

July 20, 1937.

P. J. CLIFFORD

2,087,838

APPARATUS FOR DIAGNOSING AND TREATING DEAFNESS

Filed Jan. 20, 1932

5 Sheets-Sheet 1

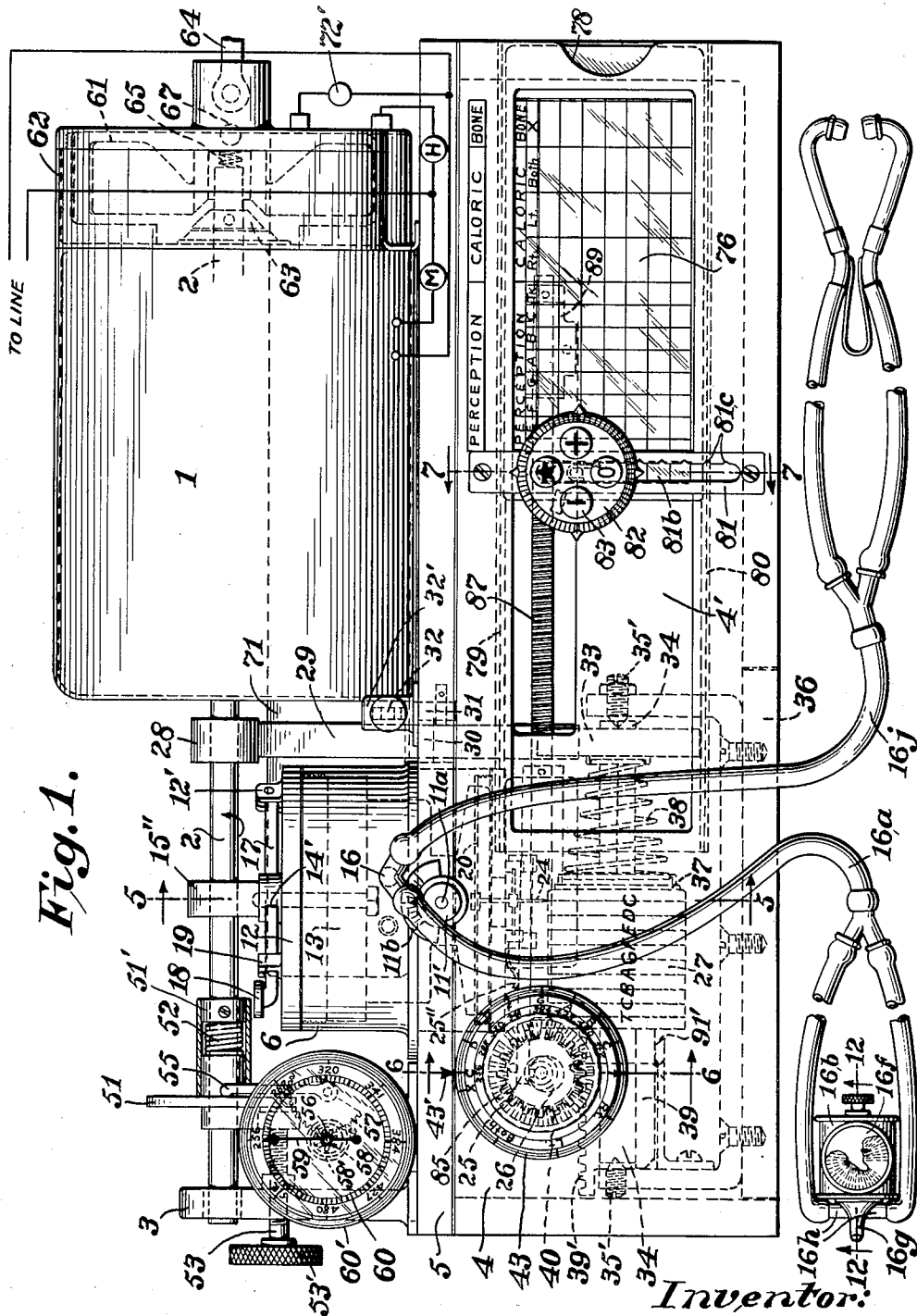


Fig. 1.

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July 20, 1937.

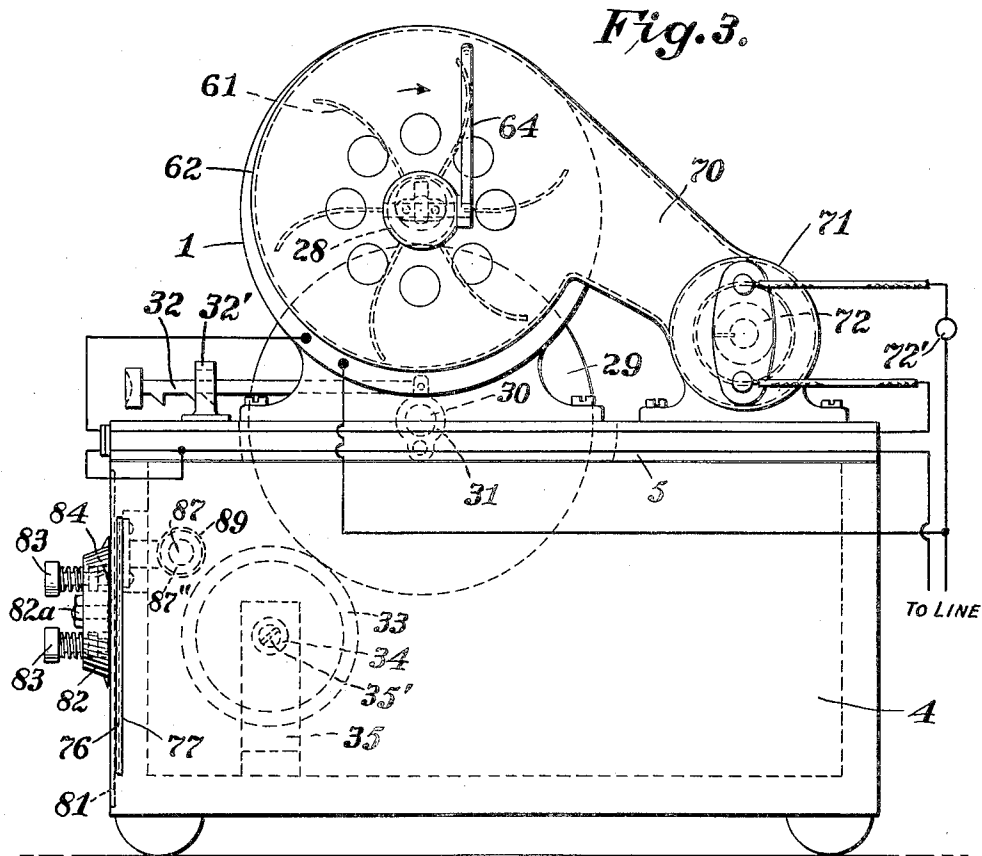
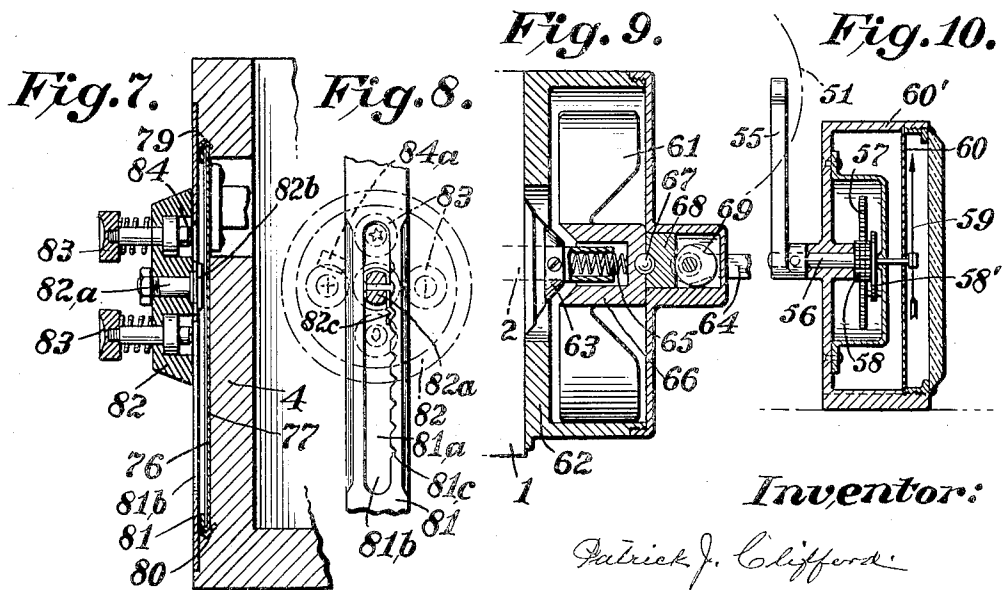
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APPARATUS FOR DIAGNOSING AND TREATING DEAFNESS

Filed Jan. 20, 1932

5 Sheets-Sheet 3



July 20, 1937.

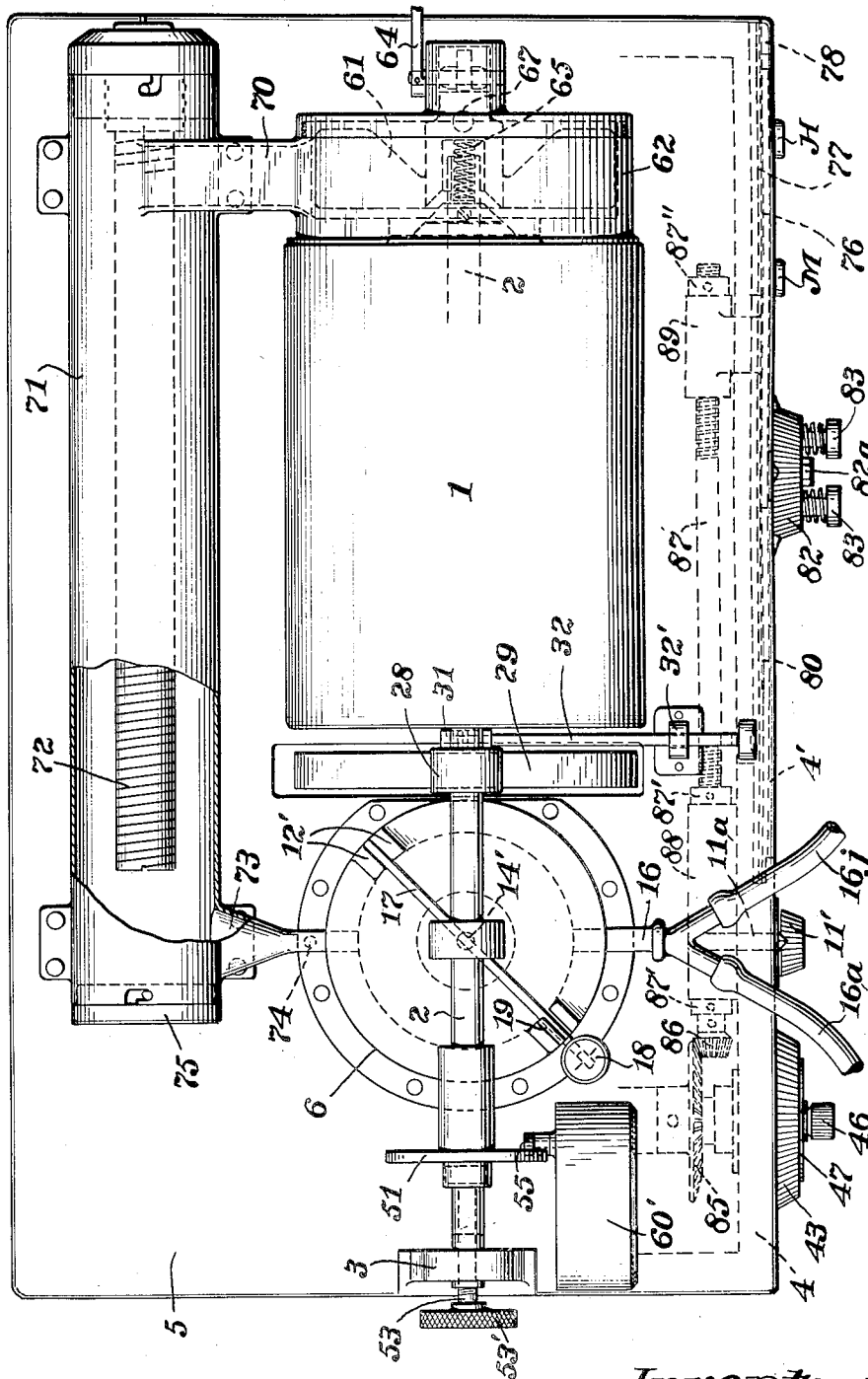
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APPARATUS FOR DIAGNOSING AND TREATING DEAFNESS

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5 Sheets-Sheet 4



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APPARATUS FOR DIAGNOSING AND TREATING DEAFNESS

Filed Jan. 20, 1932

5 Sheets-Sheet 5

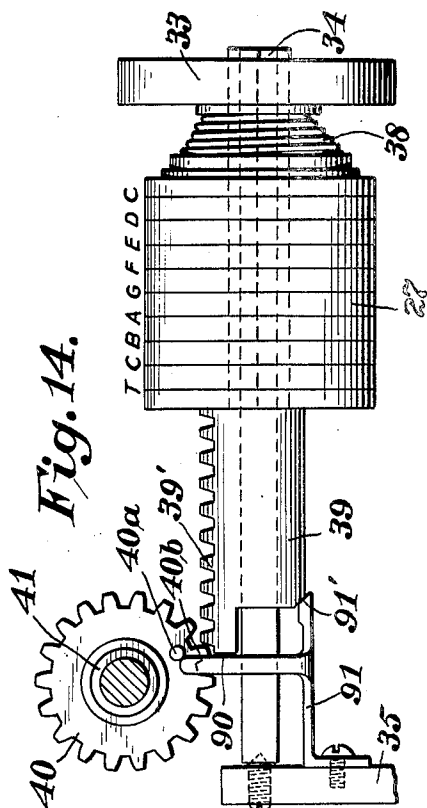


Fig. 14.

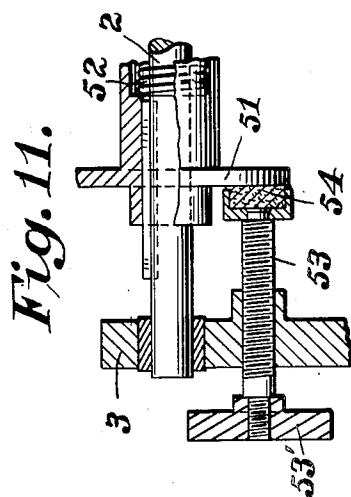


Fig. 11.

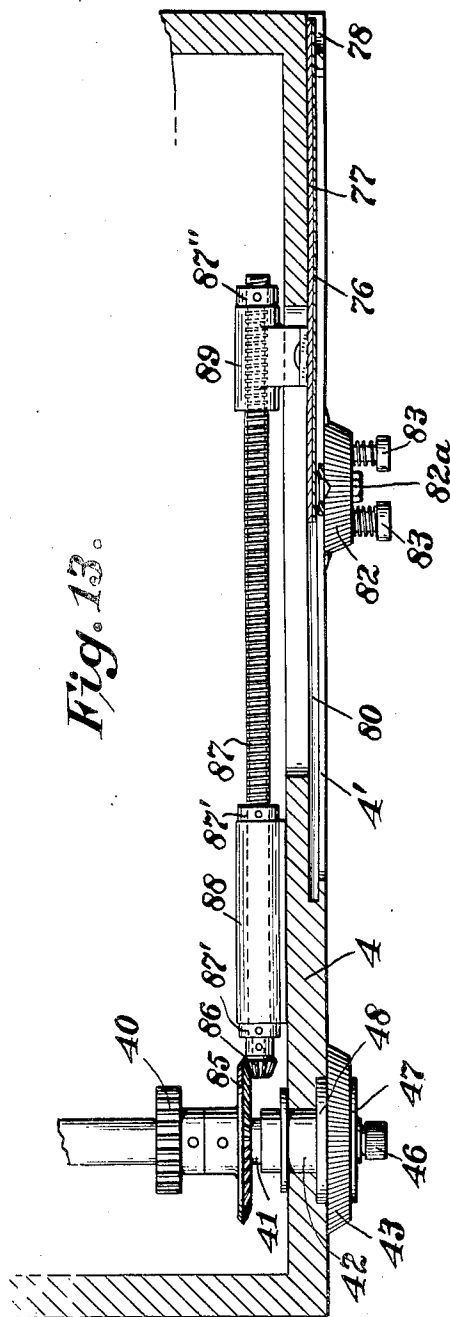


Fig. 13.

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UNITED STATES PATENT OFFICE

2,087,838

APPARATUS FOR DIAGNOSING AND TREATING DEAFNESS

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Application January 20, 1932, Serial No. 587,826

26 Claims. (Cl. 128—2)

My invention relates to that class of instruments used by otologists in testing, diagnosing and treating defects in the organs of hearing.

The object of the invention is to provide a machine so constructed as to be capable of producing, singly or in combination, by means contained therein, functional tests of the ear to determine a degree of deafness, the reason therefor, and the treatment thereof, while the part being tested or treated and the effect produced thereon is autoptically visible to the operator, together with synchronizing means to produce a printed chart of the complete examination or, in so far as the ear is concerned, a health audit.

Other and further important objects of the invention will be apparent from the disclosures in the accompanying drawings and the following specification.

In the drawings, forming a part of this specification, like characters of reference refer to similar parts throughout the several figures, in which:

Figure 1 is a front elevation of the complete apparatus including the flexible tubing for the use of the patient and operator.

Fig. 2 is an end elevation, viewed from the left of the machine.

Fig. 3 is a similar view from the right end.

Fig. 4 is a top plan view.

Fig. 5 is a vertical transverse sectional view taken on line 5—5 of Fig. 1.

Fig. 6 is an enlarged vertical transverse section on line 6—6 of Fig. 1.

Fig. 6a is a detail plan view of locking plate shown in Fig. 6.

Fig. 7 is an enlarged fragmentary section on line 7—7 of Fig. 1.

Fig. 8 is a fragmentary face view of the printing dial carriage with the dial showing in dot and dash lines for clearness.

Fig. 9 is a vertical longitudinal section through the fan mechanism.

Fig. 10 is an enlarged central vertical section through the vibratory indicator.

Fig. 11 is an enlarged fragmentary sectional view of the motor speed control.

Fig. 12 is an enlarged sectional view of the visascope on line 12—12 of Fig. 1.

Fig. 13 is a fragmentary horizontal sectional plan view of the automatic chart moving mechanism.

Fig. 14 is an enlarged detail view of the sound record alignment mechanism.

In the drawings 1 indicates a silent motor having a speed of 8000 R. P. M., or more, provided

with an elongated shaft 2, journaled at one end in a vertical standard 3. Actuating means are disposed on this shaft for setting in motion the various parts of the machine.

A case 4 is provided in which part of the apparatus is housed, said case having a hinged cover 5, upon which the motor assembly is mounted. There is also provided an air and sound casing 6, (see Fig. 5) of cylindrical form, and being flanged centrally thereof for mounting into the cover 5. The casing 6 is divided internally into two uneven chambers 7 and 8, the dividing wall 9 having a central opening 10, in which is mounted sound insulating means, comprising a valve 11. The casing 6 is closed at its top by the screw cap 12.

Mounted in the chamber 7 is a heavy, resilient diaphragm 13, which is seated on the annular shoulder of the chamber, and rigidly held in place by the screw threaded flange of the cap 12. A vibrating member 14 is fixed in the center of diaphragm 13, the stem of which extends upward, and is guided in its movement by a central opening in cap 12. Motion is imparted to the vibrating member 14 by means of a plate cam 15, the edge of which is shaped to give the required reciprocating motion. A leaf spring 15' is interposed between the cam 15 and the member 14, and in constant engagement with both, to provide a wiping, noiseless contact, to depress member 14. The cam 15 is enclosed in a suitable housing 15'', which is attached to the screw cap 12. The actuation of cam 15 will cause the member 14 to vibrate the diaphragm 13 four times for each complete revolution of the motor shaft 2, by reason of the four elevations on the face of the cam. Thus, there will be produced in chamber 7, air pulsations of a predetermined value, depending on the speed of the motor, the control of which will be described hereinafter, said pulsations being discharged through the outlet tube 16, and diverted by one of its bifurcated ends to flexible tube 16a, through a visascope 16b to the ear of the patient (Fig. 1).

The visascope 16b (Fig. 12) is provided with focusing means consisting of a suitable lens 16c, and an inclined mirror 16d of the magnifying type, which is adapted to be adjusted by a thumb screw 16e to bring an enlarged and clarified view of the part being tested or treated upon a ground glass plate 16f.

An auricle tube 16g, is provided with transverse tubular passages 16h, adapted to receive the bifurcated ends of the flexible tube 16a. The lens 16c is mounted in the large part of the auricle

tube 16g, in the rear of air passages 16h, and the usual light bulb 16i is provided for proper interior illumination. A flexible tube 16j (Fig. 1) is provided in order that the operator may check the functions of the machine when testing.

Means are provided for removing the vibrating member 14 from operative contact with the cam 15 (see Figs. 2 and 5). This means comprises a lever 17, pivoted at one end in lugs 12' near the outer edge of screw cap 12, and extending transversely across the top thereof, and through the slot 14' of the vibrating member 14, terminating in a button 18. Detent means 19 is provided to hold the said lever in depressed position. The bottom chamber 8 (Fig. 5) is constructed along the lines of the well-known phonograph reproducer, the purpose of which is to convey sound into chamber 7 for discharge therefrom. Chamber 8 contains a diaphragm 20, held in place by a bottom screw cap 21 of casing 6.

Attached to the center of the diaphragm 20 by suitable means is a tone arm 22, which extends down through the center opening of screw cap 21, being fulcrumed in lugs at 23 and adapted to hold the stylus 24 at its outer end. The tone arm is capable of being raised or lowered, in or out of operable contact by means to be hereinafter described.

Sound mechanism is provided, consisting of a suitable record 27 of cylindrical shape, upon which may be recorded any number of desired sounds for the purpose herein specified.

Each sound is a separate and distinct recording, forming a continuous groove on the periphery of the record, and being equally spaced, to assure synchronic relation with a movement of the record and a setting of a dial 43 for tone selection, the method of which will be hereinafter described. Mounted on shaft 2 of motor 1, is provided a small friction gear 28, (see Figs. 1 and 3) which drives a large, intermediate friction gear 29, which in turn, drives a friction gear 33 comprising a gear-train to drive the sound mechanism. Gear 29 is journaled on a stud shaft 30, and carried in a movable bearing 31 mounted in the cover 5, and adapted to be moved in or out of operable contact with the gears 28 and 33, through the action of a push-pull bar 32, and held in either position by detent means 32'.

Gear 33 is fixed on a shaft 34 which is supported by adjustable pivot bearings 35' in a yoke shaped frame 35. This yoke shaped frame is mounted on a hinged door 36, which is part of the bottom of case 4, being so constructed as to permit easy access to the sound mechanism.

Slidably mounted on shaft 34 (Fig. 5) is a cylinder 37, adapted to carry the sound record 27. The shaft 34 is squared for about two-thirds of its length, and the bearing of the cylinder 37 is correspondingly squared to assure positive rotation. Cylinder 37 is normally pressed leftward (Fig. 1) by a conical coiled spring 38 against a sleeve 39, which is slidably mounted on the round part of shaft 34.

The sleeve 39 (Figs. 6 and 14) has on its upper surface a rack 39', adapted to mesh with a gear 40 which is fixed on a hollow shaft 41, the outer end of which is flanged, and adapted to have attached thereto, a dial 43. Shaft 41 rotates in a bearing 42 attached to, and supported in the front wall of case 4. Set screw 44 is provided to engage with an annular groove 45 in the shaft 41, allowing rotation, but preventing longitudinal movement thereof, and to hold the dial 43 flush with the wall of case 4.

The dial 43 has on its face a series of characters, accurately calibrated, which, when aligned with an arrow 43' on the wall of case 4, will designate the sound selected, and indicate that a sound groove in record 27 is properly aligned to receive the needle 24, and bring the chart 76 to its proper position under the printing dial to receive a character by means hereinafter to be described.

A knurled knob 46, is suitably attached to the outer end of a solid shaft 26'', holding a metal disc 47 rigidly fixed against the shoulder of the shaft. This shaft has for its bearing the hollow shaft 41, and has limited rotatable and longitudinal movement therein. On its inner end, and being an integral part thereof, is a barrel cam 26, having a groove 26' milled in the body of the cam to the extent of one-half of its circumference, or an arc of 180 degrees, as shown in Fig. 6.

The groove 26' is engaged by a lever 25, hinged and guided in lugs 25', the engagement being assured by a leaf spring 25''. The angle of the groove in the cam is designed to move the shaft 26'' longitudinally in either direction, simultaneously with the lifting of the lever 25, when the cam is rotated. The front wall of case 4 is recessed to a depth that will permit a washer 48 to be forced over bearing 42 until it is flush with the face of case 4. Washer 48 has a plurality of holes 48' (Fig. 6a) in it, equal to the number of sound calibrations on the face of the dial 43, and so designed, that the top hole in the washer 48, a character on dial 43 and the arrow 43' will be in exact alignment, when a sound groove has been selected. Dial 43 has a hole in it directly beneath the characters C 256, the bottom of which is the flanged end of the hollow shaft 41. The purpose of this hole is to contain a locking tumbler 49, which has two diameters, the smaller adapted to fit a hole in the flange 41', and any hole in the washer 48, (Fig. 6) and is spring pressed outwardly against the disc 47, by a coil spring 50. The purpose of the mechanism just described is three-fold:

1. To raise the needle and unlock dial 43.
2. To lower the needle and lock dial 43.
3. To prevent longitudinal movement of the record 27 while the needle is in a sound groove, thus positively preventing injury thereto.

The sequency of these operations is as follows: When knob 46 is turned clock-wise to its full limit, cam 26 will raise lever 25 which lifts tone arm 22, and raises the needle out of contact with record 27; simultaneously therewith, the action of lever 25 in cam groove 26' through shaft 26'' forces disc 47 outward when tumbler 49, by the action of its spring 50, is forced out of engagement with a hole 48' in washer 48, completing the unlocking movement. Dial 43 is now free to be rotated in either direction to select another tone groove, bringing tumbler 49 directly over another hole in the washer 48.

When the selection is completed, knob 46 is turned counter-clockwise to its full limit, causing shaft 26'' to move inward, when disc 47 will force tumbler 49 into a hole in the washer 48, locking dial 43, and allowing lever 25 to lower tone arm 22, and the needle 24 will be in a tone groove in record 27 ready for test.

The intensity of the tones produced is controlled by the valve 11 through a knob 11' mounted on a shaft 11a. Dial means 11b (Fig. 1) is calibrated to indicate distance in feet in order that the operator may determine the exact distance a sound is audible to the ear of a patient,

i. e., when the valve 11 is open to its full extent, the indication on the dial 11b shows no distance, and the maximum volume of tone is delivered to the ears of the patient. As the valve is closed, the distance on the dial is increased, to the point where the sound is no longer audible, so that when the maximum distance is indicated the valve is positively closed, and all sound is beyond the range of the patient's hearing.

10 The number of pulsations produced in the chamber 7 may be varied as required, by the use of a control mechanism consisting of a disc 51 (Fig. 1) slidably mounted and feathered on shaft 2, and pressed outwardly by spring 52, which is seated against a fixed collar 51' on the shaft. Mounted in the upright standard 3 is a threaded stem 53 (Fig. 11) having on one end, a cup, adapted to hold a pad 54 to bear against the face of the disc 51, and on the other end, a knurled thumb nut 53', the turning of which will vary the speed of the shaft 2 by frictional contact with disc 51. Means for indicating the number of pulsations per second, associated with the control disc 51, and consisting of an arm 55, mounted on the rear end of shaft 56, as shown in Fig. 10, to which is fixed a segmental gear 57, that meshes with, and rotates a pinion gear 58, against the tension of a hair spring 58', the purpose of which is to return a hand 59 to its normal position on a dial 60, (Fig. 1) which is suitably held within the case 60'.

As heretofore stated, if the speed of shaft 2 is 8000 R. P. M., and the speed is decreased by the pressure of pad 54 against the disc 51 until the R. P. M. of the shaft is 3840, it is obvious that the cam 15 will depress the member 14, four times for every revolution of the shaft, or 15,360 times per minute, which will be 256 times per second, or the same number of vibrations produced by the tone of middle C of the musical scale. When the dial 60 is set to indicate 256, and the dial 43 shows a like indication, the air pulsations and tonal vibrations will be delivered in perfect synchronism.

45 A current of pressure air, as distinguished from air pulsations, is delivered to chamber 7 of casing 6 by means of the fan mechanism shown in Fig. 9. A fan 61 (Fig. 3) contained in a housing 62 is mounted on the rear end of motor housing 1, and adapted to be actuated by a clutch 63 fixed on the motor shaft 2. Means is provided to put the fan in or out of operable contact with the clutch 63 by a lever 64. Shaft 2 is hollowed to receive a spring 65, (Fig. 9), which exerts sufficient pressure against fan hub 66, to keep it out of contact with cone 63, and to secure a ball-bearing 67 in place between the said hub and a bearing block 68, which rests against a cam 69, being normal position as shown. The raising of lever 64 to a vertical position as shown in Fig. 3, will cause the fan assembly to move into operable contact with clutch 63. Air is then forced by way of a passage 70 (Fig. 4) into an elongated tube 71, adapted to receive at one end thereof, a heating element 72, thermostatically controlled by button H, and having in its circuit a light 72' to indicate the on or off condition of the element. At the other end of tube 71 is an outlet 73 connected with chamber 7 of casing 6 for the passage of air thereto. The passage 73 is provided with a check valve 74 of the ball type, making it unidirectional. The cap 75 of the tube 71, is held in place by a bayonet slot, and is for the purpose of inspecting the interior of tube 71.

75 Charting means, forming a part of the appa-

ratus, is provided, and is adapted to record upon a suitable card or form, the final results or tests produced by the device. In the front wall of the case 4 as clearly shown in Figure 1, is an elongated window 4' through which the face of the chart or record-form 76 is accessible for recording thereon. This chart is of slightly greater width than the window but only half as long, and is adapted to be carried in a metal plate 77, having its upper and lower edges turned to hold the card in place; case 4 is suitably recessed and slotted a sufficient distance along its front wall to receive and guide the metal plate 77. Thumb notch 78' is provided to facilitate the removal of the card 76.

Parallel guide rails 79 and 80 are arranged horizontally in corresponding recesses in the front wall of case 4 above and below the chart window. The metal chart carrying plate 77 is adapted to be guided by the rails 79 and 80. A carrier bar 81 (Fig. 13) is attached to the front wall of case 4 at a point intermediate of the chart window 4', and is adapted to carry a rotary printing dial 82, which is vertically adjustable in slot 81b of the carrier bar 81 and is designed to contain a series of depressible keys 83 normally spring retracted, and provided with printing characters 84 on their bottom faces, corresponding with the characters shown on the keys 83, the star indicating normal, the plus sign, abnormal, the minus sign, subnormal, the zero, nil.

Reverting to the dial 82 on the carrier bar 81, details of which are shown in Figures 7 and 8, it will be seen that the stem 82a is flattened to pass freely in the slot 81a, and is provided with an enlarged head 82b, engaging the under side of the slot to hold the disc firmly against the carrier bar. Around the flattened portion of the stem 82a is fixed a detent spring 82c, adapted to engage notches 81c spaced to correspond with spaces on the chart. A small inking roller 84a is provided under the dial 82 in the path of the printing characters 84 as they are brought to the printing point.

The chart 76 is adapted to have the results of 45 tests symbolically printed in the proper spaces, and is so designed as to receive a number of complete recordings printed thereon, each in its designated space, in accordance with the printed characters on the chart. Each space on the chart will be automatically moved to align with a selected character of the printing dial 82, and in synchronism with the corresponding movement of dial 43. This is accomplished by means of a bevel (Fig. 13) gear 85 fixed on the hollow shaft 41 and meshing with a small bevel gear 86 fixed on the end of a horizontal shaft 87, mounted in an elongated bearing 88, which is fastened to the rear of the front wall of case 4 and held against longitudinal movement by the collars 87' 80 pinned thereon. Beyond bearing 88 the shaft 87 is threaded for the remainder of its length, to receive and move a nut 89 which is adapted to be fastened to the back of the metal plate 77 by suitable means for imparting movement thereto. The nut 89 is limited in its movement in one direction by the collar 87' and in the other direction by the fixed collar 87''.

The gear 40 which actuates the rack 39' previously described, is provided with a pin 40a (see Fig. 14) which is adapted to pass over the upper end of and force down a vertical bar 90, forming part of a spring 91, which is fastened to one end of the yoke shaped frame 35. The purpose of the spring 91 is to hold the rack 39 out of mesh with 75

the gear 40 when it has been moved rightward to its full limit. The sleeve 39 is chamfered at its lower edge, and the spring 91 is correspondingly shaped as shown at 91'. When the tooth 5 40b of gear 40 forces the last tooth of rack 39' clear of the gear 40, against the pressure of spring 38 (Figs. 1 and 14) the chamfered end of spring 91, as shown at 91', will force itself upward against the chamfered edge of the sleeve 39, 10 thus allowing free rotation of gear 40 for the selection of tests other than tonal tests, namely, caloric, right, left, both, and bone conduction tests. When the dial 43 is turned to its full limit, the character X will be in line with the 15 arrow above it (see Fig. 1) and the X space on the chart will be directly under the uppermost character on the printing dial 82, thus completing a hearing test. To return the sound apparatus to its normal position as shown in 20 Figure 1, the dial 43 is turned clockwise causing the pin 40a to pass over the vertical bar 90 forcing it downward to disengage the edge 91' from the chamfered edge of sleeve 39, thus permitting the last tooth to mesh in timed relation with 25 the rack 39', bringing the rack back to its normal position ready for another test. The printing dial 82 is then moved one detent lower and the apparatus is in position to begin again.

30 *Principles underlying the tests of hearing*

1. The normal range of hearing is from 16 to 48,000 double vibrations per second.
2. When the conduction apparatus is diseased or obstructed, the hearing for the low tones of 35 the scale is impaired or lost.
3. When the perception apparatus is diseased, the hearing for the high tones is lost.
4. The normal ear hears about twice as long by air conduction as by bone conduction. That 40 is, a sound heard by bone for 20 seconds will be heard about 40 seconds when held close to the auricle.
5. When the conduction apparatus is diseased or obstructed, bone conduction is increased and 45 the time left in which the sound should be heard by air conduction is diminished; or bone conduction may be so much increased that the sound is heard longer than by air conduction.
6. When the perception apparatus is diseased 50 bone conduction is diminished or shortened, and the relative time of hearing by air conduction is exaggerated.

The functional tests of the auditory apparatus and their purpose is well known to those skilled 55 in otology, so, I will confine myself to describing how the apparatus makes these tests.

Technique.—The patient being seated, places the auricle tube 16g in the ear, then an enlarged view of the eardrum will show on the ground 60 glass plate 16f of the visascope exposing its condition. After adjusting the tube 16j to his ears, the operator causes the machine to operate by pushing button M. It is obvious that he may now produce any of the functional tests of the 65 ear by proper manipulation of the controls and note the effect by means of the visascope, but for the sake of clarity, I will describe a full test of the machine, to determine the acuity of hearing, the degree thereof, and the method of treatment. 70 The machine as shown in Fig. 1 is ready for test, or in normal condition. The adjustable member 18 is depressed, preventing actuation of the diaphragm rod 14 (Fig. 4). Fan control lever 64 has the fan out of actuating contact 75 (Figs. 9 and 1). Control 32 is in position to

cause the gear train (Figs. 1 and 3) to operate the sound mechanism as shown in Fig. 1. It will be noted that the dial 43 is set at C—256, and valve 11 (Fig. 5) is opened to half of its full extent. The eardrum is now receiving tonal vi- 5 brations at the rate of 256 per second, of normal intensity, produced by the musical note middle C, and the space on the chart directly under the character C is in proper alignment to receive 10 the impression of any of the printing characters 83 of the dial 82, to designate the degree of audibility. If the patient does not hear the tone, the sound mechanism is speeded up by manipulating thumb screw 53', thus intensifying the tone until it is heard. When thumb 15 screw 53' allows full speed, the rapidity of the record 27 has increased the tone intensity to its maximum point; then valve 11 is opened to its full extent. If the patient does not hear then, printing dial 82 is turned until the zero charac- 20 ter is over the space on the chart, under C, and the zero character is impressed, denoting total loss of hearing. If the patient hears the normal tone, with valve 11 in normal position, the degree, plus or minus, of hearing is determined 25 by turning knob 11' right or left, i. e., if audibility is faint, but perceptible knob 11' is turned leftward until the tone is clearly heard, this denotes "minus" hearing of that tone. If audi- 30 bility is distinct, the knob 11' is turned rightward until the hearing of the tone has completely died out, thus denoting a "plus" degree of hearing. The patient is tested for entire series of tones as indicated on the chart, as described, 35 and the degree, normal, plus, minus, or zero is printed by proper manipulation of the dial 82.

It is obvious from the above description that the audibility of the ticking of a watch as recorded on record 27, may be determined as to 40 whether it is heard above or below normal, or not heard at all.

To produce nystagmus, the lever 64 of the fan is put into actuating position, when air of a less temperature than the body will be forced against 45 the eardrum, and functional tests of the vestibular apparatus may be produced.

A thorough knowledge of the vestibular reactions to certain stimuli under both normal and pathological conditions is absolutely essential 50 to the differential diagnosis of several labyrinthine and intracranial pathological processes. Under certain conditions the use of water, hot or cold, is positively contraindicated, irrigation is dangerous when a fistula through the lateral labyrinth wall exists, pus may be carried to new 55 points, easily converting a circumscribed into a diffuse labyrinthitis.

Two tests, each attended with different reactions are produced by the machine:

Heat test.—The fan 61 is put into operation by 60 lifting lever 64. After heat element 12, (Fig. 4) in tube 71 is heated by heat control button H, warm air will flow to the ears of the patient as heretofore described. As the endolymph in the utriculus is warmed, it rises through the 65 anterior vertical semi-circular canal, and thus stimulates the crista ampullaris of this canal upon the plus side of greatest physiological activity. The result is, therefore, limited to rotary nystagmus to the right. 70

Cold test.—The heat is cut off, and air less than body temperature flows into the ear. As the endolymph in the anterior vertical and horizontal canals and the utriculus is cooled, it seeks the lowest level, hence the movement of the 75

endolymph in the anterior vertical canal is from the ampulla to the utriculus. The crista ampullaris is thus stimulated upon the side of least physiological activity and causes rotary nystagmus to the left. The endolymph also flows downward from the utriculus through the ampulla of the horizontal canal, and stimulates the crista ampullaris upon its side of least physiological irritability and produces horizontal nystagmus to the left. The total result of the cold air application is, therefore, a combined horizontal and rotary nystagmus to the left, or opposite side. It will be clearly noted that if the eardrum is perforated, air (hot or cold), will penetrate into the tiniest interior cavity without danger of carrying pus thereto. If the production of nystagmus is stubborn in either event, detent lever 18 is released and vibrations of any desired amount set up, and favorable results are produced by the added vibratory stimulation.

A bone conduction test is performed as follows: Place the aural tube 16g on the median line of the skull and have the external meatus of one ear closed, and all parts of the machine out of operation except the sound mechanism. If the sound lateralizes to the left ear, the sound-conduction apparatus of that ear is diseased. If the sound lateralizes to the right ear the perception apparatus is affected.

If the patient fails to respond to tonal sounds the detent 18 is released and with the vibrations synchronized with the tone, the result will be amazing. The combination of both will cause the most stubborn case to respond at once.

The same is true if the ear fails to respond to tones, the synchronic tones and vibrations combined will overcome a stiffened tympani and the result is instantaneous.

Pneumomassage is given with the combined heat and vibratory elements of the machine operating, and the degree of massage controlled by the manipulation of thumb screw 53'.

Tympanic inflation is produced by inserting the aural tube 16g into the nose, with the fan, vibratory and heat element in operation differing from the usual method, as heat adds to stimulation, vibration breaks down the hardened mucosa and allows the air to flow to the inner ear resulting in the effects previously described in this specification. During this process the ridge forming the posterior lip of the mouth of the Eustachian is visible to the operator, its patency and the effects of the treatment clearly observed.

It will be understood that the apparatus above described is illustrative of my invention and is not to be considered in a restrictive sense, and changes can be made without departing from the principles involved.

I claim:—

1. In an apparatus for testing and diagnosing defects of the organs of hearing, so constructed as to be capable of producing singly or in combination, by means contained therein, functional tests of the ear to determine the degree of deafness, and the reason therefor; comprising driving means, air pulsating means actuated by said driving means, dial means to indicate the number of air pulsations produced by said driving means; means actuated by said driving means to produce specific tones, adjusting means associated therewith adapted to synchronize the said tones and air pulsations with means to indicate the vibrational number of the said tones; valve means to control the volume thereof; means to produce a current of air pressure, with means to heat the

said air to required temperatures; a chamber to receive the products of the apparatus, being integral therewith; control means to cause said tones and the air current of pre-determined temperature and the air pulsations, to be produced singly or in combination within the said chamber; tubular devices associated with said chamber to convey the said products to the ear of the patient; and charting means, forming a component part of the apparatus, for recording the result of a test for diagnostical purposes.

2. In an apparatus of the class described the combination of a motor, means associated with said motor for producing air pulsations of varying rapidity, an indicator to show the number of pulsations being produced, means for producing sound having known characteristics, adjusting means for synchronizing the said pulsations and sound, and means for conveying the synchronized pulsations and sound to the same part to subject the same simultaneously to the conjoint action of said pulsations and sound, substantially as described.

3. In an apparatus of the class described the combination of a motor, means associated with said motor for producing air pulsations, adjusting means for varying the rapidity of said air pulsations, an indicator to show the number of pulsations produced, means for producing sounds having different rates of vibrations, means for synchronizing the said pulsations and sounds with means for discontinuing the pulsations or the sounds and for varying the intensity of the sound.

4. In an apparatus of the class described the combination of a motor, means associated therewith for producing air pulsations, adjusting means for varying the rapidity of said air pulsations, means for producing sounds having different rates of vibrations, means for conveying said pulsations and sounds jointly to the ears of a patient, means for synchronizing said pulsations and sounds, with means for supplying through said conveying means air at different temperatures to the ears of the patient in combination with the said pulsations and/or sounds.

5. In an apparatus of the class described the combination of a motor and vibrating means connected thereto, controlling means therefor, including braking means to reduce the speed of the motor, means actuated by the said controlling means to indicate the number of vibrations produced per second, means to eliminate the vibratory means without interfering with the braking means and means operated by the motor and generating a force, to be applied to the ear, other than that derived from the vibrating means.

6. In an apparatus of the class described including sound reproducing means having capacity to reproduce any one of a number of different tones, actuating means therefor, means for selecting any one of said tones, dial means to indicate the character of the sound produced and means associated therewith to control the intensity of the sound of the tone selected, said sound reproducing means comprising a plurality of sound reproducing elements each of which is individual to only one of the series of tones to be selected, said one tone being individual to one of said elements.

7. In a device for diagnosing and testing deafness, comprising means for producing different forces, means for setting the device for producing one of the different forces, means for conveying said forces to the ear of a patient, means for permanently recording the effects of said forces

on the patient's ear, comprising a card and a holder therefor moving under a printing station, characters on the card representing various tests, with means for bringing that portion of the card under the printing station which has a character corresponding to a given force produced by the machine, said last mentioned means being connected to and actuated as a consequence of operating the setting means.

8. In a device for diagnosing and testing deafness, comprising means for producing different forces, means for setting the device for producing one of the different forces, means for conveying said forces to the ear of a patient, means for permanently recording the effects of said forces on the patient's ear, comprising a card and a holder therefor moving under a printing station, characters on the card representing various tests, with means for bringing that portion of the card under the printing station which has a character corresponding to a given force produced by the machine, said last mentioned means being connected to and actuated as a consequence of operating the setting means, with means for printing on the card the effects of the forces on the patient's ear.

9. In a device for diagnosing deafness, comprising means for producing different sounds by a phonograph record which has adjustment relative to a phonograph needle to produce the different sounds, means to convey said sounds to a patient's ear, means for permanently recording the effects of said sound conveyed to the patient's ear, said recording means including a paper and holder therefor which moves under a printing station, means for effecting the adjustment of the phonograph record and the simultaneous adjustment of the paper holder, with locking means to prevent movement of said holder and paper held thereby, and also the adjustment of the phonograph record until the phonograph needle is moved out of contact with said phonograph record.

10. Apparatus according to claim 1 in which means are provided for segregating the production of the air pulsations, the production of the sounds, and the production of the air pressure.

11. Apparatus according to claim 1 in which charting means are adjustable automatically through connections leading from the indicating means for the sound producing means.

12. In combination in apparatus of the class described, an auricle tube, means for producing pulsations of air through said tube, means for producing tone vibrations in said tube simultaneously with the existence therein of the air pulsations, and means for varying the rate of air pulsations in said tube to synchronize with the tone vibrations in said tube, substantially as described.

13. Apparatus according to claim 12 in which the rates of tone vibrations may be varied, substantially as described.

14. Apparatus according to claim 12 in which a pressure current of air as distinguished from air pulsations is delivered to said tube simultaneously with the existence in said tube of air pulsations and tone vibrations.

15. Apparatus according to claim 12 in which a pressure current of heated air is delivered to said tube simultaneously with the existence therein of air pulsations and tone vibrations.

16. Apparatus according to claim 12 in which means are provided for varying the strength of

the tones existing in the tube to determine the distance at which the tones can be heard.

17. Apparatus according to claim 12 in which means are provided for varying the strength of the tones to determine the distance at which the tones can be heard, and means for indicating said distance.

18. In apparatus of the class described, an auricle tube, means for producing continuously any one of a plurality of tones in said tube, a valve for regulating the strength of any selected tone delivered to said tube to determine the distance of hearing, means for moving the valve to increase, or decrease, the size of the opening through which the sound is delivered to said tube, and an indicator connected with the valve operating mechanism to show the setting of said valve and to indicate the distance of hearing.

19. In apparatus of the class described, an auricle tube, adjustable means for selecting and producing in said tube any one of a plurality of tones, a chart automatically adjusted with the adjustment of said tone selecting means, and a printing device in relation to which the said automatic adjustment takes place, substantially as described.

20. In combination in apparatus of the class described, a chamber in which there is a vibratable diaphragm operative to cause air pulsations, means for vibrating said diaphragm, an auricle tube leading from said chamber, a sound producing diaphragm with means for vibrating it to produce sound, an inlet into said chamber for the passage of sound from said sound diaphragm, and a valve device for limiting the passage of sound from said diaphragm into the vibrator chamber, said vibrating diaphragm and sound diaphragm being operable simultaneously to produce in said auricle tube simultaneously air pulsations and tone vibrations.

21. In an apparatus of the class described, means for producing air pulsations, a motor, connections between said motor and the air pulsating means for operating the same, a brake for varying the transmission of power to said air pulsating producing means, and an indicator for indicating the rate of air pulsations, said indicator being variably controlled by the braking means according to the degree of the braking effect.

22. In apparatus of the class described, means for producing air pulsations, means for producing tones, means for synchronizing the rate of air pulsations with the rate of vibrations of the tones, and means for delivering to the ear the synchronized air pulsations and tone vibrations, substantially as described.

23. In an apparatus for testing and diagnosing defects of the organs of hearing, so constructed as to be capable of producing singly or in combination, by means contained therein, functional tests of the ear to determine the degree of deafness, and the reason therefor; comprising driving means, air pulsating means actuated by said driving means, dial means to indicate the number of air pulsations produced by said driving means; means actuated by said driving means to produce specific tones, adjusting means associated therewith adapted to synchronize the said tones and air pulsations with means to indicate the vibrational member of the said tones; valve means to control the volume thereof; means to produce a current of air pressure, with means to heat the said air to required temperatures; a chamber to receive the products of the apparatus, being integral therewith; control

means to cause said tones and the air current of predetermined temperature and the air pulsations, to be produced singly or in combination within the said chamber; tubular devices associated with said chamber to convey the said products to the ear of the patient; and means for viewing the parts being tested to observe the effect of said tones and the current of predetermined temperature and the air pulsations thereon.

10 24. Apparatus according to claim 23 in which means are provided for segregating the production of the air pulsations, the production of tones, and the production of the air pressure.

15 25. The combination of a tubular device adapted to convey sound and/or air pulsations to the ear, an auricle tube to enter the ear and com-

municating with said tubular device, and means for viewing parts of the ear subjected to said pulsations.

25. The combination of a tubular device adapted to convey sound and/or air pulsations to the ear, an auricle tube to enter the ear and communicating with said tubular device, and means for viewing parts of the ear subjected to said pulsations, said means comprising a visascope provided with a lens, an inclined mirror of magnifying type associated therewith, adjusting means for the mirror, a light in proximity to said mirror, and a ground glass plate operatively related to said mirror to receive the magnified and clarified view.

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