

Sept. 29, 1970

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METHOD AND APPARATUS FOR THE TESTING AND
TREATMENT OF HEARING DEFICIENCIES

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2 Sheets-Sheet 1

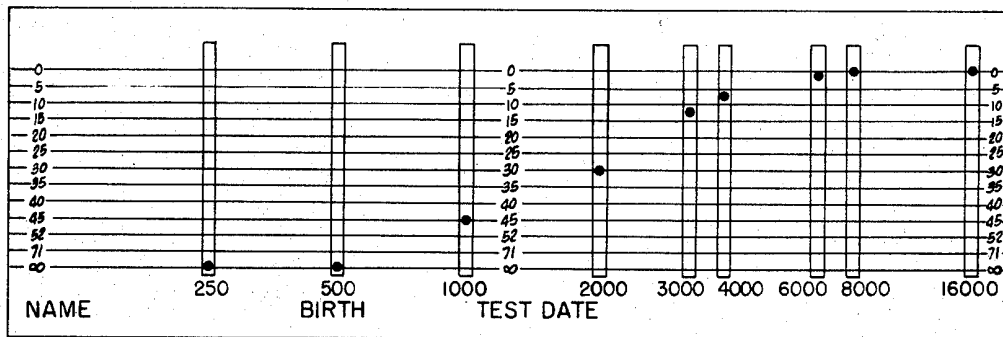


FIG. 1.

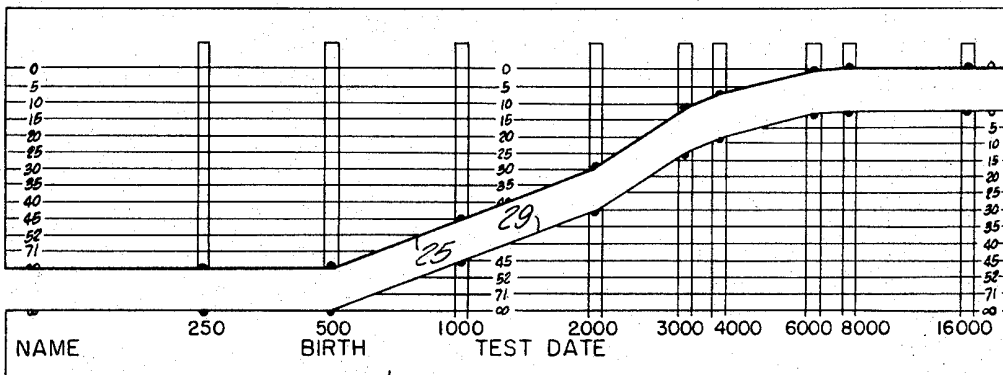


FIG. 2.

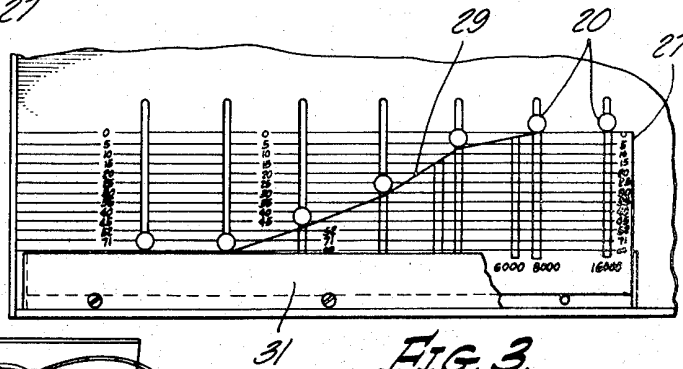


FIG. 3.

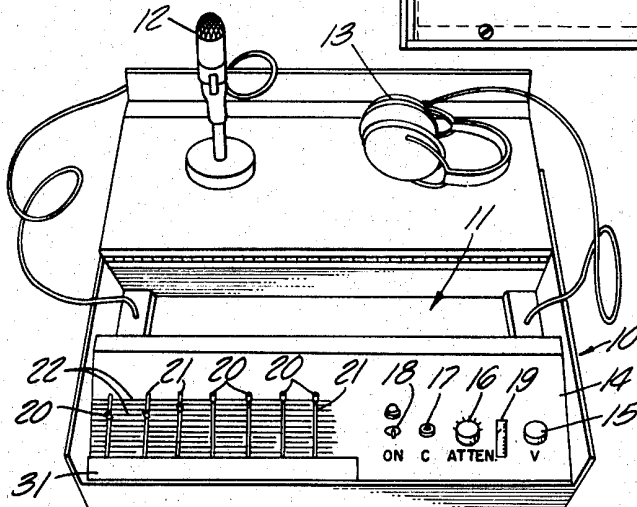


FIG. 4.

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2 Sheets-Sheet 2

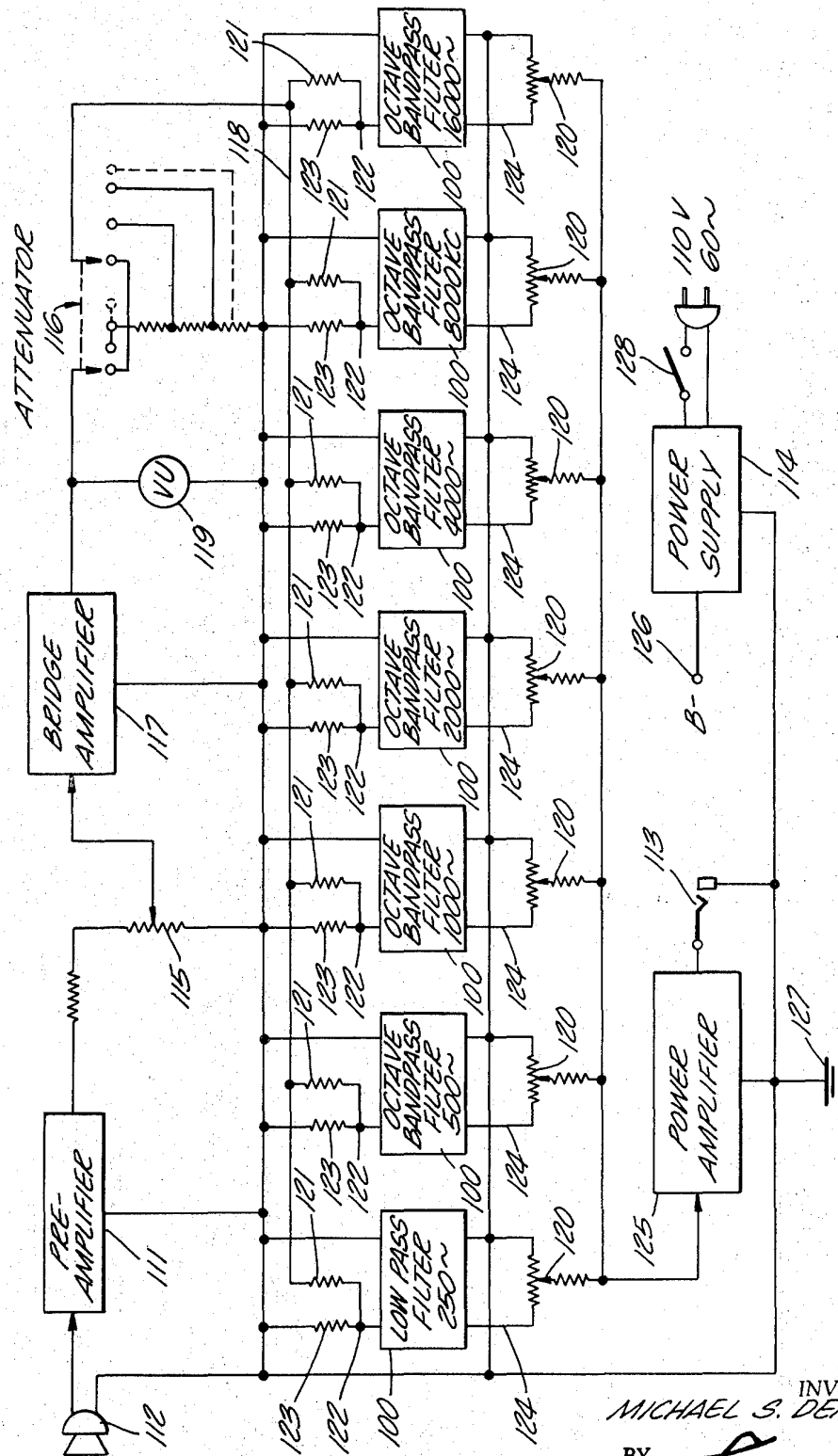


FIG. 5.

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3 Claims

ABSTRACT OF THE DISCLOSURE

The present invention relates generally to a method for testing and treating hearing deficiencies, and in addition, to apparatus for carrying out such method. More specifically, the present invention provides an apparatus with which an individual's hearing can be treated to determine the characteristics of his hearing deficiencies, whereupon the apparatus can be employed to treat those hearing deficiencies by adjusting the apparatus to compensate for the individual's hearing loss characteristics. The apparatus includes an amplifying device which first divides an incoming signal into a plurality of signals each having a discrete bandwidth the plurality of which span the audible frequency spectrum and which are separated by approximately octave steps. Means is then provided to vary the attenuation in each bandwidth so that the frequency response of the amplifier can be matched to an individual's hearing loss characteristics. Following the individual attenuators, the outputs are recombined in a mixing stage and then fed to an output amplifier. The apparatus also includes a unique method for easily setting the frequency response characteristics of the device.

The causes of hearing loss are many, there being a number of diseases which cause various degrees of loss as well as the harmful effects of certain medications and accidents which may either temporarily or permanently impair a person's hearing. But deafness is not an absolute, and there are as many degrees and types of deafness as there are persons having deficiencies. Although each individual's pattern of hearing loss may not be as distinctive as his fingerprint, it is at least as varied as each individual's pattern of eyesight may be. In other words, an individual's hearing loss pattern will seldom, if ever, be identical to the pattern of another individual. Even persons whose hearing is considered normal will, when tested, indicate that their threshold of hearing varies with respect to changes in the frequency of the sound being heard.

It has been the practice for some years to test an individual's hearing by varying the frequency and volume of a tone signal in order to plot an individual's hearing response curve of frequency versus volume. Such tests have frequently been made by persons known as audiologists or otologists who then use such response curves to aid in the diagnosis of the nature of a person's hearing defect. In other words, the response curve can give a skilled medical practitioner competent symptomatic evidence which can be of assistance in diagnosing the nature of a hearing defect, i.e., determine whether there is a blockage in the ear canal, a damaged eardrum, ossification of the bones in the middle ear or defects in the inner ear. Such audiological tests also frequently include a test to determine, throughout the range of audible frequencies, the individual's threshold of pain, and such information will also provide valuable evidence from which to diagnose the cause of hearing defects. These audiological reports also are of value to persons fitting hearing aids in order to determine which particular type of hearing aid,

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having a given frequency response and level of volume, will be satisfactory for a particular patient.

The process of hearing is not solely a physical reaction to incoming sound waves in which the ear, the connecting nerve pathways and the brain invariably react to produce the same response in the brain, but it also depends a great deal upon the audio education of each individual. Audio education in turn has an important bearing on the development of speech and accent as well as a somewhat indirect effect upon the learning process of children. It is well known that children reared in various different areas of the English-speaking world will develop a manner of speech and accent which is peculiar to the accent of those with whom he is closely associated during his formative years although the child may be completely unaware that his speech habits are any different from those of others. This is because he will conform his speech patterns to the sounds that he hears about him.

It is clear then that a child who is born with a severe hearing loss will be unable to develop a pattern of speech which is easily recognizable to persons of normal hearing since the individual has no way of comparing the sounds he is making to the sounds of others. It is equally true that children having a partial hearing loss at birth, or occurring during the important speech-forming years, will develop speech habits normally considered speech defects but which are not caused by defects in the patient's vocal pattern. In the latter, the speech per se of the individual is not impaired, but due to his hearing deficiency, his speech sounds the same to him as others.

The most common types of hearing deficiency are characterized by greater losses occurring in the upper frequencies of audible speech. For persons having such a deficiency, it may very well be that their speech will develop substantially normally but they will have difficulty in learning the distinctions between certain syllables and will have difficulty pronouncing some of them. The distinguishing sounds of the consonants are generally supplied by higher frequency sounds and unless a person has hearing capable of detecting them, it is frequently difficult to tell such consonants apart as P, T, D and K and S, F and Th. For children learning to read and spell, it becomes rather confusing and difficult if they cannot properly detect the difference between these sounds.

In addition, an individual's hearing has an important bearing upon the ability of that person to learn to speak a foreign language with proper accent and inflection. Although the individual learning a language may feel he is pronouncing a word in the same manner as his instructor because it sounds the same to him, his pronunciation may be poor either because he has not correctly heard the instructor or doesn't correctly hear what he himself is saying. It has only recently become a practice to use tape recordings so that the person can hear exactly how he is pronouncing the language. The difficulty, of course, with such language laboratories is that for persons having hearing loss deficiencies, certain of the important consonants encountered in various foreign languages will not be sufficiently distinct to that person so that he can tailor his speech accordingly. Thus, even slight hearing loss deficiencies can be of importance to the adult as well as to the child in the speech-forming years.

The present invention provides a method of educating the hearing of an individual by permitting him to hear full frequency range sound compensated for his individual loss characteristics whereby the sensitivity of his hearing to various frequencies can be increased thereby tending to gradually decrease his hearing losses at various frequencies. Although it is not contemplated that the introduction of full frequency range sound will cause sufficient physical changes in the hearing structure to significantly

reduce the actual level of hearing loss, it is found that the effective level of hearing loss will be reduced through audio education. This principle can be demonstrated by the following situation: The telephone system commonly in use today does not provide for a broad frequency range of transmission and the frequency through which the amplification remains constant is about 100 to 3,000 cycles per second. Audible speech, however, under normal circumstances, usually varies over a range of about 20 to 10,000 cycles per second and as mentioned above, a great number of the higher frequencies distinguished many of the distinctive sounds in our speech. If a person from birth were permitted to hear speech only over the telephone, it is highly unlikely that he would understand a great deal of what he heard and in any case he would develop what we would consider several speech defects. Normal persons, however, do not have difficulty communicating over the telephone although it is obvious that they cannot hear all of the audible speech that they normally hear. This is because the audio education of the brain fills in the gaps. To the same extent, through the use of the method of the present invention, it is possible to train the audio memory of an individual so that during normal speech he can fill in the gaps and therefore hear normally. Then, even for persons having severe hearing loss, through the use of the hearing aids now available, which do not provide full frequency range sound with a sufficient volume to compensate for many hearing losses, a person having received audio education through the method of the present invention can hear more normally since he can fill in the gaps himself.

The object, therefore, of the present invention is to provide a method for treating hearing loss.

Specifically, it is an object of this invention to provide a method for determining the level at which a person's hearing losses occur and for treating such losses.

More specifically, it is an object of this invention to provide a method of determining the degree of hearing loss by measuring the volume at which the loss occurs as a function of frequency and then using those measurements to treat the patient.

It is a further object of the present invention to provide a method for testing and treating hearing deficiencies by obtaining readings of a patient's hearing loss as a function of frequency, then using such measurements to fully compensate for the hearing deficiencies and treating such deficiencies by the introduction of compensated full frequency range sound.

It is also an object of the present invention to provide apparatus for the testing and treating of hearing deficiencies.

It is an object of the present invention to provide apparatus having means to determine the degree of hearing loss at various frequency levels.

It is also an object of the present invention to provide an apparatus for the treatment of hearing deficiencies having means to fully compensate for various characteristics of hearing deficiencies whereby compensated full frequency range sound will be introduced to the patient.

It is a particular object and advantage of the present invention to provide apparatus having means operative both for the testing and the treatment of hearing deficiencies.

Further objects and advantages of the present invention will become apparent upon reading the ensuing description together with the accompanying drawings in which:

FIG. 1 is a drawing of a key card used in accordance with the present invention.

FIG. 2 is another view of the key card used in accordance with this invention.

FIG. 3 is an enlarged partial view of one portion of the apparatus showing the position of the key card thereon.

FIG. 4 is a front perspective view of the apparatus.

FIG. 5 is a schematic circuit diagram showing the general details of the testing and treatment unit.

Turning now to the details of the drawings, FIG. 4 shows a perspective view of the unit consisting of a cabinet 10 completely housing all of the electronic components of the unit including appropriate power supplies so that the unit may be plugged into conventional AC outlets. A storage well 11 is provided in the center portion of the cabinet 10 to permit convenient storing of the various accessories such as the microphone 12 and the earphones 13. The front portion of the cabinet 10 is provided with a front panel 14 upon which are mounted the various controls for the unit as will be more definitely described hereinafter. Such controls include the volume control 15, an attenuator control 16, a calibration control 17, and a power switch 18. Also, on the front panel 14 there is mounted a meter 19 which indicates, together with the setting of the attenuator control 16, the volume level of the incoming signal. On the left-hand side of the panel 14 are a plurality of attenuator control arms 20 which are mounted so as to move in the vertical slots 21 provided in the control panel 14. A plurality of graduation marks or lines 22 are inscribed on the face of the panel 14 running horizontally across the area through which the attenuator control arms 20 are adapted to move. These graduation lines 22 are calibrated in terms to give an approximate evaluation of the degree of attenuation added by each control arm with the zero location in the uppermost position for the control arms 20. Thus, as a control arm is moved downwardly, the attenuator to which it is attached increases the amount by which it attenuates the signal coming therethrough.

FIGS. 1 through 3 demonstrate the key card designated generally 23 used in conjunction with the unit. As can be seen in FIG. 1, the key card 23 is printed in the form of a graph in which the abscissa is divided into units of frequency in cycles per second on a logarithmic scale and the ordinate is divided in units of volume in decibels, decreasing upwardly. The key card shown in the drawings includes nine definite frequency values at which the patient's minimum sound perception level is determined. By the testing procedure which will be hereinafter more fully described, the patient is tested at each of the nine stated frequencies to determine at each frequency the approximate lowest volume level at which sound is perceived. Those values are then plotted on the graph of FIG. 1 as shown by the dots placed in each of the vertical boxes under the values 250, 500 and so on. As shown in FIG. 2, a line is then drawn connecting the dots in each of the boxes. The resulting curve represents the inverse of the patient's hearing ability or in other words it represents directly the magnitude of his hearing deficiency. Since it is noted in a majority of cases that hearing loss decreases with an increase in frequency, the representative graph shown in the drawings shows a gradual rise in the curve 25 at the higher frequencies.

In order to use the apparatus for treatment, the key card 23 is then cut along the curve 25, leaving the lower portion of the key card 27, the upper surface 29 of which follows the hearing loss curve precisely. The lower portion 27 of the key card then becomes the attenuator setting card 27 shown in FIG. 3. The card is inserted in the holder 31 secured to the front of the panel 14 and is indexed against the far left edge thereof. The attenuator control arms 20 are then brought downwardly until they contact the upper surface 29 of the card 27. This then precisely sets each of the attenuator controls so that the least attenuation, and therefore the most amplification will be provided where the control arms 20 are in their uppermost positions as demonstrated in FIG. 3, thereby permitting the most amplification in the frequencies most difficult to hear. The patient is then permitted to hear through the earphones 13 common ordinary sounds such as speech or music and the attenuators compensate for his hearing losses so that he hears normal sound as near-

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ly as possible. By means of the attenuator and volume controls 15 and 16, sufficient boost can be given to the sound to reach the residual hearing levels of those persons formerly considered stone deaf. Persons having a hearing loss of a magnitude of 80 decibels or more have formerly been considered totally deaf and have heretofore been unreachable by hearing aids or treatment devices although such persons do have some residual hearing. The present device provides sufficient volume boost up to 120 decibels without objectionable harmonic distortion in order to reach such persons.

Turning now to FIG. 5 in the drawings, a schematic circuit diagram of the amplifier and filter network is provided. This consists of seven band pass filters 100, the center frequencies being set approximately one octave apart, or as indicated in FIG. 5, at 250 c.p.s., 500 c.p.s., 1,000 c.p.s., etc. The microphone input designated 112 is coupled into a preamplifier 111, the output of which is coupled to the master level or volume control 115. The wiper of control 115 couples to the input of the bridge amplifier 117. The VU meter 119 is connected to the output of the bridge amplifier 117 as shown, and the output of amplifier 117 also connects to one terminal of attenuator 116, which has a plurality of discrete steps as shown.

The other terminal of attenuator 116 is connected to a common input line 118 which in turn is coupled through appropriate resistors 121 to the input terminal 122 to each of the band pass filters 100. The resistors 123, also coupled to input terminal 122, provide appropriate bias for the band pass filters. The output terminal 124 of each band pass filter 100 couples to a voltage divider 120 and it is this control 120 to which the attenuator control arms 20 on the front panel of the unit are connected. The output of each voltage divider 120, obtained from the wiper arm thereof, is coupled in turn to the power amplifier 125 shown diagrammatically in FIG. 5. The output of power amplifier 125 is coupled directly to the headphone jack 113. Appropriate power supply means 114 are provided, affording sufficient B minus power at terminal 126 for all of the amplifiers in the unit, and the powersupply 114 is connected to common ground 127 as shown. The power switch designated 18 on the front panel in FIG. 4 is shown at 128 in FIG. 5.

From the above description, it will be apparent that each of the band pass filters is coupled in the circuit in the same manner and therefore it is deemed unnecessary to explain the illustrated details of each. From this circuit it can be seen that the setting of the volume at control 115 will be indicated on the meter 119 and the attenuator 116 setting will set up the appropriate incoming signal level to all of the band pass filters. Each of the filters will pass its appropriate frequency band without introducing appreciable loss, but then the level at each octave can be adjusted by each voltage divider attenuator 120 thereby affording means for compensating various portions of the broad frequency input signal by individual settings of each of the dividers 120. Thus, the input signal is tailored according to the frequency-volume characteristics desired. By subsequently altering the volume control 115 or the attenuator 116, the overall level of the amplified signal received at the earphone jack 113 can be varied without altering the frequency-volume characteristics.

From the above description of the apparatus of this invention, the method of testing and treatment using said apparatus will probably be apparent. For the purposes of clarity, however, the steps of the method will be briefly stated hereinafter. The earphones are placed on the patient's head and a single frequency input signal is introduced at the input microphone or through an auxiliary input as desired. The input frequency is first set at 250 cycles and the volume level thereof is slowly increased until the patient indicates that he hears the tone. At that point, the operator notes the level of the input signal on

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the meter 19 and records the value. The input signal is then adjusted for 500 cycles and the volume slowly increased from zero until the patient again indicates perception of the tone. This procedure is repeated for each of the nine frequencies shown on the key card. The values obtained are then taken and a corrected score of zero is assigned to the frequency at which the greatest amount of amplification was required for the patient to exhibit perception of the signal. This is termed the frequency of greatest loss. The attenuator value settings for the other frequency levels are then obtained by subtracting the tested value at each frequency from the value of the greatest loss and those scores are recorded on the graph of FIG. 1 as previously described to obtain a hearing loss response curve. The key card is then cut out and placed on the unit and the attenuator control arms 20 are moved into contact with the upper portion of the curve. This quickly sets the attenuators at the appropriate value to compensate for the hearing loss at the various discrete frequency levels. The training of the patient then begins. Normal speech is ordinarily used as the input signal at the microphone 112 and the attenuator and volume control settings are set for a comfortable level for the patient. The patient may use the unit for several hours per day for therapy purposes and after sufficient training periods with the unit, it is found that the hearing ability of the student is enhanced to a great extent.

Following are two typical case histories:

I

The first is Patty J., born Mar. 18, 1955, who began therapy at the age of five years and seven months. Her initial audio response curve was as follows:

Cycles/second	500	1,000	2,000	3,000	4,000	5,000
(1) Free field, unaided, db...	10	35	30	60	65	70
(2) Free field withaid, db...	0	0	0	45	Max.	Max.

Patty's difficulty was initially noticed by her kindergarten teacher who noticed that Patty had trouble following directions. Patty was tested and found to have the above loss pattern, commonly referred to as a "ski slope" loss. In other words, she could hear low tones well enough to understand some speech but she was unable to reproduce sounds adequately to have intelligible speech.

Patty was fitted with two hearings aids, providing her with a response pattern shown at number 2 above. She progressed rapidly, attended regular school, and by the age of ten could say all sounds clearly except the fricatives of s, j, ch and the blends. It may be noted from line number 2 that the loss at 3000 was diminished somewhat by the aids, but remained severe. Above 3000 the aids acted like an earplug, supplying an even greater loss than present without hearing aids. This is because of the inherent shortcomings of all hearing aids and by the difficulty in accurately compensating for a particular long curve with the hearings aids now available. The aids could not cover here higher frequency losses and not still over-compensate the relatively mild 10 db loss at 500 cycles. Patty was recently given treatment with the device of the present invention, adjusted to her recise loss and compensated in the higher frequencies above 4000 cycles where the formants of the consonants are heard. After eight months of using the device, Patty has learned all sounds and blends and can now speak clearly and intelligently as any hearing child of her age.

II

The second case is that of Timmy M., born July 6, 1957. At the age of 14 months, Timmy had not yet learned to walk and his hearing loss was severe. Timmy

was what is normally described as a congenitally deaf child. Following is the audio response curve taken in 1958:

Cycles/second	500	1,000	2,000	3,000	4,000	6,000	8,000
(1) Right ear with earphone, db.	70	80	75	75	75	80	85
(2) Left ear with earphone, db.	70	80	85	90	90	95	100
(3) Free Field, unaided db.	65	75	85	85	95	90	100
(4) Free Field, with aids, db.	40	40	35	50	55	max.	max.

Timmy's loss is essentially flat, through the audible spectrum. Timmy was first fitted with two strong hearing aids, giving the response shown at line number 4. In two weeks he had fully learned to walk. He responded to sounds and understood speech but his own speech was slow. He attended regular nursery school and kindergarten but his speech was so limited that he was sent to a special school for children with hearing difficulties.

At age seven, Timmy had some words but they were largely unintelligible because there were many sounds he could not say as k, s, t, and ch. He knew he could not say the sounds and so was very shy. He had continuous speech therapy lessons but seemed to reach a plateau. Then Timmy began to use the machine of this invention. It was adjusted for his loss and sufficient power gain applied that Timmy heard many new sounds for the first time. The teacher repeated various words using the consonants such as car, cat, six, seven, boat, eight. Within a few minutes Timmy was clearly repeating those sounds for the first time in his life. After ten months of continued lessons with this machine, Timmy can now reproduce any sound and any blend as he needs it for speech.

The unit, and particularly the key cards 23, provide other means for the training of students having certain hearing or speech problems. For example, rather than to cut out a key card conforming to the hearing deficiencies of the patient, it is also contemplated that the card can be cut out to accentuate certain patterns of speech, such as the formation of certain consonants. For example, the sounds of the consonant T have important frequency components in the range of 1,000 to 2,000 cycles. By cutting out a card which provides strong attenuation across the frequency range with the exception of the area from 1,000 to 2,000 cycles, the testing unit can be quickly set for therapy in this area. It is contemplated that a large variety of such therapy cards may be pre-cut and made available with the testing unit to form the distinctive formative sounds of the various consonants and other speech and accent sounds. Each patient using the machine will have his own hearing loss therapy card as well as have available to him the sound formation cards and each time he comes in for treatment, it is a simple matter to select his card from a file, place it in the machine, set the attenuators and proceed with the therapy.

In addition to the speech and hearing therapy cards for the various English sounds, similar sounds or accent cards can be designed for aid in the learning of a foreign language. For example, certain foreign languages have distinctive consonant sounds which do not have a counterpart in the English language and therefore are sometimes difficult for students to master. With the help of pronunciation or accent cards, the student can more readily be taught these sounds.

While a particular embodiment of the present invention has been shown and described, it will be apparent to those persons skilled in the art that changes and modifications might be made without departing from the invention in its broader aspects and, therefore, it is the aim of the appended claims to cover all such changes and modifications as fall within the true scope and spirit of this invention.

I claim:

1. A method for treating an individual's hearing deficiencies wherein means are employed for introducing

sound signals to the individual's ears, wherein the means includes means for varying the magnitudes of said sound

signals including a plurality of attenuators having control arms, the steps comprising:

sequentially introducing a plurality of first signals having different frequencies;

individually varying the magnitude of each of said first signals;

noting the lowest magnitude of each of said first signals at which the individual indicates the signal is audible, plotting upon a card an analogue curve of the magnitudes of said first signals with respect to each frequency thereof, forming the physical outline of said curve along one edge of said card;

obtaining a plurality of second signals having different frequencies the totality of which span the audible frequency range;

positioning said card adjacent said control arms and adjusting said arms in accordance with the curve formed along the edge thereof whereby the magnitude of each of said second signals is adjusted to a value complementary to the lowest audible magnitude of each of said first signals; and,

then mixing said second signals and introducing them to the individual's ears whereby full frequency range sound is provided, compensated for said individual's hearing deficiencies.

2. A method for treating an individual's hearing deficiencies wherein means are employed for introducing sound signals to the individual's ears wherein said means includes means for varying the magnitudes of said signals by using a plurality of attenuators having vertically movable control arms, and wherein the individual's auditory response curve is known, the steps comprising:

dividing an input signal into at least six secondary signals each having a distinct bandwidth the totality of which span the audible frequency range;

plotting a curve representing an analogue function of the individual's auditory response curve upon a key card, forming an edge of said card into the configuration of said curve, positioning said card adjacent said attenuator control arms, then moving said control arms into contact with the edge of said card, whereby each of said attenuators adjusts the magnitude of each of said secondary signals to a value complementary to said auditory response curve; and

then mixing said signals whereby full frequency range sound is introduced to the individual's ears, compensated for his hearing deficiencies.

3. Apparatus for treating hearing deficiencies wherein the individual's auditory response curve is known, comprising:

means for sensing sound and producing a first electrical signal;

means coupled to said sensing means for dividing said first signal into at least six second signals according to frequency, said second signals each having discrete bandwidths the totality of which span the audible frequency spectrum;

control means coupled to each dividing means for independently adjusting the magnitude of each of said second signals, said control means comprising a plurality of attenuators, each of said attenuators having outwardly projecting control arms;

a key card bearing a plotted curve formed along the

outer edge thereof, said curve representing a relationship between volume and frequency over the audible frequency range;
 means for receiving said key card in a position adjacent said attenuator control arms whereby said control arms are movable into contact with the edge 5 of said card to set the magnitude of each of said second signals at a level which compensates for the individual's hearing loss within each bandwidth;
 mixing means coupled to said control means for mixing said second signals after the magnitudes thereof have been set, said mixing means providing a third signal;
 amplifying means coupled to said mixing means for introducing said third signal to the individual's ears.

References Cited

UNITED STATES PATENTS

1,965,720	7/1934	Nicolson	179—1.2
2,156,945	5/1939	Huth et al.	179—1.7
3,385,937	5/1968	Lafon	179—107

FOREIGN PATENTS

131,540	2/1949	Australia.
1,085,682	7/1954	France.
1,309,425	10/1962	France.

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