this hypothesis is correct the sooner a dose is given after infection the more likely it will be to answer its purpose, for we must assume that the microbes are localized at first to the seat of inoculation and to the neighbouring lymphatics and glands. We should also like to know how often salvarsan must be given and at what intervals, remembering that it is desirable to give as few injections as is consistent with a due regard to complete destruction of the spirochaetes. I hope that these points will be emphasized and that we shall obtain answers from those who will take part in the discussion with a larger and more special knowledge than I possess.

COMBINED TREATMENT.

What is the best treatment for syphilis in the present state of our knowledge of the disease? Taking, for the sake of example, the case of a surgeon or of a nurse who is inoculated in the course of professional duty, the wound should be well washed under running water, like a wound obtained in the *post-mortem* room. It should then be dried and covered with an ointment consisting of 10 grams of calomel in 30 grams of lanoline. This mercurial ointment should be gently rubbed into the wound for five minutes, and a dose of salvarsan (0.6 gram) should be given intravenously. The prophylactic action of the mercurial ointment appears to end—at any rate experimentally—within twenty-four hours of inoculation; the salvarsan is said to be serviceable in checking the generalization of the disease even when the seat of inoculation has become characteristically indurated and the lymphatic glands are enlarged. The fact, however, that the lymphatic glands do not return wholly to their natural condition after the administration of salvarsan in early syphilis rather inclines me to distrust the drug as a sole remedy, and should lead one to give mercury in some form or another as soon as possible.

A Wassermann test should be made at an early period after inoculation, although it will probably be negative in the very earliest stages, for, as has been stated already, our present knowledge shows that it is usually positive in five to eight weeks after infection; it is positive in 95 per cent. of cases during the secondary stage, and in 75 per cent. during tertiary manifestation, but it is only positive in 50 per cent. of cases where syphilis is latent. Mercury should be given at once when the infection is undoubted, but in the more difficult cases, where the diagnosis is doubtful, it may be withheld until a positive Wassermann's reaction has been obtained.

Preferably the mercury should be given by intramuscular injection, and Colonel Lambkin's formulae are quite satisfactory as far as I have used them. If, for any reason, the intramuscular method cannot be employed inunction may be employed. But when, as in ordinary private practice, the drug has to be given medicinally, I think the perchloride is better than the grey powder which has been used in England for a long time past. It seems to me that so long as mercury is given in small doses, systematically, and for long periods of time, the exact preparation used does not matter very much. The mercury should be given with regulated periods of rest, and a Wassermann's test should be made at the end of each period just before the mercury is recommenced. If the test is negative an intravenous injection of salvarsan may be given with a view to elicit a positive result. If the test still remains negative after this injection the mercury may be discontinued for a further period so long as there are no signs of syphilis, and at the end of a further period of two months the test should be again employed. Marriage may be permitted under these conditions when the Wassermann test has remained negative and there have been no syphilitic symptoms for at least a year.

In this manner we shall avoid giving mercury for a longer time than is absolutely necessary, whilst the drug will be continued until the syphilis is cured, even when the absence of symptoms might seem to make a further mercurial course unnecessary. We shall also have taken a step in advance of Colonel Lambkin, who was obliged to take a time limit with absence of symptoms as a guide for discontinuing a mercurial course because the scientific test had not yet become available.

There are two objections to the use of Wassermann's test as an answer to the question whether or not an individual is cured of syphilis. In the first place, it is purely

a laboratory test, and we are consequently at the mercy of the pathologist who makes this examination. This objection is easily surmounted by always employing the same pathologist. The second objection is much more serious. It involves the fallacy that Wassermann's test is an absolute proof of the presence or absence of spirochaete infection, and even in the light of our present knowledge it is certain that we are not justified in making such an assumption, for the figures given above show that the test remains negative in a certain percentage of cases in every stage of syphilis. Clinical experience and the caution begotten of it must still guide our advice therefore, but recent advances in the treatment of syphilis have been so great that we need not despair of obtaining some reliable test even in the immediate future.

ELECTRO-CARDIOGRAPHY AND ITS IMPORTANCE IN THE CLINICAL EXAMINATION OF HEART AFFECTIONS.

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PART I.

The Method Employed in Obtaining Electro-cardiograms.

THE electro-cardiographic method is one by means of which curves are obtained of electric changes which result in the body from the activity of the heart's muscle. The installation required for this work comprises a sensitive galvanometer and its accessory switchboards, and an arc light and camera.

The galvanometer used for the purpose is a peculiarly sensitive one;† it is composed of a heavy electromagnet, the poles of which are closely approximated. Between the poles, and lying in the magnetic field, an extremely light conducting fibre is stretched, which consists of a finely drawn platinum or silvered quartz thread. It is this thread which acts as the recorder. If a small current is passed through it while it lies in the magnetic field, it becomes deflected and takes up a new position, a position which is governed by the direction in which the current flows through it, by the strength of the current and the sensitivity of the instrument. The sensitivity of any given instrument is controlled by the magnification of the string and its tension. The magnification is arranged by means of a microscope driven through one pole of the magnet; the other pole is bored to contain a condenser. A beam of light, falling through the condenser and concentrated upon the string, projects the magnified image of the string upon the screen of the camera. The magnification usually adopted is approximately 600 diameters; it is kept constant. The sensitivity of the instrument, from time to time, consequently depends upon the tension of the conducting fibre, and this is arranged to give a standard deflection for a given electric change. The standard adopted by all who practise human electro-cardiography is the same. When the ends of the string are connected to form a circuit and an electro-motive force of $\frac{1}{1000}$ volt is introduced into this circuit, the deflection of the projected string image amounts to 1 cm. The deflection of the string is in exact proportion to the strength of current which passes through it. Thus, if $\frac{1}{1000}$ volt are introduced into the circuit a deflection of 2 cm. results. If, instead of introducing an electro-motive force from a battery, the human body is connected to the string by suitable means, the string moves in response to changes of potential produced in the body as a result of the heart beat; and the movement of the string's shadow in response to these natural cardiac electric effects is of sufficient amplitude to permit it to be photographed upon a moving plate surface. The photographic apparatus consists of a moving plate camera, the string is vertical, and its shadow falls upon the vertical screen on the front of the camera. Its movements are from side to side across the front of the camera, and across a horizontal slit in the front, behind which the plate

* Working the tenure of a Beit Memorial Fellowship.

† Such a galvanometer is supplied by the Cambridge Scientific Instrument Company.

travels. As the plate travels the shadow of the moving string protects the sensitive surface of the plate from the light, and when the plate is developed the record of the movements remains upon the plate as a white band upon a black background. Prints from this plate, such as are here reproduced, show a black band upon a light background. The plate falls on its end in the camera, the print is turned upon its side for reproduction. As the plate moves the light is also prevented from falling upon its surface by a screen on which fine lines are ruled at intervals of 1 mm. These lines are horizontal in the records and serve to facilitate measurement; each is equivalent to $\frac{1}{1000}$ volt (see Fig. 1). The light is also shaded by a vibrating time marker, which records thirtieths of a second upon the plate.

The object of standardizing the movements of the string is as follows: If allowance is made for the whole resistance of the circuit, consisting of string, the human body, and the connecting wires, the development of a given potential difference at the points of the body from which the current is led off gives rise to a deflection of the string of a definite value, which may be compared with the deflection resulting from the employment of a potential difference of known amount. The same heart will give electro-cardiograms similar in outline and magnitude from time to time; and it will yield similar records with different instruments, providing that the body is connected to the galvanometer in the same manner. Thus an absolute comparison may be made of curves taken from the same subject from time to time; and to a lesser extent of curves from patient to patient. The electro-cardiograms from no two subjects are the same; they differ slightly both qualitatively and quantitatively. Such being the case, and the type of electro-cardiogram remaining constant in any healthy person for long periods, the identification of any individual from his electro-cardiograms is a matter of no great difficulty.

It is customary in leading off the heart currents from the patient to adopt three leads: *I*, horizontal, from the right arm to the left arm; *II*, oblique, from the right arm to the left leg; and *III*, vertical, from the left arm to the left leg. I shall speak of these leads hereafter simply as leads *I*, *II*, and *III*. In the illustrations these leads are marked in the upper left-hand corner of each strip of curve. The limbs are connected to the instrument by plunging them in baths of salt water, the baths being themselves connected to the string. As soon as the string is placed in circuit with the body in this fashion its movements commence, and may be recorded when appropriate adjustments have been made. And within certain limits it is a matter of indifference how far away the patient sits from the instrument; the wires which carry the current from his body may be several miles in length. Providing that they are properly protected, and that their own resistance is allowed for, the records remain unchanged.

The Form of the Human Electro-cardiogram.

The form of the human electro-cardiogram varies according to the points of the body from which the current is derived. As I have said, three leads are commonly employed. For the time being let us consider a single one, the most serviceable—namely, that which is

Fig. 1.—A normal electro-cardiogram from lead *II* (R. A. to L. L.). It shows two heart cycles; each consists of *P*, the auricular summit, and the deflections *Q*, *R*, *S*, and *T*, the ventricular deflections. The line is straight and horizontal during diastole. The normal electro-cardiogram is inscribed only when the heart-beat starts at the normal site, traverses the auricle and the auriculo-ventricular bundle, and is distributed to the ventricle and through its substance by the usual and recognized channels. The time marker of this and subsequent figures is in $\frac{1}{30}$ seconds, and is seen along the bottom edge of the curve. The fine horizontal lines at millimetre distances facilitate measurement. Each centimetre of a heart deflection is equivalent to $\frac{1}{1000}$ volt.

in the nearest line to that of the heart's axis, the right arm to the left leg (lead *II*). Such an electro-cardiogram

from a normal subject usually consists of five separate phases, and these are called *P*, *Q*, *R*, *S*, and *T* (see Fig. 1). It is necessary to examine but briefly the meaning of these phases. *P*, the first phase, is due to the simultaneous contraction of the two auricles. *Q*, *R*, *S* and *T* (of which *R* and *T* are the most prominent) are the result of simultaneous contraction of the two ventricles. We will be content with this statement for the time being, without further attempting the explanation of the various summits and depressions of the curves. We have in electro-cardiography the only certain method of obtaining separate records of the movements of the upper and lower chambers of the human heart; and, as we shall see, these records may tell us a great deal as to how the separate chambers are fulfilling their functions.

The curves from the other leads, *I* and *III*, are not altogether dissimilar to those derived from lead *II*; though they never duplicate it (Fig. 2). The main summits,

Fig. 2.—Three normal electro-cardiograms from the same subject as Fig. 1. They were taken from lead *I* (R. A. to L. A.), lead *II* (R. A. to L. L.) and lead *III* (L. A. to L. L.). Each shows *P*, the auricular representative, and *R* and *T*, ventricular representatives, *Q* and *S* are present in varying degrees. Note the conspicuous *R* summit in each lead and the variations in height of the several deflections from one lead to another. The heights of the peaks in the second lead are similar to those found in Fig. 1. The two figures were taken from the same subject and same lead, but on different days.

P, *R* and *T* are still seen, and *Q* and *S* also appear in varying degree. We shall understand the special values of these leads almost immediately.

The Direction of Lead.

In speaking of the value of electro-cardiograms in the diagnosis and management of cardiac affections, we may choose certain illustrations; in selecting them at the present time, I shall not only choose them as illustrations of the method, but I shall also specially select those which have an immediate and unquestionable practical value. And the first illustration is a simple one; it shows that the direction of lead is all-important, and demonstrates the particular value of a given lead under certain circumstances. Supposing that in a normal subject we lead off from right arm to left arm (lead *I*). The curve which results will be similar to that shown in Fig. 3A. But supposing that we lead off in the reverse direction—that is, from left arm to right arm, what will result? We change the direction in which the same currents flow through the string. Its movements will consequently be of similar amplitude and similar form, but *opposite in direction*. The two pictures will differ from each other in one respect, and one only. The second will be upside down (Fig. 3B). The practical value of this fact is seen when we turn our attention to transposition of the heart. Regarded from the point of view of the heart, the right arm in the subject of heart transposition is where the left should be; the left is where the right should be. Consequently an electro-cardiogram from lead *I* in a subject who has a transposed heart will also be similar to an electro-

cardiogram from a normal subject from lead I, but it will be inverted. In other words, all the summits and depressions of the curve will be upside down. This reversal of the picture applies to lead I alone, for it is the only symmetrical lead. Now transposition of the heart is a rare condition, but it not infrequently happens that the human heart is displaced, and it is also by no means uncommon that the cause of its displacement cannot be found; in all such instances the question of transposition may arise. The electro-cardiographic method returns a perfectly clear answer to the question, Are we dealing

Fig. 3A.—A normal electro-cardiogram from lead I (R.A. to L.A.), the only symmetrical lead. P is small, R and T are conspicuous. The deflections are in the usual directions.

Fig. 3B.—An electro-cardiogram from the same subject. The lead was from L.A. to R.A. (bad I reversed). The electro-cardiogram is upside down. Such curves are obtained from lead I (R.A. to L.A.) when the heart is transposed, and in this condition alone.

with a transposed heart? Displacement of the heart certainly alters the form of the electro-cardiogram, and deforms the normal curve in definite and known ways, which I do not propose to consider at the present time. It is sufficient to know that displacement never yields the completely inverted electro-cardiogram; transposition always does. The electro-cardiographic test is the most certain means of differentiating the two conditions.

Enlargement of the Heart.

The chief object of recording the electro-cardiographic curves of one subject by means of three leads is the attempt to differentiate between right-sided and left-sided hypertrophy of the heart. If curves are taken from normal subjects, it is the rule to find that the summit R is a prominent upward deflection in all leads (see Fig. 2); S, if present, is a small downward deflection. If, on the other hand, the same leads are adopted in a case in which there is clear evidence of right-sided hypertrophy, certain changes in the shape of the curves are discovered (Fig. 4). In lead I, R is small or absent and S is deep. In lead III, S is small or absent, and R is relatively high. If the curves (Fig. 4) are examined it will be seen that the prominent

Fig. 4.—Three electro-cardiograms (leads I, II, and III) from a case of mitral stenosis. The figure demonstrates the exaggerated P summit in lead II, which is so frequently found when there is auricular hypertrophy; it shows the modifications of the ventricular deflections which consort so commonly with right ventricular hypertrophy; R is almost absent in lead I, while S is deep; R is tallest in lead III, while S is absent.

deflections in question, R in lead III, and S in lead I, point towards each other; the deep S of lead I and the tall R of lead III are directed upwards and downwards

towards the centre of the figure. If the same three leads are adopted in a frank instance of left-sided hypertrophy the reverse picture may be anticipated (Fig. 5): R is large in lead I, S is small or absent; R is small or absent in lead III, S is large. The exaggerations of the peaks R in lead I and S in lead III are away from each other.

It is in the new-born child, in pulmonary stenosis, and in mitral stenosis that the first grouping (Fig. 4) is so frequently encountered; it is in aortic and renal disease that the last grouping (Fig. 5) occurs most commonly.

The difficulty of differentiating right as opposed to left-sided hypertrophy in anything but the frankest of cases by ordinary physical signs is well known; often—indeed, frequently—it is impossible. The electro-cardiographic curves are not the least valuable indications which we possess to-day; and they may be of special service in several groups of cases. Apart

from the intrinsic value of the differentiation, it is of special importance to ascertain the relative degree of right and left-sided hypertrophy in cases where there are murmurs at the base of the heart. It may be that, with the presence of a diastolic murmur in the aortic area in a patient who has a rheumatic history, a presystolic sound or actual murmur is heard at the apex; and the question arises as to whether stenosis of the mitral valve is present, or whether the apical murmur is of the kind described by Flint and attributable to the aortic lesion also. If it can be decided that left-sided hypertrophy predominates, such a fact emphasizes the aortic lesion; if right-sided hypertrophy predominates, the presystolic murmur may be attributed to constriction at the mitral orifice. Confusion not uncommonly arises in young subjects between the diagnosis of pulmonary and aortic lesions. The two valves which guard the respective arteries are near to each other; lesions of the former are accompanied by right-sided, and lesions of the latter by left-sided, hypertrophy. Again, how frequently one meets with cardiac patients—patients who have mitral stenosis, but in whom the presystolic murmur is absent; in such cases electro-cardiographic examination is often of great value, for it indicates that the muscle of the right side predominates. And this is especially the case, as will appear hereafter, when the heart's action is irregular.

(To be continued.)

THE Section of Balneology and Climatology of the Royal Society of Medicine held its annual meeting this year at Woodhall Spa, in Lincolnshire, on June 1st. The proceedings included a reception given by the directors of the Spa Company, an inspection of the hydropathic establishment, and a demonstration of the various methods of treatment adopted thereat.

THE American Medical Association held its sixty-third annual meeting in Atlantic City from June 3rd to 7th. Dr. Abraham Jacobi was installed as President in the room of Dr. John B. Murphy, and delivered an address on the best means of combating infant mortality. The report of the secretary stated that the membership of the association on May 1st, 1912, was 34,283, a net increase for the year of 323. The report of the treasurer showed that the total assets of the association were 511,759 dollars (a little over £102,351); the net income for the year was 53,815 dollars (£10,763).

Fig. 5.—Three electro-cardiograms (leads I, II, and III) from a case of aortic disease and enlargement of the heart. The figure shows the modification of the deflections so frequently found where there is left-sided hypertrophy. R is tallest in lead I and S is short. S is deep in lead III, while R is almost absent. The arrangement is the reverse of that seen in Fig. 4.