.

The invention will be better understood from the following description taken in conjunction with the accompanying drawings in which—

Fig. 1 shows diagrammatically an embodiment

of the invention in the form of a single valve amplifier;

Fig. 2 represents the signal voltages received at a receiver;

Fig. 3 shows a typical characteristic curve of the amplifier of Fig. 1;

Fig. 4 shows a preferred form of amplifier embodying the invention; and

Fig. 5 shows the characteristic curve of the amplifier shown in Fig. 4.

Referring firstly to Figs. 1 and 2, the signal received is shown in Fig. 2 as a voltage V which is developed across resistance 1, 2 (Fig. 1) in the input grid circuit of the well known variable-μ amplifier 3, Fig. 1. The signals are applied as negative voltages as indicated by the arrow A in Fig. 1 indicating that the current flows in the resistance from 2 to 1. The voltage V varies from one value to another in dot-dash rhythm, the variation between dot and dash amplitudes depending upon the degree of "off course" and distance from the transmitting antennae. By means of the application of the signals in the manner specified the grid of the amplifier is swung negative with respect to the cathode and a signal as shown at 01 and 02 Fig. 3 is obtained, the input signal being represented respectively by 11 and 12 Fig. 3. It will be seen that the dot-dash ratio of the signal in the output of the amplifier becomes smaller and approaches unity as the mean input level increases.

It will be observed that the signals are inverted, the stronger input dot signal being the weaker in the output, but one more amplification stage will reinvert the signals so that the stronger dot input signal will be represented by the stronger dot output signal. It will be thus seen that the dash-dot ratio of the output signal 02 is approximately 9:10 whereas that of the input signal 12 is approximately 1:2. In the case of the lower level signal input 11 which also has a dot-dash amplitude ratio of 1:2, the amplitude ratio of the output signal is also approximately 1:2.

An amplifier having a type of characteristic as that shown in Figure 3 and which may be varied to suit circumstances is shown in Fig. 4.

The amplifier shown in Fig. 4 comprises two electron discharge valves 3, 4 feeding into a common load resistance 6 and whose inputs are taken from different points on an input resistance 1, 2. The valve 3 has a characteristic as shown at 10 in Fig. 5 while valve 4 on account of the high resistance 5 in its anode circuit and the smaller proportion of the input voltage applied to its grid has a characteristic as shown at 11 in Fig. 5. The overall characteristic is shown at 12 Fig. 5 which is the result of the combination of curves 10 and 11. Curve 12 has a more gradual bend than the curve of Fig. 3 and the shape of the bend may be varied by proportioning the values of the resistances 1, 2 and 5. Curve 12 is not the mere addition of curves 10 and 11. For curves 10 and 11 the abscissae represent grid volts. For curve 12 the abscissae represent the voltage across the resistance 1, 2 and part of which only is the grid voltage of valve 4.

This non-linear amplification of the input signals may be used in two ways:

1. Independently of the maximum amplitude value of the received signal. In this case a good automatic gain or volume control is used on the receiver prior to the non-linear amplifier, in order to keep the maximum amplitude of the signal applied to the non-linear amplifier constant. In this case the curve 12 should have a very gradual slope so that small differences in anode current are obtained for large differences in the signal voltages applied to the input of the non-linear amplifier. In this way the listener will hear a dot-dash signal whose ratio might be say 95:100 in his telephone whereas the signal applied to the receiver might have a dot-dash ratio of 80:100. It has been found in practice that a ratio of 95:100 is best for listening to as it is the ratio which is just apparent to the ear. From the point of view of reliable operation, however, it is better to work with a large ratio say 80:100 as interfering signals, noise etc., are thus less noticeable. Thus the best listening and operating condition can be combined by adjusting the effective portion of the curve 12 for the constant level input signal of the non-linear amplifier.

2. It is sometimes desirable to make the non-linearity of the amplification small, i. e. the divergence from linear amplification small, when the amplitudes of the input signals are small and the receiver is far from the transmitter although near the approach path, and to make the amplification diverge more from linearity as the amplitudes of the signals increase, i. e. as the receiver approaches the transmitter. For example, in a particular blind approach system, when an aircraft is far away, if the aircraft departs from the approach path or course by 100 ft. the receiver must be very sensitive to record this departure, whilst if at a few hundred yards from the transmitter for the same departure from course the indications would be too violent. One foot off course at a distance of 440 yards from the transmitter produces approximately the same amplitude ratio as 80 ft. off course at 20 miles from the transmitter. It is, therefore, desirable to decrease the dot-dash signal amplitude differences as the dot-dash signal amplitudes increase when the receiver is nearing the transmitter. This variation of amplitude difference of the received signals with distance may be obtained by utilising known automatic gain control arrangements which are slow enough not to affect the A—N signal ratio, but allow the average amplitude of the signals applied to resistances 1 and 2 to increase slightly although the input signal to the receiver may greatly increase. For example, if the relative field strength of the signal at 20 miles and 440 yards was 80:1, the automatic gain control might limit the ratio of the voltages applied to resistances 1 and 2 to 3:1. Thus the value of the input signal voltages to the non-linear amplifier would move round the bend of curve in Fig. 5 and the anode current change in the output of the non-linear amplifier for a given voltage change at the input of the receiver becomes less the greater the said input voltage.

Whilst two embodiments only have been described, by way of example, other embodiments falling within the scope of the invention as defined in the appended claims will occur to those skilled in the art.

What is claimed is:

1. In combination in a radio receiver, an output circuit including a resistor, an amplifier unit comprising a plurality of tubes connected in parallel and each having a cathode, an anode and a control grid, a common output circuit for the anodes of said tubes, connections between said grids and points on said resistor at different potentials, and a resistor between the anode of one of said tubes and said common output circuit.

2. In combination in a radio receiver, an output circuit for the receiver including a resistor,

an amplifier unit comprising a plurality of tubes each having a cathode, an anode and a control grid, a common output circuit for the anodes of said tubes, means for applying a different portion of the voltage drop across the resistor in said first output circuit to the control grids of different tubes, and a resistor in the anode circuit of one of said tubes.

3. An amplifier unit adapted to have an automatically variable amplification characteristic comprising an input circuit, a plurality of tubes each having at least a cathode, an anode and a control grid, a common output circuit for the anodes of said tubes, a resistor connected between said input circuit and the grid of one of said tubes, and a resistor in the anode circuit of one of said tubes.

LOUIS JOHN HEATON-ARMSTRONG.

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