screened by a dew-cap. A diaphragm in the middle carries a lens to form an image of the sensitometer on the plate. A simpler way is to obtain the negative by direct contact, in which case the sensitometer should be screened from the general sky illumination of the horizon.

OBSERVATIONS ON ISOLATED NERVE.

THE work which Dr. Waller has recently summed up in the Croonian Lecture, is an experimental study of the influence of reagents upon excitable—that is to say, living—protoplasm. The choice of nerve as the most convenient form of living matter in such an inquiry is justified by the consideration that nerve, as is now generally admitted, is practically inexhaustible. That nerve fibre, apart from its end organs, is peculiarly responsive to even slight changes of chemical condition; and, further, that with this tissue there is the advantage of a wide and regular range between minimal and maximal effects. A previous research had shown (*Brain*, 1895) that in nerve, contrary to what obtains in muscle, stimulus and response, cause and effect are proportional, the curve expressing their relation to one another being a straight line. Probably, however, the autographic records of these nerve experiments will afford the most convincing argument for the employment of nerve fibre as a test tissue.

The main principle upon which the inquiry is based is the proposition of Du Bois-Reymond and of Hermann, that disturbed protoplasm is electro-negative to the normal; that excited is electro-negative to resting protoplasm. The excised and still living nerve of the frog gives off to the galvanometer a current, called by Hermann "the current of inquiry," which current, on stimulation of the nerve, undergoes a reversal of direction, the "negative variation," or "current of action." Supposing the nerve to be set up so that the current of inquiry is manifested as a northward deflection of the galvanometer (the arrangement followed in these experiments), the negative variation will be south. It is the magnitude of this negative variation which is taken as the index to the magnitude of chemico-physical change aroused in the nerve under various chemical conditions. To a series of stimuli of uniform intensity and duration, given at regular intervals, the nerve responds by a series of uniform deflections or negative variations, which persist for an indefinite time in the absence of modifying agents. A short series of such normal deflections precedes, in these experiments, the application of a reagent, after which, the stimuli being continued, the effect of the drug appears as increase, diminution, or abolition of the negative variations, as the case may be. The galvanometer deflections are recorded on a slowly-moving photographic plate.

The nerve, it should be said, is enclosed in a moist chamber, and rests on two pairs of electrodes, those leading off to the galvanometer, and a pair of wires from an induction coil by which the stimulations are sent in; these consist of weak tetanising currents of 8 secs. duration, given at minute intervals. Where gases are used, they are simply driven through the nerve chamber by pressure; where drugs in solution are employed, the nerve is removed from the electrodes and bathed in the solution for one minute.

Such is, briefly, the method employed. Of the results hitherto obtained, those which relate to the action of anæsthetics upon living matter will have a wide interest from their bearing upon a great practical issue. There is, of course, no question of the crude application of laboratory experience to therapeutics; yet a test so delicate and regular in its working, cannot but have its value in any estimate of the relative advantages and perils of various anæsthetic agents.

The comparative action of carbon dioxide, of ether, and of chloroform has been studied at length. All these in small quantity produce primary augmentation, and a pretty experiment consists in simply blowing through the nerve chamber, when the characteristic rise is produced by the carbon dioxide contained in the expired air. In larger quantity carbon dioxide gives abolition or diminution (Figs. 5 and 6); several minutes may elapse during which there is no response to the regularly repeated stimuli, but the abolition is not permanent, the deflections reappear, attain to, and for a time surpass their normal size. Ether vapour produces a more prolonged anæsthesia, followed by complete recovery of excitability (Fig. 1). Chloroform vapour gives a still more prolonged and often final abolition, recovery, where it takes place, being much less complete than in the case of ether (Fig. 2). Carbon dioxide added to chloroform counteracts the toxic effect and renders it more perfectly anæsthetic—that is to say, there is complete abolition followed by complete recovery.

Of the many other gases tried, oxygen (Fig. 3), carbon monoxide, and nitrous oxide (Fig. 4) give little or no effect, anæsthesia by the last is probably a carbon dioxide effect.

Passing by many groups of chemical substances of which the action has been tested, we may note merely that the study of the comparative action of haloid salts brings out with much clearness the analytical value of the method.

In regard to the acids, a fundamental question to be determined was as to whether their action upon living protoplasm was in proportion to acidity or to avidity. The answer obtained is to

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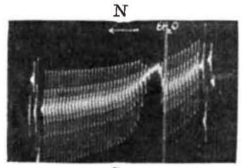

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FIG. 1.

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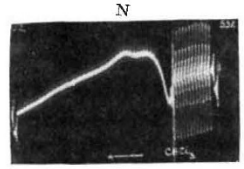

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FIG. 2.

the effect that acidity is the chief determining factor. Three acids of widely different avidities, viz. nitric, sulphuric and acetic, have approximately equal effects at the same acid strength. Yet acids have also their specific action, a comparison of, for instance, lactic and oxalic acids of equal strength shows the former to be far more powerful than the latter.

But the most interesting result of these experiments, from the purely physiological point of view, is the demonstration of the evolution of carbon dioxide in the nerve itself. As the chief terminal product of protoplasmic activity carbon dioxide had received a large share of attention, and its influence had been recognised as giving the clue to a curious puzzle with regard to the nerves. In the earlier experiments, when a frog was killed, one sciatic nerve was removed for use, while the other was

FIG. 3. FIG. 4.

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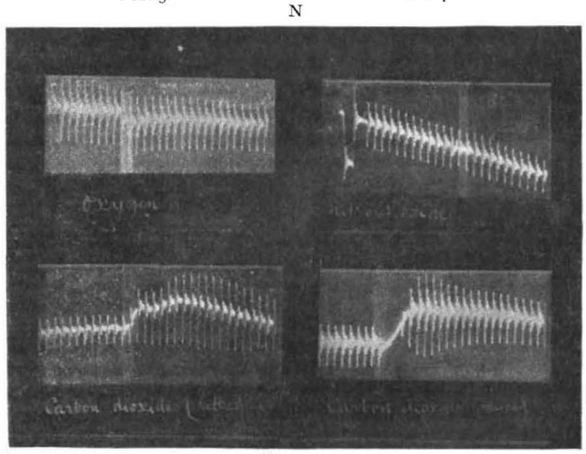

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FIG. 5. FIG. 6.

The light band across the plates marks the passage of the gas through the nerve chamber.

left in the body until required. It was noticed that the second nerve was usually more excitable than the first, and when, as sometimes happened, a nerve had been left in the body all night, the negative variation was often a very large, though a declining one. To recognise that this augmentation was due to carbon dioxide given off by the surrounding tissues, was to have a fresh example of the delicacy of nerve as an indicator of the presence of the gas; and the question suggested itself: Supposing carbon dioxide to be evolved during nerve activity, *i.e.* prolonged tetanisation, ought not its presence to be marked by the now familiar augmentation of the negative variation? To test this, recourse was had to a very simple experiment; but before making it, a forecast of its probable course was drawn upon a black-board. The usual series of normal deflections having been recorded, tetanisation was to be prolonged for five minutes, with the result that the succeeding variations would show an increase which would gradually sink back to the normal. In the actual experiment these anticipations were exactly fulfilled.

Further experiments upon nerve in different conditions (the particulars of which cannot here be described) showed the effect of carbon dioxide as still coinciding with that of prolonged tetanisation, such effect consisting primarily in an augmentation of the negative variation; hence the conclusion is drawn that tetanised nerve evolves carbon dioxide.

In favourable conditions augmentation of the negative variation may be produced by the series of brief tetani employed in the rhythmic excitation of the nerve, when the effect closely resembles the well-known "staircase" phenomenon occurring in contractile tissue. Dr. Waller leaves it an open question whether or no the phenomenon is of carbon dioxide production in muscular as well as in nervous tissue.

Of other sub-positive considerations touched upon, one of chief interest is the surmise as to the functional and chemical relations between grey axis and white sheath in a medullated nerve fibre. The stability of nerve is that of perfect compensation, not that of slowness or absence of change; and it is probable that the investing white sheath supplies the means of rapid repair to the functional grey matter.

It is perhaps not too much to hope that an elucidation of the processes of assimilation and dissimilation will be among the gains to our knowledge of living matter brought about by this new method in the immediate future. S. C. M. S.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE annual Spring Meeting of the Institution of Mechanical Engineers was held last week on the evenings of Wednesday, April 29, and Friday, May 1. The President, Mr. E. Windsor Richards occupied the chair on both occasions. The meetings were held in the theatre of the Institution of Civil Engineers, lent by the Council of that body for the purpose. The new buildings, which are now being erected for the Institution of Mechanical Engineers, are fast progressing, and probably the present year will be the last during which the latter Society will be dependent for a meeting-place upon the hospitality, always so freely accorded, of the older Institution.

The agenda for the meeting contained two papers, as follows:—

(1) "Steel Steam Pipes and Fittings, and Benardos Arc Welding in connection therewith." By Mr. Samuel MacCarthy, of London.

(2) "Research Committee on the Value of the Steam Jacket. Experiment on a Locomotive Engine." By Prof. T. Hudson Beare and Mr. Bryan Donkin.

The first business of the meeting, the usual formal proceedings having been disposed of, was the reading of his address by the President. Mr. Richards, as is well known, is a prominent steel manufacturer, having held important positions in steel works both in South Wales and in the Cleveland district. As might have been expected, therefore, he dealt more with the raw material which engineers use, rather than the methods of working it up; that is, mechanical engineering proper. It would be ungracious to find fault with the address, which must have involved much labour in its preparation, but the members of the Institution could hardly but feel a little disappointed that the President did not deal more with the machinery used at iron and steel works, rather than with the form of blast furnaces and their products. Mr. Richards' wide experience would have made of the greatest value his remarks on rolling-mills, rolling-mill engines, blowing engines, and many other pieces of machinery which are strictly examples of mechanical engineering used in iron and steel works. However, he elected to confine his attention more particularly to blast furnaces, and his remarks on the subject, although perhaps more in keeping with the other technical society, of which he is a yet more prominent member, the Iron and Steel Institute, were nevertheless of considerable interest. Mr. Richards referred to the delegation organised last year, through the British Iron Trade Association, to visit Belgium and Germany, with a view to ascertaining how it was that these countries were able not only to compete with us in neutral markets, but were also able to sell their products even in our own markets. As the address said, the inquiry undertaken by the delegation involved great labour, and some of our readers may perhaps remember that at the time it stirred up some very angry feelings; the Germans specially resenting what they considered an intrusion into their country. We have not space to follow the President in his discussion upon blast furnace practice in various countries, though it may be generally stated that the Americans show an amount of intelligence and energy in their iron and steel works, which is not surpassed and hardly equalled in any other country. Indeed in blast furnace practice the United States may justly claim to take the leading position in the world, not even excepting ourselves. At the present time near Pittsburgh there is being erected an addition to the Duquesne Works, which will cost about £600,000. Four blast furnaces of a height of 100 feet are being erected, together with the necessary blast engines and other plant. A production of 500 tons of pig-iron every twenty-four hours is expected from each furnace, thus bringing the total product for the year up to the enormous amount of 180,000 tons. Quick working generally means short life in a blast furnace, as in so many other things, and it has been often contended by English iron-makers that the slower working followed in this country is more profitable. If, however, it be allowed that the lining of the new American furnaces only lasts for four years, no less than 700,000 tons of pig-iron will be obtained in that time; a quantity which, as the address pointed out, an English furnace would require fourteen years to produce. Putting aside the question of furnace lining and renewing, it will be easily seen the large advantage a system of quick working gives in respect of labour, establishment charges, and, in fact, all the items that go to make up the cost of producing pig-iron, excepting the raw material. Under these circumstances it is hardly to be wondered at that the American output in the iron trade is advancing with such gigantic strides. Mr. Richards stated that generally in America the whole labour cost per ton of Bessemer pig-iron, is from 80 cents to 1 dol., and it is expected that the new Duquesne plant will reduce that cost by nearly one-half. English manufacturers have, however, perhaps less to fear from competition across the Atlantic, than from that of continental States, and from this point of view the details given of the production of the German and Luxemburg iron districts are of great interest. We do not find the same gigantic output as in America, but "in Germany there is a readiness to adopt new methods, and to take advantage of every point in the game of international competition, which cannot but go far to ensure success." A good example of this is given in the readiness with which German steel makers have adopted the basic process. This process had its origin in England, and though taken up by a few enterprising firms of steel makers, it may be said to have been received with but cold welcome by the trade in general. English makers preferred to import the hematite ores suitable for the acid process, neglecting our own vast resources of ore not suitable for acid steel. The Germans having somewhat similar iron ores, eagerly took up basic steel making, so as to utilise native deposits, and did not rest until they had overcome those defects and difficulties in manufacture, which always attend a new process, and which were, perhaps, exceptionally formidable in this case. They have received their reward, for at the present time an enormous trade is done in Germany in basic steel which can be produced at a cheap rate, whilst the quality is sufficiently good for ordinary engineering purposes. In Belgium, too, we see the result of an intelligent appreciation of modern improvements—both by masters and men—combined with a perseverance and industry which enables advantage to be taken of the smaller details that, in the bulk, go to make success. One thing the English manufacturer has against him is railway rates, and this is very strikingly brought out in a comparison made between the facilities which English manufacturers possess, as against those of the Belgium and German producer. As regards labour cost, Mr. Richards tells us there is not much to our disadvantage, but he says that our labour has become "far more difficult to manage, is much more ready to stop work in order to obtain an increase of wages, and is constantly agitating for fewer hours of work. Every concession made renders it more and more difficult to compete with the continent in the markets of the world, but our workmen cannot yet be brought to see this, neither can they be persuaded to cease opposition to machinery devices for saving labour and reducing cost; indeed all such appliances are jealously watched, and, if possible, their success is prevented." There is much truth in these remarks of