

Dec. 8, 1942.

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2,304,095

METHOD OF AND APPARATUS FOR INDUCING AND SUSTAINING SLEEP

Filed Jan. 9, 1939

7 Sheets-Sheet 1

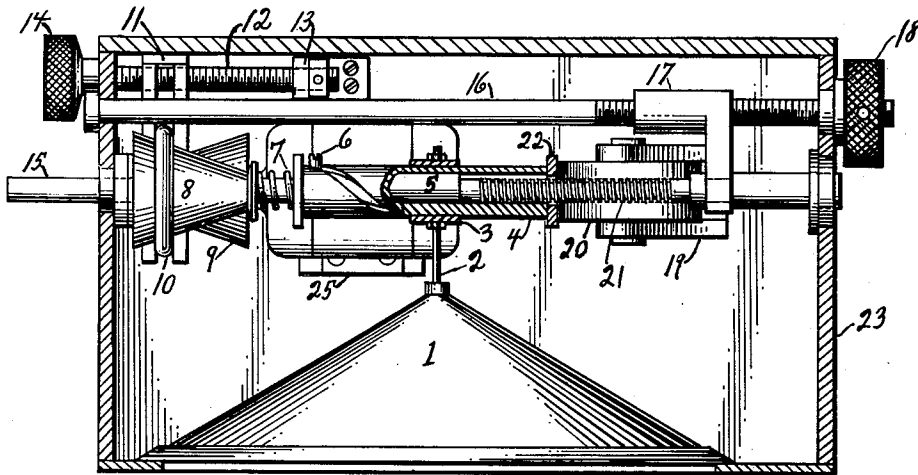


Fig. 1.

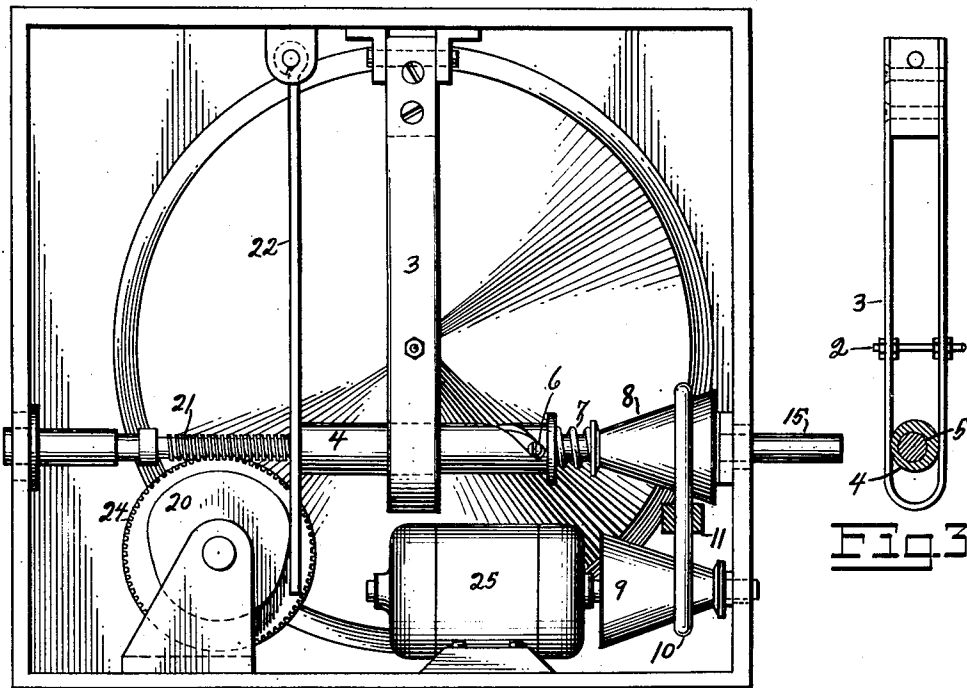


Fig. 2.

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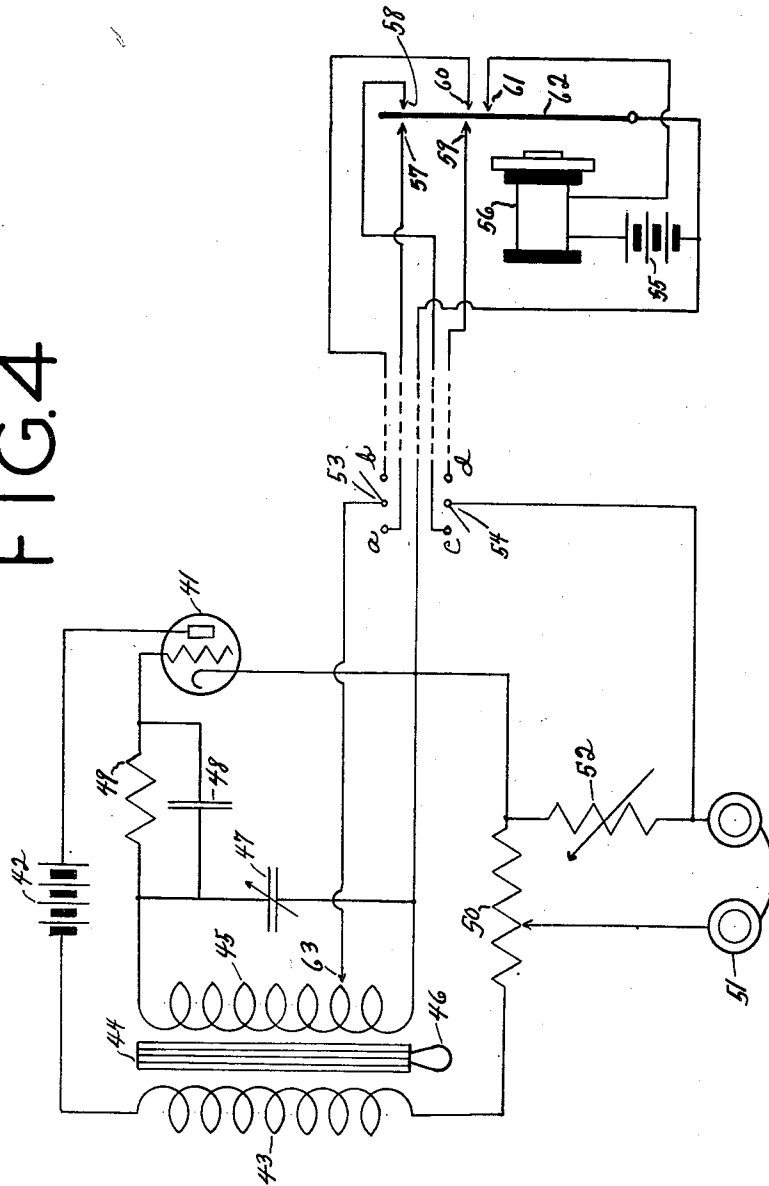
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FIG. 4



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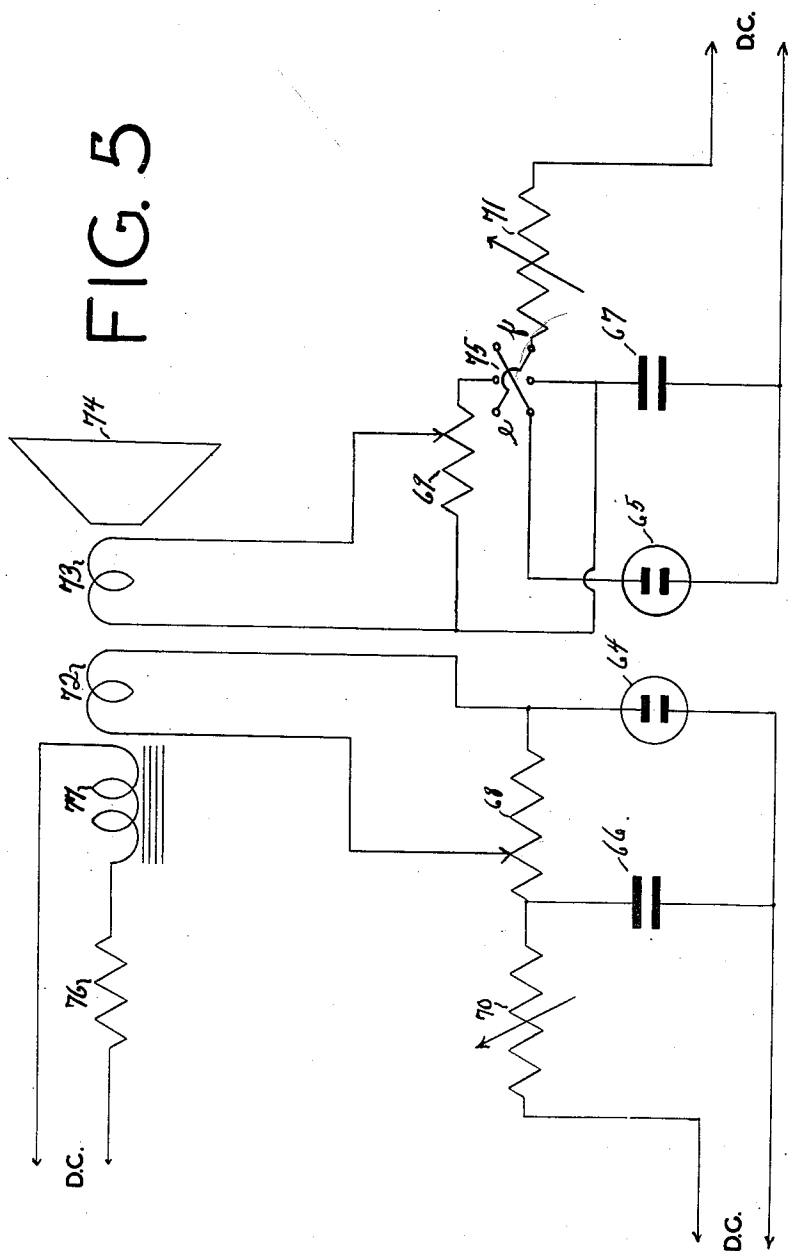
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FIG. 6

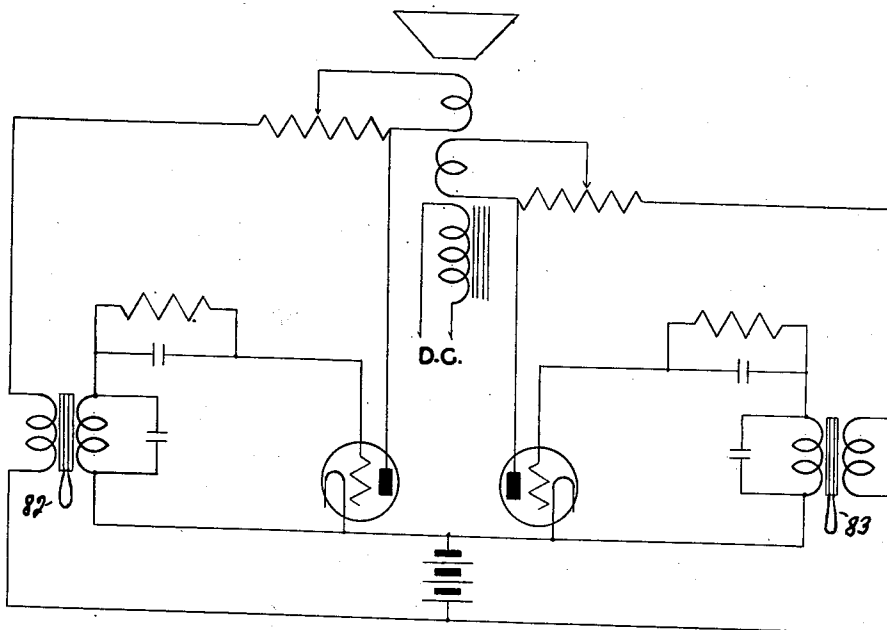
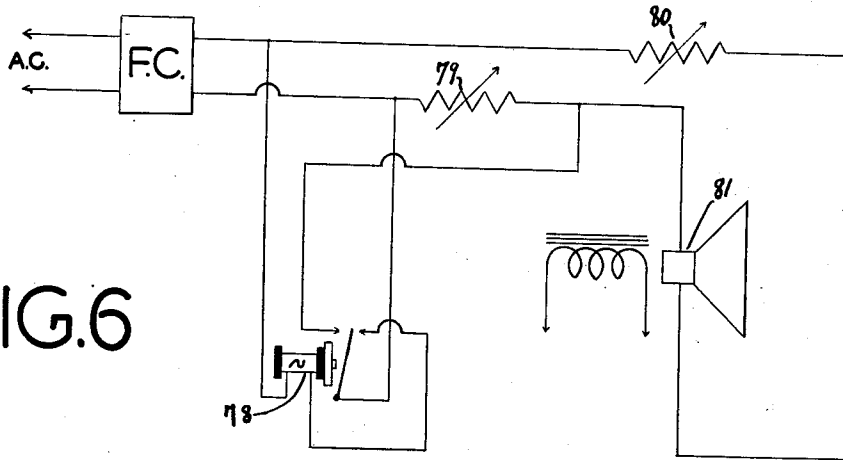


FIG. 7

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FIG. 8.

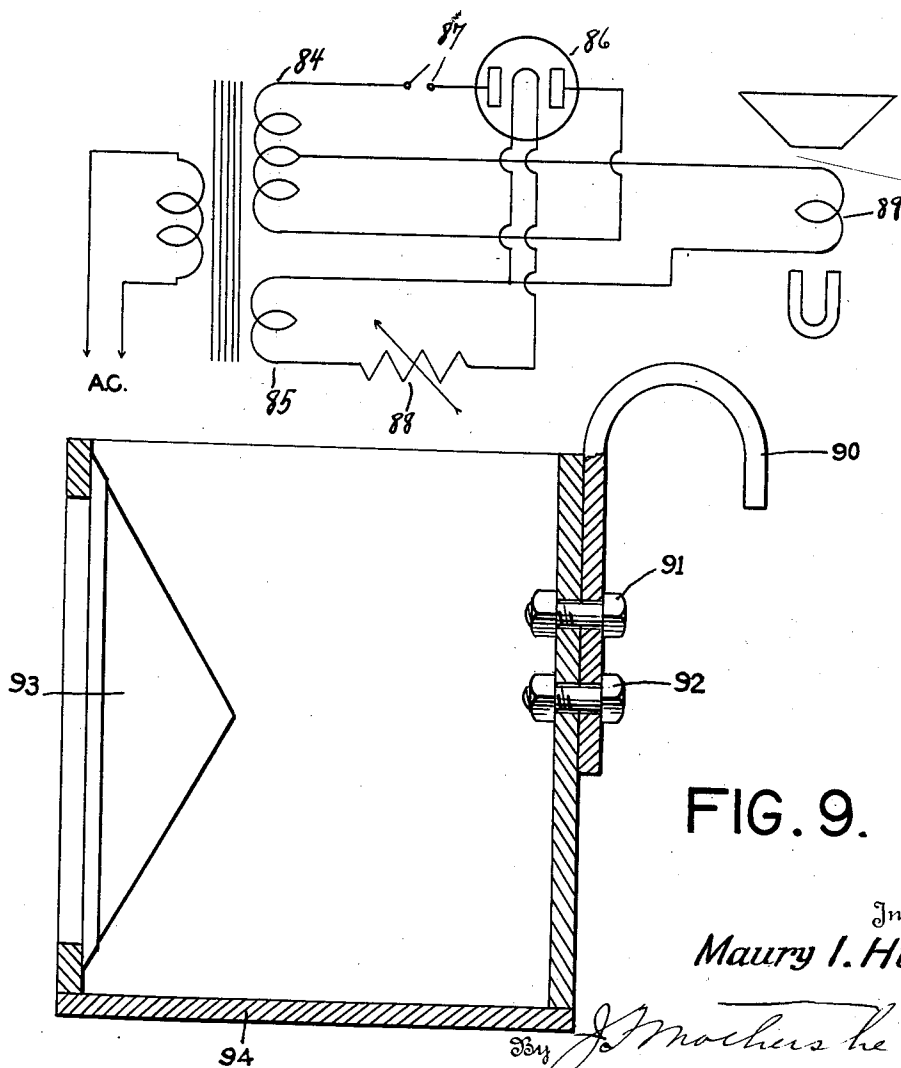


FIG. 9.

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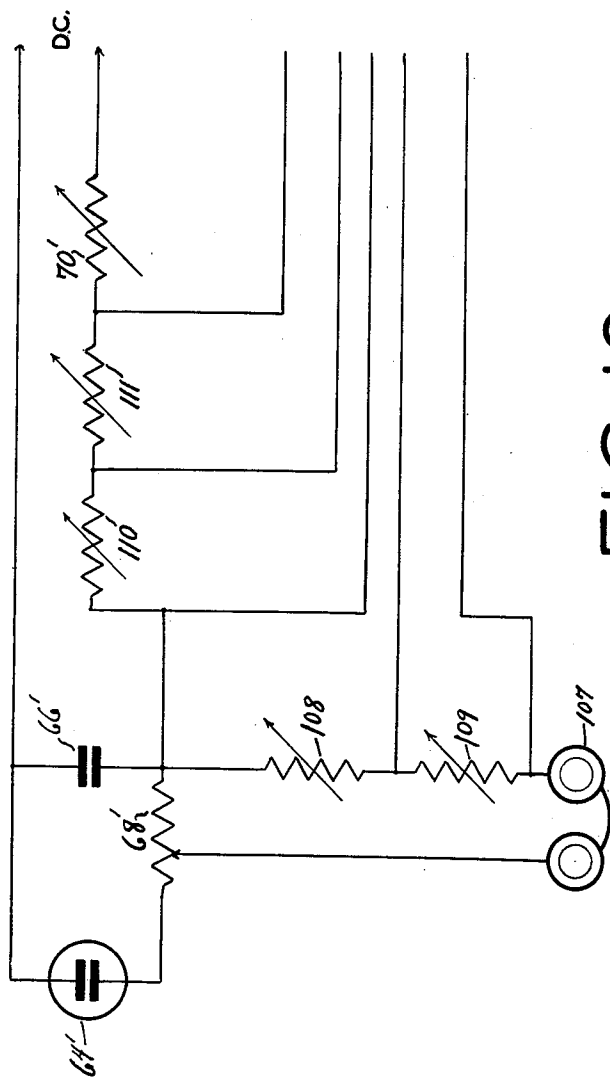


FIG. 10

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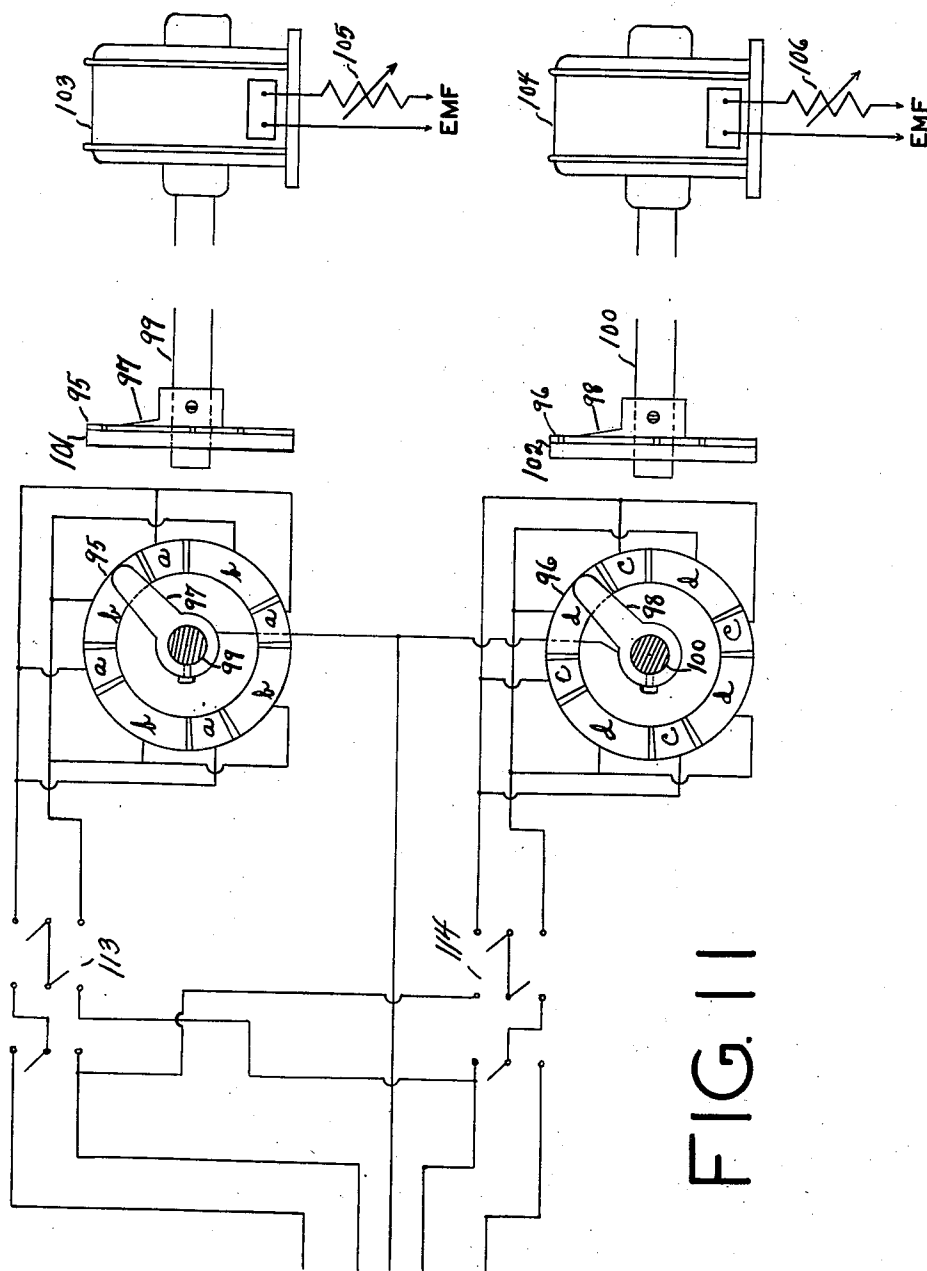
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## UNITED STATES PATENT OFFICE

2,304,095

## METHOD OF AND APPARATUS FOR INDUCING AND SUSTAINING SLEEP

Maury I. Hull, Washington, D. C.

Application January 9, 1939, Serial No. 249,973

5 Claims. (Cl. 128—1)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to a method of an apparatus for inducing sleep. It is known that during sleep the respiration becomes slower and deeper. Often the respiratory movements become periodical in character tending to rise and fall in strength. Also, the heart rate during sleep is slower and the circulation of blood in the brain is materially decreased. The invention herein disclosed provides a method of and means for inducing a lowered rate of respiration and heart beat with audible or tactual vibrations. Means are provided for producing sound or tactual vibratory motion of a sustained pitch and amplitude with means for varying the pitch and amplitude, or either, so that they will be more pleasing to the patient.

The method and apparatus disclosed herein is believed to function in accordance with the following physiological and psychological principles:

1. Continual listening to a sustained monotone of low pitch has a mild hypnotic effect producing mental relaxation or fatigue.

2. The sustained sound establishes a threshold of audibility and sounds which were before of sufficient amplitude to act as stimuli are no longer heard because they are not of sufficient strength to "override" the sustained sound, but they are "masked" thereby. In this way extraneous noises which would annoy a sleeper in the absence of the sustained sound are no longer heard in the presence of said sustained sound.

The effect pointed out in (1) above is sometime noticed by those who listen for periods of time to electric fans, dynamos, automobile or airplane motors.

The effect noted in (2) above is sometimes noticed by those who have had a fan or other machine producing a hum running in close proximity after the device has been turned off. Immediately they become aware of sounds which had formerly been masked and which they had not noticed.

The method and apparatus may be made more efficacious in certain instances if the pitch or amplitude or both of a sound generated for sleep inducing purposes are varied at a rate somewhat slower than either the rate of heart beat or respiration. Both of these are slower when a person is asleep than when awake, resulting in less oxygen in the blood, less blood in the brain, etc., conditions promoting sleep. These physiological processes tend to synchronize with a sustained sound apparently in much the same manner that two mechanical devices vibrating at

frequencies nearly identical will tend to synchronize. The frequency of variation is made slower than the physiological process rate so that the synchronization will result in a lowering of the cycle of physiological processes.

The principal object of this invention is to provide a method and an apparatus for physiologically and/or psychologically bringing about and inducing artificially the conditions that exist in the body when asleep to thereby induce and sustain sleep in individuals without the aid of drugs.

Other and further objects of the invention will become apparent from the specification and drawings herein, and are pointed out in the appended claims.

In the drawings,

Fig. 1 is a plan view partially in cross-section of a preferred form of a device suitable for practicing the invention.

Fig. 2 is a rear elevational view of the device shown in Fig. 1, with certain parts removed for clarity.

Fig. 3 is a detailed view of the diaphragm actuating device disclosed in Figs. 1 and 2.

Fig. 4 is a circuit diagram of another embodiment of the system.

Fig. 5 is the circuit diagram of a sleep inducing device in which the sound stimuli are generated by means of neon or other gas tube relaxation oscillators.

Fig. 6 is a circuit diagram of a further modification.

Fig. 7 is a circuit diagram of a sleep inducing device employing two audio frequency oscillators.

Fig. 8 is a circuit diagram of a sleep inducing device operating from a 60 cycle A. C. source.

Fig. 9 is a sectional view of a sleep inducing device showing the hook 90 for hanging or supporting the same on a bed.

Figs. 10 and 11 are a circuit diagram of a system in which either one or both of the factors, comprising pitch and amplitude of a sound stimuli, may be varied simultaneously.

Referring now to Figs. 1, 2 and 3, numeral 1 is a conical sound diaphragm mounted in the frame or casing 23 in a manner similar to the conventional cone type of loud speaker. The central portion or apex of the cone has attached thereto a pin or rod 2 which is attached to the vibrating strap 3. The strap 3 encircles a sleeve eccentric 4 which rides on an eccentric 5 of small throw made integral with the shaft 15. The eccentric 5 on shaft 15 carries a pin 6 which

is screwed into this eccentric. The sleeve eccentric 4 is of equal throw to the eccentric on the shaft and rides on the shaft and engages the pin 6 by means of a helical slot. The sleeve eccentric 4 is normally urged by the spring 7 in a direction away from the conical pulley 8 mounted on shaft 15. Opposing the conical pulley 8 is a second conical pulley 9. By means of the flexible belt 10 running over pulleys 8 and 9, and guided by the belt guide 11, the shaft 15 may be driven at any desired predetermined speed by the motor 25 on whose shaft the conical pulley 9 is mounted. The belt guide 11 is provided with a screw thread opening through which the adjusting screw 12 passes. The belt guide adjusting screw 12 is mounted in bearings in the members 13 and 23 which permit the adjusting screw to be turned without axial movement thereof. The screw 12 is provided with a knurled belt shifting knob 14. A shaft 16 is journaled in bearings in casing 23. Shaft 16 is provided at one end with screw threads which engage a screw follower or nut 17. A knurled adjusting knob 18 is mounted on the end of shaft 16 for turning the same to adjust the position of the screw follower 17. The screw follower 17 is arranged to move shaft 15 and cam 5 thereon axially as control knob 18 is turned. This movement varies the effective eccentricity of cams 4 and 5 when considered as a unit. A bearing hanger 19 is mounted on the frame 23. Journaled in this hanger 19 is a shaft carrying a gear 24 and a cam 20. The gear 24 meshes with a worm gear portion 21 on shaft 15. The cam 20 engages with a cam follower 22 abutting against the sleeve eccentric 4.

The device operates as follows:

With motor 25 going, pulleys 9 and 8 are rotated and the speed of rotation of the pulley 8 and its shaft 15 can be adjusted manually by turning of the belt shifter knob 14 to shift belt 10 to and fro on the pulleys. The turning of the shaft 15 and the cam 5 causes the sleeve cam 4 and the strap 3 to be moved to and fro along the direction of the pin 2 to vibrate the cone 1. The amplitude of this vibration of the strap 3 and cone 1 depends upon the relative positions of the cams 4 and 5. The relative positions of cams 4 and 5 can be regulated by turning the adjusting knob 18. The relative positions of the cams 4 and 5 is also variable cyclically by means of the worm gear 21 which turns gear 24 and cam 20 to rock the arm 22 back and forth and slide sleeve cam 4 with respect to the cam 5 on shaft 15. This causes a periodical variation in the amplitude of vibration of the strap 3, pin 2 and cone 1 as the cam shifting lever 22 is alternately forced back and forth under the action of the cam 20 and the spring 7 which presses against the sleeve cam 4 and forces this cam against the lever 22. As stated before, when the sleeve cam 4 is moved axially it turns in relation to the shaft 15 and cam 5 changing the combined eccentricity and increasing or decreasing the amplitude of movement of the strap 3 to increase or decrease the amplitude of the sound. The rate at which this periodic increase or decrease in amplitude occurs may be changed by changing the gear ratio of the worm wheel 24 or the speed of the shaft 15. In the latter case the tone, however, is changed.

In Fig. 4, 41 is a triode or other vacuum tube connected in a circuit designed to produce audio frequency oscillations. The circuit includes a source of plate potential 42 one end of which

is connected to the plate of the tube 41 and the other end of which is connected to one end of the primary 43 of an audio frequency transformer. The other end of the primary 43 of the audio frequency transformer is connected by way of a resistor or other impedance 50 to the cathode of the tube. The primary 43 of the audio frequency transformer is inductively associated with a secondary 45. A soft iron core 44 is associated to lie within the fields of the primary 43 and the secondary 45 of the audio frequency transformer. This core is movable with respect to the transformer primary and secondary, and is provided with a handle or other device 46 for moving the core with respect to the remainder of the transformer for the purpose of controlling the coupling between primary and secondary. One end of the secondary 45 of the audio frequency transformer is connected to the cathode of the tube 41. The other end of the secondary 45 is connected by means of the shunt connected grid condenser 48 and grid leak 49 to the grid or control electrode of the tube 41. A variable condenser 47 is connected across the secondary 45 of the audio frequency transformer for the purpose of tuning the frequency of oscillation of the audio frequency oscillator tube 41.

A pair of head phones or a loud speaker device 51 is connected by means of the variable resistor 52 across all or a selected part of the resistor 50. A pair of double throw switches are provided at 53—54. The switch blade 53 is connected to the variable tap 63 associated with the secondary 45 of the audio frequency transformer. Switch blade 54 is connected to a point between the head phones or loud speaker 51 and the variable resistor 52. A battery is shown at 55 one terminal of which is connected to one terminal of an electro-magnet 56. The other terminal of the electro-magnet 56 is connected to the back contact 61 associated with the armature 62 controlled by electro-magnet 56. The terminal of the battery 55 opposite the terminal connected to the electro-magnet is connected to the armature 62 of the electro-magnet 56 so that the electro-magnet 56 and its armature 62 and its back contact 61 serves to provide a self-interrupting type of buzzer circuit. The armature 62 of electro-magnet 56 is provided with front contacts 57 and 59 and with two additional back contacts 58 and 60. The forward contact 57 is connected to the terminal *a* of switch 53. The back contact 58 is connected to terminal *c* of switch 54. The front contact 59 is connected to switch contact *d* of switch 54. The back contact 60 is connected to the switch contact *b* of switch 53.

In the arrangement shown in Fig. 4 the audio frequency at which the tube 41 oscillates is controlled by varying the capacity of condenser 47, or by varying the value of the inductance of transformer secondary 45, or by varying the tap 63, or the inductance of both windings of the transformer by moving the core 44 in or out. The output volume of the sound device at 51 may be controlled by varying the value of the resistance 52 or by varying the amount of resistance 50 across which the sound device 51 is connected. The electro-magnet 56 by means of its circuits is adapted for periodically increasing or decreasing the output volume of the sound device 51 or for periodically increasing or decreasing the pitch or frequency of sound in the device 51, or both, or any combination of these, at any predetermined definite rate.

In operation the armature 62 is normally spring-pressed outwardly so that contact is made with the contacts 58, 60 and 61. The connection between armature 62 and contact 61 serves to energize the electro-magnet so that the armature 62 moves towards the electro-magnet 56 breaking the circuits through armature 62 and contacts 58, 60 and 61, and making the circuit between the armature 62 and contacts 57 and 59.

The electromagnet 56 is shown as a slow energizing type. Once the armature 62 has left the spring contact 61, the electromagnet 56 is no longer energized except in so far as the copper slug short-circuiting winding thereon shown at the right tends to keep it energized. After a time interval, however, the magnetic flux in the electromagnet 56 decays and the armature 62 is forced by spring tension against the back contacts 58, 60 and 61 to repeat the cycle of operations. The period or speed of making and breaking of the contacts may be controlled by other means than that shown such, for example, as by dash-pots, short-circuited windings, etc.

In the operation of the electromagnet 56 to control the frequency or amplitude from the speaker or other sound source 51, it will first be assumed that the switch 53 (which controls the timing of frequency changes) is on contact b. Contact between armature 62 and back contact 60 short-circuits that portion of the winding 45 between the tap 63 and the lower end thereof it being understood that the circuit including armature 62 and contact 60 is of low resistance when closed. During that period when the armature 62 is against contacts 57 and 59 the circuit between armature 62 and contact 60 will be broken and the entire winding 45 of the secondary is used to determine the frequency of oscillation in the oscillator tube 41 and the sound emitted from the sound source 51. With the alternate moving back and forth of the armature 62, first the frequency is determined by the inductance of the whole of transformer secondary 45 and then by only a portion thereof. With the switch 53 against contact a the portion of transformer secondary 45 below the slide contact 63 is shorted out only during such periods when the electromagnet 56 is energized and the armature 62 is drawn against front contact 57 it being understood that the circuit including armature 62 and contact 57 is of low resistance when closed. With switch 54 on contact c the resistance 52 is normally short circuited by the circuit extending between the armature 62 and the back contact 58 it being understood that the circuit including armature 62 and contact 58 is of low resistance when closed. When the electromagnet 56 is energized and the armature 62 is pulled against contacts 57 and 59 the short-circuit across the resistance 52 is removed with the opening of the circuit between contact 58 and the armature 62.

When the armature 62 falls back against the contact 58 the resistance 52 is again short-circuited and during this period the amplitude of the sound in the phones or sound device 51 is momentarily increased. At such times as the short-circuit across 52 is removed, the sound is decreased.

When switch 54 is moved against contact d the resistance 52 is not short-circuited at such times as the armature 62 is away from contact 59, but it is short-circuited at such periods as the armature 62 is in contact with 59 it being understood that the circuit including armature 62 and con-

tact 59 is of low resistance when closed. With switch 54 against either contacts c or d, the resistance 52 is alternately short-circuited and open-circuited so that there is an alternate increase and decrease in the volume of the sound from the phones or sound source 51. The amount of the increase or decrease in the volume of this sound may be controlled by varying the resistance 52. Either of switches 53, 54 may be closed to respective contacts to control either the amplitude or the pitch or both of the sound emitted from the phones in Fig. 4, dependent upon the selected position of the switches 53 and 54. In the above described operation it is to be understood that contacts 58, 60 and 61 all make or break contact with armature 62 simultaneously, that the resistance of armature 62 and its connection to battery 55 is extremely low as is the resistance of the connection between the relay 56 and the contact 61 so that the potential difference across the battery 55 is never effectively applied to directly cause the flow of current of an appreciable amount in any circuit but the circuit including the winding of the relay 56 energized from the battery 55 by way of the contact 61 and armature 62.

In Fig. 5 another means for producing sleep inducing and sustaining sound is shown. 64 and 65 are neon or other glow discharge tubes connected in oscillating circuits including condensers 66 and 67, respectively. Variable resistances 70 and 71 are used to control the rate of charge of the condensers 66 and 67, respectively, from a D. C. source. Resistances 68 and 69 control the rate of discharge of the condensers 66 and 67, respectively. These condensers are charged to the respective threshold potentials required to produce current flow in glow discharge tubes 64 and 65, respectively. 72 and 73 are windings of a dynamic speaker or other type of device for producing sound signals. The winding 72 is connected across a selected portion of the resistance 68 by means of a potentiometer slider. Winding 73 is connected across a selected portion of resistance 69 by means of a potentiometer slider. The loud speaker or sound emitting device, including coils 72 and 73, includes a cone 74 or other type of diaphragm to which the coils 72 and 73 are affixed. A field is provided for the speaker energized from a source of D. C. potential through resistance 76 to field winding 77.

A double-throw double-pole switch 75 is provided so that either the charge or discharge current of the condenser 67 may be used to excite the coil 73. When the switch 75 is thrown to the left the charging current for the condenser 67 passes through the resistance 69 and coil 73 to charge the condenser. When the switch 75 is thrown to the right the discharging current from condenser 67 passes through the resistor 69 and coil 73. By leaving the switch 75 unclosed either way and bridging between or electrically connecting all three upper contacts thereof, both discharge and charge currents of condenser 67 pass through resistance 69 and coil 73.

In operation, the system shown in Fig. 5 works as follows:

The current flowing through resistance 70 charges condenser 66 until a certain threshold voltage is reached which breaks down the resistance of tube 64 producing ionization and conduction takes place through the gas, discharging the condenser 66, whereupon the flow of current in the gas tube 64 ceases at the extinction potential and the condenser 66 begins to charge again, and

so on. The rate of the process of charging the condenser will depend upon the capacity of the condenser 66, the charging voltage applied by the source of D. C. potential and the value of the resistance 70. The rate of the process of discharging the condenser 66 will depend upon the value of the resistance 68, the resistance of coil 72, the current carrying capacity of the gas tube 64 and the threshold and extinction potentials of said tubes, so that the rate of charging and discharging of the condenser 66 may be regulated in many ways to control the rate of pulsing of current in the coil 72. Increasing the capacity of condenser 66 and increasing the resistance of the resistance 70 decreases the frequency of the cycle of operations. Likewise, a variation in the circuit parameters of the discharge portion of the circuit acts to some extent to control the frequency of operation. Each time the condenser 66 discharges through the gas tube 64, a portion of the discharge current flows through coil 72 causing the speaker to emit a sound having a pitch corresponding to the frequency of this cycle of operations. In practice the pitch of the sound may most easily be controlled by varying the resistance 70 and the volume most easily controlled by varying the position of the potentiometer slider on resistance 68. The charging and discharging of the condenser 67 is substantially the same as that outlined in connection with condenser 66.

When it is desired to cause the amplitude of the sound from the speaker to increase or decrease periodically, both circuits, including tubes 64 and 65, are put into operation. When the frequency of one of these circuits is adjusted to be slightly less than the other, beats are produced in the speaker due to the difference in the frequency of the currents in coils 72 and 73. These beats will cause an alternate increase and decrease in volume of the sound from the speaker diaphragm 74 at a rate determined by the difference between the two frequencies. If the tube 64 is conducting at a rate of 30 cycles per second and the tube 65 is conducting at a rate of 29½ cycles per second, then beats will occur every three seconds causing a cyclic increase and decrease in volume. In operation the strength of the current in one of the coils 72-73 would be adjusted to a value considerably less than the other. In certain cases it is desirable to have the tube 65, say, adjusted to become conducting at a frequency of ⅓ or ¼ of a cycle per second. While this is, of course, way below the audible range, it is useful for the purpose of increasing and decreasing the volume of sound at that rate from the speaker cone 74.

With the part of the circuit including tube 65 and coil 73 not operating, and with the tube 64 operating, the volume of sound from the cone 74 depends upon the force exerted when current flows through coil 72, setting up a field which opposes the field produced by the field coil 77. The volume of the sound may therefore be controlled by varying either the amount of the current in coil 72 and hence the strength of its field or the current in coil 77 and the strength of its field. This may be done by varying the value of the resistance 76.

From the above it will be seen that the momentary flow of current through the coil 73 caused by the flow of current in tube 65 at a frequency of ⅓ or ¼ cycle per second will either increase or decrease the total field by adding to or subtracting from the field from coil 77 depending

upon the direction of current flow in the winding of coil 73. Hence the force exerted by currents flowing in coil 72 will be momentarily increased or decreased, and the volume of sound will be likewise increased or decreased.

The resistance of the winding 73 and the resistance 69 serves to lengthen the period of discharge of the tube 65, as in the corresponding circuit including tube 64, the rate may be varied by varying the charging voltage, the capacity of the condenser and the discharge circuit parameters.

In Fig. 6, a frequency converter FC (a frequency divider or multiplier) is connected to a source of alternating current and the output circuit thereof is connected through variable resistances 79 and 80 to the field coil of a dynamic speaker. Also connected to the output circuit of the frequency converter FC is a self-interrupting circuit opening and closing device 78. This device is arranged to open its own circuit cyclically and, during such periods as its own circuit is opened, to close a short circuit around the variable resistor 79. During such periods as resistance 79 is short-circuited the amplitude of the sound emitted by the dynamic speaker or sleep inducing sound source 81 is increased. The self-interrupting opening and closing device 78 operates in a manner similar to the operation of relay 56 heretofore described in connection with Fig. 4.

Fig. 7 is a further modification of the device employing double audio oscillating circuits similar to the audio frequency oscillating circuit, including tube 41 shown in Fig. 4. The frequency of oscillation of each of the oscillating circuits is varied by varying the position of the cores 82 and 83 of the respective audio frequency transformers. The output circuits of each of the audio frequency oscillators of the double oscillating circuit are connected to respective windings of a dynamic speaker or other sound producing device. In operation the description applicable to Fig. 4 is applicable here in so far as the audio frequency oscillating circuits are concerned. The combining of the separate frequencies to produce a periodic increase and decrease in the amplitude is similar to the operation of Fig. 5 heretofore described.

In Fig. 8, a source of alternating current energizes the transformer having two secondary windings 84 and 85. The secondary winding 84 is center-tapped and the center-tap thereof is connected to one terminal of the voice coil 89 of an appropriate loud speaker. The other terminal of the voice coil 89 is connected to the cathode of a thermionic rectifier having two anodes 86. The cathode of the rectifier 86 is energized from the secondary 85 through variable resistor 88. One of the anodes of the tube 86 is connected to one of the end terminals of the transformer secondary 84. The other end terminal of the secondary 84 is connected to one terminal of a switch 87, the other terminal of which is connected to the remaining anode of the tube 86. By means of the variable resistance 88 the cathode energization may be controlled to control the value of the rectified current flowing from the rectifier 86. When the switch 87 is opened only one of the anodes or plates of the tube 86 is utilized in applying a potential to the speaker coil 89. This current is uni-directional but pulsating. With the switch 87 open and with an alternating current of 60 cycles applied to the input circuit of the transformer the cone or speak-

er diaphragm or other sound source energized by coil 89 will be moved back and forth at a frequency of 60 cycles. With the switch 87 closed the pulses of current from the tube 86 occur at 120 cycles. In both cases the value of the current flowing in the speaker coil 89 may be regulated by varying the value of the resistor 88.

In Fig. 9 a hook or handle 90 is attached by bolts 91 and 92 to the frame 94 of a loud speaker, or other sleep inducing sound source having a diaphragm 93 so that the same can be fitted over the head of a bed or be hooked onto the side of the bed near the head of the sleeper. The space behind the rear of the diaphragm 93 within the case or frame 94 carries the mechanism disclosed in Figs. 1 to 3 or other suitable devices, for actuating the diaphragm to vibrate within a predetermined desired range of amplitude and frequency at a constant value or varying at a value somewhat below the rate of respiration and heart beats.

Referring now to Figs. 10 and 11, a neon lamp or other glow discharge device is shown at 64' connected to be energized intermittently from a source of D. C. potential. Connected between the source of D. C. potential and one of the terminals of the glow discharge tube 64' are variable resistors 68', 110, 111 and 70' connected in series. A condenser 66 is connected between the lead extending directly from the source of D. C. potential to the glow discharge tube 64' and to a point between the resistors 68' and 110. A pair of head phones, a loud speaker or other appropriate sound device 107 is connected across a selected portion of the resistor 68' by means of the series connected variable resistances 108 and 109. The glow discharge tube circuit described above in connection with Fig. 10 operates in substantially the same manner as described heretofore in connection with Fig. 5. By short-circuiting resistance 108 or adjusting it to have a zero value of resistance a minor increase in the amplitude of the sound from the phones, or sound source 107, is produced.

By short-circuiting both resistances 108 and 109 a major increase in volume or amplitude of the sound is produced. The amount of the various increases of volume can be controlled by varying the relative resistances of resistors 108 and 109. When the resistance 110 is short-circuited there is a minor increase in the pitch of the sound generated in the system and issuing from the sound source 107. When both resistances 110 and 111 are short-circuited there is a major increase in the pitch of the sound from the speaker or sound device 107. By appropriate means both the pitch and the amplitude of the sound from the speaker or sound source 107 may be varied in any predetermined cyclic order. A means for varying the pitch and the amplitude of the system is shown in Fig. 11 when the same is used in connection with that portion of the system shown in Fig. 10.

In Fig. 11, 95 and 96 are a pair of double commutators. In commutator 95 all of the alternate commutator segments are connected together; that is, the segments shown as narrow segments are all connected together and the segments shown as wide segments are all connected together. The commutator segments of commutator 96 are connected likewise. Contact arms 97 and 98 are associated with commutators 95 and 96, respectively. These arms are mounted on shafts 99 and 100, respectively, for rotation around the commutators with which they make contact with

the various segments at a rate dependent upon the speeds of rotation. The arms 97 and 98 are driven by motors or other sources of power 103 and 104, respectively. The speed of the motors 103 and 104 may be controlled independently of each other by rheostats or controllers 105 and 106, respectively. In the side views of the commutator mechanisms, 101 and 102 are insulating rings upon which the contact segments of the commutators are mounted.

Multiple pole, double throw switches are shown at 113 and 114. The two groups of commutator segments of the commutator 95 are connected to a pair of the switch contacts of switch 113. The two groups of commutator segments of the commutator 96 are connected to a pair of the switch contacts of switch 114.

The contact arms 97 and 98 of the two commutators 95 and 96 are connected together and to a point between the resistances 108 and 110 (in Fig. 10). The other end of resistance 110 is connected to contacts of switches 113 and 114. The other end of resistance 108 opposite resistance 110 is connected to contacts in each of switches 113 and 114. The end of resistance 109, away from the resistance 108, is connected to a contact in switch 114. The end of resistance 111, away from resistance 110, is connected to a contact of switch 113.

In operation, the system shown at Figs. 10 and 11 operates similar to the system shown in Fig. 5, in so far as the oscillator circuit is concerned. The frequency and amplitude of the sound generated may be controlled cyclically in accordance with a predetermined code by the commutators 95 and 96, dependent upon the setting of switches 113 and 114, and the speed of rotation of motors 103 and 104.

With the system shown in Figs. 10 and 11 various combinations of variations of pitch (frequency) and amplitude (volume) may be accomplished. Assuming that it is desired to produce sound variations which will have a component of variation slightly below the heart beat and breathing rates, there can be produced:

1. A minor variation in amplitude at rate 1 and a minor variation in pitch at rate 1.
2. A minor variation in amplitude at rate 1 and a major variation in amplitude at rate 2.
3. A major variation in amplitude at rate 1 and a major variation in pitch at rate 2.
4. A major variation in pitch at rate 1 and a minor variation in amplitude at rate 2, etc., etc.

To illustrate, the pitch of the sound might be made to alternately increase and decrease at a rate slightly below the heart beat rate, and the amplitude could be alternately increased and decreased at a rate slightly below the breathing rate, or vice-versa, or the amplitude might be made to increase and decrease a small amount at the heart beat rate and a large amount at the breathing rate or vice-versa, although from a psychological standpoint the former is to be preferred. The pitch might be made to increase and decrease a small amount at the heart beat rate and a large amount at the breathing rate, or vice-versa, or both the pitch and amplitude could be increased and decreased a major or minor amount at either of these rates.

This is apparent from an examination of Figs. 10 and 11 wherein if it is assumed that the commutator arm 97 is revolving at the slower rate (breathing rate), and since there are four segments to the commutator, the arm will revolve once for every four cycles of variation. When

contact arm 98 makes contact with the alternate segments of the commutator it can short out resistance 108, or both resistances 108 and 109, or resistance 110, depending upon how the switches 113 and 114 are thrown.

When it is wished to vary the amplitude at one rate and the pitch at another, the pitch variations are controlled by commutator 95 and the amplitude variations by commutator 96. But when it is wished to increase and decrease the pitch at two rates the switches are so thrown that commutator 95 makes the major variation and commutator 96 makes the minor variation. On the other hand, when it is wished to vary the amplitude at two rates the switches are so thrown that the commutator 96 makes the major variation in amplitude and commutator 95 makes the minor variation.

In the above described embodiments of the invention motors have been disclosed as prime movers, but it is to be understood that spring driven mechanisms or other types of prime movers could be used.

It is also to be understood that in any of the embodiments of the invention disclosed above, automatic time clocks, or the like, may be employed to cut off the sleep inducing mechanism at a certain predetermined time after the mechanism has been started and the sleeper has gone to sleep.

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

What is claimed is:

1. A sleep inducing and sustaining device comprising means for generating sustained sound waves and means comprising an electro-magnetic device having means for opening and closing its own energizing circuit, and means for opening and closing at least one other circuit for cyclically varying at least one of the factors included in the pitch and amplitude of said waves, and means for varying the periodicity of operation of said electro-magnetic means whereby the same may be adjusted to operate at a slightly

lower rate than at least one of the rates of the physiological processes of respiration and the beating of the heart.

2. A sleep inducing and sustaining device comprising means for generating sustained sound waves, an electro-magnet, a circuit for energizing said electro-magnet, means for interrupting the circuit of said electro-magnet responsive to complete energization thereof, and means for cyclically varying at least one of the factors included in the pitch and amplitude of said waves at a rate dependent upon the rate of energization and de-energization of said electro-magnet.

3. A device in accordance with claim 2, including means for varying the rate at which said electro-magnet is energized and deenergized.

4. A device for inducing sleep in individuals having a sense of hearing comprising means for producing sustained sound waves of an amplitude sufficient to mask the extraneous sounds incident to the vicinity of the individual desiring to sleep, manual means for regulating the pitch and amplitude of the sound waves produced whereby a range of sounds most effective for sleep inducing purposes may be selected, said device including a revolving shaft, a cam mounted on said shaft, a sound diaphragm actuated by said cam, and means for controlling the effective eccentricity of said cam for controlling the amplitude of vibration of said diaphragm.

5. A device for inducing sleep in individuals having a sense of hearing comprising means for producing sustained sound waves of an amplitude sufficient to mask the extraneous sounds incident to the vicinity of the individual desiring to sleep, manual means for regulating the pitch and amplitude of the sound waves produced whereby a range of sounds most effective for sleep inducing purposes may be selected, said device including a revolving shaft, a cam mounted on said shaft, a sound diaphragm actuated by said cam, and means for automatically cyclically controlling the effective eccentricity of said cam for controlling the amplitude of vibration of said sound diaphragm.

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