tonus (represented by the distance above the base line) are seen, in Fig. 1-b, to be increased during the second plane of anesthesia.

The effect of ether in decreasing intestinal activity[6] was also confirmed.

Conclusion. Cyclopropane causes an increase of both intestinal contractions and tone in the first 2 planes of third stage anesthesia; in the lower planes of third stage contractions are inhibited but tone is maintained. Ether, on the other hand, causes an abolition of the contractions in all planes of surgical anesthesia.

9922 P

Response of the Optic Cortex of the Cat.*

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Following a single electric stimulus applied to the optic nerve, electrical potentials of 3 types are recorded from the optic cortex (Fig. 1). The first is a series of 4 or more spikes, each of 1 m.s. duration, comparable to the spikes of peripheral axons. The second is a series of waves, each of 5 to 10 m.s. duration, and the third, a series of waves of much longer duration (Fig. 2), comparable to the alpha waves. These slower potentials do not behave like after-potentials of the spikes. The first spike may follow a stimulus within 1.8 m.s. The following spikes occur at about 1.5 m.s. intervals, and are not simple repetitions of the first, but can be differentiated from it by differences in polarity at different depths in the cortex, by effects of anesthetics, etc. The spikes appear to represent activation of successive groups of elements rather than repetitive activation of one group. These spikes had not previously been recognized in the rabbit cortex, but with improved recording technic can now be seen to be present there also, of relatively lower amplitude. The short waves, 2 or 3 in number, correspond to those identified in the rabbit as the specific visual response. The long waves, often repetitive at 1/5 to 1/8 second intervals, correspond to the

6 Miller, G. H., *J. Pharm. and Exp. Therap.*, 1926, **27**, 41.

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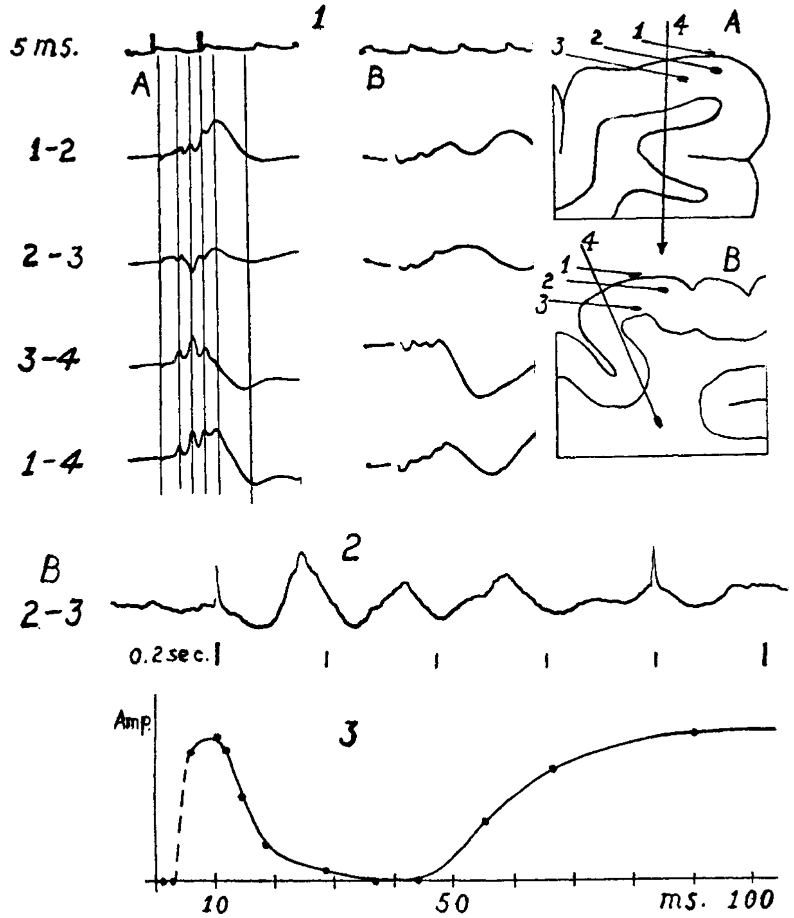

FIG. 1.

Records from upper, middle, and lower regions of the optic cortex. 1-2 etc. indicates leads from electrodes 1 and 2 of insert diagrams of cortex. A, gyrus lateralis; B, gyrus suprasylvius. Amplification 15 mm/mv except 2-3A, which is recorded at 2.5 $\times$ the amplification of the rest, corresponding to the smaller vertical distance between this pair. Deflection upwards indicates negativity at lower of electrode pair. Photographed directly on bromide paper.

FIG. 2.

Slow record of waves following those shown in 2-3B of Fig. 1. The first sharp spike represents the whole of the faster record, and is followed by a train of alpha waves at 6 per second.

FIG. 3.

Plot of amplitude of the first wave of a second response at different times after a first response, both stimuli 3 $\times$ maximal. Magnesium sulphate and ether. Without the ether and with very light $MgSO_4$, the curve does not fall to the base line at 40-50 m.s. With more ether the first hump of the curve at 10 m.s. is abolished. The second hump is repeated at the frequency of the alpha rhythm of Fig. 2.

response in the rabbit of the alpha mechanism. These 2 series of slower potentials are differentiated characteristically by anesthesia and strychnine, as in the rabbit (Bartley, O'Leary, and Bishop[1]).

We have investigated the responses of these elements to repetitive stimulation in the cat under different degrees of anesthesia. Magnesium sulphate, 0.25 g/kg or less, with ether as necessary during the preliminary operative procedures, has given the most satisfactory results. Under anesthesia sufficient to keep the animal quiet, the same phenomenon is observed as in the rabbit, that no response follows a second stimulus during the slow surface-negative phase of a first response, but a second response does follow during the positive phases of the alpha waves following this (Bartley[2]). Under lighter anesthesia, if the interval is shortened to about 25 m.s. or less, a second response also occurs, the maximum second response in this time range occurring at about 10 m.s. after the first. At this interval the second response may be of twice the amplitude of the first, both shocks being supramaximal. Ether very effectively suppresses this second response, which accounts for previous failure to observe it (Bartley[2]) even though certain summation effects below maximal suggested that both shocks were producing an effect. We thus find 2 periods of "facilitation," associated with the fast and slow responses respectively, separated by a "refractory" interval.

It may be inferred from the above that 2 optimal frequencies should be found for repetitive stimulation via the optic nerve, one at about 100 per second, which is the frequency range of rhythmic optic nerve response to retinal stimulation by light (Adrian and Matthews[3]), the other at the frequency of the alpha rhythm; and this proves to be the case. Within 3 m.s., no second response at all is obtained (Fig. 3). At a given stage of anesthesia, and with greater intervals, the first few stimuli result each in a response; the more responses occurring, the nearer the frequency falls to 100 per second, and the lighter the anesthesia. After an interval of 1/5 to 1/8 second, a second burst of responses occurs in the continuous train of stimuli, and this cycle is repeated. With very light anesthesia, each stimulus may cause a response, the amplitude varying rhythmically.

These effects of graded anesthesia suggest that in the completely unanesthetized cat, no period would be found where a stimulus

1 Bartley, S. H., O'Leary, J., and Bishop, G. H., *Am. J. Physiol.*, 1937, **120**, 604.

2 Bartley, S. H., *J. Cell. and Comp. Physiol.*, 1936, **8**, 41.

3 Adrian, E. D., and Matthews, R., *J. Physiol.*, 1927, **64**, 279.

would be ineffective; but that cyclic changes in irritability might manifest themselves as a modulation of the responses to repeated stimulation. Considering that photic stimulation of the retina results in repetitive responses of optic nerve fibers, a steady illumination should correspond to steadily repetitive stimulation of the optic nerve, and flickering illumination to repeated bursts of repetitive stimulation. Such bursts should be maximally effective if the individual nerve responses approached the optimum rate (100 per second for the cat), and if the bursts occurred at the frequency of the alpha rhythm.

The accompanying paper (Bartley) contains certain evidence on the sensory effects of flicker frequency that suggests such a relationship in human subjects.

9923 P

A Central Mechanism in Brightness Discrimination.*

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Rapidly repeated flashes are seen as steady light, equivalent in sensory brightness to the same amount of light uniformly distributed in time. This is Talbot's law, and the outcome is what would be expected from a simple train of events copying the output of the photoreceptors.

But as soon as flash rate is reduced below the fusion point for steady sensation, the flashes begin to produce an average impression which is greater than that expected from photochemical considerations. As the rate is reduced more and more, the flashes produce an effect more and more nearly equivalent to steady light of the same physical intensity, and finally surpass it, reaching a maximum when the rate is reduced to the neighborhood of 8 or 10 per second. With still slower rates, the flashes approximate equivalence to steady light, with the recognized exception that single isolated flashes always appear brighter than steady stimulation of the same intensity.

The phenomenon of enhancement was first observed in 1864 by Brücke with rotating black and white sectored discs, but was not plotted for various rates of intermittency. The phenomenon shall

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