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HEARING AID

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Fig. 1.

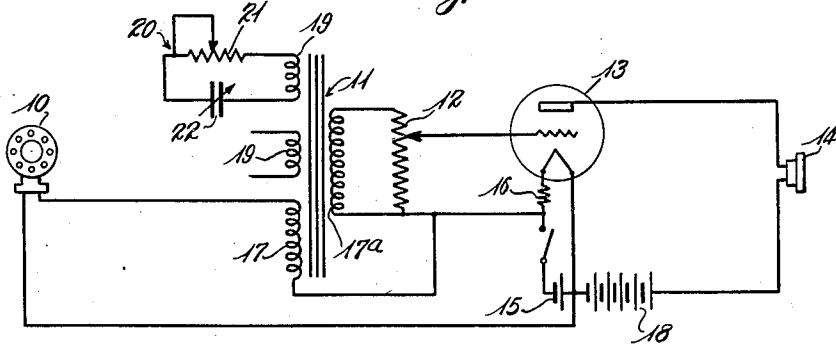
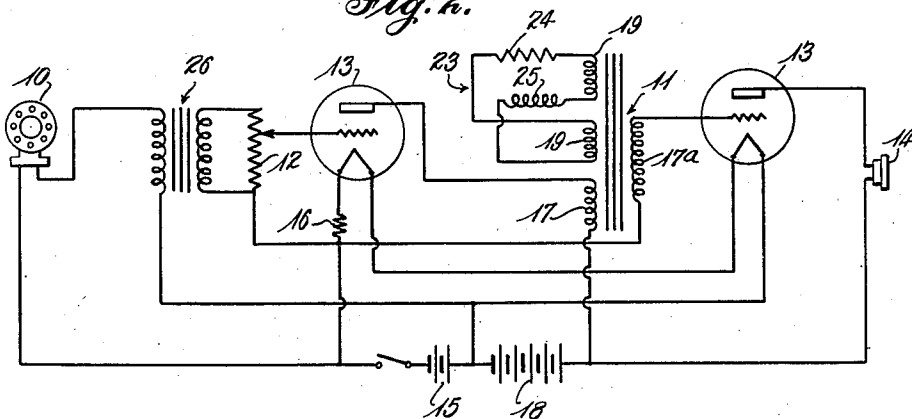


Fig. 2.



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HEARING AID

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4 Claims. (Cl. 179—1)

This invention relates to a new and improved method and apparatus to be used in aiding the hearing of those who are partially deaf.

It is well known that deafness exists in varied forms. Each of these different forms of deafness requires a hearing device of different characteristics. Moreover, no two people with the same type of deafness will suffer exactly the same hearing loss at each frequency. The well known types of hearing aids comprising a microphone and receiver, and in some cases an amplifier, either of the mechanical or vacuum tube type, amplify all of the frequencies more or less uniformly, not taking into account the individual differences among those who are deaf.

For ordinary conversation the essential range of frequencies for intelligibility is approximately 200 to 3000 cps. The ordinary telephone system transmits approximately this band of frequencies. For more natural reproduction and a fuller appreciation of music a range from 100 to 5000 cps. is desirable.

A satisfactory hearing device must not only accentuate a certain group of frequencies to which the person is less sensitive than normal, but must accentuate each frequency throughout the entire range (100 to 5000 cps.) exactly the right amount. The right amount of amplification at each frequency is that amount which makes the sensation level of the deaf person the same as that of a normal person. The sensation level at a given frequency is the number of decibels which the sound at that frequency is above the threshold of hearing.

Ordinary conversation is carried on at a level of approximately 50 db. above threshold. Hence, to a person whose threshold of hearing was 50 db. higher than normal, the conversation would just be audible.

It is an object of this invention to provide a simple device and method for amplifying sound in accordance with the individual requirements of persons with defective hearing so as to make the sensation level of the deaf person at all frequencies within the range of 100 to 5000 cps. substantially the same as that of normal persons so that ordinary conversation will be heard at approximately 50 db. above threshold.

It is not possible in every case to make the sensation level of the person with defective hearing equal to that of a normal person. This occurs when the degree of deafness is so great that raising the level the required amount would place it at the threshold of feeling. Such cases are rare, however, and the device and method of the

present invention, by selectively amplifying the frequencies to which the deaf person is least sensitive approaches more nearly to ideal conditions than prior devices.

It is another object of the present invention to provide a device which may be adjusted to fit the individual requirements of a deaf person having varying hearing losses at different frequencies. The hearing loss at each frequency of a particular deaf person can be determined by means now available, for example, by audiometer measurements.

Another object of the invention resides in the provision of an adjustable frequency responsive coupling transformer apparatus in the amplifying system for selectively amplifying the frequencies to which the individual person is least sensitive.

Other objects and advantages of the invention will appear in the following description of the preferred embodiments of the invention shown in the attached drawing of which:

Figure 1 is a schematic diagram of a hearing aid device showing an adjustable frequency responsive transformer apparatus and a single stage amplifier;

Fig. 2 is a schematic diagram of a modification of the device showing a two-stage amplifier, and Referring more particularly to the drawing, in Figure 1, 10 indicates a microphone, 11 indicates a transformer having a plurality of windings, 12 indicates a volume control, 13 indicates an amplifying tube, and 14 indicates a receiving device. The microphone 10 is connected in series with the primary 17 of the transformer 11 and a suitable battery 15 which may also supply the filament of the vacuum tube 13 through a grid bias resistor 16. The secondary 17a of the transformer has connected across its terminals the resistance of the volume control 12 so as to impress an adjustable audio frequency voltage between the filament and grid of the tube 13. The receiving device 14 is connected in the plate circuit of the tube in series with a battery 18 for supplying plate potential.

The transformer 11 differs from the ordinary audio-frequency transformer used in radio in that it has one or more extra or tertiary windings 19 in addition to the ordinary primary and secondary windings. The tertiary windings 19 are used as control windings by closing them through suitable impedances or interconnecting them or both, the response-frequency characteristic depending upon the nature of the closing impedances and the mode of connecting them.

By way of example, I have shown one of the windings 19 connected to an impedance indicated generally by 20 and consisting of a variable resistance 21 and a variable condenser 22 in series. It is understood, however, that various other combinations including resistance, inductance and capacitance alone may be used with either or both windings and that in actual practice, after the correct impedances for a given individual have been determined, fixed instead of variable impedances will ordinarily be used, the tertiary windings providing a means for adjusting the transformer by the use of such fixed impedances.

At any given frequency the proportion of the microphone output power which is delivered to the primary and hence passed to the secondary of the transformer will be determined primarily by the primary impedance. Maximum power transfer from the microphone to the primary of the transformer will occur when the primary impedance equals the microphone impedance. For smaller or greater values of primary impedance the power delivered to the transformer will be correspondingly less. One function of the tertiary or extra windings is to vary the effective primary impedance as a function of frequency, thus causing the device to amplify sound frequencies selectively in accordance with the needs of the individual whose hearing is impaired.

The effective primary impedance will depend upon the value of the impedances of the other elements of the device, namely, the impedances of the secondary winding and of the load connected thereto and the impedances of the tertiary winding or windings, having resistances, inductance or capacitance connected thereto and the impedances of these elements as well as the actual primary impedance, if the various windings are closely coupled as in conventional audio-frequency transformers. For a given transformer and a given frequency all of these impedances will be fixed except the impedance 20 connected to the tertiary winding. By varying the impedance 20, the frequency response characteristic of the amplifying system can be varied. For example, if the impedance 20 of Fig. 1 consists of a resistor in series with a condenser, then for given values of the resistor and condenser, this impedance will decrease in magnitude as the frequency increases. It can be shown mathematically or experimentally that this will cause the effective primary impedance of the transformer to decrease as the frequency increases. Hence, the power transferred to the amplifier will be less for higher frequencies than for lower ones. The value of the resistance 21 fixes the final value of the impedance 20, since at the high frequency the reactance component of this impedance approaches zero. The impedance 21 also has another effect upon the frequency response characteristic, which adds to the one just discussed. Since the reactance component of impedance 21 is less at the higher frequencies with resultant proportionally greater currents at these frequencies through the resistance 21, more power at the higher frequencies is dissipated due to the resistance of the impedance 20 and winding 19 than at the lower frequencies, so that a lesser proportion is delivered to the secondary 17a at the higher frequencies.

By choosing an inductance instead of a condenser for the reactive element of the impedance 20, exactly the opposite effects are obtained. The impedance of 20 would decrease with a de-

crease in frequency, thus decreasing the effective primary impedance as the frequency decreases so that the high frequency sounds would be amplified more than the low. Also, the decrease in the reactive component of the impedance with decrease in frequency would cause a greater dissipation of power by the resistance of impedance 20 and the winding 19 at the lower frequencies resulting in a proportionally smaller transfer of power to the secondary 17a at the lower frequencies.

In Figure 2 I have shown a modification of my device, including a two-stage amplifying system and having both tertiary windings 19 of the transformer 11 interconnected in series with an impedance indicated generally by 23 and comprising a fixed resistance 24 and fixed inductance 25. In this modification, the adjustable transformer couples the two amplifying tubes and another transformer 26 couples the microphone 10 to the first amplifying tube.

This modification illustrates the use of two tertiary windings 19 to produce a greater effect upon the frequency response characteristics of the transformer and the employment of an inductance 25 to cause greater amplification of the higher frequencies instead of the lower frequencies as in the case of Figure 1. As I have heretofore stated, various other combinations of similar nature may be had such as capacitances, inductances, or resistances, singly or in combination of any or all in series or parallel, so as to adjust the transformer or amplifying system to suit the individual requirements of the deaf person.

The volume control 12 shown in both modifications may be employed to regulate the gain of the device without greatly affecting the selective amplifying characteristics thereof.

In accordance with the invention herein disclosed, the frequency-response characteristic of the hearing aid may be varied without the use of filters or other corrective circuits to produce the required accentuation. The transformer which necessarily must be used to couple the microphone to the receiving device is modified in a simple and inexpensive manner so that it may be adjusted for frequency-response either by mere tap changing or the insertion of suitable impedances.

The present invention has advantages over the usual filter circuits. Filters cannot be designed to give a certain specific attenuation at each of several frequencies throughout a given range. A filter is a structure which has a negligible transmission loss over a certain definite range or ranges of frequencies, and an appreciable loss at all other frequencies. Hence, by using a filter the only result obtained is to pass all frequencies in the pass band and exclude the rest. This is not what is required in a hearing device. What is required is a device which gives a certain specific accentuation of certain frequencies throughout the audible range. The transformer with means for adjusting response-frequency characteristic is capable of doing this. The transformer corrective device simplifies the entire adjustment of the hearing aid. The transformer may be easily adjusted for practically any condition, whereas a different type or design of filter is necessary for each case and must be designed beforehand.

Also, to obtain the calculated performance a filter must operate between certain specific terminal impedances. When used in vacuum tube

circuits the terminating values are such that it is difficult or impossible to obtain the required cut-off frequency and attenuation value and simultaneously have the proper terminating value. The value of the terminating impedance is one of the fundamental factors in filter design and is interlocked with the cut-off frequency and attenuation. This greatly reduces the practicability and flexibility of the filter unit. Furthermore, the use of a filter in vacuum tube circuits usually calls for some special method of applying the D. C. potentials because the D. C. path is blocked by condenser elements. The transformer of the present invention may be designed to operate between widely different terminating impedances and does not disturb the D. C. path.

While I have described the preferred embodiment of my invention, the examples shown are to be considered illustrative only and it is understood that my invention is not limited to the particular forms shown but may be varied within the scope of the appended claims.

I claim as my invention:—

1. A device for aiding hearing by accentuating the frequencies to which a user of the device is least sensitive; said device comprising an audio frequency transformer having a primary winding, a secondary winding, and at least one tertiary winding closely coupled therewith; an input circuit connected to said primary winding; an output circuit connected to said secondary winding; and an impedance circuit connected to said tertiary winding; said impedance circuit including an element having an impedance which varies with changes in frequency, whereby the effective primary impedance of said transformer may be made to vary with changes in frequency with respect to the impedance of said input circuit in order to selectively accentuate desired frequencies.

2. A device for aiding hearing by accentuating the frequencies to which a user of the device is least sensitive; said device comprising an audio frequency transformer having a primary winding, a secondary winding, and at least one ter-

tiary winding closely coupled therewith; an input circuit connected to said primary winding; an output circuit connected to said secondary winding; and an impedance circuit connected to said tertiary winding; said impedance circuit including a condenser, whereby the effective primary impedance of said transformer may be made to vary with changes in frequency with respect to the impedance of said input circuit in order to selectively accentuate desired frequencies.

3. A device for aiding hearing by accentuating the frequencies to which a user of the device is least sensitive; said device comprising an audio frequency transformer having a primary winding, a secondary winding, and at least one tertiary winding closely coupled therewith; an input circuit connected to said primary winding; an output circuit connected to said secondary winding; and an impedance circuit connected to said tertiary winding; said impedance circuit including an inductance, whereby the effective primary impedance of said transformer may be made to vary with changes in frequency with respect to the impedance of said input circuit in order to selectively accentuate desired frequencies.

4. A device for aiding hearing by accentuating the frequencies to which a user of the device is least sensitive; said device comprising an audio frequency transformer having a primary winding, a secondary winding, and at least one tertiary winding closely coupled therewith; an input circuit including a microphone connected to said primary winding; an output circuit including an amplifying tube connected to said secondary winding; and an impedance circuit connected to said tertiary winding; said impedance circuit including an element having an impedance which varies with changes in frequency, whereby the effective primary impedance of said transformer may be made to vary with changes in frequency with respect to the impedance of said microphone in order to selectively accentuate desired frequencies.

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