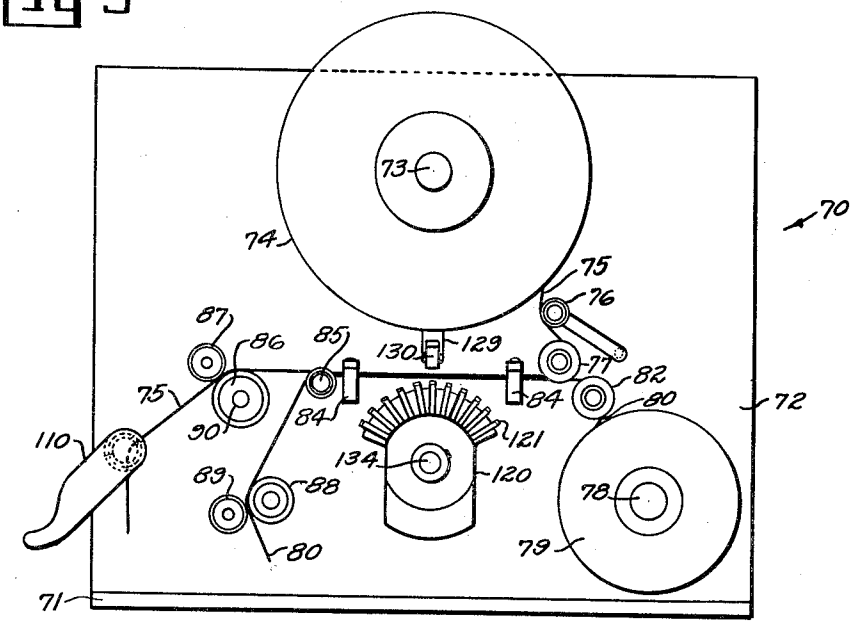
Feb. 12, 1957 F. A. BROGAN 2,781,416

AUTOMATIC AUDIOMETER

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Fig 3



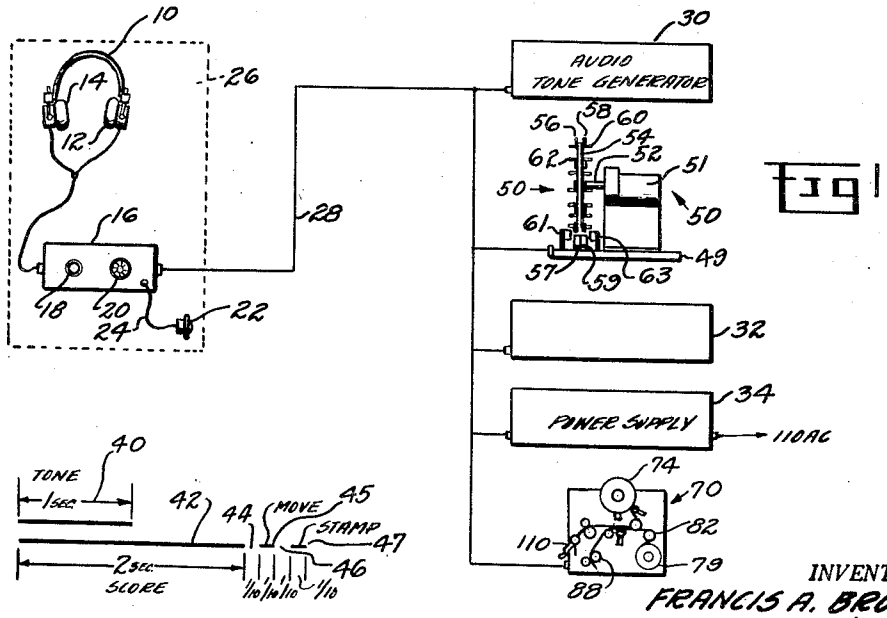


Fig 1

Fig 8

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AUTOMATIC AUDIOMETER

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Fig 2

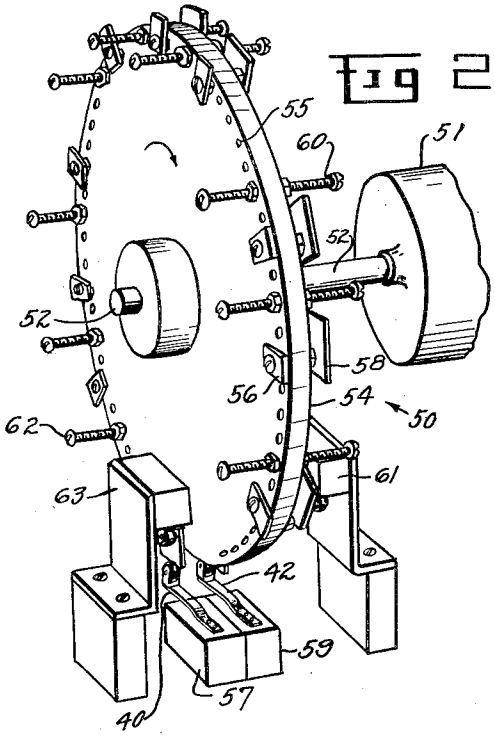
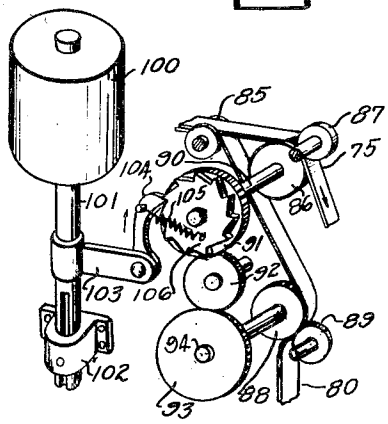


Fig 4



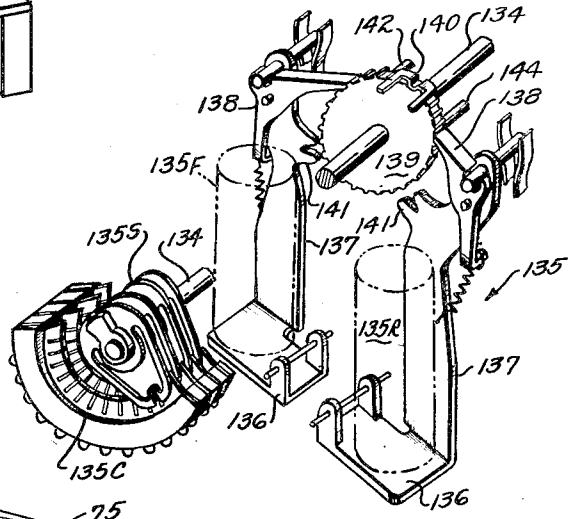


Fig 6

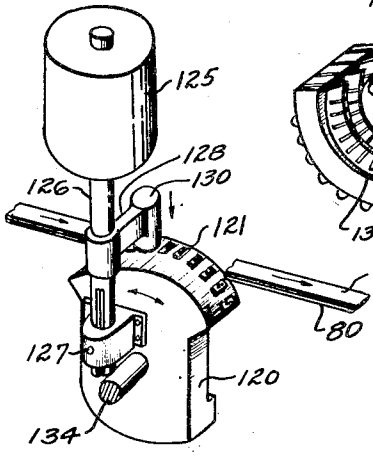


Fig 5

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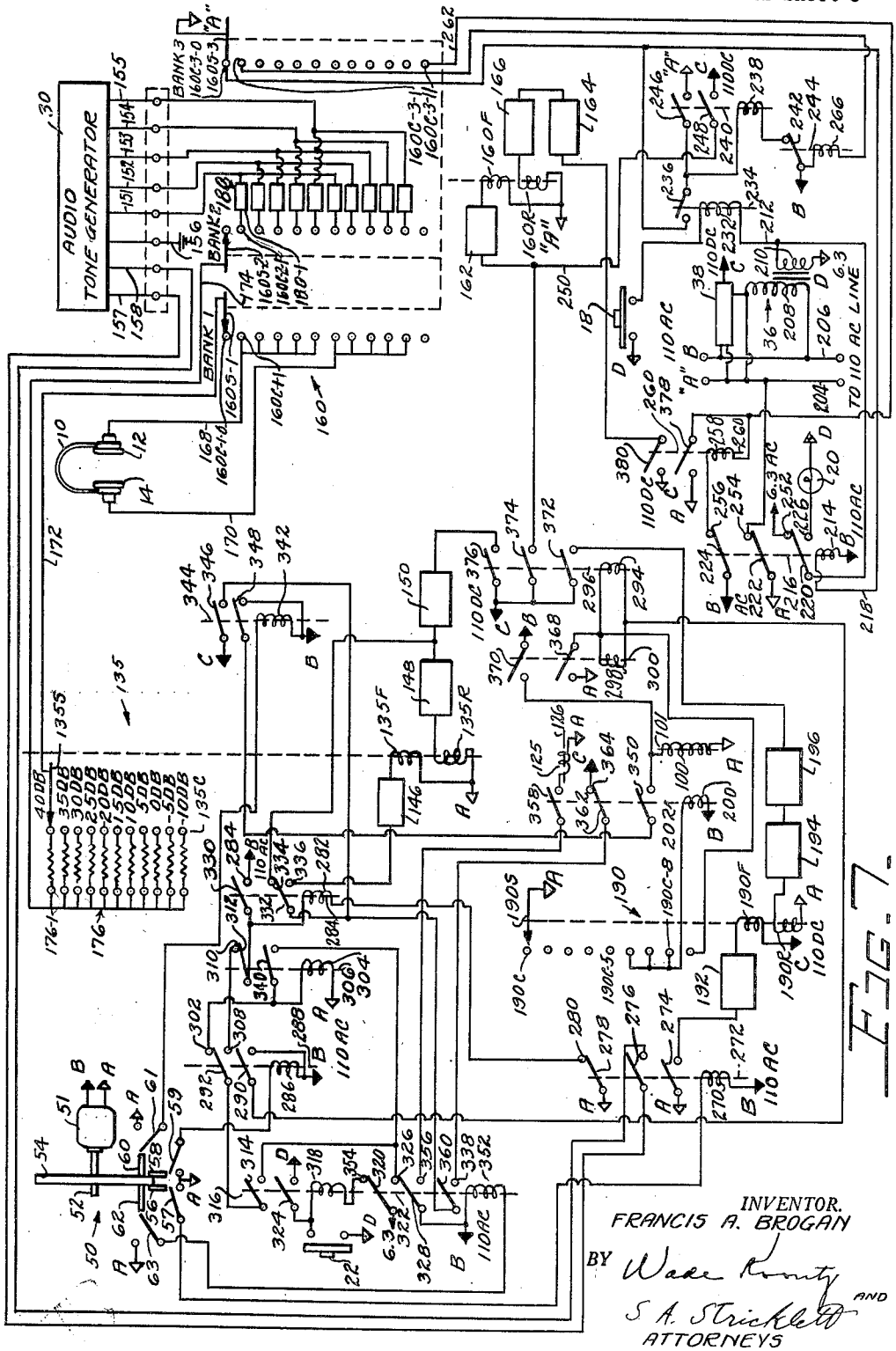


FIG. 7

United States Patent Office 2,781,416 Patented Feb. 12, 1957

2,781,416

AUTOMATIC AUDIOMETER

Francis A. Brogan, San Antonio, Tex., assignor to the United States of America as represented by the Secretary of the Air Force

Application July 12, 1955, Serial No. 521,653

11 Claims. (Cl. 179—1)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

The present invention relates to an automatic audiometer and particularly to an audiometer actuated by the patient's response to give a printed record of the hearing response of both ears of the patient.

In the armed forces there is a distinct need for a knowledge of an individual's hearing status at the time of induction to determine whether there has been any service connected loss of hearing at a later time. The making of an audiogram employing a conventional manually actuated audiometer requires considerable skill and training and a skilled operator can test only approximately one hundred persons per day. The supply of trained personnel is inadequate for making tests of very large numbers of patients in a short time.

The present invention provides a means of conducting screening audiometric tests on a large number of people in a short time, each individual test taking only a few minutes and the printed record of each test can be transferred to a conventional audiogram card for a permanent record. Those cases found to have a serious hearing impairment can then be referred to a skilled audiometer operator or to an otologist for more extensive testing and treatment.

In accordance with the present invention a conventional audio oscillator unit capable of supplying a plurality of pure tone outputs of different frequency is provided, each output being passed through a respective calibrating attenuator to adjust the output to the normal standard threshold of hearing for the particular frequency. A stepping switch is automatically sequentially switched from one frequency to another. A separate stepping switch operates to attenuate each tone through a series of discrete steps from a level of, for example, 40 decibels above to 10 decibels below the normal hearing threshold. The tones are presented to a patient for a predetermined interval, after which there is a predetermined scoring interval with the final score being automatically recorded on a record strip. A programming switching device controls the tone presentations, the scoring period, record paper movement and printing of the record.

After initiating the start of the test the patient is presented with the highest intensity tone at the first frequency in the right earphone and if a response is made within the scoring period of say two seconds the intensity stepping switch steps the intensity down through a ten decibel range. This process continues so long as a proper response is made until a predetermined number of tone presentations N, for example five, have been made. The tone intensity will then correspond to the normal threshold of hearing at that frequency. The next three tone presentations are made with a five decibel drop and each is printed on a record tope.

In the event of a closure of the response switch prior

to the scoring period, or a failure to respond, the intensity stepping switch reverses to the next higher tone except for the first tone presented so that after N presentations the patient may not have arrived at the normal threshold of hearing and the next three presentations will then determine his actual threshold since the intensity will reverse on failure or advance five decibels on proper response and all are printed. After the $N+3$ tone presentation a relay system advances the frequency stepping switch to the next step and the process is repeated for each of the audio frequencies. At the termination of the tone presentation program for each frequency the series is repeated connecting the left earphone. At the conclusion of the tests the circuits are then de-energized and the system conditioned for a new test. A printed record will be had indicating the threshold of hearing of each ear at each of the selected test frequencies and the data can later be transferred to a standard audiogram card or placed on a punched card record.

It is accordingly an object of the invention to provide an improved audiometer.

It is a further object to provide an automatic recording audiometer.

It is another object to provide an audiometer responsive to the patient's response.

Although the invention has been briefly outlined above, all of the features of the invention will be better apparent by reference to the description hereinafter given and to the appended drawings in which:

Fig. 1 is a block diagram of the components of the invention;

Fig. 2 is a perspective view of a programming control device employed in the invention;

Fig. 3 is a front elevation of the printing device;

Fig. 4 is a schematic view of the record strip feed mechanism;

Fig. 5 is a perspective view of the printer with parts broken away;

Fig. 6 is a schematic perspective view of the stepping switch with parts broken away and in section;

Fig. 7 is a general circuit diagram; and

Fig. 8 is a graphical presentation of the time intervals.

Referring now to Fig. 1, the invention in general comprises a test set including a headset **10** having right and left earphones, **12** and **14**, connected to a junction box **16** which has mounted thereon a push button **18** for starting the test, an indicator light **20** which when lit indicates that no test is in progress and a subject's response pushbutton switch **22** connected to the junction box **16** by a cable **24**. The above apparatus is positioned in a sound-proof room or booth **26** indicated in dotted lines.

A control set including a tone generator **30**, a programing device **50** and a recording device are located externally of the booth **26** and connected to the test set by a cable **28**.

The audio tone generator generally indicated by the reference numeral **30** is capable of producing a desired number of pure audio tones of different frequency. In the present case five different frequencies are employed namely, 250, 500, 1000, 2000 and 4000 cycles per second which are standard frequencies employed in audiometry to cover the normal hearing range. The frequency range could be extended if desired.

The cable **28** is also connected to a programming switch generally indicated by the reference numeral **50** which includes a cam disc **54** driven by a constant speed synchronous motor **51** at a rate of one revolution per minute. The programmer **50** determines the time of transmission of each tone, the scoring period within which a proper response must be made and energizes the

paper moving and record stamping solenoids in the recorder unit.

The cable also interconnects a relay console generally indicated by the reference character 32 which contains all of the relays, a rotary stepping switch for counting the number of tone presentations, the attenuators for adjusting the audio output of the tone generator 30 for the normal threshold of hearing for each earphone, 12 or 14, at each selected frequency and a three bank rotary stepping switch for frequency selection.

A power supply unit generally indicated by the reference numeral 34 which includes a transformer 36 and suitable rectifiers 38 supplies 6.3 volt A. C. power to the push to start button switch 18, indicator lamp 20 and patient's response switch 22 in the test booth 26, 110 volt D. C. power for operation of the rotary stepping switches and 110 volt A. C. power for relay operation.

A recorder or printer generally indicated by the reference numeral 70 completes the system assembly and is operative after a predetermined number of tone presentations have been made to print the last three tone intensity values for each frequency. The printer type bars 121 are positioned by the rotary intensity selector switch 135 which is mounted on the printer panel 72.

Prior to describing the specific circuitry details, the programmer 50 and printer 70 will be described.

Referring to Fig. 2 the programmer is generally indicated by the reference numeral 50 and includes a base 49 on which is mounted a geared head synchronous motor 51 having a shaft 52 driven at a constant speed of, for example, one revolution per minute. On the shaft 52 is mounted a timing disc 54, which is provided with a series of spaced holes 55 adjacent its periphery. A plurality of pairs of cam lugs 56 and 58 are mounted on the disc 54, one of each pair, 56 for actuating a tone switch 57 and the other 58 for actuating a score switch 59, the cams 56 and 58 have their leading edges in alignment but cams 56 have an arcuate length of one-half that of cams 58. The pairs of cams 56 and 58 are randomly spaced to prevent patient synchronism. The tone switch 57 and score switch 59 are mounted adjacent the edge of the disc 54 and each provided with roller actuating arms 40 and 42 which are engaged by the respective cams 56 and 58. The switches 57 and 59 are of the well-known snap action type and are closed at the same time by the cams 56 and 58 (as shown in Fig. 8), the tone switch 57 remaining closed for a period 40 of one second and the score switch 59 remaining closed for a period 42 of two seconds when respectively actuated by the cams 56 and 58. The time duration 40 and 42 of closure of the tone and score switches may be varied from that here employed if so desired.

Screws 60 are arranged in substantially annular projecting relation on one face of the disc 54 and are adapted to actuate a paper move roller actuating switch 61 and similar screws 62 arranged in alignment with the screws 60 actuate a similar stamp switch 63. The screws 60 and 62 are positioned just aft of the trailing edge of the cams 58 and the switches 61 and 63 are shifted relative to each other so that the time duration of switch closure is as shown in Fig. 8. In this figure it is seen that tone switch 56 and score switch 58 close together with tone duration 40 of one second and score duration 42 of two seconds. After a one-tenth second delay 44 the move switch 61 is closed for a one-tenth second period 45 and after a corresponding delay 46 the stamp switch 63 is closed for a one-tenth second period 47. Suitable conductors (not shown) in cable 28 serve to connect the programmer switches to the other units of the system.

The recorder or printing mechanism is shown in Figs. 3, 4 and 5. As seen in Fig. 3, it is generally indicated by the reference numeral 70 and comprises a base 71 having secured thereto a vertical panel 72 on which is mounted by means of a removable stud 73 a paper roll 74. Paper strip 75 from the roll 74 passes over a spring pressed tension roller 76 and over a flanged guide roller 77. A removable stud 78 serves to mount a roll 79 of carbon paper strip 80 which is led over a guide roller 82 to emerge immediately beneath the paper strip 75. The paper and carbon strips 75 and 80 pass through stationary guides 84 and over a flanged guide roller 85. The paper and carbon strips are then separated, the paper passing over a feed roller 86 and under a pressure roller 87 and the carbon strip 80 passing over a feed roller 88 and under a pressure roller 89.

As seen in Fig. 4, the paper feed roller 86 is mounted on a shaft 90 which passes through the panel 72 and has a gear 91 fixed thereon which meshes with an idler gear 92 which in turn drives a gear 93 mounted on a shaft 94 which in turn drives the carbon strip feed roller 88 in the same direction and at the same speed as paper feed roller 86. An electrical solenoid 100 provided with a spring pressed plunger 101 is suitably supported from the rear of panel 71 Fig. 3, and the plunger guided by a guide 102. The plunger is provided with an arm 103 which carries a pawl 104 pivoted thereon. The pawl 104 is suitably biased by a spring 105 so as to engage a toothed ratchet wheel 106 fixed on the inner end of the shaft 90 and driving the same. Each time the solenoid coil 100 is energized the plunger 101 is retracted upward causing pawl 104 to advance the ratchet wheel 106 which drives shaft 90 and feed roll 86 to move the paper strip 75 and through gearing to drive shaft 94 and feed roller 88 to move the carbon strip 80. The paper strip 75 after passing between feed roller 86 and pressure roller 87 passes through a conventional spring loaded manually actuated paper cut-off 110 (Fig. 3).

As seen in Figs. 3 and 5, a rotatable printing head 120 is mounted on the front side of the panel 71 of the printer assembly 70 and has type bars 121 mounted on the exterior arcuate surface thereof. There are eleven type bars 121 having numerical indicia ranging from 40 decibels through zero to minus 10 decibels in steps of five decibels corresponding to the normal range of intensity employed in audiometric testing. The type bars 121 are adapted to print by pressure on the carbon strip and paper.

As seen in Fig. 5, a stamp solenoid coil 125 adapted to be mounted on the rear of the panel 71, Fig. 3, is provided with a spring loaded plunger 126 and guide 127. The solenoid 125 when energized moves the plunger 126 downward moving the integral arm 128 with it. The arm 128 extends through a slot 129 in the panel 71, Fig. 3, and has a stamp 130 mounted on its outer end and adapted to strike the paper strip 75 and carbon strip 80 onto that type bar 121 which happens to be located immediately beneath the stamp 130.

As seen in Figs. 3 and 5, the rotary printing head 120 is fixed on the outer end of a shaft 134 which forms a part of an intensity selector switch assembly generally indicated by the reference character 135, Fig. 6. The shaft 134 extends through the panel 71, Fig. 3, with the printing head positioned on the front side of the panel as previously described.

The intensity selector switch assembly 135 schematically illustrated in Fig. 6, is mounted on the rear of the panel 72 (Fig. 3) of the printer unit 70. The switch 135 which is of a commercially available type includes a pair of actuating coils one 135F for forward operation and the other 135R for reverse operation, the coils being shown in phantom. Each coil is provided with a pivoted armature 136 provided with a vertical extension 137 which carries a spring biased actuating pawl 138 adapted to engage a toothed ratchet wheel 139 to cause forward or reverse actuation thereof and to drive the shaft 134 in a corresponding direction. A friction detent 140 is provided and in addition teeth 141 on each vertical armature extension 138 engage the ratchet 139 to limit the rotation thereof to a predetermined number of teeth in either direction. Pins 142 and 144 on the ratchet wheel 139 are adapted to actuate limit switches 146 and 148.

A four bank, twelve position switch is mounted on the

inner end of shaft **134**, the switch blades **135S** being fixed on the shaft **134** and each engaging one of the banks of contacts **135C**. Eleven contacts on each bank are employed one corresponding to each tone intensity. The corresponding active contacts on each bank are connected in parallel so as to reduce contact resistance to a negligible value. Each time the coil **135F** is energized the switch blades **135S** are advanced to the next contact in each bank each contact representing a 5 decibel step-down and coil **135R** when energized will cause a stepping of one contact space in the reverse direction. When the limit is reached in the forward direction limit switch **146** opens the circuit. Limit switch **148** opens the circuit in the reverse direction. The reversing coil **135R** may be pulsed by an interrupter **150** for rapid resetting. The intensity selector switch **135** is operated by 110 volt direct current which is also employed to operate the frequency selector and to count stepping switches.

With reference to Fig. 7 the relation of the tone generator frequency selector switch **160** and intensity selector switch **135** is made clear in the general circuit diagram. In this figure the audio tone generator generally indicated by the reference numeral **30** which as previously described is of conventional character being a vacuum tube oscillator type capable of producing five or more discrete audio frequency outputs. The outputs appear on the respective conductors **151** to **155** inclusive and are 250, 500, 1000, 2000, and 4000 cycles per second. The tone generator is connected to ground at **156** and conductors **157** and **158** connect the generator to a tone interrupter blade **276** which permits audio output only when the relay **272** is closed.

Each of the output conductors **151** to **155** is connected to a pair of attenuators arranged in a bank and generally indicated by the reference numeral **180**. The conductor **151** is connected to the first and sixth attenuators, **152** to the second and seventh, etc. The attenuators are each adjustable 500 ohm T pads and are employed to calibrate the earphones **12** or **14** so that the audio output at each frequency with the intensity selector switch **135** at the zero level will correspond to the normal threshold of hearing at that frequency. In order to avoid the use of expensive calibrated earphones separate attenuators **180** are used for each frequency for left and right earphones permitting standard Air Force headsets to be employed.

A three bank rotary stepping switch is provided for frequency selection and is generally indicated in Fig. 7 as **160** and identical in construction to the intensity selector switch **135** of Fig. 6 previously described. The coil **160F** causes forward operation of the switch to increase frequency and a reverse operating coil **160R** for resetting the switch to the zero or initial position. The forward coil **160F** has a limit switch **162** and the reversing coil has an interrupter **164** and limit switch **166** associated therewith the interrupter pulsing the switch coil **160R** for rapid resetting.

The contacts **160C–1** in bank 1 of switch **160**, twelve in number have the first or zero contact dead, the next five contacts connected in parallel to conductor **168** which leads to the right earphone **12**, contacts six through ten connected in parallel by conductor **170** to the left earphone **14** and the eleventh contact dead. The switch blade **160S–1** on bank 1 connects by conductor **172** to the switch blade assembly **135S** of the intensity selector switch **135** here shown schematically but previously described above with reference to Fig. 6.

The contacts **160C–2** of bank 2 of switch **160** are twelve in number with the zero contact dead, contacts one through ten each connected to one of the attenuators **180** and contact eleven dead. The switch blade **160S–2** on bank 2 is connected by conductor **174** in parallel to a bank of intensity attenuators generally indicated by the reference numeral **176**. The attenuators **176** are each connected to one of the eleven active contacts **135C** of the intensity selector switch **135** and serve to respectively reduce the audio tone intensity in steps of five decibels from a level of 40 decibels above the normal threshold to ten decibels below the zero or normal threshold.

The contacts **160C–3** on the third bank of the switch **160**, Fig. 7, are all dead except the zero and first contacts which respectively function in de-energizing the system and energizing the system respectively and the eleventh contact which serves in a resetting operation all to be later described. The switch blade **160S–3** of bank 3 of switch **160** is connected to a point "A" or return side of the 110 volt power supply to serve as a common when the common point of other return circuits is opened in de-energizing the system.

By reference to the composite circuit diagram, Fig. 7, it will be evident that when the stepping or frequency selector switch **160** is energized through its coil **160F** the switch blades will move on all three banks when the frequency equals zero or start position to the first active position. When the audio tone generator **30** is rendered operative by a circuit being completed through conductors **157** and **158** by closing switch **159** a tone output at the first frequency of 250 cycles per sec. will appear on conductor **151** and will pass through the first of the attenuators **180**, switch blade **160S–2** on bank 2, conductor **174** and through the first of the intensity attenuators **176** associated with the intensity selector switch **135**. The 250 cycle tone will be attenutated to a level of forty decibels above the normal threshold of hearing for that frequency and will pass from the first contact on intensity selector switch **135** to switch blades **135–S** and conductor **172** to the switch blade **160S–1** on bank 1 of frequency selector switch **160**. The tone will then pass to the first active contact on bank 1 to conductor **168** and to the right earphone **12**. As will be later explained, each successful patient response will send two pulses to the coil **135F** of the intensity selector switch **135** causing the switch blade **135S** to advance two contact spaces for dropping the intensity ten decibels. When a total of eight tone presentations has been made the frequency selector switch will step one contact space and the intensity selector switch is reset to start the second series of tone presentations at a frequency of 500 cycles per second. After the fifth frequency the selector switch arm **160S–1** will transfer to the left earphone **14** and the frequency series will repeat beginning with the 250 cycle tone.

A counter switch **190** is similar to switches **135** and **160** and has a forward operating coil **190–F** and a reverse operating coil **190–R**. Switch blade **190–S** is connected to the common circuit A and successively engages the contacts **190C**. A forward limit switch **192** limits the forward progression of the switch **190** and a limit switch **194** stops the switch return at the zero position. An interrupter **196** facilitates a rapid return to the zero position. The primary group, herein five, of the contacts is open or disconnected. A second group, herein three, is connected in parallel and controls the energization of the actuating coil **200** of the printer control relay **202**.

The control circuitry is best understood in connection with the operation of the system.

In the operation of the audiometer 110 volt alternating current is connected to the principal pair of conductors **204** and **206** having terminals "A" and B. All switches are actuated to zero position at which time blade **160S–3** of switch **160** will be in contact with contact **160C–3–0**. Blade **160S–3** is directly connected to conductor terminal "A" while rectifier **38** is fed across conductors **204** and **206** to supply 110 D. C. to terminal C and a return connection through conductor **204** to terminal "A." Likewise the primary winding **208** of transformer **36** is connected across conductors **204** and **206** to energize secondary winding **210** at 6.3 volts which appears across common terminal D and conductor **212**.

The engagement of blade 160S–3 with contact 160C–3–0 energizes coil 214 of relay 216 through terminal B, the conductor 218 and the blade 160C–3–0 to terminal "A." Energization of coil 214 moves the switch blades 220, 222 and 224 of relay 216 into front position disconnecting terminal B from the audiometer and terminal "A" from common terminal A while front contact 226 engaged by blade 220 applies the potential between terminal D and conductor 212 to the signal lamp 20 thus indicating that the audiometer is de-energized.

The patient enters the booth 26 and adjusts the headset 10 after which the patient actuates the starter switch 18 which connects coil 232 of relay 234 between conductor 212 and terminal D thus momentarily energizing relay 234 to close blade 236 and energizing coil 238 of relay 240 between terminals B and "A" by blade 242 of relay 244, conductor 218, contact 160C–3–0 and blade 160S–3. Energizing coil 238 closes blades 246 and 248. Closing blade 246 locks in coil 238 between terminals B and "A" through blades 242 and 246 after which release of start button 18 de-energizes coil 232 moving blade 236 to open position. Closing blade 248 energizes forward stepping coil 160F of frequency selector switch 160 between terminals C and "A" by way of blade 248, conductor 250 and limit switch 162 causing selector switch to move one step forward moving blades 160S–1, from contact 160C–1–0 to contact 160C–1–1, blade 160S–2 from contact 160C–2–0 to contact 160C–2–1 and blade 160S–3 from contact 160C–3–0 to contact 160C–3–1. Moving blade 160S–3 from contact 160C–3–0 de-energizes coil 214 so that relay 216 opens and blade 220 engages back contacts 252 connecting conductor 212 to the 6.3 volt terminal 252 and de-energizing signal lamp 20 informing the patient that the recording is about to begin, blade 222 engages back contact 254 and connects terminal A to "A," also, blade 224 engages back contact 256 connecting coil 258 of relay 260 to contact 160C–3–11 by way of conductor 262. The closing of blade 222 connects the common return and starts motor 51 which rotates cam disc 54.

The arrival of blade 160S–3 at contact 160C–3–1 energizes coil 266 of relay 244 and opens blade 242 thus de-energizing coil 238 so that relay 240 opens blades 246 and 248 resetting the starting circuit.

Simultaneously blades 160S–1 and 160S–2 arrive at contacts 160C–1–1 and 160C–2–1, respectively. This connects the tone generator 30 by conductor 151, T-attenuator 180–1, blade 160S–2, conductor 174, attenuator 176–1, blade 135–S, conductor 172, blade 160S–1 and conductor 168 to right earphone 12 of headset 10.

Rotation of cam disc 54 causes cams 56 and 58 to simultaneously close switches 57 and 59. Closing switch 57 energizes coil 270 of relay 272 which then moves blades 274, 276 and 278 to front position. Closing blade 274 energizes coil 190F of count switch 190 through limit switch 192 so that count switch blade 190S advances one step with each closure of relay 272. Closing blade 276 applies the tone of generator 30 to the earphone at the level determined by the position of blade 135S of switch 135. Closing blade 278 opens back contact 280 and prevents energization of coil 282 of relay 284. Closing of switch 59 energizes coil 286 of time relay 288 which closes its blades 290 and 292. Closing blade 290 applies potential to coil 294 of resetting relay 296 and coil 298 of relay 300 which however remain de-energized until count switch 190 reaches its final contact. Closing blade 292 opens back contact 302 preventing energization of coil 304 of relay 306 and closing front contact 308 to connect to coil 282 of relay 284 through back contact 310 and blade 312 of relay 306.

At the end of one second cam 56 opens switch 57 which releases blade 276 to terminate the application of the tone to the phone 12 and blade 278 will engage back contact 280 to complete an activating circuit for coil 282 by way of blades 312 and 292 to blade 314 of patient response relay 316.

The further operation of the device is dependent on the response of the patient which may be of either of the following types:

1. Successful: in which the patient hears the tone and responds in the proper score interval.

2. Failure: in which the patient fails to respond in the score interval.

3. Guess: in which the patient responds at other than the score interval. Cheating is substantially defeated by the unequal spacing of the cams 56 and 58.

(1) In successful operation, i. e., if during the score interval after the closing of switch 57 and before the opening of switch 59, the patient closes response button 22 energizing coil 318 of response relay 316 from the 6.3 terminal through blade 320 of relay 322 through button 22 to return terminal D. Energizing coil 318 causes relay 316 to close blade 324 locking in relay 316 and completing the activating circuit of coil 282 through back contact 326 and blade 328 of relay 322 to terminal B. This energizes coil 282 which causes relay 284 to close blade 330 and lock itself in from terminal B through blades 330 and 278 to terminal A, and moving blade 332 from back contact 334 to front contact 336 connecting coil 135F from terminal A through limit switch 146 and blade 332 to blade 360 of relay 322.

At the end of interval 42 switch 59 will open de-energizing coil 286 opening blade 290 and moving blade 292 from contact 308 to back contact 302 energizing coil 304 from terminal A by way of blade 292, blade 314 and blade 328 to terminal B. Relay 306 then closes blade 340 and locks itself in by way of blade 328 and also moves blade 312 out of engagement with back contact 310.

At the end of interval 44 cam 60 closes move switch 61 energizing coil 342 of relay 344 which closes blades 346 and 348. Closing blade 346 energizes coil 135F from terminal C by way of blade 346, blade 332 and limit switch 146 to terminal A and moves blade 135S forward one step. Closing blade 348 connects terminal B over blade 348 to blade 350 of relay 202 which is open because of the position of switch 190.

At the end of interval 45 switch 61 opens de-energizing coil 342 and allowing blades 346 and 348 of relay 344 to open.

At the end of interval 46 cam 62 closes stamp switch 63 energizing coil 352 of relay 322 which moves blade 320 out of engagement with back contact 354 resetting the response system. Blade 328 moves from back contact 326, de-energizing coil 304 resetting relay 306, to front contact 356 connecting terminal B over blade 328 to blade 358 of relay 202. Also, closing blade 360 connects terminal C over blade 362 of relay 202, blade 360, blade 332, limit switch 146 and coil 135F of switch 135 to terminal A causing a second step movement of switch 135.

At the end of interval 47 switch 63 opens de-energizing coil 352 allowing the response system to return to recycling condition.

Assuming that the patient's hearing is sufficiently acute to respond over the entire test range, the selector switch 135 will move two steps until blade 190S of count switch 190 arrives at contact 190C–6 at which time coil 200 of relay 202 will be energized by way of terminal B, contact 190C–6 and blade 190S to terminal A. Energizing coil 200 closes blades 350 and 358 and moves blade 362 out of engagement with back contact 364 inhibiting the second pulse to coil 135F so that switch 135 moves only one step per cycle. With switch 190 closed closing of move switch 61 causes energization of paper feed solenoid 100 from terminal B by way of blades 348 and 350 to terminal A causing a paper feed at each cycle. Also, closing of recording switch 63 causes energization of stamp solenoid 125 from terminal B over blade 328, back contact 356 and blade 358 to terminal A causing plunger 126 to move presser 130 into printing relation with the type bars 121. Arrival of blade 190S

at contact 190C–9 connects coils 294 and 298 to terminal A so that closing of switch 59 energizes relays 296 and 300 from terminal B over blade 290. Relay 300 closes blade 368 to lock in relays 300 and 296, also closes blade 370 to apply an impulse to paper feed solenoid 100 to move the printing out of the printer 70 to takeoff device 110. Relay 296 closes blades 372, 374 and 376. Closing blade 372 connects terminal C over blade 372, interrupter 196, limit switch 194 and coil 190R to terminal A. The impulses 196 produces a series of impulses to step the switch 190 in reverse until limit switch 194 breaks the circuit. Closing blade 374 applies an impulse from terminal C over blade 374 and limit switch 162 through coil 160F to terminal "A" to cause switch 160 to move forward one step to connect another tone to the test phone. Closing of blade 376 connects terminal C over blade 376, interrupter 150, limit switch 148 and coil 135R to terminal A, the interrupter 150 providing impulses until the circuit is interrupted by limit switch 148.

(2) Failure; if total will prevent forward stepping of switch 135 so that a final printing of 40 decibels indicates total failure. However, most failures are partial and occur after switch 135 has made one or more pairs of forward steps. Failure to actuate button 22 maintains coil 282 de-energized so that blade 332 remains in engagement with back contact 334 whereby closing of blade 346 in response to closing of switch 61 energizes coil 135 from terminal C by way of blade 346, blade 332, back contact 334, limit switch 148 and coil 135R to terminal A causing a step in reverse of selector switch 135. If blade 362 is in engagement with back contact 364 closing of switch 63 will likewise cause a reverse step returning the setting to the last heard tone application. After relay 202 is energized, blade 362 will be out of engagement with back contact 364 so that switch 135 will advance or reverse only in single steps thus insuring that the printer 70 will record the lowest response level.

(3) Guess; if the patient presses button 22 at a time when relay 288 is not energized relay 306 will be energized locking itself in and opening blade 312 thus preventing energization of relay 284 so that switch 135 will be reversely moved in the same way that failure causes reverse stepping.

After the series of tones, herein indicated as five, have been presented to one ear, the switch 160 will connect the tone application to the other ear. Upon the completion of tone applications to both ears blade 160S–3 arrives at contact 160C–3–11 energizing coil 258 of relay 260 which locks itself in by blade 378 and applies potential from terminal C by way of blade 380, interrupter 164, limit switch 166 and coil 160R to terminal "A". The interrupter 164 applies successive pulses until blade 160S–3 engages contact 160C–3–0 which energizes coil 214 of relay 216 which closes blades 220, 222 and 224 to de-energize the device and energize signal lamp 20.

It will be apparent that the device automatically finds and records a patient's auditory perception level at a plurality of frequencies.

For purposes of exemplification, a specific embodiment of the invention has been illustrated and described according to the best present understanding thereof. However, it will be apparent that many changes and modifications in the construction and arrangement of the components of the device may be readily resorted to within the true spirit and scope of the invention.

I claim:

1. An audiometer comprising a tone generator, a tone reproducer adapted to be applied to the ear of a patient, an attenuator connected between said generator and said reproducer and operable to match said generator and said reproducer, a switching device, means controlled by said switching device for intermittently applying a tone from said generator to said reproducer, a group of attenuators operable to provide a plurality of tone intensity levels, an intensity selector switch operable to selectively connect one of said group of attenuators in controlling relation between said generator and said reproducer, forward and reverse actuating means for said selector switch, means controlled by said switching device to apply actuating current for said actuating means in timed relation to said tone applications, a patient actuated switch determining the direction of actuation of said actuator means, a recording device operatively connected to said selector switch and means responsive to a predetermined number of tone applications for energizing said recording device.

2. An audiometer comprising a tone generator operable to produce a plurality of tones, a tone reproducer adapted to be applied to the ear of a patient, an attenuator connected between said generator and said reproducer and operable to match said generator and said reproducer, a switching device, means controlled by said switching device for intermittently applying a tone from said generator to said reproducer, a group of attenuators operable to provide a plurality of tone intensity levels, an intensity selector switch operable to selectively connect one of said group of attenuators in controlling relation between said generator and said reproducer, forward and reverse actuating means for said selector switch, means controlled by said switching device to apply actuating current for said actuating means in timed relation to said tone applications, a patient actuated switch determining the direction of actuation of said actuator means, a recording device operatively connected to said selector switch, a means responsive to a predetermined number of tone applications for energizing said recording device, a tone selector switch and operating means adapted to actuate said tone selector switch in response to a predetermined number of tone applications.

3. An audiometer comprising a source of a plurality of tones of preselected frequency, right and left ear phones, attenuator means adjustable to match each of the tones of said source with each of said phones, a tone selector switch operable to select a tone from said source, an attenuator device operable to provide a plurality of tone intensity levels, an intensity selector switch operable to select a tone level, a programming device operable to apply the selected tone to one of said phones for a predetermined interval, an intensity selector switch actuating mechanism including forward and reverse coils, circuit means controlled by said programming device for applying actuating impulses to said actuating mechanism, a manually controlled relay operative to determine the coil energized by said impulse, a printing device including indicia selecting means operatively connected to said intensity selector switch, actuating means operatively connected to said printing device, circuit means operative in response to a predetermined number of tone level presentations to energize said printing actuating means.

4. An audiometer comprising a source of a plurality of tones of preselected frequency, right and left earphones, attenuator means adjustable to match each of the tones of said source with each of said phones, a tone selector switch operable to select a tone from said source, an attenuator device operable to provide a plurality of tone intensity levels, an intensity selector switch operable to select a tone level, a programming device operable to apply the selected tone to one of said phones for a predetermined interval, an intensity selector switch actuating mechanism including forward and reverse coils, circuit means controlled by said programming device for applying actuating impulses to said actuating mechanism, manually controlled means operative to determine the coil energized by said impulse, a printing device including indicia selecting means operatively connected to said intensity selector switch, actuating means operatively connected to said printing device, circuit means operative in response to a predetermined number of tone level presen-

tations to energize said printing actuating means, an actuating mechanism operably connected to said tone selector switch, said actuating means including forward and reverse coils, circuit means responsive to a predetermined number of tone level presentations to energize said forward coil.

5. An audiometer comprising a source of a plurality of tones of preselected frequency, right and left earphones, attenuator means adjustable to match each of the tones of said source with each of said phones, a tone selector switch operable to select a tone from said source, an attenuator device operable to provide a plurality of tone intensity levels, an intensity selector switch operable to select a tone level, a programming device operable to apply the selected tone to one of said phones for a predetermined interval, an intensity selector switch actuating mechanism including forward and reverse coils, circuit means controlled by said programming device for applying actuating impulses to said actuating mechanism, manually controlled relay means operative to determine the coil energized by said impulse, a printing device including indicia selecting means operatively connected to said intensity selector switch, actuating means operatively connected to said printing device, circuit means operative in response to a predetermined member of tone level presentations to energize said printing actuating means, an actuating mechanism operably connected to said tone selector switch, said actuating means including forward and reverse coils, circuit means responsive to a predetermined number of tone level presentations to energize said forward coil, circuit means responsive to a predetermined number of forward steps of said tone selecting switch to energize the reverse coil of said actuating mechanism.

6. An audiometer comprising a source of a plurality of tones of preselected frequency, right and left earphones, attenuator means adjustable to match each of the tones of said source with each of said phones, a tone selector switch operable to select a tone from said source, an attenuator device operable to provide a plurality of tone intensity levels, an intensity selector switch operable to select a tone level, a programming device operable to apply the selected tone to one of said phones for a predetermined interval, an intensity selector switch actuating mechanism including forward and reverse coils, circuit means controlled by said programming device for applying actuating impulses to said actuating mechanism, manually controlled switching means operative to determine the coil energized by said impulse, a printing device including indicia selecting means operatively connected to said intensity selector switch, actuating means operatively connected to said printing device, circuit means operative in response to a predetermined tone level presentation to energize said printing actuating means, an actuating mechanism operably connected to said tone selector switch, said actuating means including forward and reverse coils, circuit means responsive to a predetermined tone level presentation to energize said forward coil, circuit means responsive to a predetermined number of forward steps of said tone selecting switch to energize the reverse coil of said actuator mechanism, said circuit means including in series circuit relation an interrupter device and a limit switch.

7. An automatic recording audiometer comprising a tone generator operable to supply a plurality of tones in the audible range, a pair of earphones adapted to be applied to the ears of a patient, a first attenuator adjustable to match each of the tones supplied by said generator with each of said phones, a second attenuator operable to provide a plurality of tone intensities, a tone selector switch operable to selectively connect the tones of said generator to one of said phones, an intensity level selector switch operative to determine the intensity level of the tone, a programming device including a plurality of switch actuating means, a forward and a reverse actuating coil for said intensity level selector switch, a tone applying circuit controlled by said programming device, a scoring control circuit controlled by said programming device, a first and second impulse circuit successively controlled by said programming device, a patient response switch, a relay responsive to the condition of said response switch for determining the connection of said impulse circuits to one of said forward or reverse actuating coils.

8. An automatic recording audiometer comprising a tone generator operable to supply a plurality of tones in the audible range, a pair of earphones adapted to be applied to the ears of a patient, a first attenuator adjustable to match each of the tones supplied by said generator with each of said phones, a second attenuator operable to provide a plurality of tone intensities, a tone selector switch operable to selectively connect the tones of said generator to one of said phones, an intensity level selector switch operative to determine the intensity level of the tone, a programming device including a forward and a reverse actuating coil for said intensity level selector switch, a tone applying circuit controlled by said programming device, a scoring control circuit controlled by said programming device, a first and second impulse circuit successively controlled by said programming device, a patient response switch, a relay responsive to the condition of said response switch for determining the connection of said impulse circuits to one of said forward or reverse actuating coils, a rotating cam disc, a plurality of groups of switch actuating cams on said disc, said groups of cams being unequally spaced apart on said disc.

9. An automatic recording audiometer comprising a tone generator operable to supply a plurality of tones in the audible range, a pair of earphones adapted to be applied to the ears of a patient, a first attenuator adjustable to match each of the tones supplied by said generator with each of said phones, a second attenuator operable to provide a plurality of tone intensities, a tone selector switch operable to selectively connect the tones of said generator to one of said phones, an intensity level selector switch operative to determine the intensity level of the tone, a programming device including a forward and a reverse actuating coil for said intensity level selector switch, a tone applying circuit controlled by said programming device, a scoring control circuit controlled by said programming device, a first and second impulse circuit successively controlled by said programming device, a patient response switch, a relay responsive to the condition of said response switch for determining the connection of said impulse circuits to one of said forward or reverse actuating coils, a printing device including indicia corresponding to the tone level determined by the intensity level selector switch, an actuating coil for said printing device, a circuit means operative in response to predetermined number of tone applications to energize said actuating coil for said printing device.

10. An automatic recording audiometer comprising a tone generator operable to supply a plurality of tones in the audible range, a pair of earphones adapted to be applied to the ears of a patient, a first attenuator adjustable to match each of the tones supplied by said generator with each of said phones, a second attenuator operable to provide a plurality of tone intensities, a tone selector switch operable to selectively connect the tones of said generator to one of said phones, an intensity level selector switch operative to determine the intensity level of the tone, a programming device including a forward and a reverse actuating coil for said intensity level selector switch, a tone applying circuit controlled by said programming device, a scoring control circuit controlled by said programming device, a first and second impulse circuit successively controlled by said programming device, a patient response switch, a relay responsive to the condition of said response switch for determining the connection of said impulse circuits to one of said forward or reverse ac-

tuating coils, a printing device including indicia corresponding to the tone level determined by the intensity level selector switch, an actuating coil for said printing device, a circuit means operative in response to a predetermined number of tone applications to energize said actuating coil for said printing device, a forward stepping coil operatively connected to said tone selector switch, circuit means responsive to a predetermined number of tone applications for energizing said forward stepping coil.

11. An automatic recording audiometer comprising a tone generator operable to supply a plurality of tones in the audible range, a pair of earphones adapted to be applied to the ears of a patient, a first attenuator adjustable to match each of the tones supplied by said generator with each of said phones, a second attenuator operable to provide a plurality of tone intensities, a tone selector switch operable to selectively connect the tones of said generator to one of said phones, an intensity level selector switch operative to determine the intensity level of the tone, a programming device including a forward and a reverse actuating coil for said intensity level selector switch, a tone applying circuit controlled by said programming device, a scoring control circuit controlled by said programming device, a first and second impulse circuit successively controlled by said programming device,

a patient response switch, a relay responsive to the condition of said response switch for determining the connection of said impulse circuits to one of said forward or reverse actuating coils, a printing device including indicia corresponding to the tone level determined by the intensity level selector switch, an actuating coil for said printing device, a circuit means operative in response to a predetermined number of tone applications to energize said actuating coil for said printing device, a forward stepping coil operatively connected to said tone selector switch, circuit means responsive to a predetermined number of tone applications for energizing said forward stepping coil, a reverse stepping coil operatively connected to said tone selector switch, circuit means including a limit switch and an interrupter for energizing said reverse stepping coil in response to a predetermined number of operations of said forward stepping coil.

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