are at present available, but these can be used only as research tools because of the complexity of instrumentation and assemblage of data. The present interphase analyzer, in contrast, requires little additional time or training and affords a measure of a single variable which is practically significant.

The apparatus has been designed in such a manner that it can be connected between the pre- and power amplifiers of a 6-channel Grass electroencephalograph without alteration of standard equipment. Switches are provided to connect the analyzer with the EEG, or to disconnect it, at will. When disconnected, the usual 6-channel EEG record is obtained. When connected, 4 of the 6 channels continue to record the usual EEG while the remaining channels produce the phase analysis.

In the analyzer, the push-pull alternating potentials obtained from the preamplifiers are converted to single-ended operation (Fig. 1). This is accomplished by inverting half of

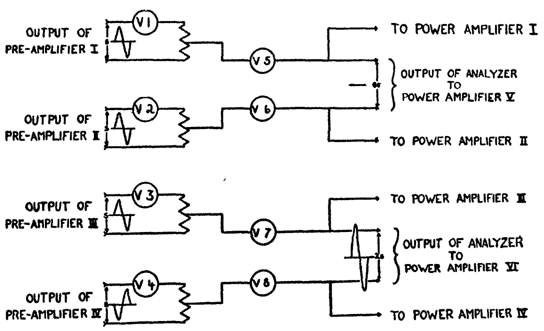

FIG. 1. Diagram of circuits of interphase analyzer.

the varying push-pull voltage of each of the preamplifiers of the first 4 channels. Both uninverted and inverted halves of the signal of each channel are then connected to $\frac{1}{2}$-megohm resistors, and the single-ended output is taken from the junction of these. The single-ended output of channels 1 and 2 is fed to the grids of tubes V5 and V6, respectively; that of channels 3 and 4, to tubes V7 and V8, respectively. It will be noted that tubes V5 and V6 as well as V7 and V8 are operating in push-pull again. The output of the push-pull circuit V5 and V6 is then the analyzer voltage which is recorded as the instantaneous voltage differences between the activity of channel 1 and that of channel 2 on channel 5. Similarly, the output of the circuit V7 and V8 is the analyzed record of the simultaneous potential differences between the activity of channel 3 and that of channel 4, and appears on the record of channel 6.

The operation of the instrument is best shown by records of the two possible extremes. Such records are always made as part of the calibration procedure during analysis of all EEG's. These limiting conditions are demonstrated in Fig. 1. Channels 1 through 4 are here recording from a single cortical area. Channel 5 shows the resultant analysis of the in-phase activity between channels 1 and 2. Since all activity is simultaneously in-phase, the output is zero, or a straight line on the record. Channel 6 depicts the analysis of the activity of channels 3 and 4 shown in complete phase opposition. The output here is double the amplitude of the original activity. This is true only if activity of both areas is approximately of the same amplitude. If a marked difference in amplitude exists, it must be taken into account by considering the base line to be the difference in amplitude of the two areas under analysis rather than zero. In the analyzer, frequency and phase differences are detected only by means of phase discrimination, the amount of frequency or phase discrepancy being expressed as phase shift. Hence, focal differences either in phase or frequency become significant.

Practically, it is well known that phase relationships between cortical areas are important. However, using the ordinary visual interpretation, their detection is limited to low frequencies within the range of alpha activity or less, since above that level the resolving power of the eye, the speed of recording, and the accuracy of pen alignment is too limited for detection of phase reversals. In these higher frequency ranges, the analyzer can show phase shifts or reversals which are significant. Furthermore, in many instances in which the EEG suggests a focus which is indefinite and in which phase reversals may be present only temporarily, clear delineation by use of the analyzer is often possible.

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Effective Copying of Kymographic Records

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The copying of kymographic or other smoked-paper records has many intrinsic difficulties well known to workers therewith. Direct copying can be done, using the record as the negative, and with such papers as Insurance Bromide grade RR (Eastman) fairly good results are obtainable. However, these as a general rule are not satisfactory for publication purposes.

Introduction during the war of new types of waterproof papers has entirely changed this situation, and copies of all records may be made with the greatest possible ease and success. The writer has experimented with several types of material including Resisto (Eastman) and some ex-Army material, but by far the best so far encountered is Grade 4 QUIK.[1] This material behaves like a medium chloride paper and is exceedingly tolerant of exposure variation, which is around 30 seconds for an ordinary tracing using 5 daylight bulbs dimmed to about half strength. Development is with ordinary hydroquinone 1;;1 developer and takes about 1–2 minutes. Fixing with fresh material may be complete within 3 minutes, and washing in free flowing water in 10 minutes. As the base is quite waterproof, drying is very fast, and not much curling occurs.

In order to facilitate printing and eliminate a great many unavoidable variations in smoking and varnishing, it is well to brush the back of the record, over the parts required for copying, with a mixture of light petroleum. This can best be done visually over the safelight in the printing box. Providing there is no actual excess of oil, no difficulties are occasioned thereby,

[1] Obtainable from Grant Photo Products, 401 4th Avenue, New York.

and the paper can be placed immediately over the record and printed. One assistant and I completed over 80 such prints in 3½–4 hours. The records had been previously sorted, but the oiling was done at the time of printing. The oil, being volatile, slowly disappears and in no way harms the records.

Fig. 1 shows an ordinary blood pressure and salivary secretion record obtained in this manner. Comparing this latter

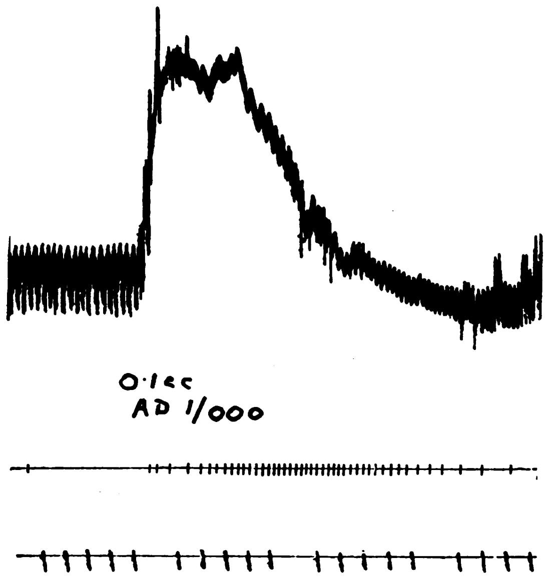

FIG. 1

with the bottom time tracing, one may see the irregularities of a poorly working signal faithfully reproduced. This is not a picked tracing and is varnished with a particularly poor

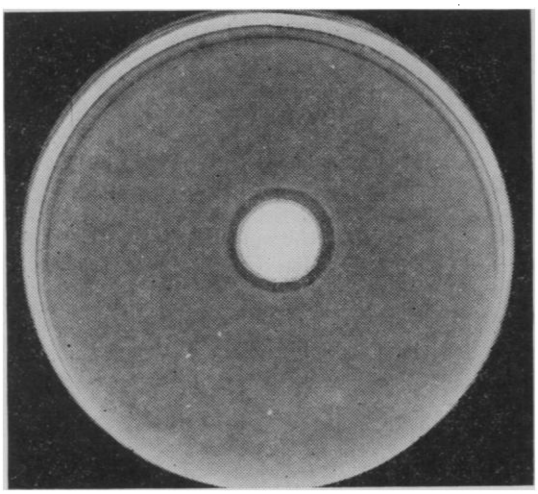

FIG. 2

wartime material which would render ordinary photographic reproduction difficult.

The same paper serves well to make direct prints of culture plates for permanent record of antiseptic tests. An example of this is shown in Fig. 2, which depicts a 48-hour *Staphylococcus aureus* culture. For this purpose the lid must be removed. Under an ordinary 100-watt lamp at a distance of 2 feet a 2-second exposure is about right. Such records do not have the clarity of photographic reproduction because of irregularities in the culture dishes, but they are quite satisfactory for ring measurements and permanent records of such labile results.

An Adaptable Three-dimensional Graph Model

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Three-dimensional graphs offer a convenient visual means of evaluating the effects of two variable factors upon a third factor—for example, the effect of different temperature and moisture levels on the rate of inactivation of 2,4-D in soil. With the aid of such a graph maximum and minimum combined effects, contours, and trends are readily apparent.

Construction of this type of graph is generally time consuming. However, when once constructed, the graph described (Fig. 1) can be easily readjusted to present data obtained

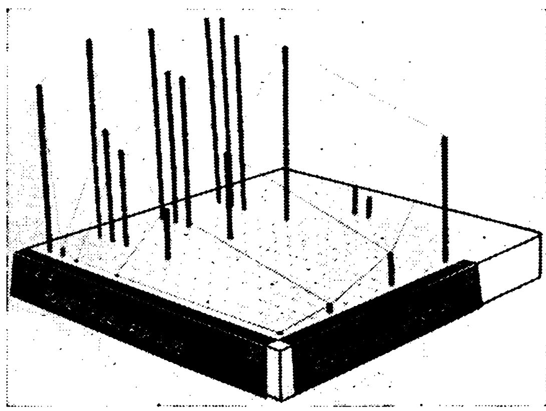

FIG. 1

from various problems involving three different factors; or, where more than three factors are concerned, it can be made to show relations of combinations of these.

This apparatus lends itself readily to photographic reproduction so that the data can be permanently recorded.

A board, 17 x 17 x ⅝ inches was marked off in square inches. Holes ¼ inch in diameter were drilled at the line intersections. The base was then painted with Kodak brushing lacquer No. 4. The upright pegs were made from ¼-inch doweling cut in lengths of ½, 1½, 2½,... 10½ inches as required; and, in this case, they were graduated in inches by pasting strips of black gummed paper around them. The upper ends of the series of pegs were connected by white cotton thread as shown in the figure. Clips to hold the thread were attached to the pegs with the aid of a gun-type stapler.

Data can be presented on this model in semilog form. A base graduated in logarithms would, of course, be necessary for log-log presentation.

Differences required for significance at the 5 and 1 per cent levels can be shown by pegs at one side of the graph.