June 6, 1950 C. E. RUDIGER 2,510,480

SYSTEM AND METHOD FOR FITTING HEARING AIDS

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Fig. 2.

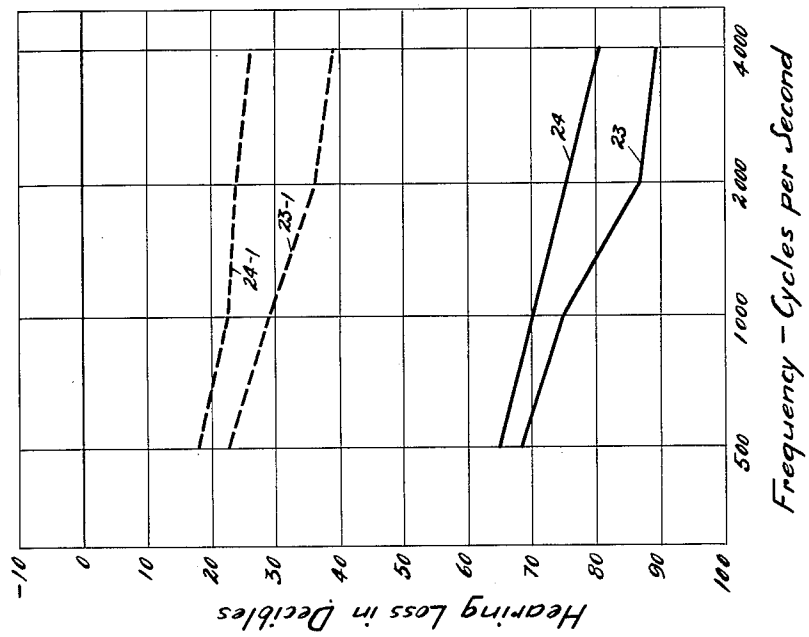
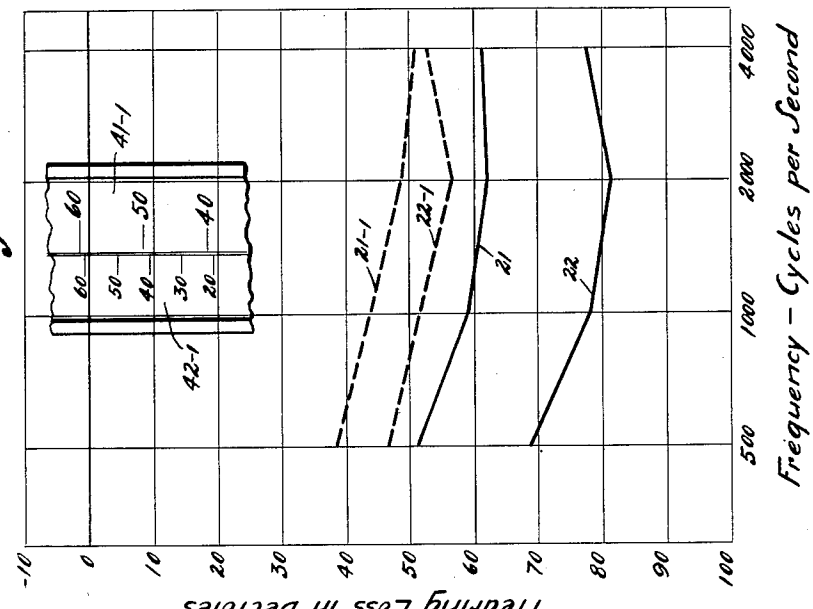


Fig. 1.

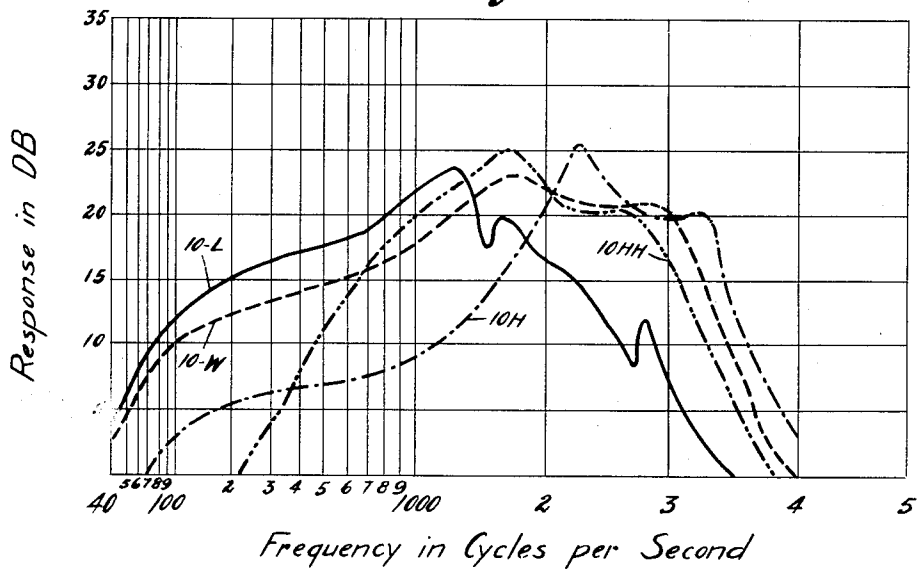


INVENTOR
Carl E. Rudiger
BY Pineles & Greene
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Fig. 3.



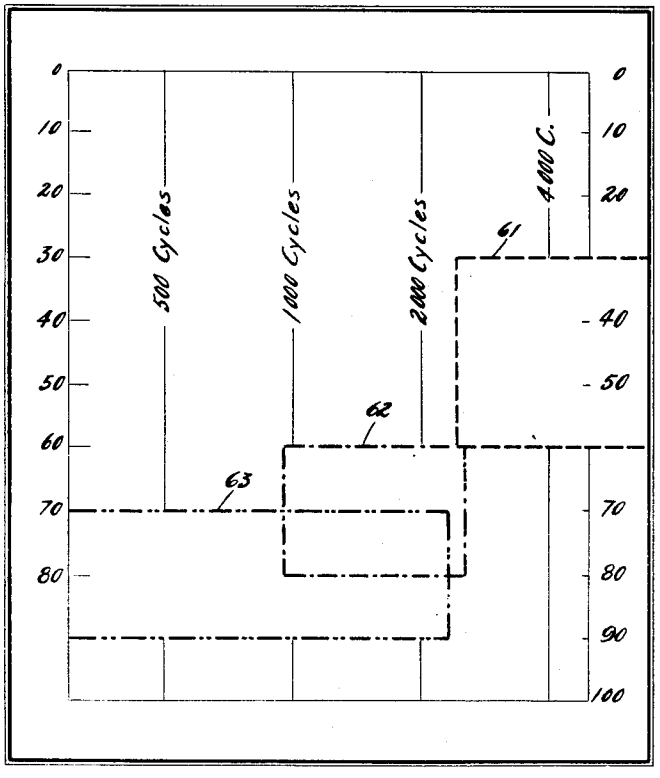


Fig. 12.

INVENTOR
Carl E. Rudiger
BY Pinilles & Greene
ATTORNEYS

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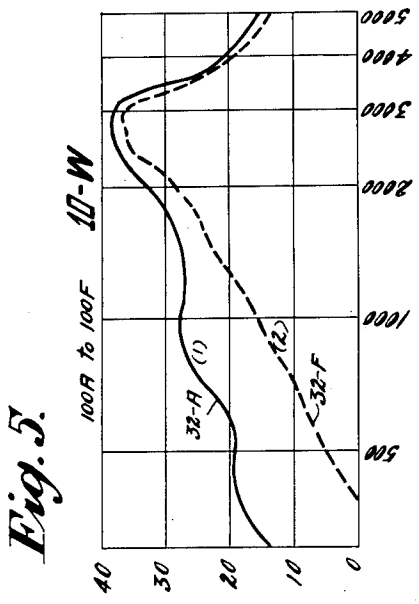


Fig. 5.

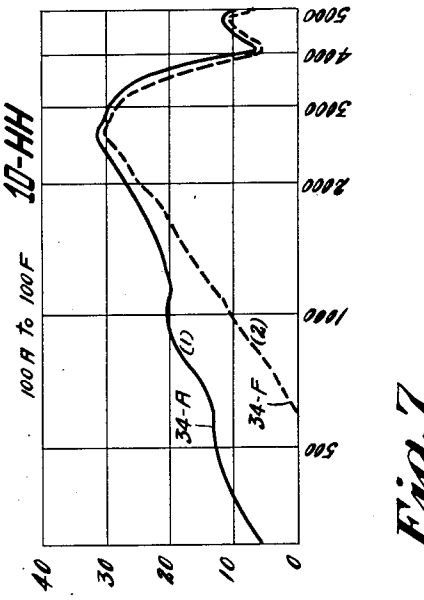


Fig. 7.

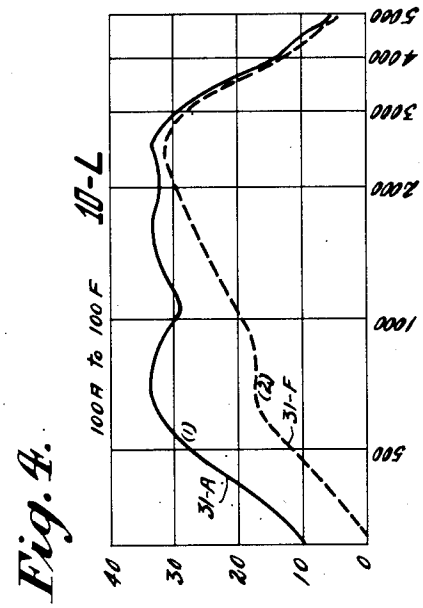


Fig. 4.

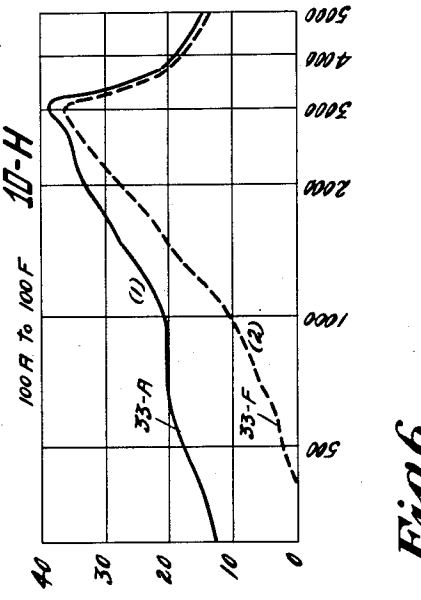


Fig. 6.

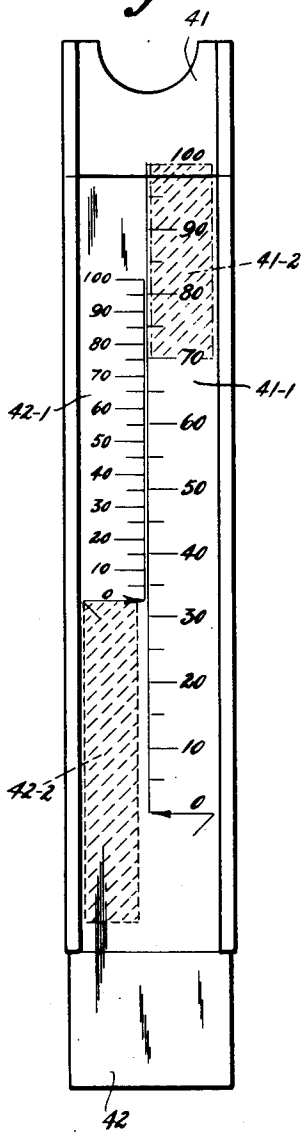
INVENTOR
Carl E. Rudiger
BY Pinckes & Greene
ATTORNEYS

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Fig. 8.



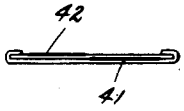
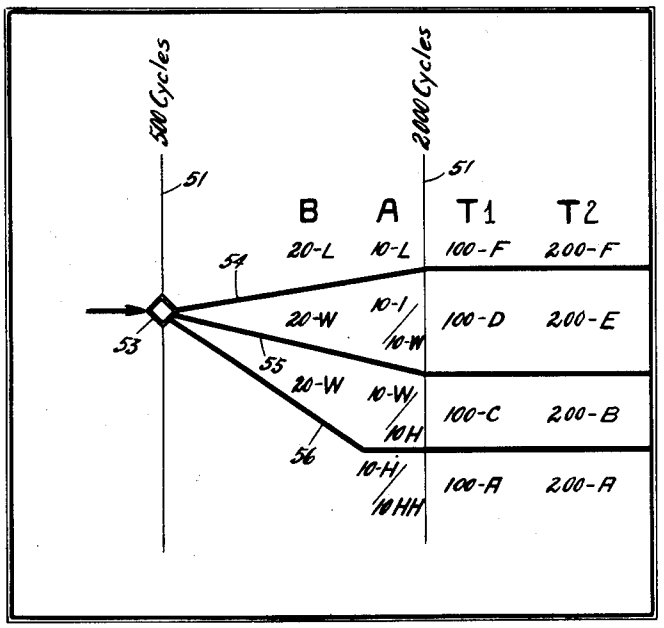


Fig. 8A.

Fig. 9.



INVENTOR
Carl E. Rudiger
BY
Pindles & Green
ATTORNEYS

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Fig. 11.

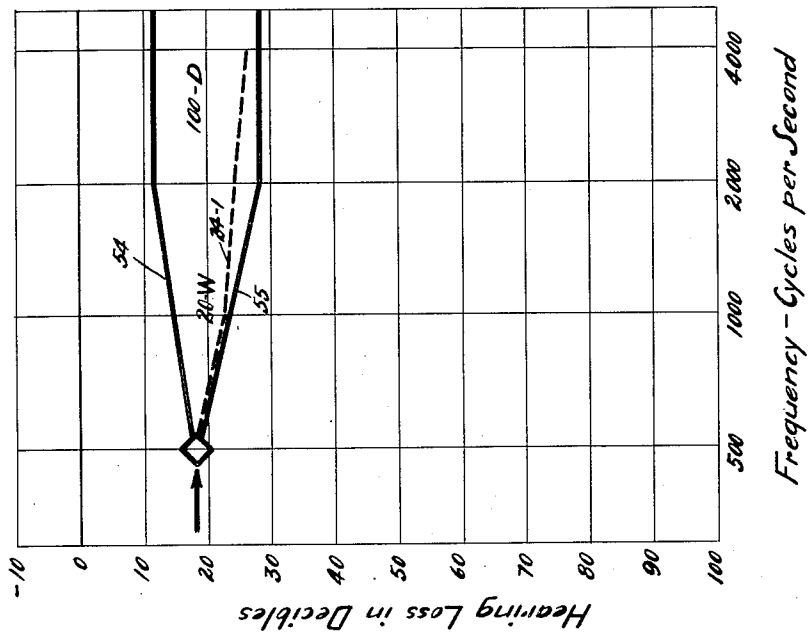
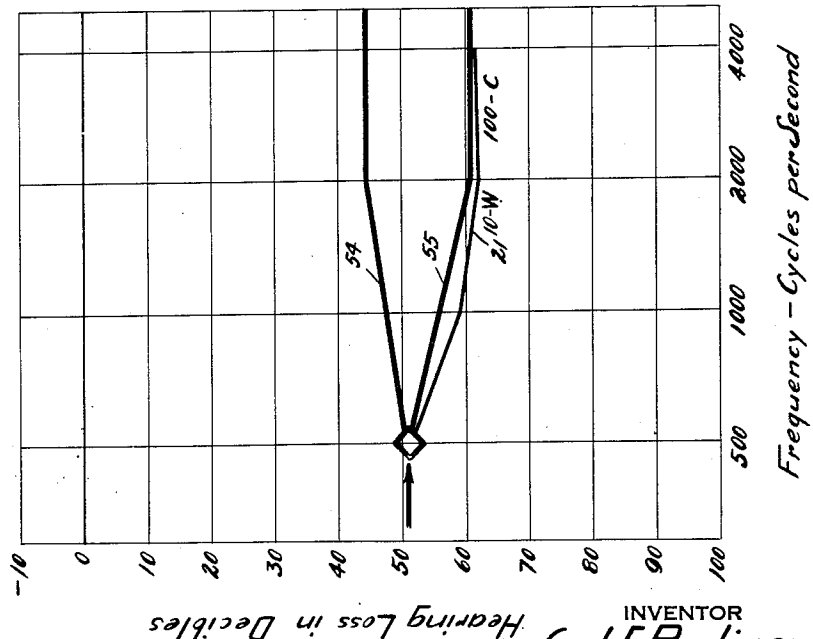


Fig. 10.



INVENTOR
Carl E. Rudiger
BY Pinckes & Gruene
ATTORNEYS

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UNITED STATES PATENT OFFICE

2,510,480

SYSTEM AND METHOD FOR FITTING HEARING AIDS

Carl E. Rudiger, Hawthorne, N. Y., assignor to Sonotone Corporation, Elmsford, N. Y., a corporation of New York

Application September 22, 1945, Serial No. 618,029

4 Claims. (Cl. 179—107)

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This invention relates to systems and methods for fitting hearing aids, and it has among its objects a novel and effective system on the basis of which the audiometric measurement of the hearing loss of a deafened person makes it possible to determine which of a number of receivers of known performance and frequency response characteristics, and, in combination with the receiver, which of several tone control settings of any available hearing aid amplifier systems will be most suitable to compensate for the hearing deficiencies of the user.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings wherein

Fig. 1 is an audiogram of a hard of hearing person whose hearing impairment is representative of the predominantly nerve type;

Fig. 2 is an audiogram of a hard of hearing person whose hearing impairment is representative of the predominantly obstructive type;

Fig. 3 is a curve diagram showing the frequency response characteristics of a series of different receivers with which a given hearing aid amplifier circuit is designed to operate;

Figs. 4 to 7, inclusive, show the overall frequency response of one type of commercial hearing aid when operating in combination with the four different types of receivers, the characteristics of which are shown in Fig. 3;

Fig. 8 is a plan view of a slide scale designed for cooperation with audiograms of the type shown in Figs. 1 and 2 for indicating which ear of the individual having the hearing impairment shown in such audiogram should preferably be fitted with a hearing aid receiver, and whether he would preferably use an air conduction receiver or a bone conduction receiver;

Fig. 8A is an end view of the slide scale of Fig. 8;

Fig. 9 is a plan view of a chart designed for cooperation with an audiogram of the type shown in Figs. 1 and 2 for indicating which of the receivers, the characteristics of which are shown in Fig. 3, and which tone control setting of a hearing aid amplifier having the overall response characteristics shown in Figs. 4 to 7, will provide best compensation for the given hearing impairment;

Fig. 10 is a part of the audiogram of Fig. 1 with a part of the chart of Fig. 9 superimposed thereon;

Fig. 11 shows a part of the audiogram of Fig. 2 with a part of the chart of Fig. 9 superimposed on it;

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Fig. 12 is a plan view of a chart designed for cooperation with an audiogram of the type shown in Figs. 1 and 2 for indicating which types of sounds the user will have difficulty in hearing.

Referring to Fig. 1, which is a typical audiogram of a person suffering from a predominantly nerve-type hearing impairment, full-line curve 21 indicates the overall hearing loss for the right ear, and full-line curve 22 indicates the overall loss for the left ear, both measured with a standard audiometer and a standard air conduction receiver, while dotted-line curves 21—I and 22—I show the loss in hearing for bone conduction for the right and left ears, respectively, when measured with a standard audiometer and equipped with a standard bone conduction receiver.

In order to provide a person of defective hearing with an effective hearing aid, its amplifying characteristics should be such as to compensate for the loss indicated in the audiogram, without subjecting him to undesired nervous reactions or tiring him. The overall amplification and frequency response characteristics of a hearing aid are determined by the integrated response characteristics of the microphone, amplifier and the receiver and the different tone controls usually provided in the amplifier.

The frequency response curves of Fig. 4 show the overall response characteristics of a standard commercially-available hearing aid equipped with an air conduction receiver having the frequency response characteristics shown by curve 10—L of Fig. 3. In the curves of Fig. 4, the upper full-line curve 31—A represents the overall frequency response of the hearing aid with its receiver referred to above when its tone setting is set to give the maximum overall amplification. The hearing aid in question has a tone control which makes it possible to cut its low frequency response over a continuous range extending over six principal settings A, B, C, D, E, and F, respectively, curve 31—F of Fig. 4 representing the overall frequency response of this hearing aid receiver combination with the tone control set for the setting F in which the low frequency response is cut to a maximum.

In Fig. 5, the two analogous curves 32—A, 32—F represent the overall response of the same hearing aid in combination with a receiver having the frequency response 10—W of Fig. 3.

In Fig. 6, the two analogous curves 33—A, 33—F represent the overall response of the same hearing aid in combination with a receiver having the frequency response 10—H of Fig. 3.

In Fig. 7, the two analogous curves 34—A,

34—F represent the overall response of the same hearing aid in combination with a receiver having the frequency response 10—HH of Fig. 3.

A hearing aid designed to operate with overall response curves and tone controls of the type referred to above is described in U. S. Shapiro Patent 2,327,320.

If now, a person having a hearing impairment of the type shown in the audiogram of Fig. 1, is to be fitted with a hearing aid having the response characteristics of the type shown by the curves of Figs. 3 to 7, the slider scale arrangement of Fig. 8 is employed to determine first, which ear is to be fitted, and second, whether air conduction or bone conduction receivers are to be employed. The slide scale of Fig. 8 has two relatively movable slide members 41, 42. Slide member 41 is shown provided with a main scale 41—1 which is a replica of the hearing loss scale of the audiogram charts in connection with which they are used, such as shown in Figs. 1 and 2.

In the chart of Fig. 1, the line of zero hearing loss, that means the line of normal hearing, is shown at the top of the chart, and the hearing loss is indicated in decibels. In the slide scale 41—1, the zero indication of the hearing loss is at the bottom of the scale.

A part of the main scale 41—1 of slide member 41 has an additional region mark 41—2 which serves as the ear selector mark and is so placed thereon that when the zero line of its scale 41—1 is placed over the audiogram chart of Fig. 1, opposite the air-conduction threshold of hearing of the poorer ear of the given individual, at a selected portion of the speech frequency spectrum corresponding to average hearing, such as about 1500 cycles per second (C. P. S.), and part of the scale 41—1 extending above the ear selector region mark 41—2 overlaps or crosses the zero line of the audiogram, it is preferable that the hearing aid should be fitted to the other ear which has a lesser hearing loss. The region mark 41—2 corresponds, in effect, to an indication that if the air-conduction hearing loss of the poorer ear is greater than indicated by the region mark 41—2, it is better to fit a hearing aid to the better ear because fitting the better ear will give greater benefits, taking into account the distance-range of hearing, the servicing of the instrument and economy.

For the particular instrument in connection with which the system here described has been designed, it has been found that if the air-conduction loss of the poorer ear at 1500 C. P. S. is greater than 70 decibel it is preferable to fit the instrument to the better ear. Thus, if the slide scale 41—1 is applied to the audiogram of Fig. 1, with the zero mark of slide scale 41—1 opposite the point of the air-conduction threshold of hearing of the poorer ear shown by curve 22 at 1500 C. P. S., the region mark 41—2 of scale 41—1 will be below the zero line of the audiogram and this will be an indication that the better ear, which, in the present case, exhibits only a hearing loss of about 60 db. at this frequency, is to be fitted.

The use of the slider scale 41—1 with its ear selector mark 41—2 is simplified by making it of transparent sheet material so that when it is placed over an audiogram such as shown in Figs. 1 and 2, the audiogram curves and data are visible. Furthermore, the entire upper part of the slider scale 41—1 extending above the region mark 41—2 is given a distinguishing color, indicated by the slanted dash shade lines so that the colored transparent upper part of the scale 41—1 shall serve as the ear selector region mark 41—2.

As indicated in Figs. 8, 8A, the transparent slider member 41 is shown arranged as a guide for the other slide member 42, which is likewise made of transparent sheet material. The other slide member 42 has a scale 42—1 which is shorter than the scale 41—1 of the other slider, and is so related thereto, that the full length of scale 42—1 indicates the maximum bone conduction loss of hearing at which an individual could be effectively fitted with the particular type of bone-conduction instrument, the full length of the other scale 41—1 of the other slide member 41 representing the maximum air-conduction loss of hearing at which an individual could be fitted with an air-conduction instrument. The slide scale 42—1 has a graduation corresponding to the graduation of the main hearing loss scale 41—1 of the slide member 41, the spaces between the graduation marks of scale 42—1 or its divisions being proportionately reduced.

The two slider members 41, 42, with their scales 41—1, 42—1 serve to determine whether the ear which is to be fitted will be better served by air conduction or bone conduction. To this end, the zero line of the scale 42—1 of slider 42, or the slider part extending below the zero line of scale 42—1, and shown by the area with the slanted dash shade lines 42—2, serves as the bone conduction selector region mark, so that when the scale 42—2 is placed over the audiogram with a graduation of its scale corresponding to the air conduction loss of hearing on the zero line of the audiogram at the average hearing frequency, such as 1500 C. P. S., and the bone conduction threshold of hearing of the ear which is to be fitted falls below the zero mark of scale 42—1 or within the area of the bone-conduction selector region 42—2, this is an indication that the user should be fitted with an air-conduction instrument.

When using a slider arrangement of the type described in connection with Figs. 8, 8A, one may proceed, in connection with the case represented by the audiogram of Fig. 1, as follows:

Having previously determined that the better ear of the individual should be fitted, the zero mark of slide scale 41—1 is placed over the audiogram chart of Fig. 1, the curve of the air conduction threshold of hearing 21 of the ear which is to be fitted at the frequency of his average hearing ability, at about 1500 C. P. S. After noting on scale 41—1 of slide member 41 crosses the zero line of the audiogram at 58, the other slide member 42 is moved till its scale likewise crosses the zero line at the same numerical indication, namely, 58. This is indicated in Fig. 1 by superimposing thereon parts of the two scales 41—1, 42—1 in the alignment just described.

If now, the bone conduction selector mark 42—2 of scale 42—2 is intersected by the curve of the bone-conduction threshold curve 21—1 of the ear which is to be fitted, then this is an indication that air conduction should be fitted, the hearing loss being primarily of the nerve type rather than of the obstructive type. In general, these scales help to determine whether the bone conduction loss is so great in relation to the air conduction loss as to indicate that it is better to fit the ear in question with an air conduction instrument.

By using the slide scale arrangement in an analogous manner in connection with audiogram chart of Fig. 2, it may be readily determined that in that case likewise the better ear is to be fitted. Furthermore, by adjustably setting the two slide

scales 41—1, 42—1 on the audiogram data of Fig. 2 in the manner just described in connection with Fig. 1, it will be found that bone conduction selector mark 42—2 of the slide member 42 not crossed by the bone-conduction threshold line curve 24—1 of the better ear which is to be fitted, indicating that the user should be fitted with a bone conduction instrument.

Summarizing, the slider scale of the type described above in connection with Figs. 8 and 8A and designed to form part of a system for fitting hearing aid instruments of predetermined component and overall performance characteristics in accordance with the hearing loss of the user, as indicated by audiometric curves of a hearing aid on an audiogram chart having a frequency scale and a hearing loss scale, embodies the following important features:

One slider scale member is a scale corresponding to the loss scale of the audiogram chart and an ear selector mark is so placed on its loss scale that when this scale member is placed in a predetermined position on the audiogram chart, the relationship of the selector mark to the curve data of the audiogram chart will indicate whether the hearing aid instrument is to be fitted to the better ear or to the poorer ear of the user.

The slider scale has an additional slider scale member having a scale shorter than the hearing loss scale of the audiogram, so correlated to the performance characteristics of the instrument of the hearing aid and the audiometric curves of the audiogram chart, that when this scale member is placed in a predetermined position on the audiogram chart, the relationship of the elements of the additional scale to the curve data of the audiogram chart will indicate whether the user is to be fitted with a bone conduction instrument or an air conduction instrument.

The two slider scale members are made of transparent sheet material so that they may be superimposed on the audiogram chart without obscuring the data of the audiogram chart, and one slider is movable to the other slider member so that the scales of the two slider members may be correlated to each other and to the data of the audiogram chart for determining whether the hearing aid is to be fitted to the better ear or to the poorer ear of the user as well as to indicate whether the user is to be fitted with a bone conduction instrument or an air conduction instrument.

In order to make it possible to determine, with a hearing aid amplifier instrument having tone controls of the type described above, which of the various receivers and which tone controls should be used, there is provided an additional fitting guide shown in Fig. 9. This fitting guide is likewise made of a plastic transparent sheet member so that when it is superimposed on the audiogram, its curves and markings will be clearly seen. The chart of Fig. 9 has a vertical line corresponding to the 500-cycle line of the audiogram, and another vertical line corresponding to the 2000-cycle line of the audiogram. It has been found that the region between the two frequencies is a good criterion for determining in a general manner which type of instrument and what type of controls will fit best, or will compensate best for the hearing impairment of the user.

In other words, the two lines marked 500 and 2000 of Fig. 9 correspond to the adjacent boundaries of the frequency range which it has been found practical to use for determining the instrument and the type of controls which are likely to best fit the user. The lower frequency boundary line, in the present case, the line 500, has thereon a window mark 53 which is to be placed on the corresponding frequency line of the audiogram of the individual, on the threshold point of the air conduction loss curve or bone conduction loss curve, depending on whether he has to be fitted with an air or bone conduction instrument. In the case shown, the lower boundary line is the 500 cycle line, and when used in connection with the audiogram of Fig. 1, the window mark 53 is placed over the threshold curve 21 at the 500 cycle frequency.

The two divergent lines 54, 55 extending from the window mark 53 of the chart of Fig. 9 are so placed thereon as to provide boundary lines between cases of hearing loss as shown in the audiograms requiring instruments which provide predominant amplification in the low frequency range or in the high frequency range or requiring more or less uniform amplification over the entire frequency range. Thus, the boundary line 54 is the lower boundary line for the audiogram area requiring low frequency amplification, the boundary line 55 is the upper boundary line for the audiogram area requiring high frequency amplification, while the audiogram area extending between the two boundary lines 54, 55 defines the region best served by substantially uniform overall amplification.

In the region of the chart of Fig. 9 extending between the two frequency boundary lines 51, 52, there are shown two vertical columns of legends indicating the type of receivers that are to be fitted. In the case shown, the column headed by the mark A indicates the different types of air conduction receivers and the column headed by the mark B indicates the different types of bone conduction receivers. There is also shown in the chart an additional mark T heading the tone controls of the different instruments which are to be fitted.

Fig. 10 which contains the threshold curve 21 of the audiogram of Fig. 1 has superimposed thereon the mark lines of Fig. 9 to indicate how the particular user will be fitted with a hearing aid by the indications on the chart of Fig. 9. It will be seen that since the threshold line 21 is below the curve 55, he may be fitted with an air conduction receiver 10—W and an instrument with a tone control setting C corresponding to the instruments and tone control settings described above in connection with the charts of Figs. 3 to 7.

Fig. 11 is an audiogram corresponding to the audiogram of Fig. 2, but showing only the loss curve 24—1 of the ear which is to be fitted, and it has chart marks of Fig. 9 superimposed thereon. As indicated thereon, since the threshold curve 24—1 is between the boundary lines 54, 55 of the fitting chart of Fig. 9, the ear should be fitted with a bone conduction instrument 20—W and an instrument with a tone setting 100—D.

In other words, in using the chart of Fig. 9, its window mark 53 is placed over the 500-cycle point of the threshold curve of the ear and type of hearing which is to be fitted. If the threshold curve of hearing extends above the boundary line 54, the ear will be fitted either with an air conduction or bone conduction instrument indicated above the boundary line 54 and with a tone control likewise indicated above the boundary line 54.

If the threshold curve of hearing of the ear

which is to be fitted extends between the two boundary lines 54, 55 of the chart of Fig. 9, it is to be fitted either with an air conduction receiver or a bone conduction receiver of the type indicated between the boundary lines 54, 55 and with an instrument having a tone control setting likewise indicated between the boundary lines 54, 55. It will be noted that under column A of air conduction receivers, there is the legend 10—L over 10—W in the area between the two boundary lines 54, 55. This indicates that the particular person may be fitted either with a receiver having the response curve 10—L of Fig. 3 or with a receiver having a response curve 10—W of Fig. 3.

If the threshold curve extends below the boundary line 55, then the user should be fitted either with an air conduction receiver or a bone conduction receiver indicated on chart 9 by the legend below the boundary line 55 and by an instrument having tone controls likewise indicated on the chart of Fig. 9 below the boundary line 55. The chart of Fig. 9 also shows an additional boundary line 56 which is lower than the boundary line 55 to indicate that if the threshold of hearing of the ear to be fitted extends below the line 56, it should be fitted with receivers and tone settings indicated by the legends below line 56.

Summarizing, the fitting chart described above in connection with Fig. 11, is designed for cooperation with audiogram charts showing the hearing loss of the user, of the type described in connection with Figs. 1 and 2 and has aligning data which makes it possible to align the chart with the data of the audiogram, the fitting chart being made of transparent material so that when it is superimposed on the audiogram the audiogram data and curves are not obscured by it. The fitting chart has a plurality of boundary lines and instrument data so correlated to the performance characteristics of the component parts and the overall performance of the instrument data associated with the boundary lines and arranged for cooperation with the data of the audiogram chart, so that the relationship of the audiometric curve elements of the ear which is to be fitted, as shown in the audiogram chart, to the boundary lines of the fitting chart, indicates which combination of instrument components and instrument settings will best fit the needs of the user.

The chart of Fig. 12 has likewise formed thereon a boundary outline corresponding to the boundary outline of the audiogram, having thereon an area indicated by dash lines 61, the level and frequency region of unvoiced consonants of speech, an area indicated by a dash-dot line 62, the level and frequency region of voiced consonants of speech, and an area indicated by the dash double-dot line 63, the level and frequency region of the vowel sounds of speech. By placing such transparent outline chart of the type shown in Fig. 12 on an audiogram, it is possible to determine at a glance what type of speech sounds the person having a particular type of impairment, as indicated by his threshold curve corresponding to curve 21 of Fig. 1, and that he will partially hear the vowel sounds and voiced consonants.

Similarly, by placing the chart of Fig. 12 over the audiogram of Fig. 2, it will indicate that only the vowel sounds will be heard by a person having a hearing loss as represented by air conduction threshold 24 in Fig. 2, but he will not hear the voiced consonants or the unvoiced consonants of speech.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplifications thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific exemplifications of the invention described above.

I claim:

1. In a system for fitting hearing aid instruments of predetermined component and overall performance characteristics in accordance with the hearing loss of the user as indicated by audiometric curves of the threshold of hearing on an audiogram chart having a frequency scale and a hearing loss scale: a scale member of sheet material provided with a transparent scale region having a complementary scale corresponding to the loss scale of the chart; and an ear selector mark so placed on the complementary scale of the scale member that when the scale member is placed in a predetermined position on the chart, the relationship of the selector mark to the curve data of the chart will indicate whether the hearing aid is to be fitted to the better ear or to the poorer ear of the user.

2. In a system for fitting hearing aid instruments of predetermined component and overall performance characteristics in accordance with the hearing loss of the user as indicated by audiometric curves of the threshold of hearing on an audiogram chart having a frequency scale and a hearing loss scale: a scale member of sheet material provided with a transparent scale region having a complementary scale shorter than the loss scale of the audiogram and a graduation so correlated to said performance characteristics and the audiometric curves that when said scale member is placed in a predetermined position on the audiogram chart the relationship of the elements of the complementary scale to the data of the audiogram chart will indicate whether the user is to be fitted with a bone conduction instrument or an air conduction instrument.

3. In a system for fitting hearing aid instruments of predetermined component and overall performance characteristics in accordance with the hearing loss of the user as indicated by audiometric curves of the threshold of hearing on an audiogram chart having a frequency scale and a hearing loss scale: slider scale means having two relatively movable slider members of sheet material each having a transparent region; the transparent region of one slider member having a first scale corresponding to the loss scale of the chart; and an ear selector mark so placed on said loss scale that when the slider is placed in a predetermined position on the chart the relationship of the selector mark to the curve data of the chart will indicate whether the hearing aid is to be fitted to the better ear or to the poorer ear of the user; the transparent region of the other slider member having a second scale shorter than the first scale and a graduation so correlated to said performance characteristics and the audiometric curves that when said other slider is placed in a predetermined position on the audiogram chart the relationship of the elements of the second scale to the data of the audiogram chart will indicate whether the user is to be fitted with a bone conduction instrument or an air conduction instrument.

4. In a system for determining the effect of the hearing loss of a deafened person on his perception of speech: an audiogram chart having a frequency scale and a hearing loss scale for indicating thereon by an audiometric hearing-loss curve the threshold of hearing of a person, and in combination therewith an additional chart of transparent sheet material having aligning indications for aligning the additional chart with the scales of the audiogram chart, said additional chart having a plurality of different boundary lines bounding areas corresponding to the level and frequency distribution of unvoiced consonants of speech, of voiced consonants of speech and of vowel sounds of speech, said different boundary lines being arranged so that when the additional chart is superposed over an audiogram chart, the relation of the hearing-loss curve to said different boundary lines indicates whether the person has difficulty in hearing the unvoiced consonants, the voiced consonants and the vowel sounds.

CARL E. RUDIGER.

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