AQUARIUS* ELECTRONICS

Post Office Box 627
Mendocino, California 95460
United States of America

TO

*trademark of Aquarius Electronics

Tim's Testing Bench copy Only!

1972 catalog of bio-feedback tools

by

Aquarius Electronics

ALPHAPHONE* headset • ALPHAPHONE* basic e.e.p.
ALPHAPHONE* brainwave analyzer • AQUARIAN* photon coupler
AQUARIAN* FM transmitter • AQUARIAN* percent/time chart recorder

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Mendocino, California, 95460

CONTENTS

About Aquarius

Aquarius Electronics is a small corporation located on the north coast of California, near the town of Mendocino. We are not a commune, although some of our workers live on nearby communes. The company is not communally owned, but everyone (regardless of position) receives the same wages.

We have several advisors (medical, psychological and spiritual), but none of us are doctors, psychologists, neurophysiologists, swamis or gurus. Nor have we any intention of pretending to be. In the pages of this booklet, we are trying to present a nutshell account of the field of brainwave feedback and our instruments. The correlation section of this booklet is more thoroughly covered in our instruction manuals, each of which also contains a long bibliography. We recommend that you purchase a manual for a more complete introduction.

We have a program of distribution that is designed to allow individuals with a minimum of capital to handle our instruments. These are usually people who happen to own one or more of our instruments and are willing to demonstrate them for a small commission. We currently have no stocking distributors. Demonstrators send piles of business cards so that when we receive an inquiry from their area we can staple their cards to the catalog. (See inside front cover.)

A few of our demonstrators also conduct classes and individual training in brainwave control. In some cases these teachers may express opinions or speculations at variance from our own (which is as it should be), so we want it to be clear that our opinions and speculations are limited to Aquarius Electronics publications. As with demonstrators, we staple the cards of teachers in the vicinity of the addressee of this booklet on the inside front cover.

History

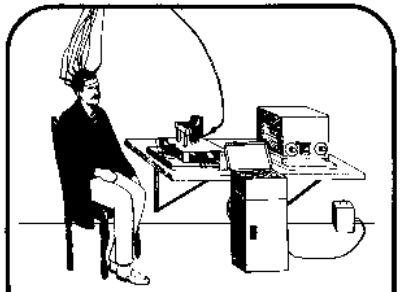
The normal waking consciousness is but one of many possible types of consciousness. This notion was first presented to Western science in 1902 by Psychologist William James. He went on to insist that "No account of the universe in its totality can be final which leaves these other forms of consciousness quite disregarded."

In the East, there has been a long tradition of explorations into the variations in consciousness — a tradition which has produced quite a few practical techniques for such explorations. Yet, because of a combination of cultural and intellectual influences, the deliberate investigation of "altered states of consciousness" did not appeal to Western science until recent years. While Psychology has been developing methods of probing the mind of man, Physiology has been taking advantage of advances in electronic instrumentation to develop methods of monitoring bodily changes. Together, these two sciences are adding insightful knowledge to our view of the whole man.

Late last century, a British researcher named Caton disclosed his finding that the brains of monkeys and rabbits generate electric currents that vary with arousal from sleep, death, exposure to light flashes, and other such changes and stimulation. These first experiments made use of a sensitive (for the time) galvanometer, with electrodes (electronic sensors) being placed directly on the surfaces of the animals' brains.

In following decades, other work of this type was performed on animals. In 1929, a German medical doctor by the name of Hans Berger published work in which the electro-encephalograms (EEG — an electronic monitor of brain currents) of human Subjects had been monitored from outside the head by placing the electrodes of his galvanometer on their scalps. He observed that these currents varied in frequency and amplitude and bore a relation to changes in consciousness.

Berger is credited with discovering the alpha and beta rhythms and with relating them to mental states. He worked with a variety of Subjects — schizophrenics, manics, epileptics, drug users, etc. — and with "normal" people. While much of his work was speculative in nature, it has largely been borne out by the subsequent formal research of Lord Adrian and others. Berger's primary interest was less in defining diseases than in understanding the curious relation between the mind and body of man. In 1938, while still actively at work, Hans



Subject with Hans Berger's EEG tools

Berger was abruptly "retired" by the Nazis.

Since that time, interest and research in the rhythmic pulses of electricity generated by the brain (called brainwaves) have been gaining. Until the last decade, this interest was primarily in the realm of pathology. That is, brainwaves were monitored mainly to identify brain tumors, epilepsy, mental illnesses and other disorders of the mind and body.

Several independent research projects conducted in Japan, India and America have pointed toward a correlation between brainwaves and the peaceful states of meditation fostered by the Eastern disciplines of Zen, Yoga, and their relatives.

Of these studies, perhaps the most detailed and interesting are those by Kasamatsu and Hirai and by Akishige (studies of Zen), by Anand, Chhina and Baldev Singh (study of Raj Yoga), and by Wallace (study of Transcendental Meditation). In all cases the meditators were found to generate high amplitude, high percent/time alpha in all lobes of the brain. As the meditative sessions progressed, the alpha became louder, slower, and more even and rhythmical.

Researcher Joe Kamiya pioneered the synthesis of Western science and Eastern "religious" discipline in studying the abilities of meditators and novices to control their alpha rhythms through the techniques of brainwave feedback. Training subjects both to enhance and suppress alpha in the same session, he found that: 1) meditators and other internally oriented people learned alpha control more easily than externally oriented, analytical types; 2) Subjects found alpha enhancement quite enjoyable, especially for extended periods, so much so that he soon had a long waiting list of people eager to learn alpha control.

Other recent EEG work has included studies in attention, extrasensory perception, creativity, learning, sleep and the hypnagogic state (wake/sleep boundary), hyperkinesis in children and adolescents, meditation, psychology of music, left/right hemisphere alpha synchronization, alpha synchronization between people, and the effects and possible replacement of tranquilizers, stimulants, coffee, tobacco, alcohol, psychedelics and other drugs.

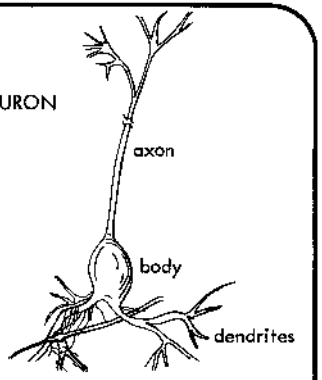
It is important to observe that in bio-feedback the instrument is a passive monitor which the human uses as an extended sense to bring the unconscious workings of the mind/body in line with self-imposed discipline. There are no pulses injected into the brain and the learning, although relatively easy, is not automatic.

By learning to suppress alpha, you may discover an attention focusing mechanism that you can control and strengthen. By learning to enhance alpha, you may discover a way to release that focusing mechanism and relax into a calm, centered state. This control is first learned with the aid of bio-electronic sensing instruments. Once learned, however, your own five or more senses are sufficient.

Definition

Brainwaves, like atoms, can be defined; but what they actually are is still a matter of models, theories and speculations. To complete a general picture of the subject of brainwaves, we are sketching in some of the more outstanding features of a currently popular model. However, it must be remembered that all models lose their accuracy where they gain simplicity. Like a toy airplane, our model of the nature of brainwaves conveys only an approximation of the real article.

The cells that compose the brain and the nervous system are called "neurons." They resemble an uprooted sapling tree — a bulbous body with a rootlike structure surrounding it, and a thin trunk dividing into branches at the end. There are millions of interwoven neurons relaying pulses along complex circuits. The axon (see drawing) of the neuron receives electrical stimulation from other neurons. This charge is carried along the trunk of the axon to the neuron body. When the charge builds to a certain level, the body sends a pulse of current out the dendrites to waiting axon tips of other neurons.

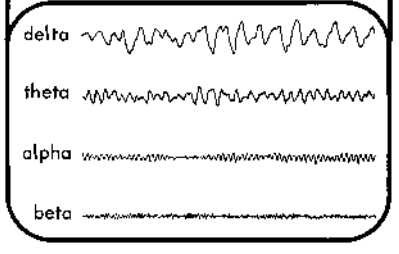


The brainwave patterns that are sensed by EEG tools are the rhythm of pulses fired by the neurons. When nearby neurons fire their pulses synchronously, or "on the beat" with each other, the EEG records show slow patterns of high amplitude. When, on the other hand, the pulses are out of synch with each other, the EEG records show fast patterns of low amplitude.

Brainwaves have been divided (somewhat arbitrarily) into four major frequency (or pulse rate) categories, named by the Greek letters, beta, alpha, theta and delta. The term Hertz (Hz) is used to indicate cycles or pulses per second. Beta waves have frequencies of more than 13 Hz (though some writing defines beta as 18 to 30 Hz, leaving the band from 14 to 17 Hz unnamed and referring to those above 30 Hz as the "very fast band"). Alpha waves have frequencies from 8 to 13 Hz, theta from 4 through 7 Hz, and delta, less than 4 Hz.

Because brainwaves are called "waves", it is easy to confuse them with radio or light waves, that is, as something that travels through space according to the laws that govern those phenomena. "Brain rhythms" might have been a better choice of terminology, but the convention has been set. According to a broad definition of waves, which includes ocean waves, that's what they are.

As well as the temptation to liken them to radio waves (and perhaps think of them as carriers of ESP), there is an even greater temptation to think of them as the states of mind themselves. In fact, they are merely biological parameters of states of consciousness, amid other such indicators as galvanic skin response, heart rate, blood pressure, anterior-posterior DC potential, muscle tension, etc.



Correlation

We are all very familiar with the old cliche of the one who is unable to see the forest for the trees —unable to get a general grasp of an overall idea because of involvement with its particulars. In the case of brainwave research, all we really have as yet is a collection of trees. We can see patterns in it, make generalizations about it, but whether it is really a forest — or a grove, or a jungle, or an orchard, or something else — remains to be seen.

In our instruction manuals, we have attempted to describe in some detail a cross section of the research which we are interpreting. Those who are interested in having a clear understanding of the brainwave field might first read one of our manuals and then use its bibliography to follow this reading by research in the nearest medical library. Given the limitations of space, the inherent tree/forest problem, and our knowledge, we will try to sketch in a broad overview of the subject.

The four basic brainwave frequency ranges are loosely associated with the following:

beta

anxiety - focussed attention (particularly visual) - long attention span (with exceptions) - the active mode - yang - outwardly directed attention - use of the rational mind and senses - schizophrenia and mania - a generally high level of activity and involvement

alpha

a relaxed state of mind - the passive mode - receptivity - yin - inwardly directed attention - disuse of the rational mind and senses - alert inattention - short attention span (with exceptions) - psychoses - a generally low level of activity and involvement - receptivity to ESP

theta

dreaming - access to unconscious material - creative inspiration (and perhaps many scientific discoveries) - anger - "visions" (from wrathful to ecstatic) - very deep meditation - receptivity to ESP

delta

dreamless sleep - newborn babies (who vascillate between slow delta and superfast beta) - some mental or neurophysical disorders. (We are a little unclear about the relation of delta to consciousness as there is less source material to interpret. Most work with delta has been in pathology.)

sleep

When the average person relaxes, the largely beta range "activating pattern" of wakefulness gives way to alpha of medium amplitude (averaging 30 microvolts) at the back of the head in the occipital lobes (visual processing center). As the relaxed, alert, non-objective wakefulness turns to drowsiness, the occipital alpha slows down and becomes mixed with theta to some degree. As the individual passes into sleep, the theta waves begin to predominate and are mixed with 14 Hz "spindle" waves, generally signifying dreaming. As sleep deepens (and the dreams give way to imageless thought), delta begins to predominate, and the spindle waves subside. In the deepest sleep, the brainwave pattern is almost exclusively delta.

trance

In general, hypnosis and trance states do not greatly alter the EEG pattern. That is, trance states are often typified by beta waves. There have been instances of slow wave activity reported in trance, but other researchers than those reporting have postulated that the subjects had fallen into normal sleep. Through the use of rather extreme feedback techniques, however, researchers Galbraith, London, Hart, et al., have demonstrated that susceptibility to hypnosis can be increased by learning frontal alpha control.

meditation

Studies conducted in the Orient and the Occident have revealed that meditation of the schools of Zen and Yoga and their relatives produce high amplitude alpha activity. The alpha has been observed to decrease in frequency and to increase in amplitude.

When the normal person relaxes, alpha from the occipital region appears on the EEG. This alpha activity generally has a mean amplitude of about 30 microvolts. When the Zen and Yoga practitioners were observed, the alpha appeared in all lobes of the brain, not just the occipital. The alpha was quite even and rolling, with few or no lapses into beta, and it had amplitudes approaching 100 microvolts.

blocking

Another device used to distinguish states of consciousness, besides the direct measurement of frequency and amplitude, is the phenomenon of alpha blocking. If a person, normally relaxed and producing average occipital alpha, hears a click or is exposed to a flash of light or some similar stimulus his alpha will give way to beta for about 20 seconds. The next time the stimulus is presented, the blocking time will be shorter. This process continues until there is no blocking whatever.

In Zen, the blocking time started and remained at about two or three seconds. There was no initial attachment to the stimulus, and no "deaf ear" turned to it later. In the case of the Yogis studied, there was no blocking from the outset.

This may be an indication of one of the differences between Zen and Yoga — in the former, meditation is conducted with the eyes open and unstructured receptivity to environment (usually a blank wall) is maintained; in the latter, the eyes are closed, attention is turned completely within and the physical senses are totally ignored.

Blocking has also been used to distinguish the theta of deep meditation and of drowsiness. The Zen masters and their oldest monks who were studied exhibited theta activity at the deepest stage of meditation. When presented with a click, the theta was blocked for a few seconds and spontaneously reappeared. In the case of a drowsy monk, the theta he produced was permanently blocked and replaced by alpha, that is, he woke up and resumed meditation.

E S P

The subject of extra sensory perception has been receiving a growing interest among the scientific community recently. While there is some doubt as to whether ESP itself is a wave phenomenon, there appears to be evidence that it is related closely with EEG alpha activity. Researchers in ESP at the University of Virginia School of Medicine have reported that receptivity to ESP is associated with slow alpha wave activity, while the mental focussing required to recognize the input

requires that the alpha frequency speed up somewhat.

Dr. Stanley Krippner and Dr. Charles Honorton, researchers at the Maimonides Medical Center in Brooklyn, have added a self-evaluation of internal states to the measurement of alpha activity. On a scale of 0 to 4, Subjects rate their attention from "normally alert and aroused" to "internally directed attention". The better ESP scores were obtained from those who had a high percent/time alpha activity and also a high degree of internal direction to their attention. These researchers are also using brainwave monitoring and feedback to study the theta frequency range in connection with ESP. (See Analyzer Accessory section, Jean Mayo's light display.) As it has long been observed that there can be strong ESP experiences in dreaming, training in the cultivation of theta waves may well prove to be useful experimentation.

theta training

Research studies involving brainwave feedback cultivation of theta waves are still only beginning to be published. Aside from feedback, theta waves have been found to correlate to dreaming, a few minutes at the end of a Zen master's meditation (not in the earlier part and not in most of his monks' meditations), and maybe creativity. Dr. Elmer Green and his coworkers have been studying the incidence of theta activity in a variety of people. It is possible that theta relates to intuitional creativity, to seeing visions, and to scientific discoveries. The relation between feedback-cultivated theta, theta induced through other techniques (such as Zen), and naturally occurring theta is yet nebulous.

The frequency response of the ALPHAPHONE headset and ALPHAPHONE basic e.e.p. is contoured to cover the alpha-theta range. Using the instruction record as a guide, one can use these instruments to recognize and cultivate the theta sound. The ALPHAPHONE brainwave analyzer has a period measuring filter and will accurately detect theta. One can set it so that only theta waves activate the tone, or so that only theta turns it off. The PERCENT/TIME METER will indicate the amount of time spent in theta, averaged over one of two time constants: 2 sec. and 5-1/2 sec.

hyperkinesis

Considerable attention has been turned toward a learning and behavior problem found in schoolchildren known as "hyperkinesis" or "hyperactivity". Thought to be a disorder of the inhibitory mechanisms in the central nervous system, it results in the inability to exclude irrelevant stimuli, a general lack of ability to concentrate, and a persistent restlessness. This problem has been receiving so much attention because a frequent treatment for it is the prescription of amphetamines, held to be among the most dangerous and abused of drugs.

Through brainwave research, Taranath Shetty of Boston City Hospital found that he could predict which students would respond favorably to amphetamine treatment on the basis of EEG. Those whose alpha increased after the injection of amphetamines improved in learning ability and calmness. Those whose alpha did not increase became talkative, sleepless and restless, which is typical of the drug in normal adults and non-hyperkinetic children. There is yet unpublished work in preparation in other parts of the country aimed at training hyperkinetic children to increase their alpha generation by way of brainwave feedback.

Increase in alpha doesn't seem to be the whole story, however. The Reverend George von Hilsheimer, Superintendent of the Green Valley Residential Treatment Center, Orange City, Florida, found that some of the hyperkinetic children generate predominantly alpha, with sleep associated 14 - 16 Hz "spindle" pulses in the EEG.

Rev. von Hilsheimer's postulation is that these students are entering the hypnagogic state (wake/sleep boundary) as an operantly conditioned response to stress. Working with an ALPHAPHONE headset, he found that "successful training of naive and unaware subjects to produce alpha rhythms on signal can readily be demonstrated." (von Hilsheimer, "Some simple techniques in biological and behavioral feedback", 1971.)

Initially assuming that increase in alpha generation would lead to a decrease in stress and improved behavior, von Hilsheimer found that adolescents who have some variation of idiopathic brain dysfunction and have large amounts of natural alpha activity learn to increase alpha generation with no difficulty and with no change in behavior. Following a report of Stern, et al (1961), he trained his students to suppress alpha with the eyes closed. 19 of 21 students learned to suppress alpha in six 10 minute training sessions. Success was defined as complete suppression of alpha for 15 minutes. Of the 19 successful alpha suppressors, 15 demonstrated significant increase in attention span, measured by formal tests in arithmetic and grammar.

attention

As a general rule of thumb it can be said that beta waves are predominant during strong sensory attention. Alpha waves tend to predominate more during periods of diffuse inattention or when the attention is non-sensory and turned inward.

There have been several studies at the UCLA Brain Research Institute which have dealt with the abilities of monkeys to solve game problems under conditions of simulated space flight. The monkeys generally performed better (made the correct tic-tac-toe choice or pushed the button of the right color) when their brains were in the beta range.

Dr. Thomas Mulholland has assembled an attention correlated slide projection system based on a brainwave filter-computer. In one mode of operation, beta activity causes the image to be projected. If the subject slips into alpha, the image disappears. He has suggested that this device may be used as a trainer to increase the attention span (by learning to hold the image on the screen for longer periods or by learning to generate stronger beta activity.)

Recent studies in attention seem to indicate that strongest attention isn't necessarily accompanied by pure beta activity. Perhaps it is that a mixture of alpha and beta in some proportion is conducive to the strongest attention. We have assembled the brainwave filtering and percent/time switching circuitry necessary to perform experimentation on EEG and attention with slide projection or other feedback display. These instruments are described in the ALPHAPHONE brainwave analyzer accessory section.

imagery

In a report published in England in 1960, Kenneth Slatter suggested that there is a marked difference between the EEG records of "visualizers" and "verbalizers". He found that those whose thinking is primarily in pictures tend to generate less occipital lobe alpha than those whose thinking is primarily in words.

Most people are mixtures of the two types and use pictures and/or words to think, depending on the situation. When asked to recall an image or perform a task of thought that requires visual imagination, one's alpha will generally give way to beta to some degree. Slatter noted that mental imagery did not block alpha to the same extent as visual attention to the outer world, except in a few rare cases of visual imagination. He also substantiated the report of Shipton and Grey Walter that there is a 12 Hz rhythm that appears in the EEG during adept visual recall and imagination. While technically within the alpha range (8 - 13 Hz), this rhythm is not considered an alpha wave. We currently know of no formal attempts to cultivate visual imagination through narrow band 12 Hz feedback, but consider the prospect interesting.

We make a tunable version of the ALPHAPHONE brainwave analyzer which is capable of monitor, record and feedback work with specific frequencies, such as the 12 Hz rhythm associated with visual imagination. See analyzer accessories.

Speculation

We maintain a correspondence with professional and amateur brainwave researchers who are using our instruments to further the general grasp of the nature of consciousness. From this correspondence, from the professional journals and from our own investigation we see a lot of interesting questions emerging. Most of these questions have yet to be answered in any complete way. Some of them are clearly areas of research for medical professionals. Others are areas where many amateur experimenters are fruitfully working. As the results of various research projects reach us, we'll modify our literature to include the new information.

Meditation

Does the alpha produced in the frontal lobes correlate with meditative states? (apparently so)

Does a correlation of frontal alpha with meditation mean that learning to produce frontal alpha is the same as learning to meditate? (not necessarily but the results are interesting)

Could teachers of meditation use alpha/theta measurements to gauge their students' progress? (some do)

Do different electrode placements "work" better for different people in learning to meditate with biofeedback?

Does synchronizing left and right hemisphere alpha aid centering?

What disciplines (Yoga, Autogenic Training, etc.) are useful complements to brainwave feedback training?

Attention

Alpha production correlates with inattention in some people. Can alpha be used as an alertness alarm (for truck drivers, pilots, etc.)?

Does learning to suppress alpha for extended periods lead to an increased attention span?

Can some hyperkinetic children learn to improve attention through alpha suppression? (yes)

In other hyperkinetic children can training in alpha enhancement improve attention and learning skills?

Can further research into the physiological correlates of attention lead to the development of a practical attention-correlated teaching device?

Can measurement of brainwaves allow us to learn when we are best able to pay attention and when least?

Can we make more effective use of our talents and resources by learning to sense our natural rhythms?

Could art schools use narrow band feedback of 12 Hz brainwaves to foster visual imagination?

Relaxation

Can alpha training help an uptight businessman relax?

Can alpha training relieve tension headaches?

Is it possible to overcome insomnia through brainwave feedback?

Drugs

What effects do various drugs have on brainwaves?

How does the influence of a particular drug affect one's ability to control brainwaves?

Is it possible to use brainwave feedback as a meaningful substitute for drug use? (some do)

Healing

Do people who are "healers" exhibit unusual brainwave patterns?

Can psychosomatic disorders be treated with brainwave feedback?

Can healers "project" alpha onto one's brainwave pattern and thus relax him?

Is parietal lobe feedback useful in treating mental illness?

ESP

Are special brainwave patterns generated by people engaging in psychokinesis, precognition, clairvoyance, etc.?

If so, does learning to generate those special patterns aid in learning the related paranormal skill?

Would cultivating the 12 Hz brainwave associated with visual imagination aid in "sending" ESP information?

Are the brainwaves of people who are telepathically communicating synchronized?

Would synchronizing brainwave patterns with someone through tandem analog feedback foster ESP experiences?

Is internal centering of attention necessary to telepathic reception?

Epilepsy

If epileptic seizures can be diagnosed and detected by brainwave measurements, can epilepsy be treated with brainwave feedback?

Music

Do different kinds of music affect your brainwaves differently?

How about modulating musical tones with brainwaves?

Are brainwaves themselves a kind of music?

Emotions

How do emotions affect brainwave patterns?

Does learning to control brainwaves aid in controlling emotions? Does it aid in releasing them?

Are anger and creativity (both related to theta waves) interchangeable in some people? Can anger be converted into creativity?

The EEP

We make two types of brainwave feedback instruments: "analog" (qualitative) and "digital" (quantitative). The ALPHAPHONE headset and ALPHAPHONE basic e.e.p. are analog instruments; that is, they present a musical warbling sound that corresponds to the actual fluctuations in your brainwave patterns. This warbling sound contains much qualitative information about the brainwave signal that is lost in a straight on/off approach (regardless of the computing technique).

Qualitative instruments such as the headset and basic e.e.p. will tell you what kind of brainwave you are generating and what subtle sound changes it undergoes as your consciousness changes. They will not tell you, in numbers, how much of the time you are generating a given brainwave category.

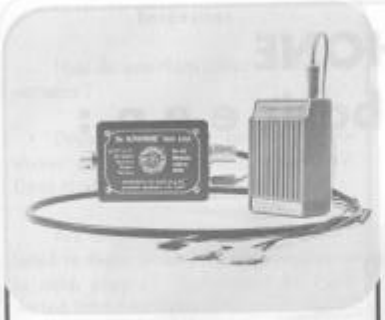
The ALPHAPHONE brainwave analyzer may be used as an analog EEP, but its primary value is as a digital/quantitative tool. It will quite accurately determine the percentage of time you spend in any given brainwave category and will simultaneously feed back and record this information in several ways. It uses a zero crossing detector and period measuring filter in combination with peak amplitude measuring circuitry to determine brainwave type and exclude noise and muscle artefacts.

This method is not to be confused with low cost amplitude filters which claim to yield percent/time data but really are just as satisfied to call your eye-blinks alpha as your brainwaves. If low cost is a necessity, it is far better to stick with a good quality AM-FM encephalophone than to use a misleading percent/time instrument.

The ALPHAPHONE basic e.e.p.:

$80.

- is not a kit; comes completely wired and tested.
- has an AM-FM preamplifier of exceptional durability.
- has minimum circuit noise (less than 5 microvolts peak to peak).
- includes electrodes, batteries, headband, cream, printed recorded instructions, one year warranty.
- affords choice of audio transducer: headphones, speaker/amplifier, tape recorder, FM audio transmitter, etc.



Circuit

The ALPHAPHONE* headset was the first EEP to use a headset design. Now, Aquarius Electronics presents a new first — the ALPHAPHONE* basic e.e.p. — the first economy EEP to have an AM-FM, low noise circuit as well as a low price.

To build the ALPHAPHONE basic e.e.p., we started with the same low noise preamplifier used in the ALPHAPHONE headset. By "low noise" we mean less than 5 microvolts peak to peak noise (much less than that in terms of "RMS" noise). Having built quite a few headsets using this preamplifier, and having shipped them all over the planet, we are sure of its reliability. We guarantee its reliability for a full year of daily use (and get very few instruments back for repair).

Since we had already trimmed the price of the headset to the bone, we had to trim away some of the headset's convenience to come up with a lower priced companion instrument. We substituted a good quality, albeit plain, plastic box for the headset's expensive earphones. We took out the output jacks and their related circuitry. We took out the speakers (as most people either have their own or can buy them cheaply). We spread the components out on an easy-to-wire, square board, thus avoiding the problems caused by extreme miniaturization.

What we didn't cut away was the quality of the essential ingredient — the low noise, AM-FM preamplifier. The result is a fine and useful EEP for only $80, better known to some as $79.99.

The reason we originally chose the headset design, and still prefer it, is that it allows mobility to the user. The shorter electrode wires move with the head, cutting down on artefacts caused by jiggling or bumping them. As well, their shortness cuts down on alpha-like warbling caused by movement through the earth's magnetic field. But, for the difference in price, many feel it is worth it to use the basic e.e.p. and sit still. Certainly, if anything is to be sacrificed, it should be the mobility and not the circuit quality.

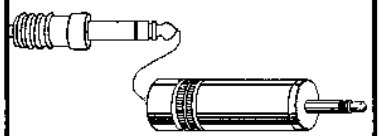
Output

The ALPHAPHONE basic e.e.p. is shipped completely assembled and includes electrodes, batteries, headband, electrode cream and printed and recorded instructions. It does not, however, include headphones or other audio transducers. These must be provided by the user.

The output for the basic e.e.p. is a mini-phone jack. This is compatible with transistor radio accessories. If you are going to use headphones with a stereo phone plug you will need an adapter to reduce to the smaller mini-phone jack. We stock several audio output accessories for the headset which are usable as primary outputs for the basic e.e.p. See headset accessory section.

Each of the various methods of transducing the audio signal has its peculiar advantages and disadvantages. The NOVA-FONE^{tm} earphone hangs lightly on one ear and is easy to carry. The REALISTIC^{tm} speaker/amplifier magnifies the sound so that several people can listen and so that nothing but the electrodes need be worn on the head; this device is useful in describing brainwave sounds to others. The AQUARIAN FM transmitter broadcasts the brainwave sound to an FM radio with the least background whine of any FM transmitting component we have tested. Headphones which dampen sound are useful in excluding traffic and street noises from your meditation. Hearing aid type earpieces (used with transistor radios) provide maximum portability at minimum cost.

stereo plug to mono adaptor



The ALPHAPHONE headset:

$140.
&
$150.

- is completely self-contained and portable.
- is the original EEP headset.
- is packaged in a high quality pair of earphones.
- has two audio outputs, one which cuts off the feedback sound.
- has an FM output for recording and later analysis of EEG signal.
- has an EEG output for direct analysis of EEG signal.
- comes in two versions: one with tone control, one without.
- includes everything necessary for use: headset, electrodes and headband, electrode cream, batteries and printed/recorded instructions.

The ALPHAPHONE headset is more than a basic encephalophone. It is a completely self-contained and miniaturized brainwave feedback and monitor instrument, part of a growing system of complementary instruments. Today's ALPHAPHONE headset is a rugged yet refined descendant of the original headset encephalophone — the Model 101 ALPHAPHONE headset. It is a carefully wired tool that has the batteries and solid state circuitry in the earphone shells to keep the center of gravity low. Most of our competitors still use the box-on-top design, which we discarded in 1970 because it makes the unit topheavy.

The experimental designs possible with the ALPHAPHONE headset are not in any way limited to simple analog feedback of the brainwave signal. Its four output jacks provide a means of connecting to another ALPHAPHONE headset, an accessory amplifier or earphone, an oscilloscope, a tape recorder, an FM transmitter, a chart recorder and other similar accessories.

Despite all this professional versatility, the ALPHAPHONE headset is a convenient personal centering aid. It is easy to carry and to use. While many accessories are possible, none are needed. Its low price beats any model of similar quality.

As with all our instruments, each and every ALPHAPHONE headset is 100% factory tested to meet specifications and guaranteed for one full year.

Output Jacks and Accessories

The output jacks on the ALPHAPHONE headset are miniature phone jacks — the same type commonly used on transistor radios. The corresponding plugs are available at most radio shops. Below are descriptions of each jack's uses.

EXT A and B

The EXT A and EXT B jacks are wired in parallel with the ALPHAPHONE headset's earphones. They make the sound heard in the headset available to an external headset, speaker/amplifier, tape recorder, or other monitor.

The EXT A jack contains a switch so that inserting a plug will cut off the feedback sound in the headset, useful in non-feedback monitor/recording.

The EXT B allows both feedback and audio monitor/record possibilities, useful in demonstrating the headset's sound to others. The output impedance of both jacks is 8 ohms.

The NOVA-FONE[tm] earphone is a light, pocketable earpiece that hangs on one ear, leaving the observer's hands free. Includes patch cord with appropriate mini-phone plug for connection to either headset or basic e.e.p. . . . . $4.

The AQUARIAN FM transmitter bolts directly to the headset and will broadcast the brainwave sound (from either the headset or basic e.e.p.) to any nearby (100 ft.) FM radio. Its unique advantage is that it allows a way of amplifying the sound while providing isolation and maintaining Subject mobility. . . . . $20.

The REALISTIC[tm] speaker/amplifier is a battery powered transducer that allows many people to hear the brainwave sound. This is especially useful when instructing in brainwave control and demonstrating brainwave sounds. . . . . $10.

When the situation demands that the headset's output be recorded or amplified by AC powered equipment (a situation rarely encountered in normal use), the best solution is the Model 501 AQUARIAN photon coupler. This unit provides the necessary isolation to insure against electrical shock and the necessary 60 Hz filtration to eliminate powerline noise. (We provide specially equipped photon couplers to those areas of the world where powerline noise is 50 Hz.)

While the AQUARIAN photon coupler is primarily intended for use with the EEG output, it can also be used with the FM, EXT A or EXT B outputs. This is especially valuable where recording of different kinds of data at the same time requires the use of multi-channel line operated equipment. Simultaneously isolating two outputs would, of course, require two photon couplers.

The Model 502 photon coupler is the same as the Model 501 except that it contains a booster amplifier. This may be used in all of the above applications, but its primary purpose is to serve as a link between the headset's EEG output and the brainwave analyzer's EEG input.

Tandem Use

A wire with a mini-phone plug on each end can be used by two people wearing ALPHAPHONE headsets to hear each other's brainwaves. If the EXT A jacks are used, each will hear only his partner's brainwaves. If the EXT B jacks are used, the brainwaves of both people will be heard by both people. By using a "Y" connector, the brainwaves may be both heard by both partners, and recorded on a cassette recorder.

FM Output

The FM output provides positive 5-volt pulses from a low impedance source that is in synch with the voltage controlled oscillator (and therefore with the brainwave signal). This FM signal is not as clearly intelligible to the human ear as the AM-FM sound heard in the headset, (which you can observe by plugging earphones into the FM jack), but it is useful in technical recording and telemetry applications where amplitude modulation is not desirable.

The signal from the FM output is of such a nature that technically accurate recordings may be made on inexpensive recording equipment, such as a battery powered cassette recorder. (As with all outputs from the headset, the FM jack must be isolated from AC powered equipment.) This combination, a cassette recorder connected to the FM output of the ALPHAPHONE headset, could find application in medical and research circles. Recordings could be made in the field, leaving the bulky analysis equipment in the laboratory to sort out the signal at the operator's convenience.

Another advantage of tape recording the FM signal is the ability to select only the more interesting segments of a lengthy experiment for chart recording (which is quite expensive), or other analysis. If the AM-FM and FM signals are synchronously recorded, the former may be used to find the interesting sections and the latter to provide information for analysis.

To use the FM output signal from an ALPHAPHONE headset or an ALPHAPHONE brainwave analyzer for recording, you need the following:

1) an ALPHAPHONE brainwave analyzer (Model 100IA) or an ALPHAPHONE headset (Model 102A or 102T).

2) a Model 600 pulse forming network (which improves the waveform of the FM output for best recordings). – $15.

3) a battery operated tape recorder (or a Model 501 AQUARIAN photon coupler connected to a powerline operated tape recorder. Suitable recordings may be made with battery powered cassette recorders, often costing as low as $30. Powerline operated tape recorders may have less "wow" and "flutter," however, and would be preferable in critical applications. The cost of the Model 501 AQUARIAN photon coupler is $75.).

4) a Model 610 calibration oscillator. At the push of a button, the Model 610 produces an accurate synthetic brainwave signal, 40 microvolts in amplitude and 10 Hz in frequency (± 5%). – $40.

At the beginning of each recording session, the Model 610's three clip leads are attached to the EEP's electrodes with the EEP's controls set to the values to be used during the recording. The Model 610's signal is recorded for a few moments to provide a reference tone so that later when the recording is played back and demodulated accurate frequency and amplitude measurements can be made.

To recover the EEG signal from the FM recording, you will need:

1) a tape recorder
2) a Model 620 Demodulator

The demodulator decodes the FM signal and re-converts it back into an EEG signal. The Model 620's output can drive the ALPHAPHONE brainwave analyzer's EXT EEG INPUT directly so the recorded brainwave signals can be analyzed. It will drive a 4.7 k ohm load bypassed by .2 microfarad. Thus, it can easily supply signals to almost any chart recorder or oscilloscope. While the output amplitude of the Model

620 will vary (depending on the settings of the EEP's SENSITIVITY and TONE controls at the time of the recording), it is generally comparable to the EEP's EEG OUTPUT signal amplitude. In other words, the deviation which is most comfortable for listening to one's brainwaves with an EEP is about right for recording FM signals. – $70.

Thus a complete recording outfit would include:

- an EEP with FM output
- a battery powered tape recorder (at various prices)

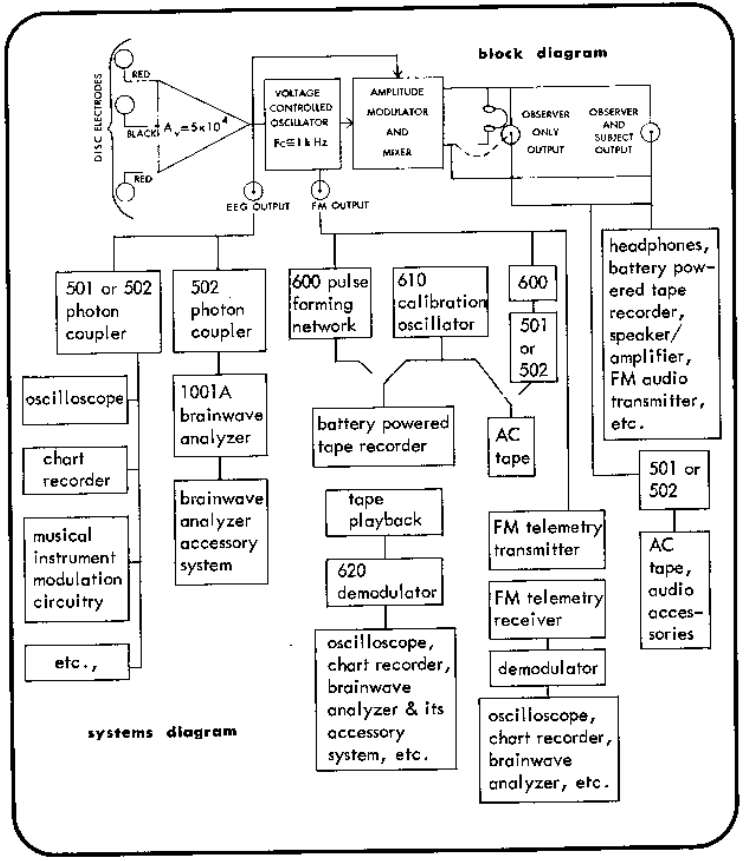
and

– a Model 600 pulse forming network	$15.
– a Model 610 calibration oscillator	$40.
– a Model 620 demodulator	$70.
	$125.

EEG

The EEG output provides a high current, low voltage replica of the brainwave signal without the audible tone. This signal is intended for use with the AQUARIAN photon coupler, as all of the present systems which make use of it are powerline operated. The photon coupler insures against the hazard of shock and eliminates powerline noise (60 Hz hum).

The EEG signal taken directly from the EEG output, or demodulated from the FM output, is useful in many applications. It can be used to present a visual display by plugging the isolated signal into a chart recorder, oscilloscope, light show, etc. It can be used with suitable additional circuitry to modulate electronic musical instruments.



The ALPHAPHONE brainwave analyzer:

- accurately filters for beta, alpha, theta and delta; uses zero crossing (Z/C) detector followed by a period measuring filter (as distinct from a notch or bandpass filter) to yield ± 5% frequency accuracy. Each cycle is measured individually.
- can provide feedback for more than one brainwave category (e.g., tone on when in either alpha or theta) by connecting outputs with a patch cord.
- automatically rejects aretfacts and noise with adjustable high and low amplitude limits.
- offers a choice of five built-in audio feedback modes —
  1) ANALOG is the same AM-FM sound heard in the headset and basic e.e.p.;
  2) DIGITAL + turns on a steady tone when the chosen brainwave category is dominant;
  3) DIGITAL – turns off the tone when chosen category is dominant;
  4) SWITCHED ANALOG + turns on the ANALOG sound when chosen brainwave category is dominant;
  5) SWITCHED ANALOG – turns off the ANALOG sound when chosen brainwave category is dominant.
- will use either DIGITAL mode to turn on/off the sound from a battery powered tape recorder.
- employs PERCENT/TIME METER with choice of two time constants (2 sec. and 5-1/2 sec.) for a quantitative real time appraisal of brainwave activity.
- employs large light emitting diodes for indication of ongoing brainwave state with only one cycle latency (i.e., it follows fast shifts in brainwave pattern).
- has a 60 Hz notch rejection filter and differential preamplifier; may be used with monopolar or bipolar electrode montages.
- has category outputs providing low level logic signals for driving counting devices, projection systems, percent/time chart recording and feedback systems, etc.
- is entirely self-contained and battery operated. Weighs only 13 pounds including batteries.

$450.

The ALPHAPHONE brainwave analyzer is a real time EEG computer designed for professional needs. Its many inputs and outputs provide a link to a tremendous variety of recording, monitoring and feedback instruments. Its SWITCHED ANALOG feature makes it ideal as a teaching instrument — through it one can easily learn to distinguish his own, individual brainwave sounds and apply this knowledge to an AM-FM home trainer such as the ALPHAPHONE headset or ALPHAPHONE basic e.e.p. Its EXT EEG input makes it a useful accessory to conventional laboratory EEG equipment.

The ALPHAPHONE brainwave analyzer is as innovative today as the ALPHAPHONE headset was in 1970. As with the headset, we expect to have many imitators but no peers.

The digital filtering system used in the ALPHAPHONE brainwave analyzer accepts, within a 5% error, all signals within the chosen frequency range. This is in contrast to "notch" filtering which tends to heavily favor one specific frequency (such as 11 Hz), to the exclusion of others in the same range. In spite of all its versatility and accuracy, the ALPHAPHONE brainwave analyzer is portable and battery powered. At $450, it is without doubt the best buy in serious brainwave feedback tools.

tunable analyzer

Some brainwave research requires a tunable filter. For instance, there is a 12 Hz brainwave associated with visualization. ESP and meditation have both been found to relate to changes in one's alpha frequency. One may generate 10 - 12 Hz brainwaves in one state of relaxation and 8 - 10 Hz waves in another. Also useful to study is the border between the alpha and theta ranges. To implement research into subtle frequency changes we are now offering a tunable version of the analyzer.

In standard ALPHAPHONE brainwave analyzers, the edge limits of the frequency sorting circuitry are set at 4 Hz, 8 Hz and 13 Hz. In the tunable model, the limits are variable in 1 Hz increments from 3 - 13 Hz, 5 - 15 Hz and 7 - 17 Hz respectively. This custom brainwave analyzer costs $650; F O B Mendocino. Delivery is four to six weeks, A R O.

The battery life of this and the standard ALPHAPHONE brainwave analyzer is well in excess of 100 hours. Since all of the analyzer's internal circuitry is powered by two voltage regulator circuits that hold the power supply within 0.1% of constant voltage, the instrument's operation is not affected as the batteries age through their normal useful life. There is a battery test switch which allows the percent/time meter to indicate battery condition.

ALPHAPHONE brainwave analyzer specifications

ALPHAPHONE brainwave analyzer specifications for serial numbers 125 and higher.

input sensitivity

40 microvolt input at 10 Hz yields 1.5 volt output (± 10%).

equivalent input noise

Less than 5 microvolts peak to peak measured with input grounded over a 15 second period.

frequency response

± 3 db for signals of 6 to 20 Hz (which is flatter than response of basic e.e.p./headset preamplifier).

60 Hz notch filter

Notch rejection filter. Preamplifier response down at least 60 db at 60 Hz.

noise threshold

Panel mounted control, adjustable from 0 to 100% noise threshold. It is linear, ± 10%. 100% noise threshold is 2.0 volts peak to peak (± 10%) for signals applied to the EXT EEG INPUT. Using the internal preamplifier, this corresponds to a 53 microvolt signal (± 10%) at 10 Hz.

artefact threshold

The artefact threshold control allows a choice of two artefact threshold values, high and low:

high artefact threshold

High artefact threshold is 4.0 volts (± 10%) peak to peak for signals applied to EXT EEG INPUT. Using the internal preamplifier, this corresponds to a 107 microvolt peak to peak (± 10%) 10 Hz signal.

low artefact threshold

Low artefact threshold is 2.5 volts (± 10%) for signals applied to the analyzer's EXT EEG INPUT. Using the internal preamplifier, this corresponds to a 67 microvolt peak to peak (± 10%) 10 Hz signal.

NOTE: both the NOISE THRESHOLD and the ARTEFACT THRESHOLD have disabling switches to allow user choice of bypassing their circuitry.

input impedance

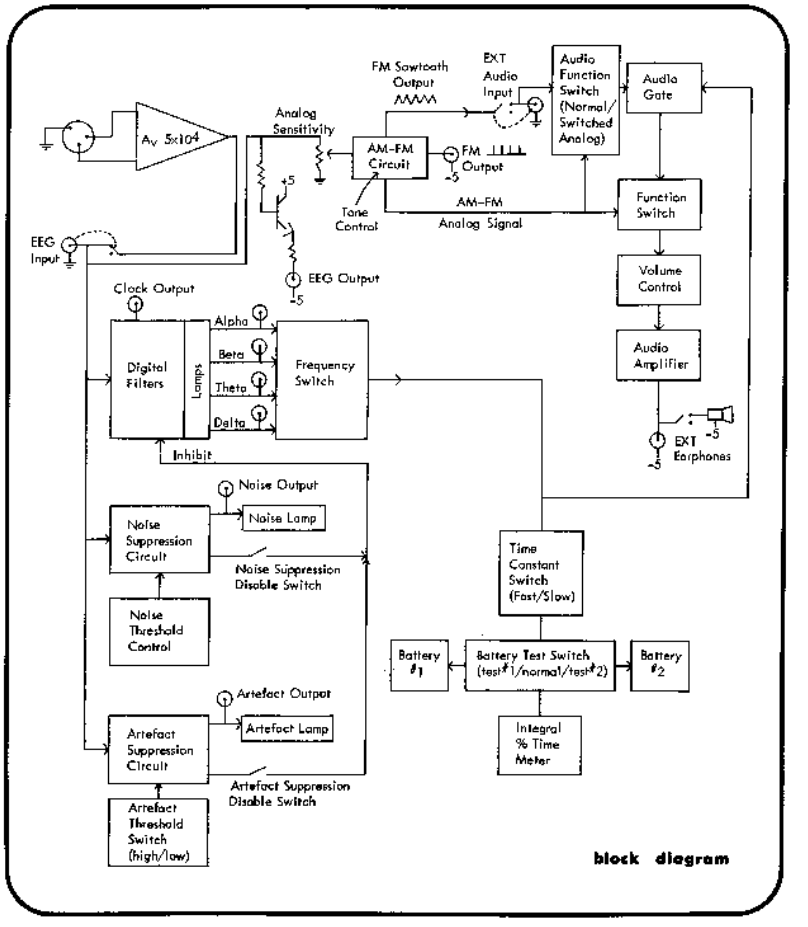
The internal preamplifier (and hence the INPUT) has an input impedance of 1 megohm, bypassed by .001 microfarad. The EXT EEG INPUT has an input impedance of 4.7 K ohms, bypassed by 2. microfarad.

accuracy of frequency analyzing

The period of each cycle of the input signal is measured. There are three frequency limits to which each cycle is compared: 4, 8 and 13 Hz. These frequency measurements and comparisons are accurate within ± 5% error. The tunable version of the ALPHA-PHONE brainwave analyzer has adjustable frequency limits, useful in singling out specific frequencies. The frequency limits are adjustable in 1 Hz increments. Their ranges are: 3-13 Hz, 5-15 Hz and 7-17 Hz, respectively. As with the standard brainwave analyzer, the same ± 5% accuracy applies.

common mode rejection

1001:1 or better for 60 Hz signals of less than 0.5 volt peak to peak amplitude. Measured with a 0.1 volt 10 Hz test signal.



block diagram

Custom accessories for the brainwave analyzer

The ALPHAPHONE brainwave analyzer was designed to be adaptable to many professional situations through the addition of accessories. Each of the category lights relates to an output jack. Thus with the same short latency a wide variety of counting, recording and feedback instruments can further assimilate the brainwave signal. As needs in this area vary, most analyzer accessories are custom made to suit individual requirements. In the following, we would like to present an idea of the possibilities and a picture of some of the modules from which custom accessories are made.

Prices are all F O B Mendocino. Delivery times quoted are A R O (after receipt of order). All prices are subject to change without notice.

NOTE:

In attaching equipment to the ALPHAPHONE brainwave analyzer, observe that it is WELL connected to the head. Some form of isolation MUST be provided between the subject and any AC powered tools. Besides the avoidance of the danger of electrocution, isolation must be provided to keep 60 Hz hum from drowning out the weak brainwave signal. To eliminate such problems as these, we use optical isolation, i.e., a light emitting diode — photo transistor coupled pair. For simple isolation of an analog signal, we market the AQUARIAN* photon coupler — a one channel optical isolator. For sophisticated instrumentation, using the category outputs, we custom design the isolation into the switching circuitry and use as many channels as are necessary.

direct switching circuits

It is often useful to control AC powered equipment with the ALPHAPHONE brainwave analyzer's category output jacks. In addition to providing isolation for this application, a high power switching circuit is necessary to convert the low level logic signals to usable voltages. The price for modular isolator/switches with 10 amp, 120 volt switching capability is $150 each. That is, $150 for each channel to be isolated and switched, if ordered separately. If more than one isolator/switch is to be incorporated into the same cabinet, the additional channels will cost $40 each. Thus, four channel switching would cost $270, etc.

AQUARIAN percent/time chart recorder

The AQUARIAN percent/time chart recorder will record on rolling chart paper the percentage of time spent in each of the four brainwave frequency ranges. This instrument consists of: 1) a Rustrak four channel chart recorder with one inch/minute chart speed; 2) four isolating circuits; and 3) four integrating circuits which average each output for driving the recorder. In typical use, the recorder is used to keep track of percent/time production of artefacts, beta, alpha and theta.

Using such an instrument, the experimenter can easily see the changes brought about through the presentation to the Subject of various stimuli and tasks. As much of the subject of correlation of brainwaves with states of consciousness is expressed in terms of percent/time measurements, this is a most valuable tool. The four channel percent/time chart recorder costs $650. A deposit of $400 is required at the time of the order (to pay for the Rustrak recorder). Delivery time is four to six weeks.

percent/time switching circuits

Many experimental designs demand minimum latency for feedback, and thus the brainwave analyzer's output follows very fast shifts in the brainwave signal. A less labile signal is required in other designs where constant on/off switching would be a distraction to the subject or where feedback is desired only for high percent/time states. Our approach is to aver-

age the output signal from the category output jacks and relay this information to variable threshold power switching circuits.

Using an instrument of this type, the operator can choose the percent/time level for a given frequency range by adjusting a front panel control calibrated from 0 - 100%. The instrument's output is activated only if the percent/time exceeds the chosen percentage level. The circuit of such an accessory would be divided into four parts —isolator, integrator (averager), level detector and power switching circuit could be built into the same instrument for $200 per channel. If you choose not to order the recorder, the cost of each integrator/switch channel would be $300 for the first and $250 per additional in the same case. The price for a four channel unit without chart recorder would be $1050. A four channel unit with chart recorder would be $1450. Delivery is six to eight weeks.

isolated preamp

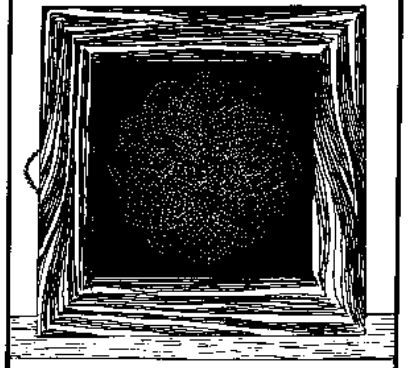
All of the above discussion of accessories assumes that the necessary isolation from AC power will be inserted between the analyzer and the accessory. There is, however, another approach: we can isolate the EEG signal and run it to the analyzer's external EEG input, thus circumventing the built-in preamplifier. One method of implementing this approach is to use the ALPHAPHONE headset as the EEG preamplifier and to use the AQUARIAN photon coupler as the isolator (see headset accessories for information on the photon coupler).

Because the standard Model 501 photon coupler has a transmission loss of about 75% it lowers the EEG amplitude enough to significantly displace the artefact and noise thresholds. A special Model 502 photon coupler is available with a booster amplifier to supply the analyzer with the signal amplitude it needs for best results. This is available for $100. Delivery is six to eight weeks.

note:

If you decide to take advantage of this approach, you would have to be sure that the analyzer is not unwittingly connected to the unisolated accessory boxes. If this approach is taken, and thus if the accessories are built without isolators, the cost of each channel on a typical accessory would lower by $30.

Jean Mayo's visual feedback display



Jean Mayo is an artist and brainwave feedback teacher working in San Rafael, California. Collaborating with Dr. Stanley Krippner of the Menninger Dream Laboratory, Maimonides Medical Center, Brooklyn, New York, Jean Mayo has developed a uniquely pleasing visual feedback display that uses the category outputs from the ALPHAPHONE brainwave analyzer. This instrument, which Dr. Krippner is using to further his now famous study of ESP and brainwaves, is constructed of hardwood and plexiglass with a lighting circuit. The edge lit plexiglass sheets are drilled with mandala-like patterns. The user sits in front of the instrument. The changes in brainwave patterns are displayed as changes in the colored patterns. The display is very effective and offers a good possibility to learn eyes open alpha and theta control. Price for a four channel display is $250. Delivery is four weeks. Price does not include requisite four channel switching circuit.

(something new

is coming)

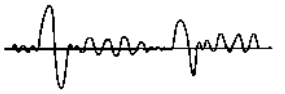
Limits

The problem of brainwave analysis is not a simple one. It requires considerable training to visually interpret the EEG tracings made by a chart recorder. While auditory analysis of the EEG signals from an EEP (such as the ALPHAPHONE headset) is considerably easier to learn, it still requires attention and practice. It should come as no surprise then that a computer would have some difficulty doing something that is a task for a human brain.

Computers are by nature stupid and can only follow orders blindly. The definitions of the brainwave types that are programmed into a computer limit the meaningfulness of its output. However sophisticated the equipment, any computer analysis of brainwaves will have inherent limitations. As well as its many strong points, the ALPHAPHONE brainwave analyzer has such limitations and if you are considering its purchase you should understand them.

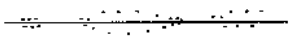
As a simplification, brainwaves can be considered to have two main parameters: amplitude and frequency. The initial problem of brainwave analysis by computer is to provide a measurement of these factors.

Since brainwaves vary constantly in amplitude, it is necessary to carefully consider what we mean when we say that a particular brainwave signal has some stated amplitude. One approach is to measure average amplitude. The principal drawback to this approach is that most artefacts are very high in amplitude while many brainwave signals (especially beta waves) are very weak in amplitude. If their amplitudes are averaged, then a great deal of information is lost—an occasional eye blink can totally distort the data.



Artist's rendering of EEG signal

Average Amplitude Measurement



Peak Amplitude Measurement

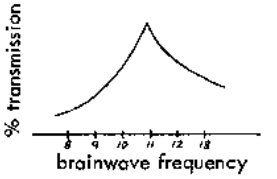
Another approach is to measure the peak amplitude of each individual brainwave cycle. In this way, a weak beta wave will be accurately measured, even though it lies next to a strong artefact. While this approach still involves a simplification of the original waveform, it does not add gross distortion to the simplicity.

Measurement of frequency can be even more complicated than measurement of amplitude. Brainwave signals usually contain a mixture of several frequencies. While one frequency will often dominate, there will nearly always be small (and sometimes large) portions of other frequencies mixed in with the dominant frequency. The only really accurate means of resolving all of the component frequencies and amplitudes are such techniques as Fourier analysis.

Fourier analysis is an expensive process that entails a large computer. To provide the analysis in "real time", i.e., at the time the brainwaves are being monitored, is even more costly than the usual procedure of recording the data and analyzing it later when computer time is available

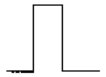
Therefore, because of expense, time lag, complexity and bulk, Fourier analysis is not accessible to most schools, labs, clinics and so forth as an analysis/feedback technique.

A much cheaper way to approach the problem of analyzing brainwave patterns is 'notch' filtering. This technique, like averaging amplitudes, compounds the inherent limitations of simplification with undue distortion.

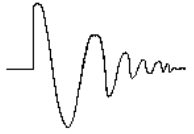


This type of notch filter strongly emphasizes one narrow band of frequencies while suppressing others in the same range. The arbitrary labels for frequency ranges, such as 'alpha', refer to broad ranges, not single frequencies. Thus, a filter which responds to an 11 Hz signal much more sensitively than an 8 or 12 Hz signal, for example, would introduce too much distortion to be of practical use.

As well as the innacuracy of notch filtering, there is another problem with this technique. Notch filters tend to ring—they tend to produce a false brainwave-like signal when shocked by a fast rising, high amplitude waveform, such as an eyeblink or a muscle twitch.



Input
(large fast rising input signal)

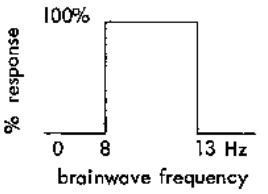


Output
(ringing)

Above is an artist's rendering of the type of ringing a sharp "notch" type filter may produce. Every eyeblink can turn into a burst of false brainwave signals.

This tendency, when coupled with their fundamentally inaccurate filtering, led us to decide that building a notch filtering brainwave analysis circuit would be too high a degree of simplification in the interest of economy.

An ideal filter for frequency data would respond equally well to all signals within a given frequency range while rejecting everything outside that



band. The device should also allow the possibility of filtering for any of the four basic frequencies, not just alpha. To approach this goal, we are using a zero crossing (Z/C) detector followed by a period measuring filter in the ALPHAPHONE brainwave analyzer. The filter accepts all signals within chosen range while rejecting signals outside that range. The error is less than 5%, e.g., the edge limits for the alpha range are 8 Hz ± o.4 Hz to 13 Hz ± 0.65 Hz.

This method yields information on the dominant brainwave frequency quite accurately and quickly, and provides that information in such a way that it is instantly useable to operate a wide variety of accessory counting and feedback systems.

The principal limitation on this technique is that it provides dominant frequency information only. Amplitude information is not taken into account. For this reason, we have supplemented the period measuring circuit with a peak amplitude measuring circuit as mentioned earlier. This is used primarily to discard artefacts and noise. The brainwave analyzer has adjustable upper and lower amplitude limits. If a signal is too strong or too weak, it is thrown out, regardless of whether it happens to be in the selected frequency range.

The result is a tool that uses an imposed definition of brainwave type, i.e., a signal between certain frequency and amplitude limits, to perform averaging and switching tasks. The percent time meter averages frequencies over one of two several second periods to yield a running account of percentage of time a certain brainwave type is present. The category outputs (which are instantaneous indicators — not averaged) may be averaged to build variable threshold switching circuits for experiments in attention, etc.

We are of the bias that frequency and amplitude computing should be done well or not at all. Given the alternatives (a much cheaper method that is unsuitable and a much more expensive method that is impractical for feedback purposes), we feel that period measuring is the best technique. We do not feel that the simple numerical averaging of amplitudes is free enough from complications to be of use, so have used amplitude measurement only to provide definitive limits of acceptance for brainwave patterns. At the time of this writing, we are in the final stages of development of a new method of visual analysis that provides both frequency and amplitude information in a way that is both accurate and easily understandable. As soon as that is perfected we will offer it.

switched analog

The Model 1001A ALPHAPHONE brainwave analyzer's SWITCHED ANALOG feature overcomes one of the major limitations of digital brainwave analysis: the loss of amplitude information and subtle nuances from the feedback signal. In this mode, the analyzer's computer decides if the incoming signal is within the chosen frequency and amplitude limits. If it is, the computer turns on the AM-FM analog representation of the brainwave signal. In this way, both the frequency accuracy of the digital mode and the amplitude information of the analog mode are preserved.

EEG in space

NASA uses a zero crossing detector (Z/C) with a period measuring filter and a percent/time chart recorder to monitor brainwave activity on manned space flights. They report: "The Z/C technique is the most rapid computer technique operating with acceptable real time; consequently it is the lowest in cost since it also lends itself to a variety of small, compact, inexpensive computers. ...Despite the problems inherent in the simple Z/C analysis (inability to use poor quality records such as those derived during eating), the method in combination with our standard deviation criterion has provided extremely high resolution of the subject's state of consciousness as recorded during the flight. ... The benefits of this analysis are further demonstrated by its ability to classify extremely light sleep (for example, that occurring between 08:00 and 10:00) which is classified as "eyes closed but awake" by routine visual analysis. These facts...have provided the electroencephalographer with a quantitative tool heretofore unrealized in the clinical evaluation of EEG's." (NASA SP-5078m, U.S. Government Printing Office, Washington, D.C., 20402, $2).

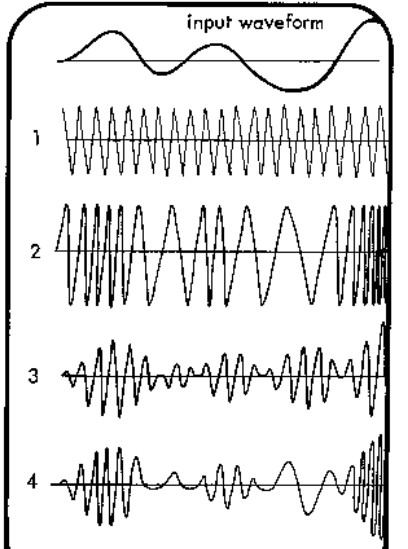
The Preamplifier

All of our three primary instruments, the ALPHAPHONE headset, the ALPHAPHONE basic e.e.p. and the ALPHAPHONE brainwave analyzer, share essentially the same preamplifier. The exception to this is that the analyzer preamp has been modified to have a flatter frequency response and to contain a 60 Hz notch filter to exclude powerline noise.

One of the main features that sets the basic e.e.p. and headset apart from other instruments in their price range is the low noise AM-FM preamplifier that the instruments share. Most (if not all) of the currently available low cost EEPs modulate either the frequency or the amplitude of the internally generated tone, not both.

The difference between AM-only, FM-only and AM-FM modulation is important to understand. It can make the difference between whether or not the instrument is understandable and useful. In the classical paper on EEPs, Peter Stewart, William Belcher and John Morris report on their findings with these three approaches (EEG and Clin. Neurophysiol., 11:161-164, 1959). They conclude that: "The sound of the output from the EEP (encephalophone) when brainwaves are fed into it is difficult to describe verbally. In general, amplitude modulation is not very satisfactory. The chief difficulty is that it is not polarity sensitive, so that the apparent frequency of repetitive signals such as the alpha wave is twice the actual frequency. Frequency modulation permits the ear to follow the EEG tracing very easily and to pick out characteristic patterns as they occur. The only objection to FM alone is the constant background level, regardless of signal intensity, which becomes distinctly unpleasant after a brief period of listening. Combining amplitude and frequency modulation eliminates both of the difficulties, and provides a very sensitive method of analysis of brainwave patterns. With very little practice, characteristic patterns can be readily detected by ear and recognized when they occur."

It is somewhat clearer to represent the three approaches to brainwave modulation of a tone with diagrams. Figure 1 is the unmodulated tone, a single constant sound generated within the circuitry. Figure 2 illustrates FM-only modulation. The spaces between zero crossings, measured horizontally, are sensed by the ear as a changing rhythm of constant loudness. Figure 3 illustrates AM-only modulation. The



distances between the wave peaks, measured vertically, are sensed by the ear as a tone of constant pitch, or as white noise in some instruments, with only the loudness changing. This doubles the apparent frequency of the brainwave signal. Figure 4 illustrates the combination of AM and FM modulation. The internally generated tone is varied both in frequency and amplitude, (both horizontally and vertically in graphic terms and both in pitch and volume in common ones).

The human ear is a very sophisticated harmonic analyzer. It can distinguish fine subtleties in speech that are far more complex than the sounds produced by an EEP. Provided the EEP is of good quality and of AM-FM design, an average person with only a little practice can hear fine variations in his brainwave patterns. For some purposes, some researchers consider auditory analysis of EEP sounds to be superior to visual scrutiny of EEG ink tracings. This is especially the case when using brainwaves for feedback purposes with naive subjects.

Experimenting with hyperkinetic adolescents (who have much weaker powers of attention than the average person) the Rev. George von Hilsheimer, Superintendent of the Green Valley Residential Treatment Center in Orange City, Florida, reported that "successful training of naive and unaware subjects to produce alpha rhythms on signal can readily be demonstrated." (von Hilsheimer, Some simple techniques in biological and behavioral feedback, annual meeting of A.A.B.T., Washington, D.C., 1971). Author of How to Live With Your Special Child and many professional papers and monographs, he further reported in this 1971 paper that: "After experimenting with a number of inexpensive alpha filters which signal alpha production with light or sound, we have concluded that the most flexible and reliable is the ALPHAPHONE [headset], made by Aquarius Electronics, P.O. Box 627, Mendocino, California 95460 ($140)".

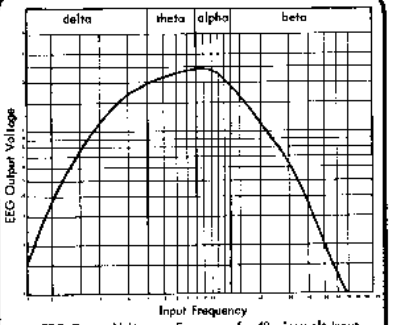
Another yardstick of EEP quality, besides the basic approach used in modulation of the tone, is noise. There are three main sources of noise that are potential problems in EEP preamplifier design: 1) noise generated within the circuitry, 2) DC electrode potentials and electrode artefacts, and 3) 60 Hz hum (powerline noise).

The first problem is handled in our instruments by efficient design, good choice of components, careful workmanship and thorough testing. The equivalent input noise of each instrument is measured on an oscilloscope to be less than 5 microvolts peak to peak. We consider peak to peak noise measurement to be more meaningful than RMS noise measurement. In terms of the latter the figure would be considerably lower than 5 microvolts, which is why many companies with noisy circuits prefer to list their noise tolerances in those terms.

In many current EEP designs there is a need for expensive rare metal electrodes and for great care in placing them on the scalp. Without the expensive electrodes and careful contacts, the relatively weak brainwave signals would be drowned in a flood of noise from electrode artefacts and DC electrode potentials.

By rolling off the frequency response in the delta range (see diagram of frequency response, following) the problem of DC electrode potentials is non-existent in our instruments. By using a high enough input impedance in the preamplifier, the problem of artefacts due to poor electrode contact was eliminated. Thus there is no need to pay for gold or silver electrodes and no need to use any more than normal care in placing them on the scalp.

The preamplifier's high frequency response has been similarly rolled off to suppress the intrusion of 60 Hz noise. The frequency response is down at least 20 db at 60 Hz, enough to suppress powerline noise and high frequency muscle signals. Powerline noise usually becomes a problem when the electrodes are not properly contacting the scalp. By designing the preamplifier so that electrode contacts are not critical, this problem is further reduced. In practice, you would have to be within inches of an electric clock or fluorescent light (the strongest household generators of electric noise) to hear any buzzing.



EEG Output Voltage vs Frequency for 40 microvolt input
(This is a typical curve, which will vary with battery condition)

Preamplifier Specifications

input impedance

1 megohm

common mode rejection

1000: 1 or better for 60 Hz signals of less than 0.5 volt peak to peak amplitude. Measured with 0.1 volt test signal.

frequency response

Covers the high delta range, all theta and alpha, and the low beta range. (See graph). Down at least 20 db at 60 Hz. Rejects high frequency EMG

(muscle) and low frequency electrode artefacts.

equivalent input noise

Less than 5 microvolts peak to peak with inputs grounded. Measured with an oscilloscope at output over at least 15 second period.

gain

Typically between 50,000 and 100,000 for headset and basic e.e.p. Typically between 25,000 and 50,000 for brainwave analyzer.

60 Hz notch filter

The brainwave analyzer's preamp has a 60 Hz notch filter built into it. This provides at least 100,000: 1,60 Hz rejection. This does not apply to the headset or basic e.e.p.

electrodes

Due to frequency response roll off at low frequency end, D C electrode potentials are not a problem with our instruments. Due to high enough input impedance, electrode artefacts are minimized. Rare metal electrodes are not needed with our instruments.

AM-FM circuit

Our preamplifier design uses chopper modulators for AM-FM mixing. The combination of the chopper modulator and Aquarius's unique squelch circuit gives excellent carrier suppression for zero EEG input voltage, thus eliminating annoying background sound.

center frequency

The basic e.e.p. and Model 102A headset have fixed center frequency (pitch of the audible tone). This frequency will fall somewhere between 400 Hz and 2 K Hz. The Model 102T headset and the brainwave analyzer have tone controls for adjusting the center frequency over at least one octave within the 400 Hz to 2K Hz range.

FM deviation

The amount of FM deviation produced by the voltage controlled oscillator (VCO) varies depending on the tone and sensitivity control settings. In any case, it is at least 10% for a 40 microvolt input signal at maximum sensitivity.

audio output

The AM-FM circuit's audio output is sufficient to drive most low impedance headphones (8 or 16 ohm).

It should be understood that while brainwave feedback is spreading from the confines of the laboratory into the field of social application, the work is still highly experimental. Although our instruments are advanced for their time, they are sketches and prototypes for more sophisticated instruments yet to be designed.

We are in uncharted waters and are soliciting explorers rather than tourists. We would appreciate feedback from our customers as to how our instruments might better be designed to serve self-understanding. We would also appreciate a mature use of brainwave feedback to discourage the media's thirst for sensationalism.

We make no medical claims for our instruments. We do not yet know of any hazards associated with brainwave feedback, but neither can we predict the future. Thus we can assume no responsibility for any risks.

Ordering Information

Please read carefully.

ORDERING

We have two ordering plans:

1) You may send payment with your order (check or money order), in which case we ask that you use registered mail.

2) You may order C.O.D., and pay your post office when the products arrive. C.O.D. orders may only be accepted from within the United States (by postal regulation). If you live outside the United States, please send your remittance by registered mail, in U.S. funds. If we receive an order without enclosed payment, we will assume that it is a C.O.D. order.

SHIPPING

We always ship by the fastest possible U.S. Postal Service (unless otherwise instructed). If you live nearby, we will ship via Parcel Post - Special Handling. Otherwise, we will ship via Air Parcel Post. In any case, orders are shipped insured for their full cash value or for the postal maximum of $200, whichever is less. Prepaid orders are shipped with return receipt requested so that we know your order has been received safely.

POSTAGE

We will ship orders with shipping charges collect unless you prepay them. The shipping weight of each item is listed on the order form. If you add the weights of the items you wish to order, and add the dollar value of these items for computing insurance, your local post office will be able to give you the exact shipping charges. As all major items are shipped separately, only those whose individual dollar value is greater than $200 (such as the brainwave analyzer) will be insured for less than their full value.

If you would prefer not to calculate the shipping charges, you may either have your instrument shipped collect (pay the postage when you receive the instrument), or overpay enough to cover the charges (and receive refund of difference). For example, the cost of shipping an ALPHAPHONE* headset anywhere in the United States is less than $3. The cost of shipping a headset anywhere in the world (not including customs duty) is less than $10.

FOREIGN ORDERS

Since C.O.D. shipments are not accepted by the postal service for delivery outside the U.S.A., we must ask that you enclose payment with your order. This payment should be in the form of a bank draft drawn on an American bank and must be in U.S. funds. Such a draft has the U.S. bank's identification number printed in its upper right hand corner. An example of such a number is: $\frac{90\text{-}380.}{1211}$

Almost any bank can provide such a draft. Payment in this form allows our bank (Fort Bragg, California, office of Crocker National Bank) to credit our account immediately instead of after a three to four week delay.

Customs charges and regulations change frequently. It is therefore impossible for us to keep ourselves accurately informed of these changes, so it is the buyer's responsibility to find out what these charges and regulations are. You will have to pay any customs duty due when you receive your shipment.

If you would like us to label the package in any special (legal) way to aid in customs clearance, let us know when you place your order. To aid in describing these instruments to your customs officials, explain that they are bio-electronic monitors and inject no current into the body.

INVOICES

If you need invoices to be either enclosed with shipment or sent under separate cover, please let us know at time of ordering. We do not enclose invoice with order unless specifically requested.

We cannot afford to extend credit except in the case of universities and other large institutions who cannot make purchases any other way, for which we apologize.

TELEPHONE ORDERS

We will accept telephone orders for instruments to be shipped C.O.D. We cannot accept collect calls or ship C.O.D. to APO, FPO or foreign addresses.

If you place a telephone C.O.D. order, please send a confirming written order stating date of call in space provided. Brainwave feedback has proven to be useful in a variety of ways and holds exciting potentials. It is, however, an exploratory field and our instruments are exploratory tools. We ask for a written confirming purchase order so that we will have a signed understanding that the buyer is in essence a pioneer, charting a yet barely charted area.

Model #	Product	Price
201	ALPHAPHONE basic e.e.p. Includes: instrument, batteries, headband, electrodes, electrode cream, instruction book and record, one year warranty. Shipping weight: 2 lbs.	$80.
102A	ALPHAPHONE headset (without tone control). Includes: headset (with integral electrodes), batteries, headband, electrode cream, instruction book and record, one year warranty. Shipping weight: 2-1/2 lbs.	$140.
102T	ALPHAPHONE headset (with tone control). Includes: same as Model 102A. Shipping weight: 2-1/2 lbs.	$150.
1001A	ALPHAPHONE brainwave analyzer. Includes: brainwave analyzer, electrode assembly (bipolar), headband and electrode cream, one year warranty. Batteries are not included due to their high shipping cost. Shipping weight: 7-1/2 lbs.	$450.
1001A-B	Battery set for brainwave analyzer, installed. We recommend you save shipping cost and buy locally. Shipping weight: 6 lbs.	$5.

Model #	Product	Price
501	AQUARIAN photon coupler. Includes: photon coupler, batteries, instructions and one year warranty (no patch cords). Shipping weight: 2 lbs.	$75.
502	AQUARIAN photon coupler (with booster amplifier). Includes same as above. Shipping weight: 2 lbs.	$100.
600	Pulse forming network. Includes: instrument, instructions. Shipping weight: about 1/2 lb.	$15.
610	Calibration oscillator. Includes: instrument, instructions. Shipping weight: about 1 lb.	$40.
620	Demodulator. Includes: instrument, instructions. Shipping weight: 1/2 lb.	$70.
301	AQUARIAN FM transmitter. Includes: transmitter (with bolts for attaching to headset or basic e.e.p.), batteries, instructions. Built-in cord. Shipping weight: 1/2 lb.	$20.

Model #	Product	Price
CN 1	REALISTIC™ battery powered audio speaker/amplifier. Includes: speaker/amplifier, battery, patch cord and instructions. Shipping weight: 10 oz.	$10.
CN 2	NOVA-FONE™ earphone. Includes: earphone, patch cord. Shipping weight: 6 oz.	$4.
CN 3	Patch cord with male mini-phone plugs on either end. 3 feet long. Shipping weight: 6 oz.	$1.25
CN 4	Patch cord with male RCA (phono) plug on one end, mini-phone plug on the other. 3 feet long. Shipping weight: 6 oz.	$1.25
1501	Four channel switching/isolating circuit. Includes: switching box, cables for connecting to analyzer. Allow 4 to 6 weeks delivery. Shipping weight: about 10 lbs.	$270.
1502	Four channel percent/time chart recorder. Includes: chart recorder, cables for connecting to analyzer. Allow 4 to 6 weeks delivery. Shipping weight: about 20 lbs.	$650.

Model #	Product	Price
1503	Four channel variable threshold isolator/switch with percent/time chart recorder. Includes: chart recorder and switching circuit, cables for connecting to analyzer. Allow 4 to 6 weeks for delivery. Shipping weight: about 30 lbs.	$1450.
	For more or less channels, custom designing, etc., please call or write the factory. Our number is 707 - 937 - 0064	
1504	Jean Mayo's visual feedback display. Includes: handmade hardwood/plexiglass instrument with cables for connecting to isolator/switching box (direct or variable threshold). Does not include switching box. Delivery is at least 4 weeks.	$250.
B1	ALPHAPHONE headset instruction manual. Includes: correlation, practice (emphasis on meditation), research bibliography, instrument operation, technical information, questions and answers on brainwave feedback. 98 pages.	$2.50

Model #	Product	Price
B2	ALPHAPHONE basic e.e.p. instruction manual. Includes same as above with supplemental instructions for basic e.e.p. 102 pages.	$2.50
B3	ALPHAPHONE brainwave analyzer instruction manual. Includes same as above, but has operating instructions and technical information for brainwave analyzer instead. 100 pages.	$2.50
B4	ALPHAPHONE headset instruction record. Describes analog (AM-FM) brainwave sounds.	$ .50

All orders for instruments naturally include instructions. If you would like to buy your manual in advance, we will credit you with $2.50 against the purchase of an EEP. Please mark appropriate box on order form if you are buying an instrument and already have the instruction manual. Booklets, with or without a record, will be shipped airmail for 50¢ additional. Californians please add 5% sales tax. Orders from out of state to be shipped to addresses in California should also include 5% sales tax.

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quan.	mod.#	product	ship. wt.	price	total

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dealer | 5% California sales tax

ship collect | postage

ship C.O.D. | Total

☐ confirming telephone C.O.D. order of ___/___/___

-over-

I understand that I am buying and will be using these instruments at my own risk.

signature _____ date _____

comments:

AQUARIUS ELECTRONICS

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United States of America