June 4, 1935. C. M. R. BALBI 2,003,875

ADJUSTED SOUND AMPLIFICATION

Filed June 29, 1932

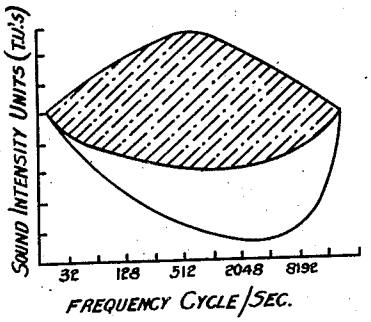


Fig.1.

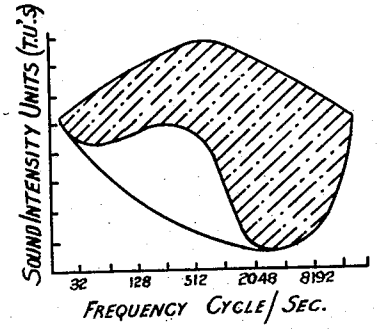


Fig.2.

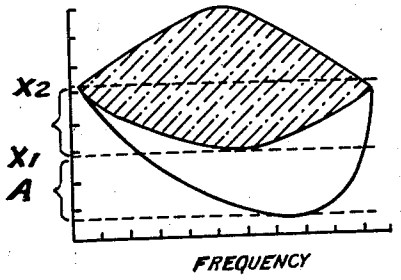


Fig.3.

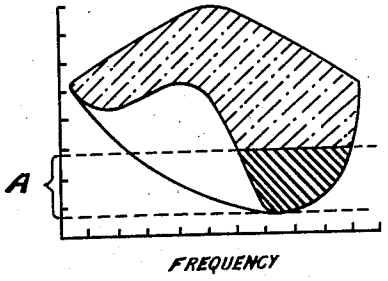


Fig.4.

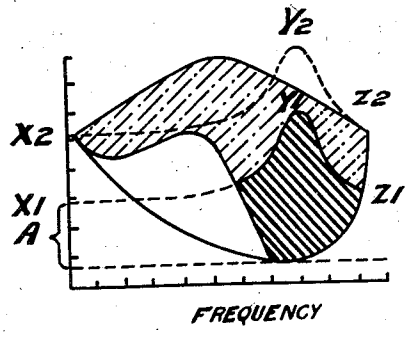


Fig.5.

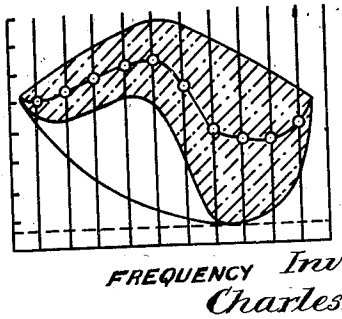


Fig.6.

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ADJUSTED SOUND AMPLIFICATION

Charles Mackenzie Raphael Balbi, London, England

Application June 29, 1932, Serial No. 620,019
In Great Britain August 18, 1931

1 Claim. (Cl. 179—107)

My invention consists of a sound amplifying device for deafened persons constructed in accordance with certain physical laws which are set out hereunder.

It is now well known that the audibility of the human ear has certain well defined limits in terms of frequency and intensity. There is a curve for the "threshold of minimum audibility" below which no sound of any frequency can be heard and a "threshold of maximum audibility" above which sound is observed as pain. The two curves meet at the upper and lower frequency limit of audibility thus enclosing an area which is known as the "audition area for the normal ear".

Deafness has been defined as a subtraction from this area of acuity and it is found from numerous tests that have been made that people's hearing differs greatly in character. Hitherto sound amplifying apparatus for deafened persons have been constructed with the object of amplifying sound over as much of the audible frequency range as possible and with as even a response as possible but even so each apparatus had a certain amount of distortion and moreover in consequence of inaccuracies in manufacture each apparatus had a different characteristic from the other, with the result that when deaf patients came to select an instrument, they found that one apparently similar instrument might suit them better than the other, so that selection resulted in a method of trial and error and hence it was not possible to prescribe a hearing instrument on the same lines as a pair of spectacles, where a doctor may make a prescription of a patient's eye-sight in some distant part of the world and order the lenses to be made in another with the assurance that when the spectacles arrive they will be satisfactory for the patient concerned.

It is the object of the present invention to provide a method according to which sound amplifying apparatus for deafened persons may be scientifically designed and constructed so as to suit the particular persons for whom they are intended.

The invention will be the more clearly understood from the following description, reference being made to the accompanying drawing, wherein:—

Figure 1 is a diagram illustrating the audition area of a person suffering from some form of obstructive deafness, as compared to that of a normal person.

Figure 2 is a similar diagram for a person who is bass deaf.

Figure 3 is a similar figure to Figure 1 illustrating the effect of applying a uniform amplifier to the obstructive deaf person.

Figure 4 is a similar figure to Figure 2 illustrating the effect of applying a uniform amplifier to the bass deaf person.

Figure 5 is a similar figure to Figure 2 illustrating the effect of applying to the bass deaf person, an amplifier whose response characteristic increases in the range of treble frequencies.

Figure 6 is a similar figure to Figure 2 illustrating the response characteristic which an amplifier should have in order to suit the bass deaf person.

Referring to Figure 1 the maximum area is the audition area for the normal ear and the shaded part is the audition area for a person suffering from some form of obstructive deafness. The shaded portion of Figure 2 is the audition area for a person who is bass deaf.

Referring to Figure 3 on which is shown the characteristic of the deaf man plotted in Figure 1, if a uniform amplifier is applied it will be equivalent to raising the audibility level by an amount "A" as shown, which will enable him to hear sounds of about the same minimum intensity as persons with normal hearing and a signal made of strength equal to X_1 would by virtue of the amplification be heard comfortably by him at a sound intensity level X_2, whereas without the amplifier it would just be inaudible to him; but if uniform amplification such as was applied to this case is now applied to a person who has a bass deaf characteristic as shown in Figure 2, then his hearing will be sensitive to sounds inaudible to ordinary persons, hence his hearing will be greatly disturbed by noises inaudible to the ordinary person. This proves to be as would be expected, very distressing to the listener. This super-sensitive area for this particular combination of person and instrument can be depicted as shown by the darkened area in Figure 4.

Up to this point I have only been considering what may take place when the amplification is of a uniform character but in order to describe the purpose of this invention I will suppose the amplification is not uniform and I will imagine a response characteristic as shown by the line X_1 Y_1 Z_1 in Figure 5 which has an initial amplification of the amount "A" as in the previous examples. From this it will at once be seen that the listener is still troubled with the reception

of sounds that are inaudible to the person with normal hearing, as shown by the darkened area, but in consequence of the shape of the characteristic another and worse disadvantage will be felt, for a sound of normal intensity X_1 will when amplified be represented by X_2 Y_2 Z_2 and will thus overlap the threshold of maximum audibility and cause pain to the listener. Constant use of such an amplifier may cause great distress to the listener on account of the pain produced and it can be seen that the listener not only gains nothing by the amplification in such a case but actually loses a large part of his useful audition area as it has been found that sounds that have died away until they are of an intensity below that perceptible by the normal ear, have lost the intelligibility of speech or the character of music so that the listener only picks up noise.

We have now seen that a deaf person with an audiograph as presented in Figure 2 is not suited by:—

(*a*) Uniform amplification

(*b*) Nonuniform amplification of the form shown in Figure 5 so I will now show what form of amplification characteristic is needed to be prescribed to give the best results.

Take for example the audiograph of the deaf person concerned namely Figure 2 and then draw a number of vertical lines parallel to the T axis, as shown in Figure 6 and then plot out a curve which is given by the bisection of the distances between the thresholds of maximum and minimum audibility, this result then gives:—

(*a*) The optimum shape of the amplifier characteristic required.

(*b*) The optimum intensity level for reception by the listener.

This process applies to any audiograph record taken for a deaf person.

The physical laws connected with the taking of an audiograph are well known and have been described in such papers as "Physical Characteristics of Audition and Dynamical Analysis of the External Ear" in Electrical Communication Vol. 1, November 2, 1922.

Having therefore arrived at this point it remains for me to show how an amplifier characteristic may be manipulated to coincide with the data obtained and for this purpose I employ what are known as filter circuits consisting of various arrangements of capacities, inductances and resistances in accordance with certain laws described by K. S. Johnson in his book "Transmission Circuits for Telephone Communication". Then by calculation, a filter circuit can be built up which is expected to give the amplifier characteristic desired.

The results should be checked by any practical method now employed for the purpose of obtaining the output characteristic of acoustic apparatus.

Although electrical correction or filter circuits are the most easy method to apply in regard to my invention I do not exclude mechanical manipulation. As is known a spring is the mechanical equivalent of electrical capacity and correspondingly inertia and friction take the place of inductance and resistance. Hence Johnson's laws relating to electrical filter circuits may be applied by suitable substitution to any mechanical vibrating system, such as the diaphragm of a microphone or receiver.

What I claim and desire to secure by Letters Patent is:—

The method of adjusting the intensity-frequency characteristics of a sound delivered to a sound observing organ which comprises determining the maximum and minimum values respectively of sound intensity which said organ is capable of usefully observing for different values of sound frequency, determining for each of said frequencies the mean useful value of sound intensity as the mean of the maximum and minimum useful values for said frequency, and amplifying said sound intensity non-uniformly with frequency in such a manner that sound of a given frequency is amplified by an amplification factor proportional to said mean useful value of sound intensity as determined for said organ for said frequency.

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