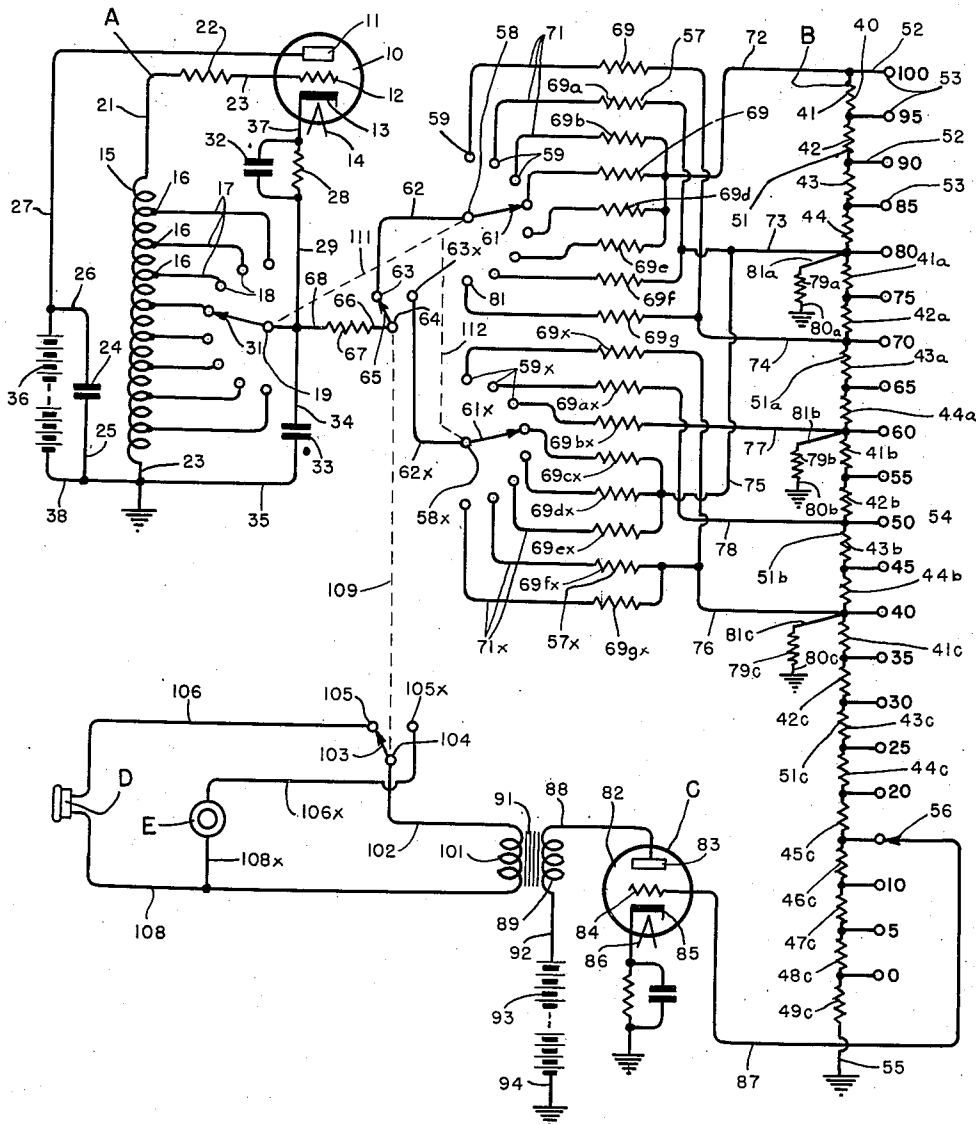


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 AUDIOMETER FOR AIR AND BONE CONDUCTING RECEIVERS
 HAVING A SCALE WITH A SINGLE ZERO
 HEARING LOSS REFERENCE
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AUDIOMETER FOR AIR AND BONE CONDUCTING RECEIVERS HAVING A SCALE WITH A SINGLE ZERO HEARING LOSS REFERENCE

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My invention relates to audiometers and particularly to audiometers having a frequency generator and attenuator associated therewith and feeding an amplifier adapted to energize either an air conducting receiver or a bone conducting receiver.

An object of the invention resides in providing an audiometer of such type in which the same hearing loss scale can be used with both the air conducting receiver and the bone conducting receiver at all frequencies.

Another object of the invention resides in providing an audiometer in which overloading of the frequency generator and amplifier is prevented during the measurement of hearing loss at extreme frequencies and particularly in the use of the bone conducting receiver.

A still further object of the invention resides in providing an audiometer in which the output of the frequency generator or amplifier need not be excessively great.

Another object of the invention resides in providing an audiometer in which the range of measurement of hearing loss may be appreciably increased at certain frequencies when using a bone conducting receiver.

An object of the invention resides in providing an audiometer using an attenuator employing a relatively small number of resistors.

A still further object of the invention resides in providing the attenuator with a number of resistors connected in series and arranged in groups and in further utilizing one or more shunting resistors, shunting certain of said groups of resistors and in further providing separate circuits associated with the frequency generator, connected to the attenuator and having equalizing resistors therein.

Another object of the invention resides in feeding the output of the attenuator to the amplifier.

A still further object of the invention resides in employing two sets of circuits energized by the frequency generator and in forming said attenuator with a section used in measuring high hearing loss and with another section used in measuring low hearing loss and in connecting some of the first named circuits to the high loss section of said attenuator and some of the second named circuits to the low loss section of the attenuator.

Other objects of the invention reside in the

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novel combination and arrangement of parts and in the details of construction hereinafter illustrated and/or described.

In the drawings:

The figure is a wiring diagram of an audiometer illustrating an embodiment of my invention.

My improved audiometer includes a frequency generator A which delivers currents of different frequencies to an attenuator B. This attenuator feeds an amplifier C and from which the power derived is used to operate either of two receivers D or E. The receiver D is an air conducting receiver and the receiver E is a bone conducting receiver. The construction of these parts and the method of connecting and using the same will now be described in detail.

The frequency generator A consists of an electronic oscillator which includes a thermionic tube 10 having a plate 11, a grid 12, a cathode 13, and a heater 14 for the same. The said generator further includes an inductance 15 which has a number of taps 16 at various localities throughout the extent of the same. The taps 16 are connected by means of conductors 17 to the fixed contacts 18 of a frequency selector switch 19. One end of the inductance 15 is connected by means of a conductor 21 to a resistance 22 which serves as a grid leak and which in turn is connected by means of a conductor 23 with the grid 12 of the tube 10. The other end of the inductance 15 is connected by means of a conductor 23 to ground. For providing plate voltage for the tube 10 a battery 36 is employed. This battery is connected by means of a conductor 27 with the plate 11 and by means of another conductor 38 with ground. Paralleling the battery 36 is a by-pass condenser 24 which is connected by means of a conductor 25 to ground. This condenser is further connected by means of a conductor 26 to conductor 27 previously referred to. The cathode 13 is connected by means of a conductor 37 to a biasing resistor 28 which in turn is connected by means of a conductor 29 with the movable contact 31 of the switch 19. The resistance 28 is shunted by means of a by-pass condenser 32. The generator A includes a condenser 33 which is connected by means of a conductor 34 to the conductor 29 and contact 31 and is further connected by means of another conductor 35 to ground.

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The inductance 15 is divided into two sections by means of the switch 19 which is connected to the cathode 13. One section of said inductance is connected to the plate 11 and the other to the grid 12 of tube 10. The condenser 33 shunting the plate section forms a resonant circuit which receives energy from the tube 10 to form an electronic oscillator which operates in the customary manner, setting up an oscillating current, the frequency of which depends upon the relative values of the condenser 33 and the inductance 15. The taps 16 of the said inductance are so arranged that by operating the switch 19 a current of any predetermined frequency within the range of the device may be produced by the same. The output of the frequency generator A is derived from the conductor 29 connected to the movable contact 31 of the switch 19. While I have shown the frequency generator as an electronic oscillator it can be readily comprehended that any type of frequency generator suited to the purpose may be used.

The attenuator B includes a resistance 40 made up of a number of resistors which are connected in series. These resistors are arranged in groups designated by the reference characters 51, 51a, 51b and 51c. The individual resistors of group 51 are designated 41, 42, 43 and 44. The other groups have corresponding resistors designated by the same reference characters as those in group 51 and modified by the suffix a, b or c to correspond with the suffix of the group in which they are situated. The group 51c includes additional resistors 45c, 46c, 47c, 48c and 49c not found in the other groups. These resistors as stated are all connected together in series and the points of connection of the same are connected by means of conductors 52 to the fixed contacts 53 of an attenuator switch 54. The last resistor 49c is connected by means of a conductor 55 to ground. In conjunction with the resistors above referred to, I employ three shunting resistors 79a, 79b and 79c which are connected by means of conductors 81a, 81b and 81c to the resistance 40 at localities between resistors 44 and 41a, between resistors 44a and 41b and between resistors 44b and 41c respectively. These shunting resistors are connected by means of conductors 80a, 80b and 80c to ground. Since the resistance 40 is also grounded, the said resistors shunt certain portions of said resistance. The resistor 79c shunts group 51c of the resistance 40, the resistor 79b shunting that group and also the group 51b. Resistor 79a similar to 79b shunts groups 51c, 51b and 51a. The switch 54 also includes a movable contact 56 which is connected in a manner to be subsequently described.

The attenuator B further includes two equalizers 57 and 57x. The equalizer 57 is used where the air conducting receiver is employed and the equalizer 57x is utilized where the bone conducting receiver is employed. The equalizer 57 includes an equalizing switch 58 which has a number of fixed contacts 59 and a movable contact 61, there being one fixed contact 59 to correspond with each contact 18 of switch 19. The movable contact 61 is connected by means of a conductor 62 with a fixed contact 63 of a receiver selector switch 64. The said switch has a movable contact 65 which is connected by means of a conductor 66 with a resistor 67. This resistor is in turn connected by means of a conductor 68 with the conductor 29 and the movable contact 31 of the frequency selector switch 19. The equalizer 57 includes a number of re-

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sistors 69a, 69b, 69c, 69d, 69e, 69f and 69g, there being one such resistor to correspond with each of the contacts 59 of the switch 58. These resistors are in turn connected by means of conductors 71 to the respective contacts 59 of the switch 58. The resistors 69b, 69c, 69d and 69e are all connected together and to a common conductor 72 which in turn is connected to the end of the resistance 40 and to the resistor 41. The two resistors 69a and 69f are connected together and to a common conductor 73 which in turn is connected to the resistance 40 at the point between the resistors 44 and 41a. In a similar manner the two resistors 69 and 69g are connected together by means of a common conductor 74 which is connected to the resistance 40 at the point between the two resistors 42a and 43a.

The equalizer 57x includes an equalizing switch 58x having a movable contact 61x and fixed contacts 59x corresponding with the contacts 59 of switch 58. The said equalizer also includes a number of resistors 69x, 69ax, 69bx, 69cx, 69dx, 69ex, 69fx, 69gx. These resistors are all connected by means of conductors 71x to the fixed contacts 59x of switch 58x. The movable contact 61x of this switch is connected by means of a conductor 72x to another fixed contact 63x of the switch 64. The three resistors 69cx, 69dx and 69ex are connected together by means of a common conductor 75 which is connected to the conductor 73 previously referred to. The resistors 69x, 69fx and 69gx are all connected together by means of a common conductor 76 which in turn is connected to the resistance 40 at a locality between the resistor 44b and the resistor 41c. The resistor 69bx is connected by means of a conductor 77 to the resistance 40 at a locality between the resistors 44a and 41b. The resistor 69ax is connected by means of a conductor 78 with the resistance 40 at a point between the two resistors 42b and 43b. All of the three switches 19, 58 and 58x are ganged, the movable contacts 31, 61 and 61x being mechanically connected together as indicated diagrammatically by the dotted lines 111 and 112.

The amplifier C consists of a thermionic tube 82, having a plate 83, a grid 84, a cathode 85 and a heater 86 for the same. The grid 84 of this tube is connected by means of a conductor 87 with the movable contact 56 of the attenuator switch 54. The plate 83 of this tube is connected by means of a conductor 88 with the primary 89 of an output transformer 91. The other end of this primary is connected by means of a conductor 92 with a battery 93 which furnishes plate voltage to the tube 82. Said battery is further connected by means of a conductor 94 to ground. The secondary 101 of this transformer is connected by means of a conductor 102 to the movable contact 103 of a receiver selector switch 104. This selector switch has two fixed contacts 105 and 105x. The contact 105 is connected by means of a conductor 106 with the air conducting receiver D. This receiver is in turn connected to a conductor 108 which is connected to the other side of the secondary 101 of transformer 91. The contact 105x is connected by means of a conductor 106x to the bone conducting receiver E which is further connected by means of a conductor 108x with the conductor 108. The two switches 64 and 104 are ganged, the two movable contacts of the same being mechanically connected together as diagrammatically indicated by a dotted line 109.

In the drawing no source of current for heat-

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ing the heaters 14 and 86 of the tube 10 and 82 has been shown. It can, however, be readily comprehended that suitable circuits properly energized such as are now well known in the art may be used for the purpose.

In the construction of the attenuator B I have found that with a 6J5 tube used in both the frequency generator and amplifier a total impedance of 500,000 ohms for the resistance 40 produces satisfactory results. I have also found that with the selection of the proper shunting resistors that the values of the corresponding resistors in each group can be made the same. The values of the resistors in group 51 are as follows: Resistor 41 is 219,000 ohms, resistor 42, 123,000 ohms, resistor 43, 69,000 ohms and resistor 44, 39,000 ohms. Shunting resistor 79a is 55,555 ohms. The values of the resistors then repeat, resistors 41a, 41b and 41c all being 219,000 ohms and the other corresponding resistors also the same. Likewise the shunting resistors 79a, 79b etc. are also the same. Resistors 45c, 46c, 47c, 48c and 49c in such case would be 21,900 ohms, 12,300 ohms, 6,900 ohms, 3,900 ohms and 5,000 ohms respectively. It will become apparent that even though the equalizing resistors are of low value the total resistance to ground across the generator A is never less than 43,000 ohms so that proper operation of the generator A is procured. Also the resistance from contact 56 to ground connected to grid 84 of amplifier tube 82 never exceeds 500,000 ohms so that stable operation of tube 82 results.

Since the ability of a person to perceive sounds depends upon the intensity of the same and since the intensity of the sounds generated depend upon the voltage applied to the grid of the amplifier tube, it will be readily comprehended that the position of the movable contact 56 of switch 54 will indicate the hearing loss of the patient being examined. On the actual audiometer a scale is employed which is associated with switch 54 and which designates hearing loss in decibels. This scale runs from 0 to 100. The resistance 40 is so designed that the various contacts 53 correspond to sounds produced at the ear of the patient differing by five decibels increments. The scale on which the intensity of the sounds produced is recorded has not been shown in the drawing but the exact value of such sounds in decibels has been placed opposite each contact 53 in the drawing. For the purpose of reference I have designated the portion of the resistance 40 from 60 decibels to 100 decibels as the high hearing loss section of said resistance and the portion of the same below 60 decibels as the low hearing loss section.

In the construction of audiometers embodying my invention I have found that the ordinary air conducting and bone conducting receivers are limited in their power handling ability. I have found that a tube such as the 6J5 when used as in an amplifier will supply all of the power necessary to drive the air conducting receiver at intermediate frequencies throughout the entire hearing loss range. Such a tube does not, however, produce enough power to operate throughout the entire range at the extreme frequencies or when a bone conducting receiver is employed. Since the voltage drop along the resistance 40 is a logarithmic function, it will become evident that an exceedingly great amount of power would be required were it necessary to procure full range performance with a bone conducting receiver. It therefore becomes necessary to use less power and to be content to limit the range

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of performance of the air conducting receiver at extreme frequencies and the bone conducting receiver at all frequencies. I have found that a tube such as the one above specified delivers about as much power as is practical to employ and also gives ranges of performance of both air conducting and bone conducting receivers satisfactory for the purpose. In an audiometer in which the output of the oscillator feeds into the attenuator resistance at various points along the same oscillator, a tube having a low plate impedance is desirable. The 6J5 tube has a relatively low impedance. However this tube does not have a low enough impedance to permit of feeding into the low loss section of an attenuator utilizing a resistance in which the resistors progressively decrease in value logarithmically throughout the entire attenuator. It was hence necessary heretofore to connect the oscillator to the attenuator at the high loss section of the attenuator resistance. Since the bone conducting receiver has an appreciably smaller range of performance than the air conducting receiver, heretofore a separate scale was necessary for the bone conducting receiver. The above problem was solved by utilizing in combination with the other elements of the invention the shunting resistors which together with the attenuator resistors of the increased individual value increased the resulting impedance to ground in the low loss section of the attenuator resistance to a value great enough to prevent overloading of the oscillator tube when the output of said tube was connected to the low hearing loss section of the attenuator and without increasing the input impedance on the amplifier tube above the desirable minimum.

The method of operation of the invention is as follows: When the audiometer is to be used with an air conducting receiver switch 64 and switch 104 which are ganged are turned to the left closing switch 64 through contact 63 and switch 104 through contact 105. The frequency generator or oscillator 19 produces an alternating current in the customary manner, the frequency of which is dependent upon the amount of inductance included in the resonant circuit of the same. The frequency of this current is determined by the position of the switch 19. Switch 64 when in its denoted position transfers the energy from generator A to the equalizer 57 which in turn transfers the energy to the attenuator B. The attenuator B is in effect a voltage dependent in value upon the position of the attenuator switch 54. Switch 104 transfers the amplified power from the amplifier C to the receiver D. Resistance 40 is so designed that the positions of switch 54 corresponding to the contacts 53 thereof coincide with the divisions of a scale calibrated to read in decibels, with reference to the threshold of hearing, the values of sound intensity at the ear of the person tested. If the bone conducting receiver is to be used, switches 64 and 104 are moved to their opposite positions. This transfers energy from the frequency generator A to the equalizer 57x which in turn transfers the same to the attenuator B. The energy then follows the same channel as previously described except that switch 104 transfers the energy to the bone conducting receiver E. The equalizer 57x being connected to the resistance 40 at the low loss section of the same, it is possible to make the zero point of each scale coincide by the selection of the proper equalizers for each receiver circuit and thus make all points coincide for all the frequencies at which the receivers are oper-

able. Thus a single scale may be employed for making examinations with either an air conducting receiver or a bone conducting receiver.

The advantages of my invention are manifest. In the ordinary audiometer when used with a bone conducting receiver a second scale on the attenuator is made necessary by the inherent insensivity of bone conducting receiver. At the extreme frequency this reduced the range of measurements possible at the middle frequencies even through the bone conducting receiver sensitivity would allow a considerably greater range at these frequencies because the whole attenuator could not be used. By arranging an attenuator so that the input for extreme frequencies can be applied to the low loss section and thereby using the same zero reference point as for air conduction the range for bone conduction can be greatly increased in the middle frequencies. The device functions with the same type and capacity of frequency generator and amplifier as ordinarily used. With my invention distortion of the sound produced is greatly reduced and overloading of the frequency generator is prevented. My improved audiometer is simple in construction and positive in performance.

I claim:

1. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, a number of circuits energized by said generator, there being one circuit for each frequency, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, said circuits being permanently connected to said resistance at various predetermined points between resistors, an attenuator switch connected to said resistance at various points between resistors, a receiver and means controlled by said attenuator switch for energizing said receiver.

2. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, a number of circuits energized by said generator, there being one circuit for each frequency, equalizing resistors in certain of said circuits, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, said circuits being permanently connected to said resistance at various predetermined points between resistors, an attenuator switch connected to said resistance at various points between resistors, a receiver and means controlled by said attenuator switch for energizing said receiver.

3. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, two sets of circuits energized by said generator, there being one circuit of each set for each frequency, equalizing resistors in certain of said circuits, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, the circuits of one set of circuits being permanently connected to said resistance at various predetermined points between resistors and the circuits of said other set being permanently connected to said resistance at various predetermined points between resistors, some of the points of connection of the circuits of said second set differing from those of said first set,

two receivers, one associated with the first set of circuits and the other with the second set of circuits, an attenuator switch connected to said resistance and means controlled by said switch for energizing said receivers.

4. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, two sets of circuits energized by said generator, there being one circuit of each set for each frequency, equalizing resistors in certain of said circuits, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, said resistors in each group decreasing in value toward one end of said resistance, a shunting resistor shunting certain of said groups of resistors, the circuits of one set being permanently connected to said resistance at various predetermined points between resistors and the circuits of said other set being permanently connected to said resistance at various predetermined points between resistors, some of the points of connection of the circuits of said second set in a certain group being between resistors of lower value than the resistors between which the corresponding circuits of the other set are connected, two receivers, one associated with the first set of circuits and the other with the second set of circuits, an attenuator switch connected to said resistance and means controlled by said switch for energizing said receivers.

5. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, two sets of circuits energized by said generator, there being one circuit of each set for each frequency, equalizing resistors in certain of said circuits, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, the circuits of one set being permanently connected to said resistance at various predetermined points between resistors and the circuits of said other set being permanently connected to said resistance at various predetermined points between resistors, an air conducting receiver associated with said first set of circuits, a bone conducting receiver associated with said second set of circuits, an attenuator switch connected to said resistance, means controlled by said switch for energizing said receivers and a selector switch for rendering either of said receivers and the circuits associated therewith ineffective.

6. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, a number of circuits energized by said generator, there being one circuit for each frequency, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, a second shunting resistor shunting all of the groups shunted by said first shunting resistor and one additional group, said circuits being permanently connected to said resistance at various predetermined points between resistors, an attenuator switch connected to said resistance at various points between resistors, a receiver and means controlled by said attenuator switch for energizing said receiver.

7. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, two sets of circuits energized by said generator, there being one circuit

of each set for each frequency, equalizing resistors in certain of said circuits, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, the circuits of one set being permanently connected to said resistance at various predetermined points between resistors and the circuits of said other set being permanently connected to said resistance at various predetermined points between resistors, said resistance having a section used in measuring high hearing loss and another section used in measuring low hearing loss, the points of connection of the circuits of said second set corresponding to the extreme frequencies being connected to said resistance between resistors in said low loss section, an air conducting receiver associated with said first set of circuits, a bone conducting receiver associated with said second set of circuits, an attenuator switch connected to said resistance, means controlled by said switch for energizing said receivers and a selector switch for rendering either of said receivers and the circuits associated therewith ineffective.

8. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, a number of circuits energized by said generator, there being one circuit for each frequency, an attenuator including a resistance having a number of resistors connected in series, a shunting resistor connected to said series resistors and shunting certain thereof, said circuits being connected to said resistance at various points between resistors and one of said circuits being connected to said attenuator at the locality of connection of said shunting resistor thereto, an attenuator switch connected to said resistance at various points between resistors, a receiver and means controlled by said attenuator switch for energizing said receiver.

9. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, an attenuator for varying the output of the audiometer including a resistance having a number of resistors connected in series and a movable contact adapted to be connected to said resistance at points between resistors, said resistors being arranged in groups, an output device including an electrical component and two conductors connected thereto, one of said conductors being connected to one end of said resistance, and the other of said conductors being connected to said movable contact, said output device further including two receivers one of lesser sensitivity than the other, said attenuator having a single scale associated therewith and denoting hearing loss, a shunting resistor shunting certain of said groups of resistors, two sets of circuits, one for each receiver, there be-

ing one circuit for each frequency, equalizing resistors in certain of said circuits, the circuits of the set corresponding to the receiver of greater sensitivity being connected to said resistance at points between resistors remote from the denoted end of said resistance and the circuits of the set corresponding to the receiver of lesser sensitivity being connected to said resistance at points closer to said denoted end of said resistance than said first named circuits to compensate for the variations in sensitivity of the two receivers and to procure the same hearing loss readings on the same scale for both receivers.

10. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, a number of circuits energized by said generator, there being one circuit for each frequency, an attenuator including a resistance having a number of resistors connected in series, said resistors being arranged in groups, a shunting resistor shunting certain of said groups of resistors, a second shunting resistor shunting all of the groups shunted by said first shunting resistor and one additional group, said circuits being permanently connected to said resistance at various predetermined points between resistors, one of said circuits being connected to said resistance at the locality of connection of one of said shunting resistors thereto, an attenuator switch connected to said resistance at various points between resistors, a receiver and means controlled by said attenuator switch for energizing said receiver.

11. In an audiometer, a frequency generator adapted to produce alternating currents of predetermined frequencies, a number of circuits energized by said generator, there being one circuit for each frequency, an attenuator including a resistance having a number of resistors connected in series, one of said circuits being connected to said resistance at the locality of connection of said shunting resistor thereto, an attenuator switch connected to said resistance at various points between resistors, a receiver and means controlled by said attenuator switch for energizing said receiver.

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