relations, if they exist, can be more readily established. One action which is retained by compounds based on phenylethylamine, in spite of considerable changes in the molecule, is an action on smooth muscle.

In some cases this can be described as a sympathomimetic action, in others as a direct action on muscle, in others as a mixture of these actions. In virtue of these actions they affect all organs containing smooth muscle—heart, blood vessels, bronchi, intestinal canal, uterus, spleen, etc. They have thus a wide range of activity with potential therapeutic uses. Some of them also stimulate the central nervous system, especially the motor cortex and the respiratory centre. Some examples have been given of how the molecule can be altered to diminish or intensify the various effects of the resulting compounds. The assessment of their therapeutic values, usually a slow process, probably lags behind the pharmacological knowledge we already possess, but some consideration of such therapeutic progress as has been made will be given in the second lecture.

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(The second of the two lectures will appear next week.)

The National Institute of Industrial Psychology (Aldwych House, London, W.C.2) has issued a report on rest-pauses and refreshments in factories. The results are based on information obtained by personal interviews with responsible officials in 1,050 factories, employing about 305,000 workpeople. Equal numbers of factories were visited in seven industrial areas of Great Britain. A wide variety of industries was included, though such non-factory activities as mining, building, transport, shipbuilding, the distributive trades, and offices were omitted. The object of the inquiry was to record the facts of existing practice, and to discuss the views of those who contributed to the inquiry. It was found that 52.9 per cent. of the factories visited made provision for official rest-pauses, either in the morning or afternoon. More than half of the factories visited which have rest-pauses have introduced them during the past decade. In practically all instances official rest-pauses were spent in taking refreshments. Of those employers who gave information relative to the effects of rest-pauses on efficiency 82 per cent. considered that the effects were good, while only 3.4 per cent. regarded the results as unfavourable. Although the primary object of rest-pauses is to reduce fatigue and nervous strain, it appeared that other reasons influenced employers more when introducing rest-pauses. The most important of these reasons were the need of refreshments by those, especially young girls, who had inadequate breakfasts; Factory Act requirements; and the desirability of regularizing unofficial rest-pauses which employers had found to be unsatisfactory.

THE ELECTRO-ENCEPHALOGRAM AS AN AID IN CLINICAL NEUROLOGY

BY

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It has long been known that nervous activity is accompanied by changes of electrical potential. In 1929 Berger, employing thermionic amplification, was able to record from the intact cranium rhythmical electrical changes which he claimed were produced in the cerebral cortex. It was not until 1934, when Adrian and Matthews confirmed this work and introduced important refinements into the technique, that the ground was prepared for further research into the electrical activity of the brain. Since then a considerable amount of experimental work has been done on the action potentials of the exposed cortex of animals. Grey Walter (1936, 1937), employing a modification of the method devised by Adrian and Matthews, studied the electrical changes associated with pathological states of the human brain, and his work in this field has already attained considerable importance.

Evidence exists that numerous electrical rhythms or discharges arise from various areas of the brain and that the type and nature of these rhythms are in some way related to variations in the cyto-architecture. It is not surprising to find, after all the investigations into the electrical nature or accompaniment of the propagation of nervous impulses, that the cell stations in the central nervous system responsible for these impulses do themselves show evidence of electrical flux. It would appear that within the central nervous system there are an infinite number of potential changes—as many changes as there are active neurones; but it is only when certain groups of units, because of a common cyto-architecture, or because of like activity in the physiological sense, act in unison or “beat” together that it is possible to pick up characteristic changes on the surface of the exposed brain. Further complications arise when the electrical changes are studied with the overlying structures intact—that is to say, cerebrospinal fluid, meninges, bone, and superficial tissues. These act as a number of resistances of different values linked in parallel and common to all intracranial electrical events. The effect of the overlying structures is to reduce very considerably the magnitude of the electrical changes which occur—so much so that isolated groups of changes can no longer be picked up, and only the results of mass or “beat” action of a group of events can be detected. The issue is still further complicated because these overlying structures either exhibit or conduct further bio-electric changes—eye movements and action potentials from muscles, such as the temporal muscle, being the most obtrusive. A factor to which too little attention seems to have been paid by some workers in this field is the “noise-signal” ratio of the amplifiers themselves. One sees many records published in which much of what is assumed to be brain activity is in reality a summation of background noise and other unwanted potential changes, with nothing more than an “overlay” of the actual changes. Many of the undesirable effects occur at relatively high frequencies and can be reduced to negligible proportions by the incorporation of suitable filter circuits. These

various considerations must all be taken into account in the design of apparatus.

The basis of this study is a series of observations made in the Nuffield Department of Surgery at Oxford. A room was set aside in the centre of the neurosurgical ward at the Radcliffe Infirmary while the building was still in progress, and was adequately screened. The equipment which we have built (Fig. 1) consists of three

FIG. 1.—Subject with electrodes attached to scalp. In actual practice we have all patients lying either in bed or on a couch; this ensures better relaxation.

separate channels of amplification. The impulses from the patient's skull are picked up by means of "silver-silver chloride" non-polarizing electrodes, and are led off to the pre-amplifiers. The pre-amplifier is a balanced input stage, carefully screened. The tubes chosen for the pre-amplifiers are triodes with a low noise-ratio. The main amplifiers consist of three stages of resistance-capacity-coupled pentodes, the final stage again being a balanced "push-pull." The electrodes are arranged on the skull in pairs, the connexions with the amplifiers being made in such a manner that in the event of any change of electrical potential occurring beneath any one of the electrodes the recording apparatus of the adjacent two amplifiers will be caused to operate in different directions. The electrical events as they are recorded are then said to be out of phase. This is an important principle in determining the localization of abnormal electrical activity within the skull. Fig. 2 will serve further to clarify this point.

FIG. 2.—A, X, B represent three electrodes placed over the skull. When a change of potential occurs under the centre electrode X the hands of the two galvanometers G_1 and G_2 move in opposite directions as indicated.

The electrical impulses picked up from the brain with the skull and soft tissues *in situ* are very small in most cases, and very high amplification is necessary to record the changes. The amplifiers are designed so as to make possible the recording of changes as small as 2 to 5 μV (1 $\mu V = 1/1,000,000$ volt). The amplification is critical and the amplifiers need considerable supervision. For

recording purposes we are using three cathode-ray oscillograph tubes with a long after-glow. This allows of constant inspection of the events as they occur, and simultaneous photographic records can also be made.

To show some of the normal findings, and some of the commoner abnormalities associated with intracranial pathology, I propose to take examples from our records and give a brief description of each. In order to keep this paper short and to avoid confusion I shall endeavour, so far as possible, to cite as examples only those cases in which there is some similarity of electrode position over the skull.

Normal Brain Potentials

Fig. 3 is a record for control purposes taken from a normal person with the electrodes in the position indicated in the diagram. In all the records in this paper the

FIG. 3.—O represents an electrode in position on top of the skull. The figures I, II, III indicate the number of the amplifier to which the electrodes are connected. Note that any two amplifiers have one electrode in common.

rate of travel of the film is the same—that is, 2 cm. per second—and in no case is greater amplification employed than in Fig. 3. The amplification factor in each record is indicated in the top right-hand corner of the record. Fig. 4 has been included as a matter of interest as it

FIG. 4.

shows the α or Berger rhythm recorded from a normal subject on a single amplifier. The subject's eyes were closed at the time the record was taken, and one electrode was placed over the occipital region as indicated in the diagram.

Expanding Intracranial Lesions

Fig. 5 gives a record taken from a girl aged 9 who was admitted suffering from headaches and vomiting. On examination she was found to have papilloedema and

FIG. 5.

a slight sensorimotor hemiplegia down the right side. The record clearly shows the slow slightly irregular discharge of waves at the rate of two to three per second and of great amplitude, even though the amplification employed is much less than in the previous figures. Slow waves not unlike these are found in normal sleep, but in the waking state have only been observed in association with certain pathological conditions. The important feature of this record is the phase relationship of the waves in the different leads. The waves are out of phase between I and III, thus indicating a focus of

electrical disturbance from the region in the left frontal area, as shown in the diagram.

In our experience a discharge of this nature has been found to emanate from the region of a variety of pathological conditions within the brain. However, when, as in this case, there is presumptive evidence of raised intracranial pressure, a focus of this type, localized as it is, can be assumed to be coming from the region of an expanding lesion, and thus is of great value in indicating the exact situation of that lesion. In this particular case it was possible to localize the lesion accurately enough to dispense with ventriculography. At operation a left frontal flap was turned and a large cortical astrocytomatous tumour was found immediately behind the focus of electrical disturbance; this was removed completely. The post-operative course was uneventful.

Fig. 6.—A man aged 52 was admitted complaining of headache, vomiting, and fits. On examination he was found to have papilloedema and some mental deterioration, but no

FIG. 6.

localizing signs to indicate the site of the lesion. On the basis of the mental changes and the absence of other signs it was thought that the tumour was frontal, but there was not the slightest clinical indication of its lateralization. The electro-encephalogram showed a slow abnormal delta discharge originating from fairly low down in the left frontal lobe. In the record the large waves out of phase between I and II can be clearly seen. At operation later the site of the lesion was verified; it was a glioma, and was completely removed.

Fig. 7.—A man aged 51 was admitted with fits, headache, and vomiting. On examination he was found to have papilloedema, nominal aphasia, and slight right sensorimotor hemi-

FIG. 7.

plegia. The record shows delta waves of high amplitude, and is of particular interest because the waves are out of phase between amplifiers I and III, thus indicating a lesion of wide area, extending beyond the area encompassed by the leads of amplifier II. The clinical history in this case was short, and suggested a very malignant growth. A burr hole was made over the left frontal region and a small portion of tissue aspirated for histological examination from a depth of 6 cm. This showed the tumour to be a malignant glioblastoma multiforme, and therefore nothing further was done.

Fig. 8.—A young man aged 19 was sent up with a history of scarlet fever five weeks previously. His convalescence had been characterized by headaches; in the fortnight before ad-

FIG. 8.

mission these had become increasingly severe, and he had become progressively more drowsy. On admission he was difficult to rouse. He had intense bilateral papilloedema.

There was very slight left-sided motor weakness, the left abdominal reflexes were absent, and both plantar reflexes were extensor in type. The electro-encephalogram showed a very slow delta discharge of high amplitude, out of phase between amplifiers II and III, thus indicating the site of the disturbance emanating from the right frontal pole. Operation was immediately carried out; a right frontal flap was turned, and an abscess found and aspirated. At a later stage the abscess was removed, and the patient made an uninterrupted recovery.

The Epilepsies

Considerable interest is attached to the study of the epilepsies by this method. This is only natural because of the dramatic electrical changes associated with the actual seizures. Nevertheless it is in the epileptic group that the greatest difficulty occurs in the evaluation of results. It would appear that in many cases of the group known as "idiopathic grand mal" there is constant electrical flux, sometimes generalized and arising from the whole cortex, but very often arising from one or more foci. Such foci frequently occur in the region of one or other frontal adverse field, area 6 $\alpha\beta$ of Vogt, but they are quite commonly post-central or even occipital in origin. In some cases the changes resemble closely those found in association with expanding lesions; in many, however, we have found that the rhythm is slightly faster, with a tendency towards variations in rate and amplitude. In some cases, too, we have found a tendency towards a frequent shift of the focus: sometimes the shift is only one of a few centimetres, but at other times there may be quite a sudden shift of the focus to a corresponding point in the opposite hemisphere. These remarks apply only to those cases of epilepsy in which there is a "resting focus" of electrical flux—that is to say, changes which can be detected between the actual fits. So far as we have been able to judge, these changes, when they are found in a patient, are constant in that individual, and do not bear any time relation to the actual fits. There is, however, evidence that before a fit, perhaps for hours, perhaps for a day or even longer, there is an accession in the electrical changes. On records taken at such times we see what appear to be bursts of waves of increased amplitude and varying rate, not at all unlike the "larval" attacks of petit mal described by Lennox and his associates (Gibbs *et al.*, 1936).

It is necessary to add that there are many cases that clinically appear to be idiopathic grand mal in which we have not been able to detect any abnormality of the electrical rhythm. Why this should be so is difficult to decide at present, but from our experience there seems to be some relation between the resting focus and cortical degeneration.

In another group of cases numerous minor seizures occur. In these there is an almost constant electrical flux with occasional sudden bursts of increased activity which have been described as larval or subclinical seizures, and then again the actual petit mal attacks with even greater alterations of amplitude. Much stress has been laid on the rather constant and characteristic pattern of the wave form in these cases. It is interesting to note that the pyknolespsies are said to fall into this group—with this point of distinction, that the focus of discharge appears to be far back over the occipital region. As the diagnosis of pyknolespsy is difficult until spontaneous recovery has been definitely and permanently established, considerable time will have to elapse before we can assess the full value of such contentions.

It has been claimed that in the so-called traumatic epilepsies there is never any evidence of a resting focus of electrical abnormality. On the whole our experience

supports this, for many cases with fits after a head injury have yielded negative findings on electro-encephalography. These are usually cases without penetrating fracture or other evidence of gross brain damage. There are, however, in our records several cases of gross localized cortical damage in which alterations of potential were observed, in all ways similar to those found with expanding intracranial lesions. In such cases we have assumed an underlying area of gliosis. This aspect of the subject would certainly repay further study.

Fig. 9.—A young man aged 19 was admitted with a history of having had a head injury associated with unconsciousness some seven years previously. About a year after the injury

FIG. 9.

he developed fits and continued to have them at intervals, and his case had been diagnosed as traumatic epilepsy. The record clearly demonstrates the large abnormal discharge arising from the region of the left frontal adverse field: the out-of-phase waves between amplifiers II and III indicate the source of origin of the discharge. In view of these findings we are inclined to label this patient as an idiopathic epileptic who would in all probability have developed his fits regardless of the injury.

We have now had the opportunity of examining several patients in whom the onset of fits occurred in later life, from 40 onwards, and in whom the full neurological investigation, including examination of the cerebrospinal fluid, was negative. In such cases one of the chief concerns of the clinician is to rule out the possibility of an expanding lesion, and air studies are often called for. In our series the electro-encephalogram has always been normal when the encephalogram was normal, but further work is necessary before the reliability of the method can be accurately assessed.

Conclusion

From experience to date in the examination of intracranial tumours, although the electro-encephalogram is surprisingly accurate in localization in most cases, we would not like to dispense with the additional help given by ventriculography when operation is contemplated. Information as to the depth of a neoplasm, its absolute size, and its relation to the ventricles, basal ganglia, etc., can only be obtained at present by adequate air studies; and such information is essential in planning the scope of an operation or deciding upon the operability of a tumour.

It is important to emphasize that electro-encephalography by itself is in no way a short cut towards the establishment of the anatomical and pathological diagnosis of intracranial lesions. Like the electrocardiogram, its value is greatest when taken in conjunction with the clinical picture.

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SEA-SICKNESS

BY

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I must go down to the seas again,
 to the vagrant gypsy life,
 To the gull's way and the whale's way,
 where the wind's like a whetted knife;
 And all I ask is a merry yarn from
 a laughing fellow rover,
 And quiet sleep and a sweet dream when
 the long trick's over.

Sea Fever, by JOHN MASEFIELD.

These lines were intended by the Poet Laureate to describe the feeling of seafaring folk, but they may now be applied to a much wider section of the public, for with the development of holiday cruising a great many business and professional people have learned to love shipboard life and the care-free existence of an ocean voyage.

Certain shipping lines have organized winter cruises as long as I can remember, but during the past few years all steamship companies have developed the idea to meet a new public taste. Formerly cruising liners only catered for the well-to-do; nowadays cruises are arranged to meet all pockets, and thousands of people have experienced the joys of ocean travel who up till recent years would never have dreamed of undertaking a voyage on the high seas. New resorts have been opened up by the cruising ships, and such places as the West Coast of Africa, formerly regarded as the "white man's grave," are now regularly visited by Christmas trippers.

There are, moreover, a growing number of people who have found shipboard life so agreeable that they prefer to spend their lives at sea. "Permanent passengers" of this kind are far from uncommon, and on a recent voyage round the world I met a lady who had spent about five years on the journey backwards and forwards to Australia round the Cape. Each voyage she "signed off," but time after time sailing day found her installed once more in her old quarters. The ship chosen by this lady was not a luxury liner but a moderately comfortable old ship with a purser who loved her and did his utmost to make everyone comfortable.

Among the medical profession there are a good many who suffer from what John Masefield has christened "sea fever." A few general practitioners make the sea their life work, but many act as relief surgeons, and not a few retired medical officers of the fighting services and colonial surgeons have found congenial employment in the service of many of our great companies. Since my own so-called "retirement" I have sailed the seas either as a passenger or as a surgeon every year, and during the past two years I have been to South America, round the world via Australia and South Africa, and across the North Atlantic a dozen times. So many thousands of miles of ocean travel in all sorts of ships have given me a good deal of experience of the distressing condition which is the crumpled rose-leaf in the bed of so many lovers of the sea.

I have been induced to write this article by various medical friends and brother officers who insist that some sort of stocktaking of our present knowledge is needed. There seems to be truth in this, and although a good deal has been written on the subject, when I was going to sea again after a long "shore spell" I found it very difficult to turn up the facts I wanted to know in a single article.

Symptoms of Sea-sickness

Sea-sickness, with its train of unpleasant sensations and physical signs resulting by no means invariably in the final act of vomiting, is the reaction of susceptible individuals to a disturbing and unusual environment. Mark Twain in *Innocents Abroad* says: "We all like to see people