THE ELECTROENCEPHALOGRAM IN MANIC-DEPRESSIVE PSYCHOSIS.

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THE main object of this investigation is to verify the claim of Pauline Davis (1941) that manic-depressive depressed psychotics (M.D.D.s) tend to possess frequencies of alpha rhythm in the E.E.G. at 10 c./sec. or slower, whilst manic-depressive manic patients (M.D.M.s) tend to show alpha frequencies at 10 c./sec. or faster; furthermore that there is no shift in alpha frequency corresponding to change in psychotic phase or in degree of phase. These claims are of importance in relation to a recent paper by Mundy-Castle (1951*b*) in which a significant correlation was reported between ratings of the Heymans-Wiersma temperament variable secondary function and mean frequencies of alpha rhythm in normal adults, since both Heymans (1929) and Wiersma (1932) maintained that M.D.D.s possessed a high degree of secondary function and M.D.M.s a low degree of this variable. To explain this in more detail, secondary function is postulated as being present in individuals in different degrees varying over a continuous scale ranging from domination of the conscious field by secondary function to domination by primary experience (relative lack of secondary function). Individuals displaying the former may be referred to as secondary functioning, their behaviour being characterized by steadiness of action, continuity of interest, evenness of mood and psychic tempo, reduced stimulability and a tendency for mental events to perseverate. Individuals in whom secondary function is relatively lacking (it can never be wholly absent) may be termed primary functioning, their behaviour being characterized by impulsiveness, mobility, high stimulability and a quick and variable psychic tempo. The Heymans-Wiersma temperament scheme has been developed extensively by Biesheuvel (1935, 1949). Mundy-Castle's study revealed that subjects rated as secondary functioning possessed low alpha frequencies whilst those rated as primary functioning possessed high alpha frequencies. The present investigation should help to elucidate the view of Heymans and Wiersma concerning secondary function and manic-depressive psychosis.

Also to be presented will be a detailed analysis of the E.E.G. characteristics found in manic-depressive psychosis and involutional melancholia compared with a normal control group, studying in particular any E.E.G. patterns which are akin to the Davis "choppy" classification. The latter encompasses diffuse or localized, intermittent or permanent, disorganized low voltage fast activity ranging from 26 to over 50 c./sec. It was claimed not to be artifact

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or muscle activity and was regarded as an abnormal interference with the normal physiological activity of the cortex. In support of this contention, Davis presented evidence that choppy activity is associated with organic pathology (1940, 1942) and with direct chemical stimulation of the cerebral cortex (Davis and Sulzbach, 1940). The choppy pattern was reported to be prominent in the E.E.G.s of schizophrenics (60 per cent.), whilst the figure for manic-depressive psychotics was 39 per cent. (Davis, 1942). It should be stressed that the choppy classification was criticized by Walter (1942) and Hill (Hill and Parr, 1950, ch. ix) who point out that such a pattern might well be due to alpha rhythm inhibition plus attenuated muscle potential artifact, and will be apparent if short time constants such as those of Davis are used.

Material and Procedure.

The material of this investigation comprises 165 E.E.G.s recorded from 117 manic-depressive and involutional melancholic patients of Weskoppies Hospital, Pretoria, there being 48 repeats. Their mean age was 54·96 years, standard deviation 14·48 years. The patients were transported by van from Pretoria to the National Institute for Personnel Research, Johannesburg, a distance of about 38 miles, which meant that the first-named author was in their company for two periods of about an hour during the journey, as well as during the test and often at other times of the day. The recordings were carried on for a period of over two years, from 21 April, 1949, to 21 June, 1951. A control E.E.G. study of 160 young normal adults (mean age 22·4 years, standard deviation 5 years) was available for comparison purposes.

Clinical and Psychological Assessment.

A standard classification of manic-depressive psychosis and its sub-groups was adopted. The diagnosis of the condition as manic-depressive psychosis was dependent on the strict conception of the disease, namely, care was taken to exclude: (1) schizophrenics whose psychosis starts with an episode of excitement; (2) cases with persistent hallucinations and ideational dissociation, i.e., schizophrenes; (3) depressions of a reactive or situational nature, which are better classified as psychoneurotic; (4) cases which do not revert to the usual level of affective intensity, integration and dynamics after attacks (allowing for self-protective timidity). The sub-groups employed were as follows:

(1) mania, chronic mania, recurrent mania;

(2) depression, recurrent depression;

(3) alternating, i.e., with normal intervals between psychotic episodes which are of both manic and depressive types;

(4) circular, i.e., episodes of both manic and depressive types running into each other;

(5) attacks of double form, i.e., each psychotic episode comprising a manic and a depressive phase merging into each other but with intervals of normality between each of these double-form attacks. One case only of this type occurred in our series and for statistical reasons it was accordingly grouped with the circular cases.

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The standard view of involutional melancholia was adopted rather than the wider concept of involutional psychosis enunciated by Kallmann (1950). Only those cases are included which manifest melancholic mental content for the first time in the involutional period, without impairment of their intellectual functions.

The degree of the mania or depression at the time of the E.E.G. was assessed on a 3-point scale, as follows :

Mania.

Degree 1 (M1) : Hypomania-euphoric and/or aggressive, mildly overactive, talkative in a rapid fashion with a tendency to distractibility and mild flight of ideas.

Degrees 2 and 3 (M2 and M3) : Moderate and gross exaggeration of the features of degree 1, often associated with rapidly changing delusions of grandiose and persecutory types.

Depression.

Degree 1 (D1) : Relatively mildly depressed mood, with mild inhibition or agitation but without delusions of depressed type.

Degrees 2 and 3 (D2 and D3) : Exaggeration of the depressed mood and of the agitation or inhibition of degree 1 (amounting in degree 2 to mild and in degree 3 to profound stupor) and often with overt or indirect evidence of delusions of depressed type.

Our material contained examples of both degrees 2 and 3 depression but none of degree 3 mania for the obvious reason that no such grossly excited case could be transported as described and be submitted to an E.E.G. test. For statistical purposes, therefore, we have decided to group degrees 2 and 3 depression together for the sake of uniformity with the manics so that in both cases there are sub-groups exhibiting a milder and severer degree of the tendency in question.

The problem of what is meant by a mixed phase merits special consideration as there is often a tendency to refer to circular or even alternating forms of manic-depressive psychosis as mixed in view of the fact that both types of phase are represented. In the present study such usage is rejected, the term being used in the strict sense of the co-existence at one and the same time of symptoms characteristic of both the manic and the depressed phase—or at the very least extremely rapid fluctuations within a matter of seconds between manic and depressive features. These states are classified in Kraepelin's standard system under the heads of maniacal stupor, agitated depression, unproductive mania, depressive mania, depression with flight of ideas and akinetic mania. Henderson and Gillespie (1944) regard all of these, but for agitated depression and sometimes maniacal stupor, as transition phases between manic and depressed attacks.

Insight into the composition of such mixed states may be obtained by regarding them as mixtures of varying degrees of the three psychological components :

(1) mood, elated or plus, inhibition or minus ;

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(2) motility, overactivity or plus, inhibition or minus ;

(3) psychic tempo, as revealed in rapid talk with distractibility and flight of ideas rated as plus, or in retardation of speech and varying degrees of inaccessibility rated as minus. Accordingly we have rated all our cases at the time of the test as plus or minus on each of these components.

In addition to a clinical and psychological assessment of each case at the time of the test, an assessment was made on the basis of a thorough study of the case record as to whether the manic or depressive phases were predominant or whether they were equal.

Thus, to summarize our salient psychiatric data to appear in the statistical analysis, as regards the phase at the time of the test, cases were classified as (1) manic, (2) depressed, (3) normal, (4) mixed, and as regards the predominant phase of the case as (1) manic, (2) depressed, (3) manic = depressed. Distribution of the psychotic material is presented in Table I.

TABLE I.—*Distribution of Psychotic Material According to Predominant Phase.*

	Manic.	Depressed.	Manic-depressed.	Totals.
Involutional melancholia	0	18	0	18
Recurrent chronic, plain mania	25	0	0	25
Recurrent, chronic, plain depression	0	17	0	17
Alternating	12	2	9	23
Circular	20	7	7	34
Totals	57	44	16	117

Our psychiatric and psychological assessment of every case was checked by a review of the case at the end of the project. There was, moreover, a precaution against subjective bias in diagnosis in that no case was included in our series where the diagnosis of manic-depressive psychosis or involutional melancholia had not also been made independently by the doctors' conference of Weskoppies Hospital (average size of conference 7–8 doctors, approximately half of whom can lay claim to senior psychiatric experience).

E.E.G. Recording Procedure.

A six-channel standard Ediswan E.E.G. was used, together with an Ediswan Walter type frequency analyser for the later recordings. Silver-silver chloride saline pad electrodes were secured to the head by a rubber and whalebone cap, and the standard bipolar electrode combinations were as follows :

(i) fronto-parietal, parieto-occipital, parieto-temporal left and right hemispheres ;

(ii) fronto-temporal, temporo-occipital, parieto-temporal, left and right hemispheres.

Whenever an abnormal focus was noted, detailed spatial analysis was employed. The majority of cases were tested whilst lying supine on a couch

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with a head-rest designed to exclude interference with the electrodes. As the subjects were mental patients a few cases were too resistive or otherwise-uncooperative for this position and were tested whilst seated. Paper speeds of 1·5 and 3 cms./sec. were both used on all patients, in some cases 6 cms./sec. in addition. In all cases an adequate sample of the record was made with high frequency filters set to cuts of 15 per cent. down at 75 cycles, whilst the standard time constant setting was 0·3 sec. Each recording lasted for a minimum of 8 minutes, during which time study was made of E.E.G. changes during eye opening and closure, 3 minutes' hyperventilation (when possible) and rhythmic photic stimulation with a Scophony electronic stroboscope. Full details of administration of the latter have been given by Mundy-Castle in an earlier paper (1953).

The interval between the E.E.G. and the time of the last meal was also noted, as the degree of starvation or satiety, as reflected notably in the blood-sugar level, is known to affect the E.E.G., particularly during hyperventilation.

The interval between the E.E.G. and shock therapy and the extent of the course of shock treatment were also recorded in every case with a view to assessing the extent to which abnormalities in the records might be referable to such shock therapy. The consensus of opinion is that with E.C.T. such changes disappear in 2 to 3 months (e.g., Kennard and Willner, 1948), but but Mosovich and Katzenelbogen (1946) claim to have detected signs of cerebral dysrhythmia as long as 10 months after treatment. McNeel *et al.* (1941) and Hoagland *et al.* (1937) agree that disturbances introduced into the E.E.G. by high dosage insulin are short-lived.

The E.E.G. concepts employed correspond to those of the British school of Walter and Hill (Hill and Parr, 1950), and include alpha (8–13 c./sec.), beta (14–30 c./sec.), theta (4–7 c./sec.) and delta (1–3·5 c./sec) rhythms. Alpha rhythm is additionally defined as of occipital or parieto-occipital origin and showing attenuation during visual and sometimes mental attention. Alpha activity is also described in terms of responsiveness according to the work of Golla, Hutton and Walter (1943): three classifications are used, (1) R or responsive, showing a normal blocking response; (2) P or persistent, showing little or no blocking response; and (3) M or minus, where alpha rhythms are of low voltage and rarely present. These types have been shown to be related to differences in mental imagery, with M type rhythms being associated with predominantly visual imagery, R types with visual and other imagery equally, and P types with non-visual imagery (see also Short, 1951).

Finally, the records were rated as normal, questionably normal or abnormal, these classifications being based on the criteria of abnormality laid down on pp. 379 and 380 of Hill and Parr (1950).

Results.

1. *Alpha Frequency and Psychotic Phase.*

An association between fundamental psychiatric and psychological features on the one hand and the alpha rhythm on the other was demonstrated, viz., that the manic phase with its positive rating of mood, motility and psychic

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tempo is associated with relatively high alpha frequency, and that the depressed phase with its negative ratings on the same three psychological variables is associated with low alpha frequency (see Tables II and III).

This is true of :

(*a*) predominant phase ;
(*b*) phase at test, which may be a reflection of (*a*).

There were no other significant differences or associations in E.E.G. characteristics corresponding to psychotic phase.

TABLE II.—*Significance of Differences in Alpha Frequency According to Psychotic Phase.*

	Manic.			Depressed.			Critical ratio.	Probability.
	Mean.	S.D.	N.	Mean.	S.D.	N.		
Alpha frequency predominant phase (c/s)	10·36	1·09	54	9·74	0·89	42	2·95	<0·005 significant
Alpha frequency phase at test (c/s)	10·21	1·16	41	9·58	0·86	37	2·71	<0·01 significant

TABLE III.—*Association between Alpha Frequency and Psychotic Phase.*

	Predominant phase.		Phase at test.	
	Manic.	Depressed.	Manic.	Depressed.
Above mean alpha frequency	31	9	23	7
Below mean alpha frequency	23	33	18	30
	$X^2 = 12·58$ $P < 0·001$ significant		$X^2 = 11·36$ $P < 0·001$ significant	

It is *not* true of change of phase or change of degree of phase in the same individual at different tests. This was checked as follows : degrees of depression and mania were rated on a three-point scale, D1, D2, D3 and M1, M2, M3, in order of increasing severity. In assessing the shift of phase the following scale was therefore employed : D3–D2–D1–0–M1–M2–M3. Shift to the right was rated plus and to the left minus. One-step, two-step and three-step shifts were compared *inter se*, and as a combined group they were compared with the group of cases that had shown no shift between tests, to ascertain the degree, if any, of quantitative changes in E.E.G. characteristics, notably alpha frequency. No significant differences or associations were found in this statistical analysis.

2. *Low Voltage Fast Irregular E.E.G.s, Choppiness.*

A special study of low voltage fast irregular records was undertaken as an extension of the Davis choppy classification. After careful analysis of our E.E.G. data it was decided to discard the classification " choppy " and in its

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place use the following sub-classifications of low voltage fast irregular (l.v.f.i.) records :

Type l.v.f.i.A.—Records showing low voltage rare or intermittent alpha activity considerably disturbed by low voltage fast rhythms ranging from 14–30 c./sec. of a diffuse nature. Some intrusion of low voltage diffuse theta activity is sometimes apparent.

A variant of the above manifesting itself in the form of flat E.E.G.s was originally treated as a separate type designated as l.v.f.i.C. After careful consideration with the aid of frequency analysis these records were reclassified as l.v.f.i.A., the "flatness" being attributed to asynchrony of random high frequency components. Examples of l.v.f.i.A. type records are shown in Fig. 1*a* and *b*.

Davis's choppy activity may be regarded as a variant form of l.v.f.i.A., but with a higher frequency of the fast activity than that designated in our definition. Only 2 of these were found in our material, an example being shown in Fig. 1*c*.

Type l.v.f.i.B.—Records showing excessive diffuse theta activity of medium voltage combined with typical l.v.f.i.A. characteristics. Alpha activity is sometimes of rather higher amplitude than in the l.v.f.i.A. type however (see Fig. 2).

Borderline l.v.f.i.A. and l.v.f.i.B. types.—Those records in which the characteristic activity is less clear and often showing a relatively well-formed though intermittent alpha rhythm.

The incidence of these record types was compared with that in the control group of 160 normal adults. Statistical analysis revealed that when the borderline l.v.f.i.A. and l.v.f.i.B. records are added to the true l.v.f.i.A. and l.v.f.i.B. records there is a significantly higher incidence of l.v.f.i.A. and l.v.f.i.B. records, both separately and combined, in the psychotic group than in the control group. When the borderline groups are treated separately the significant difference persists in the case of l.v.f.i.A., borderline l.v.f.i.A. and borderline l.v.f.i.B. groups, but not with the l.v.f.i.B. records. These figures are shown in Table IV. There were no significant differences in the incidence of any of these low voltage fast irregular records between the predominantly manic and the predominantly depressed sub-groups.

TABLE IV.—*Comparison of Incidence of L.V.F.I. E.E.G.s in the Psychotic and Normal Groups.*

Type of l.v.f.i. E.E.G.	Psychotics.		Normals.		Critical ratio.	Probability.	Whether significant.
	Incidence.	Percentage.	Incidence.	Percentage.			
L.v.f.i.: A	21	17·95	15	9·37	2·03	<0·05	Yes
L.v.f.i.: B	14	11·97	10	6·25	1·60	>0·05	No
Borderline A	18	15·38	8	5·00	2·77	<0·01	Yes
Borderline B	12	10·26	0	0	3·66	<0·001	„
L.v.f.i.: A + Borderline A	39	33·33	23	14·37	3·67	<0·001	„
L.v.f.i.: B + Borderline B	26	22·22	10	6·25	3·72	<0·001	„
All l.v.f.i. records	66	56·41	33	20·62	6·40	<0·001	„

To test the significance of the age factor the incidence of these types in those psychotics above and below 55 years of age was checked. No significant differences were found.

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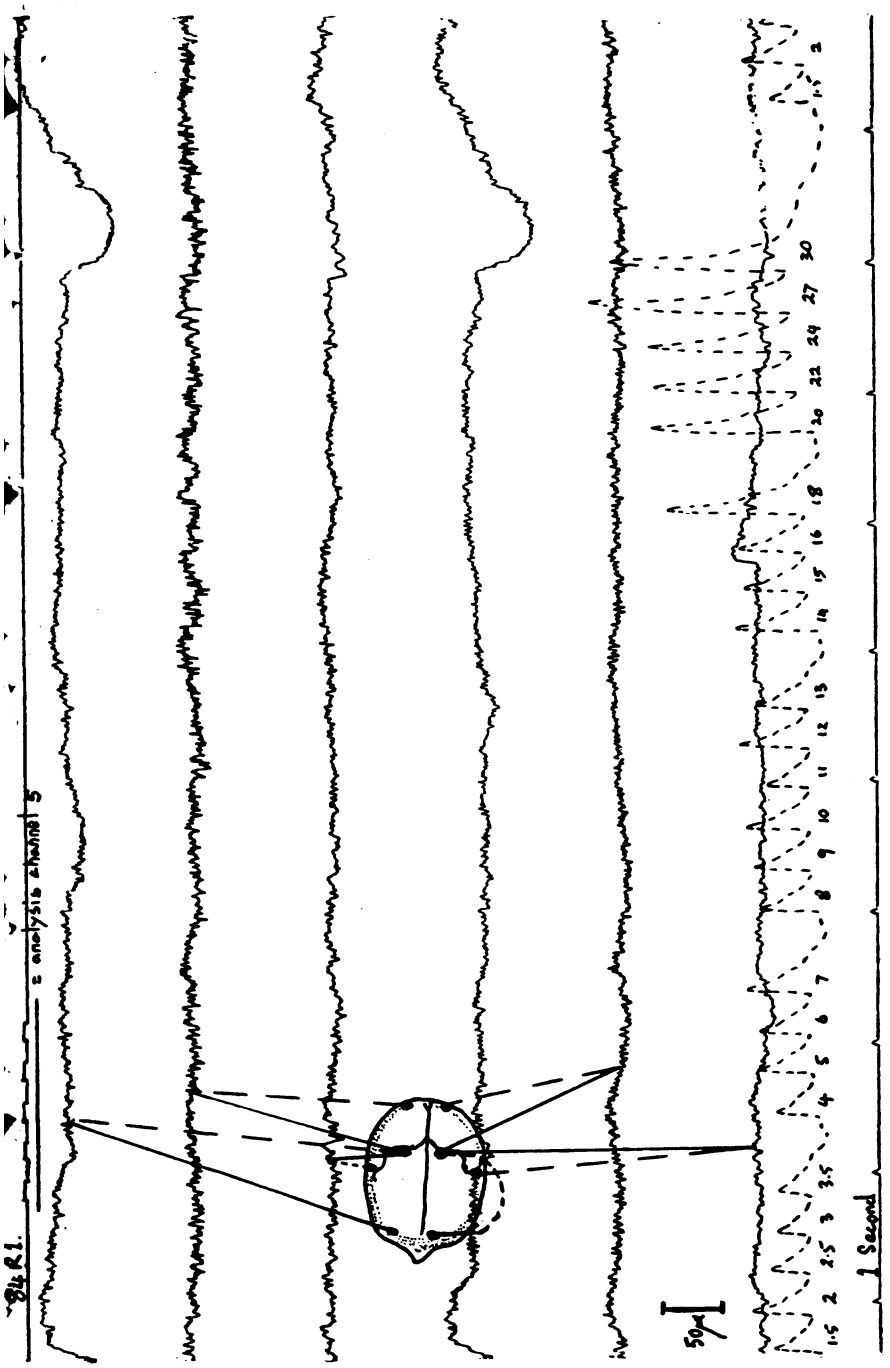
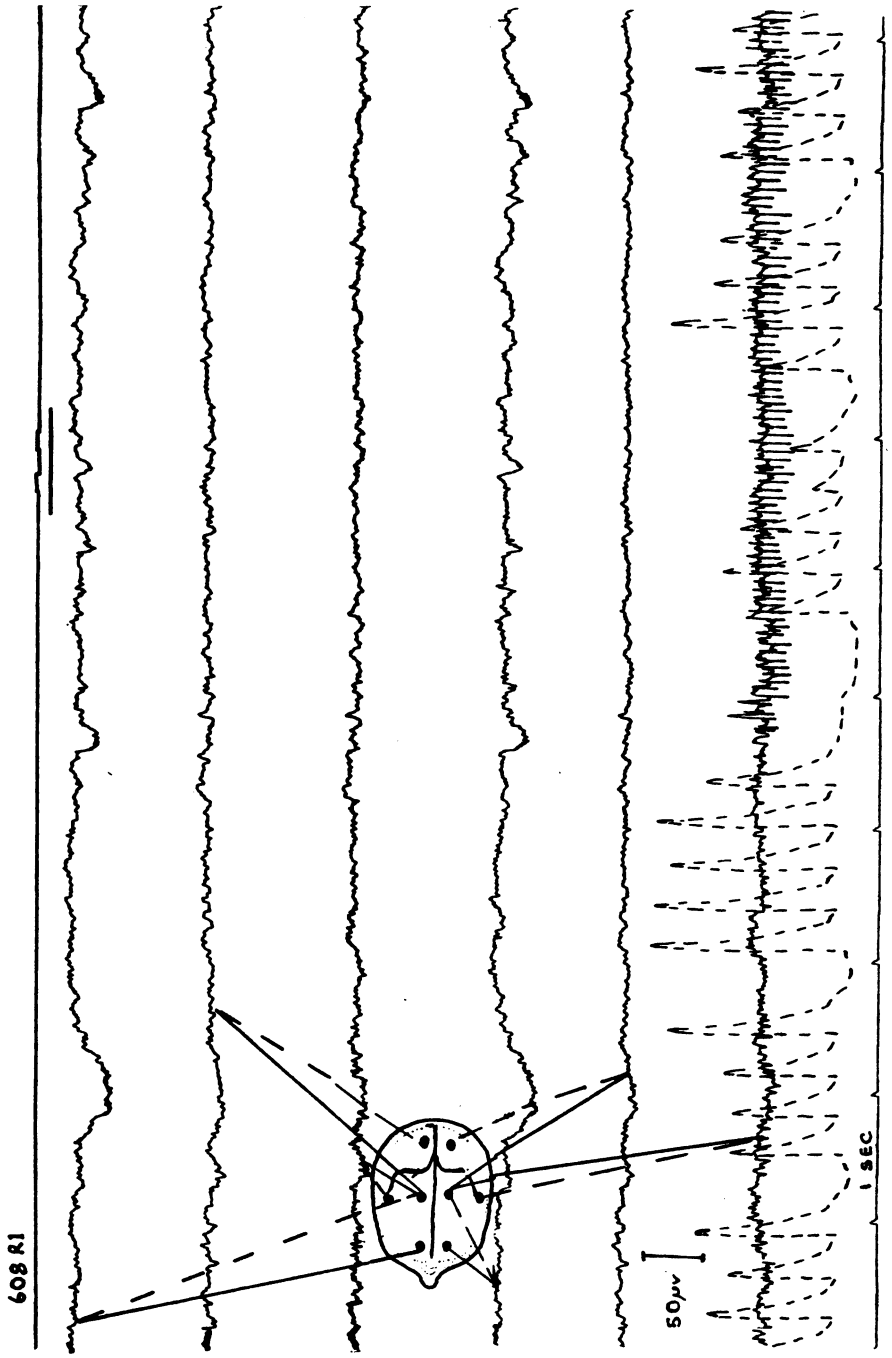


FIG. 1 (*a*).—L.v.f.i.A. record from predominantly depressed patient. Note characteristic frequency spectrum with fast activity dominant, little or no alpha rhythm. (*b*) L.v.f.i.A. record from predominantly manic patient, showing more theta rhythm than in Fig. 1 (*a*). The spikes from channel 6 are of muscular origin. (*c*) Typical Davis "choppy" E.E.G. from predominantly depressed patient. Such an E.E.G. is considered to be a variant of the l.v.f.i.A. classification. Frequencies of fast activity up to 36 c/s ec.

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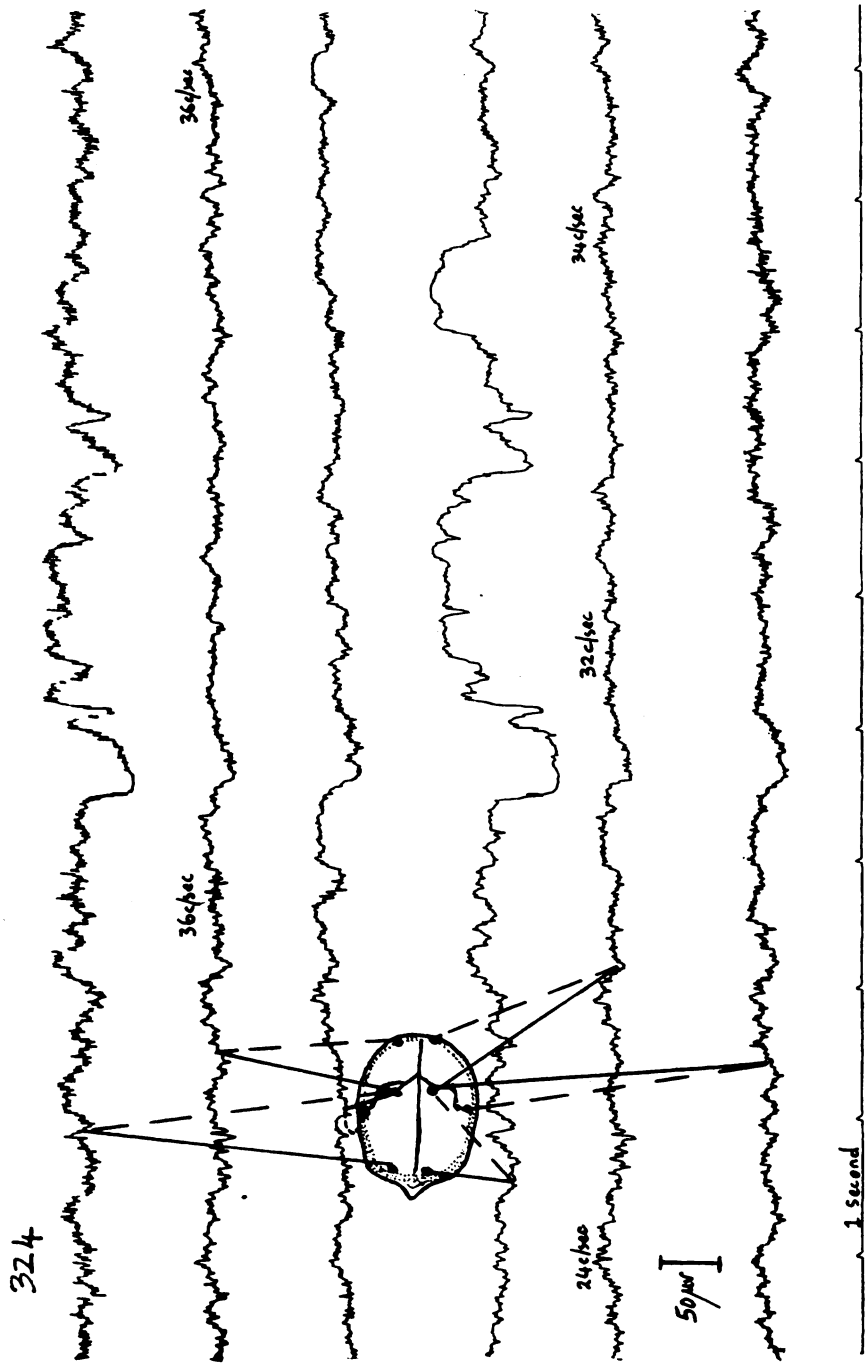


FIG. 1 (c).

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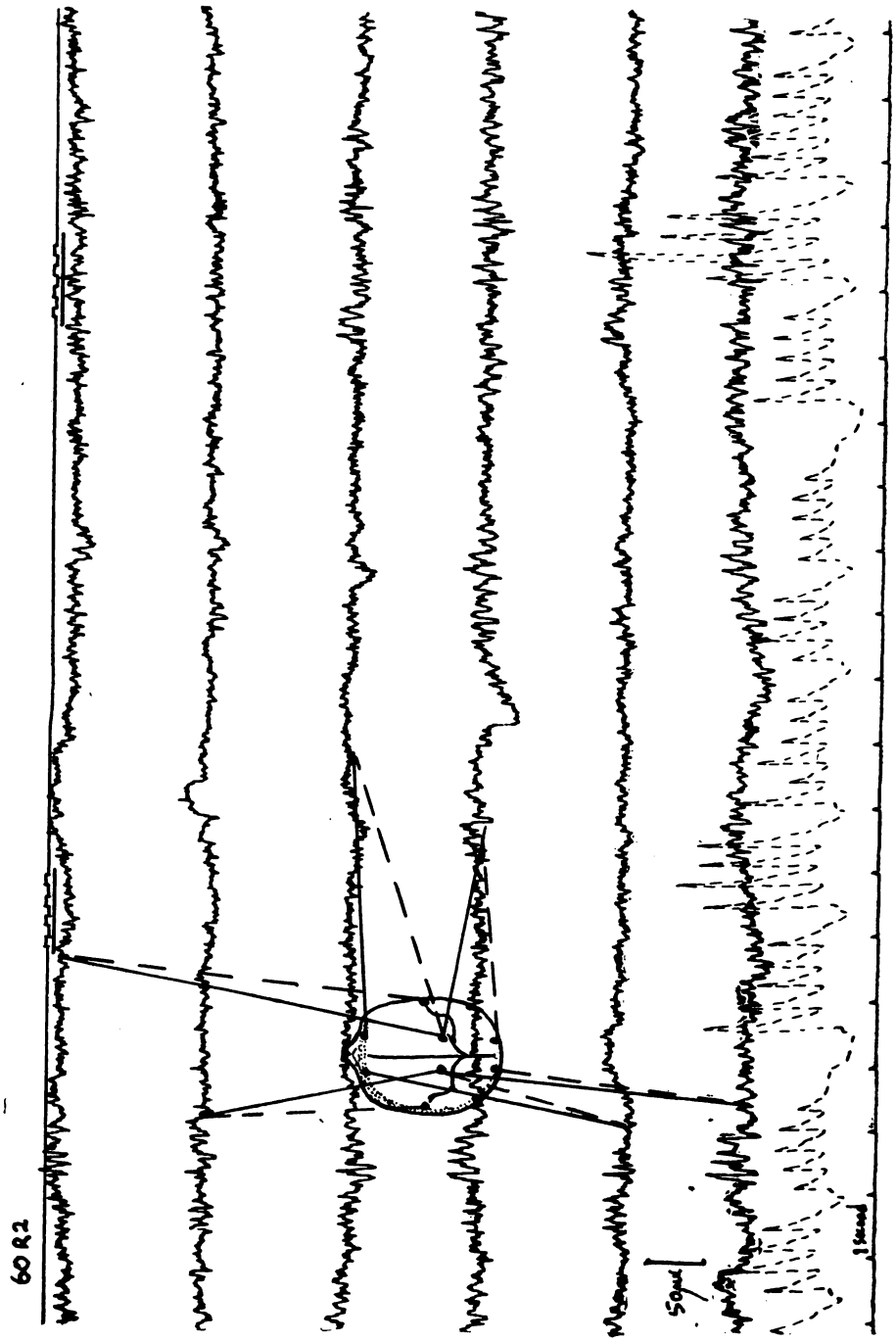


FIG. 2.—L.v.f.i.B. record from involutional melancholic patient. Note excessive theta rhythm combined with l.v.f.i.A. characteristics.

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3. *Incidence of Abnormality.*

There were 28 (24 per cent.) abnormal E.E.G.s in the total psychotic group, this being significantly different from the incidence in the normal control group (10 per cent. abnormal; $p < 0{\cdot}01$). The incidence of questionably normal E.E.G.s was also significantly higher, being 25 (21 per cent.) as opposed to 11 per cent. ($p < 0{\cdot}05$).

The influence of age on the normality or otherwise of the E.E.G. was again checked, in view of the fact that about half of our psychotic material falls in the age group 55 years and over, where arteriosclerotic and senile brain changes may affect the E.E.G. Statistical analysis revealed no significant differences in the incidence of questionable or abnormal records between the age groups above and below 55 years of age.

Similar care was taken to evaluate the possible disturbing effects of E.C.T. on the E.E.G. As the estimates of post-E.C.T. disturbances vary from 6 weeks to nearly a year, in our study untreated cases were grouped with cases treated over a year before testing, and compared with cases treated within one year before the test. There were no significant differences.

4. *Comparison of E.E.G. Characteristics with Normal Control Group.*

Statistical details are shown in Table V. It should be noted that the mean age of the psychotic group is significantly greater than that of the control group (CR = 26·50, $p < 0{\cdot}001$). The following are the salient results:

(i) *Alpha Characteristics.*

(*a*) Mean alpha frequency is significantly lower in the psychotic group.

(*b*) Mean alpha amplitude is significantly lower in the psychotic group.

(*c*) Mean per cent. time alpha is significantly lower in the psychotic group.

(*d*) There was no significant difference in distribution of R, P and M alpha types between the psychotic and normal groups.

(ii) *Beta Characteristics.*

(*a*) Mean beta frequency is significantly higher in the psychotic group.

(*b*) Mean beta amplitude just fails to be significantly higher in the psychotic group (p approx. 0·06).

(iii) *Theta Characteristics.*

Theta amplitude is significantly higher in the psychotic group.

(iv) *Beta and Theta Incidence.*

The incidence of beta rhythm is significantly higher and of theta rhythm significantly lower in the psychotic group.

5. *Flicker Response Characteristics.*

All aspects of responses to rhythmic photic stimulation were compared with those from the normal control group. The figures derived from the latter

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TABLE V.—*Comparison of Spontaneous E.E.G. Characteristics: Psychotic and Normal Groups.*

E.E.G. variable.	Psychotics. Mean.	S.D.	N.	Normals. Mean.	S.D.	N.	C.R.	Probability.	Whether significant.
Alpha frequency (c./sec.)	10·04	1·12	112	10·32	0·98	160	2·15	<0·05	Yes
Alpha amplitude (μv.)	24·37	15·85	112	31·99	20·93	160	3·25	<0·001	,,
Per cent. time alpha	43·70	30·18	112	56·10	31·09	160	3·28	<0·001	,,
Beta frequency (c./sec.)	18·98	3·30	86	17·93	3·03	85	2·15	<0·05	,,
Beta amplitude (μv.)	10·85	8·72	86	8·74	5·14	85	1·92	>0·05	No
Theta amplitude (μv.)	22·88	13·28	47	16·60	11·91	105	2·90	<0·01	Yes

have been presented earlier by Mundy-Castle (1953) together with an analysis of the factors contributing to their occurrence and suggestions concerning the origin of individual differences. In the present study we will give only those figures which are significantly different from the control group.

(i) *Flicker following.*—The mean amplitude of responses to flicker over the 4–20 f./sec. range was significantly greater than in the control group, but not in the 21–26 f./sec. range (see Table VI).

TABLE VI.—*Comparison of Mean Flicker Response Amplitudes: Psychotic and Normal Groups.*

Frequency (c/sec.).	Psychotics. Mean amp. (μv.).	S.D.	Normals. Mean amp. (μv.).	S.D.	Critical ratio.	Probability.	Whether significant.
Theta: 4–7	17·19	15·78	12·64	10·01	2·62	<0·01	Yes
Alpha: 8–10	21·46	15·79	13·68	11·90	4·28	<0·001	,,
Alpha: 11–13	22·53	16·20	16·28	12·28	3·35	<0·001	,,
Beta: 14–20	13·99	13·16	10·80	7·80	2·23	<0·05	,,
Beta: 21–26	10·60	12·06	9·07	8·03	1·14	>0·05	No

(ii) *Harmonically related responses.*—There were no significant differences in the incidence of second and third harmonics, nor second and third subharmonics, although the latter (third subharmonics) bordered on significance at the 10–5 per cent. level, since 31 per cent. psychotics showed third subharmonics as opposed to 9 per cent. normals.

(iii) *Abnormal responses.*—There were 7 per cent. abnormal and 5 per cent. questionably normal responses to flicker in the psychotic group. Neither of these figures is statistically significantly greater than in the control group, although both are larger (control incidence was 3·90 per cent. A, 3·25 per cent. ? N).

A qualitative analysis of the nature of abnormal responses revealed that 5 of the 9 were in the frontal spike category (1 of these being associated with initial wave-spikes), 2 showed generalized spike bursts with occasional slow spike wave complexes, 1 was a pure wave-spike response and 1 fell into the dysrhythmic category. Only 2 of these 9 subjects with abnormal flicker responses possessed abnormal resting E.E.G.s. Frontal spikes were accompanied either by jerks or twitches, 2 of them by laughter in addition (both of the latter being D–D2 at the time of recording). Two others showed signs of acute emotional distress. Two subjects with a frontal spike response exhibited complete adaptation after several initial evoked abnormalities, one of these showing a recurrence of evoked abnormallties during a repeat E.E.G. one year

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later, when there was no adaptation. Another subject showed an abnormal response (frontal spike) only on a second recording twenty-two months after the first, during which time there was a phase change from 0 to D1. An example of an abnormal flicker response from a manic-depressive patient is shown in Fig. 3.

(iv) *Intra-group differences.*—The following differences between the predominantly manic and predominantly depressed groups were tested for significance :

(*a*) Incidence of second and third harmonics of the stimulus frequency in the flicker response pattern.

(*b*) The occurrence of flicker following in the beta range (14–20 c./sec.). When second and third harmonics were considered separately the differences were not significant, but when treated together, the manic group showed a significantly greater incidence of harmonics (manic= 91 per cent., depressed = 71 per cent., C.R. = 2·32, $p < 0{\cdot}025$). The manic group also showed a significantly greater occurrence of flicker following in the beta range than did the depressed group (manic = 75 per cent., depressed = 54 per cent., C.R. = 2·14, $p < 0{\cdot}05$).

6. *Hyperventilation.*

There were no distinctive features relating to responses to hyperventilation among the psychotic group. Seven subjects revealed an augmentation of existing abnormalities, and no subjects with a normal resting record showed an abnormal response.

Discussion.

The results of this investigation confirm the report of Davis that there is a relationship between alpha frequency and predominant psychotic phase in manic-depressive psychosis, and that there is no change in alpha frequency with shift in phase.

We have already alluded to the report by Mundy-Castle (1951) of a relationship between alpha frequency and ratings of the Heymans-Wiersma temperament variable secondary function. Both Heymans and Wiersma maintained that the poles of the manic-depressive continuum are comparable to extremes of the primary-secondary function continuum, and that the two continua are comparable. The present findings do not support this contention, since change of phase in the individual manic-depressive is not accompanied by a shift in alpha frequency. This is not surprising, however, since the diagnoses " manic " or " depressed " are probably determined as much by assessments of mood and motility as by psychic tempo, which is the clinical variable most likely to be related to primary-secondary function. It therefore seems invalid to regard mania and depression simply as extremes of primary and secondary function. The most likely hypothesis to explain our finding of the importance of predominant clinical phase as the determinant of mean alpha frequency is that this predominant phase indicates a basic temperamental factor, i.e., degree of

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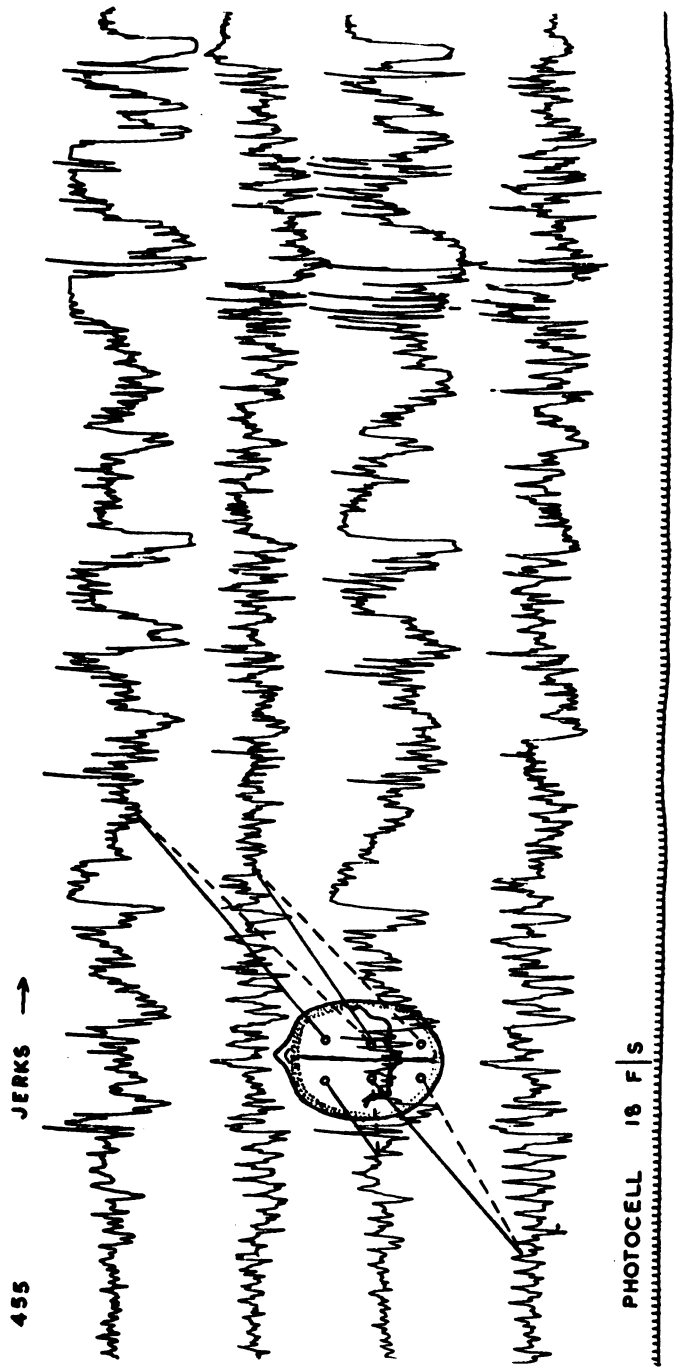


FIG. 3.—Abnormal flicker response from involutional melancholic patient. Note build-up of occipital second subharmonic, to break down into slow irregular activity followed by frontal spikes and jerks. Some of the later abnormalities are generalized.

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secondary function, and that swings towards the opposite phase are brought about by some extraneous factor or process. If this is so, the view that mania and depression are extremes of primary and secondary function should be discarded, since apart from the absence of change in alpha frequency with change in phase, there is no predominance of very high or very low alpha frequencies in the psychotic group, nor is there a significantly greater scatter about the mean than in the control group. In support of the hypothesis that predominant psychotic phase is related to the secondary function temperament variable are the results concerning differences in flicker response characteristics between the predominantly manic and predominantly depressed groups. In this analysis the former group showed a significantly greater incidence of harmonics and a significantly greater incidence of flicker following in the 14–26 c./sec. range than the latter. The implications of these findings accord with the report of Mundy-Castle (1953) that among normal subjects there are significant associations between alpha frequency, the occurrence of harmonics during flicker, and the occurrence of flicker following in the 14–26 c./sec. band: subjects with high alpha frequencies displayed a significantly greater incidence of second and third harmonics during flicker and a significantly greater occurrence of flicker following in the 14–26 c./sec. band than did subjects with low alpha frequencies. It was postulated that these differences, together with the apparent relationship of alpha frequency to degree of secondary function, are attributable to differences in excitability within the central nervous system, i.e., that primary functioning subjects possess higher excitability characteristics than secondary functioning subjects. Evidence of a different kind in support of this view has been provided by Heymans (1929), Wiersma (1932), Biesheuvel (1938) and Mundy-Castle and McKiever (1953). Gastaut *et al.* (1951) appear to have provided further supporting evidence, for although these workers did not invoke the secondary function concept, the terms they used to describe behavioural differences corresponding to different levels of cortical excitability are clearly very similar to those connoted by primary-secondary function. In view of the foregoing considerations it is proposed that similar differences are present among manic-depressive psychotics, namely that levels of central nervous excitability are higher among predominantly manic than predominantly depressed subjects. On this view, the former are likely to possess primary functioning temperaments and the latter secondary functioning temperaments.

The remaining consideration is that of the significantly greater incidence of low voltage fast irregular E.E.G.s in our manic-depressive and involutional melancholia group when compared with the normal control group. Further research is necessary to establish the significance of this type of E.E.G., but in the meantime a possible explanation for its predominance in our psychotic group is that it reflects the effects of an intermittent physico-chemical disturbance of cortical cells brought about by attack by a chemical noxa, probably of endocrine type. This hypothesis has been presented in detail by Hurst (1952*b*) and is an extension of a hypothesis evolved by Kallmann (1938, 1950) for schizophrenia, and elaborated by Hurst (1950, 1952*a*) for the same disease. In support of such a toxic-organic view of manic-depressive psychosis, Hurst

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(1952*b*) cites in particular the neuropathological findings based on human biopsy material as well as animal experimentation of Penfield and Cone (1926), Elvidge and Reed (1938), Cardona (1934) and others. The most significant observation derived from these studies is acute swelling of oligodendroglia found in manic-depressive psychosis, schizophrenia, organic brain disease and epilepsy, but not in patients who are mentally normal. This pathological process was found to occur at any depth in the white matter between the grey matter of the cortex and the ventricle, perhaps more prominent at a depth of 1 cm. and in the deeper layers. It may be patchy or generalized. Also of relevance are the reports of Rupp and Wilson (1949) and Papez and Bateman (1949) describing cortical degenerative changes in groups of psychotic patients among whom were a total of 17 manic-depressives and 2 involutional melancholics. The majority of the remainder in these two studies were schizophrenics (62).

Taking these findings in conjunction with the type of evidence offered by Davis to explain her "choppy" E.E.G.s, in particular that choppy activity is associated with organic pathology and with direct chemical stimulation of the cortex, it is possible that the l.v.f.i. predominance in our psychotic group reflects such a toxic-organic pathogenesis of manic-depressive psychosis, although clearly such a hypothesis can only be tentative.

In view of the predominance of rare intermittent and low voltage alpha rhythms in the l.v.f.i. E.E.G.s, a check was made on the possible rôle of attention in producing this kind of record by comparing the incidence of l.v.f.i.A and l.v.f.i.B records in manic and depressed cases, both in terms of predominant phase and phase at test, since these phases contrast psychologically and particularly in attention. No significant differences were found.

The significantly greater incidence of abnormal and questionable E.E.G.s in the psychotic than in the control group might be construed as further support for the toxic-organic view, but it must be remembered that the psychotic group has a significantly higher mean age than the control. We have established that in normal seniles the incidence of abnormality is far greater than in young normal adults (our figure for 50 normal seniles with a mean age of 75 years was 26 per cent.(Mundy-Castle *et al.*, 1953), so that the significance of the abnormality incidence in the psychotic group is not wholly clear. The lack of a significant difference between the under and over 55 year age groups suggests, however, that the greater incidence of abnormality among the psychotics is not solely due to an ageing process.

It is interesting to note that there is a significantly greater mean amplitude of flicker following in the 4–20 c./sec. range among the psychotic than in the control group. We had noticed before the statistical analysis that amplitudes of flicker following were often large in the psychotic group, a typical example being shown in Fig. 4. As yet no reason can be given for this difference from normals, unless it is related to an attention factor, e.g., that the psychotics pay less attention to the stimulus than the normals, thereby permitting a greater degree of synchronization of the cortical cells participating in the response pattern.

The remaining significant differences in E.E.G. characteristics between

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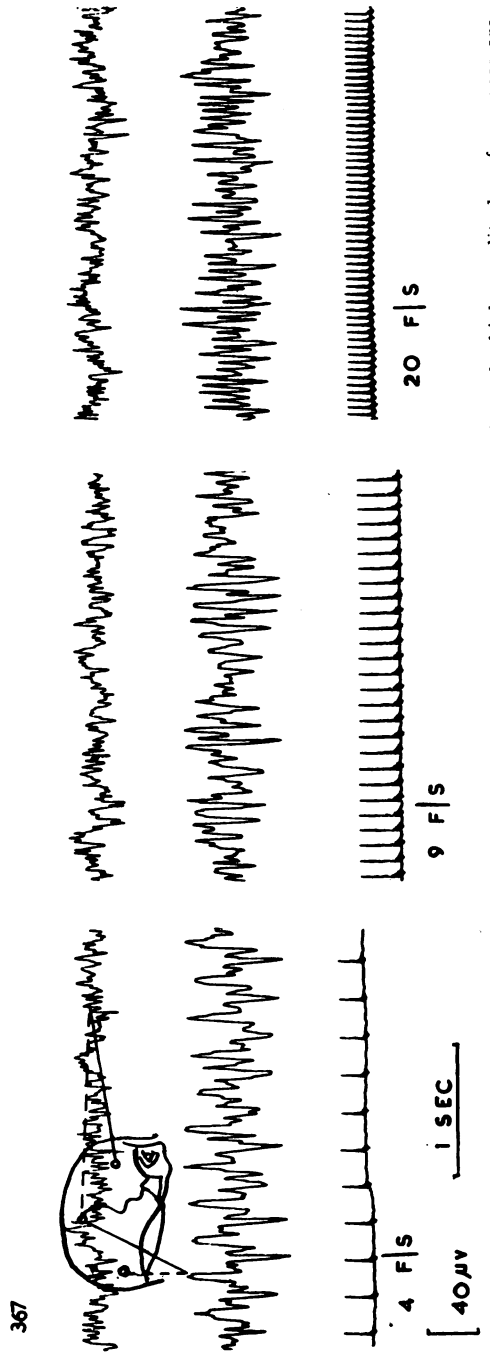


FIG. 4.—High voltage flicker responses from predominantly depressed patient. Note how the high amplitudes of response are maintained at both low and high frequencies. High amplitudes of flicker response are common amongst manic-depressive psychotics.

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the psychotic and control groups are explicable in terms of the age factor and that contributing to the occurrence of l.v.f.i. records. Alpha frequency, amplitude and per cent. time all decrease with age (Mundy-Castle *et al.*, 1953) whilst the last two are by definition less prominent in l.v.f.i. records. Incidence of theta rhythm decreases with age whilst its amplitude increases, suggesting a different kind of theta rhythm, probably related to the increased incidence of abnormality (Mundy-Castle, 1951*a*). The significantly higher mean beta frequency and greater incidence of beta rhythm among the psychotics can be attributed to the difference in incidence of l.v.f.i. E.E.G.s.

Summary.

1. The E.E.G.s of a group of 117 manic-depressive and involutional melancholic patients (mean age 55 years) were analysed. Forty-eight patients were given repeat E.E.G.s. A control group of 160 normal adults (mean age 22 years) was available for comparison. The following are the salient results:

(*a*) There were associations between cases with a history of predominantly manic phase and relatively high frequency of alpha rhythm, and cases with a history of predominantly depressed phase and low alpha frequency.

(*b*) There was no shift in alpha frequency corresponding to change in psychotic phase or change in degree of phase.

(*c*) There were significantly more low voltage fast irregular E.E.G.s among the psychotics than the normal subjects. This did not appear to be related to age.

(*d*) There were significantly more abnormal (24 per cent.) and questionable (21 per cent.) E.E.G.s among the psychotics than the normals. The age difference may contribute to this finding.

(*e*) Predominantly manic patients showed a significantly greater incidence of second and third harmonics and of following in the 14–26 c./sec. band in their flicker response patterns, than did predominantly depressed patients.

2. The relationship between alpha frequency and predominant phase in manic-depressive psychosis is attributed to differences in degree of the basic temperamental variable secondary function. The differences in flicker response characteristics between predominantly manic and predominantly depressed cases support this hypothesis together with the postulate that secondary function is related to levels of excitability within the central nervous system. It is suggested that subjects who are primary functioning and develop manic-depressive psychosis are more likely to be manic than depressed; conversely, subjects who are secondary functioning are more likely to be depressed than manic. Changes in phase are attributed to an extraneous factor or process.

3. The possibility that the high incidence of low voltage fast irregular E.E.G.s in the psychotic group is related to a toxic-organic pathogenesis of manic-depressive psychosis is discussed. Such a view can only be tentative and verification is dependent on future research.

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