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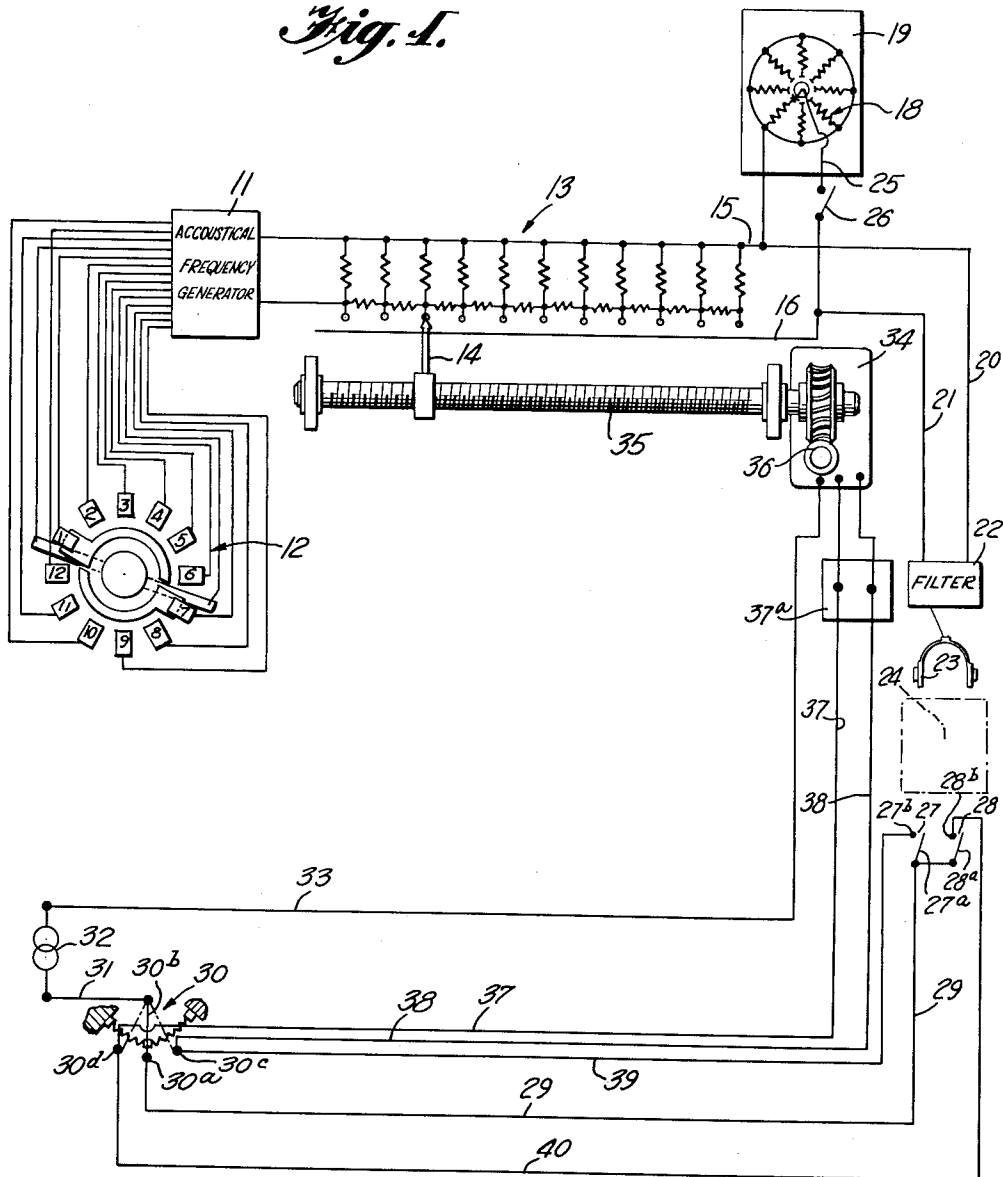
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APPARATUS FOR MEASURING PSYCHOLOGICAL-PHYSIOLOGICAL RELATIONSHIPS

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2 Sheets-Sheet 1

Fig. 1.



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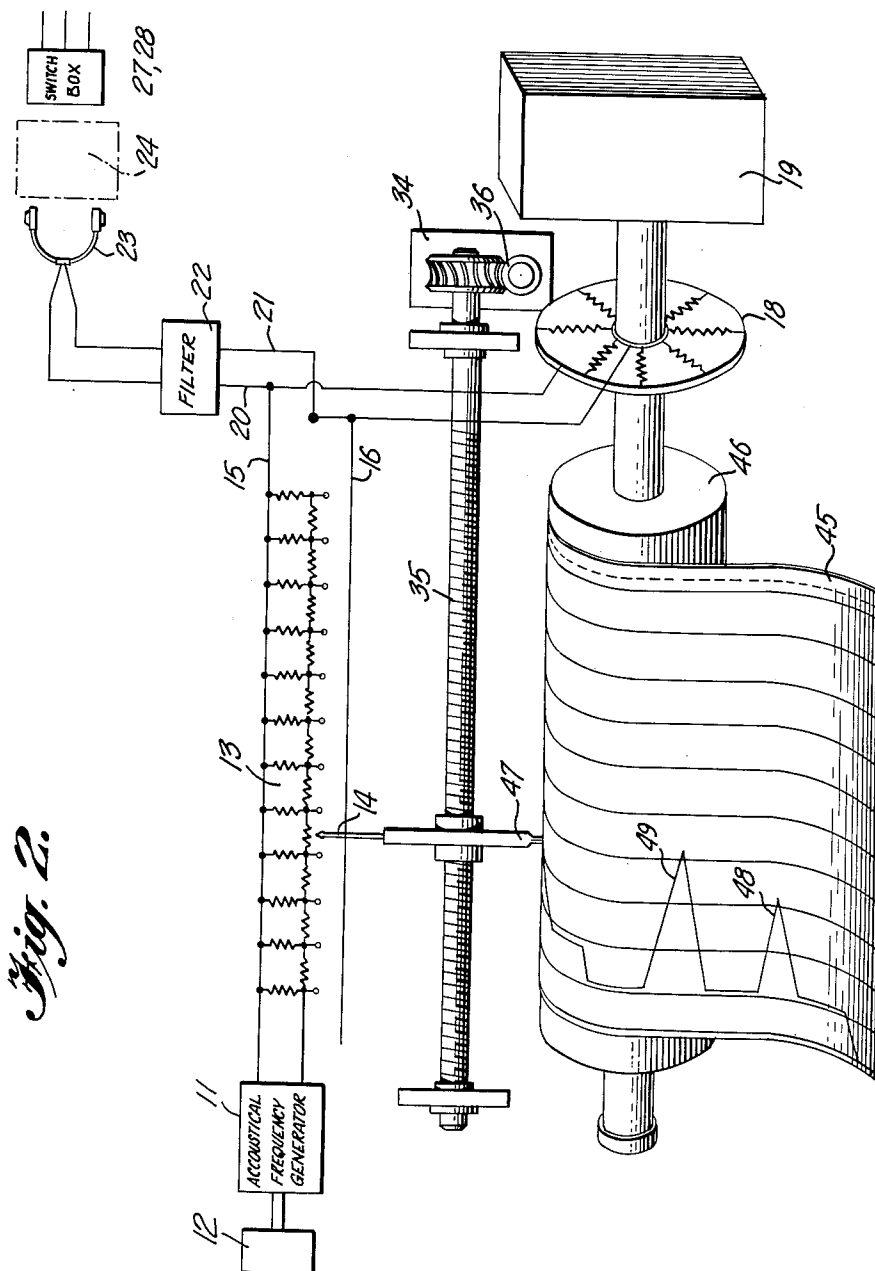


Fig. 2.

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APPARATUS FOR MEASURING PSYCHOLOGICAL- PHYSIOLOGICAL RELATIONSHIPS

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8 Claims. (Cl. 179--1)

The present invention relates in general to methods and apparatus for measuring the relation between a frequency of a physical stimulus adjustable to different frequencies and the intensity of the stimulus indicative of the response of a test subject affected by the stimulus, and more particularly to methods and apparatus such as audiometric devices and the like for measuring or recording the threshold of sensitivity of the test subject to different frequencies of a physical stimulus.

The present invention is designed to facilitate determination of the relation between a sensation and a variable physical quantity, to make available information needed in connection with a number of medical and psycho-technical problems. For example, determination of the relationship between minimum light intensity perceptible to the eye and the wave length or frequency of light for different subjects may be desired. Such a determination may be made by exposing the test subject to light of a certain selected frequency and continuously increasing or decreasing the intensity of the light until the subject identifies his threshold of sensitivity to the selected frequency. For example, light of a selected wave length may be continuously increased in intensity from a point below the threshold level until the subject first receives a sensation of light, and the light intensity at that level is then recorded. Then, light of other selected frequencies is produced and measurements of the subject's threshold to response are repeated until a sufficient number of values of frequency and threshold light intensity are obtained to plot a curve over the entire frequency range of light waves.

Another technique for determining such a relationship is to produce light of time variable wave length or frequency wherein the intensity of the light at each different wave length increases until the subject receives a sensation of light whereupon the subject actuates a control element in a direction to decrease the intensity until the sensation of light disappears, this procedure being repeated and recorded graphically until a curve is obtained over the entire frequency range to be studied.

More commonly, such determinations are made to measure hearing sensitivity of individuals. In many investigations of hearing capabilities, it becomes desirable to determine the sound intensity impression of a tone in relation to the frequency of that tone. Instruments which are commonly termed audiometers are usually resorted to determine the sound intensity of the limit of audibility of a tone in relation to its frequency for a plurality of different frequencies to automatically plot an audiogram or a graphic recording of the subject's sensations.

An object of the present invention is the provision of a novel method and apparatus for measurement of psychological-physiological relationships wherein different discrete frequencies of a physical stimulus are varied in intensity with time to facilitate determination of the threshold of sensitivity of a subject and the subject under test has more or less complete control of the intensity of the stimulus thereby relieving the supervisor of the appa-

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ratus of much of the manual labor normally associated with such methods and equipment.

Another object of the present invention is the provision of novel apparatus for subjecting a subject to stimuli of selected discrete frequencies, each of which are of variable intensity, in a manner facilitating more accurate judgment by the subject of the threshold of reaction to the stimuli.

Another object of the present invention is the provision of an improved method and apparatus for recording plots of a subject's determination of threshold of response to intensity variable physical quantities of selected discrete frequencies within a range of frequencies.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawing of preferred embodiments of the invention.

In the drawings:

Figure 1 is a diagrammatic and schematic illustration of apparatus embodying one preferred form of the present invention.

Figure 2 is a diagrammatic and schematic illustration of a second embodiment of the present invention arranged to automatically plot an audiogram or graphic recording of a subject's response to stimuli over a controlled frequency range.

While the invention in principle is applicable to a variety of different types of sensible quantities, the ensuing description will be directed to specific embodiments of the invention applied to measurement and recording of a test subject's hearing response to tones or sounds of different selected frequencies.

Referring to the drawing wherein like reference characters designate corresponding parts throughout the several figures, there is illustrated in Figure 1 measuring apparatus comprising an acoustical frequency generator 11 of a type which will produce acoustical output signals or tones of any of a plurality of selected discrete frequencies generally within the audio range. The acoustical frequency generator 11 is controlled by a frequency selector switch 12 arranged to permit the operator or supervisor to adjust the frequency generator 11 to produce an output signal of a selected frequency.

The frequency selector switch 12, as is schematically illustrated in Figure 1, may have a plurality of individual contact elements designed to be selectively contacted by a wiper controlled by a manually adjustable knob or the like and coupled to the acoustical frequency generator 11 through separate leads adjusting the generator 11 to produce a selected different discrete frequency assigned to each of the contacts.

The signal output of the acoustical frequency generator 11 is then applied to a primary adjustable attenuator 13 of conventional form having a sliding contact 14 movable along the attenuator 13 to vary the intensity of the selected frequency acoustical signal at the output leads 15, 16. Also connected across the output leads 15, 16 of the primary attenuator 13 is a secondary continuously variable attenuator 18 which is driven by an electric motor 19 and is arranged to impose cyclically variable attenuating resistance across the leads 15, 16 to impart cyclic intensity modulation to the selected frequency acoustical signal. This cyclically varied acoustical signal of a selected discrete frequency is then applied through the leads 20, 21 and a filter 22 to a suitable transducer 23 such as headphones to produce sound energy of the selected frequency and of the intensity determined by the setting of the attenuator 13 to be applied to the test subject indicated at 24.

Attenuators for making audiometric measurements are

customarily designed to attenuate the electrical output applied to the transducer in terms of a logarithmic scale expressed as the hearing loss in decibels above the lower threshold of hearing of a normal person. The attenuator 13 may comprise a ladder network of series and shunt resistors as shown provided with taps to be engaged by the sliding contact 14, each tap increasing the attenuation by uniform discrete steps, for example 5 decibels. The attenuator 18 may be provided with a plurality of discrete resistances of different values designed to modulate the intensity of the selected frequency signal at the output of the primary attenuator 13 through a range corresponding to 10 decibels or less. For example, the attenuator 18 may comprise a series of radially extending, angularly spaced resistances having contacts adjacent a rotating wiper which are progressively contacted by the wiper to communicate the resistors successively through the lead 25 and switch 26 to the output lead 16 of attenuator 13. For one preferred example, the primary attenuator 13 is variable over a 100 decibel range in 5 decibel steps or increments, while the attenuator 18 cyclically produces a 5 decibel variation. It will be appreciated, however, that attenuators which vary continuously over a selected range rather than in discrete steps may be substituted for either or both of the attenuators 13 and 18.

Two single-pole, single-throw, spring-loaded, normally open subject control switches 27 and 28 are provided at the test subject position to be manipulated by the test subject. The movable contact arms 27a and 28a of these control switches are connected through a common lead 29 to the stationary center contact 30a of a three-position operator control switch 30 normally contacting a movable contact arm 30b which is spring loaded to center position. The lead 31 is connected to the movable contact arm 30b of the switch 30 and forms one supply lead from an alternating current voltage source indicated at 32, the other supply lead 33 therefrom extending to an electric motor 34 for driving a lead screw 35 through a worm and worm gear unit 36 to shift the sliding contact 14 along the primary attenuator 13. Leads 37 and 38 having a condenser 37a connected across them extend from directional field windings of the motor 34 to the right and left stationary contacts 30c and 30d of the switch 30, which stationary contacts are in turn connected by leads 39 and 40 with stationary contacts 27b and 28b of the switches 27 and 28 respectively. The switch 30 is preferably disposed at a position readily accessible to the operator or supervisor of the apparatus. The switches 27 and 28 are designed to permit the test subject to regulate the direction of rotation and the energization of the motor 34 and therefore the direction and extent of movement of the sliding contact 14 in desired relation to the response sensed by the test subject to the acoustical tone produced at the headphones 23, while the switch 30 permits the operator or supervisor to take control of the intensity of the stimulus away from the test subject.

In the operation of the apparatus, the supervisor conducting the test sets the frequency selector switch 12 to a desired position, which will condition the acoustical frequency generator 11 to generate an output tone at a selected frequency, for example 500 cycles per second. The adjustable attenuator 13 is initially adjusted to a position of low attenuation so that the selected frequency tone applied thereto from the generator 11 is well above the threshold of sensitivity of the test subject. The cyclically variable attenuator 18 modulates this tone through a range of roughly 5 decibels and this modulated tone of selected frequency is then applied to the test subject through the earphones 23. The test subject is instructed to adjust the control switches 27 and 28 until he can hear the sound as often as he cannot hear it, or until he hears the tone go on and off for approximately equal periods or duty cycles. If the test subject hears this sound at all times, he activates the switch 27 which completes the

supply circuit to one of the directional field windings of the motor 34, for example through the circuit comprising the leads 31, 29, 39, 37, the associated field winding, and lead 33, to drive the motor 34 and the lead screw 35 in a direction shifting the sliding contact 14 to progressively higher attenuation positions along the adjustable attenuator 13 and thereby progressively decreasing the intensity of the tone produced at the earphones 23. This is continued until the sensation resulting from the particular level of attenuation established by the adjustable attenuator 13 and the cyclically variable attenuator 18 is intermittent with approximately equal on and off periods of sound. If the test subject overshoots the threshold point or if sound is not initially heard, the control switch 28 is closed to establish the supply circuit through the other directional field winding of the motor 34 to shift the sliding contact 14 in a direction decreasing attenuation to progressively increase the sound intensity until the threshold level is reached. The operator conducting the test then notes the position of the sliding contact 14, for example along a fixed scale graduated in terms of decibels adjacent the sliding contact 14 and the particular frequency established by the position of the selector switch 12, and activates the selector switch 12 to a different frequency selecting position whereupon the procedure is repeated. The accumulation of a series of frequency and sliding contact position readings then supplies the necessary values for plotting of the subject's sensations in terms of frequency. By this arrangement, indications are obtained from the position of the attenuator sliding contact 14 of the threshold of audibility for different frequencies, the precise selection of the threshold point by the test subject being facilitated by reason of the continuous variation of sound between a barely audible value and a non-audible value just below audibility due to the continuous cycling of the variable attenuator 18. The operator can check the threshold position of the sliding contact 14 as selected by the test subject by actuating the switch 30, permitting the operator to take control of the motor 34 regulating the position of the sliding contact 14 away from the test subject to assume a different attenuating value.

This arrangement markedly facilitates the proper exercise of judgment by the test subject to effectively adjust the attenuator sliding contact 14 to the appropriate position to indicate the sensitivity threshold level. In view of the continuous modulation through a limited range of the tone produced by the generator 11 due to the cycling of the variable attenuator 18, the test subject is able to effectively judge whether the position of the sliding contact 14 is close to or far away from the threshold value. If the tone heard by the test subject is well above threshold level, the test subject hears only a slight modulation of loudness. This he uses as a clue to immediately judge that the position of the adjustable attenuator sliding contact 14 is producing a signal level well above threshold. The test subject does not have to make a judgment of absolute loudness as he would if, for example, the signal were merely automatically or manually pulsed on and off rather than modulated. As the test subject adjusts the position of the sliding contact 14 by regulation of the control switches 27, 28 to positions approaching the threshold position, the modulation imposed by the cyclically variable attenuator 18 more nearly approaches 100% amplitude modulation. This change in percentage amplitude modulation is also sensed as a clue to obtaining a precise adjustment of the sliding contact 14 to the threshold position. The test subject judges that he is at threshold position by observing that he hears a signal that is 100% amplitude modulated with a 50% duty cycle.

If it is desired to automatically record the movements of the adjustable attenuator sliding contact during the conduct of the test, apparatus of the type illustrated in Figure 2 may be used. This apparatus is basically similar

to that illustrated in Figure 1, the similar components being indicated by identical reference characters to those employed in Figure 1. Additionally a roll of recording paper indicated by the reference character 45 having intensity calibrations thereon is provided, the paper being withdrawn from a supply roll and drawn over the surface of a drum 46 which may, for example, be driven continuously by the motor 19 which also drives the cyclically variable attenuator 18. The drum 46 is disposed in parallelism with and adjacent to the lead screw 35 to serve as a backing surface for the paper 45 and support the paper in the path of movement of a recording stylus or pen 47 coupled to and continuously movable with the adjustable attenuator sliding contact 14 at a position to receive markings from the stylus 47. In all other respects, the construction is identical to that disclosed in Figure 1. By this arrangement, the reactions of the test subject are continuously plotted on the recording paper 45 by movements of the stylus 47 with the attenuator sliding contact 14. Traces similar to those indicated at 48 and 49 result when the operator manipulates the overriding control switch 30 to check the threshold position previously selected by the test subject providing a record of when the operator overrode the test subject. It is contemplated that the operator will write on the recording paper at appropriate positions the different frequencies which he selects to provide a permanent record of the sliding contact positions in relation to frequency.

While but one preferred example of the present invention has been particularly shown and described, it is apparent that various modifications may be made therein within the spirit and scope of the invention, and it is desired, therefore, that only such limitations be placed on the invention as are imposed by the prior art and set forth in the appended claims.

What is claimed is:

1. Apparatus for measuring the relation between a selected frequency of a physical stimulus and the intensity of the stimulus determined by a test subject subjected to the effect thereof to indicate the threshold of response of the test subject to the stimulus, comprising means for generating a physical stimulus signal of the selected frequency for application to the test subject including primary variable attenuating means for adjusting the intensity of the selected frequency signal to a selected intensity level within a substantial range of intensity levels and secondary variable attenuating means for cyclically modulating the selected frequency signal by continuously varying the intensity thereof through a preselected range, reversible motor means for adjusting said primary attenuating means to different intensity levels, and test subject control means operative by the test subject for activating said motor means in a direction-selective manner to adjust said primary attenuating means to an intensity level substantially corresponding to the threshold of response of the test subject.

2. Apparatus for measuring the relation between a selected frequency of a physical quantity and the intensity of the quantity determined by a test subject subjected to the effect thereof to indicate the threshold of response of the test subject to the quantity, comprising means for generating an output signal of the selected frequency having a continuously variable intensity alternating cyclically through a preselected narrow intensity range for application to the test subject, variable attenuating means for adjusting the mean intensity of the continuously varying selected frequency signal to a selected intensity level, reversible motor means for adjusting said attenuating means to different intensity levels, and test subject control means operative by the test subject for activating said motor means in a direction-selective manner to adjust said attenuating means to an intensity level substantially corresponding to the threshold of response of the test subject.

3. Apparatus for measuring the relation between the

frequency of a physical quantity adjustable to a plurality of discrete frequencies and the intensity of the quantity for the different discrete frequencies determined by a test subject subjected to the effect thereof, comprising variable frequency generating means for generating output signals of a plurality of selected discrete frequencies, selector means for adjusting said signal generating means to produce a selected one of said discrete frequency output signals, primary attenuator means for reducing the intensity of the selected frequency output signal through a selected intensity range, continuously operative cyclic attenuator means for amplitude modulating the selected frequency output signal of selected intensity determined by adjustment of said primary attenuator means by cyclically varying the amplitude of the signal through a preselected narrow range, transducer means responsive to the output signal of selected frequency and intensity to apply a stimulating signal of corresponding frequency and intensity to the test subject, reversible motor means for adjusting said adjustable attenuator means to different signal intensity levels, and test subject control means operative by the test subject for activating said motor means in a direction-selective manner to adjust the level of said primary attenuator means locating the stimulating signal intensity level substantially at the threshold of response of the test subject.

4. Apparatus for measuring the relation between the frequency of a physical quantity adjustable to a plurality of discrete frequencies and the intensity of the quantity for the different discrete frequencies determined by a test subject subjected to the effect thereof, comprising variable frequency generating means for generating output signals of a plurality of selected discrete frequencies, selector means for adjusting said signal generating means to produce a selected one of said discrete frequency output signals, primary attenuator means coupled to the output of said signal generating means and having a movable contact adjustable to different positions for reducing the intensity of the selected frequency output signal through a selected intensity range, continuously operative cyclic attenuator means for amplitude modulating the selected frequency output signal of selected intensity determined by adjustment of said movable contact by cyclically varying the amplitude of the signal through a preselected narrow range, transducer means responsive to the output signal of selected frequency and intensity to apply a stimulating signal of corresponding frequency and intensity to the test subject, reversible motor means for adjusting the position of said movable contact to adjust the primary attenuator means to establish different signal intensity levels, and test subject control means operative by the test subject for activating said motor means in a direction-selective manner to adjust the level of said contact member locating the stimulating signal intensity level substantially at the threshold of response of the test subject.

5. Apparatus for measuring the relation between the frequency of sound of a plurality of discrete frequencies and the intensity of the sound for the different discrete frequencies determined by a test subject hearing the sound, comprising a variable acoustical frequency generator for producing electrical output signals, selector means for adjusting said generator to produce one of said output signals of a selected discrete frequency, means cyclically modulating the amplitude of the selected frequency output signal through a narrow intensity range to produce continuous cyclic variation of the intensity of the output signal, adjustable attenuator means coupled to the output of said said acoustical frequency generator for reducing the intensity of the output signal, transducer means responsive to the cyclically varying output signal of selected frequency and of a mean intensity established by said adjustable attenuator means for generating sound energy of corresponding frequency and intensity to be applied to the test subject, reversible motor means for

adjusting said adjustable attenuator means to different signal intensity levels, and test subject control switches for remote, direction-selective control of said motor means operative by the test subject for activating the motor means to adjust said adjustable attenuator means to establish a sound energy level substantially at the threshold of hearing of the test subject.

6. Apparatus for measuring the relation between the frequency of sound of a plurality of discrete frequencies and the intensity of the sound for the different discrete frequencies determined by a test subject hearing the sound, comprising a variable acoustical frequency generator for producing electrical output signals, selector means for adjusting said generator to produce one of said output signals of a selected discrete frequency adjustable attenuator means coupled to the output of said acoustical frequency generator for reducing the intensity of the output signal, a continuously driven modulating attenuator coupled to the output of said adjustable attenuator means for continuously varying the intensity of the selected frequency signal at the adjustable attenuator means output through a narrow intensity range, transducer means responsive to the cyclically varying output signal of selected frequency and of a mean intensity established by said adjustable attenuator means for generating sound energy of corresponding frequency and intensity to be applied to the test subject, reversible motor means for adjusting said adjustable attenuator means to different signal intensity levels, and test subject control switches for remote, direction-selective control of said motor means operative by the test subject for activating the motor means to adjust said adjustable attenuator means to establish a sound energy level substantially at the threshold of hearing of the test subject.

7. Apparatus for recording graphically the relation between the frequency of sound of a plurality of discrete frequencies and the intensity of the sound for the different discrete frequencies determined by a test subject hearing the sound, comprising a variable acoustical frequency generator for producing electrical output signals, selector means for adjusting said generator to produce one of said output signals of a selected discrete frequency, means cyclically modulating the amplitude of the selected output signal through a narrow intensity range to produce continuous cyclic variation of the intensity of the output signal, adjustable attenuator means coupled to the output of said acoustical frequency generator for reducing the intensity of the output signal including a linearly movable contact member for regulating the level of attenuation thereof, transducer means responsive to the cyclically varying output signal of selected frequency and of a mean intensity established by said adjustable attenuator means for generating sound energy of corresponding frequency and intensity to be applied to the test subject, reversible motor means for

adjusting said adjustable attenuator means to different signal intensity levels, and test subject control switches for remote, direction-selective control of said motor means operative by the test subject for activating the motor means to adjust said adjustable attenuator means to establish a sound energy level substantially at the threshold of hearing of the test subject, a chart supporting member located adjacent said adjustable attenuator means contact member, a recording chart positioned on said supporting member means for driving said supporting member and said chart to advance said chart along a selected advancement axis, and a recording device actuated by said adjustable attenuator means over said chart along axes perpendicular to said advancement axis to continuously record the conditions of adjustment of said adjustable attenuator means on said chart.

8. Apparatus for recording graphically the relation between the frequency of sound of a plurality of discrete frequencies and the intensity of the sound for the different discrete frequencies determined by a test subject hearing the sound, comprising a variable acoustical frequency generator for producing electrical output signals, selector means for adjusting said generator to produce one of said output signals of a selected discrete frequency, means cyclically modulating the amplitude of the selected output signal through a narrow intensity range to produce continuous cyclic variation of the intensity of the output signal, adjustable attenuator means coupled to the output of said acoustical frequency generator for reducing the intensity of the output signal including a linearly movable contact member for regulating the level of attenuation thereof, transducer means responsive to the cyclically varying output signal of selected frequency and of a mean intensity established by said adjustable attenuator means for generating sound energy of corresponding frequency and intensity to be applied to the test subject, reversible motor means for adjusting said adjustable attenuator means to different signal intensity levels, and test subject control switches for remote, direction-selective control of said motor means operative by the test subject for activating the motor means to adjust said adjustable attenuator means to establish a sound energy level substantially at the threshold of hearing of the test subject, a chart supporting member located adjacent said adjustable attenuator means contact member, a recording chart positioned on said supporting member, means for driving said supporting member and said chart to advance said chart along a selected advancement axis, and a recording stylus coupled to said contact member for movement therewith over said chart along axes perpendicular to said advancement axis to continuously record the conditions of adjustment of said adjustable attenuator means on said chart.

No references cited.