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**Special Reports
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Communication by Electromagnetic Energy

EDWIN WAIN

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4- AFCRL-64-910
NOVEMBER 1964

2^a **Special Reports
No. 12 .**



2 **Communication by Electroencephalography,**

3 **E.M. DEWAN**

The experiment reported here was performed in the Stanley Cobb Laboratories for Psychiatric Research at Massachusetts General Hospital while the author was on leave of absence from Air Force Cambridge Research Laboratories

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10 (AIR FORCE CAMBRIDGE RESEARCH LABORATORIES) (MICROWAVE PHYSICS LABORATORY) PROJECT 5635 (UNITED STATES AIR FORCE) L.G. HANSCOM FIELD, MASS.

Declassified and Approved For Release 2011/12/01 : NSA-RDP96X00790R000100020029-5

Abstract

The alpha rhythm can be blocked by visual concentration to control an electric switch at will. This could in turn be used for purposes of control or communication directly via EEG signals—in other words, by thought manipulation. Although practical applications of this idea have yet to be investigated, the actual demonstration of a thought-controlled device is in itself of interest.

Communication by Electroencephalography

If a person could manipulate a switch simply by altering his thoughts in some way, he could communicate with or control some part of his environment without recourse to motor activity. Certainly, a device that could do this would have a number of possible applications—for example, in the field of prosthetics. Ideas of practical applications will be left to the reader, however, since a thought-controlled device is of possible interest in itself, and this report will be confined to a description of methods and equipment.

The main purpose of this note is to point out that under certain circumstances a person can utilize well-known properties of the alpha rhythm to turn a switch on and off merely by regulating his thoughts in a way to be described. To prove the feasibility of such an approach, the author has used the electronic equipment described below and has successfully turned a desk lamp on and off at will solely by manipulating his own EEG. (This experiment has on several occasions been successfully performed in the presence of an audience, one member of which was asked to say "now" whenever he desired the lamp to be switched on or off.)

It is well-known among electroencephalographers that many individuals possessing prominent alpha rhythms (10 cps approx.) can cause such activity to "block" by opening their eyes, or even by keeping their eyes closed and concentrating on a vivid mental picture of some object, scene, or pattern. Such individuals can turn their alpha waves on merely by "resting," or turn them off by thinking

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visually. It is a relatively simple matter to amplify EEG voltages so that they can trigger a relay—whenever the alpha rhythm is on, say; hence, such individuals could signal by using Morse code, for example, merely by thought manipulation.

The following is a detailed description of the procedure used by the author as the subject in the above-mentioned feasibility test (see Figure 1 for the general diagram).

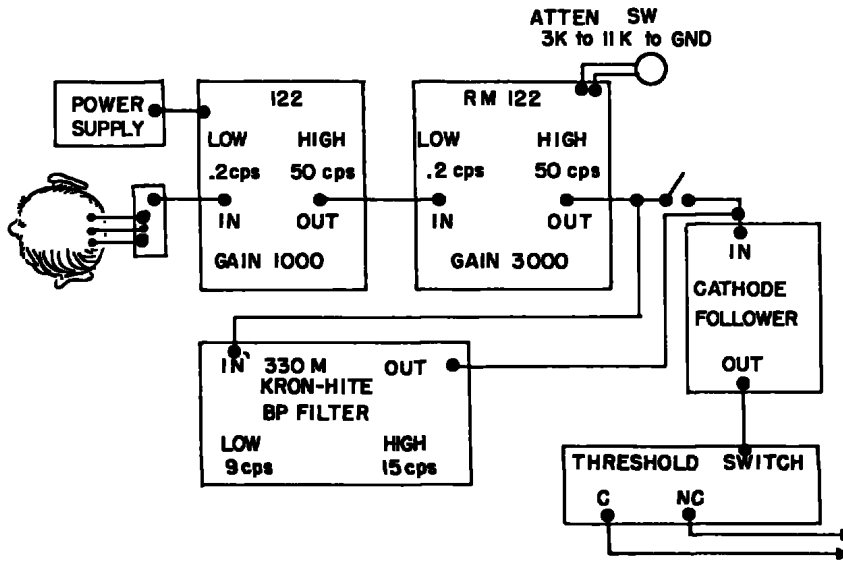


Figure 1. Block diagram of integrating threshold switch and associated equipment.

1. A pair of EEG scalp electrodes were attached to the occipital region in the usual manner.

2. Two high-gain amplifiers (a Tektronix Type 122 low-level preamplifier and a Tektronix RM 122 preamplifier) were connected in series and used to raise the voltage of the alpha rhythm signal to 3 or 4 volts.

3. Next the signal was sent through a bandpass filter (Model 330M KRON-HITE Bandpass Filter, 2 cps to 20 kcps), which had been set for a range of 9 to 15 cps.

4. A cathode follower was inserted to allow the signal to operate the next device.

5. An integrating threshold switch (Figure 2) was activated whenever the alpha rhythm was on for more than a very short duration.

Figures 3(a) and (b) show oscilloscope traces of the EEG during blocking and alpha activity, respectively. It should be mentioned that these were obtained with the help of a shielded chamber to cut down electrical interference. In contrast,

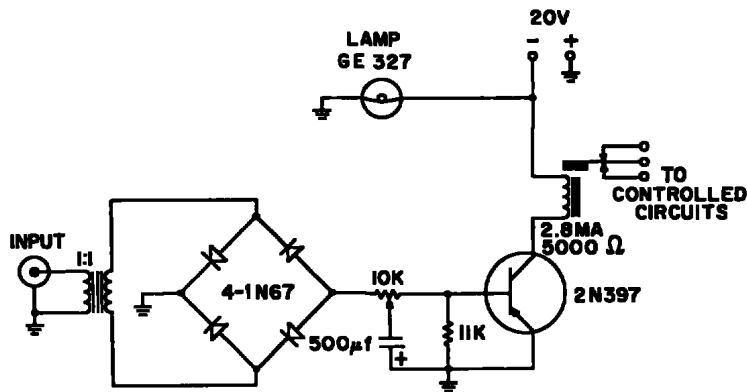


Figure 2. Schematic diagram of integrating threshold switch.

Figures 4(a) and (b) show the filter-induced enhancement of the difference between blocking and alpha activity. Under the ideal conditions of the experiment, there is no ambiguity as to whether the alpha rhythm is on or off. The use of shielded chambers might under most circumstances be avoided by using the filter.

There are several possible ways of modifying the equipment to improve both the form and quantity of the information output. For example, there is no reason in principle why the series of information bits could not be used to operate an electromechanical typewriter such as could be provided by some sort of modified and augmented* teletype machine.

The output might also be used to control electromechanical devices that could manipulate things in the environment, such as a very crude "grasping" instrument. An even further extension of this idea exists in the possibilities of increasing the information output by using the right and left hemispheres of the brain independently.† It could even be speculated that a person could learn to modulate the frequency of his alpha rhythm.

In summary, under certain circumstances it is possible for a person to manipulate his EEG in a way that permits communication without motor activity.

*As pointed out in a private communication by Dr. F. Brooks of IBM, a special purpose computer might be necessary to eliminate problems arising in communication with a mechanical device utilizing imperfectly timed coded signals. In other words, it is not obvious how a device such as a teletype could "recognize" Morse code signals with dots and dashes not having constant time values, unless some sort of intermediate recognition device were added.

†This idea was suggested by Dr. W. McCulloch of Massachusetts Institute of Technology who pointed out that the alpha rhythm of the hemispheres could be independently blocked by focusing attention on particular parts of the visual field.

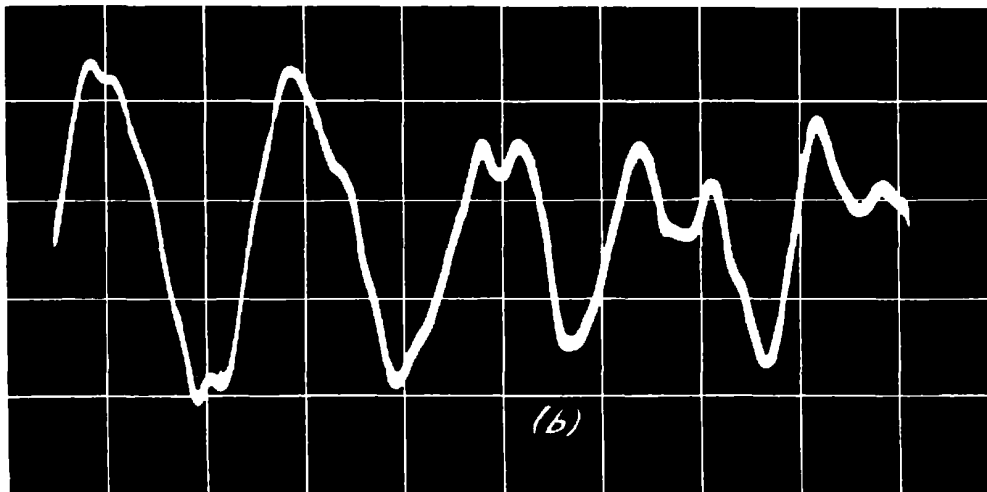
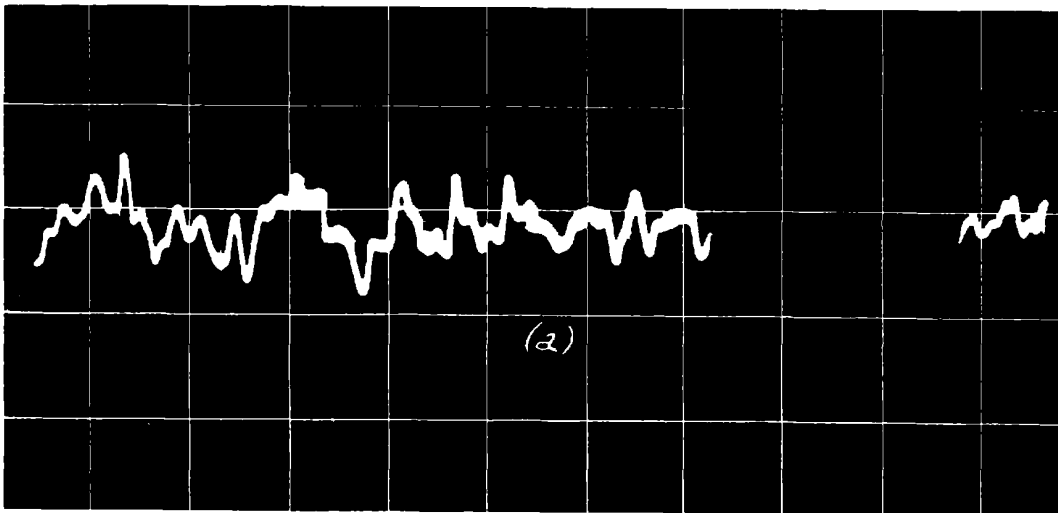


Figure 3. Oscilloscope tracings of amplifier output: (a) alpha blocked, (b) alpha on. (1 v per abscissa division and 50 msec per ordinate division)

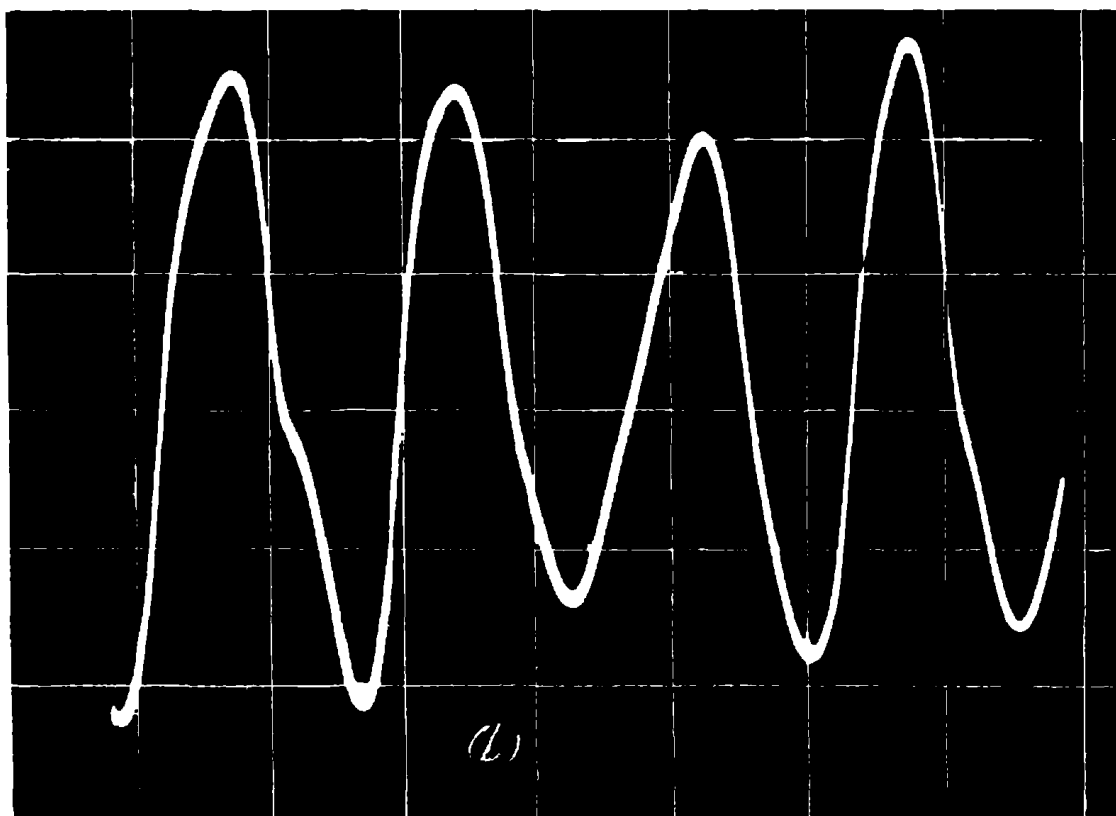
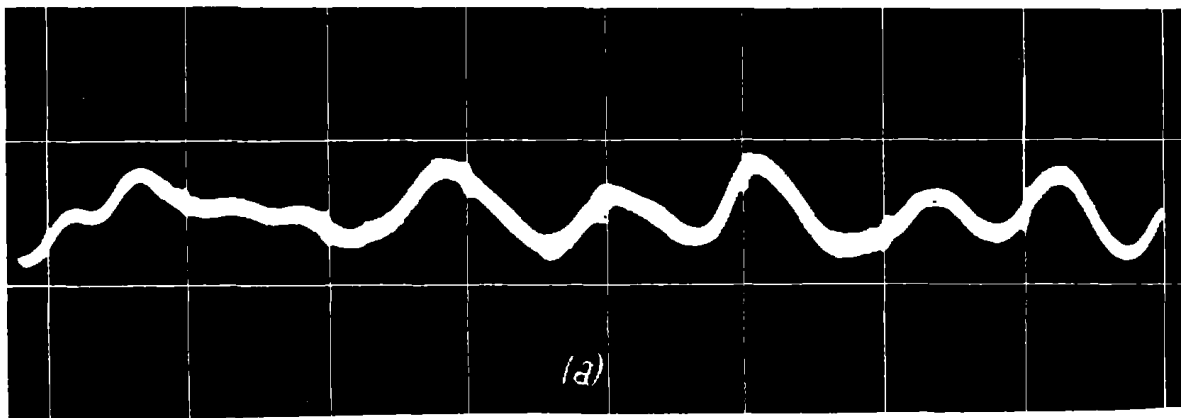


Figure 4. Oscilloscope tracings of amplifier output after filtering: (a) alpha blocked, (b) alpha on. (1 v per abscissa division and 50 msec per ordinate division)

ADDENDUM

1. An investigation of the channel capacity of this method of communication has since elicited that an average of 16 to 20 sec per letter gives reliable communication with the present apparatus. (Morse code was used and the light was replaced by an audio oscillator.) The major difficulty seemed to be that hysteresis in the threshold switch caused a gap of approximately 2.5 v between the On and Off thresholds. Presumably, this could easily be remedied, and many other refinements could be made to enhance reliability and speed.

2. It has been brought to the attention of the author by reliable authority that patients without any motor control whatever simply do not exist. Even if they cannot move a muscle, they still have detectible electromyographic potentials that could be utilized. Since it is likely that the resulting signals would be far more reliable than those from modulated brain potentials, a computer converting Morse code into more useful outputs (such as teletype) might be much more efficient when applied to electromyographic potentials than to EEG potentials. The use of EEG for communication purposes therefore seems to have very little likelihood of practical application at this time.

3. On the other hand it should be mentioned that there are epistemological implications of this work with respect to the operational definition of consciousness, for example, in the hypothetical case of a brain in vitro without efferent and afferent connections. If such a preparation is assumed to have originally been part of a human organism that could in its natural state use the method of communication described in this report, then it could perhaps continue to respond meaningfully to messages sent to it by direct cortical stimulation (say, to the auditory projection area). Assuming the responses were meaningful and consistent, then there would be justification for concluding that the isolated brain was still conscious.

For further work on the epistemological problems of defining consciousness, see "Other Minds: An Application of Recent Epistemological Ideas to the Definition of Consciousness," by E. M. Dewan, in Philosophy of Science 24:70, January, 1957.

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