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ELECTROENCEPHALOGRAPHY AND CEREBRAL TUMOURS

A Symposium on the Significance of Electroencephalography for the Diagnosis of Intracranial Space-occupying Lesions

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A SYMPOSIUM ON THE SIGNIFICANCE OF ELECTROENCEPHALOGRAPHY FOR THE DIAGNOSIS OF INTRACRANIAL SPACE-OCCUPYING LESIONS

WASSENAAR (THE NETHERLANDS), 1959

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ELECTROENCEPHALOGRAPHY AND CLINICAL NEUROPHYSIOLOGY

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Dedication

Michelle B. Dell 1919-1959

Michelle Dell was consultant to the Psychiatric Hospitals of Paris. She was a former pupil of Prof. Barré, to whom she owed her excellent neurological training, and of Dr. Fischgold, under whose guidance she became an expert electroencephalographer. She was a member of the neurosurgical team of Prof. David and was Head of the Department of Electroencephalography of the Psychiatric Hospital of Sainte-Anne.

Since 1945 she worked with the veteran of French electroencephalography, Prof. Baudouin and all those who founded the French EEG Society, of which she was a member from the very beginning. From then on she devoted herself to the practice of clinical electroencephalography and to systematic research, mainly concerning clinical electroencephalographic correlations. Her chief contributions centered on temporal lobe epilepsy and on psychiatric syndromes associated with frontal and fronto-temporal tumours. More recently she had started, with Dr. Talairach and Dr. Bancaud, to perform depth electrography studies.

Being somewhat reserved, she was perhaps not always appreciated at her real value, but her friends can testify to her lively intelligence, her capacity for work and her excellent social adjustment. Beside the strong personality of her husband, the neurophysiologist P. Dell, she succeeded in maintaining and developing her own personality.

Dr. M. B. Dell had been invited to take part in the Symposium on Electroencephalography and Cerebral Tumours in Wassenaar, but had been unable to accept owing to pressure of work and ill health. She died suddenly a few days before the beginning of the Symposium. As she had been a close collaborator and friend of some of the participants, and had been known and highly esteemed by all, the shadow of her untimely death fell over the meeting. It was the unanimous wish of all who were present that the results of their work be dedicated to her memory.

Preface

It is inevitable that new diagnostic procedures should pass through stages of changing acceptability. There is often a time of over-enthusiasm, when advocates claim hopefully that here is a method of positives and negatives, as reliable as a Wassermann reaction or a penny-in-the-slot machine. That is apt to be a time, too, when clinicians of shallow experience accept it joyfully and those of greater caution reject it completely.

Good clinicians have always been hesitant to accept diagnostic innovations, considering them, at first sight, unnecessary. This has been true of neurosurgeons as well as neurologists. I remember the time when Harvey Cushing looked on Walter Dandy's startling procedures of pneumoencephalography and ventriculography with alarm and disapproval!

In the early days of electroencephalography, patients coming to our clinic in Montreal with a diagnosis of focal epilepsy brought with them electrographic reports, the great majority of which proved to be misleading. What a change has taken place in twenty years! Now the EEG, in the hands of wise encephalographers, is a vital and indispensible guide to the effective handling of epileptics by medical or surgical means.

In the field of tumours and other intracranial "space-occupying lesions", the role of electroencephalography has continued to be a matter of debate. The symposium called to the Ursula Clinic by Magnus and Storm van Leeuwen a year ago, was therefore altogether timely. The general conclusions which are now made available in English, will go a long way toward establishing the EEG in its true perspective of usefulness in the field of brain compressions.

The neuroradiologist has long been the neurosurgeon's most trustworthy ally with his simple radiography, followed by ventriculography and arteriography. Bancaud points out, in his excellent chapter in this book, that it is "vain to compare its (the EEG's) merits with those of contrast radiography, because it explores very different aspects of the neoplasm."

The EEG is a test for brain activity, normal and abnormal. It may reflect acute brain destruction, absence of brain activity, or alteration of activity or, finally, the irritative epileptic activity that appears around practically all neoplasms after the lapse of sufficient time.

To make the best use of the EEG as a diagnostic tool, all other information about the patient should be set in the balance. Only then should therapeutic or prognostic decision be made. The electroencephalographer and the clinician, both, must understand the physiological processes of the brain, normal and pathological, before they are qualified to read this balance and to act wisely. The EEG should not be called upon for an unqualified yes, or no, regarding tumor. But to the thoughtful clinician it contributes information that cannot be obtained from any other medium.

Neurosurgeons and radiotherapists who must deal with brain tumours will benefit greatly from the collection of studies in this volume, as well as electroencephalographers. Much of the work has not before been accessible in English.

Electroencephalography, in general, has made an extraordinary contribution to neurology in the quarter century of its development as a diagnostic tool. In the hands of thoughtful neurophysiologists, who have gone beyond technology, this tool will discover much more for us in the next quarter century. Let us give them, then, the recognition and the opportunity which is their just due.

"Honour the physician with the honour due unto him for the uses which ye may have of him."[1]

WILDER PENFIELD
Montreal, June, 1961

[1] The Apocrypha, Ecclesiasticus: 38: 1.

Introduction

During the last few years a number of rather extensive studies concerned with the EEG's of patients with cerebral tumours appeared, notably those of Hess, Bancaud and Van der Drift. A similar study by Fischgold and his collaborators was nearly complete.

Though in many respects the results of these studies were in agreement or were complementary, in a number of aspects there seemed to be marked differences of opinion.

It therefore seemed useful to gather a small group of workers in this field for discussion and comparison of their results. Accordingly, a meeting was held in the St. Ursula Clinic, Wassenaar, The Netherlands, in which the following took part:

J. Bancaud, W. A. Cobb, H. van der Drift, H. Fischgold, Y. and H. Gastaut, R. Hess, O. Magnus, C. W. Sem-Jacobsen and W. Storm van Leeuwen.

It soon appeared that differences of opinion or of interpretation were more apparent than real. They could be cleared up relatively easily by full discussion. At the end of the meeting it was felt that it would be worth while to make the results of the reported investigations available to a larger audience. The participants agreed to re-edit and re-group their material for this purpose, taking into account the discussions which had been held at the symposium.

This book is the result of this common effort. It represents the experiences gained in a number of neurosurgical centres in several countries of Western Europe with large series of patients suffering from cerebral tumours or related conditions. It intends to help electroencephalographers in their clinical work and to elucidate the value and limitations of the contribution which electroencephalography can make in this field.

CONTENTS

CHAPTER 1

On the Technique of Location by Electroencephalography

O. MAGNUS

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In subsequent chapters the abnormalities of the electroencephalogram caused by cerebral tumours and other lesions will be described and discussed.

However, the difficulties in the EEG interpretation of cases with a cerebral lesion do *not* begin *after* the EEG has been recorded and the various EEG signs have been recognised, located and described, but actually at the moment when the patient enters the EEG department. In such cases it is often particularly important to make the record in such a way that the different pathological signs show up as clearly as possible. And even then it often remains difficult to form for oneself a picture of the location and extent of the different EEG phenomena. An erroneous interpretation not infrequently appears to be due to an inadequate recording technique or to a lack of understanding of the principles of interpretation, and not to a lack of knowledge of the diagnostic criteria.

For these reasons we have considered it useful to discuss some of the problems involved in recording and interpretation in this chapter. No attempt will be made to cover these subjects completely. Only those aspects which we consider to be of importance in cases suspected of having a brain lesion will be considered.

RECORDING TECHNIQUE

Electrodes and electrode positions need not be discussed in detail. As regards electrodes it is not so important which type is used. What matters is that they must be stable enough to allow one to record with a sufficiently long time constant (see below). The electrode positions recommended by the International Federation (the 10–20 system) is adequate for most cases and it is being adopted by an increasing number of EEG laboratories (Fig. 1A).

Special care should be taken to ensure that the electrodes are fixed in the right and symmetrical positions in view of the importance of location and of asymmetries in the record.

During the actual recording it is in most cases not adequate to make a "routine" record. First, it is of special importance to pay attention to the condition of the patient, to his state of alertness, and to test this reactions to various stimuli. And further, valuable information may be gained by changing recording parameters, such as paper speed, time constant, etc. and by choosing various types of electrode combinations.

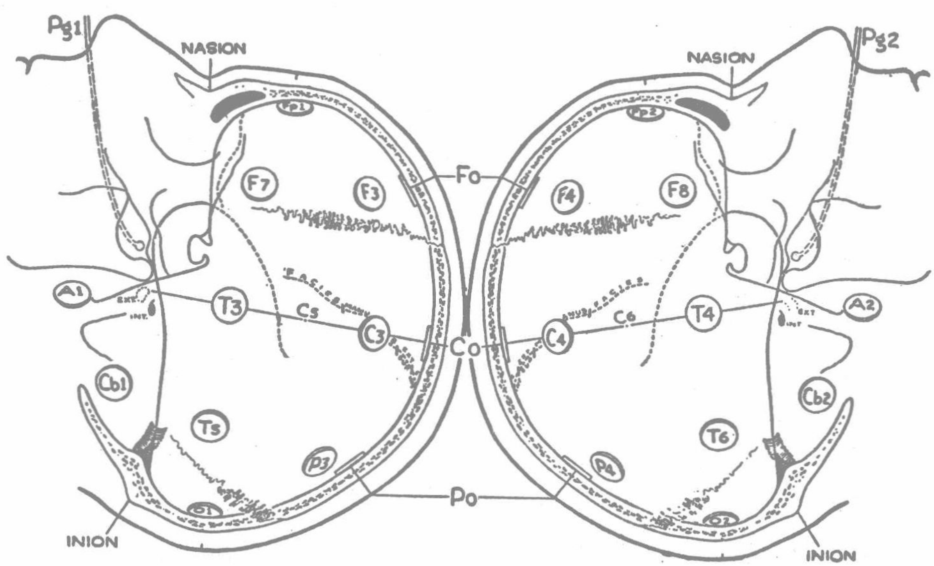

Fig. 1A
Electrode positions of the 10–20 system used in the following figures.

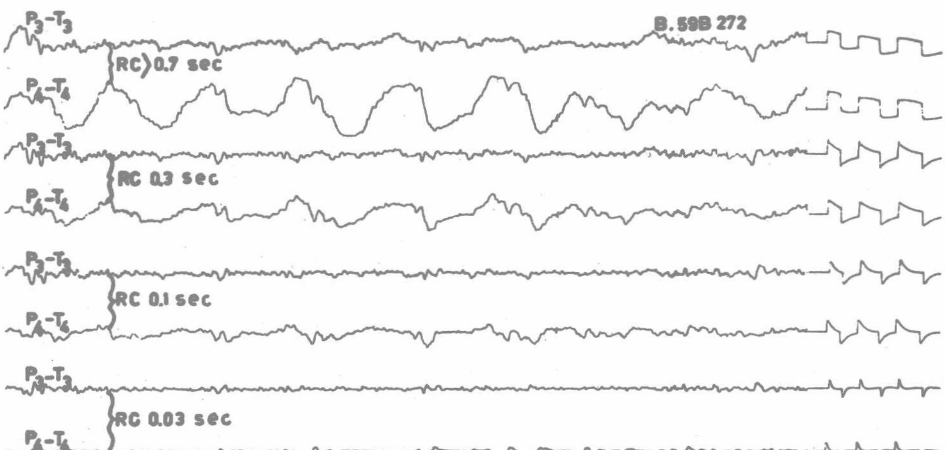

Fig. 1B
Simultaneous recording with different time constants to show the influence on slow activity. Calibrations with the same 100 μV signal are shown on the R. side.

Time constant

With certain types of cerebral lesions activity of very low frequencies, *e.g.*, 1/2–1/5 c/sec, occurs which makes it necessary to record without a cut off at these frequencies. This necessitates recording with time constants of about 0.7 sec or more (*cf.* Fig. 1B).

As an approximation one can take that, when recording with a time constant *t*, frequencies lower than $1/2\pi t$ are cut off significantly. The frequencies at which the amplitudes are reduced to 70 per cent for different time constants are:

Time constant		Cut-off frequency (70%)
0.7 sec	:	1/4 c/sec
0.3 sec	:	1/2 c/sec
0.1 sec	:	2 c/sec
0.03 sec	:	5 c/sec

On the other hand, in cases with a considerable amount of slow activity, it is often difficult to study the faster background activity because it usually has a much lower voltage than has the delta activity. In such cases we have found it very useful to record with a time constant of 0.03 sec so that frequencies below 5 c/sec are cut off (Fig. 1C).

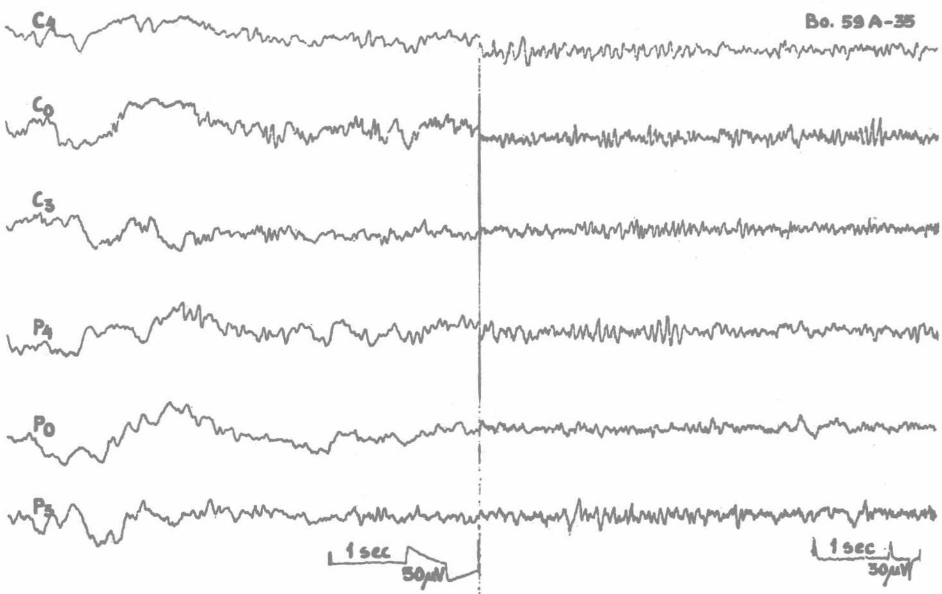

Fig. 1C
Recording with long and short time constant to show that the background activity can be studied more clearly with a short time constant. Average reference.

Then the gain can be increased, the background activity of theta, alpha and beta frequencies can be studied, and differences between the two sides can be better evaluated. In this way it becomes much easier to detect a local depression of background activity in an area of delta activity. The importance of this sign for location has also been studied by Hess (Chapter 4) and by Arfel and Fischgold (Chapter 2). The latter authors use the term "flat polymorphic delta activity" for irregular low voltage delta activity mixed with little or no faster background activity. The smooth aspect of this type of delta activity, indicating an absence of faster activity, is often clear in the record made with a long time constant but a finer evaluation, and particularly comparison with activity on the opposite side, may be facilitated by recording with a short time constant.

Paper speed

Paper speeds of 3 and 1.5 cm/sec have both been accepted as standard by the International Federation. They have both their advantages and disadvantages. But, as in cases with cerebral lesions the detection of slow activity may be important, it can be useful to apply the lower paper speed at least for part of the recording. The very slow activity (slower than 1 c/sec) in particular, does not show up very well with a paper speed of 3 cm/sec. For there must be a certain relationship between the length (= duration) and the height (= amplitude) of a curve for it to be most easily recognised by the eye. The height should be at least equal to the length. With a paper speed of 3 cm/sec and an amplification of 100 μV/cm, in the case of a slow wave with a duration of 2 sec and an amplitude of 100 μV the length is 6 times the height of the curve, which makes it difficult to distinguish. The shapes of slow waves and patterns of series of such waves can also be better distinguished with a slower paper speed and this may make it much easier to recognise them and to differentiate them from artefacts (Fig. 2A).

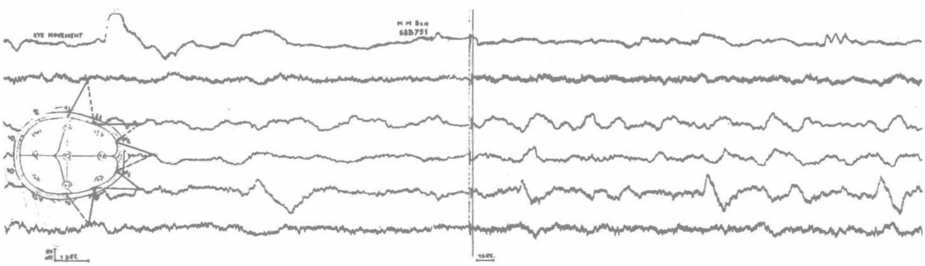

Fig. 2A

Frontal delta activity in a case of selective leucotomy (*cf.* Chapter 9). Recording with 2 cm/sec and 1 cm/sec to show that slow activity shows up better in a recording with lower paper speed and that the shape becomes clearer. The difference would even have been more marked if a paper speed of 3 cm/sec would have been used.

In certain cases, for instance with very slow waves, with repetitive phenomena, or with slow variations in the curve such as are seen in sleep or disturbances of consciousness it may be helpful to use a still slower paper speed, *e.g.*, of 0.5 cm/sec (Fig. 2B and Fig. 1B, p. 154).

Electrode combinations

On this aspect of the location process there has been the most animated divergence of opinion, especially centering on the question of the so called "uni-polar" and "bi-polar" techniques. Therefore it seems desirable to discuss the general principles underlying the choice of derivations.

From an EEG recorded with the usual equipment we can read directly the variations of potential difference between 2 electrodes in time, *i.e.*, we can count the frequency of a certain rhythm and we can read directly the "form" of a "wave"[1].

[1] The term "wave" is misleading as we are dealing with local oscillations, *i.e.*, variations of potential in time and usually not with waves which are propagated oscillations. The oscillations acquire the appearance of waves through the recording technique, by which the factor time is transposed into "distance". Of course there are also true propagated oscillations which travel over the brain (*cf.* Petsche and Marko 1954; Shaw and Roth 1955; Rémond 1955).

Fig. 2B

Recording with 2 cm/sec and with 0.5 cm/sec to show that the pattern of slower variations is seen more clearly in a recording with low paper speed.

However, we cannot estimate directly the potential distribution on the skull of the disturbances to be studied. If we want to have an idea of the location and orientation of the generators of the brain causing these disturbances, we must first know what the potential distribution of these disturbances is.

Before we can discuss the reconstruction of the potential field it may be useful to visualize how these changing potential fields on the head are transformed into an EEG by the process of recording. Let us assume (Fig. 3) that there is a focus of isolated slow waves in the vertex area and that there is no other "background" activity, the potential field changing from the time t_1 through t_2, t_3 etc. to t_7, as shown in Fig. 3A; the referential recording of such a disturbance to an ear electrode (in this case assumed to be "inactive") is seen in Fig. 3B; the bipolar recording is given in Fig. 3C. It will be evident, on the other hand, that, starting from a certain EEG, we can reconstruct the potential field[1] (Fig. 4).

In the case of a referential recording to an inactive electrode we put down the amplitude directly on the diagram. With bipolar recording we must add or subtract the measured amplitudes. In other words: the amplitude in a bipolar recording represents an approximation of the first derivative of the potential gradient. A maximum or a minimum is indicated by a change in sign of the deflection ("phase reversal"). The absence of a deflection denotes equipotentiality. We shall later discuss this more in detail.

[1] By this we really mean: "reconstruct the change in the potential field in a certain time interval", because our condensor-coupled amplifiers do not record absolute potential values, but potential variations.

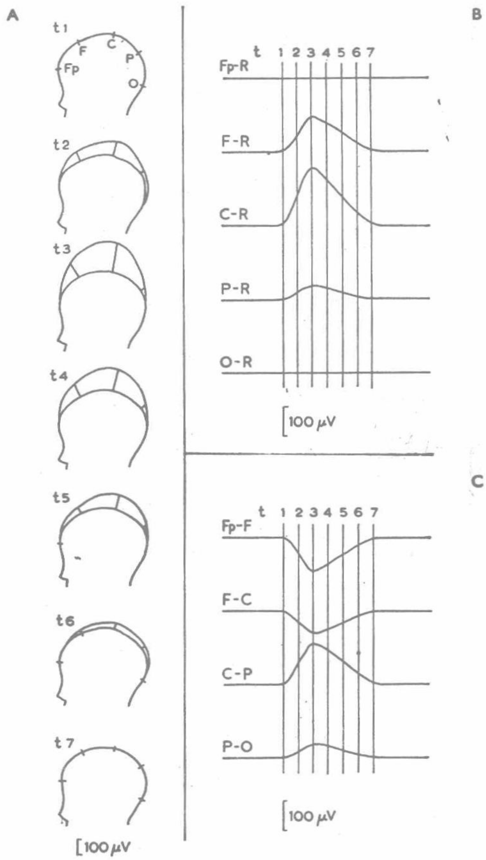

Fig. 3
For explanation see text.

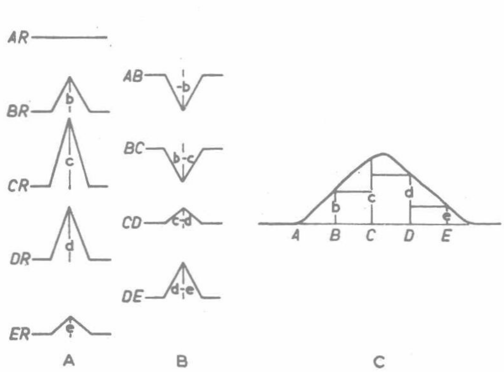

Fig. 4

A. Unipolar recording to a distant electrodc.
B. Bipolar recording of the same disturbance.
C. The potential field is reconstructed from A by putting down the amplitudes at the corresponding electrode positions. The same field is obtained from B by adding the amplitudes with the proper sign.

Now, if we want to make an EEG in such a way that we can reconstruct the potential distribution of the most important disturbances as easily as possible, we must first consider the effect of changing the following factors:

1. The distance between electrodes
2. The orientation of the electrode-pairs
3. The combination of electrode-pairs.

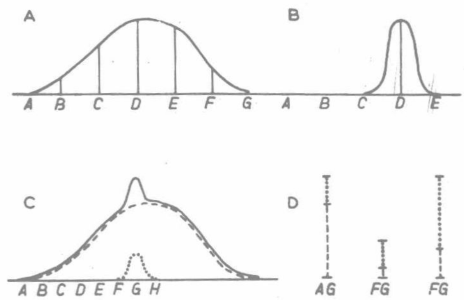

Fig. 5

In Fig. A the amplitude will be greater when the electrode distance increases, in Fig. B the amplitude recorded between *A* and *D* is equal to the amplitude recorded between *C* and *D*.
In Fig. C two superimposed potentials, one more diffuse (- - - - -), one more local (. . . . . . .) are represented. In Fig. D the relative amplitudes recorded from these potentials are represented with widely and with closely spaced electrodes, in the first two with equal gains, in the last with increased gain. It will be seen that in the recording with widely spaced electrodes the more diffuse potential is recorded with relatively greater amplitude, while in the recording with closely spaced electrodes the local potential is relatively the more important.

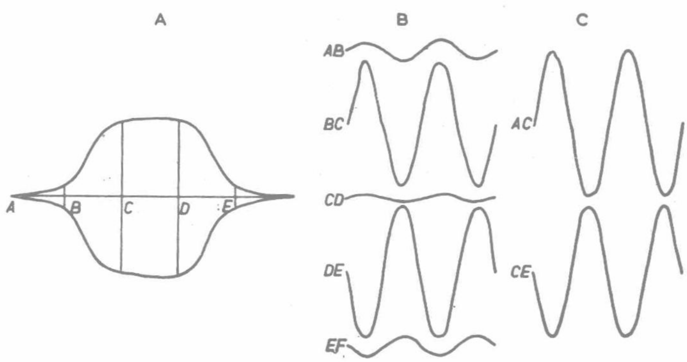

Fig. 6

In Fig. A a fairly diffuse potential field, with an equipotential area is represented. With more closely spaced electrodes the equipotential area between *C* and *D* becomes evident (Fig. 6B); with more widely spaced electrodes the equipotential area is missed (Fig. 6C).

1. *The distance between electrodes.* In general, with a fairly diffuse potential distribution, the greater the inter-electrode distance the greater the amplitude recorded between those 2 electrodes. The potential difference between *AB*, *BC*, or *CD* in Fig.

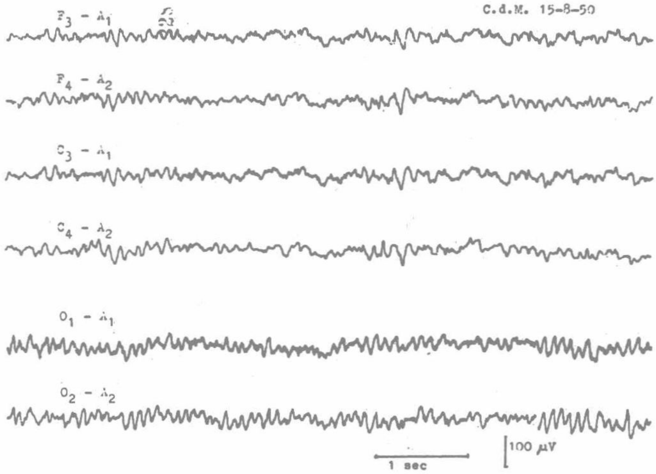

Fig. 7A
Referential recording to ipsilateral ear electrodes. No clear asymmetry is seen. Patient with a large fronto-centro-temporal cyst, verified at operation.

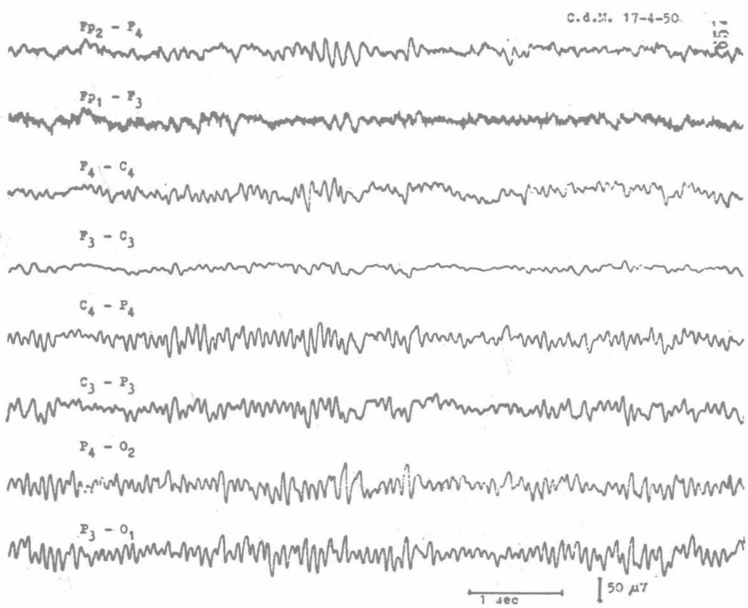

Fig. 7B
Same patient. Bipolar recording showing a clear asymmetry.

5A is smaller than the potential difference between *A* and *D*. In order to compensate for this effect the gains must usually be increased when recording with smaller inter-electrode distances. If, however, we study a disturbance which is strictly localized in comparison with the inter-electrode distance, the amplitude does not change appre-

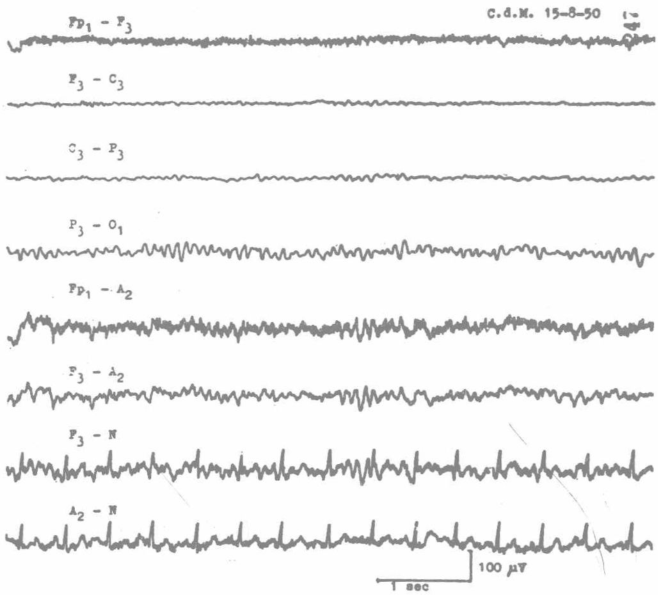

Fig. 7C

Bipolar and referential recording combined. Same gains in all channels. The same activity is recorded with right ear electrode and neck electrode as references (5th–7th channel), whilst this activity is not recorded between right ear and neck electrode, suggesting that it is not derived from the reference electrode but that the cyst acts as a diffuse electrode, picking up activity from the surrounding intact cortex.

Fig. 7D

Pneumo-encephalogram showing the large cyst in this patient.