

MIND CONTROL TECHNOLOGY PATENTS

The following pages contain facsimile reproductions of patents that have been granted by the Patent Office of the United States of America for the purposes of mental monitoring and mind alteration:

- /// *Hearing Device*—United States Patent 4,858,612.
- /// *Apparatus and Method for remotely Monitoring and Altering Brain Waves*
—United States Patent 3,951,134.
- /// *Biomagnetic Analytical System Using Fiber-Optic Magnetic Sensors*
—United States Patent 4,951,674.
- /// *Brain Electrical Activity Mapping*—United States Patent 4,408,616.
- /// *Method of Inducing Mental, Emotional and Physical States of Consciousness,
Including Specific Mental Activity, in Human Beings*
—United States Patent 5,213,562.
- /// *Method of and Apparatus for Inducing Desired States of Consciousness*
—United States Patent 5,356,368.

United States Patent No. 4,858,612—*Hearing Device*:

ABSTRACT

A method and apparatus for simulation of hearing in mammals by introduction of a plurality of microwaves into the region of the auditory cortex... A microphone is used to transform sound signals into electrical signals which are in turn analyzed and processed to provide controls for generating a plurality of microwave signals at different frequencies. The multifrequency microwaves are then applied to the brain in the region of the auditory cortex. By this method sounds are perceived by the mammal which are representative of the original sound perceived by the microphone.

You will not find a better description of the means by which voices can be electronically transmitted into a human mind. Although the text of the patent presents the invention as a therapeutic aid for individuals who have hearing impairments, the potential mind control applications of the device are

obvious.

But why stop at the mere electronic transmission of voices into the human brain? Why not electronically alter the brain waves themselves by means of radio transmissions? Consider, for example, United States Patent No. 3,951,134 - *Apparatus and Method for Remotely Monitoring and Altering Brain Waves*. The abstract says:

ABSTRACT

Apparatus for and method of sensing brain waves at a position remote from a subject whereby electromagnetic signals of different frequencies are simultaneously transmitted to the brain of the subject in which the signals interfere with one another to yield a waveform which is modulated by the subject's brain waves. The interference waveform which is representative of the brain wave activity is re-transmitted by the brain to a receiver where it is demodulated and amplified. The demodulated waveform is then displayed for visual viewing and routed to a computer for further processing and analysis. The demodulated waveform also can be used to produce a compensating signal which is transmitted back to the brain to effect a desired change in electrical activity therein.

Quoting again from the text of the patent:

SUMMARY OF THE INVENTION

The present invention relates to apparatus and a method for monitoring brain waves wherein all components of the apparatus employed are remote from the test subject. More specifically, high frequency transmitters are operated to radiate electromagnetic energy of different frequencies through antennas which are capable of scanning the entire brain of the test subject or any desired region thereof. The signals of different frequencies penetrate the skull of the subject and impinge upon the brain where they mix to yield an interference wave modulated by radiations from the brain's natural electrical activity. The modulated interference wave is re-transmitted by the brain and received by an antenna at a remote station

where it is demodulated, and processed to provide a profile of the subject's brain waves. In addition to passively monitoring his brain waves, the subject's neurological processes may be affected by transmitting to his brain, through a transmitter, compensating signals. The latter signals can be derived from the received and processed brain waves.

The import of the invention could not be clearer. This patent spells out, in black and white, an electronic method and apparatus for remotely monitoring and altering the brain waves of human beings, by use of radio transmitters and computers. The subject's brain waves are electronically monitored, received, routed to a computer, modified, and then transmitted back to his/her brain, with the stated intention of altering the "electrical activity" of the subject's brain. As the patent states:

... the subject's neurological processes may be affected by transmitting to his brain, through a transmitter, compensating signals. The latter signals can be derived from the received and processed brain waves.

The potential for electronic mind control is transparent.

Thanks to modern electronic technology the electrical activity of the human brain can be precisely monitored and displayed. The subtle electromagnetic fields and accompanying electrical activity in the brain can be electronically monitored and recorded in real time. United States Patent No. 4,951,674—*Biomagnetic Analytical System Using Fiber-Optic Magnetic Sensors* describes one such method and apparatus:

ABSTRACT

A biomagnetic analytical system for sensing and indicating minute magnetic fields emanating from the brain or from any other tissue region of interest in a subject under study. The system includes a magnetic pick-up device constituted by an array of fiber-optic magnetic sensors mounted at positions distributed throughout the inner confines of a magnetic shield configured to conform generally to the head of the subject or what-

ever other body region is of interest. Each sensor yields a light beam whose phase or other parameter is modulated in accordance with the magnetic field emanating from the related site in the region. The modulated beam from each sensor is compared in an interferometer with a reference light beam to yield an output signal that is a function of the magnetic field being emitted at the related site. The output signals from the interferometer are processed to provide a display or recording exhibiting the pattern or map of magnetic fields resulting from emanations at the multitude of sites encompassed by the region.

This device makes possible the mapping of the brain's biomagnetic activity. The data can be displayed visually, on a CRT monitor (as on a computer screen), permitting a specialist to electronically peer into a person's head and to:

... "see" a functional image of the brain on a CRT, ... the image will be a profile of the electromagnetically "active" portions of the brain, as shown by the magnetic pattern derived from data reduction...

The data can also be digitized for subsequent storage and manipulation. In the words of the patent:

The data can also be directed to a storage medium for the purpose of recording the digitized biomagnetic data for archiving and later retrieval and processing.

Patent No. 4,951,674 goes on to say that during the data processing stage, data from:

... modalities such as EEG, EKG, MRI and X-ray ... can be combined with the biomagnetic data ...

In other words, the practitioner can reconcile the biomagnetic data with an individual's EEG pattern. This means a specific pattern of biomagnetic activity can be correlated with a particular pattern of electrical activity in the brain. (See the appendix at the end of the book for the complete patent. Look at illustrations 1 to 3. Note the special helmet with the magnetic sensors that fits around the head of the person

whose brain's biomagnetic activity is being monitored and digitally recorded.)

United States Patent No. 4,408,616, *Brain Electrical Activity Mapping*, provides further information on how the human brain can be electronically monitored.

The patent abstract says, in part:

Topographic displays of brain electrical activity are produced from matrices of data derived from evoked potential (EP) and steady-state responses of skull transducers ... the rate of data sampling is sufficient to capture rapid transient events ...

In other words, the transition from one mental state to another can be observed and electronically mapped. The text of the patent explains how this is done:

Twenty electrodes (e.g., Grass gold cup) are attached to subject's skull ... Twenty leads from electrodes are connected through switch to conventional 24-channel polygraph

...

The patent succinctly explains how electrodes are attached to a person's skull and connected to a polygraph machine to record the electrical activity of their brain in real time, as it responds to various stimuli. It neatly sums up:

... (T)he brain electrical activity mapping system creates color topographic displays reflecting brain electrical activity using, as input, continuous electrical waveforms recorded from a number of points on the skull.

The data are then converted to digital form. Data are stored in individual files or combined with others into "group" files, so that a group profile of brain electrical activity in response to a variety of stimuli can be constructed. The stimulus may be a flashing light or something more complex, like being asked to distinguish between two similar, but slightly different, spoken words.

Over time, a library of digitized data (data that can be stored and analyzed by computer) about the electrical activity of the brains of individual people and groups of

people is built up. This is precisely the type of data that can be used to modulate a radio wave that is transmitted into a target subject's brain to alter his/her brainwaves. In principle, by using averaged data derived from group files of brain electrical activity, it should be possible to modulate radio broadcasts to affect the brain electrical activity of large numbers of a target population.

In many cases people's minds and brains have been tampered with and altered without their informed consent. Psychoactive drugs, microwaves, hypnosis, brain washing and electronic implants are some of the ways in which mind control victims have been attacked by these shadowy agencies.

Electronic and psychotronic mind control technologies are absolutely antithetical to the fundamental exercise of human freedom. Unfortunately, the patents and technologies described here are real. It is time for us all to wake up and see things as they are. A particularly insidious slavery is mental enslavement, accomplished by electronically or psychotronically altering people's thoughts, such that their very thoughts are not their own, but are ones that their self-appointed masters would have them to think.

[54] HEARING DEVICE

[76] Inventor: Philip L. Stocklin, P.O. Box 2111, Satellite Beach, Fla. 32937

[21] Appl. No.: 562,742

[22] Filed: Dec. 19, 1983

[51] Int. Cl.⁴ A61N 1/36

[52] U.S. Cl. 128/422; 178/419 S

[58] Field of Search 128/419 R, 419 S, 422, 128/653, 771, 732, 741, 746, 791, 304; 340/407

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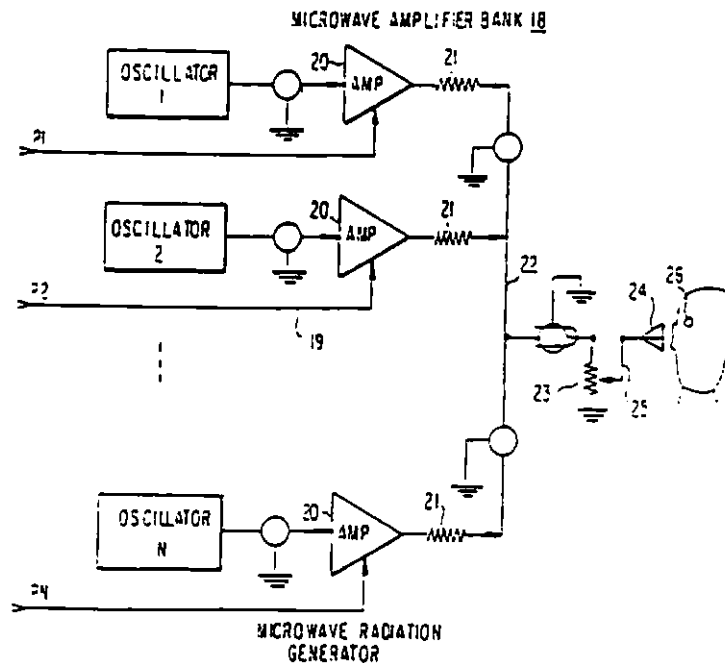
Primary Examiner—William E. Kamm

Attorney, Agent, or Firm—Wegner & Bretschneider

[57] ABSTRACT

A method and apparatus for simulation of hearing in mammals by introduction of a plurality of microwaves into the region of the auditory cortex is shown and described. A microphone is used to transform sound signals into electrical signals which are in turn analyzed and processed to provide controls for generating a plurality of microwave signals at different frequencies. The multifrequency microwaves are then applied to the brain in the region of the auditory cortex. By this method sounds are perceived by the mammal which are representative of the original sound received by the microphone.

29 Claims, 7 Drawing Sheets



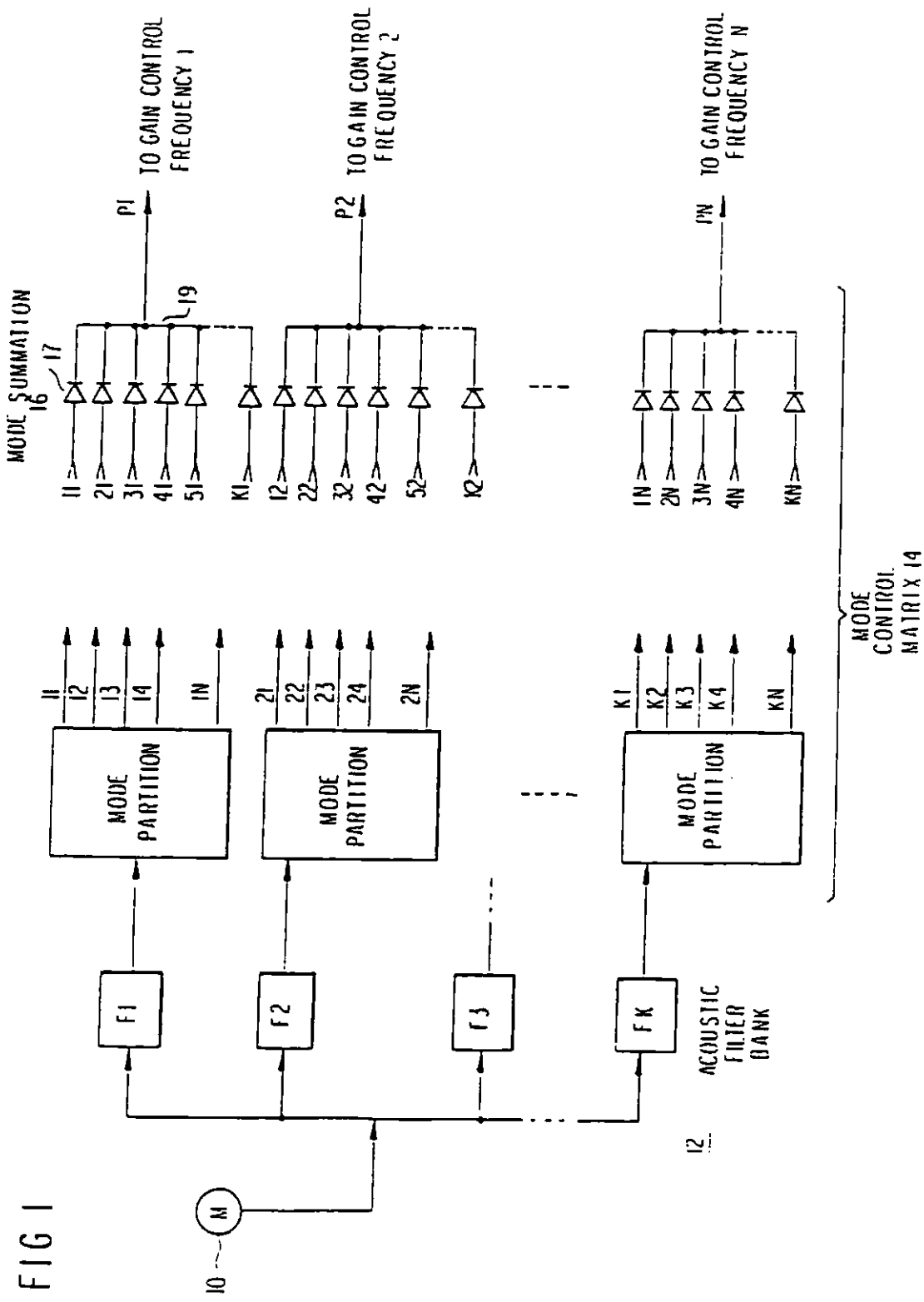
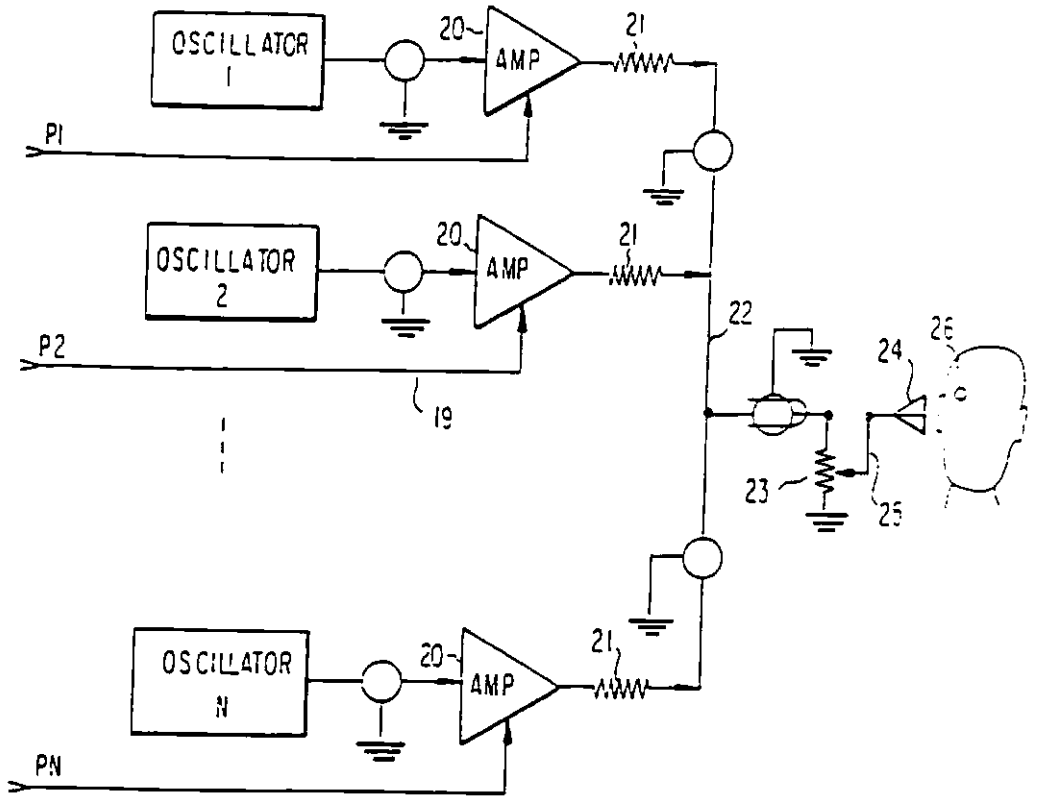


FIG. 2

MICROWAVE AMPLIFIER BANK 18



MICROWAVE RADIATION GENERATOR

FIG. 2a

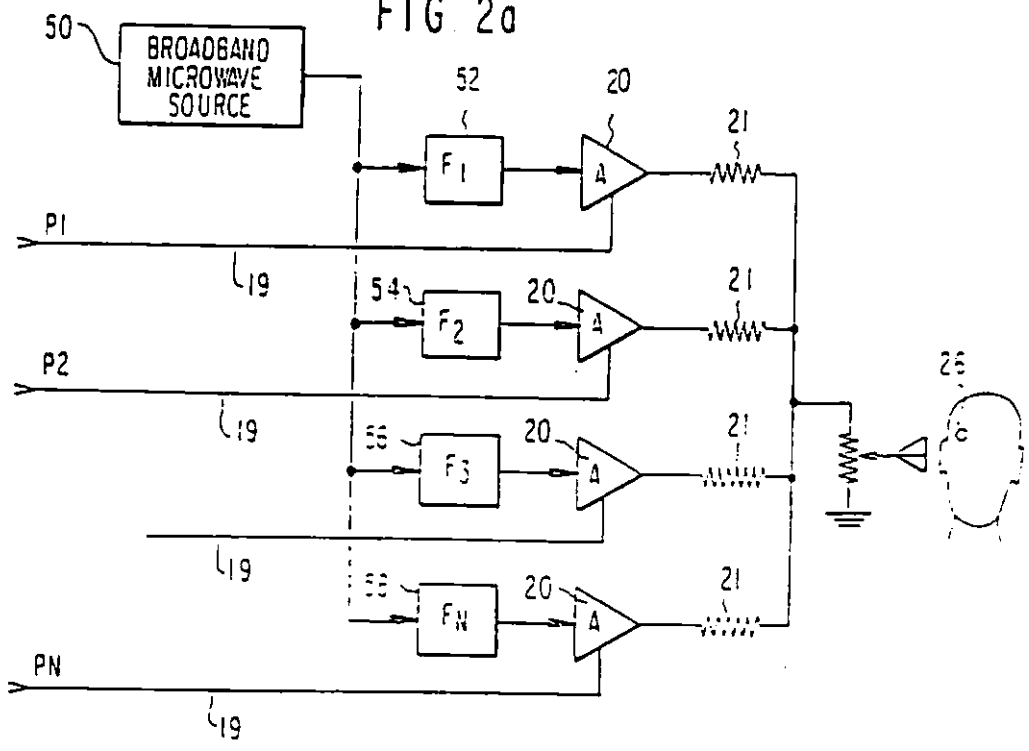


FIG. 5

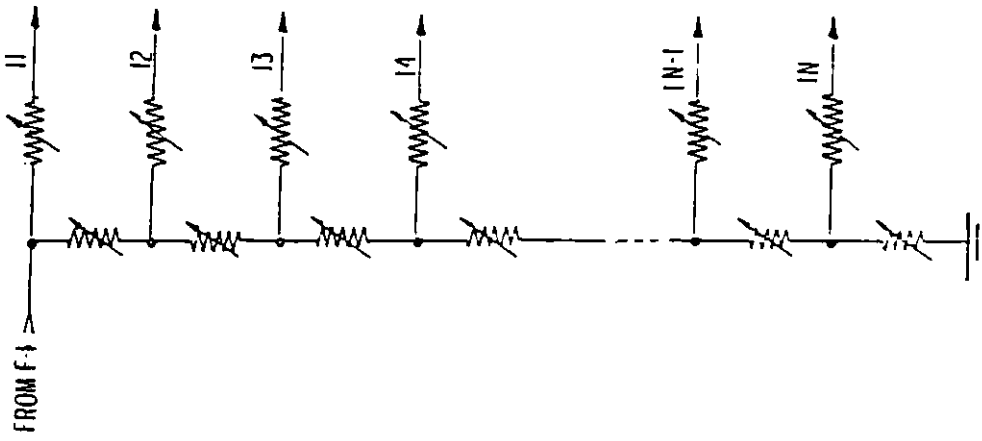


FIG. 4

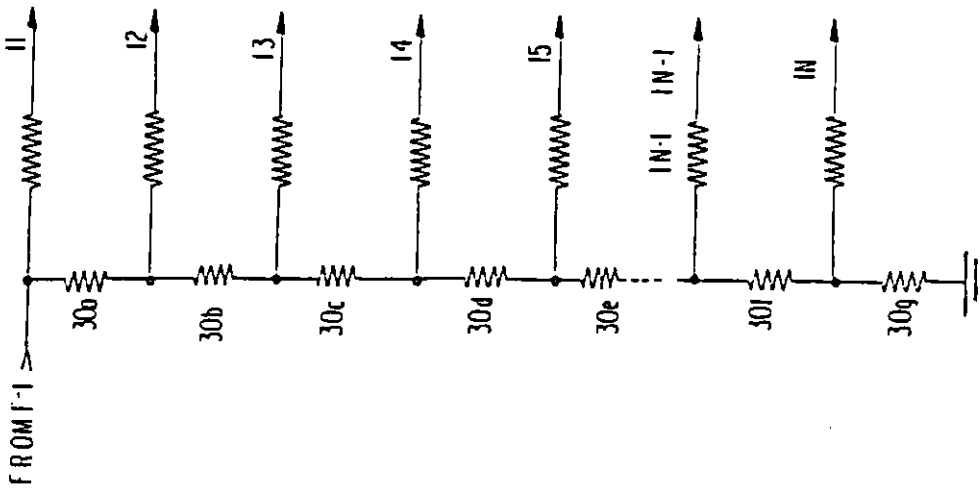


FIG. 3

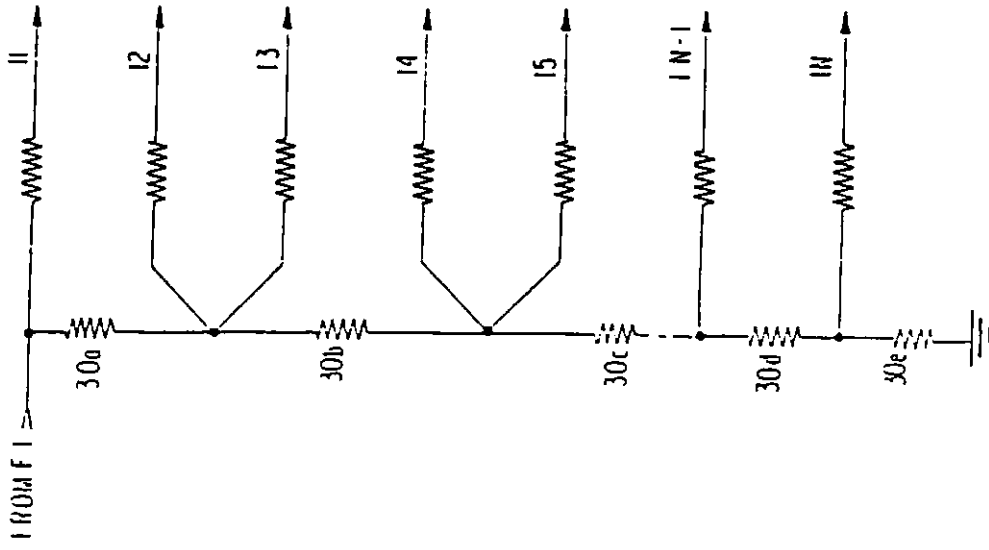


FIG 6

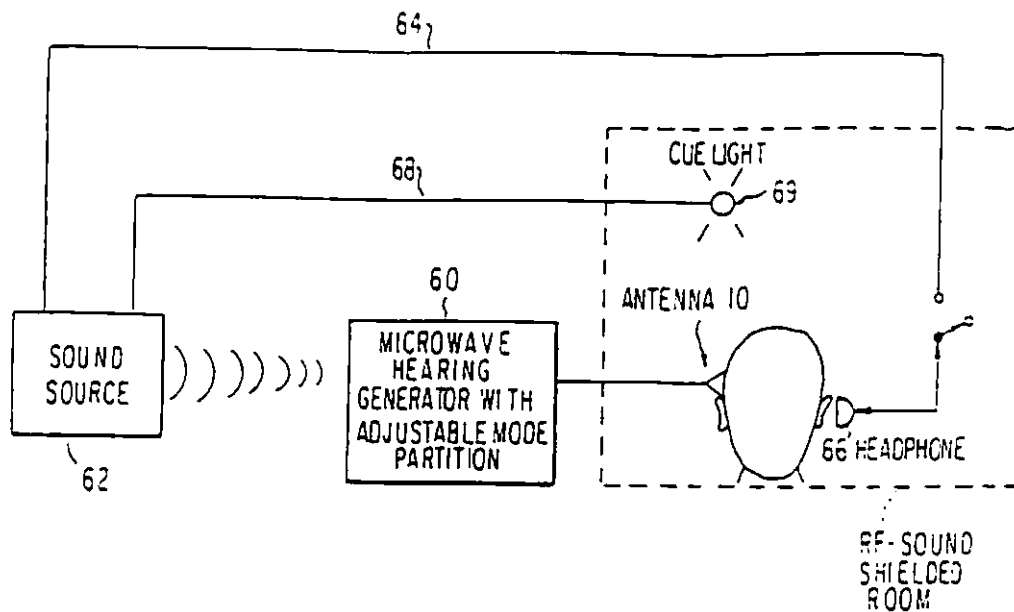
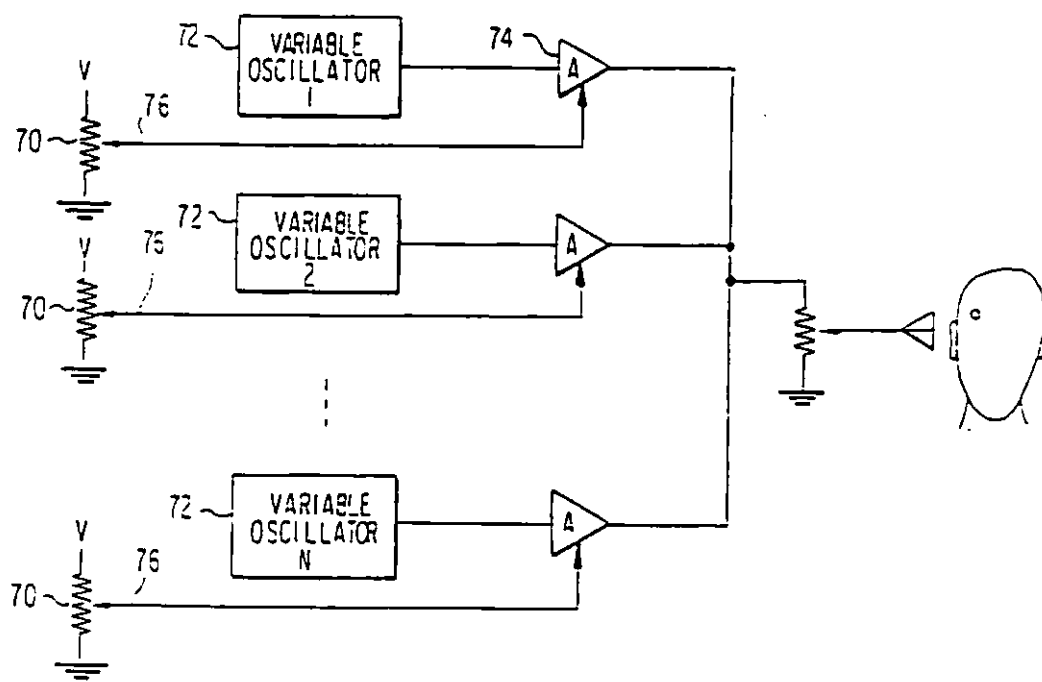


FIG 7



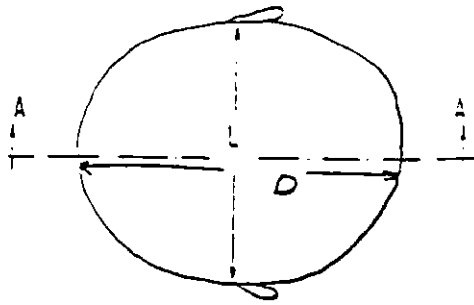


FIG. 8

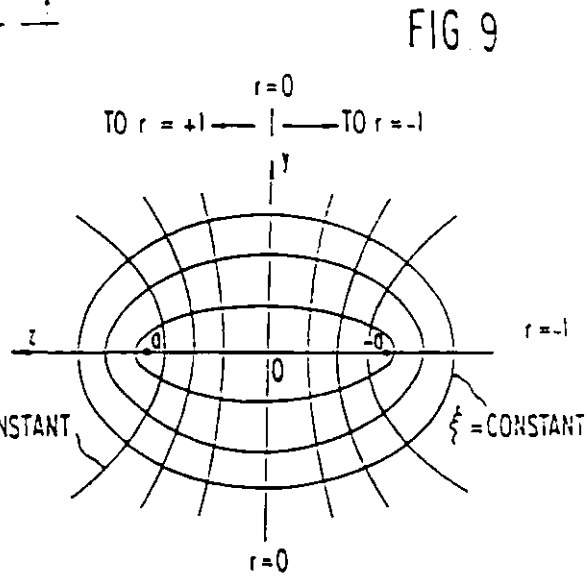


FIG. 9

$\xi, r,$ AND θ RELATED TO CARTESIAN COORDINATES x, y, z

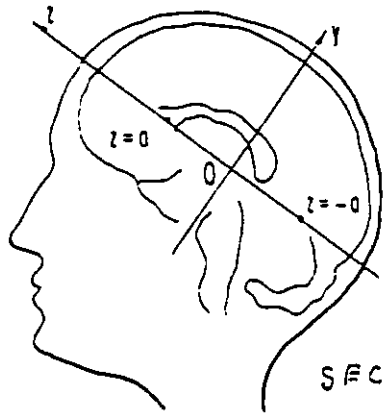
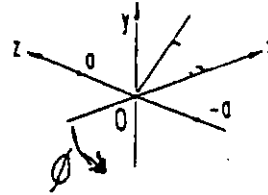


FIG. 10

SECTION A-A

TRANSFORMATION EQUATIONS

$$\left. \begin{aligned} x &= a(\xi^2 - 1)^{1/2} (1 - r^2)^{1/2} \cos \theta \\ y &= -a(\xi^2 - 1)^{1/2} (1 - r^2)^{1/2} \sin \theta \\ z &= a \xi r \end{aligned} \right\} \begin{aligned} -1 &\leq \xi \leq 1 \\ -1 &\leq r \leq +1 \\ 0 &\leq \theta \leq 2\pi \end{aligned}$$

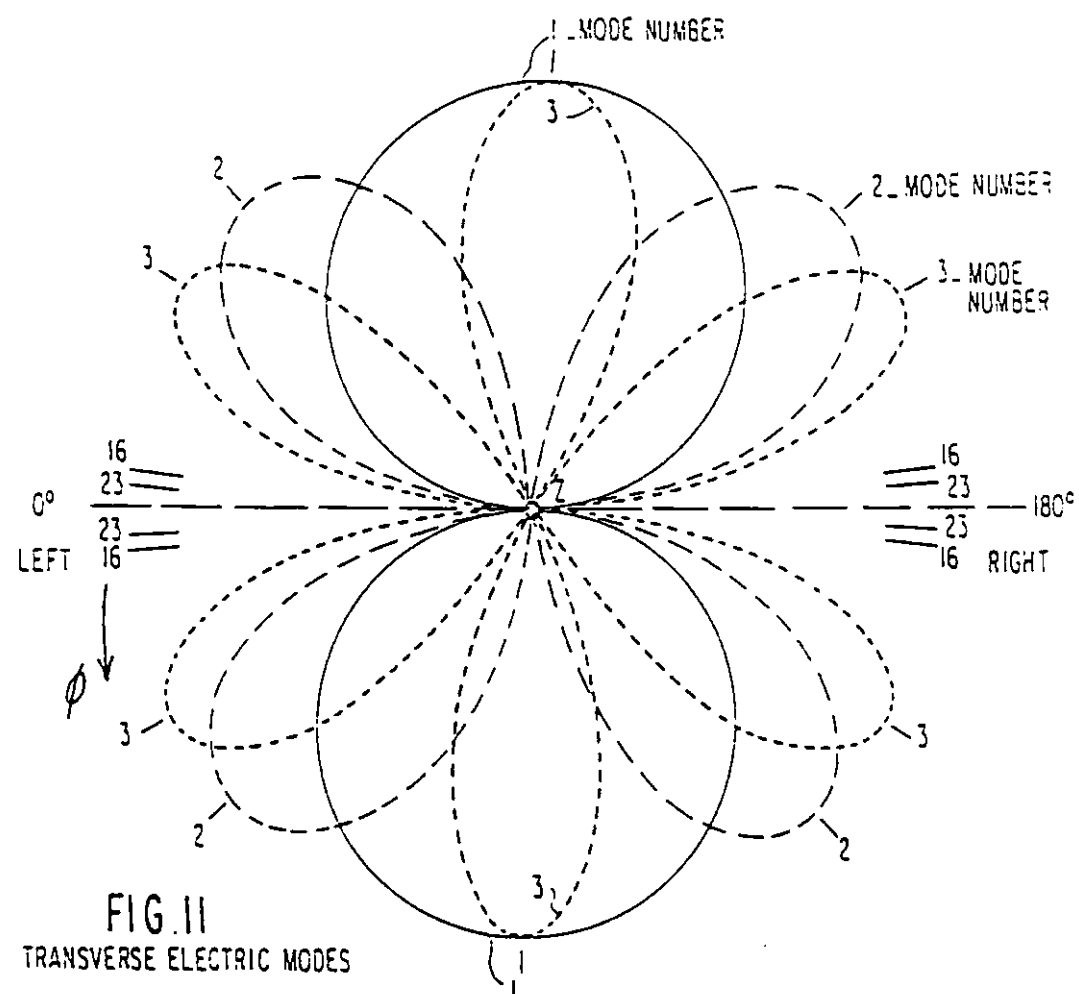
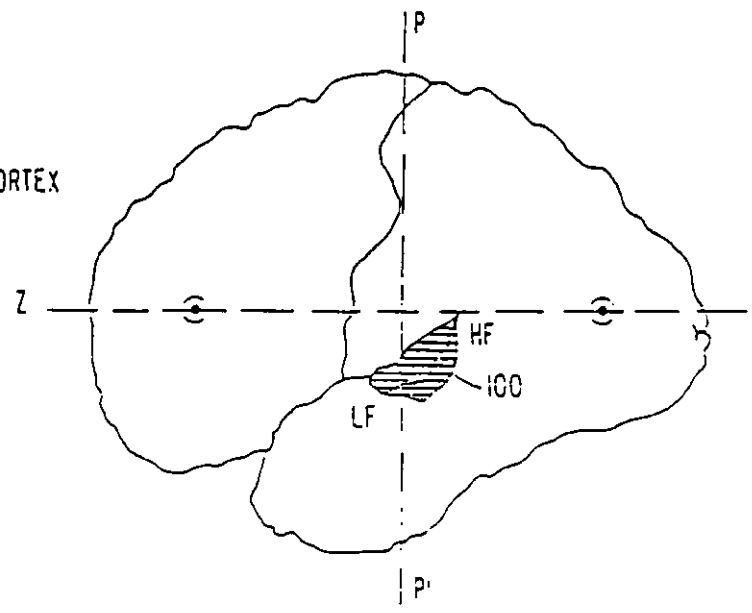


FIG. 11
TRANSVERSE ELECTRIC MODES

FIG. 12
PRIMARY AUDITORY CORTEX



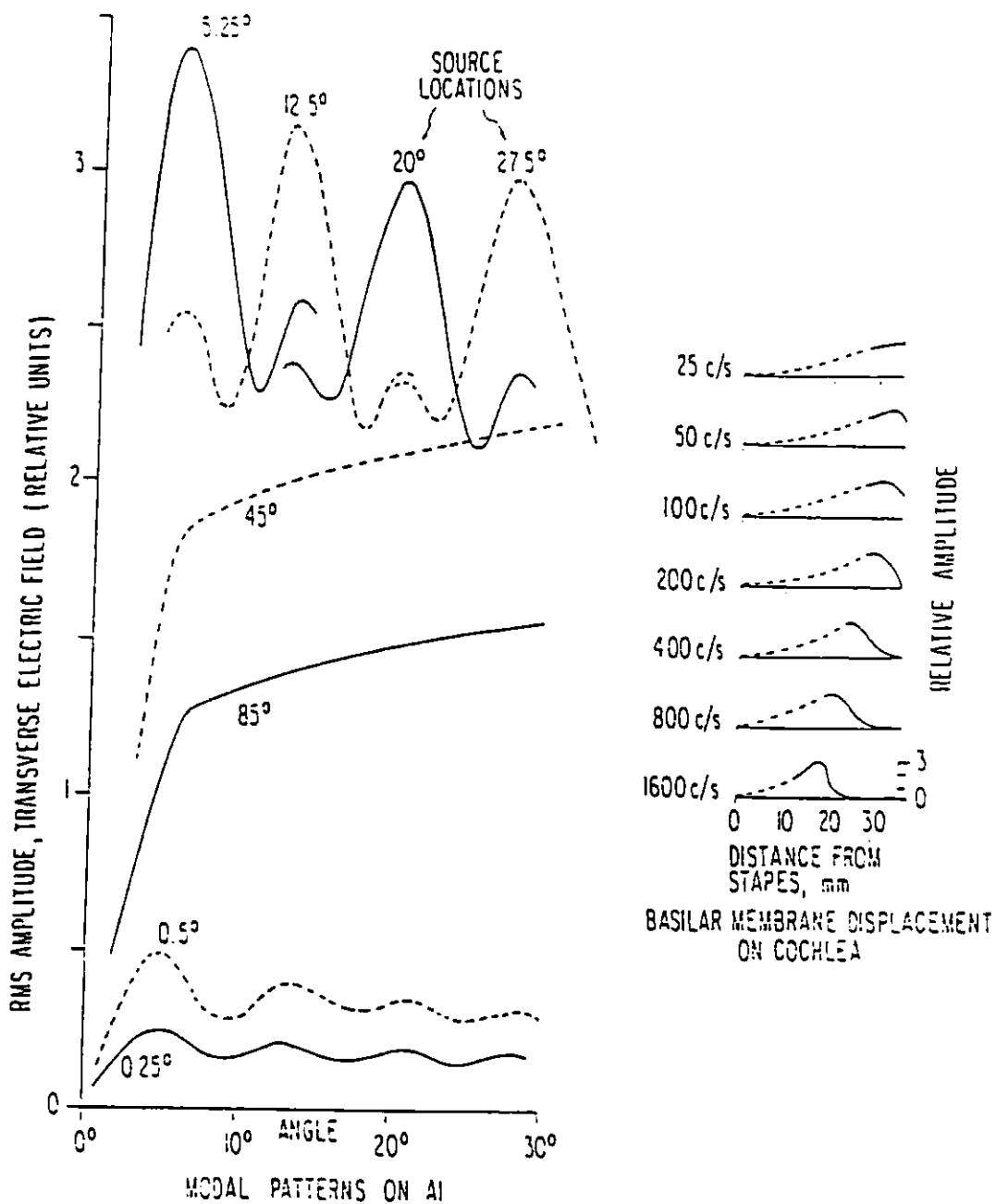


FIG 13

HEARING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to devices for aiding of hearing in mammals. The invention is based upon the perception of sounds which is experienced in the brain when the brain is subjected to certain microwave radiation signals.

2. Description of the Prior Art

In prior art hearing devices for human beings, it is well known to amplify sounds to be heard and to apply the amplified sound signal to the ear of the person wearing the hearing aid. Hearing devices of this type are however limited to hearing disfunctions where there is no damage to the auditory nerve or to the auditory cortex. In the prior art, if there is damage to the auditory cortex or the auditory nerve, it cannot be corrected by the use of a hearing aid.

During World War II, individuals in the radiation path of certain radar installations observed clicks and buzzing sounds in response to the microwave radiation. It was through this early observation that it became known to the art that microwaves could cause a direct perception of sound within a human brain. These buzzing or clicking sounds however were not meaningful, and were not perception of sounds which could otherwise be heard by the receiver. This type of microwave radiation was not representative of any intelligible sound to be perceived. In such radar installations, there was never a sound which was generated which resulted in subsequent generation of microwave signals representative of that sound.

Since the early perception of buzzing and clicking, further research has been conducted into the microwave reaction of the brain. In an article entitled "Possible Microwave Mechanisms of the Mammalian Nervous System" by Philip L. Stocklin and Brain F. Stocklin, published in the TIT Journal of Life Sciences, Tower International Technomedical Institute, Inc. P.O. Box 4594, Philadelphia, Pa. (1979) there is disclosed a hypothesis that the mammalian brain generates and uses electro magnetic waves in the lower microwave frequency region as an integral part of the functioning of the central and peripheral nervous systems. This analysis is based primarily upon the potential energy of a protein integral in the neural membrane.

In an article by W. Bise entitled "Low Power Radio-Frequency and Microwave Effects On Human Electroencephalogram and Behavior", *Physiol. Chemistry Phys.* 10, 387 (1978), it is reported that there are significant effects upon the alert human EEG during radiation by low intensity CW microwave electromagnetic energy. Bise observed significant repeatable EEG effects for a subject during radiation at specific microwave frequencies.

SUMMARY OF THE INVENTION

Results of theoretical analysis of the physics of brain tissue and the brain/skull cavity, combined with experimentally-determined electromagnetic properties of mammalian brain tissue, indicate the physical necessity for the existence of electromagnetic standing waves, called modes in the living mammalian brain. The mode characteristics may be determined by two geometric properties of the brain: these are the cephalic index of the brain (its shape in prolate spheroidal coordinates)

and the semifocal distance of the brain (a measure of its size). It was concluded that estimation of brain cephalic index and semifocal distance using external skull measurements on subjects permits estimation of the subject's characteristic mode frequencies, which in turn will permit a mode by mode treatment of the data to simulate hearing.

This invention provides for sound perception by individuals who have impaired hearing resulting from ear damage, auditory nerve damage, and damage to the auditory cortex. This invention provides for simulation of microwave radiation which is normally produced by the auditory cortex. The simulated brain waves are introduced into the region of the auditory cortex and provide for perceived sounds on the part of the subject.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the acoustic filter bank and mode control matrix portions of the hearing device of this invention.

FIG. 2 shows the microwave generation and antenna portion of the hearing device of this invention.

FIG. 3 shows a typical voltage divider network which may be used to provide mode partition.

FIG. 4 shows another voltage divider device which may be used to provide mode partition.

FIG. 5 shows a voltage divider to be used as a mode partition wherein each of the resistors is variable in order to provide adjustment of the voltage outputs.

FIG. 6 shows a modified hearing device which includes adjustable mode partitioning, and which is used to provide initial calibration of the hearing device.

FIG. 7 shows a group of variable oscillators and variable gain controls which are used to determine hearing characteristics of a particular subject.

FIG. 8 shows a top view of a human skull showing the lateral dimension.

FIG. 9 shows the relationship of the prolate spherical coordinate system to the cartesian system.

FIG. 10 shows a side view of a skull showing the medial plane of the head, section A—A.

FIG. 11 shows a plot of the transverse electric field amplitude versus primary mode number M.

FIG. 12 shows a left side view of the brain and auditory cortex.

FIG. 13 shows the total modal field versus angle for source location.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

This invention is based upon observations of the physical mechanism the mammalian brain uses to perceive acoustic vibrations. This observation is based in part upon neuro anatomical and other experimental evidence which relates to microwave brain stimulation and the perception of sounds.

It has been observed that monochromatic acoustic stimuli (acoustic tones, or single tones) of different frequencies uniquely stimulate different regions of the cochlea. It has also been observed that there is a corresponding one to one relationship between the frequency of a monochromatic acoustic stimulus and the region of the auditory cortex neurally stimulated by the cochlear nerve under the physiologically normal conditions (tonotopicity).

It has been observed that for an acoustic tone of a frequency which is at the lower end of the entire acous-

tical range perceivable by a person, that a thin lateral region ("Line") parallel to the medial axis of the brain and toward the inferior portion of the primary auditory cortex is stimulated. For an acoustic tone whose frequency is toward the high end of the entire perceivable acoustic range, a thin lateral region parallel to the medial axis and toward the superior portion of the primary auditory cortex is stimulated.

Neural stimulation results in the generation of a broad band of microwave photons by the change in rotational energy state of protons integral to the neuron membrane of the auditory cortex. The physical size and shape of the brain/skull cavity, together with the (semiconductor) properties (conductivity and dielectric constant) of the brain tissue provide an electromagnetic resonant cavity. Specific single frequencies are constructively reinforced so that a number of standing electromagnetic waves, each at its own single electromagnetic frequency in the microwave frequency region, are generated in the brain. Each such standing electromagnetic wave is called a characteristic mode of the brain/skull cavity.

Analysis in terms of prolate spheroidal wave functions indicates that transverse electric field components of these modes have maxima in the region of the auditory cortex. This analysis further shows that transverse electric field possess a variation of amplitude with angle in the angular plane (along the vertical dimension of the auditory cortex) and that is dependent only upon the primary mode number.

The auditory cortex in the normally functioning mammalian brain is a source of microwave modes. The auditory cortex generates these modes in accordance with the neural stimulation of the auditory cortex by the cochlear nerve. Mode weighting for any one acoustic tone stimulus is given by the amplitude of each mode along the line region of the auditory cortex which is neurally stimulated by that acoustic tone stimulus. A listing of mode weighting versus frequency of acoustic stimulus is called the mode matrix.

In this invention, the functions of the ear, the cochlear nerve, and the auditory cortex are simulated. Microwaves simulating the mode matrix are inserted directly into the region of the auditory cortex. By this insertion of simulated microwave modes, the normal operation of the entire natural hearing mechanism is simulated.

Referring now to FIG. 1 and FIG. 2 there is shown an apparatus which provides for induced perception of sound into a mammalian brain. This hearing device includes a microphone 10 which receives sounds, an acoustic filter bank 12 which separates the signals from the microphone into component frequencies, and a mode control matrix 14 which generates the mode signals which are used to control the intensity of microwave radiations which are injected into the skull cavity in the region of the auditory cortex.

The acoustic filter bank 12 consists of a bank of acoustic filters F1 through Fk which span the audible acoustic spectrum. These filters may be built from standard resistance, inductance, and capacitance components in accordance with well established practice. In the preferred embodiment there are 24 filters which correspond to the observed critical bandwidths of the human ear. In this preferred embodiment a typical list of filter parameters is given by Table I below:

TABLE I

Filter No.	Center Frequency (Hz)	Bandwidth (Hz)
1	50	less than 100
2	150	100
3	250	100
4	350	100
5	450	110
6	570	120
7	700	140
8	840	150
9	1,000	160
10	1,170	190
11	1,370	210
12	1,600	240
13	1,850	280
14	2,150	320
15	2,500	380
16	2,900	450
17	3,400	550
18	4,000	700
19	4,800	900
20	5,800	1,100
21	7,000	1,300
22	8,500	1,500
23	10,500	2,500
24	13,500	3,500

The rectifier outputs one through K are feed to K mode partition devices. The mode partitioning devices each have N outputs wherein N is the number of microwave oscillators used to generate the microwave radiation. The outputs 1 through N of each mode partition device is applied respectively to the inputs of each gain controlled amplifier of the microwave radiation generator. The function of the mode control matrix 14 is the control of the microwave amplifiers in the microwave amplifier bank 18. In the preferred embodiment thus will be 24 outputs and 24 microwave frequency oscillators.

Connected to each microwave amplifier gain control line is a mode simulation device 16 which receives weighted mode signals from the mode partition devices 14. Each mode simulation device consists of one through k lines and diodes 17 which are each connected to summing junction 19. The diodes 17 provide for isolation from one mode partition device to the next. The diodes 17 prevent signals from one mode partition device from returning to the other mode partition devices which are also connected to the same summing junction of the mode summation device 16. The diodes also serve a second function which is the rectification of the signals received from the acoustic filter bank by way of the mode partition devices. In this way each mode partition device output is rectified to produce a varying DC voltage with major frequency components of the order of 15 milliseconds or less. The voltage at the summation junction 19 is thus a slowly varying DC voltage.

The example mode partition devices are shown in greater detail in FIGS. 3, 4, and 5. The mode partition devices are merely resistance networks which produce 1 through N output voltages which are predetermined divisions of the input signal from the acoustic filter associated with the mode partition device. FIG. 3 shows a mode partitioning device wherein several outputs are associated with each series resistor 30. In the embodiment depicted in FIG. 4 there is an output associated with each series resistor only, and thus there are N series resistors, or the same number of series resistors as there are outputs. The values of the resistors in the mode partition resistor network are determined in ac-

cordance with the magnitudes of the frequency component from the acoustic filter bank 12 which is required at the summation point 19 or the gain control line for amplifiers 20.

The microwave amplifier bank 18 consists of a plurality of microwave oscillators 1 through N each of which is connected to an amplifier 20. Since the amplifiers 20 are gain controlled by the signals at summation junction 19, the magnitude of the microwave output is controlled by the mode control matrix outputs F1 through F_n . In the preferred embodiment there are 24 amplifiers.

The leads from the microwave oscillators 1 through N to the amplifiers 20 are shielded to prevent cross talk from one oscillator to the next, and to prevent stray signals from reaching the user of the hearing device. The output impedance of amplifiers 20 should be 1000 ohms and this is indicated by resistor 21. The outputs of amplifiers 20 are all connected to a summing junction 22. The summing junction 22 is connected to a summing impedance 23 which is approximately 50 ohms. The relatively high amplifier output impedance 21 as compared to the relatively low summing impedance 23 provides minimization of cross talk between the amplifiers. Since the amplitude of the microwave signal needed at the antenna 24 is relatively small, there is no need to match the antenna and summing junction impedances to the amplifier 20 output impedances. Efficiency of the amplifiers 20 is not critical.

Level control of the signal at antenna 24 is controlled by pick off 25 which is connected to the summing impedance 23. In this manner, the signal at antenna 24 can be varied from 0 (ground) to a value which is acceptable to the individual.

The antenna 24 is placed next to the subject's head and in the region of the subject's auditory cortex 26. By placement of the antenna 24 in the region of the auditory cortex 26, the microwave field which is generated simulates the microwave field which would be generated if the acoustic sounds were perceived with normal hearing and the auditory cortex was functioning normally.

In FIG. 2A there is shown a second embodiment of the microwave radiation and generator portion of the hearing device. In this embodiment a broad band microwave source 50 generates microwave signals which are feed to filters 52 through 58 which select from the broad band radiation particular frequencies to be transmitted to the person. As in FIG. 2, the amplifiers 20 receive signals on lines 19 from the mode control matrix. The signals on lines 19 provide the gain control for amplifiers 20.

In FIG. 6 there is shown a modified microwave hearing generator 60 which includes a mode partition resistor divider network as depicted in FIG. 5. Each of the mode partition voltage divider networks in this embodiment are individually adjustable for all of the resistances in the resistance network. FIG. 5 depicts a voltage division system wherein adjustment of the voltage partition resistors is provided for.

In FIG. 6, the sound source 62 generates audible sounds which are received by the microphone of the microwave hearing generator 60. In accordance with the operation described with respect to FIGS. 1 and 2, microwave signals are generated at the antenna 10 in accordance with the redistribution provided by the mode control matrix as set forth in FIG. 5.

The sound source 62 also produces a signal on line 64 which is received by a head phone 66. The apparatus

depicted in FIG. 6 is used to calibrate or fit a microwave hearing generator to a particular individual. Once the hearing generator is adjusted to the particular individual by adjustment of the variable resistors in the adjustable mode partition portion of the hearing generator, a second generator may be built using fixed value resistors in accordance with the adjusted values achieved in fitting the device to the particular subject. The sound produced by headphone 66 should be the same as a sound from the sound source 62 which is received by the microphone 10 in the microwave hearing generator 60. In this way, the subject can make comparisons between the perceived sound from the hearing generator 60, and the sound which is heard from headphone 66. Sound source 62 also produces a signal on 68 which is feed to cue light 69. Cue light 69 comes on whenever a sound is emitted from sound source 62 to the microwave generator 60. In this manner, if the subject hears nothing, he will still be informed that a sound has been omitted and hence that he is indeed perceiving no sound from the microwave hearing generator 60.

In FIG. 7 there is shown a modified microwave hearing generator which may be used to determine a subject's microwave mode frequencies. In this device, the acoustic filter bank and the mode control matrix have been removed and replaced by voltage level signal generated by potentiometers 70. Also included are a plurality of variable frequency oscillators 72 which feed microwave amplifiers 74 which are gain controlled from the signal generated by potentiometers 70 and pick off arm 76.

This modified microwave hearing generator is used to provide signals using one oscillator at a time. When an oscillator is turned on, the frequency is varied about the estimated value until a maximum acoustic perception by the subject is perceived. This perception however may consist of a buzzing or hissing sound rather than a tone because only one microwave frequency is being received. The first test of perception is to determine the subject's lowest modal frequency for audition ($M=1$). Once this modal frequency is obtained, the process is repeated for several higher modal frequencies and continued until no maximum acoustic perception occurs.

Another method of determination of a subject's modal frequencies is through anatomical estimation. This procedure is by measurement of the subject's cephalic index and the lateral dimensions of the skull. In this method, the shape is determined in prolate spheroidal coordinate.

Purely anatomical estimation of subject's modal frequencies is performed by first measuring the maximum lateral dimension (breadth) L FIG. 8, of the subject's head together with the maximum dimension D (anterior to posterior) in the medial plane of the subject's head. D is the distance along Z axis as shown in FIG. 10. The ratio L/D , called in anthropology the cephalic index, is monotonically related to the boundary value ξ_0 defining the ellipsoidal surface approximating the interface between the brain and the skull in the prolate spheroidal coordinate system. ξ_0 defines the shape of this interface: ξ_0 and D together give an estimate of a, the semi-focal distance of the defining ellipsoid. Using ξ_0 and a, together with known values of the conductivity and dielectric constants of brain tissue, those wavelengths are found which the radial component of the electric is the boundary condition that it is zero at ξ_0 .

These wavelengths are the wavelengths associated with the standing waves or modes; the corresponding frequencies are found by dividing the phase velocity of microwaves in brain tissue by each of the wavelengths.

A subject's microwave modal frequencies may also be determined by observing the effect of external microwave radiation upon the EEG. The frequency of the M equal 1 mode may then be used as a base point to estimate all other modal frequencies.

A typical example of such an estimation is where the subject is laterally irradiated with a monochromatic microwave field simultaneous with EEG measurement and the microwave frequency altered until a significant change occurs in the EEG, the lowest such frequency causing a significant EEG change is found. This is identified as the frequency of the M=1 mode, the lowest mode of importance in auditory perception. The purely anatomical estimation procedure (FIGS. 8, 9, 10) is then performed and the ratio of each modal frequency to the M=1 modal frequency obtained. These ratios together with the experimentally-determined M=1 frequency are then used to estimate the frequencies of the mode numbers higher than 1. The prolate spheroidal coordinate system is shown in FIG. 9. Along the lateral plane containing the x and y coordinates of FIG. 9, the prolate spheroidal coordinate variable ϕ (angle) lies FIGS. 9 and 10. Plots of the transverse electric field amplitude versus primary mode number m are shown in FIG. 11. The equation is

$$E_{\text{transverse}}(m, \phi) = E_0 \sin(m \phi)$$

The "elevation view" FIG. 12, of the brain from the left side, shows the primary auditory cortex 10. The iso-tone lines and the high frequency region are toward the top of 100 and the low frequency region toward the bottom of 100.

The formula I, set forth below is the formula for combining modes from an iso-tone line at $\phi = \phi_j$ being excited to obtain the total modal field at some other angular location ϕ . For this formula, if we let J=1 (just one iso-tone single frequency acoustic stimulus line), then it can be shown that ALL modes (in general) must be used for any ONE tone.

FORMULA I RMS TRANSVERSE ELECTRIC FIELD IN ANGULAR PLANE, f(0)

$$f(0) = \left[\sum_{m=1}^M \left\{ \sin(m\phi) \cdot \sum_{j=1}^J e^{-\Delta\phi_m} \sin(m\phi_j) \right\}^2 \right]^{1/2}$$

ϕ = ANGLE (0° LATERAL)

ϕ_j = LOCATION OF j-TH SOURCE (TOTAL NUMBER J)

$\Delta\phi_m$ = ATTENUATION LENGTH (IN ANGLE) OF m-TH MODE

m = PRIMARY MODE NUMBER (HIGHEST MODE M)

FIG. 13 shows the resulting total modal field versus angle ϕ for source location ϕ at 5.25°, 12.5°, etc. With reference to the set of curves at the left top of this figure. A spacing of approximately 7.25° in ϕ corresponds to a tonal difference of about 1 octave. This conclusion is based on the side-lobes of pattern coming from $\phi = 5.25^\circ$, etc. The total filed (value on y-axis) falls considerably below the top curves for source locations well below 5.25° (toward the high acoustic stimulus end) and

also as the source of frequency goes well above 30° (low frequency end). ϕ is plotted positive downward from 0° at lateral location as indicates in FIG. 11.

Resistor weightings are obtained from the $|\sin(m[\phi - \phi_j])|$, Formula I. The scale between acoustic frequency and ϕ must be set or estimated from experiment. Approximately 5.25° corresponds to a tonal stimulus at about 2 kHz (the most sensitive region of the ear) since this source location gives the highest electric field amplitude.

The apparatus of FIG. 7 may also be used to determine values for a hearing device which are required for a particular subject. Once the modal frequencies have been estimated, the device of FIG. 7 which includes variable microwave oscillators may be used to determine values for the oscillators which match the subject, and to determine resistance values associated with the mode partition devices of the mode control matrix.

In FIG. 7 manual control of the amplifier gain is achieved by potentiometers 76. In this manner the amplifier gains are varied about the estimated settings for an acoustic tone stimulus in the region of two thousand Hertz (2 kHz) until maximum acoustic perception and a purest tone are achieved together. The term purest tone may also be described as the most pleasing acoustic perception by the subject. This process may be repeated at selected frequencies above and below 2 kHz. The selected frequencies correspond to regions of other acoustic filter center frequencies of the subject. When modal frequency (oscillator frequency) and gain set values (setting a potentiometer 76) are noted, it is then possible to calculate fixed oscillator frequencies and control resistor values for the adjusted hearing device for this particular subject.

In the event the subject has no prior acoustic experience, that is deaf from birth, estimated resistor values must be used. Also, a complex acoustic stimulation test including language articulation and pairs of harmonically related tones may be developed to maximize the match of the hearing device parameters for those of this particular subject.

Typical components for use in this invention include commercially available high fidelity microphones which have a range of 50 Hz to 15 kHz with plus or minus 3 dB variation.

The audio filters to be used with the acoustic filter bank 12 are constructed in a conventional manner, and have Q values of about 6. The filters may also be designed with 3 dB down points ($\frac{1}{2}$ the bandwidth away from the center frequency) occurring at adjacent center frequency locations.

The diodes 17 in the mode control matrix which provide isolation between the mode partition circuits are commercially available diodes in the audio range.

The microwave oscillators 1 through N and the microwave amplifiers 20 are constructed with available microwave transistors which can be configured either as oscillators or amplifiers. Examples of the transistors are GaAsFET field effect transistors by Hewlett Packard known as the HFET series or silicon bipolar transistors by Hewlett Packard known as the HXTR series.

All the cable between the oscillators, the microwave amplifiers, and the antenna should be constructed with either single or double shielded coaxial cable.

The antenna 24 for directing microwave signals to the audio cortex 26 should be approximately the size of the auditory cortex. A typical size would be one and

one half CM high and one half to one CM wide. The antenna as shown is located over the left auditory cortex, but the right may also be used. Since the characteristic impedance of the brain tissue at these microwave frequencies is close to 50 ohms, efficient transmission by commercially available standard 50 ohm coax is possible.

The invention has been described in reference to the preferred embodiments. It is, however, to be understood that other advantages, features, and embodiments may be within the scope of this invention as defined in the appended claims.

What is claimed is:

1. A sound perception device for providing induced perception of sound into a mammalian brain comprising in combination:
 - means for generating microwave radiation which is representative of a sound to be perceived, said means for generating including means for generating a simultaneous plurality of microwave radiation frequencies and means for adjusting the amplitude of said microwave radiation frequencies in accordance with the sound to be perceived; and antenna means located in the region of the auditory cortex of said mammalian brain for transmitting said microwave energy into the auditory cortex region of said brain.
2. A hearing device for perception of sounds comprising in combination:
 - means for generating a signal representative of sounds;
 - means for analyzing said signal representative of said sounds having an output;
 - means for generating a plurality of microwave signals having different frequencies having a input connected to said output of said means for analyzing said signals, having an output;
 - means for applying said plurality of microwave signals to the head of a subject, and whereby the subject perceives sounds which are representative of said sounds.
3. The apparatus in accordance with claim 2 wherein said means for generating a signal is a microphone for detecting sound waves.
4. The apparatus in accordance with claim 2 wherein said means for applying said plurality of microwave signals is an antenna.
5. The apparatus in accordance with claim 4 wherein said antenna is placed in the region of the auditory cortex of the subject.
6. The apparatus in accordance with claim 2 wherein the subject is a human being.
7. The apparatus in accordance with claim 2 wherein said means for analyzing said signal comprises:
 - an acoustic filter bank for dividing said sounds into a plurality of component frequencies; and
 - a mode control matrix means for providing control signals which are weighted in accordance with said plurality of component frequencies, having an output connected to said means for generating a plurality of microwave signal inputs.
8. The apparatus in accordance with claim 7 wherein said acoustic filter bank includes a plurality of audio frequency filters.
9. The apparatus in accordance with claim 8 wherein said audio frequency filters provide a plurality of output frequencies having amplitudes which are a function of said signal representative of sounds.
10. The apparatus in accordance with claim 9 wherein said amplitudes are the weighted in accordance with transform function of the signal representative of sounds.
11. The apparatus in accordance with claim 7 wherein said mode control matrix device includes a voltage divider connected to each of said plurality of said audio frequency filters.
12. The apparatus in accordance with claim 11 wherein each of said voltage dividers has a plurality of outputs which are connected in circuit to said means for generating a plurality of microwave signals.
13. The apparatus in accordance with claim 2 wherein said means for generating a plurality of microwave signals comprises a plurality of microwave generators each having a different frequency and means for controlling the output amplitude of each of said generators.
14. The apparatus in accordance with claims 2 wherein said means for generating a plurality of microwave signals comprises a broad band microwave source and a plurality of filters.
15. The apparatus in accordance with claim 13 wherein said generators each comprise a microwave signal source and a gain controlled microwave amplifier.
16. The apparatus in accordance with claim 13 wherein said means for analyzing output is connected to said means for controlling microwave amplifier output amplitudes.
17. The apparatus in accordance with claim 13 wherein analyzing includes K audio frequency filters.
18. The apparatus in accordance with claim 17 wherein there are N microwave generators.
19. The apparatus in accordance with claim 18 including a mode partitioning means which provides N outputs for each of said K audio frequency filters.
20. The apparatus in accordance with claim 19 wherein said N amplifiers each have K inputs from said mode partitioning means.
21. The apparatus in accordance with claim 20 wherein said N amplifiers have K inputs less the mode partitioning means outputs which are so small that they may be omitted.
22. The apparatus in accordance with claim 20 wherein said mode partitioning output device outputs each include a diode connected to each microwave amplifier gain control to provide isolation between all outputs.
23. The apparatus in accordance with claim 20 wherein said K audio frequency filters are chosen to correspond to the critical bandwidths of the human ear.
24. The apparatus in accordance with claim 20 wherein said N microwave generators are each adjustable in frequency output.
25. The apparatus in accordance with claim 18 wherein the frequency of each N microwave generators is determined by anatomical estimation.
26. The apparatus in accordance with claim 18 wherein the frequency of the lowest frequency microwave generator is chosen by determination of the effect of external microwave generation on the EEG of the subject.
27. The apparatus in accordance with claim 18 wherein the frequency of each of said N microwave generators corresponds to the subject's microwave modal frequencies.

28. The apparatus in accordance with claim 27 wherein the subject's modal frequencies are determined by measurement of the subject's cephalic index and the lateral dimensions of the skull.

29. The apparatus in accordance with claim 28 wherein the subject's lowest modal frequency is deter-

mined by varying the frequency of the lowest frequency microwave generator about the estimated value until a maximum acoustic perception is obtained by the subject.

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[54] APPARATUS AND METHOD FOR REMOTELY MONITORING AND ALTERING BRAIN WAVES

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[22] Filed: Aug. 5, 1974

[57] ABSTRACT

[21] Appl. No.: 494,518

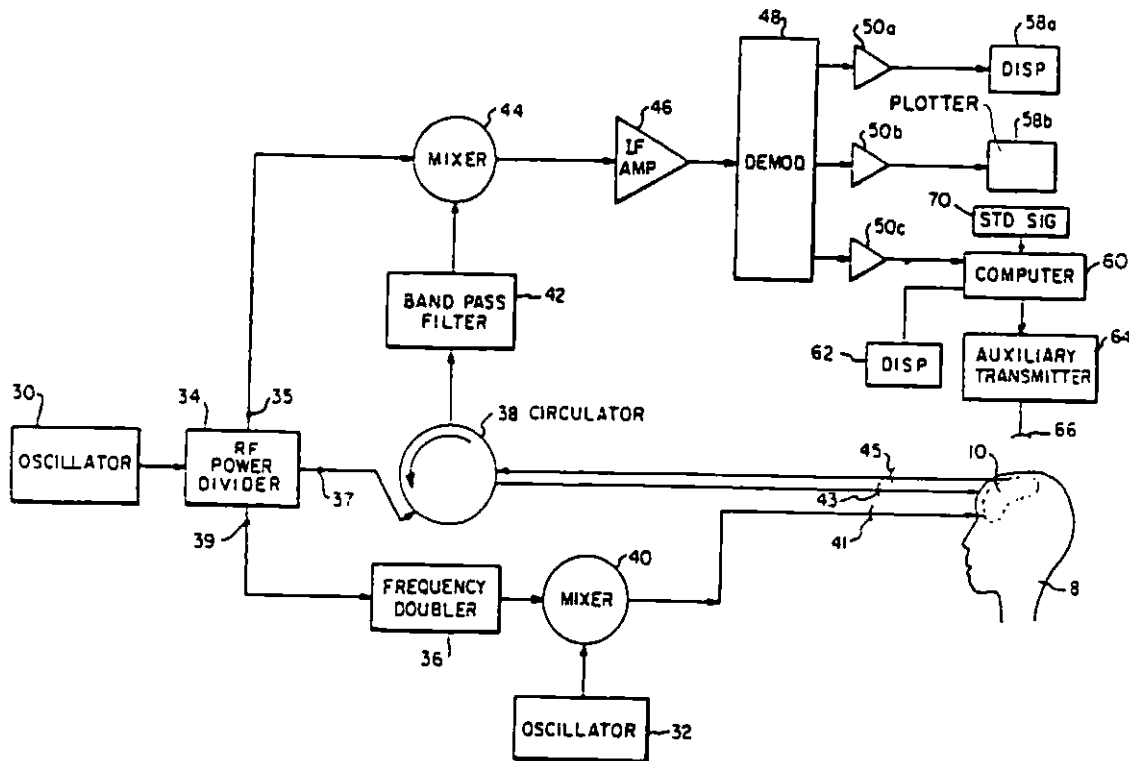
Apparatus for and method of sensing brain waves at a position remote from a subject whereby electromagnetic signals of different frequencies are simultaneously transmitted to the brain of the subject in which the signals interfere with one another to yield a waveform which is modulated by the subject's brain waves. The interference waveform which is representative of the brain wave activity is re-transmitted by the brain to a receiver where it is demodulated and amplified. The demodulated waveform is then displayed for visual viewing and routed to a computer for further processing and analysis. The demodulated waveform also can be used to produce a compensating signal which is transmitted back to the brain to effect a desired change in electrical activity therein.

[52] U.S. Cl. 128/2.1 B
 [51] Int. Cl.² A61B 5/04
 [58] Field of Search 128/1 C, 1 R, 2.1 B, 128/2.1 R, 419 R, 422 R, 420, 404, 2 R, 2 S, 2.05 R, 2.05 V, 2.05 F, 2.06 R; 340/248 A, 258 A, 258 B, 258 D, 229

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11 Claims, 2 Drawing Figures



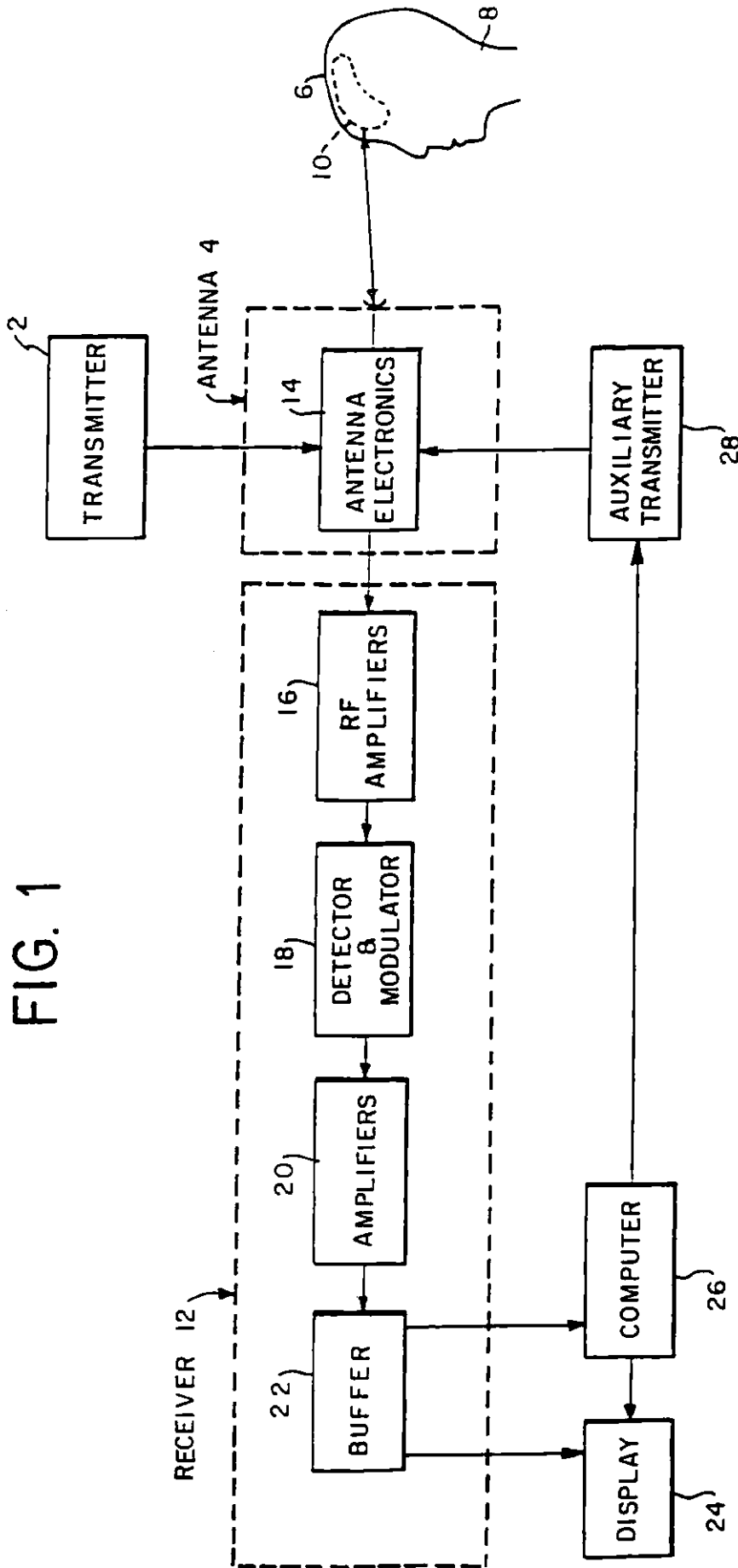
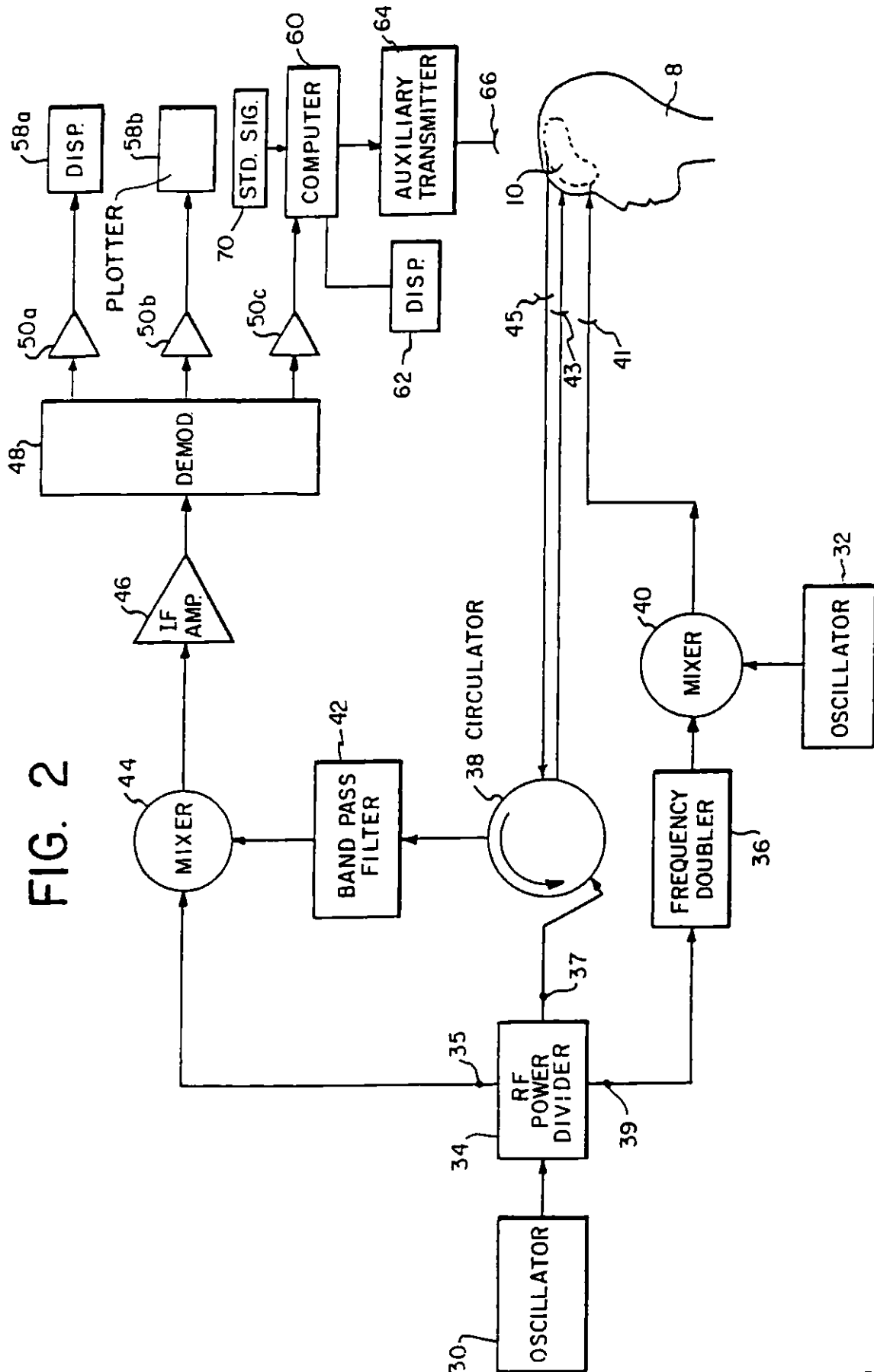


FIG. 1



APPARATUS AND METHOD FOR REMOTELY MONITORING AND ALTERING BRAIN WAVES

BACKGROUND OF THE INVENTION

Medical science has found brain waves to be a useful barometer of organic functions. Measurements of electrical activity in the brain have been instrumental in detecting physical and psychic disorder, measuring stress, determining sleep patterns, and monitoring body metabolism.

The present art for measurement of brain waves employs electroencephalographs including probes with sensors which are attached to the skull of the subject under study at points proximate to the regions of the brain being monitored. Electrical contact between the sensors and apparatus employed to process the detected brain waves is maintained by a plurality of wires extending from the sensors to the apparatus. The necessity for physically attaching the measuring apparatus to the subject imposes several limitations on the measurement process. The subject may experience discomfort, particularly if the measurements are to be made over extended periods of time. His bodily movements are restricted and he is generally confined to the immediate vicinity of the measuring apparatus. Furthermore, measurements cannot be made while the subject is conscious without his awareness. The comprehensiveness of the measurements is also limited since the finite number of probes employed to monitor local regions of brain wave activity do not permit observation of the total brain wave profile in a single test.

SUMMARY OF THE INVENTION

The present invention relates to apparatus and a method for monitoring brain waves wherein all components of the apparatus employed are remote from the test subject. More specifically, high frequency transmitters are operated to radiate electromagnetic energy of different frequencies through antennas which are capable of scanning the entire brain of the test subject or any desired region thereof. The signals of different frequencies penetrate the skull of the subject and impinge upon the brain where they mix to yield an interference wave modulated by radiations from the brain's natural electrical activity. The modulated interference wave is re-transmitted by the brain and received by an antenna at a remote station where it is demodulated, and processed to provide a profile of the subject's brain waves. In addition to passively monitoring his brain waves, the subject's neurological processes may be affected by transmitting to his brain, through a transmitter, compensating signals. The latter signals can be derived from the received and processed brain waves.

OBJECTS OF THE INVENTION

It is therefore an object of the invention to remotely monitor electrical activity in the entire brain or selected local regions thereof with a single measurement.

Another object is the monitoring of a subject's brain wave activity through transmission and reception of electromagnetic waves.

Still another object is to monitor brain wave activity from a position remote from the subject.

A further object is to provide a method and apparatus for affecting brain wave activity by transmitting electromagnetic signals thereto.

DESCRIPTION OF THE DRAWINGS

Other and further objects of the invention will appear from the following description and the accompanying drawings, which form part of the instant specification and which are to be read in conjunction therewith, and in which like reference numerals are used to indicate like parts in the various views;

FIG. 1 is a block diagram showing the interconnection of the components of the apparatus of the invention;

FIG. 2 is a block diagram showing signal flow in one embodiment of the apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, specifically FIG. 1, a high frequency transmitter 2 produces and supplies two electromagnetic wave signals through suitable coupling means 14 to an antenna 4. The signals are directed by the antenna 4 to the skull 6 of the subject 8 being examined. The two signals from the antenna 4, which travel independently, penetrate the skull 6 and impinge upon the tissue of the brain 10.

Within the tissue of the brain 10, the signals combine, much in the manner of a conventional mixing process technique, with each section of the brain having a different modulating action. The resulting waveform of the two signals has its greatest amplitude when the two signals are in phase and thus reinforcing one another. When the signals are exactly 180° out of phase the combination produces a resultant waveform of minimum amplitude. If the amplitudes of the two signals transmitted to the subject are maintained at identical levels, the resultant interference waveform, absent influences of external radiation, may be expected to assume zero intensity when maximum interference occurs, the number of such points being equal to the difference in frequencies of the incident signals. However, interference by radiation from electrical activity within the brain 10 causes the waveform resulting from interference of the two transmitted signals to vary from the expected result, i.e., the interference waveform is modulated by the brain waves. It is believed that this is due to the fact that brain waves produce electric charges each of which has a component of electromagnetic radiation associated with it. The electromagnetic radiation produced by the brain waves in turn reacts with the signals transmitted to the brain from the external source.

The modulated interference waveform is re-transmitted from the brain 10, back through the skull 6. A quantity of energy is re-transmitted sufficient to enable it to be picked up by the antenna 4. This can be controlled, within limits, by adjusting the absolute and relative intensities of the signals, originally transmitted to the brain. Of course, the level of the transmitted energy should be kept below that which may be harmful to the subject.

The antenna passes the received signal to a receiver 12 through the antenna electronics 14. Within the receiver the wave is amplified by conventional RF amplifiers 16 and demodulated by conventional detector and modulator electronics 18. The demodulated wave, representing the intra-brain electrical activity, is amplified by amplifiers 20 and the resulting information in electronic form is stored in buffer circuitry 22. From the buffers 22 the information is fed to a suitable visual

display 24, for example one employing a cathode ray tube, light emitting diodes, liquid crystals, or a mechanical plotter. The information may also be channeled to a computer 26 for further processing and analysis with the output of the computer displayed by heretofore mentioned suitable means.

In addition to channeling its information to display devices 24, the computer 26 can also produce signals to control an auxiliary transmitter 28. Transmitter 28 is used to produce a compensating signal which is transmitted to the brain 10 of the subject 8 by the antenna 4. In a preferred embodiment of the invention, the compensating signal is derived as a function of the received brain wave signals, although it can be produced separately. The compensating signals affect electrical activity within the brain 10.

Various configurations of suitable apparatus and electronic circuitry may be utilized to form the system generally shown in FIG. 1 and one of the many possible configurations is illustrated in FIG. 2. In the example shown therein, two signals, one of 100 MHz and the other of 210 MHz are transmitted simultaneously and combine in the brain 10 to form a resultant wave of frequency equal to the difference in frequencies of the incident signals, i.e., 110 MHz. The sum of the two incident frequencies is also available, but is discarded in subsequent filtering. The 100 MHz signal is obtained at the output 37 of an RF power divider 34 into which a 100 MHz signal generated by an oscillator 30 is injected. The oscillator 30 is of a conventional type employing either crystals for fixed frequency circuits or a tunable circuit set to oscillate at 100 MHz. It can be a pulse generator, square wave generator or sinusoidal wave generator. The RF power divider can be any conventional VHF, UHF or SHF frequency range device constructed to provide, at each of three outputs, a signal identical in frequency to that applied to its input.

The 210 MHz signal is derived from the same 100 MHz oscillator 30 and RF power divider 34 as the 100 MHz signal, operating in concert with a frequency doubler 36 and 10 MHz oscillator 32. The frequency doubler can be any conventional device which provides at its output a signal with frequency equal to twice the frequency of a signal applied at its input. The 10 MHz oscillator can also be of conventional type similar to the 100 MHz oscillator herebefore described. A 100 MHz signal from the output 39 of the RF power divider 34 is fed through the frequency doubler 36 and the resulting 200 MHz signal is applied to a mixer 40. The mixer 40 can be any conventional VHF, UHF or SHF frequency range device capable of accepting two input signals of differing frequencies and providing two output signals with frequencies equal to the sum and difference in frequencies respectively of the input signals. A 10 MHz signal from the oscillator 32 is also applied to the mixer 40. The 200 MHz signal from the doubler 36 and the 10 MHz signal from the oscillator 32 combine in the mixer 40 to form a signal with a frequency of 210 MHz equal to the sum of the frequencies of the 200 MHz and 10 MHz signals.

The 210 MHz signal is one of the signals transmitted to the brain 10 of the subject being monitored. In the arrangement shown in FIG. 2, an antenna 41 is used to transmit the 210 MHz signal and another antenna 43 is used to transmit the 100 MHz signal. Of course, a single antenna capable of operating at 100 MHz and 210 MHz frequencies may be used to transmit both signals. The scan angle, direction and rate may be controlled

mechanically, e.g., by a reversing motor, or electronically, e.g., by energizing elements in the antenna in proper synchronization. Thus, the antenna(s) can be of either fixed or rotary conventional types.

A second 100 MHz signal derived from output terminal 37 of the three-way power divider 34 is applied to a circulator 38 and emerges therefrom with a desired phase shift. The circulator 38 can be of any conventional type wherein a signal applied to an input port emerges from an output port with an appropriate phase shift. The 100 MHz signal is then transmitted to the brain 10 of the subject being monitored via the antenna 43 as the second component of the dual signal transmission. The antenna 43 can be of conventional type similar to antenna 41 herebefore described. As previously noted, these two antennas may be combined in a single unit.

The transmitted 100 and 210 MHz signal components mix within the tissue in the brain 10 and interfere with one another yielding a signal of a frequency of 110 MHz, the difference in frequencies of the two incident components, modulated by electromagnetic emissions from the brain, i.e., the brain wave activity being monitored. This modulated 110 MHz signal is radiated into space.

The 110 MHz signal, modulated by brain wave activity, is picked up by an antenna 45 and channeled back through the circulator 38 where it undergoes an appropriate phase shift. The circulator 38 isolates the transmitted signals from the received signal. Any suitable diplexer or duplexer can be used. The antenna 45 can be of conventional type similar to antennas 41 and 43. It can be combined with them in a single unit or it can be separate. The received modulated 110 MHz signal is then applied to a band pass filter 42, to eliminate undesirable harmonics and extraneous noise, and the filtered 110 MHz signal is inserted into a mixer 44 into which has also been introduced a component of the 100 MHz signal from the source 30 distributed by the RF power divider 34. The filter 42 can be any conventional band pass filter. The mixer 44 may also be of conventional type similar to the mixer 40 herebefore described.

The 100 MHz and 110 MHz signals combine in the mixer 44 to yield a signal of frequency equal to the difference in frequencies of the two component signals, i.e., 10 MHz still modulated by the monitored brain wave activity. The 10 MHz signal is amplified in an IF amplifier 46 and channeled to a demodulator 48. The IF amplifier and demodulator 48 can both be of conventional types. The type of demodulator selected will depend on the characteristics of the signals transmitted to and received from the brain, and the information desired to be obtained. The brain may modulate the amplitude, frequency and/or phase of the interference waveform. Certain of these parameters will be more sensitive to corresponding brain wave characteristics than others. Selection of amplitude, frequency or phase demodulation means is governed by the choice of brain wave characteristic to be monitored. If desired, several different types of demodulators can be provided and used alternately or at the same time.

The demodulated signal which is representative of the monitored brain wave activity is passed through audio amplifiers 50 a, b, c which may be of conventional type where it is amplified and routed to displays 58 a, b, c and a computer 60. The displays 58 a, b, c present the raw brain wave signals from the amplifiers

50 a, b, c. The computer 60 processes the amplified brain wave signals to derive information suitable for viewing, e.g., by suppressing, compressing, or expanding elements thereof, or combining them with other information-bearing signals and presents that information on a display 62. The displays can be conventional ones such as the types herebefore mentioned employing electronic visual displays or mechanical plotters 58b. The computer can also be of conventional type, either analog or digital, or a hybrid.

A profile of the entire brain wave emission pattern may be monitored or select areas of the brain may be observed in a single measurement simply by altering the scan angle and direction of the antennas. There is no physical contact between the subject and the monitoring apparatus. The computer 60 also can determine a compensating waveform for transmission to the brain 10 to alter the natural brain waves in a desired fashion. The closed loop compensating system permits instantaneous and continuous modification of the brain wave response pattern.

In performing the brain wave pattern modification function, the computer 60 can be furnished with an external standard signal from a source 70 representative of brain wave activity associated with a desired neurological response. The region of the brain responsible for the response is monitored and the received signal, indicative of the brain wave activity therein, is compared with the standard signal. The computer 60 is programmed to determine a compensating signal, responsive to the difference between the standard signal and received signal. The compensating signal, when transmitted to the monitored region of the brain, modulates the natural brain wave activity therein toward a reproduction of the standard signal, thereby changing the neurological response of the subject.

The computer 60 controls an auxiliary transmitter 64 which transmits the compensating signal to the brain 10 of the subject via an antenna 66. The transmitter 64 is of the high frequency type commonly used in radar applications. The antenna 66 can be similar to antennas 41, 43 and 45 and can be combined with them. Through these means, brain wave activity may be altered and deviations from a desired norm may be compensated. Brain waves may be monitored and control signals transmitted to the brain from a remote station.

It is to be noted that the configuration described is one of many possibilities which may be formulated without departing from the spirit of my invention. The transmitters can be monostatic or bistatic. They also can be single, dual, or multiple frequency devices. The transmitted signal can be continuous wave, pulse, FM, or any combination of these as well as other transmission forms. Typical operating frequencies for the transmitters range from 1 MHz to 40 GHz but may be altered to suit the particular function being monitored and the characteristics of the specific subject.

The individual components of the system for monitoring and controlling brain wave activity may be of conventional type commonly employed in radar systems.

Various subassemblies of the brain wave monitoring and control apparatus may be added, substituted or combined. Thus, separate antennas or a single multi-mode antenna may be used for transmission and reception. Additional displays and computers may be added to present and analyze select components of the monitored brain waves.

Modulation of the interference signal retransmitted by the brain may be of amplitude, frequency and/or phase. Appropriate demodulators may be used to decipher the subject's brain activity and select components of his brain waves may be analyzed by computer to determine his mental state and monitor his thought processes.

As will be appreciated by those familiar with the art, apparatus and method of the subject invention has numerous uses. Persons in critical positions such as drivers and pilots can be continuously monitored with provision for activation of an emergency device in the event of human failure. Seizures, sleepiness and dreaming can be detected. Bodily functions such as pulse rate, heartbeat regularity and others also can be monitored and occurrences of hallucinations can be detected. The system also permits medical diagnoses of patients, inaccessible to physicians, from remote stations.

What is claimed is:

1. Brain wave monitoring apparatus comprising means for producing a base frequency signal, means for producing a first signal having a frequency related to that of the base frequency and at a predetermined phase related thereto, means for transmitting both said base frequency and said first signals to the brain of the subject being monitored, means for receiving a second signal transmitted by the brain of the subject being monitored in response to both said base frequency and said first signals, mixing means for producing from said base frequency signal and said received second signal a response signal having a frequency related to that of the base frequency, and means for interpreting said response signal.

2. Apparatus as in claim 1 where said receiving means comprises

means for isolating the transmitted signals from the received second signals.

3. Apparatus as in claim 2 further comprising a band pass filter with an input connected to said isolating means and an output connected to said mixing means.

4. Apparatus as in claim 1 further comprising means for amplifying said response signal.

5. Apparatus as in claim 4 further comprising means for demodulating said amplified response signal.

6. Apparatus as in claim 5 further comprising interpreting means connected to the output of said demodulator means.

7. Apparatus according to claim 1 further comprising means for producing an electromagnetic wave control signal dependent on said response signal, and means for transmitting said control signal to the brain of said subject.

8. Apparatus as in claim 7 wherein said transmitting means comprises means for directing the electromagnetic wave control signal to a predetermined part of the brain.

9. A process for monitoring brain wave activity of a subject comprising the steps of transmitting at least two electromagnetic energy signals of different frequencies to the brain of the subject being monitored, receiving an electromagnetic energy signal resulting from the mixing of said two signals in the brain modulated by the brain wave activity and retrans-

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mitted by the brain in response to said transmitted energy signals, and, interpreting said received signal.

10. A process as in claim 9 further comprising the step of transmitting a further electromagnetic wave signal to the brain to vary the brain wave activity.

11. A process as in claim 10 wherein the step of transmitting the further signals comprises obtaining a standard signal,

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comparing said received electromagnetic energy signals with said standard signal, producing a compensating signal corresponding to the comparison between said received electromagnetic energy signals and the standard signal, and transmitting the compensating signals to the brain of the subject being monitored.

* * * * *

[54] BIOMAGNETIC ANALYTICAL SYSTEM USING FIBER-OPTIC MAGNETIC SENSORS

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[52] U.S. CL 128/653 R; 128/731; 324/244.1

[58] Field of Search 324/244 OP; 128/653 R, 128/639, 630, 731, 732

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[57] ABSTRACT

A biomagnetic analytical system for sensing and indicating minute magnetic fields emanating from the brain or from any other tissue region of interest in a subject under study. The system includes a magnetic pick-up device constituted by an array of fiber-optic magnetic sensors mounted at positions distributed throughout the inner confines of a magnetic shield configured to conform generally to the head of the subject or whatever other body region is of interest. Each sensor yields a light beam whose phase or other parameter is modulated in accordance with the magnetic field emanating from the related site in the region. The modulated beam from each sensor is compared in an interferometer with a reference light beam to yield an output signal that is a function of the magnetic field being emitted at the related site. The output signals from the interferometer are processed to provide a display or recording exhibiting the pattern or map of magnetic fields resulting from emanations at the multitude of sites encompassed by the region.

8 Claims, 2 Drawing Sheets

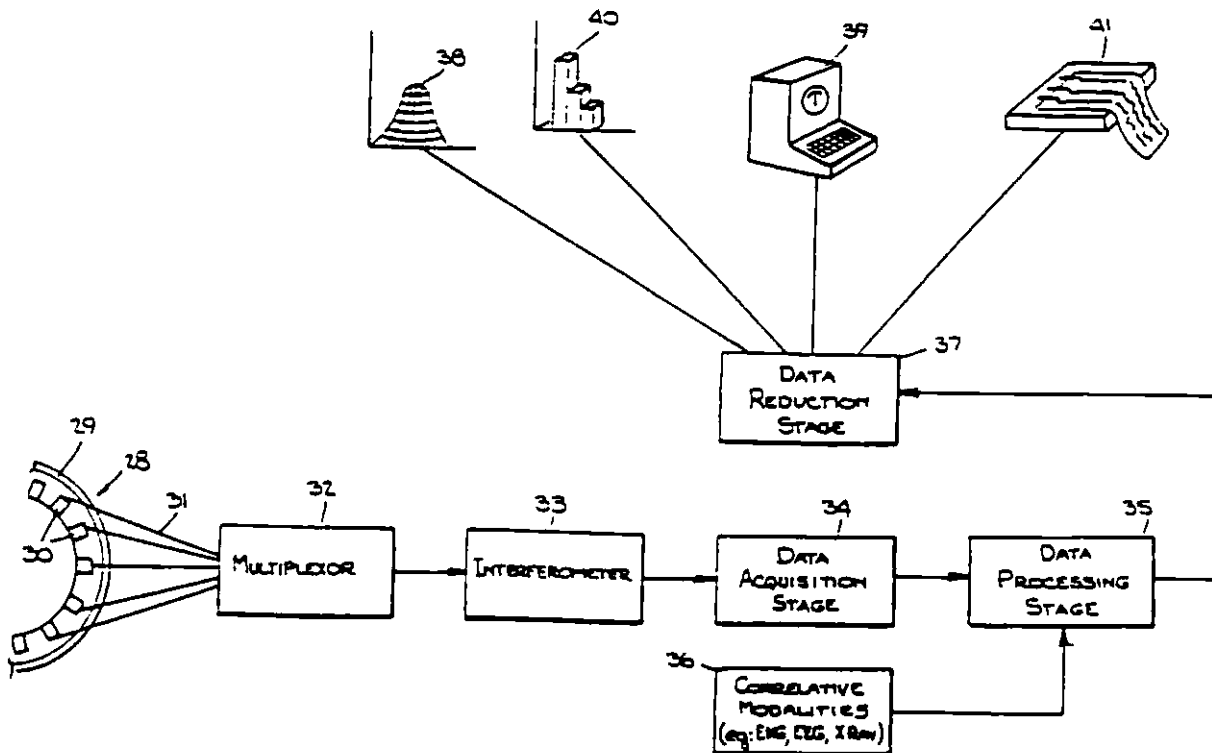


Fig. 1.

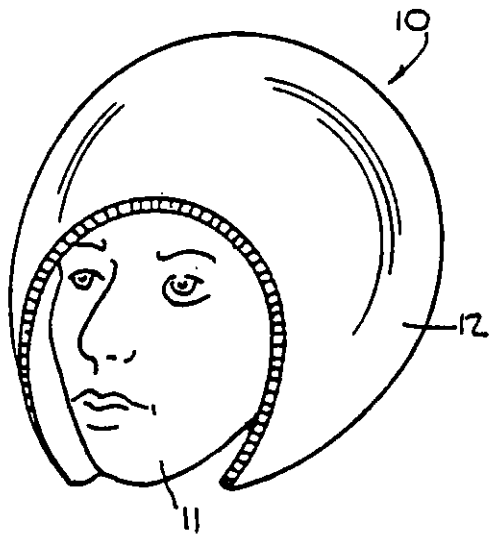


Fig. 2.

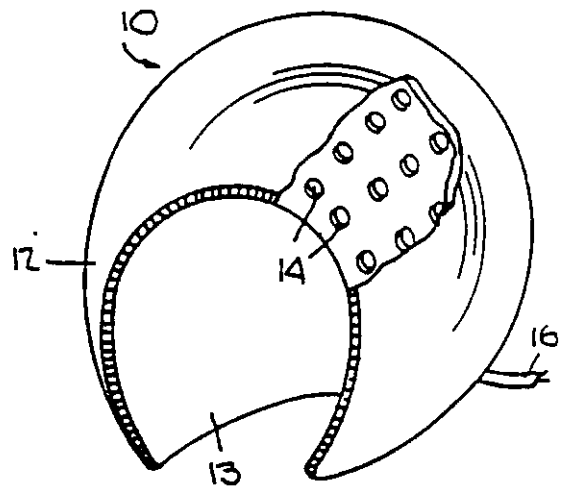


Fig. 3.

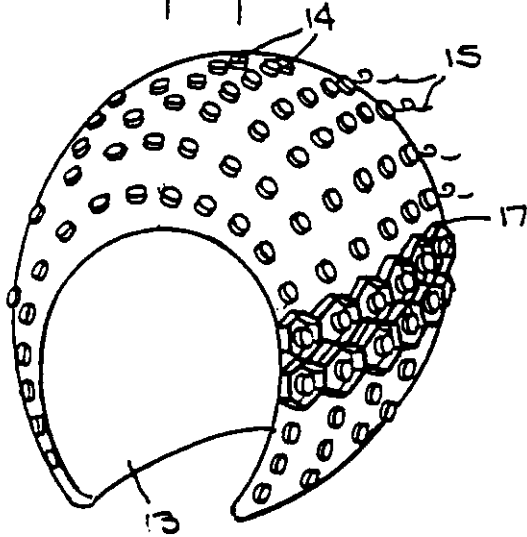


Fig. 4.

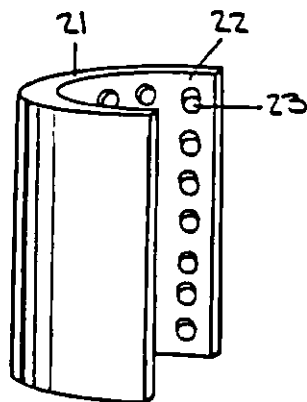
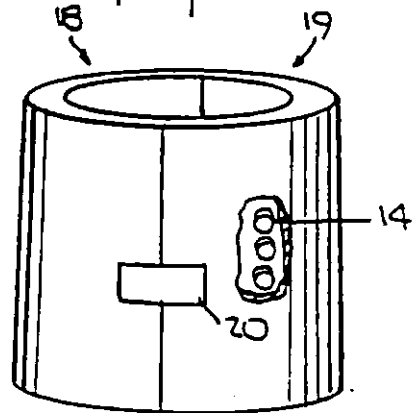


Fig. 5.

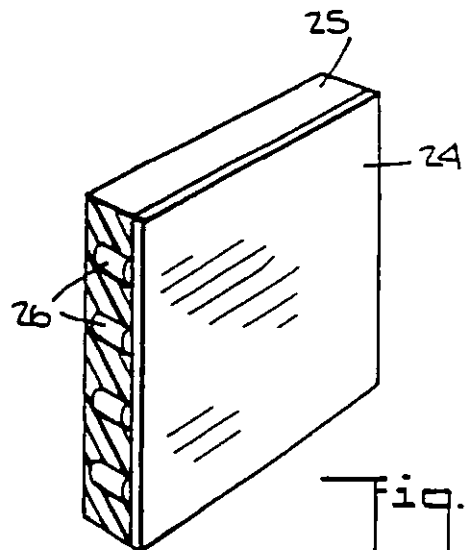


Fig. 6.

