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Electroencephalography

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ELECTRO-ENCEPHALOGRAPHY

A SENIOR THESIS
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INTRODUCTION

Electroencephalography is the art of recording potential changes in the surface of the brain and underlying structures by means of a galanometer or cathode ray deflection tube.

The potentialities of this instrument are not yet fully realized but sufficient experimental and clinical evidence has been collected to make even the sharper critics admit that this apparatus has a definite place in modern psychiatry.

With this instrument we approach the actual seat of vital phenomena, the abnormal function of the cerebral neuron. Much work has been done on microscopic anatomy, radiologic studies, complex chemical analysis but none of these methods have attacked the problem so directly, nor have they given the promising results.

> "Scientific writings are filled with classical accounts of epilepsy, described with the detachment of an apathic curiosity or attached with the anger of frustration yet the "falling sickness" has remained adomant to theraphy, resistive to timely diagnosis. The history of epilepsy is an apologia for rejected theories and discarded technique.
>
> The skepticism, then with which Berger's discovery was received is not to our discredit. It emphasizes the vitality of scientific tolerance. Caution indurated by the prejudices of experience. Consequently the new science must be subjected to severe tests before exception."

Electrical phenomena of the human body has been used for some time in diagnostic methods. The electrocardiography is an example of this. Much finer diagnosis prognosis and indication for types of therapy in ear ly diagnosis are indicated by these methods. This last factor expresses the only hope for cures and help in the mental conditions. Even as Tuberculosis, heart conditions, diabetes and cancer are given hope by early recognition and treatment. Organic lesions especially and some of the psychosis are recognized and detected much earlier than clinical evidence manifests itself.

Mental diseases are rapidly becoming a serious problem in the sociologic problems of today as well as an economic burden. Many who should be institutionalized are now denied the treatment which might correct their condition were it applied early. The possibility of making a large percentage of the now non-supporting mental cases either partialy or completely self supporting is not to be overlooked.

Localization of tumors and adhesions or other similar organic lesions would certainly make this method practical by eliminating the air encephalogram and the necessary hazzard encountered with it as well as the diagnostic use of convalescence.

In 1875, R. Canton, M. D. of Liverpool, England recorded by means of a sensitive galvanometer, potentials from a rabbit's and a Monkey's brain resulting in the following conclusions.

> "In all brains examined the galvanometer, has showed the presence of electrical currents, the gray matter being positive to the cut surface. The currents seem to be related to function. When any part of the gray matter is functionally active, its electric current exhibits negative variation. Stimulation of the retina by light showed marked changes in potential in the respective areas." (63)

This was confirmed in 1890 by Marxow and by Beck (1890). Localization of potentials to the occipital lobes was affected in 1891 by Gotch and Horsby (60) and confirmed later by Prowdiez-Neminski (1913).

With the development of the electronic valve, amplifiers have been designed which greatly magnify formerly quite insignificant potentials. This field of experiment was first reopened by Fischer and Kornmuller in Germany (1927). It was taken up by Adrian in England and Bartley and Bishop in this country.

Up to this time all work was done either on animals or during exploratory operations on human beings by direct contact with the brain surface.

Berger (1929)-(48)- (1937) was the first to show definitely that brain potentials could be recorded through the intact skull by means of surface electrodes,

thus giving a practical clinical possibility to the situation. Comparison of records from the brain (direct contact) and from the skin surface were practically identical except in amplitude.

This was confirmed by all the experimenters at this time and has duplicated several times in recent years during trephine, decompression and other brain proceedures. So it is that with the production of more efficient scientific instruments, what was formerly merely an interesting phenomena, now becomes the basis for a new method in diagnosis and recognition of mental conditions.

To appreciate the speed with which this phenomena is being enlarged and developed one need only compare the quantity and quality of articles in periodicals from 1927-1934 with those from 1934-1938.

APPARATUS AND METHODS OF RECORDING.

The first records were made with standard half-wave resistance, capacity coupled, amplifiers as used in biological work. This usually consisted of three to four stages coupled to a power output stage. The power supply to the first three or pre-amplifier stages consisted of dry cell batteries. The last stage was supplied by an alternating current power pack.

These first amplifiers showed many types of distortion. Mainly, they were designed to operate at low frequency cut-off (100-120 cycles /sec.), the period of the major brain modulations are 2-50 cycles /second.

This did not discredit the records only in that they did not show their true form. According to R.C.A engineers low frequency cut-off expressed in cycles divided into 100 times the charted value (65 pp176) for the coupling condenser gives the desired capacity for passing low frequency oscillations. It has been found that values of about 1-4 Mfd. oil type condensers are preferable because of the elimination of leakage. Ordinary paper condensers will cause false spikes and sine forms on the record and when it is realized that the average potential of brain modulations is fifty-one millionths of a volt, necessity for the best equiptment can well be understood.

With the ability of a V.T. amplifier to pass low oscillations another obstacle is encountered. In multi-stage apparatus as used in high-gain amplifiers a tendency to "feed-back" to the grid of the previous stages is encountered especially in amplifiers of more than three stages, causing an annoying low frequency oscillation, known as "motor boating". This destroys the realization of the complete gain of the pre-amplifier. Complete isolation of power supply to individual tubes is the solution to this problem either by condensers and resistors or by separate battery supply.

Microphonic noises in tubes are also found commonly in high gain amplifiers. It is necessary to use shields over the tubes, or preferably metal tubes which provide more complete shielding. The grids leads should be shielded as well as attenuators in the grid circuits. as well as care in design so as not to overload the grids of the following stages. Sponge rubber mounts for the tubes are of considerable value and only the best parts should be used throughout. Now with the high gain we find that the amplifier picks up 60 cycles of current unless a completely shielded room is available. This can be eliminated to a certain extent by the use of a filter which eliminates the high frequencies, as all we want to record are those frequencies below 50 cycles/second.

In the half wave type amplifier we encounter distortion due to harmonies generated in the tubes, th e even number harmonies being particularly trouble-some and tend to cause a fuzzy base line of varying potentials as well as distorted records. This is remedied by using a push-pull arrangement in which the grids of the out-put stage is fed 180 degrees out of phase, thus cancelling the even harmonics. This is done by some method of phase inversion.

Garceau (7) uses such an apparatus, see Illustration I. In addition he uses a vacuum tube bridge in the out-put thus getting a more perfect impedance match between the out-put and the galvanometer as well as applying a constant load to the plate circuit. This bridge is excited by a three stage pentode pre-amplifier the last stage being a phase inverter, but not of a very efficient type as un-equal potentials are applied to each push-pull grid. He found that blocking did not occur if care was exercised in attenuation of intermediary stages. This method gives a linear output without excessive voltage supply. This is a bridge known as the Wold and Wynn-Williams vacuum tube bridge and is patented by these engineers.

Garceau and Davis (56) also have designed an amplifier system for use of a four element cathod ray

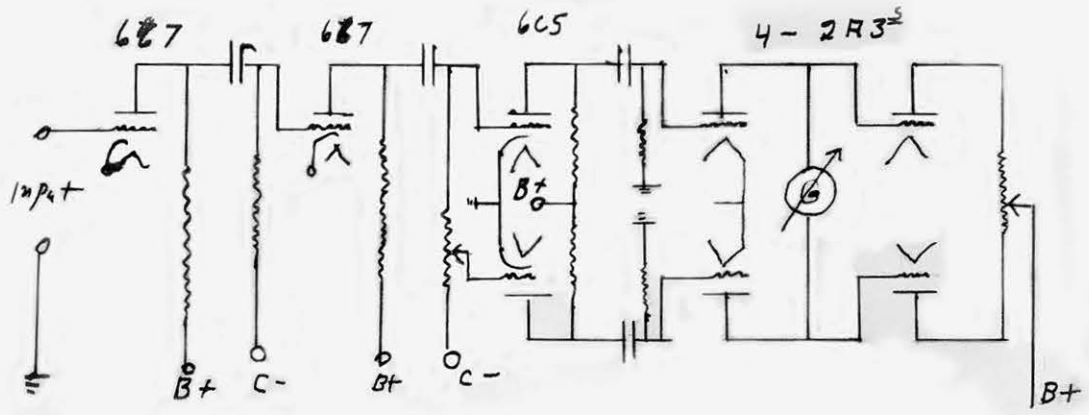
tube which consists of a three stage pre-amplifier resistance coupled, a phase inverter, a parallel stage of pentodes driving the power out-put push-pull through the inverter. This high gain is necessary for the cathode ray deflection plates. Twin triode method of phase inversion is a more practical and distortion free method of obtaining 180 degree phase currents for push-pull out-put (65). The amplifier compares closel y with one designed by Tonnes (53).

Matthews (64) designed a similar type of amplifier which is even more highly corrected for distortion using a balanced in-put. This method (see illustration #2) provides two "floating" leads in no way directly grounded. The in-put of these two tubes is then connected to the conventional type amplifier.

This method has the following advantages:

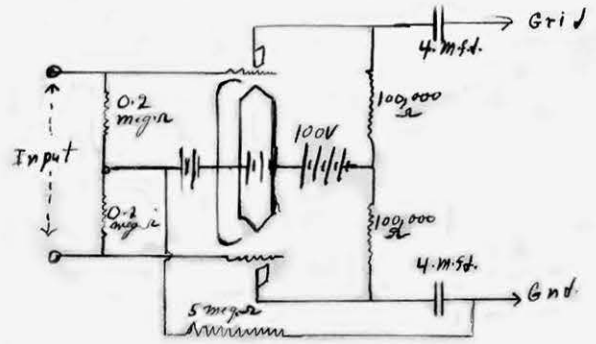
1. Immunity from electrical feed-back from later stages through the preparation.
2. Greater reduction in stimulus escape when electrical stimulation is employed.
3. Comparative freedom from external electrical interference.
4. No interconnection between multi-channel simultaneous recording.

A single tube, dual channel with a common ground or indifferent lead with two grid leads, one to the heart area, and the other direct to the liver gave similar



Wold & Wynn-Williams V.T. Bridge.

Fig. 1



Matthew's "Floating" Lead stage

Fig. 2

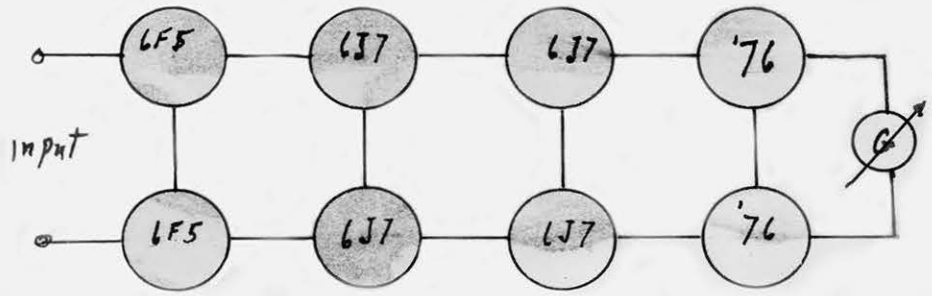
recordings. With the balanced type floating lead input this error did not occur.

Probably the most desirable form would be an amplifier using push-pull throughout (see illustration #3)

Matthews (1) has found it desirable to be able to control the frequency cut-off by various coupling condensers placed and changed in the circuit by a switch. He finds it easier to read results this way. He also finds it to an advantage to have a speaker in the out-put so that sound can be heard. Many times a loud sound will be heard where very little change in the record is to be seen.

Gibbs, Lennox, Gibbs, (28) and Gerald, Marshal and Saul (26) state that by the use of a sharply tuned amplifier frequencies are recorded which are not seen when diffuse end standard electrodes are used. This method also facilitates interpretation of records especially in localizing prodedures.

Matthews' oscilloscope has a period of one six-thousandth a second which is not necessary. The oscilloscope although free from distortion due to mechanical inertia produces records differing unnoticabely from ink-writing galvanometers. This has been confirmed by Garceau (7), Jasper and Carmicheal (2) and Kornmiller (60)--see Illustration #4.



Resistance, capcity coupled – Amplifier, class A coupling
Maximum Theoretical gain 449,412,500

Fig. 3

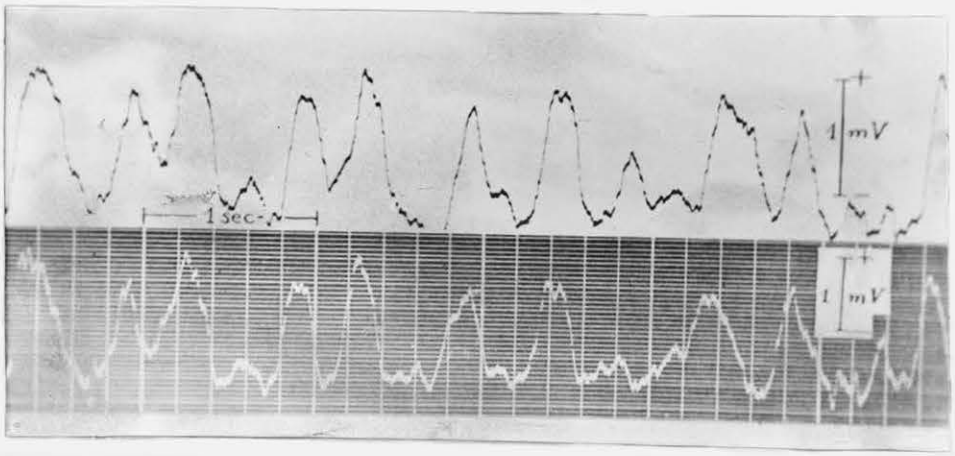


Fig. 4

Garceau (7) uses a Western Union, Boehne type 2A undulator converted to respond more quickly but even so it requires considerable power. It is much more economical as it writes on a plain paper ribbon in contrast to the use of 35mm. film in the care of the cathod ray oscilloscope which also requires a camera.

Jasper and Carmicheal (2) record a spiral record on a drum eight feet long and fourty-five inches in circumference. This gives an easier record to read. They use two dynamic type syphon recorders which are quite sensitive. One marks the brain wave and the other marks stimuli. Recently they have revised the set-up to record dual records of different parts of the brain, simultaneously in different colar ink.

The direct coupled amplifier as described by Garceau (61) has some advantages but is more linear in response than a capacity coupled amplifier.

The type of amplifier used has been described to some length. The leg of the amplifier and its ability to maintain shifting base lenes are problems to be worked out. Should the amplifier be without lag, recording only momentary impulses and returning immediately to the base line? This will be answered only by subsequent research.

The types of electrodes and their location are very important. Berger used hypodermic needles thrust through the scalp next the periosteum one on the vertex, the other in the region of the inion. It was with this type of electrodes that his first records were made. He claims for this type of electrode a more constant flow of potential with freedom from false curves formed by varying resistance of the skin contact (48 '29-'32). This method is also used by Gibbs-Lennox-Gibbs (8) who prefer this method for prolonged observation. The use of the left ear lobe and one in the vertex, after a local anesthesia is favored by them. They claim these to be free from much of the muscle twiches and E.K.G. actions. Muscles actions potential may be filtered out by a low pass filter as previously described. This method was used in the study of all electrencephlograms except Grand Mal attacks in which a crown-like diffuse ground terminal was used. This as a wire padded with cotton the whole being soaked in a salt solution. This helped eliminate the muscle action potentials which are quite strong during a convulsion. The record was identical with those made by standard leads. During violent muscle contractions, as seen in grand mal seizures, the needle electrodes did not fall off as pads electrodes formerly used requently would.

Jasper and Carmicheal (8) (2), Adrian and Matthew Loomis, Harvey, and Hobard (4) (10), Kornmuhler (60) use small coin shaped electrodes covered with felt and in connection with the scalp surface through a saline medium. These are usually held in place by rubber bands and cause some fluctuation of potential when the patient moves. Records obtained by these electrodes are about the same and this method is adequate for conditions where violent movement is not encountered.

A variation of this method which overcomes this condition is seen in technique employed by Jasper and Andrews (65).

> "The electrode consisted of small chlorided silver hats with felt covered brims. Which had an inside diameter of 5mm. Each electrode was fixed to the head with collodian, the contacts with the scalp being made through electrode jelly. The leads to the amplifier were about three feet in lengthh. The previous type (that held by rubber bands) was discontinued for this more convenient and efficient method".

The length of the leads is of considerable importance, due to interference and current losses. Experimental placement of electrodes has been conducted using a multi-channel instrument and standard placement arranged corresponding to the anatomical differential of the brain which has also been shown to be sharply demarked in electrical phenomena. (60) (26) (1)

These were used in localizing activity as was the method of phase reversal in successive pairs in a line of electrodes. See Illustration of standard placements.

In animal (8) work even more intensive work is being done since the similarity between cat (26) E. E G. and human E. E. G. Gibbs, Lennox, Gibbs(28). The effects of anesthesia must be considered in these conditions and this will be discussed later.

The Hassly-Clarke apparatus, a method by which insulated needles may be placed accurately in different deep structures of the brain offers a much more thorough method of localization to within 1mm. of the desired area. These electrodes give a diminished sensitivity especially on widewpread electrical changes. Continued rapid waves are seen which are not noticed with the diffuse type of electrode.

In all types of electrodes polarization must be considered and the records not read too finely. Then there is a battery effect in the contact of the electrode through the saline medium or different metals as in the Hassly-Clarke electrode. Evaporation from or condensation on exposed metal electrodes can cause an array of potential discharges that amazingly simulate biologic activity. (65) Metal in contact with salt solution has a photo-voltaic effect when light is flashed on or off amounting to several millivolts.

Stimulation in all cases was quite crude and without control. Light flashed in the eyes, moving objects

before the eyes, sound as metallic clicks, voices, doors slamming, light touch, pinching, ammonia vapor and electric shock from a thyrotron discharge were used and and responses observed.

THE "NORMAL" ENCEPHALOGRAM

Berger (1929) (48) in his original work described two main types of waves evident normaly in the electro-encephalogram, Alpha waves of eight to twelve per second and superimposed Beta waves ranging from 30-50 cycles per second. (54). This work has been completely gone over by many workers as Loomis, Harveyy and Hobart, Kornmuller (60) but all these workers find the same results as those by Adrian and Matthews (1).

Now it was necessary to prove the wave originated in the cortex and not in the muscles or from heart impulses. The most direct evidence that they are of cortical origin is the fact that Berger (48) noticed stronger waves when taken direct from the brain through the periostium. (58). Simultaneous E.E.G. and E.K.G. proved not direct relationship between the heart impulses and those of cortical origin. (41) Jasper and Carmicheal likewise showed that there was no relation between cortical waves and breathing (2) by records of arrested breathing and heart beat. There was some thought that the high resistance of the skull might allow the external muscles to generate a steady frequency as in the orbit due to muscle changes, (9) but free movement of the eyes showed no relationship here. The type of wave seen in the

myogram is much quicker acting and is entirely different from the Alpha or Beta waves, being of sharp spike characteristic (5). Observation in regard to pulsating vessels have been rejected after careful work by Berger.

Alpha rhythm examined by H. Davis and P. Davis (18) show that this is influenced by sight. A person seated in a dark room, eyes closed or open, completely relaxed shows the development of this typical rythm. (13) The Alpha waves may be caused to stop by the slightest flash of light which might cause stimulation of the sight mechanism. (49)

There is a difference in individual records as would be expected, (22) however, althoughtthe finer waves are different the general wave form is present. (34) The causes of some of this variability may be due to 1) the frequency of the occipital alpha rhythm may be decreased during drowsyness and increased following arousal by an adequate stimulus. (2) Adequate sensory stimulation may diminish or abolish rythmic activity in a waking person. (3) Sleep itself causes complex changes. (4) A state of excitment or unrest. (5) Temperature effects. (6) States of excitation, plus circulatory changes. (7) States of fear. (11)

An interesting observation made on blind subjects showed entire lack of the usual A rhythm. This was supposedly due to the fact that the visual pattern had long ceased and the Alpha waves due appear most pronounced just after relaxation of the normal subject. (1)

Non-Visual activity (Illustration #5) likewise shows a definite decrease in Alpha rythm as long as it is of some form which attracts the "attention". Strong muscular activity seems to have the effect of reinforcing the A-waves. Mental arithmetic, light touch, and noise all cause cessation of the Alpha waves.

The close relation of the optic mechanism with the Alpha potentials is demonstrated in stimulating the eyes with a flichering light. The potentials take up a similar beat usually twice as fast as the stimulating rhythm.

Jasper and Andrews (66) show that not only is there an Alpha wave from the occipital region but also from the precential region. They demonstrate this difference by recording separate encephalograms of these two areas with the leads quite close to-gether, and both over their respective areas. Light stimulation (6) has been shown to destroy or diminish occipital

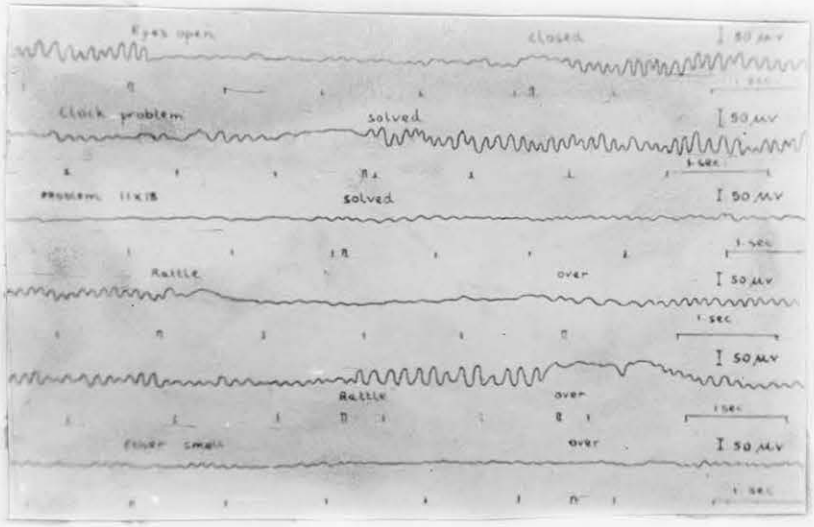

Eyes open
closed
50 μv
Clock problem
solved
50 μv
1 sec
problem 11x18
solved
50 μv
1 sec
Rattle
over
50 μv
1 sec
50 μv
Rattle
over
1 sec
Fever smell
over
50 μv
1 sec

Fig. 5

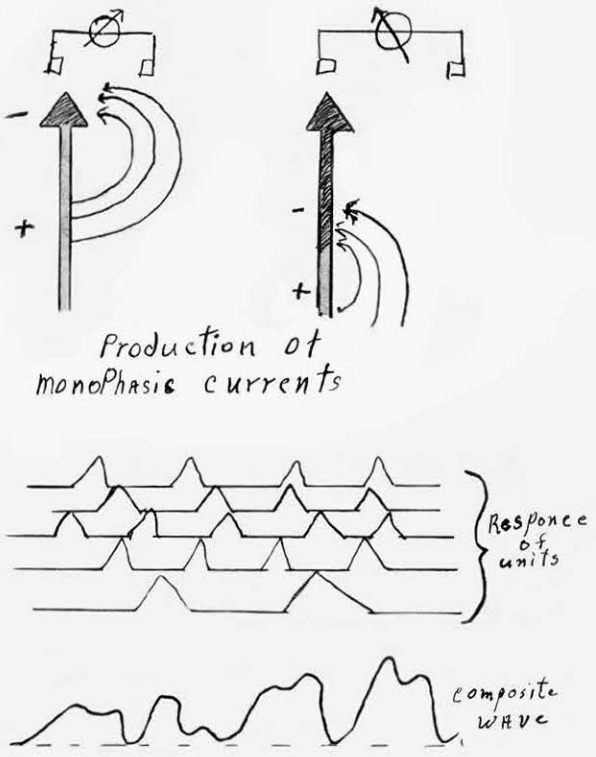

Production of
monophasic currents
Responce of units
composite wave

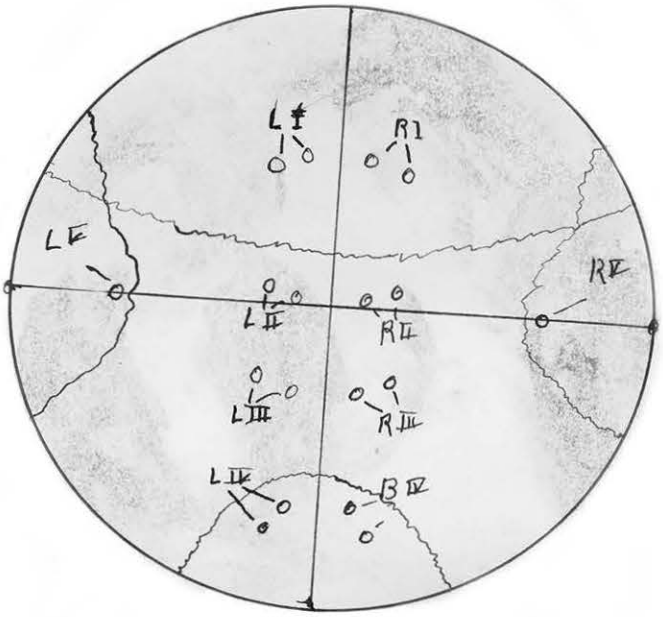
Fig. 6

Alpha rhythm but the precential rhythm continued or was even facilitated by light stimulation (9). In some cases there is a stronger precential Alpha then occipital Alpha wave (66). These two may show definite phase reversal and record quite independently of each other. Fig. 7

Berger presents an elaborate and psychological discussion of the origin of the wave based largely in terms of an inhibition theory of attention.

Adrian and Matthews (59) hold a more popular view (Illustration #6) in that they believe that low frequency waves are due to summation of many smaller higher frequency potentials originating in individual neurons. Thus a stimulation that agitates one of these sections destroys the summation effect, resulting in a decrease or obliteration of the rhythm.

Beta rhythms (66) are less discussed and of unknown significance. Berger thinks they are of the individual neuron discharge a result. They are most prominent in the precential region and have a frequency of 25 cycles per second. Jasper suggests that these frequencies above 25 cycles per second be termed Gamma rhythm (1). These waves are very (22)(34) constant for the same person over a long period of time



Standard Leads - Jasper & Andrews

This shows the types of leads used by Jasper and Andrews in their study of origin of the Alpha rhythm. The same type of leads are used in localization of tumors and other organic lesions.

even as the occipital Alpha rhythms are constant(18). Variations for these two waves (167) in a group of fifty subjects showed about ten per cent maximum difference recorded. (59) Temperature raises (37) (36) have been shown to give a definite raise in frequency. (17) Both typhoid vaccine and the Keppler hyperthermic have been used and an increase of about 15% in the frequency of Alpha and Beta waves recorded. (27)

Loomis and Harvey (10) and Hobart report a frequency of 14 cycles per second which they call sleep rhythm. They attempt to classify potentials records as to (1) trains (2) spindles (3) balls (4) and random waves. A vertex electrode showed the development of this rhythm during drowsiness and it has been suggested that this may be a slowing of the Beta waves (4). These waves occur in brief bursts and are termed trains. Slow potentials occur between bursts and are termed random waves. During the waking period spindles are seen which consist of 14 cycles per second waves diminishing in amplitude over a brief period.

Records taken from the occipital region show a marked slowing of the Alpha waves to a 3-5 per second frequency.

Definite response to afferent stimulus has been shown. The previous discussion shows the affect of

stimuli on Alpha waves. It may be added here that under hypnotic "sleep" (16) suggestion can cause the appearance of waves typical of stimulation although there is no stimulation (6). This is comparable to a conditioned reflex. Data obtained here indicates that brain waves are due to a change in brain levels, which is not constant and consequently the surrounding medium influences the type of response to be expected. The power of suggestion (41) is stronger in some persons than others. Certain subjects were found to be capable of stopping and starting waves at will by concentrating on certain types of stimulation (phantasy). This is comparable to the hypnotic phenomena.

Beta rhythms (54) (38) (12) (58) are not affected by the types of stimulation that interrupt the normal Alpha waves and this was noticed by Berger and other observers (19). This potential is supposedly referable to the sensory motor areas. This was demonstrated by Kornmuller (60) and by Gerard, Marshall and Saul (26). Tactile and auditory stimulation (58) when not expected gives the most evident effect of interruption of the Beta waves (12). It has been demonstrated that there is no definite relation between the muscle action of different groups and the Beta rhythm (31).

Kornmuller (60) working on rabbits and Gerard, Marshall and Saul working on cats showed very distinct types of waves for cyto-architectonic cortical areas. The area striata in the rabbit shows a regular smooth three per second rhythm, while the precentralis agronularis shows a predominate rhythm of 0-12 per second. This lead to the conclusion that granular type cells have a slower type rhythm and agronular layers have a faster rhythm. It will also be noticed that the ratio between the Alpha and Beta waves of man are directly proportional to those of the rabbit. Cytology of the precential region and the occipital region are also comparable.

ELECTROENCEPHALOGRAPHY IN EPILEPSY

Among other observations made by Dr. Berger, was the alteration of the normal wave pattern of the human E.E.G. by an epileptic condition (40). Further investigation showed this phenomena to be constant and typical of this condition only (62). All attempts to stimulate the convulsions by normal patients showed E.E.G. that did not in any way correspond to actual attacks of epilepsy (43).

Gibbs, Davis, and Lennox (8)(28)(38)(45)(23) have done some of the most outstanding work on this subject in the last five years which has led to a new understanding of the subject. In their work it has been suggested that a multiple channel apparatus be used and several areas examined at once (47) (28) in order to localize and obtain suitable clinical evidence of value.

Petit mal epilepsy. (Illustration #8)

Electroencephalograms of (50) patients with characteristic petit mal epilepsy were examined during seizures showed definite characteristics and confirmed Berger's (40) findings. The seizures are characterized by 100-300 microvolt waves of a frequency of .3 cycles per second and sinusoidal in form. There is usually a sharp negative spike near the positive crest of the wave and this is the most variable part of the record. Records for the same subject in successive seizures tend to be closely simiar to one another.

Between seizures the record is essentially normal except for lower potential developments simiar to the beginning of petit mal but then fading. These have been termed "Larval" seizures. Also it was discovered that the approach of petit mal could be predicted far ahead of the seizure before any clinical evidence could be demonstrated. Questionable epilepsy in which the only symptom of petit mal was a slight tingling in the head region of no disturbing degree with a few twitches of muscles which also were of little evidence. The E.E.G. showed definite petit mal rhythms. Here we must realize what this contributes to diagnosis especially in children where symptoms may be so slight as to be only a staring into space.

The work of Adrian, Matthews and Kornmuller in characteritic waves from archiatectomic (60) areas has led to a more intensive study of petit mal with electrodes arranged over several areas of cortex.

Frontal motor and occipital areas give quite characteristic records (Illustration #8). The waves pattern is best seen in the frontal region, where the spike formation is most prominent. The occipital region gives a wave and hump formation most characteristically. The spike recurs at 20-25 cycles per second and the hump recurs at 10 cycles per second which suggests that in all probability these characteristics are controlled by the underlying structures.

Study with electrodes over several areas of the cortex show that one area definitely preceeds other areas (Illustration #8). Both frontal areas may show simultaneous onset as may the whole brain area. The frontal areas seldom show this phenomena first and it is possible that they are secondarily involved.

In one case studied larval type seizures showed only in the right frontal tip which was sharply demarked by the electroencephalogram. Removal of this portion of the brain resulted in cessation of seizures. This leads to the belief that disturbances beginning in the cortex can adequately be localized.

Gibbs, Lennox, and Gibbs, observing the strength of petit mal pattern speculated in the possibility of causing the waves by introducing similar electrical waves to the surface of the brain in an attempt to simulate the attacks , but this resulted in no demonstrable effects.

In connection with petit mal it has been observed that suppre sion of seizures can be affected by mental activity, termed by the experimenters attention. Petit mal cases notice the infrequency and apparent cessation of attack while working or otherwise havingtheir attention focused. (24) This is due to a decrease of all slow waves. This points to the necessity of having the patie nt continue active work without depressants or rest. (39) (23) (38) (Illustration #9)

Sleep and light phenobarbital depression have been

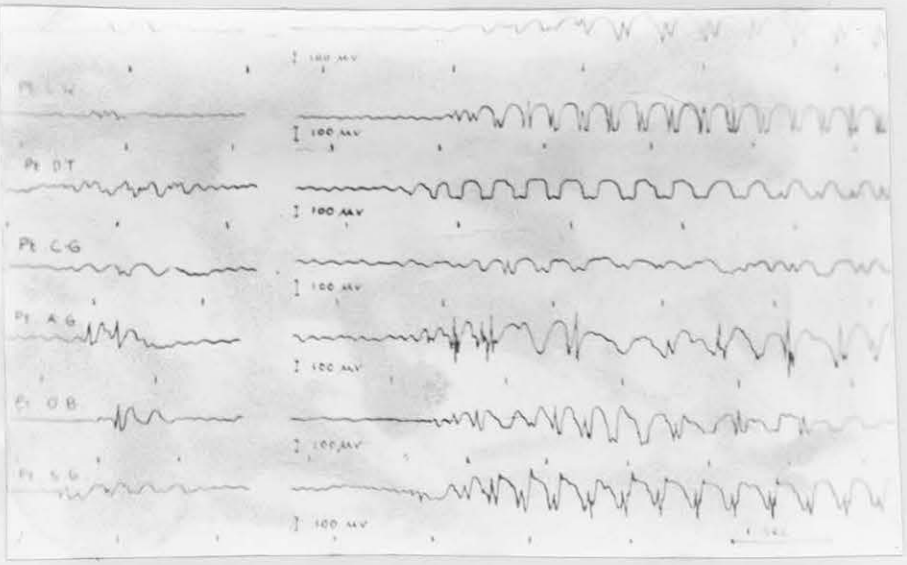
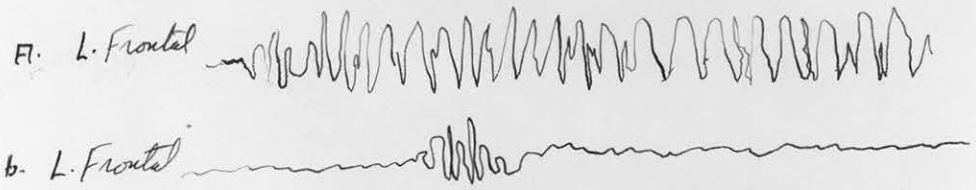


Fig. 8



A. usual petit mal.
b. Following NA Br.

Fig. 9

shown to facilitate petit mal. This is expostulated as being due to the slowing of the normal rhythms to similiar waves seen in petit mal (3 per second). Asphyxia, syncope, and over ventilation tend to produce similar condition (Illustration #10) and precipitate epileptic seizures.

Grand mal attacks (Illustration #11) are more difficult to study because of violent movements the patient exhibits during a seizure. They may start as a petit mal seizure and then swing into a grand mal seizure. This condition is related to petit mal as they both have the same pathologic basis being more of a degree of pathology.

Seizures are typified in the beginning by fast waves 10-30- per second of about 50mm. amplitude and gradually become more rapid with noticeable clumping of the waves. This is usually interrupted by the onset of the clonic phase, during which slower waves appear the fast activity decreases in voltage and becomes more intermittent. There is usually correlation between rhythms recorded and muscle twitches. In the stuporous stage or confused stage either a flat record or one of large slow waves is seen. This gradually comes back to normal. In a status epilipticus it is possi le to determine the time of the next seizure by the E.E.G.

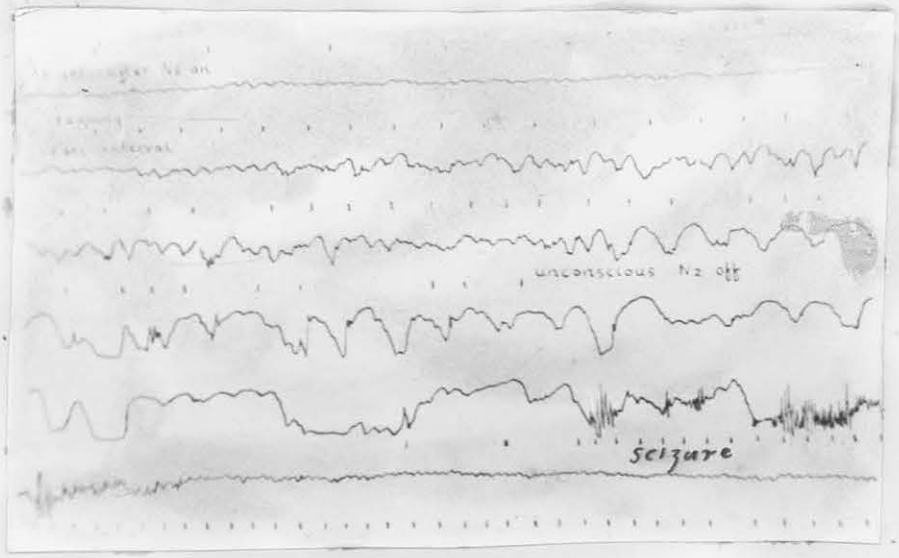

unconscious N2 off
seizure

Fig. 10

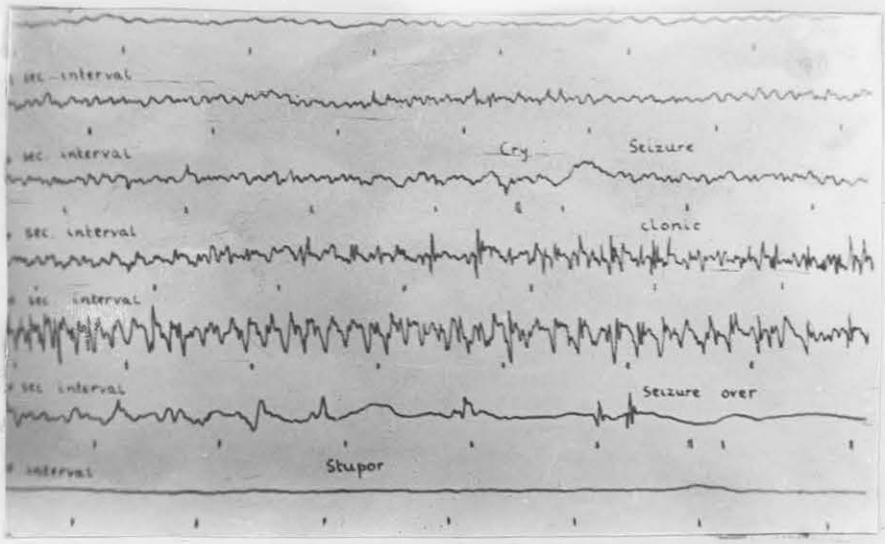

sec interval
sec interval
Cry
Seizure
sec interval
clonic
sec interval
sec interval
Seizure over
interval
Stupor

Fig. 11

As in petit mal we have "larval" grand mal attacks consisting of a pneliminary stage of fast waves followed by fast spikes of large amplitude 100-150 M.V. but nd very much clumping is seen. The phenomena is terminated by the flattening of the record of the production of slow waves. The main difference from grand mal seizures being the duration and the amplitude of the waves as stated.

One of the most interesting observations made by Gibbs, Lennox, Gibbs was on a reflex epileptic by localizing needles thrust deep into the cortex in the right motor area. The patient's attack as precipitated by a slap on the thigh was recorded. The seizure started as usual (Illustration #18) but did not register waves of any large magnitude until the clonic stage sets in, there being little evidence of the tonic period of the E.E.G. Abruptly in the middle of the seizure the waves return to small osciàlations which during the stupor stage became large slower waves. This set up allowed recording of waves only when they originated deep in the cortex which accounts for the type of record. Consequently with the type of electrode it should be practical to localize the origin. The seizure is described as spreading from the point of origination to the surrounding spaces as fire in a dry hay field.

The latest work done on the field of epilepsy by Gibbs, Gibbs, and Lennox arrived at the conclusion that epilepsy is a paroxysmal cerebral dysrhythmia. This conclusion was reached after intensive study of nine hundred hours of recordings of epileptic E.E.G. and was based on the following findings:

1. Seizures involving the cortex show distinct characteristic fluctuations of the patient.
2. Rhythm distinctive for three main types of epilepsy: grand mal, fast waves; psychic variants, slow waves; and petit mal, slow and fast waves.
3. Subclinical seizures--also seen during sleep.
4. Lack of control of cerebral rhythms.
5. Grand mal seizures predicted several hours in advance.
6. Sometimes abnormal activity in one area and spreads to others.
7. Determines value of therapy--anti-convulsant drugs best in grand mal because of the suppression of fast rhythms. CO_2 and glucose therapy of tempory value. Concentration of attention at times prevents the appearance of the attack.
8. The type of pathologic electrical activity tends to be characteristic of the area which produces it.

The child presents a most difficult problem in

epilepsy (44). His condition in petit mal may be no more than a fixed stare, he may be convulsed or may merely show a temper tantrum (20). When these conditions occur at wide spaced intervals it is difficult to determine whether there is actual epileptic phenomena present or whether the patient is showing a defensive mechanism to social mal-adjustment. E.E.G. will determine these conditions and likewise show any subclinical conditions which may prevail.

Of the many cases which do not respond to medical care, many may be responsive to surgical treatment. The brain tumor is a frequent offender. Let us now consider localization of this condition.

W. Walter (29) of the London County Hospital and Lemere in this conountry have done work typical of other experiments and have demonstrated the practibility of the use of the electroencephalogram in localizing and diagnosing brain tumors. Here again the use of two indifferent leads to the amplifier is the more desirable and it is essential to have at least a three channell amplifier and recorder. Owing to the spread of the brain potentials by the meninges, skull, and scalp as described by Tonnies (1933) the limitation of localization is in an area 4cm. in diameter. The closer electrodes can be placed with alterations in records being evident, the more accurately localization can be accomplished.

The tumor itself is inactive electrically. It may however serve to increase conduction of underlying potentials. The single channel amplifier will not give localizing information as the changes in negative and positive deflections are nearly relative to the two different points of electrode placement.

Lemere (1937) (32) (Illustration 13) showed that in bilateral cerebral lesions, rhythms are the same on both sides. Unilateral localized lesions in the frontal, parietal, or temporal lobes showed slightly stronger rhythms over the affected side with phase reversal in one of the three leads. Basal ganglia showed great increase in the waves. Walters, however, states that he obtained records only in the final stages when they were diffuse and without meaning.

Hypo-thalmic and thalmic tumors show a decided decrease in amplitude of the waves. Occipital lobe lesions ofthat side show a poor Alpha rhythm, and lesions of the optic radiation show strong Alpha rhythm. Adrian and Matthews conception is that the Alpha rhythm originates in the occipital region and this offers the best basis for explaining the above observations. Any lesion tending to isolate, but not involve the occipital lobe causes strengthening of the affected sides waves.(68)

Walters (30) shows the presence of so called "Delta" waves which are large slow irregular waves. Upon

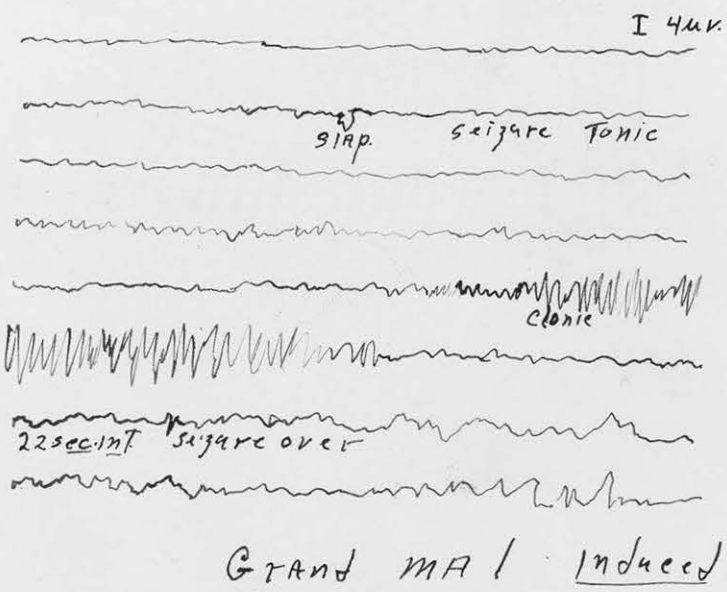
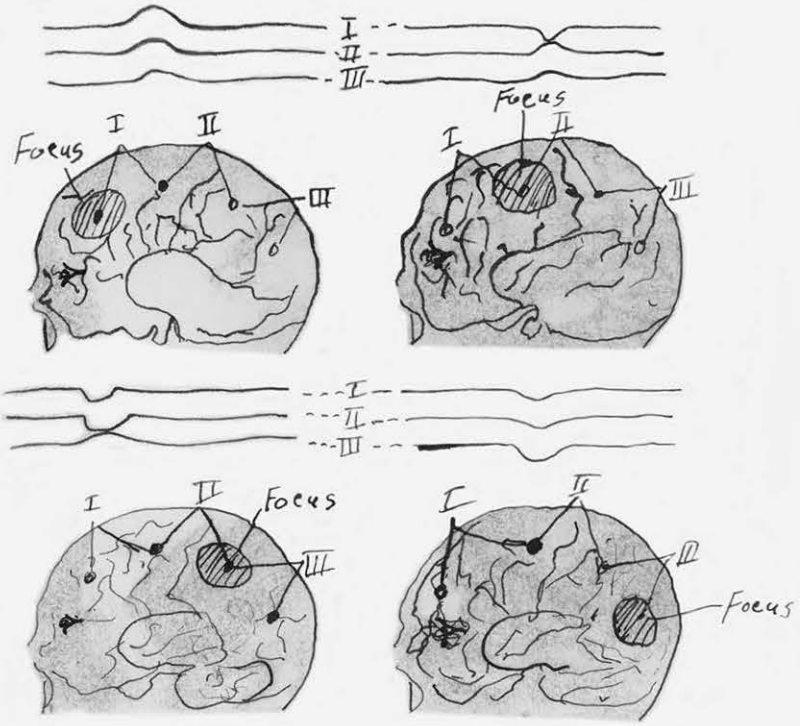


Fig. 12



Diagramatic - Waves + Localization.

Fig. 13

this phenomena is dependent the localization and recognition of tumors. The "Delta" waves are not of tumor origin. Electrodes directly placed on the tumor showed no potential changes. Walters quotes (29) this statement of the the fact that Delta waves originate in poorly functioning cortex rather than in the tumor and are merely transmitted by the tumor mass.

Case II of a white female age eight in which strong Delta waves were recorded over the left-parieto-occipital region, right side normal. Ventriculo-gram showed a multiloccular cavity connected with the posterior horn of the left ventricle. Operation showed slightly shrunken and hardened convalutions. There was an excess fluid beneath the arachnoid. A small portion of the cortex was removed, the patient then recovered but the condition was unchanged.

Walters (30) shows a definite localization of a large percentage of tumors by this method which were confirmed by electroencephalography, and by operation. Those missed showed diffuse involunt either as edema or degeneration of the surrounding area. This certainly indicates the value of this procedure which needs more experiment to have a complete understanding of the potentials recorded.

H.W. Waltman, M.D., Section of Neurology, Mayo Clinic (70) concludes that of the known research so far there is a definite indication that the E.E.G. is of value in organic lesions. Its use in the psychosis is questionable . However some definite observations have been made in this field in regard to Schizophrenia. It has been observed by Berger and other workers that schizophrenic patients are characterized by slow 2-3 per second waves in the E·E.G.

In 1937 (46) physicians at the Worchester State Hospital announced that E.E.G. records taken along with the insulin treatment introduced by Dr. Sakel could be quite benificial in following the changes in the patients condition. Also, like the insulin treatment data from the E.E.G. was reliable inversely as the duration of the disease. In older patients a practically normal record has been demonstrated. (35)

Hoagland, Cameron and Rubin (42) in a detailed discussion of this method in which the "Delta index" is the method of determination proceed as follows: the line is drawn through the E.E.G. record midway between the peaks to form a base line. This is also known as the disintegration factor. The excess of this line to 100cm. is the delta index. It varies from 0-4 cm. in the normal patient. The past sugar index is considerably less than the pre-insulin delta

index and the same relationship is shown to clinical improvement.

Eighty-four (42) indices on seven patients over several weeks treatment were made and 88% correspondence was found with independent, fluctuating, objective clinical symptoms.

Transient relapses and remissions of one patient earlier released after succes ful therapy, correlated completely with fluctuations in his delta index.

In several incidents the Delta indices change prior to clinical symptoms and prediction of clinical findings were possible.

There is considerable need for further experimentation before definite use can be made of the E·E.G. in Schizophrenia.

E.E.G. in mental deficienby

Kreezer (25) in his work on mental deficients was not able to give any definite basis for diagnosis at the present time. The fact that chronilogical age is not important but rather the mental age by the Binet method is the most reliable in this work. Berger observed that the Alpha rhythms did not develop until after the Binet age of four was demonstrated in mental deficients of the same Binet age regardless of chronological age. This is an important finding and should be worked out further.(15)

SUMMARY

1. Potential changes in the brain can be led off and recorded through the intact skull.

2. The records are predominated by large slow waves 10 cycles per second and by faster smaller waves of 25-50 cycles per second.

3. There is a definite change in organic lesions of the brain which may be differentiated and localized by the E.E.G.

4. The waves from such a localized area depend on the underlying strictures.

5. Tumors themselves are inactive but the surrounding tissues show a change in waves.

6. Epilepsy has been determined as a paroxysmal cerebral dysrhythmia and differentiation can be made between different types.

7. No attempt to simulate an epileptic seizure will give an "epileptic" record on the E.E.G.

8. The pyschosis in general are not diagnosable at present by this method although much information in therapeutic results are a guide to treatment and are obtainable.

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