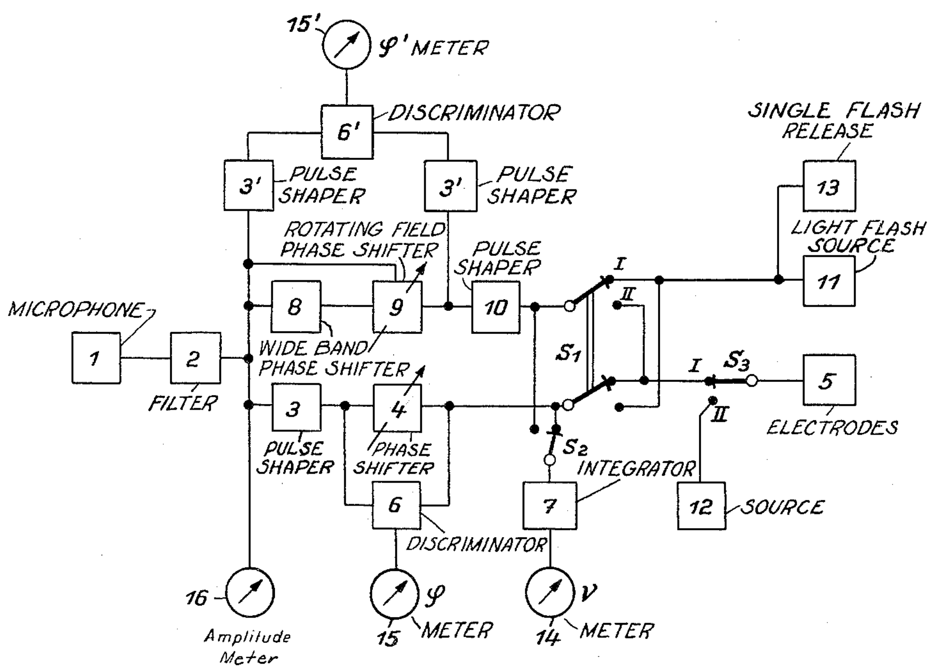
March 13, 1962 R. TIMCKE 3,024,783

VIBRATION THERAPY APPARATUS

Filed Jan. 21, 1958 2 Sheets-Sheet 1

Fig. 1



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VIBRATION THERAPY APPARATUS

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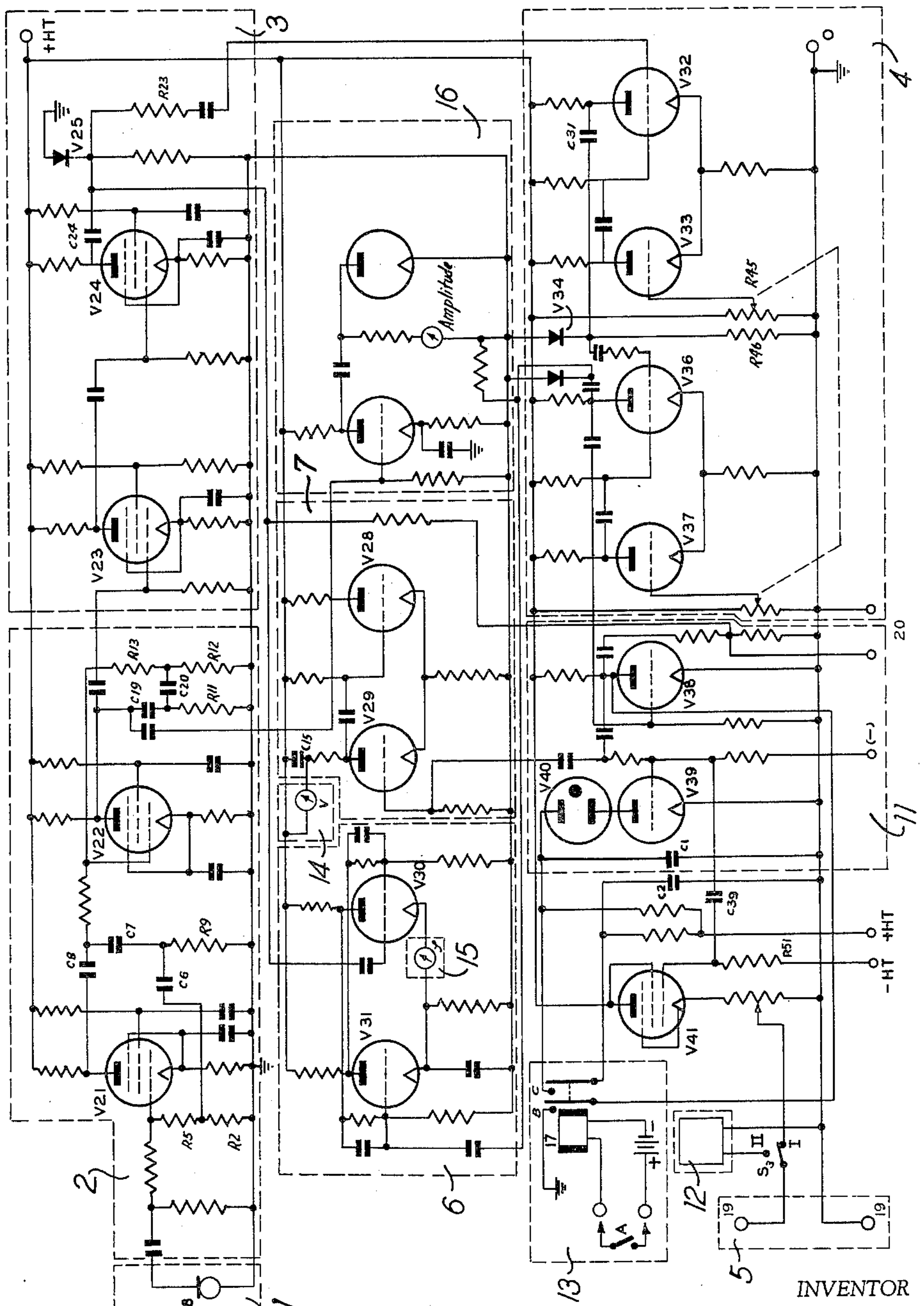

FIG. 2

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VIBRATION THERAPY APPARATUS

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This invention relates to apparatus for treating, testing, or examining sound oscillation generators or for measuring the frequencies of oscillation and is especially concerned with treating and so on the human larynx considered as an oscillating sound generator. More particularly the apparatus is for faradisation or galvanisation and vibration therapy for the treatment of the vocal organs or for testing muscular functions.

In existing faradising apparatuses the impulse frequency is adjusted to a constant magnitude and may be changed only by manual readjustment. An effective physical treatment, for example of the human laryngeal musculature during voice production cannot be carried out with the existing apparatus in such manner that each individual vibration of the vocal cords is directly stimulated or assisted. Such a treatment is desirable in view of the new "neurochronaxic" and cerebral theory of the vibrations of the vocal cords expounded by Raoul Husson of Paris. For this purpose, it is necessary for the electrical stimulating impulses to be applied to the laryngeal musculature of the patient in a completely synchronous manner with respect to the existing frequency of the vocal cords by means of suitable electrodes. In addition, the phase position of the stimulating impulses must be variable as desired in relation to the vibration of the vocal cords, in order individually to satisfy the optimum excitation conditions and to prevent the stimulating impulses from occurring within the refractory time of the muscles.

The object of this invention is to enable each individual vibration of the vocal cords to be directly stimulated or assisted.

Another object is to provide means for obtaining for examination purposes a stationary image of the sound generator (e.g. the human larynx) during the generation of the oscillations.

Yet a further object of the invention is to provide an apparatus for measuring the frequency of oscillation, for instance, of the human larynx and for testing muscular functions associated with the larynx in use.

The invention is characterised in that a microphone picks-up the sound oscillations generated by the larynx of a person and a generator produces stimulating impulses, the output of the microphone being applied to control the generator to produce stimulating impulses of a frequency having an integral relationship to the frequency of the sound oscillations, the stimulating impulses being applied to those parts of the person to be treated by electrodes which receive the generator output and is further characterised in that means is provided for constantly varying the relative phase position of the stimulating impulses and the oscillations emitted by the larynx.

An apparatus will now be described with reference to the accompanying drawings which illustrate one embodiment of the invention by way of example only.

In the drawings:

FIG. 1 is a block circuit diagram of the apparatus, and

FIG. 2 is a more detailed electric circuit diagram of the apparatus of FIG. 1.

In the examination or treatment of the vocal organs, the patient is required to emit a sound for as long as possible. The sound waves or oscillations thereby generated are converted into an electrical alternating voltage by means of a microphone 1 adapted to respond either to air-transmitted sound or to body-transmitted sound, which in accordance with the invention is applied to the trachea below the larynx. The fundamental harmonic which is the sinoidal portion of the microphone voltage, the frequency of which is equal to the vocal pitch of the patient. This fundamental harmonic is then filtered out of this input voltage with the aid of a filtering device 2 within a particular frequency interval, the width of which depends upon the nature of the filter, for example at a vocal pitch of 500 c.p.s. no frequencies which are higher or equal to 1000 c.p.s. may pass the filter; and is thereafter so converted into impulses, in known manner at 3, that exactly one impulse per cycle of the original input voltage remains. In one embodiment, these impulses are then applied to an impulse-delay device 4, operating in accordance with the uni-vibrator principle, for the purpose of phase variation. A univibrator is a one-sided stable multi-vibrator which due to its stability cannot tip independently. In a uni-vibrator two triodes (or pentodes) are coupled with their cathode and anodes. In the state of rest always one of the two valves is blocked while the second valve is opened. This position is stable. If this valve system becomes unbalanced due to a suitable impulse, for example a positive voltage impulse acting on the grid of the blocked valve, the valve having been blocked before will open, while the other one which had been open is blocked. After a period of time τ, the length of which depends on the time constant of the system, the pair of valves will tip again into their original state. The anode voltage is in this case rectangular which corresponds to multivibrators. Since only a delay time $\tau<T$, in which $1/T$ equals impulse repetition frequency, can naturally be obtained with such uni-vibrators, a number of uni-vibrators may be employed connected in series so that $\tau \geqslant T$ can now also be obtained. The impulses thus delayed are applied to the laryngeal musculature by means of the electrodes 5 after appropriate amplification and suitable curve shaping and if desired frequency reduction.

The variation of the phase-determining member of the phase shifter (potentiometer or the electrical voltage applied thereto—see circuit diagram) can then be effected by hand or by the foot or, in the investigation of periodic movements (see below), automatically, for example by a motor drive, or purely electrically, for example by means of a saw-tooth generator.

The vibration of the vocal cords may also be mechanically influenced with an arrangement similarly to the faradisation therapy referred to above. For this purpose, the electrodes 5 are replaced by an electro-mechanically operating vibratory device, which may consist of one or more vibrators. These vibrators are applied to the throat at a suitable point, whereby the vibrations are propagated at the vocal members. In microphone control the frequency of the vibration is, in an analogous manner to the stimulating impulses, equal to the frequency of the vocal cords, or if reduced, sub-harmonic.

In order that reproducible conditions may be created, it is important to be able to measure, and continuously to observe, both the frequency of the input voltage (which in this case is representative of the vocal cord frequency of the patient) and also the adjusted phase-angle, which is again frequency-dependent in this embodiment.

For measuring and observing the phase-angle φ, there may be employed (apart from an oscillographic method in which the input and output of the impulse delay device 4 are electrically added and rendered visible on an image screen) a direct-indicating measurement instrument 15 which receives an indicating current, dependent upon phase-angle, from the member 6, which may consist, for example, of a known flip-flop circuit. The flip-flop circuit is alternately changed over by the input and output impulses of the device 4. The mean anode current flowing in one of the flip-flop tubes is then a direct measure of the phase-angle φ adjusted at 4, independently of the frequency. A measuring instrument which indicates this current can therefore be directly calibrated in degrees of phase angle.

For measuring the frequency ν of the input voltage, for example the vocal cord frequency of the patient, the impulses coming from devices 4, 10 (see below) are integrated, after suitable curve shaping at 7, and applied to a direct-indicating or automatically-recording measuring instrumuent 14. The deflection of the instrument 14 is then a direct measure of the momentary frequency of the input alternating voltage and is obviously independent of intensity and curve shape of the input voltage, and therefore also independent of intensity and timbre of the sound emitted by a patient.

It is possible to carry out with the apparatus a test of the muscular function of the vocal cords (or investigations of other periodic movement processes) with varying frequencies of the vocal cords (or other moving object) as is always the case with the vocal cords. For this purpose, the output impulses leaving the impulse delay device 4, are applied after suitable amplification and curve shaping to a gas-discharge lamp 11 (switch S_1 being in position II) in such manner that exactly one light flash is emitted from the flashing lamp 11 for each nth (n=1, 2, 3, 4 . . .) release impulse. The light flashes thus released are controlled by the movement of the vocal cords or other moving object and always bear an integral frequency relation to the frequency of the generator. If the periodic movement of the object (e.g. the vocal cords) is observed with this flashing light, the object appears to be stationary in a particular phase of movement. The lamp 11 controlled in this fashion serves as a stroboscopic lamp. By variation of the phase-angle φ it is then possible to observe any desired phase of movement of the object even with variation in frequency thereof, variable curve shape and intensity of the input voltage, as is always the case, for example, in the examination of the function of the muscles of the human vocal cords.

It is often desirable in the examination of periodic movement processes to obtain a true reproduction of the movement of the moving object in slow motion. In accordance with the invention, this is effected by means of an automatic and frequency-independent phase shifter in the following manner: The sinusoidal wave coming from 2 is applied to a wide-band phase shifter 8, for example an RLC network, which shifts the applied sinusoidal voltage within the frequency interval concerned through the constant phase-angle of 90°. The input and output voltages, thus 90° phase-displaced in relation to one another, of the block 8 are then employed as input voltages for a rotating-field phase shifter 9, the rotating coil of which can then be rotated in accordance with any desired time function. A constant angular velocity of the rotating field would then correspond to a natural slow-motion movement. (A rotating-field phase shifter operates, as is known, in accorance with the principle that two currents 90° phase-displaced in relation to one another generate two magnetic fields perpendicular to one another, resulting in a circularly polarised magnetic field. If a moving coil is disposed at the centre of this field, there is induced therein a voltage whose phase-angle, in relation to that of the input voltages, varies with the angle of rotation of the coil).

The sinusoidal voltage coming from device 9 is converted into impulses in member 10, which operates similarly to the member 3 as described above, and is applied to the flashing light source 11, switch S_1 being in position 1.

The phase angle φ' set by the phase shifters 8 and 9 can again be read from a directly indicating measuring instrument 15' as in the method hereinbefore described. For this purpose, the members 3' and 6' are required,

which may be of similar construction to the members 3 and 6.

It is often desirable to record a selected phase of the movement of the object photographically with the aid of an individual flash. For this purpose, two flashing lamps are normally required. One lamp is made to flash periodically and the phase to be photographed is adjusted with the phase shifter. At the instant of the exposure, there is applied to the second, charged flashing lamp (which is individually flashed) an ignition impulse which must be co-phasal with the ignition impulses of the periodically flashing lamp. The exposure is then correctly phased, but in the first place two lamps are required, and in the second place difficulties are encountered in eliminating the parallax between the two lamps.

Both disadvantages are obviated by using the device 13. That phase of the object movement which is to be photographed is adjusted by the periodically flashing lamp 11 and the phase shifter. On release of the camera shutter, there is actuated by means of the flashlight contact of the camera (switch A in FIGURE 2), which is provided in most commercially obtainable cameras, a relay 17, which with the aid of its switch B prevents further flashing of the lamp 11 for the period t_1. This may be effected, for example, by virtue of the fact that the switch B short-circuits, with respect to earth, the ignition impulses coming from the tube 38. During the period t_1, a second relay switch C, which is released more slowly than the switch B, then connects in parallel with the lamp condenser C_1 designed for periodic flashing operation a second, charged lamp condenser C_2, at least until the switch B has opened again.

Upon opening of switch B, the ignition of the flashing lamp arrangement is re-started, and the next incoming ignition impulse releases a phased individual flash of higher intensity and free from parallax with the aid of a single lamp.

In order to ensure satisfactory operation of the apparatus, the input voltage, i.e. the microphone voltage coming from 1 or the voltage of any other generator with which the arrangement may be controlled, must not fall below a certain amplitude (threshold value), for example in the case of therapy and the testing of muscular functions, the sound emitted by the patient must not be too soft.

In the apparatus described it is not the amplitude of the input voltage that is responsible for a perfect operation but only the amplitude of the fundamental harmonic. Therefore the amplitude of the fundamental harmonic coming from the filtering device 2 is indicated by a measuring instrument 16 in accordance with the invention. This affords a reliable check of the functioning of the arrangement in all kinds of operation.

The apparatus described also permits testing of muscular functions during the faradisation or vibration. For this purpose, two channels are simultaneously required, it being possible to combine all the aforesaid devices or members in an appropriate manner.

In faradisation or galvanisation therapy, it is sometimes desirable to limit the stimulating action to particular portions of the surface of the parts of the body to be treated in order to avoid a stimulating action on tissues or organs situated at a lower level (for example for the purpose of promoting passage of the blood through the skin). In accordance with the invention this is achieved by employing for the electrodes 5, not the known plate-type or roller-type electrodes, but a number of pairs of needle electrodes which are electrically insulated from one another in a holder and spaced apart, for example in the manner of the bristles of a brush. The needles are furthermore coated with an insulated layer, with the exception of the free head, and individually connected to a suitable feed voltage through individual series resistances. The result is that the current flowing from each individual needle into the tissue is of substantially the same strength.

By reason of the relatively high current density at the needle heads, the electrode just described ensures a strong stimulating action with a depth effect which decreases in proportion with the spacing between the needles of each pair between which a potential gradient exists. Depending upon the use the feed voltage may consist of the impulses coming from device 4 or 10, intensity and curve form of which can readily be modified in accordance with such use, or it may consist of direct voltage or alternating voltage of any desired curve form, which then comes from the member 12.

The circuit diagram of FIG. 2 illustrates in detail an apparatus incorporating active RC-wave filtering, impulse retardation with uni-vibrators, phase-angle measuring devices comprising a flip-flop circuit, frequency meters with integrator circuits and amplitude indication by means of tube voltmeters.

With reference to FIG. 2, numerals designating resistors are prefixed by "R," capacitors by "C" and electronic valves by "V." In FIG. 2, 18 represents the source for an input voltage (e.g. a microphone, a generator or the like). The valve stages V21 and V22 are arranged as an amplifier with a normal feed back arrangement. The feed back passes over the capacitors C19, C20 and the resistors R11, R12 and R13 and also over the capacitors C8, C7 and C6 and the resistors R9, R2 and R5. Because of the use of resistor and capacitor combinations the feed back is in general frequency dependent. Thus the low frequencies are effectively amplified while the higher frequencies are attenuated. The valve circuits V21, V22 show a behavior similar to a low pass filter. The series connected valve stages V23 and V24 are limiter stages of normal design. A square shaped alternative voltage is present at the plate of the valve V24. The control impulses of the univibrator stages V32, V33, V36 and V37 are produced by a differentiation by means of capacitor C24 and resistor R23 and by rectification with the diode valve V25. The valve stages V32—V33 and V36—V37 are arranged as normal univibrators. The valves V32 and V33, and valves V36 and V37 are always alternatively opened and closed so that a square shaped voltage (square impulses) occurs at the plates. The direction of these squared impulses is dependent on the grid voltage of a univibrator. Therefore, the duration of the impulses may be adjusted by means of the resistor R45. The trailing edge of the square impulse coming from the univibrator V32—V33, by means of capacitor C31, valve V34 and resistor R46, is transformed into a trigger impulse for the following univibrator stage V36—V37. This univibrator V36—V37 is similarly designed as the univibrator stage V32—V33. The output pulses coming from this second univibrator then are amplified by the valve V38 and then applied to the control grid of the thyratron V39. Each time the thyratron V39 is ignited, the condenser C1 discharges its energy over the discharge valve V40 so as to emit a light flash.

Valve V41 serves for again amplifying the trigger impulses which then may be applied to the electrodes 19 for faradisation purposes. The shape of the faradisation impulses corresponds to the shape of the trigger impulses. These impulses, however, by means of the capacitor C39 and the resistor R61 or by an additional arrangement of further valve stages may receive any desired shape.

The switch contacts A, B and C have been heretofore discussed in detail. The valves V28 and V29 are designed as univibrators and the grid voltage of both valves is constant. Therefore, the valve V29 produces square impulses of constant duration which are integrated with capacitor C15 and indicated with the frequency meter V, a moving coil instrument. For measuring the phase angle valves V30 and V31 are provided which function to form a flip flop circuit. These flip flop circuits are alternatively shifted with the output pulses coming from the valves V24 and V36. The cathode current of a cross valve V30 therefore is a measure of the temporary distance between both the output pulses. The meter V therefore may directly be calibrated in phase angle degrees. Furthermore, if desired, the phase angle may be measured with an oscillograph at the terminals 20.

I claim:

1. Apparatus for the treatment of the vocal organs of a person comprising a microphone for picking up sounds emitted from the organs, a generator for producing stimulating impulses, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the microphone output for adjusting the generator control means so that the frequency of the stimulating impulses bears an integral relation to the frequency of the sounds from the vocal cords, electrodes for applying the stimulating impulses to said person at those parts to be treated, a connection from the generator to the electrodes for transmitting the generated impulses to the electrodes and a phase-shift circuit for constantly varying the relative phase position of the stimulating impulses and the sound vibrations.

2. Apparatus according to claim 1 in which a frequency meter is provided for continuously indicating the vocal cord frequency.

3. Apparatus according to claim 1 in combination with a direct indicating phase-angle measuring device.

4. Apparatus according to claim 3 in which said phase-angle measuring device consists of a measuring instrument having a flip-flop circuit.

5. Apparatus for the treatment of the vocal organs of a person comprising a microphone for picking up sounds emitted from the organs, a generator for producing stimulating impulses, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the microphone output for adjusting the generator control means so that the frequency of the stimulating impulses bears an integral relation to the frequency of the sounds from the vocal cords, an oscillator for applying the stimulating impulses to said person at those parts to be treated, a connection from the generator to the oscillator for transmitting the generated impulses to the oscillator and a phase-shift circuit for constantly varying the relative phase position of the stimulating impulses and the sound vibrations.

6. Apparatus for examining the periodically oscillating member of sound generators or other objects, comprising a microphone for picking up the generated sound, a stroboscopic flashing lamp for illuminating the oscillating member, a generator for producing impulses, means for applying the generated impulses to the lamp to produce flashing, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the microphone output for adjusting the generator control means so that the frequency of the generated impulses bears an integral relation to the audio-frequency of said member and a phase-shift circuit for constantly varying the relative phase position of the generated impulses and the sound vibrations.

7. Apparatus according to claim 6 in which a frequency meter is provided for continuously indicating the audio-frequency.

8. Apparatus according to claim 6 in which the generated impulses are also applied to provide a photographic single flash during the periodical flashing of the lamp, synchronized by the shutter of the camera being directed on to the oscillating member.

9. Apparatus for examining the periodically oscillating member of sound generators or other objects comprising a microphone for application to the sound generator to pick-up by solid transmission through the generator the generated sound, a stroboscopic flashing lamp for illuminating the oscillating member, a generator for producing impulses, means for applying the generated impulses to the lamp to produce flashing, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the microphone output for adjusting

the generator control means so that the frequency of the generated impulses bears an integral relation to the audio-frequency of said member and a phase-shift circuit for constantly varying the relative phase position of the generated impulses and the sound vibrations.

10. Apparatus for the treatment of the vocal organs of a person comprising a laryngaphone for picking up sounds emitted from the organs, a generator for producing stimulating impulses, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the laryngaphone output for adjusting the generator control means so that the frequency of the stimulating impulses bears an integral relation to the frequency of the sounds from the vocal cords, electrodes for applying the stimulating impulses to said person at those parts to be treated, a connection from the generator to the electrodes for transmitting the generated impulses to the electrodes and a phase-shift circuit for constantly varying the relative phase position of the stimulating impulses and the sound vibrations.

11. Apparatus for faradisation and galvanisation therapy for the treatment of the vocal organs of a patient comprising a microphone for picking up the voice of the patient and for converting the sound into electric current, a filter which filters out the fundamental harmonic within a suitable frequency band on the microphone current, a generator for producing stimulating impulses, means for varying the frequency of the stimulating impulses by the microphone output, means for applying the fundamental harmonic from the filter to the generator to control the generator so that the frequency of the stimulating impulses bears an integral relation to the vocal cord frequency, electrodes for applying the stimulating impulses to said person at those parts to be treated, a connection from the generator to the electrodes for transmitting the generated impulses to the electrodes and a phase-shift circuit for constantly varying the relative phase position of the stimulating impulses and the sound vibrations.

12. Apparatus as claimed in claim 11 comprising a measuring instrument for continuously indicating the amplitude of the fundamental harmonic.

13. Apparatus for examining the periodically oscillating member of sound generators or other objects comprising a microphone for picking up the generated sound and for converting the sound into electric current, a filter which filters out the fundamental harmonic within a suitable frequency band of the microphone current, a generator for producing feed impulses, means for varying the frequency of the feed impulses by the microphone output, means for applying the fundamental harmonic from the filter to the generator to control the generator so that the frequency of the feed impulses bears an integral relation to the vocal cord frequency, means for applying the generated impulses to the lamp to produce flashing and a phase-shift circuit for constantly varying the relative phase position of the feed impulses and the sound vibrations.

14. Apparatus as claimed in claim 13 comprising a measuring instrument for continuously indicating the amplitude of the fundamental harmonic.

15. Apparatus for the treatment of the vocal organs of a person comprising a microphone for picking up sounds emitted from the organs, a generator for producing stimulating impulses, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the microphone output for adjusting the generator control means so that the frequency of the stimulating impulses bears an integral relation to the frequency of the sounds from the vocal cords, electrodes for applying the stimulating impulses to said person at those parts to be treated, a connection from the generator to the electrodes for transmitting the generated impulses to the electrodes, an impulse relay circuit comprising a device permitting a phase delay through a full oscillation of 360° for constantly varying the relative phase position of the generated impulses and the vocal cord oscillations.

16. Apparatus for examining the periodically oscillating member of sound generators or other objects comprising a microphone for picking up the generated sound, a stroboscopic flashing lamp for illuminating the oscillating member, a generator for producing impulses, means for applying the generated impulses to the lamp to produce flashing, means for controlling the generator to vary the frequency of the impulses produced, means actuated by the microphone output for adjusting the generator control means so that the frequency of the generated impulses bears an integral relation to the audio-frequency of said member, an impulse relay circuit comprising a device permitting a phase delay through a full oscillation of 360° for constantly varying the relative phase position of the generated impulses and the oscillations of the object.

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