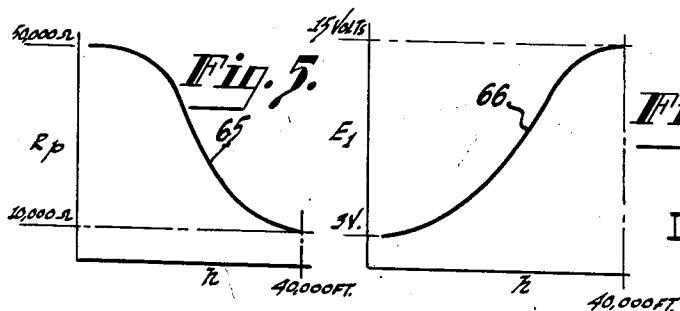
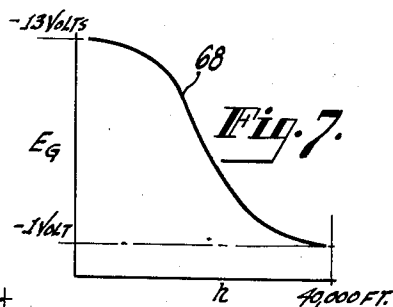
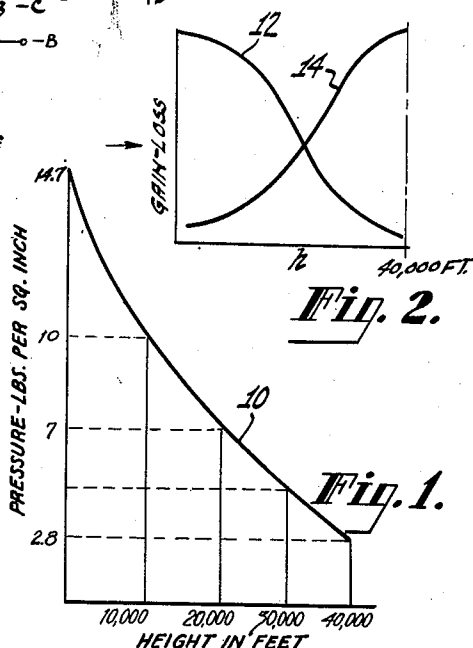
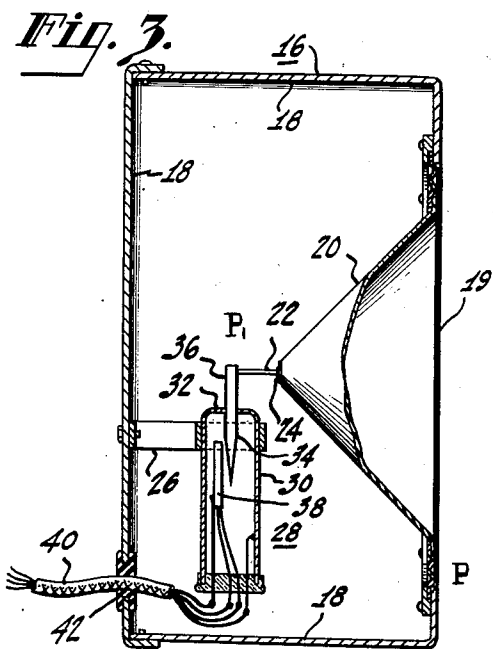
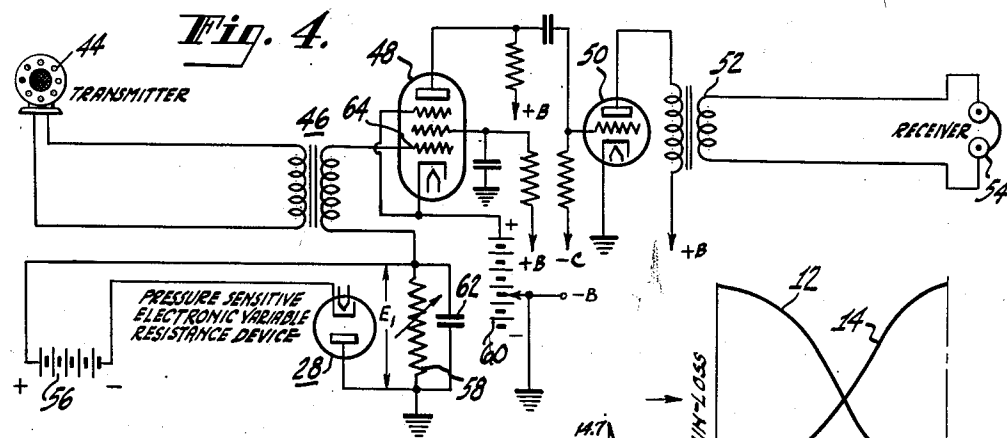


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L. J. ANDERSON
COMMUNICATION COMPENSATION SYSTEM FOR
ATMOSPHERIC PRESSURE VARIATION
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COMMUNICATION COMPENSATION SYSTEM
FOR ATMOSPHERIC PRESSURE VARIATIONLeslie J. Anderson, Moorestown, N. J., assignor to
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1 Claim. (Cl. 179—1)

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The present invention relates to the automatic gain control of amplifiers. More particularly the invention relates to a system for varying the gain of an amplifier in accordance with variations in air pressure.

It has been the experience of members of the flight crews of airplanes that, as the altitude of their crafts increased, the loudness of the sound produced by the head phones or loudspeakers of their "intercom" systems or radio receivers decreased, and as their altitude decreased the loudness of the sound produced by the headphones or loudspeakers increased.

An explanation of this phenomenon is that, for a given excursion of the diaphragm of an electro-acoustical transducer, the pressure in the ear canal, which determines, to a great extent, the loudness of the sound heard, is substantially determined by the density of the medium in which the sound is being produced. The density of air is substantially different from ground level up to 40,000 feet and varies quite rapidly with changes in altitude over this range.

In order to compensate for changes in loudness with changes in altitude, it has heretofore been necessary to change the gain of the audio amplifiers used in the systems, thereby changing the amplitude of the excursion of the diaphragm of the electro-acoustic transducer. It is readily appreciated that this constitutes a nuisance and distraction to a flight crew upon takeoffs, landings, or other altitude changes, when their attention must be devoted to the many complex tasks involved in modern flying without having to either vary the audio amplifier gain control or try to hear sound signals which are becoming fainter or louder.

It is therefore an object of my present invention to provide a gain control which automatically compensates for changes in altitude.

It is a further object of my present invention to provide an adjustable gain control for audio amplifiers which automatically compensates continuously for changes in altitude or air pressure.

It is still a further object of my present invention to provide means to maintain the output heard from a sound signal amplifying system substantially constant with changes in altitude.

These and other objects are achieved, in accordance with my present invention, by means of an atmospheric pressure responsive device having a movable element responsive to the ambient pressure, and a miniature type electronic variable resistance tube the impedance of the space path of which is varied by the movement of a control

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electrode which is coupled to the aforesaid movable element. A variable grid bias voltage is derived from the electronic variable resistance tube and is impressed upon one of the early stages of a sound amplifying system as a supplementary control bias to vary the output so that the signal heard from the electro-acoustic transducer being driven by the amplifier is maintained substantially constant with changes in air pressure.

The novel features of the invention as well as the invention itself, both as to its organization and method of operation, will best be understood from the following description, when read in connection with the accompanying drawing in which:

Fig. 1 shows a curve of pressure in pounds per square inch versus height in feet,

Fig. 2 shows curves of (1) loss in ear sensitivity with increase in altitude, and (2) the required gain in amplitude of audio signals with increase in altitude to compensate for the loss in ear sensitivity,

Fig. 3 shows in cross section one embodiment of my invention for generating a voltage the amplitude of which is dependent upon the external air pressure,

Fig. 4 shows a schematic of a typical application of my invention for controlling the output of an intercommunication system in accordance with the altitude,

Fig. 5 shows a typical curve of the variation in resistance of the electron tube of the type shown in Fig. 3 with changes in altitude, the curve having been obtained from an embodiment of my invention which was built, and

Fig. 6 shows a typical curve of the variation of the output voltage available for control bias with changes in altitude, this curve having also been obtained from an embodiment of my invention which was built.

Referring more particularly to the drawing, there is shown, in Fig. 1, a curve 10 of the change in pressure in pounds per square inch with the increase in altitude from ground level up to 40,000 feet. The pressure at ground level is substantially 14.7 pounds per square inch and as the altitude increases, this pressure substantially decreases until, at 40,000 feet, it is 2.8 pounds per square inch. The change in pressure thereafter is at a much slower rate.

In Fig. 2 is shown a curve 12 of the loss in hearing sensitivity in the ear as the altitude above ground is increased. Also shown is the curve 14 for the gain in the amplitude of audio signals

required to compensate for the loss in sensitivity of the ear caused by decreased ambient density in order that the loudness of the sound heard should remain substantially constant.

In Fig. 3 is shown an atmospheric pressure sensitive device 16 comprising a closed and sealed chamber having fairly substantial, rigid walls 18 in order to withstand changes in air pressure. One wall, however, has an opening 19 behind which is mounted a conical diaphragm 20 which moves in response to a pressure differential between the air pressure P_1 in the interior and that on the outside P . The pressure P_1 in the interior of the chamber is set at 14.7 pounds, or sea level pressure. A rod 22 attached to the apex 24 of the conical diaphragm 20 extends toward the interior of the chamber and is movable with the diaphragm 20. A bracket 26 is mounted on a wall 18 of the chamber and rigidly supports a miniature electronic tube 28 having a metallic casing 30 of elongated tubular shape as shown, and a flexible, metallic diaphragm 32 forming a part of the top casing structure. This flexible metallic diaphragm 32 supports, at its center, a rod-like electrode element 34 which extends inwardly from the diaphragm and has an external, rod-like extension 36 which is mechanically connected with the rod 22. The connection of the electrode extension 36 with the rod 22 is at a point in spaced relation to the electrode axis of rotation (in the plane of the diaphragm 32) whereby a desired degree of movement is imparted to the electrode proportionately to the movement of the diaphragm. This movement is in a direction to cause a variation in the inter-electrode space between the movable electrode 34 and a second, fixed electrode 38 which is insulated from the casing 30 and has an insulated, external connection lead extending therefrom as indicated. The movable electrode 34 is conductive and is connected with the diaphragm 32 and the casing, both of which are metallic or conductive and thus provide an electrical connection to the movable electrode. The connections 40 to the movable and the stationary electrodes, as well as to the filament of the tube 28 are made through the chamber wall using an air tight pressure seal 42.

The miniature tube 28 may be of the type shown, described, and claimed in the copending application of Harry F. Olson, Ser. No. 706,967, filed October 31, 1946, for "Electronic Transducers," now Patent No. 2,491,390, issued December 13, 1949. As pointed out therein, the control electrode 34 is supported and fulcrumed at the diaphragm 32. The rod extension 36 and the portion of the movable electrode 34 within the tube 28 are of such dimensions that relatively small forces applied by the rod 22 to the extension 36 produce displacements of the electrode 34 which are of measurable and significant magnitudes. The tube 28 therefore provides, in effect, an electronic variable resistance device.

In Fig. 4, there is shown a system employing a transmitter, such as a microphone 44 used in an intercommunication system, which impresses audio signals on an input transformer 46. The output from the transformer 46 is impressed on the control grid 64 of a first audio amplifier tube 48, the output from that stage is applied to a second amplifier tube 50, and the output from the second amplifier tube 50 is applied to an output transformer 52. The output from the transformer 52 is applied to a receiver, such as the pair of headphones 54 shown.

Thus far there has been described a typical intercommunication system comprising a microphone, an audio amplifier and a pair of headphones. In order to compensate for changes in altitude, the pressure sensitive, electronic, variable resistance tube 28 has applied across its electrodes a source of D.-C. bias 56 in series with a variable resistance 58. That end of the secondary winding of the input transformer which is not connected to the grid of the first audio amplifier is connected to one end of the variable resistance 58. The other end of the variable resistance is connected to ground or to some other suitable point of constant potential. The cathode of the first audio amplification stage is connected to a source of grid bias 60. A condenser 62 connected in parallel with the variable resistance 58 is for the purpose of by-passing any audio signal which might otherwise be set up across the resistance 58.

The grid bias 60 and the variable resistance 58 are both set at sea level to a value where the audio signal provided by headphones 54 has the desired intensity. As the altitude of the airplane or other aircraft in which this intercommunication system is located is increased, the pressure of the atmosphere is correspondingly decreased, as shown by the curve 10 of Fig. 1. The pressure P_1 inside of the enclosed chamber which was sealed at sea level therefore forces the conical diaphragm 20 outwardly causing it to move in proportion to the differences in pressures. This causes the electrode 34 of the electronic device to move proportionately closer to the fixed electrode 38. In turn, this produces decreased interelectrode resistance in the tube 28, and an increased current flows across the variable resistance 58. The grid bias applied to the grid 64 of the first audio amplifier tube 48 is thereby increased causing it to go more positive and thus increasing the amplification of the tube 48. The amplitude of the signal applied to the headphones 54 will consequently be similarly increased.

As the aircraft begins to descend, the increasing pressure P on the outside of the chamber produces a reduction in the pressure differential which causes the diaphragm 20 to move into the chamber, thus causing the movable electrode 34 to move away from the fixed electrode 38 with a consequent decrease in the voltage E_1 set up across the variable resistance 58. Therefore, the gain of the amplifier tube 48 is automatically decreased with a decrease in altitude. The system thus acts to continuously automatically compensate for the change in sensitivity in the ear with changes in altitude by correspondingly varying the gain of the amplifier.

A typical embodiment of my invention was built using the schematic shown in Fig. 4. A voltage of 150 volts D. C. was applied across the electronic variable resistance tube 28 and a variable resistance 58 of approximately 100 ohms was used. Measurements were taken of the changes in resistance across the electronic variable resistance tube 28 and also of the voltage E_1 developed across the variable resistance 58 with changes in altitude. The curve 65 in Fig. 5 shows that the resistance of the variable resistance tube 28 varied from approximately 50,000 ohms at sea level to approximately 10,000 ohms at an altitude of 40,000 feet.

The curve 66 in Fig. 6 shows that the voltage available for control purposes, using components having the above designated values, ranges from

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approximately three volts at sea level to 15 volts at 40,000 feet. It may also be seen that the curve 66 is substantially similar to the curve 14 which shows the required increase in compensatory amplification.

Using a 6D6 vacuum tube as the tube 48, with a fixed grid bias of approximately 15 volts and approximately 100 volts D. C. applied to the plate, and using the circuit shown in Fig. 4, the variable resistance 58 was adjusted so that sound of suitable amplitude was supplied by the headphones 54 at sea level. Measurement was then taken of the resultant bias voltage E_g available at the control grid, and it was found that, at sea level, the bias voltage was minus one volt and at 40,000 feet it was increased to minus 13 volts, as shown by the curve 68 in Fig. 7. The resultant volume of sound heard in the headphones over the range of altitude remained substantially constant.

From the foregoing description, it will be readily apparent that I have provided an improved system or apparatus for continuously compensating for the loss in sensitivity of the ears to the sound received from an electrical transducer with changes in the density or pressure of the air. Although I have shown and described but a single embodiment of my present invention, it should be apparent that many changes may be made in the particular embodiment herein disclosed, and that many other embodiments are possible, all within the spirit and scope of my invention. For example, the control voltage produced with the pressure sensitive apparatus of my present invention may be applied to other stages of an audio amplifier or pre-amplifier besides the input stage, in order to obtain desired results. Furthermore, it may be pointed out that, in addition to being useful to compensate for changes in altitude incident to travel in an airplane, my present invention has use in other applications, as in compensating for the effects of changes in air pressure upon descending into mines or caves, in compression

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chambers, diving, etc. Therefore, I desire that the foregoing description shall be taken as illustrative and not as limiting.

What is claimed is:

5 Apparatus to derive a control voltage dependent upon altitude comprising an enclosed chamber having a movable diaphragm as part of its wall structure, said diaphragm being exposed to and movable in response to atmospheric pressures, the remainder of said chamber walls being sufficiently rigid to withstand changes in ambient pressure, a variable resistance tube mounted inside said chamber, said variable resistance tube having a movable control electrode therein for 10 varying the space path impedance thereof, said movable electrode extending externally of said tube and being mechanically coupled to said diaphragm to be movable in unison therewith, means including a variable resistance to derive 15 a voltage from said variable resistance tube having an amplitude dependent upon the space path impedance thereof, an audio amplifier having amplitude control means, a source of audio signals coupled to said amplifier, an electro-acoustic transducer coupled to the output of said audio amplifier, and means to impress said voltage upon 20 said amplitude control means whereby the amplitude of the signals heard from said electro-acoustic transducer is continuously maintained substantially constant with changes in altitude. 30

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