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HEARING AID DEVICE

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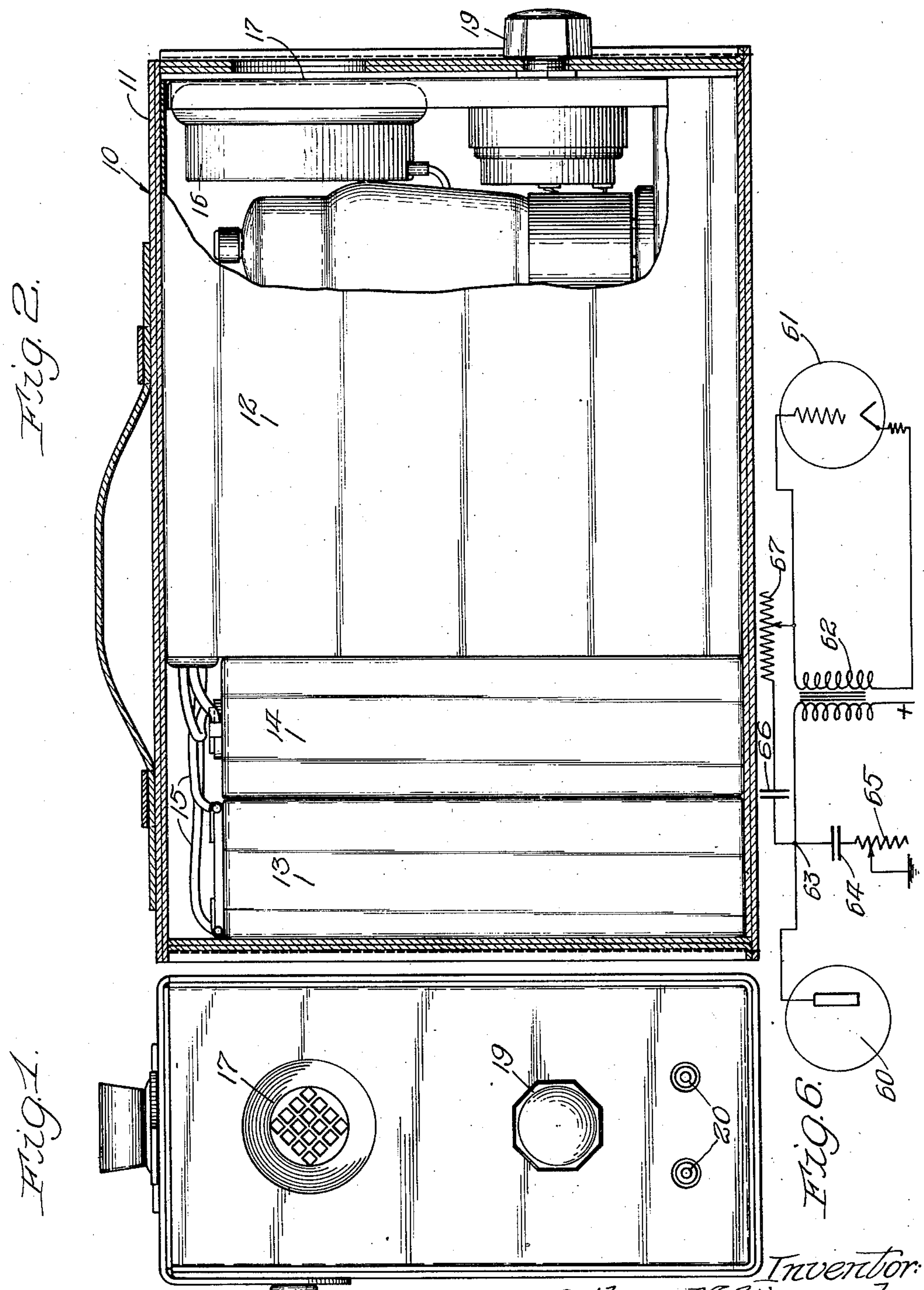

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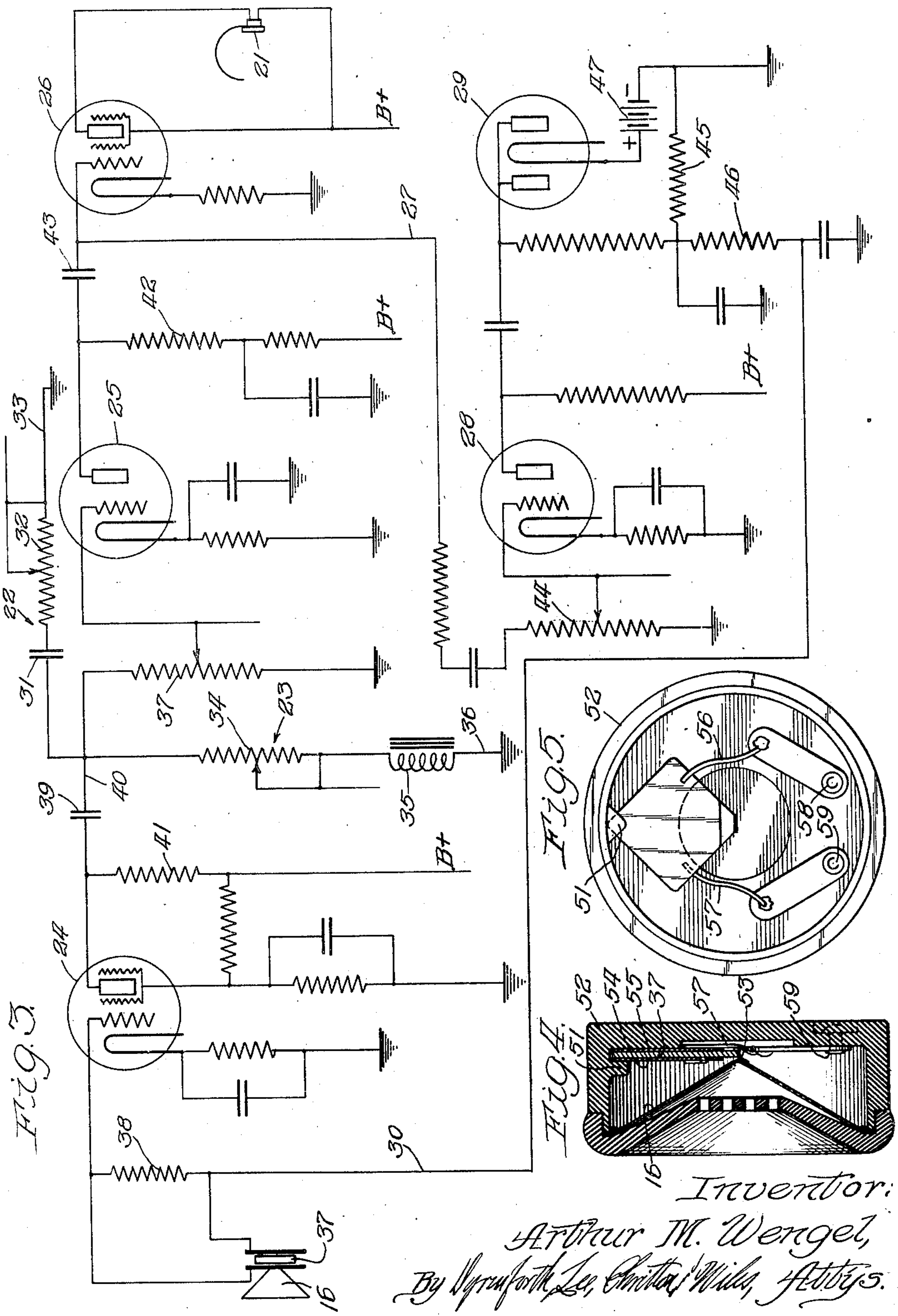

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HEARING AID DEVICE

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11 Claims. (Cl. 179—107)

This invention relates to a hearing aid device, and more particularly to a device intended to accentuate certain audible frequencies more than others.

One feature of this invention is that it is a very efficient hearing aid device; another feature of this invention is that it furnishes a deaf person with audible sounds which affect his ear in such a way as to give a normal tone pattern; yet another feature of this invention is that it accentuates the frequencies to which the ear of the hearer has a deficient response; a further feature of this invention is that microphonic noises are eliminated; still another feature of this invention is that the overtones or sounds in the higher audible frequencies are accentuated; another feature is that standard sets for stock purposes may be manufactured and then slightly added to, to meet the requirements of a particular deficient ear; a further feature is the provision of automatic control means for maintaining the output of said device substantially constant despite variations in the input; another feature is the use of a high gain audio amplifier. Other features and advantages of this invention will be apparent in the following specification and the drawings, in which:

Figure 1 is a front elevation of a hearing aid device embodying this invention; Fig. 2 is a side elevation, partly in section, of the device shown in Fig. 1; Fig. 3 is a schematic diagram of the device; Fig. 4 is a sectional view of the microphone; Fig. 5 is a view along the line 5—5 of Fig. 4; and Fig. 6 is a view of a modified tone control circuit.

It has been found that the ear of a deaf person is generally more deficient with respect to certain audible frequencies than with respect to others. That is, the deaf person's ear may have a fairly good response for frequencies in the lower range, and be very defective with respect to those in the higher range. In such a case it is very difficult for that person to distinguish between various words which depend upon overtone or higher tone quality to differentiate them from other words. The present invention provides a hearing aid device which can be adjusted to the needs of the particular user, or patient, and which will amplify the higher frequencies, for example, in a ratio which just neutralizes the deficiencies of the patient's ear. This results, of course, in the patient's receiving a tone pattern which affects him in the desired normal way.

In certain cases it has been found that the ear is more deficient with respect to low tones than to high, or the response may be good to both low and high tones and deficient with respect to a band of frequencies near the middle of the audibility range. The device disclosed herein provides means for adjusting the amplification curve in such a manner as to neutralize the deficiencies of the patient's ear.

It has also been found that the ears of certain deaf persons have rather narrow amplitude ranges. That is, the maximum and minimum intensity levels of the sounds are rather close together. Any sound of an intensity less than the minimum will not, of course, register properly in the patient's ear; and any intensity above the maximum causes pain and such jumbling of the sounds as to render understanding difficult. The present device incorporates automatic volume control means so that the intensity of the sound transmitted to the user's ear is maintained constant despite variations in the input to the device.

The automatic volume control operates in conjunction with an audio amplifier having a relatively high over-all gain. This enables relatively weak sounds, such as whispers or voices located at a considerable distance from the microphone input to the device to be amplified sufficiently to fall within the desired audibility range for the hearer.

In the usual type of hearing aid device the use of a high gain audio amplifier would result in an impractical device, since microphonic noises generated in the usual carbon microphone by vibration would be so amplified as to greatly disturb the user. This device overcomes this and other difficulties by employing a crystal mcrophone. The crystal microphone is not only free from intergranular scratching sounds found in carbon microphones, but has a very good response to all frequencies within the audible range.

It has been found that in the majority of cases of deafness the patient's ear is more deficient with respect to the higher frequencies than the lower. In the general run of cases, therefore, it is preferable to pick up and amplify the tones of higher frequency more than those in the lower band. It has been found that crystal microphones can be designed with a rising frequency characteristic, so that their output contains a higher proportion of the higher frequencies than existed in the sound waves energizing them. Such a microphone enables subsequent tone control features in the amplifier to be effective to their full extent, since the higher tones are not lost in the microphone.

In the particular embodiment of this invention disclosed herewith, a hearing aid device 10 comprises a relatively small light carrying case 11 of leather or the like, having therein a microphone-amplifier unit 12 and batteries 13 and 14 for energizing the device. The batteries are readily removable for replacement purposes, and are operatably connected to the unit 12 by wires 15 which make connection therewith through jacks plugged into sockets in the top of the battery cases. The microphone 16 is positioned behind an opening 17 through which sounds are transmitted to it for subsequent amplification and reproduction. Beneath the microphone opening is a knob 19 which acts as a switch and volume control which may be set by the patient in accordance with his wishes. At the lower part of this same end of the device sockets 20 are provided adapted to receive the tips of a flexible cord leading to a conventional receiver or bone conduction device worn by the patient. This forms no part of the present invention and is not illustrated herewith.

Referring more particularly to Fig. 3, it will be seen that the device comprises a crystal microphone 16, a high gain audio amplifier, an output here shown as a receiver 21, an automatic volume control circuit, and two independent tone controls 22 and 23.

The amplifier is here shown as comprising tubes 24, 25 and 26, at least two of the tubes, here shown as 24 and 26, being screen grid tubes with a high amplification factor. Just prior to the input to the tube 26 part of the currents passing through the amplifier is diverted by the lead 27, amplified in the tube 28, rectified in the tube 29 and the resultant direct current voltage is applied through the wire 30 to the grid or input circuit of the tube 24 to control the amplification factor thereof.

The tone control means 22 comprises a reactance element or condenser 31, a variable resistance 32, and a path 33 to ground. Since a condenser inherently passes high frequency currents and offers considerable impedance to low frequency currents, the tone control 22 provides means whereby high frequencies may be removed and dissipated to ground. The proportion thus removed is controlled by the variable resistance 32. The tone control 23 comprises a variable resistance 34, another reactance element here shown as an inductance 35, and a path 36 to ground. The inductance is here illustrated as of the iron core type, and imposes high impedance to high frequencies while easily passing low frequencies. Thus the tone control 23 provides an adjustable path through which a desired proportion of the low frequencies may be dissipated to ground. The general audibility level or volume control actuated by the knob 19 is here shown as the variable resistance 37.

The alternating current voltage developed by vibrations of the crystal 37 in the microphone 16 is developed across resistor 38 of one or two megohms and impressed upon the grid of the tube 24. The output from the plate of this tube 24 is impressed through the blocking condenser 39 of about one-tenth m. f. on the wire 40. The coupling is of the resistance type through a resistor 41 here having about 250 m. impedance. The amplified current impressed on the wire 40 has three possible paths: one is through the tone control circuit 22 through which the desired amount of high frequencies may be dissipated; another is through the tone control circuit 23 through which low frequencies may be dissipated; and the third is to the volume control or variable resistor 37, from which a desired amount is impressed on the grid of the succeeding tube 25. The plate output of this tube is in turn coupled, through the plate load resistor 42 and the blocking condenser 43 on the grid of the tube 26, also a screen grid high gain tube similar to 24. The output of this tube is developed across the ear piece or receiver 21 in order that sounds received by the microphone 16 and translated into electrical impulses may be transformed again into sound waves to affect the ear of the patient. Between the blocking condenser 43 and the grid of the tube 26, the wire 27 diverts part of the currents flowing through the amplifier, and impresses voltage developed across the variable resistor 44 on the grid of the tube 28, which is in turn resistance coupled to the rectifier 29.

This rectifier tube develops a direct current drop across the resistor 45, which is applied through the filtering resistor 46 and the wire 30 to the grid circuit of the tube 24. The bias or potential of the grid of the tube 24 with respect to ground is, therefore, a function of the potential drop across the resistor 45, which is in turn a function of the amount of current in the amplifier. A large input to the tube 24, as a result of shouting or speaking too close to the microphone of the device, thus automatically operates to reduce the amplification factor of the tube 24 and maintain the output of the amplifier developed in the receiver 21 at substantially constant intensity. It will be noted that a battery 47 maintains the filament of the rectifier tube 29 at a positive potential with respect to ground. This prevents operation of the automatic volume control portion of the circuit until the plates of the tube 29 have swung positive with respect to the filament, and thus there is a delay action which maintains the sensitivity of the amplifier at its highest level until the desired intensity for the particular hearer is reached, whereupon the volume control circuit maintains that desired intensity. The tubes are, of course, of the type particularly designed for use with batteries in order to prevent an excessive battery drain. The tube 24, for example, may be a 1–B4, the tube 25 a '30, and 26 a 1–F4. Any other tubes suitable for such a device may, of course, be substituted with the necessary changes in circuit constants.

In the commercial device the resistors 32, 34 and 44 are not variable by the patient, but are set at the factory or other place where the device may be purchased. For production purposes a standard device is produced which does not have either the tone control circuit 22 or 23 therein. It is merely a high gain audio amplifier, either with or without the automatic volume control circuit, appropriately connected to the microphone, batteries, and receiver. The particular patient for whom the device is intended is tested for frequency responses, and both the minimum level of audibility and the level at which pain is produced are determined for a number of frequencies throughout the audible range. A chart or curve is then plotted which shows the response pattern of the particular patient. Let us assume that the response is half normal for the low frequencies and drops steadily towards the higher frequencies with a slope of about 20°, so that these higher frequencies are not heard anywhere near as well as the lower ones. The reactance element comprising the tone control circuit 23 would then be inserted in the standard production device and a resistance value chosen which is known to taper off or dissipate the low frequencies at a slope of about 20°. This would result in the finished amplifier having a rising amplification characteristic; in other words, the amplification of the high frequencies would increase in proportion to the frequencies with a slope of about 20°. In the particular case of deafness described above, which is fairly common, the tone control portion 22 would not be necessary. Thus, the finished device would amplify the higher frequencies more than the lower ones by the proportion in which the patient's ear is deficient thereto, so that the final audibility pattern heard by the patient would be normal, with both high and low frequencies having the proper apparent relationship to each other. Other combinations of settings, including all possible combinations of one or both of the tone control circuits 22 and 23, would be available to provide an amplification curve adapted to compensate for the deficiencies of each particular patient. In order to be most effective, of course, the device must be completed in accordance with a prescription or chart developed from a thorough test of the patient's hearing response at various frequencies. Inasmuch as the majority of cases of deafness are deficient in response to the higher frequencies, the crystal microphone 16 is so chosen and designed as to have a rising frequency characteristic in order to make these high frequencies available. In other words, the electrical output of the crystal microphone contains a higher proportion of the higher frequencies than the sound input thereto. The advantages of the high gain amplifier and the tone control circuits may thus be realized to their fullest. The crystal microphone has two very great advantages over the usual carbon granule microphone used in such a device. One of these is the fact that high frequencies may be available for subsequent amplification, which is not possible with the usual carbon microphone; and the other is that intergranular noises resulting from vibration of the usual carbon microphone are completely eliminated, with highly satisfactory results from the patient's standpoint.

The particular microphone used in connection with this hearing aid is illustrated in Figs. 4 and 5. The crystal 37 is diamond shape and fixedly mounted at one corner 51 in the stand 52. The driving diaphragm or cone 16 is fastened to the casing 52 around its circumference, and operatively connected at its apex to one corner of the crystal 37 by the connecting means 53. Flexible electrical conductive elements 54 and 55 on each side of the crystal serve to take off the alternating currents generated by mechanical vibration of the crystal. These two elements are connected by the leads 56 and 57, respectively, to outlet terminals 58 and 59 projecting outside of the case and furnishing terminals by which the microphone may be connected in the circuit.

Where the pain level of the patient is rather close to the minimum audibility level, or where the ability to understand a differential between sounds is destroyed by too great an intensity, the automatic volume control portion of the circuit insures the desired intensity regardless of changes in the sound level with respect to the microphone or input of the device. The amount of volume control action desired may be regulated by variable resistor 44 and the threshold at which its action commences by the delay voltage 47. The use of the amplifying tube 28 ahead of the rectifying tube enables sufficient control voltage to be developed to meet all conditions. Where the output does not have to be maintained exactly constant or the variations in the input are not expected to be too great, this amplifying tube may be eliminated.

Another or modified form of the tone control portion of the circuit is illustrated in Fig. 6. The tubes 60 and 61 correspond to the tubes 24 and 25, respectively, in the circuit illustrated in full in Fig. 3. In this form, however, the plate circuit of tube 60 is coupled to the input or grid circuit of tube 61 by the transformer 62. Again three paths are provided from the point 63 on for currents flowing in the plate circuit of the tube 60; one path is through the transformer 62; another path is through the reactance element or condenser 64 and the variable resistance 65 to ground; and the other path is through the condenser 66 and variable resistance 67 directly to the grid of the tube 61. The condenser 64 and variable resistance 65 provide means for dissipating a desired proportion of the high frequencies to ground, and thus accentuating the lows. The condenser 66 and variable resistance 67 provide means for directly coupling the plate of the tube 60 to the grid of the tube 61, so that a desired larger proportion of high frequencies may be passed to the grid to accentuate these frequencies in the final output of the device.

While I have described and claimed certain embodiments of my invention it is to be understood that it is capable of many modifications. Changes therefore in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims in which it is my intention to claim all novelty inherent in my invention as broadly as permssible in view of the prior art.

I claim:

1. A hearing aid device of the character described, including: a relatively small, light case adapted for convenient carrying; a microphone so mounted in said case as to be readily energized by sound waves, said microphone including a piezo-electric crystal for translating sound waves into electrical impulses; a battery; an amplifier connected to said microphone, said amplifier having the operating currents therefor supplied by said battery; and a receiver connected to said amplifier and adapted to be worn on an ear, whereby the sound waves energizing said microphone are transmitted in amplified volume to said ear.

2. In a hearing aid device of the character described: a crystal microphone for translating sound waves into electrical impulses which have a large proportion of high frequency waves therein; an amplifier for amplifying said impulses, said amplifier being so constructed and arranged as to amplify the high audio frequencies more than the low audio frequencies; and receiver means for translating said impulses back into sound waves.

3. In a hearing aid device of the character described for a patient having a more deficient response to certain frequencies than to others in the audible range: a crystal microphone for translating sound waves into electrical impulses; an amplifier for amplifying said impulses, said amplifier having at least two tubes and being so constructed and arranged as to amplify the frequencies to which the patient is defective more

than the other frequencies in the audible range; and receiver means for translating said impulses back into sound waves.

4. In a hearing aid device of the character described for a particular patient: a crystal microphone for translating sound waves into electrical impulses; means for amplifying said electrical impulses, said amplifying means including tone control means for dssipating the frequencies to which the patient is most responsive; and receiver means for translating said impulses back into sound waves.

5. In a hearing aid device of the character described for a particular patient: a crystal microphone for translating sound waves into electrical impulses; means for amplifying said electrical impulses, said means including at least two tubes having high amplification factors and operative circuit connections therefor; receiver means for translating said impulses back into sound waves; means in said circuit between said tubes for regulating the proportion of high frequency impulses passing to said second tube; and a second means in said circuit between said tubes for regulating the proportion of low frequency impulses, at least one of said two last mentioned means dissipating a portion of said impulses.

6. In a portable hearing aid device of the character described: microphone means for translating sound waves into electrical impulses; means for amplifying said impulses; receiver means for translating said impulses back into sound waves; and means for maintaining the output of said amplifier substantially constant despite variations in the intensity of said sound waves.

7. In a portable hearing aid device of the character described: microphone means for translating sound waves into electrical impulses; means for amplifying said impulses, said means including at least two tubes having a high amplification factor and operative circuit connections therefor; receiver means for translating said amplified impulses back into sound waves; and means for maintaining the output of said amplifier substantially constant despite variations in the intensity of the sound waves entering said microphone, said means diverting a portion of said impulses in said circuit prior to the last of said tubes.

8. A portable hearing aid device of the character described, including: an audio frequency amplifier comprising at least two tubes having a grid, cathode and plate each, operative circuit connections for said tubes and input and output connections for said amplifier; a microphone connected to said input for translating sound waves into audio frequency currents in said circuit; receiver means connected to said output for translating said audio frequency currents back into sound waves; and means for controlling the amplification characteristic of the first of said tubes, whereby the output of said amplifier is maintained substantially constant despite variations in the input thereto, said means diverting a part of said current in said circuit prior to said output, rectifying said diverted current and impressing it on the grid of said first tube.

9. Apparatus of the character claimed in claim 8, including means for delaying the action of said volume control means until a predetermined desired output has been attained.

10. A hearing aid device of the character described, including: a relatively small, light case adapted for convenient carrying; a small, sensitive crystal microphone, for translating sound waves into electrical impulses, mounted in the case; and an amplifier in the case, the amplifier including at least two tubes and being adapted to highly amplify the electrical impulses from the microphone; and a receiver connected to the amplifier and adapted to be worn on a defective ear, whereby the sound waves energizing the microphone are transmitted in amplified volume to the ear.

11. A portable hearing aid device of the character described for delivering amplified sound impulses to a receiver worn on a defective ear, including: microphone means for translating sound waves into electrical impulses; amplifying means, including at least two tubes, for highly amplifying the electrical impulses from the microphone and delivering them to the receiver; and means for maintaining the intensity of the impulses delivered to the receiver substantially constant despite variations in the intensity of the sound waves actuating the microphone means.

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