



PERS 308 UTILIZATION OF THE NIPRS CLINICAL
ELECTROENCEPHALOGRAPHY SERVICE:
NOTES FOR REFERRING SOURCES AND
ILLUSTRATIVE CASE HISTORIES

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D J Murdoch

Division of Neuropsychology

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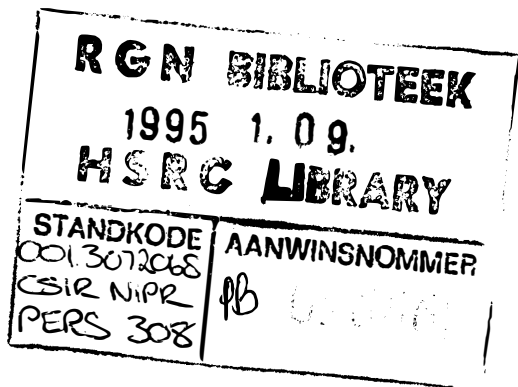
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SUMMARY

A total of 200 cases, 50 each referred by neurologists, psychiatrists, general practitioners and clinical psychologists for clinical electroencephalograms (EEGs) to the Division of Neuropsychology of the N I P R were analysed in terms of age, sex, reason for referral or provisional diagnosis, total abnormality of EEGs and electroencephalographic support for a diagnosis of epilepsy. Differences between the disciplines emerged in terms of these variables. Although the service appeared to be utilized with general efficiency, room for improvement was indicated. Suggestions for improvement and illustrative case histories are given in the appendices.

OPSOMMING

'n Totaal van 200 gevalle wat na die Afdeling Neuropsigologie verwys is vir kliniese elektroënkefalogramme (EEGs), 50 elk deur neuroloë, psigiaters, algemene praktisyns en kliniese sielkundiges, is in terme van ouderdom, geslag, rede vir verwysing of voorlopige diagnose, totale abnormaliteit van EEGs en elektroënkefalografiese ondersteuning van 'n diagnose van epilepsie ontleed. Verskille tussen die dissiplines ten opsigte van hierdie veranderlikes het voorgekom. Alhoewel die diens oor die algemeen doeltreffend aangewend is, blyk 'n mate van verbetering moontlik te wees. Voorstelle vir verbetering en beskrywings van gevalle word in die bylaes aangebied.

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INTRODUCTION

An aspect of clinical electroencephalography that has enjoyed little attention is the view of the field from the referring source's side. This embraces the indications for referral for an electroencephalogram (EEG), the meaning of the report and the significance of the report from diagnostic and therapeutic points of view.

The experience of the Neuropsychology Division of the NIPR, which has provided a clinical electroencephalographic (EEG) service for medical practitioners and specialists and paramedical professionals since the late 1940s, suggests that this view is often blurred. This vitiates against maximal optimisation of the service provided in terms of the referring source's clinical efficiency, utilization of increasingly expensive EEG equipment and skilled recording personnel, and therapeutic benefit to the patient.

This report provides evidence to support the notion of a blurred view. Issues are discussed in the Appendices directed at bringing the view into sharper focus, and illustrative case histories are provided.

METHOD AND MATERIAL

A reasonably objective index of the efficiency of utilization of the Division's clinical EEG service appeared necessary. This was sought on an interdisciplinary basis, in the number of EEG interpretations giving support to the provisional diagnosis, and/or reason for EEG referral, and between the latter and type and degree of EEG abnormality. Fifty cases referred by private practitioners representing each of 4 disciplines (general medical practice, psychiatry, neurology and clinical psychology) were extracted from the Division's clinical files. Each series of 50 patients comprised consecutive referrals by representatives of each discipline. Only cases referred for the first time were considered; follow-up and sleep EEGs were omitted. The end of March, 1980 was set as cut-off point, and the beginnings of the periods necessary for each discipline to accumulate 50 patients were as follows:

general practice - January, 1976; neurology - March, 1973;
 psychiatry - April, 1978; clinical psychology - June, 1979.

Patients were accompanied by a written history from the referring source or details were acquired telephonically. In many cases the comprehensiveness of the history was less than satisfactory. Clinical details were also obtained from each patient prior to the EEG. The provisional diagnosis was again provided in written form, or was adduced from the history.

Electrodes were placed on the scalp according to the international 10-20 system (Jasper, 1958).¹ EEGs were recorded on a Galileo E18b electroencephalograph by trained technicians in the laboratories of the Neuropsychology Division. Routine and standardized photic stimulation and hyperventilation activation procedures were employed.

EEGs were analysed according to accepted criteria (Kiloh and Osselton, 1966)², over the periods indicated, by 4 experienced clinical electroencephalographers. A standardized approach was used which rated the degree of abnormality of the record, described the features therein in terms of wave form, frequency, amplitude and location, and provided a clinical interpretation of the features. Rating of abnormality and the interpretation were made in terms of the clinical details provided by the referring source.

FINDINGS

1. AGE OF PATIENTS

	General Practitioners	Psychiat- rists	Neurolo- gists	Clinical Psychologists
Age Range (yrs)	0,75 - 46	6 - 68	4 - 57	4 - 42
Mean Age (yrs)	20,84	24,25	19,66	13,78
SD (yrs)	12,01	13,38	12,51	8,96

2. SEX OF PATIENTS (N)

Males	24	32	27	29
Females	26	18	23	21

3. PROVISIONAL DIAGNOSIS/REASON FOR EEG REFERRAL (N)

	General Practitioners	Psychiat- rists	Neurolo- gists	Clinical Psychologists
? Epilepsy/Blackouts Faints/Dizziness	38	26	29	19
? Brain Damage/Organicity	5	12	12	3
? Minimal Cerebral Dysfunction/ Learning Disability	4	8	4	23
Headaches/Migraine	4	2	1	4
Behaviour Problems/Aggression	-	5	3	1
? Tumour/Lesion	-	-	3	-

4. TOTAL EEG ABNORMALITY (N)

0 - 3,5 (Normal and borderline)	23	26	24	28
4 - 6,5 (Moderately Abnormal)	22	24	25	19
7 - 9,5 (Markedly Abnormal)	5	-	1	3

5. EEG EVIDENCE SUPPORTING A DIAGNOSIS OF EPILEPSY (N)

Non-specific (sharp and/or slow, usually px)	16	5	12	2
Specific (spike, wave and spike)	1 (6%)	3 (12%)	6 (21%)	8 (42%)
Total	17 (45%)	8 (31%)	18 (62%)	10 (53%)

Percentages are in relation to the number of cases referred with a diagnosis of epilepsy.

DISCUSSION1. PATIENT POPULATION

The age ranges, mean ages and sex distributions of patients varied for the disciplines. The mean age difference of patients were not statistically different for the medical disciplines, although the ages of patients for all the latter differed significantly from the mean age for patients referred by clinical psychologists ($p < 0,01$). This appears to reflect the interest of the psychologists in children's and juveniles' problems, and of the referring medical professions in those of older patients.

2. REASON FOR REFERRAL

The patterns of reasons for EEG referral again showed statistically

significant differences. The medical disciplines all differed significantly ($p < 0,01$) from the clinical psychologists. Further, interdisciplinary differences were significant: those between the specialities - neurology and psychiatry - on the one hand, and general practice on the other ($p < 0,05$). These could reflect the greater emphasis in psychiatric and neurological training programmes on the diagnostic utilisation of the EEG. Amongst the branches of medicine represented, the most frequent reason for EEG referral was possible epilepsy, or epileptogenic symptoms (52 to 76% of cases referred from medical sources were referred for this reason). Other popular reasons for EEG referral from medical sources were the diagnosis of brain damage or organicity (10 to 24%), and minimal cerebral dysfunction or learning disabilities (8 to 16%). General practitioners referred 8% of their cases for investigation of migraine or headaches, and psychiatrists 10% of theirs for aggression or behaviour problems. Only neurologists referred any cases (6%) for possible cerebral tumours or lesions. Amongst clinical psychologists, 46% of referrals were for possible minimal cerebral dysfunction or learning disabilities (this was the most frequent referral from this source), and 38% for epilepsy.

If, as is frequently stated (Kiloh and Osselton, 1966³; Adams and Victor, 1977⁴), the EEG is potentially most useful as an aid in the diagnosis of epilepsy, then general practitioners, followed by neurologists and then psychiatrists, referred patients in the most ostensibly effective way. However, from a therapeutic point of view, it is useful to know whether clinical signs are organically based (Small, 1973⁵) and the referral of patients with possible MCD or learning disabilities by clinical psychologists has some validity. It is of interest that patients with potential epilepsy constituted the second most frequent (38%) source of referrals by clinical psychologists.

3. TOTAL EEG ABNORMALITY

One type of criterion which can be applied to determine whether the clinical signs underlying EEG referral are valid is the total EEG abnormality rating obtained. This is based on the rationale that individuals with clinical symptoms have a greater incidence of EEG abnormality than asymptomatic individuals. Total EEG abnormality comprised rest abnormality weighted by a factor of 2 added to ratings of abnormality during photic stimulation and hyperventilation. This gave a total rating on a scale from 0 (normal) to

13 (grossly abnormal). If clinical signs were supported by EEG abnormality rating, therefore, most patients would have definitely (rating of 4 - 6,5) and markedly (rating of 7 - 9,5) abnormal EEGs. On this basis the diagnostic intuitions of the medical practitioners (48% - 54%) and clinical psychologists (44%) did not differ significantly statistically. Nor did the intuitions of the medical disciplines represented differ significantly from each other, in spite of the greater emphasis on EEG diagnosis in the specialities (neurology and psychiatry) than in general practice. Of some reassurance, however, is the fact that the incidence of abnormal EEGs in the samples represented (from 44% to 54%) appears significantly higher than the incidence of abnormal EEGs reported in groups with no clinical signs of 5 - 15% (Cobb, 1963⁶).

4. EEG EVIDENCE IN RELATION TO A DIAGNOSIS OF EPILEPSY

As indicated, the EEG is potentially of most value as an aid in the diagnosis of epilepsy. Thus, signs which could be regarded as supporting the latter diagnosis, both specific (that is, spike and wave and spike) and non-specific (sharp and/or slow, usually paroxysmal) were compared for the referring sources, each in relation to the number of patients referred with a provisional diagnosis, or signs of epilepsy. In relation to non-specific support for the diagnosis, neurologists had the best success rate (62%), differing significantly from both general practitioners (χ^2 5,8; $\rho < 0,02$) and psychiatrists (χ^2 19,3; $\rho < 0,01$), but not from clinical psychologists (χ^2 1,7; $\rho > 0,05$). This may reflect the higher frequency of referrals for epilepsy to neurologists, and their greater potential for the identification of symptomatology as epileptogenic, than for the other medical disciplines or psychologists. In relation to specific EEG signs of epilepsy, the clinical psychologists had a significantly higher success rate than any of their medical brethren, although the neurologists are again top of the medical pile. It is possible that the high success rate of the clinical psychologists in respect of both specific and non-specific EEG signs is related to the significantly younger group from which they drew their patients (see Table 1). Ajmone-Marsan and Zivin (1970)⁷ found that 80% of patients aged less than 10 years with epilepsy had an abnormal EEG. The incidence of epilepsy is higher in younger patients, and tends to diminish with age. (Kiloh and Osselton, 1966⁸; Nelson, 1978⁹). Further, seizures occurring for the first time and thereby evoking the necessity for treatment, are more likely in children than in adults. Finally, it is possible that the success rate of the clinical psychologists as a group is somewhat artificially inflated by the fact that the majority of cases (41) were from one source. This

individual had been exposed to intensive training in electroencephalography as a postgraduate student, and his experience is atypical in this respect.

Adams and Victor (1977)¹⁰ indicate that the EEG is abnormal to some extent interictally in about 40% of known epileptic patients. Ajmone-Marsan and Zivin (1970)¹¹ suggest that 56% of known epileptics have a positive EEG on first examination. In the light of these figures, the range of positive EEGs (45 - 62%) in the present study for neurologists, general practitioners and clinical psychologists suggests comparable diagnostic efficiency. That for psychiatrists (31%) is below average. However, the therapeutic concern of psychiatrists with this syndrome is probably not primary.

CONCLUSIONS

The efficiency of diagnostic utilization of the EEG in epileptic patients is acceptable in general. However, there appears, in addition, to be an emphasis on EEG referral in syndromes which do not benefit maximally from EEG results, due to non-specificity of signs. Further, when the criterion of EEG abnormality as a whole is applied, then a more selective approach to referring patients for EEG examination appears advisable.

A more comprehensive understanding of the EEG, the contents of the EEG report, and indications for EEG referral and the value and limitations of the EEG in a clinical context is desirable. These topics are therefore considered in Appendix I. Appendix II gives illustrative case histories.

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appearance

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APPENDIX I(NOTES FOR REFERRING SOURCES)WHAT IS AN EEG?

An EEG is a measure of the continually changing differences in electrical potential between 2 electrodes situated on the scalp. The differences in potential are related to the combined electrical activity of a group of neurones in the vicinity of each electrode. Electrical activity which deviates from normal may indicate abnormal neuronal function or be related to the anatomical destruction of brain cells. In a routine clinical EEG examination, 22 electrodes are used, placed against the scalp according to a standardized and internationally-recognised system. The electrodes cover the whole cortical surface, and deviant activity can be used to localise neurones which are functioning abnormally, or which are damaged.

Electrodes are positioned against the scalp, and the EEG is recorded, by an EEG technician. It is the technician's responsibility to ensure that the EEG record contains activity which originates in the brain, and is not derived artefactually from noncortical sources (for example, electromyographic artefact). The electroencephalographer deals with the analysis and interpretation of the EEG record. The interpretation of the findings is made in the light of the patient's age, clinical history (especially as related to conditions and accidents affecting the functioning of the central nervous system) and provisional diagnosis of the referring source.

WHEN SHOULD AN EEG BE REQUESTED?

The EEG has a diagnostic role to play in determining the causes of symptoms which are open to ambiguous interpretation by their nature or by virtue of the patient's age, mental status or antecedent history. This role may lie in pinpointing the underlying basis for symptoms or in reducing the number of possibilities. Examples are given in Sections 1 - 3.

1. EPILEPSY

Patients presenting with the "classic" symptoms of foaming at the mouth, tonic-clonic convulsions, loss of consciousness and incontinence pose little diagnostic challenge. The EEG may assist in confirming, if there is any doubt, that the symptoms are epileptic, and in locating any focus of abnormal

activity. The EEG has more direct relevance in "minor" seizures. This type is most frequent in children aged 4 - 14 years, and is characterised by a brief and sudden interruption of consciousness, so brief sometimes that the patient is barely aware of it. This may be accompanied by slight motor involvement, such as movements of the eyelids, arms or facial muscles. The absences may be so brief, and the patient so adept at continuing or resuming his activities or train of thought, that they may be regarded by family and friends as absentmindedness, memory or concentration lapses, or as a personality quirk. In this type of case, the occurrence of activity in the EEG commonly associated with minor seizures may point to or provide evidence substantiating a diagnosis of epilepsy. The EEG is especially valuable in this type of epilepsy as the patient may be too young to describe his symptoms to the medical practitioner or may, because of a cognitive lack, be unable to. The practitioner may also be unable to ascertain from the reports of witnesses of attacks whether these are epileptic in origin. In seizures with involvement of the temporal lobe, symptoms may also occur which are not initially recognised as epileptic. These may include visual and/or auditory hallucinations, feelings of dread, anxiety, or alienation, objects or the patient's body or body member which increase or diminish in size, or periodic outbursts of rage or aggression. A train of symptoms may be evoked, leading to an automatism. Seizures occurring at the onset of, or during sleep, or upon awakening, where the reliability of witnesses, if any, or the patient's own report, are open to question, are obvious areas for EEG investigation. Seizures reported infrequently in relation to specific situations or conditions may also be investigated in the laboratory, where the provoking situation or condition may be simulated while the EEG is being recorded. For example, seizures reported while watching television may be evoked in the laboratory by photic stimulation. Seizures occurring after sleep or food deprivation or excessive intake of alcohol may be precipitated in the laboratory after the appropriate antecedent treatment. Epileptiform phenomena or blackouts reported after chronic, excessive intake of alcohol are worthy of EEG investigation to determine whether they are epileptogenic.

2. HEAD INJURIES

Symptoms lasting for months may occur after head injuries, even although the injury may not be associated with loss of consciousness. Examples are: a general, non-specific personality change, loss of memory, slowed thought

processes, lack of concentration, tiredness, headaches and dizziness. The EEG may assist in determining whether such post-traumatic symptoms are related to brain damage. In some cases, the EEG may be a more sensitive indicator of severity of brain damage than the clinical state. It may also be useful in predicting the prognosis of the patient: an EEG which is mildly abnormal a few days after head injury is indicative of a more favourable prognosis than one which is severely abnormal. On the other hand, a normal EEG in the face of clinical signs has sombre prognostic implications. The EEG after closed head injuries may also be useful in localising the site of the injury if this is not known. It is also of value in the assessment of the risk of development of post-traumatic epilepsy. In the medico-legal context, it must be emphasised that an abnormal EEG some time after the injury is not necessarily causally related to the latter, nor does it always suggest that permanent brain damage has resulted.

3. BRAIN LESIONS

Tumours may be present with very mild symptoms initially. Sometimes it is necessary to determine from a person with long acquaintance of the patient, whether symptoms are, in fact, present. The following may be encountered in cerebral tumours: sudden decrement in work efficiency, lack of motivation for the performance of everyday tasks, excessive irritability, emotional lability, slowed reactions, lack of insight, forgetfulness, reduced cognitive capacity, etc. These may be ascribed by the patient himself to anxiety, worry or depression, and the EEG in this type of case may be important diagnostically. Symptoms of cerebral tumours at a more advanced stage provide less of a diagnostic riddle, and may comprise persistent and severe headaches, vomiting and seizures. The sudden onset of seizures in a previously asymptomatic adult is strong support for the presence of a cerebral tumour. In general, cerebral lesions (that is tumours and abscesses) which are rapidly expanding have the greatest frequency of EEG abnormalities. More slowly growing tumours and those outside the cerebral hemispheres do not always affect the EEG.

4. CEREBROVASCULAR DISEASES

The clinical distinctiveness of cerebrovascular diseases, comprising abruptness, arrest and regression of neurologic deficit, makes the EEG almost superfluous in this diagnostic context. In the milder forms, however,

the EEG may have localising significance. Further, after 3 to 6 months roughly 50% of patients with cerebrovascular accidents have a normal EEG in the face of clinical symptoms. This indicates a poor prognosis for further recovery.

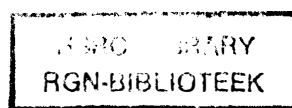
PSYCHIATRIC AND PSYCHOLOGICAL DISORDERS

The EEG would appear to have little diagnostic significance in this group of disorders. Although the incidence of abnormal EEGs appears higher in certain diagnostic categories (eg. schizophrenia, psychopathy), the specificity of patterns is not great. This vitiates against the diagnostic employment of the EEG in the individual case, although a degree of diagnostic satisfaction may be felt at the emergence of the expected EEG pattern in a patient. An abnormal EEG does not necessarily indicate that medication will prove effective, nor that psychotherapy or improvement is contraindicated. Patients are often referred for an EEG from psychiatric sources with the query: are symptoms organically-based? It must be remembered that an abnormal EEG does not provide unequivocal evidence supporting an anatomical basis for symptoms. Firstly, as indicated previously, no differentiation is possible on the basis of EEG signs between a functional or anatomical genesis for symptoms. Secondly, the non-specificity of EEG signs extends also to maturation defects or lags and cortical damage, and no differentiation between these is possible on EEG grounds, particularly in children. This point has particular relevance in patients with no definite history of cortical trauma or damage. EEG findings may have a role in the planning and application of therapy. Further, cases of malingering or hysteria may be detected after EEG examination, on occasion, however, only after application or specialised investigative procedures (such as evoked potential recording).

AREAS TO BE COVERED WHEN REFERRING A PATIENT FOR AN EEG

Not all areas will be relevant in every case. However, as complete a history as possible is desirable in order to allow the electroencephalographer to make a valid interpretation of EEG findings.

Pregnancy and birth history, problems with or delayed motor development, clumsiness, hyperactivity, school progress and problems, learning problems/disabilities, writing/reading disabilities, dizziness, blackouts, automatic



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behaviour, epileptic seizures (as full a description as possible including motor involvement, left/right asymmetries, length of loss of consciousness or absence, incontinence, confusion, etc.) episodic aggression and aggression without discernable cause, the body image, speech problems, memory and concentration problems, head injuries (again, as full a description as possible, including head area involved, date, loss of consciousness, pre- or post-traumatic amnesia, neurologic sequelae), disturbances of consciousness, high temperatures, illnesses involving the central nervous system (eg. meningitis, encephalitis), use of alcohol, dagga, drugs and medication (amount, frequency and most recent intake), family history and history of genetic and inherited diseases, headaches, muscle weakness or loss of sensation in a body area, sensitivity to flickering light or television, sudden deterioration in a specific area or ability, and the results, if any, of previous EEG and specialised investigative procedures involving the skull and cerebrum.

WHAT CAN BE EXPECTED OF THE EEG ?

A. SPECIFIC SIGNS IN EPILEPSY

The EEG is most valuable as an aid in the diagnosis of epilepsy, as a specific pattern highly correlated with this diagnosis is present in some cases. The presence of this pattern in the light of a history suggestive of epilepsy thus has considerable significance in the further investigation and treatment of the patient. A small percentage (about 2%) of "normal" individuals may, however, also show this activity. Investigation suggests that these individuals may never have had a seizure, and may never have one. However, given the right combination of precipitating circumstances (fatigue, lack of sleep, food deprivation, etc.) they may be at risk for seizure development. It is this type of finding that suggests that clinical symptoms and not an abnormal EEG should be the rationale for treatment. The importance of a comprehensive clinical history is emphasised thereby. The prime importance of the latter is further underscored by virtue of the fact that 30 - 40% of epileptics show non-specific abnormalities in the EEG between seizures. As alternative interpretations of this type of activity are possible, the diagnosis of epilepsy can only be made in relation to appropriate clinical data.

Up to 40% of known epileptics, depending on the type of epilepsy, may demonstrate a normal EEG on the first occasion of recording. Anti-convulsant therapy further tends to normalise the EEG. In cases such as this, Daly (1979)¹² suggests that a sound approach is to maintain the patient on therapy and repeat the EEG. Activation procedures, if not routinely applied, should be utilised, and procedures not routinely used (sleep recordings or recordings using special electrodes) should be considered. If the examinations consistently yield negative results, then anticonvulsant drugs may cautiously be withdrawn, and the EEG repeated after an interval sufficient to escape possible withdrawal effects.

B. NONSPECIFIC EEG SIGNS IN POSSIBLE EPILEPTICS

Labelling a patient epileptic on the basis of a non-specifically abnormal EEG in the light of an inadequate or nonexistent history can not be condoned. Even in this enlightened age, this label still carries a stigma and excludes the victim from many of the amenities so casually accepted by his fellows. On the other hand, an individual with genuinely epileptic seizure phenomena who remains untreated, is at risk of serious bodily injury in certain occupations or recreations. A child may be disadvantaged at school because of frequent absences and problems with memory and concentration. The patient may not have the emotional resources to cope with the subjective phenomena associated with seizures, particularly if, on the basis of a single normal EEG, he is informed that he is "normal". The electroencephalographer, therefore, sometimes treads a precarious path. He should not, in his report, give the impression, particularly to referring sources whose acquaintanceship with the EEG is not great, that non-specific signs are conclusive support for a diagnosis of epilepsy. On the other hand, he should not convey the equally invalid idea that non-specific signs have no diagnostic significance in a patient with a provisional assessment of epilepsy. A comprehensive clinical history is often significant in assisting the electroencephalographer to meaningfully interpret EEG signs for the referring source.

C. NONSPECIFIC EEG SIGNS IN OTHER PATIENTS

Patients with diagnoses other than epilepsy (eg. learning disability, hyperactivity) may show the same EEG pattern. From a therapeutic viewpoint,

it is not possible to ascertain whether clinical signs are due to a physiological dysfunction, or to an anatomical abnormality. However, it must be emphasised that the presence of an EEG abnormality is not a contra-indication for psychotherapy. Indeed, the location and type of EEG abnormality may dictate specific therapeutic tactics. The abnormality may improve or disappear with the clinical improvement of the patient, as remedial procedures or the ongoing maturation process stimulate neurones in the vicinity of those damaged, thus opening an alternative functional pathway. In cases where symptoms do not respond to remedial procedures (eg. in adults) therapy can be directed at intact functions, or at increasing the patient's acceptance of his disabilities.

WHAT THE EEG REPORT SHOULD CONTAIN

The EEG report written for clinical purposes should include 3 areas.

1. A judgement of the degree of abnormality of the EEG in relation to the patient's age, clinical history and condition, level of arousal and intake of medication.
2. A description of the EEG activity seen in terms of frequency, amplitude, wave form, areas of the cortex involved, periodicity and amount of activity seen. In many cases this may appear overly detailed, but these details are important for comparing changes on follow-up EEGs. The description of features is of primary significance for the electroencephalographer.
3. The interpretation, particularly of non-specific findings, is made in relation to the patient's history. Particular attention should be paid by the referring source to the wording of this section, as interpretations may, on occasion, be drawn with hesitancy. The degree of certainty with which the interpretation is made must be considered in any therapeutic context, particularly where the prescription of medication is involved. Recommendations for follow-up recordings, perhaps with sedation or specialised recording or antecedent procedures, may be made. It is at the discretion of the referring source whether these recommendations are acted upon. However, the electroencephalographer usually does not lightly ask for a repeat, bearing in mind the inconvenience and added cost to the patient.

LIMITATIONS AND ADVANTAGES OF THE EEG

1. LIMITATIONS

1.1 While a positive EEG may have diagnostic significance, a negative EEG is not necessarily compatible with asymptotology. A normal EEG does not, therefore exclude epilepsy, maturation defects or cortical damage. A routine clinical EEG recording usually lasts between 20 and 30 minutes (sleep EEGs may take longer), and the conditions evoking or augmenting the EEG dysfunction might not be operative during the examination. Further, the EEG primarily records activity in the relatively limited surface of the cortex and abnormalities localised deep within the cerebral matter may not achieve cortical representation.

1.2 The EEG reflects temporary influences which may produce signs similar to those resulting from pathological conditions. Age, metabolic influences, level of arousal and emotional state are such influences.

1.3 The analysis and interpretation of the EEG is by no means an objective and conclusive science. This means that the possibility of intra- and inter-individual differences in analysis and interpretation should be expected and allowed for. Differences in the format of reports from different laboratories may make comparison of EEG findings difficult.

1.4 Abnormal EEGs may be recorded in between 10 and 25% (depending on age) of the "normal" population with no obvious clinical symptoms. As indicated, even wave and spike activity may be recorded in individuals with no clinical signs of epilepsy.

2. ADVANTAGES

2.1 The EEG is relatively cheap, of brief duration and non-invasive. It is a technique which, with the help of sedation, may be carried out on patients of all ages and of all diagnostic categories.

2.2 The validity of the EEG may be improved with the use of special procedures and equipment, such as photic stimulation, hyperventilation, sleep and alcohol recordings, special electrodes, and follow-up EEGs. The latter are of considerable value in the determination of the effects of medication on cortical activity, the development of expanding lesions and changes after brain damage.

2.3 In cases who are unable to describe their subjective sensations and symptoms due to feeblemindedness, age, etc., the EEG may provide the only objective evidence of epilepsy. This is especially true in cases with minor clinical signs, or in individuals who are unwilling to disclose their epilepsy for fear of ridicule or of being excluded from occupations and recreations such as driving, flying an aeroplane or controlling potentially dangerous equipment.

2.4 It is not necessary for an epileptic to have an overt seizure for the EEG to be of value. Activity recorded between seizures may be diagnostically significant.

2.5 The EEG at present is the only non-invasive method of monitoring the functions of the intact, living brain.

APPENDIX II

(ILLUSTRATIVE CASE HISTORIES)

MALE WITH NO EPILEPTIC SEIZURES, BUT OTHER SYMPTOMS, AND A NONSPECIFICALLY ABNORMAL EEG.

This was an individual aged 17 years. Initially, he had been referred to the NIPR's Counselling Section for poor achievement in Matric, which he was repeating. The counselling psychologist established the following on interview:

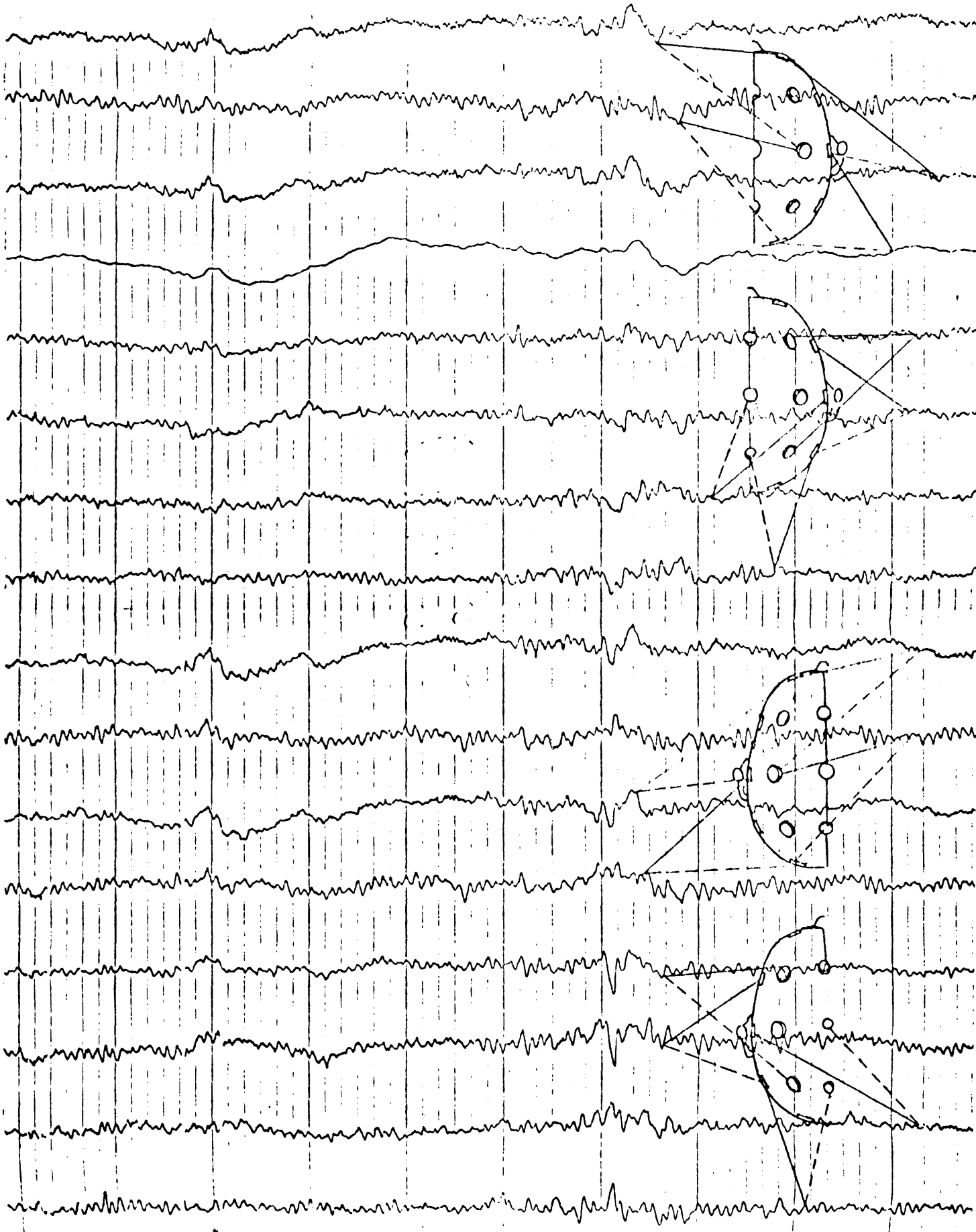
1. as a baby, a considerable amount of blood had been lost during circumcision;
2. at the age of 8 years he had suffered a minor head injury with brief loss of consciousness when his head had been trapped between 2 stands;
3. severe headaches were experienced;
4. slight learning problems were described;
5. frequent blackouts or dizziness occurred on standing.

Page 19: EEG during rest. Brief medium-high voltage runs (6-7 Hz) in all cortical areas, with an isolated sharp wave discharge, appearing focally in the left fronto-temporal region.

Page 20: The EEG after 70 seconds of hyperventilation. Slower (3-4 Hz), high voltage activity was elicited, again with focal left fronto-temporal signs, and an isolated spike discharge in this region.

The EEG was regarded as indicating a left fronto-temporal dysfunction, probably epileptogenic. It later emerged that the patient suffered blanks in concentration and found difficulty in following conversations due to "lapses". These were regarded by his family as personality eccentricities, and not manifestations of epilepsy.

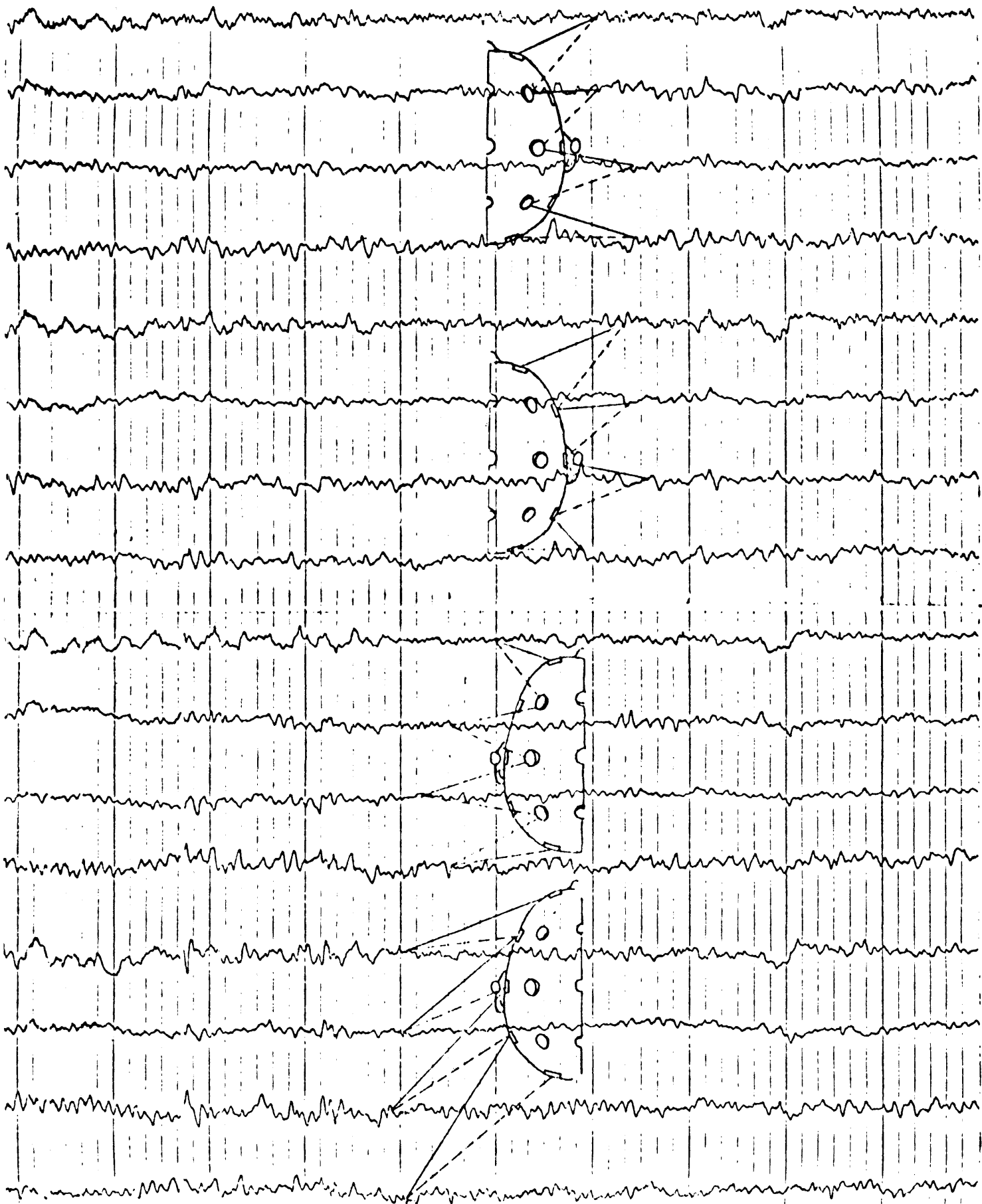
The patient was referred to a specialist who on the basis of the above, and a further EEG, prescribed anti-epileptic medication. The patient's school performance improved and his lapses and headaches disappeared.



1 sec. 50 μ V

Position 5
TC1

G 100
F 1



50 μ V
1 sec.

Hyp. 70"
Position 1
F 0

G 100
TC 1 except Ch. 1, 5, 9, 12 & 13

EEG WITH WAVE AND SPIKE ACTIVITY AFTER REFERRAL FOR SYMPTOMS NOT SUGGESTING EPILEPSY.

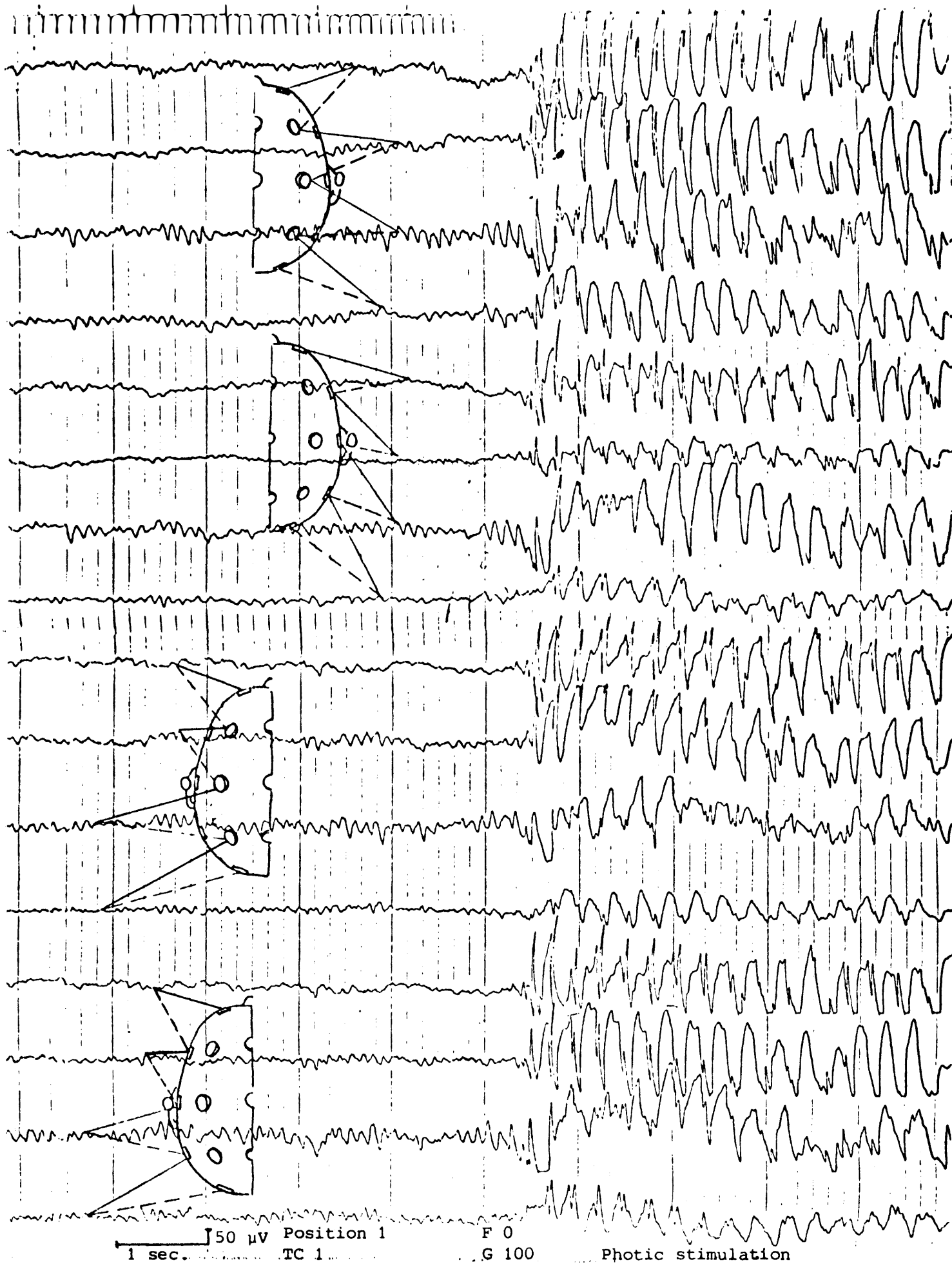
This was a 14 year-old girl with severe headaches involving the temporal areas, and behaviour problems, referred by a clinical psychologist.

The history was positive for meningitis (at 10 years). She had experienced a mild head injury at 6 years. No epileptic seizures were reported.

The EEG was normal during rest.

Page 22: The EEG during photic stimulation showed high voltage generalised wave and spike activity.

This strongly suggested epilepsy, and she was placed on anti-convulsant medication by a neurologist. Her headaches vanished (they were regarded as epileptic symptoms by the neurologist), and her behaviour improved.



1 sec. 50 μV Position 1
TC 1

F 0
G 100

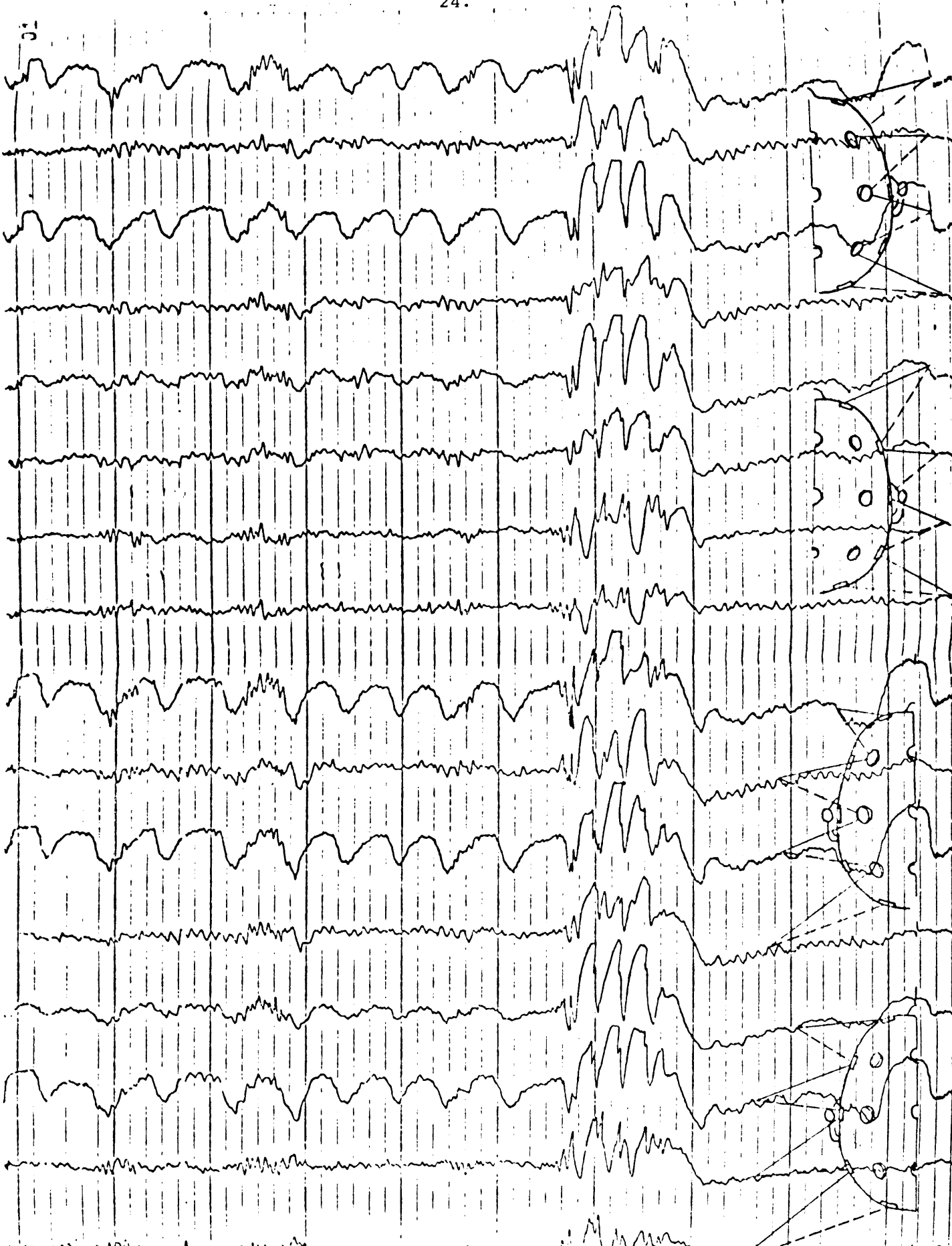
Photic stimulation

WAVE AND SPIKE ACTIVITY IN THE EEG AFTER REFERRAL FOR AGGRESSIVE BEHAVIOUR

This was a 19 year-old male referred by the State Psychiatrist for episodic outbursts of aggression. He was mentally deficient, with a very low verbal ability.

Page 24: The EEG showed a brief, high voltage generalised wave and spike discharge in response to photic stimulation. This strongly suggested epilepsy.

The EEG was highly significant in the diagnosis and treatment of this patient. In the first instance, the discharges noted in the EEG were very brief (most about 1 second in length). Thus it is unlikely that marked clinical manifestations were present during the discharges. None were seen during the recording. Second, the subject's low cognitive capacity and lack of expressive ability prevented him from adequately describing the subjective accompaniment of his discharges.



1 sec.

50 μ V

Position 1
TC 1
F 1 and 2

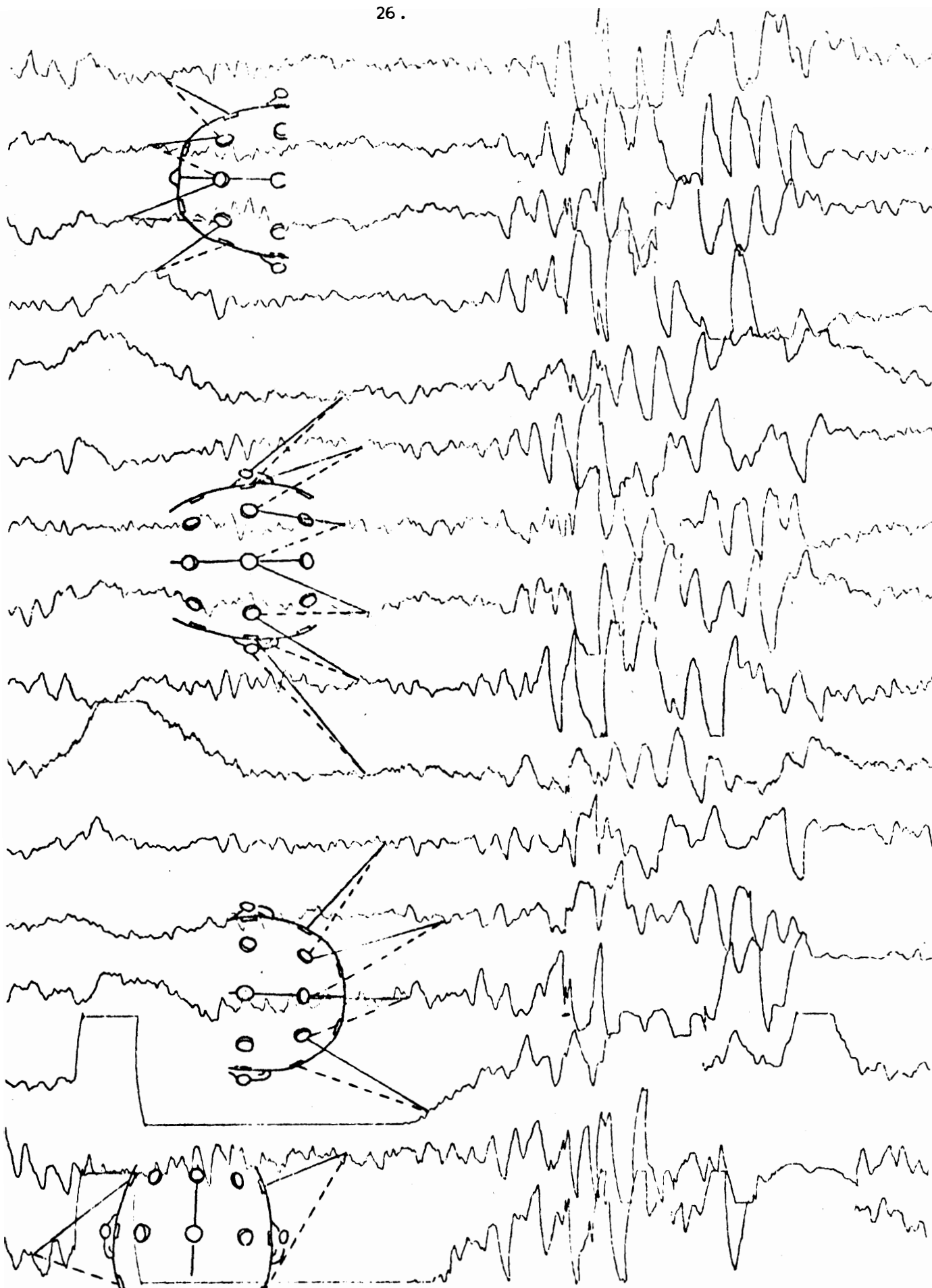
Photic stimulation
G 100

EEG WITH WAVE AND SPIKE ACTIVITY DURING DROWSINESS IN A CHILD WITH NO CLINICAL MANIFESTATIONS OF EPILEPSY.

This child, aged 3 years and 9 months was asymptomatic apart from temper tantrums. He was referred for an EEG by a clinical psychologist.

Page 26: The EEG showed a very high voltage generalised wave and spike paroxysm lasting about 2 seconds and with considerable frequency variation. The child was drowsing during the recording. Epilepsy was strongly suggested by these findings...

The temper outbursts thus appeared epileptogenic, and the child was placed on anti-convulsant therapy by a neurologist. It is possible that if the child had been old enough to articulate his subjective sensations during the outbursts, their epileptogenesis may have been shown before the EEG was recorded. The child was seen after 5 weeks of medication, and his progress was described by the neurologist as "outstanding". His symptoms had largely disappeared.



1 sec. | 50µV

Position 4
TC 1

G 100
F 0

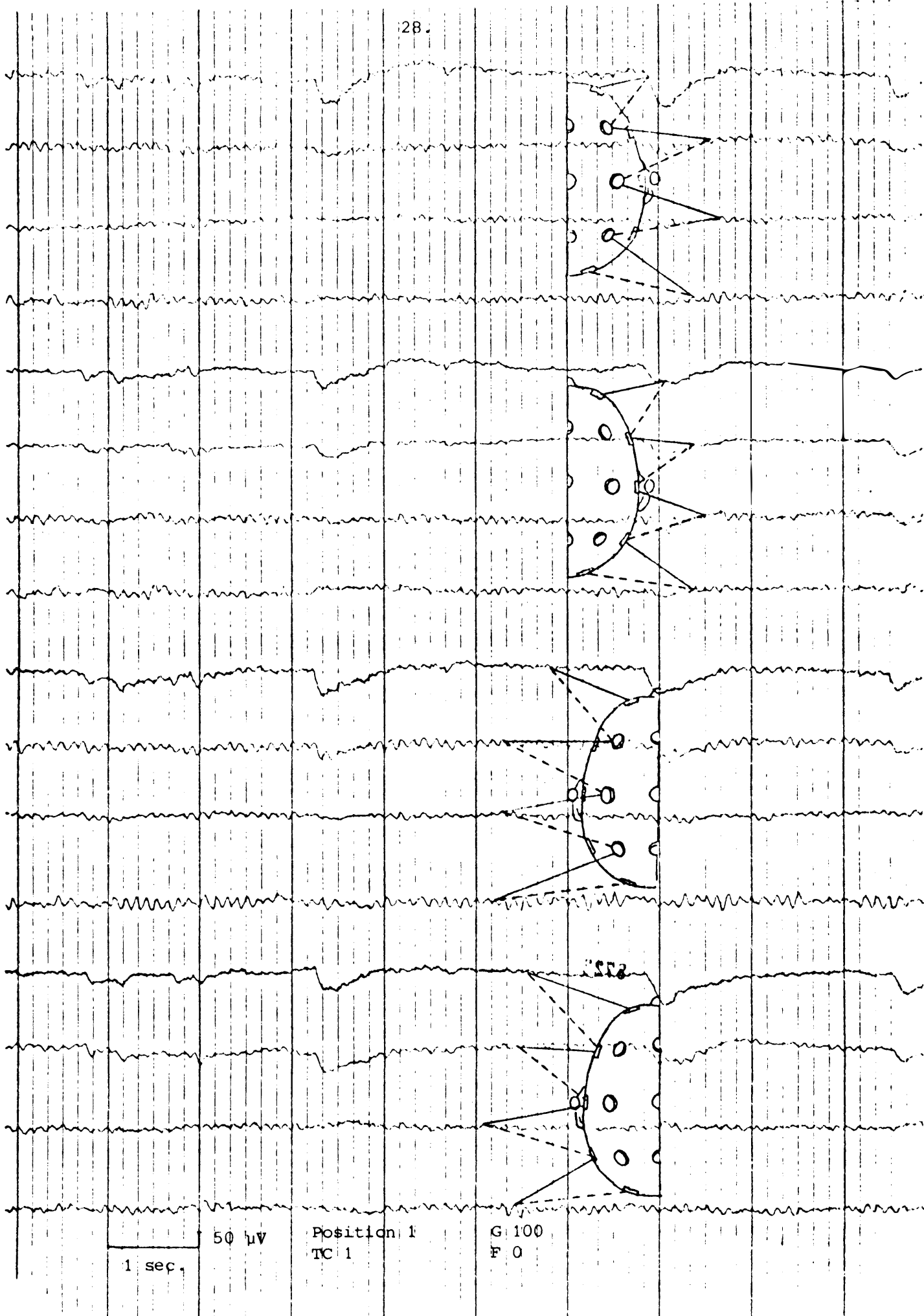
WAVE AND SPIKE ACTIVITY DURING A SLEEP EEG, WITH A NORMAL EEG ON THE FIRST OCCASION OF RECORDING.

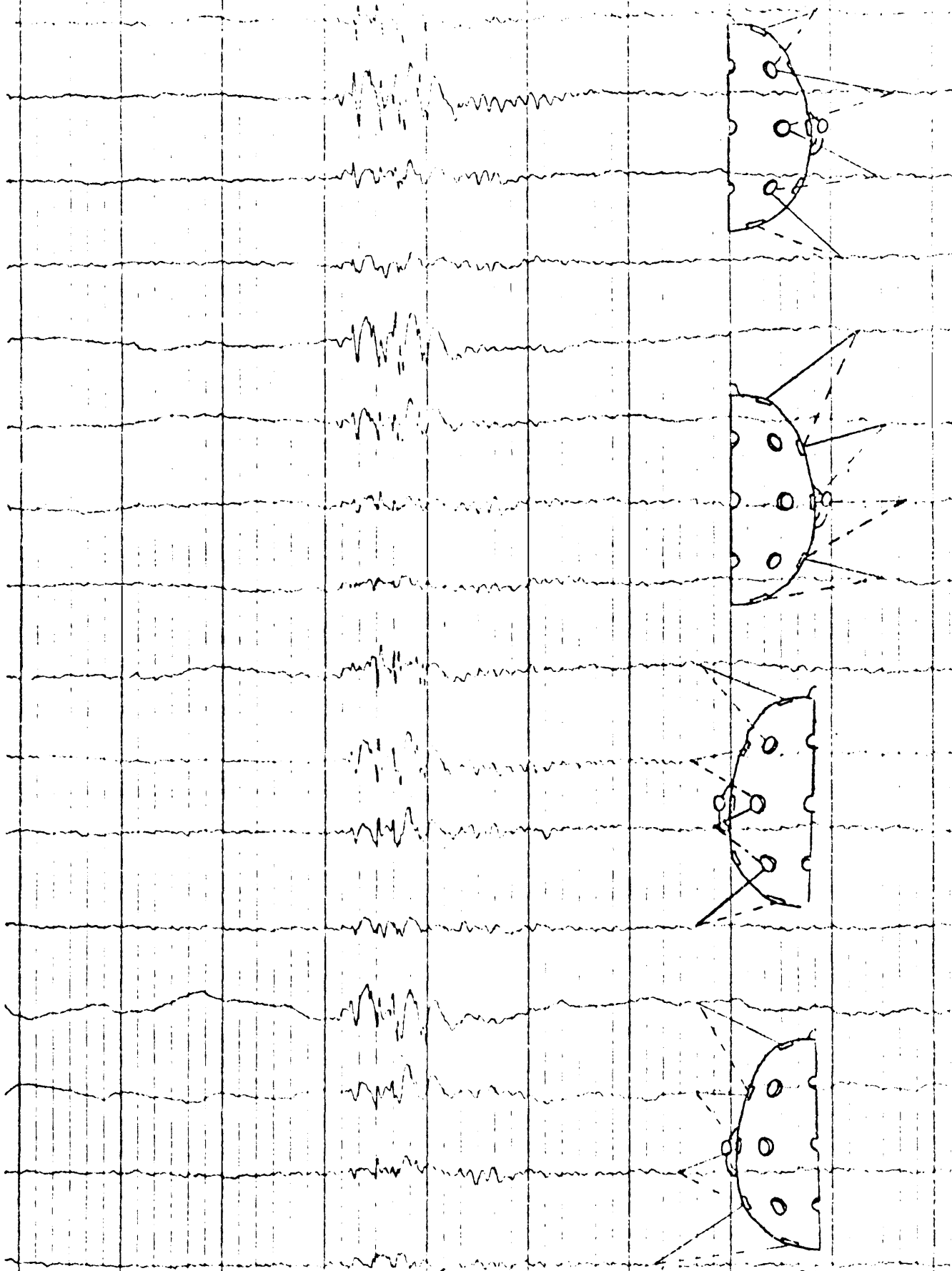
This was a male, asymptomatic until the age of 26, who had a seizure upon awakening. During the seizure his tongue protruded, his eyes rolled back, and he assumed the foetal position. The family history was negative for epilepsy.

Page 28: The normal EEG recorded on the first occasion. Alpha activity at a frequency of 8-9,5 Hz and of medium-low amplitude appears in all cortical areas. In view of the history, a repeat with sedation was suggested.

Page 29: EEG recorded after administration of sedation. The patient was in a light doze. The EEG showed generalised, high-voltage wave and spike discharges of atypical frequency. Strongly suggestive of epilepsy.

The patient was placed on anti-convulsant therapy and remained seizure-free.





1 sec. 50µV

Position 1
TC 1

G 100
F 0

2132

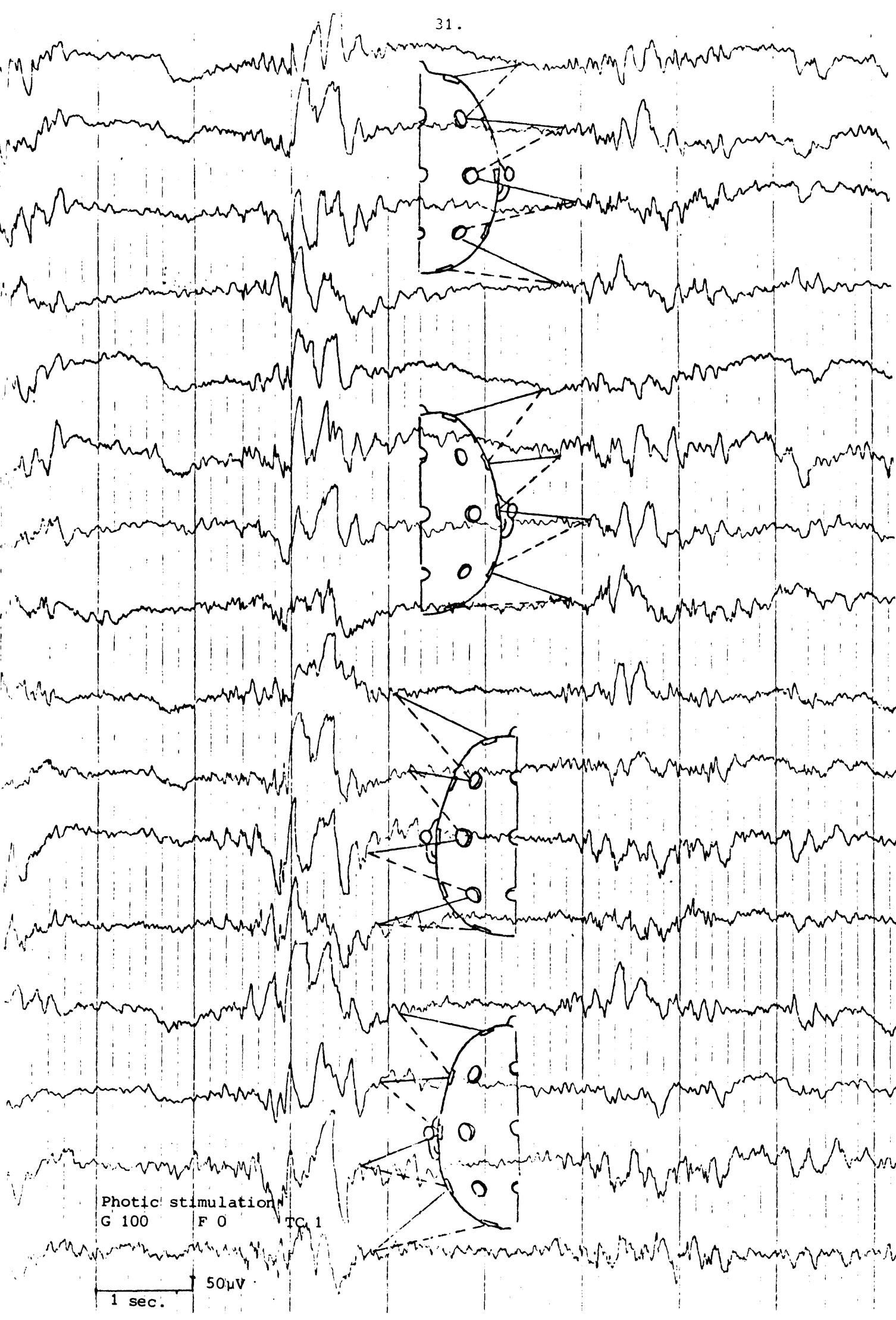
EPILEPSY WITH MAXIMAL INVOLVEMENT OF THE TEMPORAL AREAS.

This 16 year-old girl was referred by a general practitioner for an EEG with a provisional diagnosis of temporal lobe epilepsy. She had frequent déjà vu experiences, and feelings of unreality.

Page 31: The EEG in response to photic stimulation was severely abnormal with high voltage generalised atypical spike and wave paroxysms. There was a tendency for this activity to be maximal in the left temporal area.

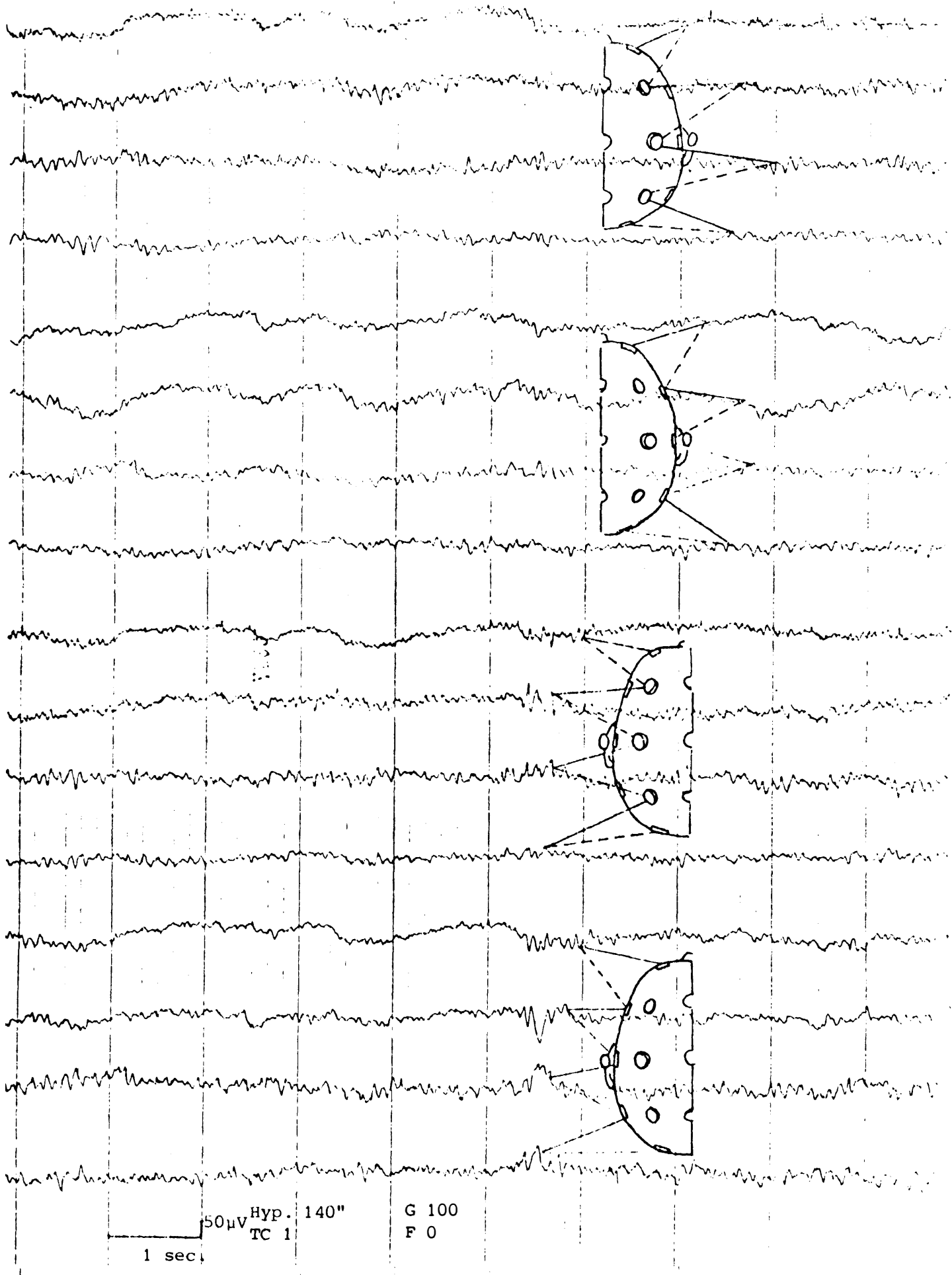
Page 32: The EEG during hyperventilation showed medium-high voltage sharp wave and 3-6 Hz discharges, focal in the left temporal area.

The EEG signs strongly suggested a generalised epileptic dysfunction with maximal involvement of the temporal areas, particularly on the left. She was placed on anti-convulsant therapy and three months later was well-controlled, with a considerable remission of symptoms.



Photic stimulation
G 100 F 0 TC 1

1 sec. 50µV

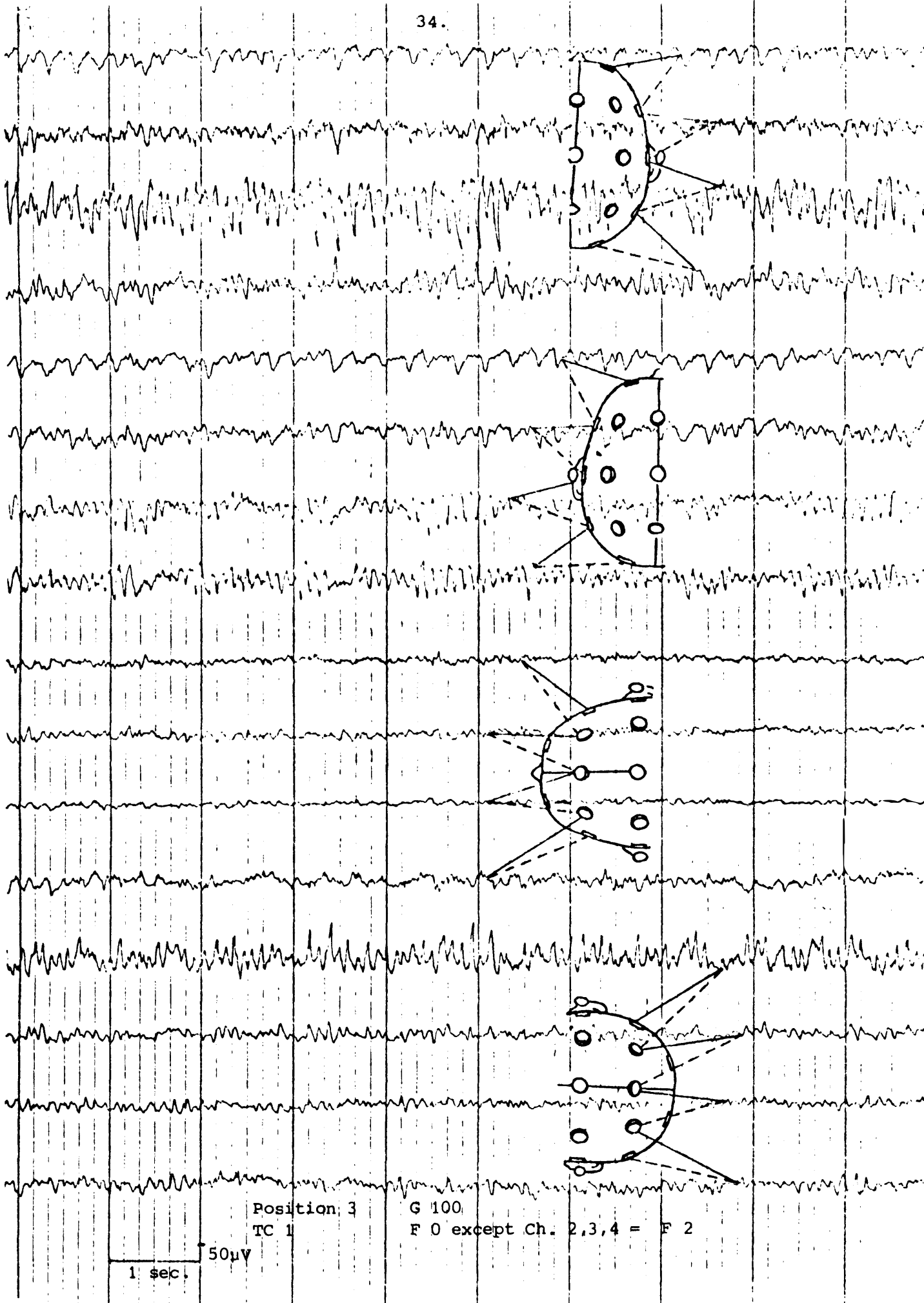


EEG WITH FOCAL TEMPORAL SPIKES IN A SUSPECTED TEMPORAL LOBE EPILEPTIC.

This was a 27 year-old mentally deficient girl who presented with hallucinations and temper outbursts.

Page 34: The EEG was markedly abnormal with very numerous, high voltage spikes appearing focally in the right post-temporal area. An epileptogenic disorder involving this region was strongly suggested.

The EEG thus supported the provisional diagnosis in a case, who could not, by virtue of her reduced cognitive capacity, give adequate utterance to the symptoms she was experiencing.



Position 3
TC 1

G 100
F 0 except Ch. 2,3,4 = F 2

1 sec. 50 μ V

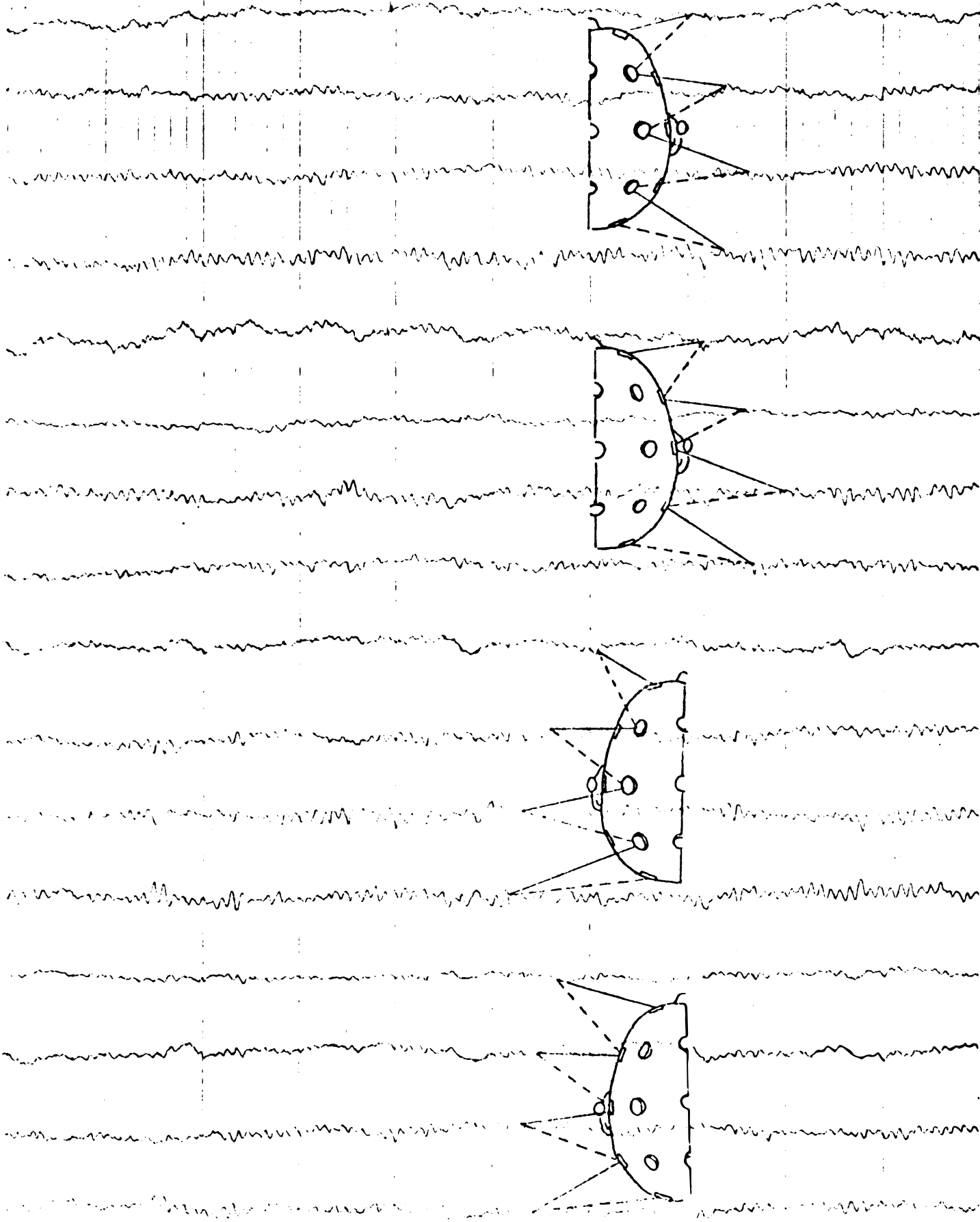
EEG WITH SLIGHT ABNORMALITIES AFTER A SEVERE HEAD INJURY.

This was an 18 year-old serviceman who was involved in a motor accident. He suffered a fracture of the base of the skull with loss of consciousness lasting 27 days.

Page 36: The EEG during rest showed occasional medium voltage 5-6 Hz and sharp waves, appearing focally in the left parietal area.

Page 37: The EEG during photic stimulation showed mild asymmetries and asynchronies, suggesting depression of function in the left occipital region. Asymmetric and asynchronous responses to activation procedures are often useful in confirming the lateralisation of abnormalities seen in the unactivated EEG.

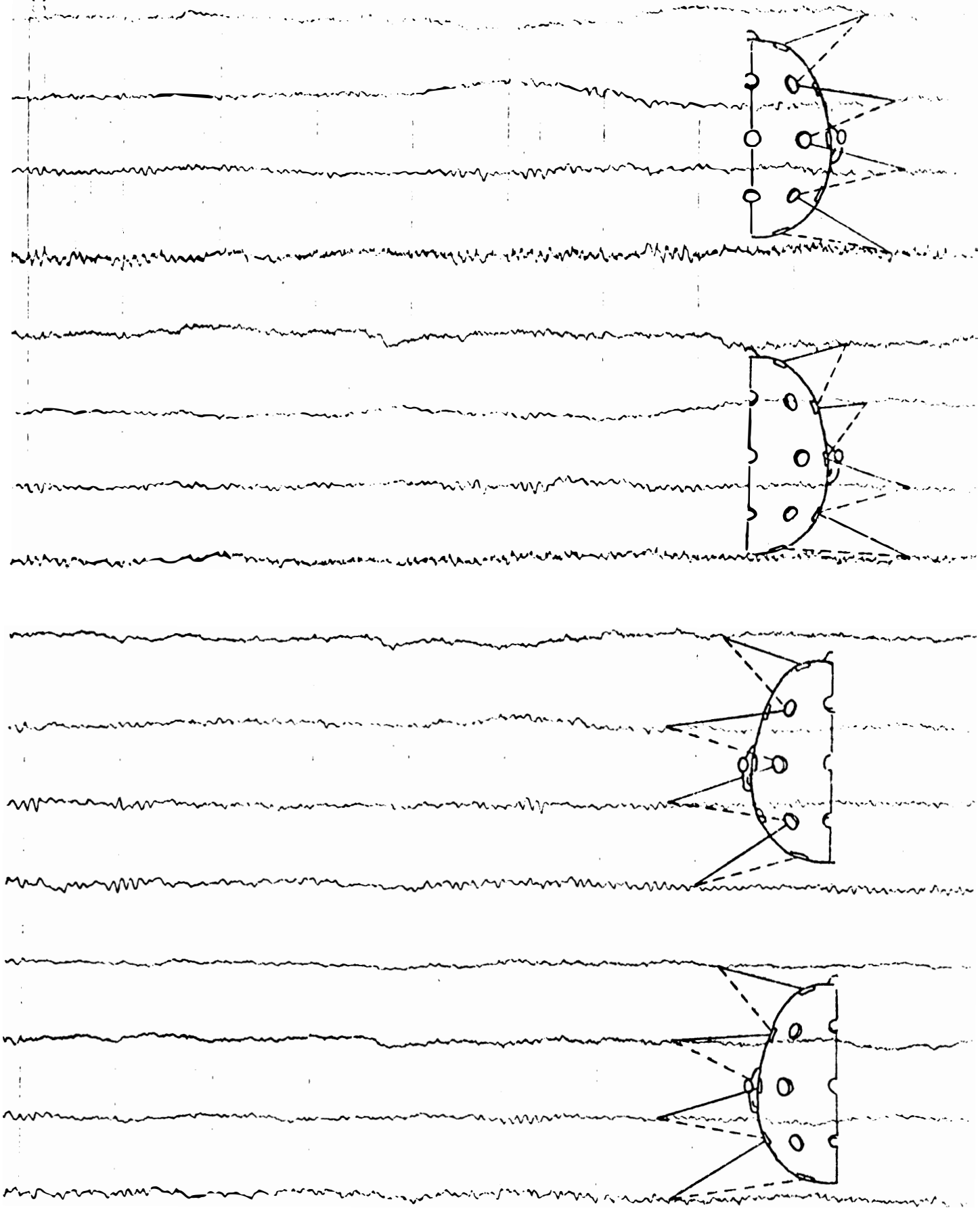
The EEG was recorded about 5 months after the patient had regained consciousness. His only symptom at the time was a mild memory loss. He went on to make a full clinical recovery. Numerous follow-up EEGs were recorded and at the time (2 years, 5 months after regaining consciousness) of the last, the abnormality had not resolved.



150 μ V
1 sec.

Position 1
TC 1

G 100
F 0



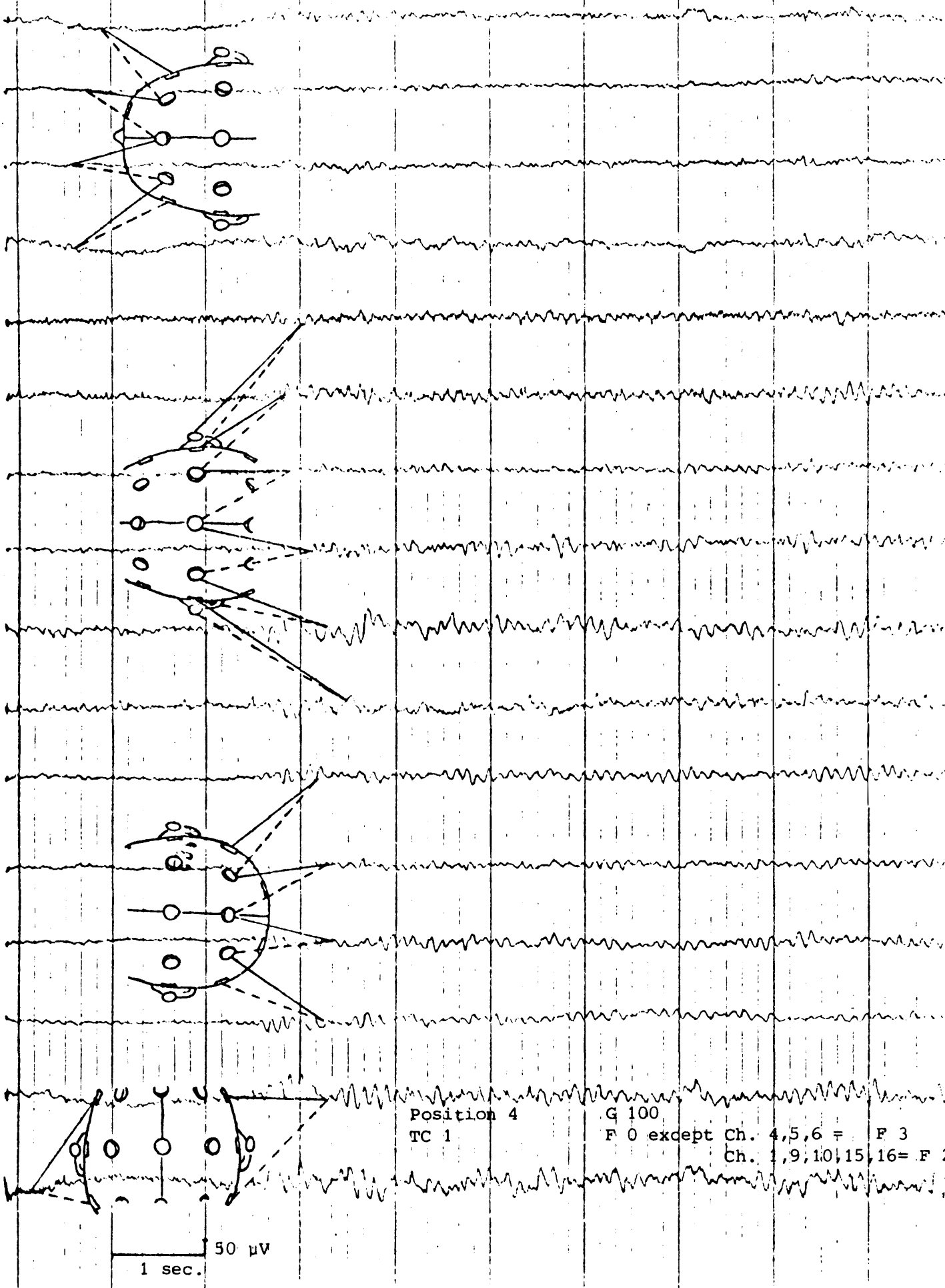
1 sec. | 50 μ V

Position 1 Photoc stimulation
G 100 TC 1 F 0

MARKEDLY ABNORMAL EEG AFTER SEVERE HEAD INJURY.

This was a 32 Year-old male, referred for an EEG by a clinical psychologist after a severe head injury sustained when his car collided with a train. He was unconscious for 6 weeks. The EEG was recorded about 8 months after the accident, and symptomatology at the time comprised delayed reactions and lack of comprehension.

Page 39: The EEG showed medium-high voltage irregular 3-5 Hz activity confined to the left fronto-temporal area. This abnormality was suggestive of localised damage to the area involved.

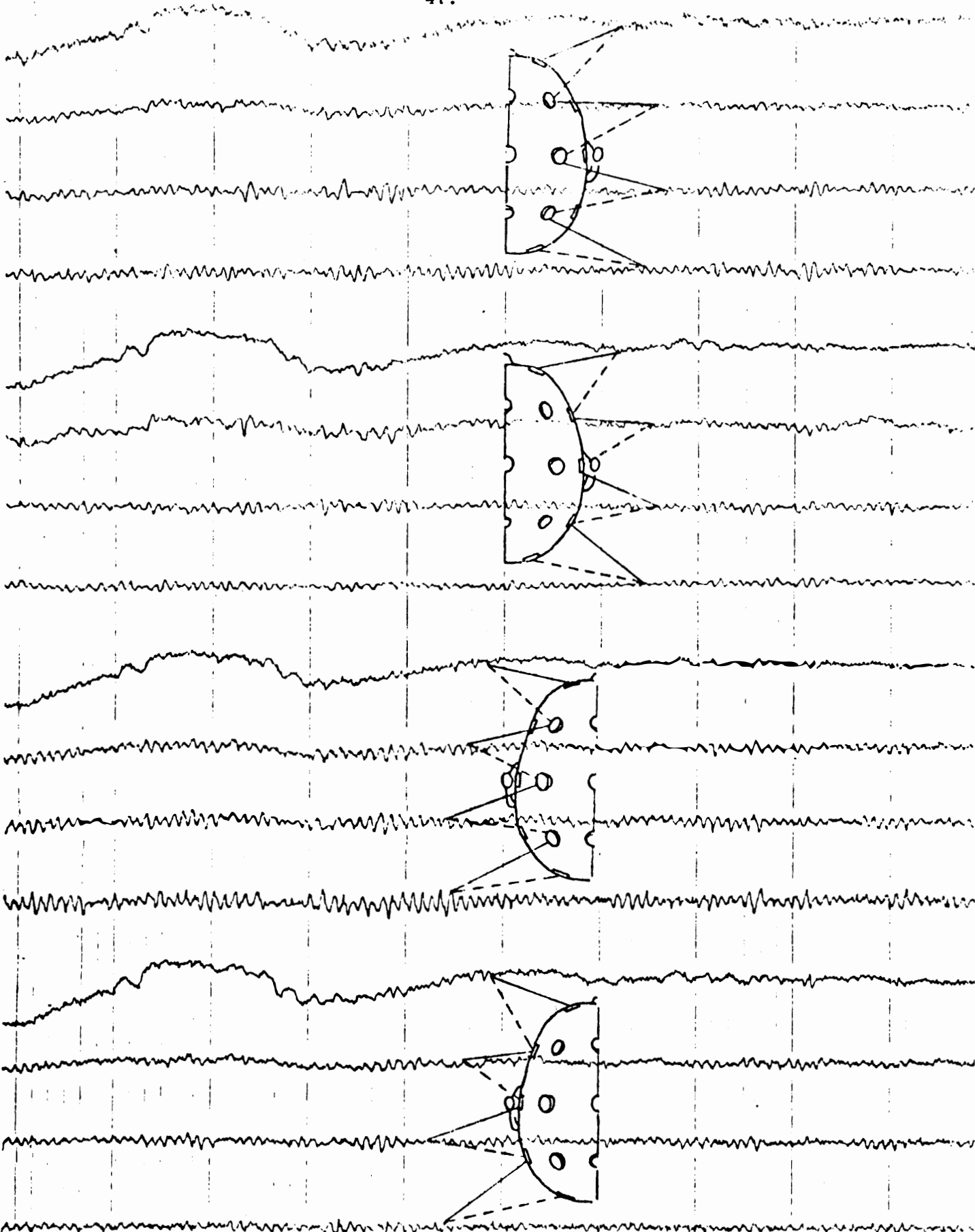


EEG WITH MILD, LOCALISED ABNORMALITIES AFTER A CEREBRO-VASCULAR-ACCIDENT.

This was a 56 year-old headmaster who suffered a CVA involving the fronto-temporal area of the right hemisphere. He was referred for an EEG by a clinical psychologist 1 year and 9 months later.

At this stage his initial symptoms (comprising confusion, bewilderment and bizarre thought patterns) had largely regressed. He presented with absentmindedness and an inability to remember names.

Page 41: The EEG showed mild, non-specific abnormalities comprising irregular and episodic medium-low voltage theta (5-7 Hz) activity, sometimes sharp-tipped, in the right fronto-temporal area.



1 sec. | 50µV

Position 1 G 100 TC 1
F 0 except Ch. 5,6,7,9,13,14 = F 2
Ch. 1,10,12,15,16 = F 1

ASYMPTOMATIC MALE WITH WAVE AND SPIKE ACTIVITY IN THE EEG DURING PHOTIC STIMULATION .

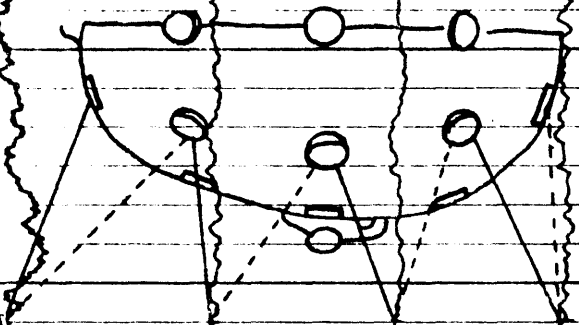
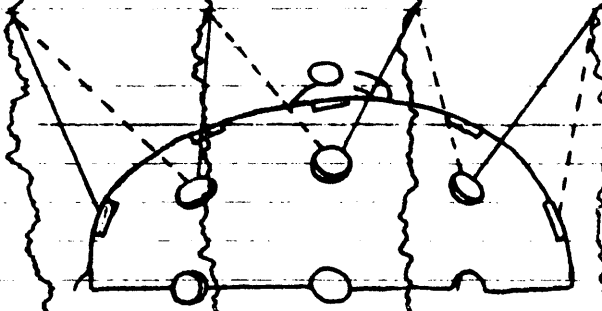
This was an 18 year-old individual with no history of seizures, faints or dizziness, and no reported head injuries. The family history was negative for epilepsy. His mother suffered migraine attacks.

Page 43: The EEG during rest was normal, showing low voltage alpha activity at 10-11 Hz maximally in the occipital areas.

Page 44: The EEG in response to photic stimulation showed brief generalised high voltage paroxysms of wave and spike activity.

Page 45: The EEG after 10 seconds of hyperventilation was again normal.

Wave and spike activity is associated in the vast majority of cases with clinical signs of epilepsy. The presence of this activity in an asymptomatic individual may indicate a latent propensity to develop clinical epileptic signs given appropriate precipitating conditions (in this case, flickering light appeared to be a trigger mechanism).



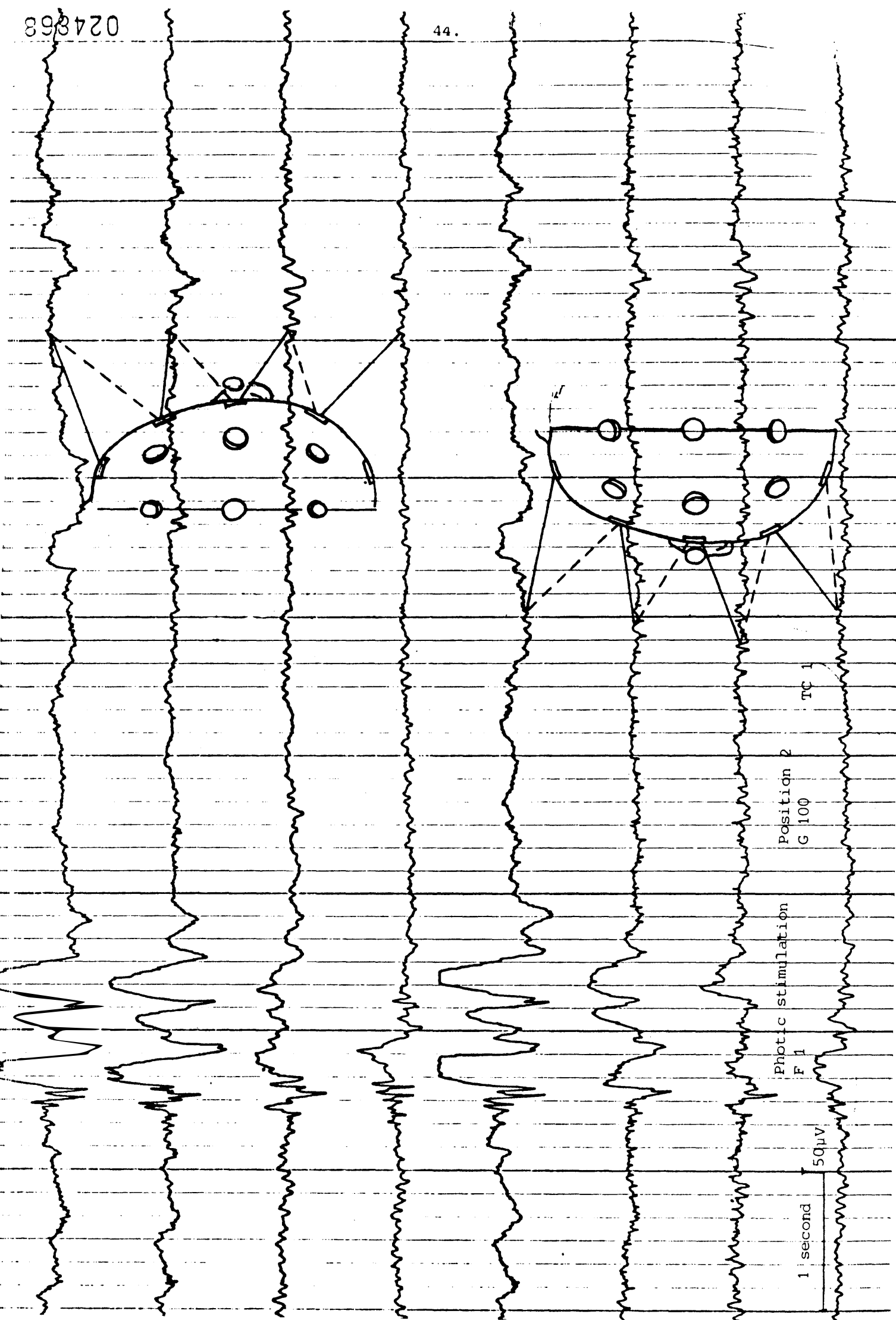
Position 1
TC 1
G 100
F 0

50 μ V

1 Second

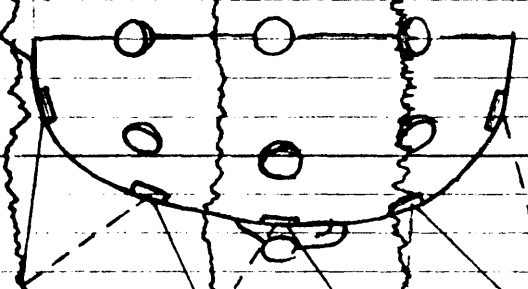
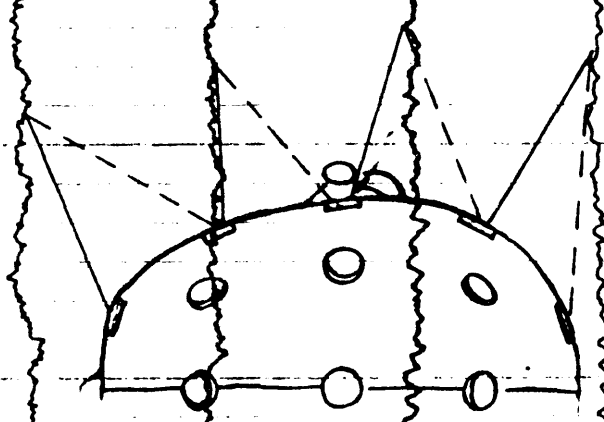
024868

44.



Photoc stimulation
 F 1
 G 100
 Position 2
 TC 1

1 second
 50µV



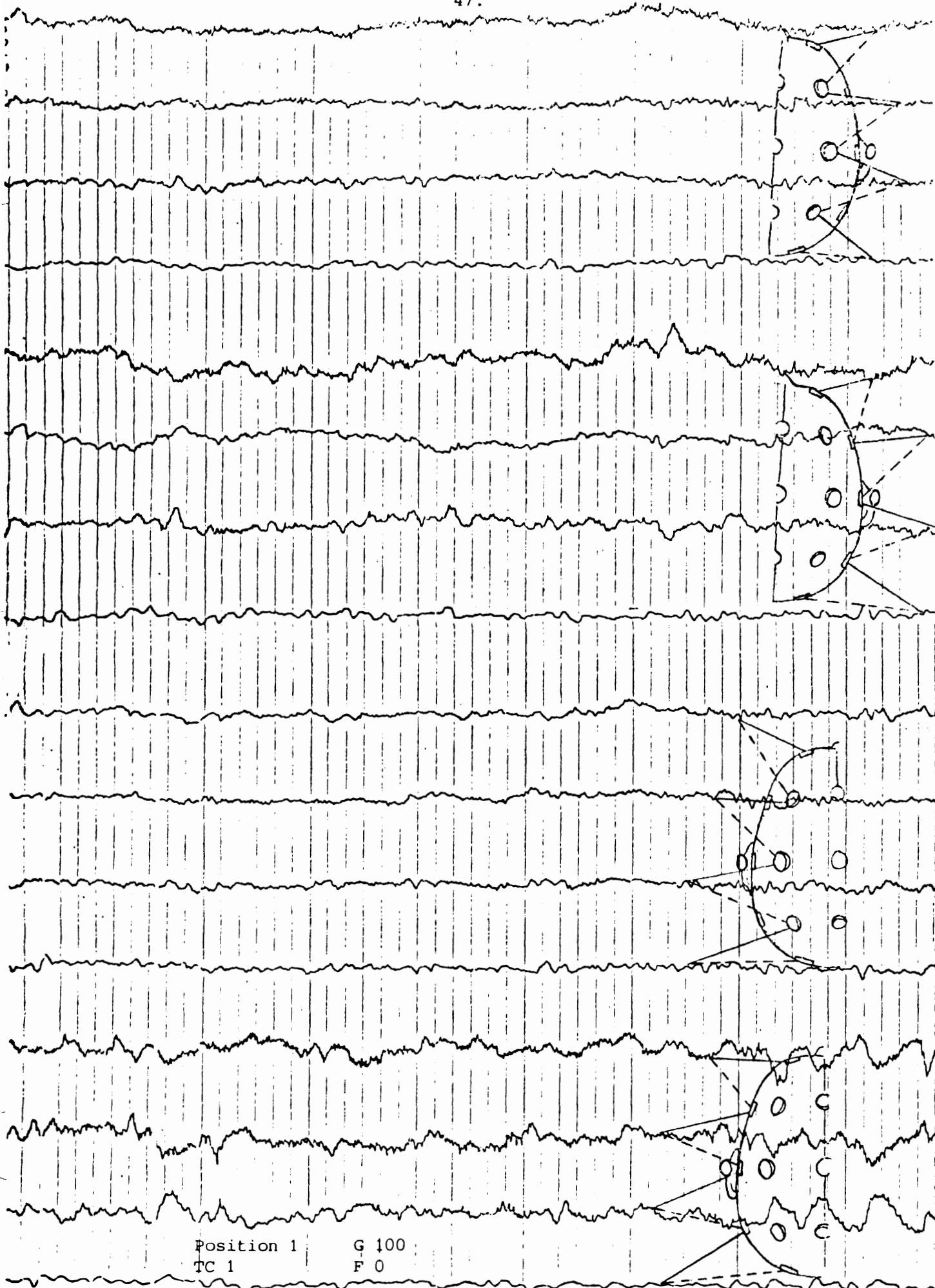
Position 2
50 μ V TC 1
F 1
Hyperventilation
G 100

1 second

EEG WITH HIGH VOLTAGE IRREGULAR DELTA FOCUS IN A PATIENT WITH A TUMOUR.

This was a 26 year-old male whose initial provisional diagnosis was encephalopathy accompanied by temporal lobe epilepsy. About 18 months prior to the EEG he had awoken in a confused state, and had had a high temperature for 24 hours. Seizures had started, and these became more frequent until he was experiencing up to 5 per day, in spite of heavy doses of anti-convulsant medication. His memory deteriorated, and he had been forced to stop work 3 months before the EEG. His EEG was followed-up by the Neuropsychology Division for 4 years, showing considerable fluctuation, usually regressing and occasionally improving. A biopsy revealed a massive progressive glioblastoma located between the midline and the left temporal area. The initial EEG recording manifested the classic signs of a tumour.

Page 47: The EEG showed high voltage irregular 2-3 Hz activity appearing focally in the left fronto-temporal area. This was strongly suggestive of a regionalised lesion.



Position 1
TC 1

G 100
F 0

1 sec.

50 μ V

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