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CAMBRIDGE PHYSIOLOGICAL INSTRUMENTS

Booklet No. V.

CAMBRIDGE PHYSIOLOGICAL INSTRUMENTS

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INTRODUCTION

WE are constantly reminded of the fact that a general catalogue dealing with Cambridge Instruments would be of service to our customers. The field covered by these instruments is so large and varied that a full descriptive list, arranged on the lines of our standard catalogues, would be too bulky in character to be of much service save as a book of reference. It is, therefore, with the object of providing the desired information in a concise, portable form that we are issuing a series of small lists, each covering a distinct group of our instruments. The present booklet, which is the fifth of the series, deals with physiological and medical instruments, the complete series consisting of :—

I.—Temperature Measuring Instruments.
II.—Engineering Instruments.
III.—Electrical Instruments for D.C. Measurements.
IV.—Electrical Instruments for A.C. Measurements.
V.—Physiological and Medical Instruments.
VI.—Special Instruments.

The Cambridge Instruments which have been developed for use in physiological and medical investigations cover a wide field, and in a booklet of this size it is not possible to give more than brief notes with regard to the construction and capabilities of each instrument. In connection with many of the descriptions, however, reference is made to the more detailed catalogue which deals with the same subject, and it is hoped that readers will apply for such catalogues when they require further information.

The electro-cardiograph now plays an important part in cardiac investigations. The records produced are of great assistance in analysing variations from the normal heart rhythm, and are frequently essential to a clear understanding of disordered heart action. Since Professor Einthoven developed the string galvanometer, various modifications have been made in it and the subsidiary apparatus employed so that the complete outfit may be as simple and robust as possible. The electro-cardiograph described on pages 18-25 of this booklet embodies improvements and additions introduced as a result of many years' experience both in research work and in general medical practice. Investigators of diseases and disorders of the heart will also be interested in the Mackenzie-Lewis polygraph

INTRODUCTION—*continued.*

(pages 16-17) and in the hot wire sphygmograph suggested by Professor A. V. Hill (pages 28-29).

Since Helmholtz made possible the study of the interior of the living human eye by his invention of the ophthalmoscope, many opticians have attempted to obtain permanent photographic records of the surface of the human retina, but have found this more difficult than visual examination, owing to the effect of reflections from the surface of the cornea and lens of the eye, and from the anterior and posterior surfaces of the ophthalmoscope lenses. The problem was solved by the late Professor Wertheim Salomonson, who designed an instrument whereby clear photographs covering a large proportion of the fundus could be obtained easily and quickly. The instrument described in this booklet (pages 30-32) is based on his original design, but includes further modifications which give a simpler manipulation.

As a result of long study of the relation of temperature to disease, it is now realised that a knowledge of the diurnal variations in the body temperature may sometimes throw light on the early stages of tuberculosis. The apparatus developed by us for the continuous registration of body temperatures (pages 36-37) has proved reliable and easy to manipulate, and is of ample sensitivity.

For many years Cambridge microtomes have had a high reputation for accuracy and reliability. The rocking microtome (page 6) originally designed over thirty-five years ago, is still a favourite instrument for cutting sections of paraffin-embedded objects, and is noted for the ease and rapidity with which long ribbons of uniform sections can be produced. The universal microtome (page 7) combines the same qualities of ease of manipulation, rigidity, and accuracy, with the additional advantage that it cuts flat sections. The hydrogen-ion apparatus (pages 34-35) will be of interest to workers in pathological laboratories for the determination of the pH value of media. The apparatus developed to measure the pH value of blood is of particular interest owing to the small capacity of the electrodes and the convenience with which the blood sample may be saturated with carbon dioxide. Included in the booklet are a number of instruments which were developed by the late Dr. Keith Lucas for use in physiological research. These instruments are characterised by accuracy, ease of manipulation, and simplicity of design.

MICROTOMES
Rocking Microtome

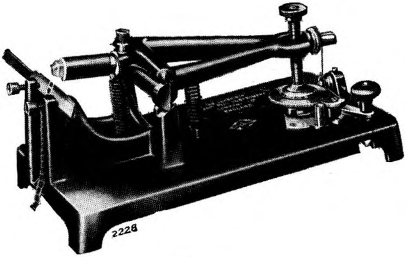


Fig. 1.
15 × 8 × 7 inches. Weight 20 lbs.

CAMBRIDGE Microtomes are well known for their accuracy, reliability and convenience of operation. The Rocking Microtome illustrated in Fig. 1 is designed for cutting sections of paraffin-embedded objects, a feature being that the sections can be made to adhere together to form long ribbons of uniform section. The object is fixed on the end of a rocking arm, the movement of which draws the object across a knife fixed horizontally with its edge uppermost. The rocking arm is pivoted on knife edges upon a second (feeding) arm, which can be tilted by means of a micrometer screw, so that the object may be fed towards the knife. The micrometer screw is automatically rotated a definite amount at each stroke of the rocking arm by means of a pawl and ratchet mechanism, which can be adjusted to give sections of any thickness between 0·002 mm. and 0·024 mm. The rocking arm is operated by means of a spring-controlled hand lever through a cord and pulley connection, and the object can be adjusted in relation to the knife by altering the length of the cord. Four interchangeable object-holders of different forms can be supplied.

Further particulars are given in List No. 182.

MICROTOMES
Universal Microtome

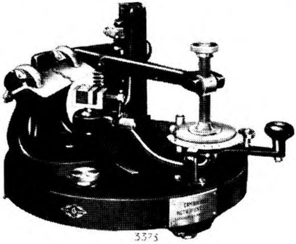


Fig. 2.

12 × 10 × 8 inches. Weight 20 lbs.

THE Universal Microtome shown in Fig. 2 is designed for cutting flat sections from objects up to 18 × 20 mm. cross section, embedded in paraffin or celloidin, or from certain non-embedded objects. Ribbons of sections can be obtained from paraffin-embedded objects. The object is carried at the end of a horizontal swinging arm, each stroke of which passes the object under the cutting edge of a horizontally clamped knife. The knife can be adjusted to enable slicing cuts to be obtained. A vertical feed is automatically imparted to the swinging arm between successive cuts by means of a lever, the end of which is raised by a micrometer screw actuated by a pawl and ratchet mechanism of similar design to that used in the rocking microtome. The feed occurs when the object is at its furthest distance from the knife, and can be adjusted to give sections of any thickness between 0·001 mm. and 0·035 mm. The swinging arm is operated by means of a hand lever attached to the arm by a link. The moving parts are light, and there is little friction ; the accuracy is unaffected by wear of the moving parts. The object holder is so designed as to facilitate precise orientation.

Further particulars are given in List No. 182.

DEPREZ SIGNAL TIME MARKERS

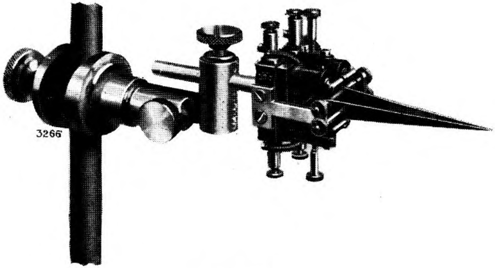


Fig. 3.
6 × 2 × 2 inches.

IN Fig. 3 is illustrated a Time Marker designed for inscribing time scales on smoked paper charts in experiments employing the apparatus described on pages 10 and 11. The instrument comprises an electro-magnet, the current through which is made and broken at each vibration of a tuning fork. To the armature of the electro-magnet is attached a style which can be set (by means of a fine adjustment) into contact with the recording surface. The movements of the style, due to the making and breaking of the current in the magnet circuit, cause marks to appear on the record at intervals which represent definite periods of time. The electro-magnets are small, and the moving parts extremely light, thus reducing to a minimum the errors due to inertia effects. The minimum current required is 0·2 ampere, or rather less. A clamp is provided to facilitate attachment to a stand. The Time Marker is generally employed with a tuning fork making 50 vibrations per second, but it may be adjusted for use with a fork having a frequency of 100 vibrations per second. The instrument shown in Fig. 3 is provided with two electro-magnets and two recording styles, enabling two time markings to be simultaneously recorded.

Further particulars will be given on request.

ROTARY TIME MARKER

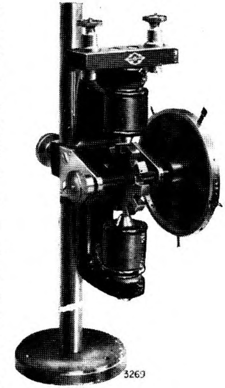


Fig. 4.
6 × 3 × 5 inches.

THE Time Marker illustrated in Fig. 4 has been designed for use with projecting microscopes. It enables time intervals to be marked on photographic records made by the projection of a beam of light on to a moving photographic plate, paper or film. The apparatus forms part of the electro-cardiograph described on pages 22 to 25. It consists of a small electric motor comprising a circular-toothed armature set vertically between two electro-magnets, and controlled by an electrically-maintained tuning fork. At each vibration of the tuning fork the current through the electro-magnet is made and broken, thus attracting each successive tooth on the armature, and rotating the armature in steps synchronous with the vibrations of the fork. To the armature spindle is fixed a disc having projecting pieces evenly spaced round its periphery, and the instrument is so set that as the disc rotates the projections intercept the beam of light falling on the photographic plate. These momentary non-exposures at regular intervals cause lines to appear on the record at distances apart which represent definite intervals of time. Discs having different numbers of spokes can be supplied, enabling time markings of different periods to be obtained. One projection on each disc is usually made wider than the intermediate ones, in order to record more prominently each complete rotation of the disc, thus facilitating the reading of time values. A phonic wheel constructed on a similar principle forms an accurate means of marking seconds.

Further particulars are given in List No. 180.

RECORDING DRUMS

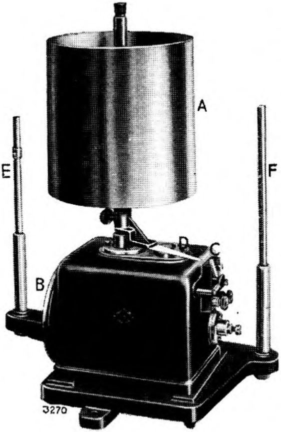


Fig. 5.
14 × 9 × 17 inches.
Weight 29 lbs.

IN Fig. 5 is illustrated a Recording Drum of the type originally developed by the late Dr. Keith Lucas for physiological experiments. It comprises an aluminium drum, A, which is mounted on a vertical shaft, and is rotated by means of a pulley, B, through an easily-operated two-speed gear, giving speeds in the ratio 1 : 80. A simple and reliable clutch is provided which enables the speed to be readily changed. The gearing is entirely enclosed. The pulley is belt-driven, and for large installations it is frequently convenient to drive the drums from shafting. For this purpose, a double driving pulley can be supplied, which is mounted loose on the main shaft, and is fitted with a clutch and carried in a pedestal bearing. By different arrangements of the pulleys, in combination with the two-speed gear of the Drum, it is possible to obtain a total range of six speeds, in the ratios 1 : 4 : 16 : 80 : 320 : 1280. For single Drums or small installations an individual drive from an electric motor is generally more convenient. A separate speed-reducing gear may be supplied, which will give a primary reduction of speed in the ratio of 20 : 1, two cone pulleys giving further reductions of 2 : 1 and 4 : 1 respectively. The cone pulleys on the Drum and on the speed-reducing gear may be interchanged to give a variety of speeds, the range covered being from 0·15 to 440

KYMOGRAPH

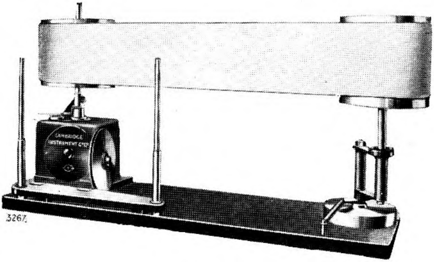


Fig. 6.
39 × 17 × 18 inches.

millimetres per second, with a motor speed of 2,400 revolutions per minute, and a pulley of 22 millimetres diameter. A trip switch C, which is operated by a steel trigger D clamped to the drum shaft, can be used to interrupt the current in one of the recording circuits once in each revolution. The Drum is mounted on a cast-iron base, and two upright pillars (E, F) are provided to carry muscle troughs, recording levers, time markers, etc. The apparatus is intended for use with smoked paper charts 52·5 cm. long by 13·3 cm. wide.

For work where a longer record is desirable than can be obtained on a single drum, the instrument can be converted into a Kymograph. A second drum, without driving gear, is then mounted together with the standard drum on a single wooden base, as shown in Fig. 6. This additional drum is fitted with a spring device that keeps the paper chart taut. The two drums will carry a loop of paper 195 cm. in length.

Further particulars will be given on request.

LUCAS CONTACT BREAKER

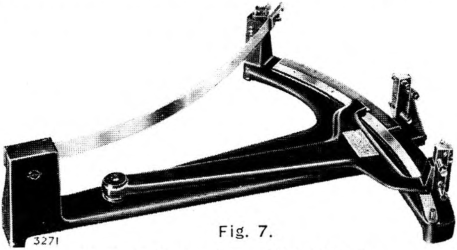


Fig. 7.

21 × 14 × 4 inches. Weight 17 lbs.

THE Contact Breaker illustrated in Fig. 7 enables electrical circuits used in physiological experiments to be broken in succession at definite intervals of time. It may be used for investigating the refractory period of a nerve or muscle (*Journ. Physiol.*, 1911, xliii., 46), and for determining the maximum time interval at which two electric stimuli—of a strength less by a known percentage than the threshold strength just required to excite a tissue—may follow one another and just provoke an excitation (*Journ. Physiol.*, 1910, xxxix., 461). It is also of value in connection with experiments for determining the minimum strength of current which will just excite a nerve or muscle, when applied for different durations of time (*Journ. Physiol.*, 1907, xxxv., 310). The instrument is particularly suitable for students' use. It consists of a loaded steel spring about 46 cm. long, arranged to swing in a horizontal plane, and initially held by a catch at one end of its travel. When the catch is released, the movement of the spring opens two electrical contacts in succession at definite time intervals, which may be adjusted by moving one of the contacts over a graduated scale, each division on which corresponds to a time interval of about 0·0003 second. The movable contact can be easily set to one-third of a division, and the time interval between the opening of the contacts may be varied from 0·0001 (or zero) to 0·03 second ; the range may be extended by increasing the weight attached to the free end of the spring.

Further particulars will be given on request.

LUCAS PENDULUMS

THE Pendulum illustrated in Fig. 8, (see *Journ. Physiol.*, 1908, xxxvii., 459), provides a means whereby results may be obtained of a more exact nature, and over a wider range, than is possible with the aid of the contact breaker shown in Fig. 7. It can be applied to any of the experiments mentioned on page 12. The instrument comprises a short pendulum B, mounted in ball-bearings, and carrying a light arm A, which engages with pawls C and D pivoted upon a vertical frame. The pendulum is first brought into such a position that the arm A rests against the pawl C. When C is raised, the pendulum swings in an anti-clockwise direction through nearly 360°, causing the arm A to open two electrical contacts E, F, in succession, and finally to reach the pawl D, which holds it in position. The contact E is fixed on the base of the instrument and is opened when the pendulum is exactly at the lowest point of its swing. The contact F is attached to a rotatable vertical wheel, 48 cm. in diameter, which can be clamped in any position. The rim of the wheel is graduated in angular degrees over 150 degrees of its circumference, and a vernier enables the position of the contact F to be read to 0·1 degree. The time interval between the successive openings of the two contacts may be varied from 0·00008 second (corresponding to an angular reading of 0·1°) to 0·16 second. If desired, a third contact can be clamped to any point of the circumference of the wheel.

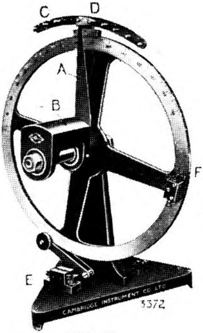


Fig. 8.
13 × 20 × 26 inches.

Further particulars will be given on request.

LUCAS MUSCLE TROUGH

Fig. 9. 3275
9 × 4 × 3 inches. Weight $1\frac{1}{2}$ lbs.

WHEN conducting class experiments on muscle and nerve, it is important to prevent the drying of tissues. The Muscle Trough (see Fig. 9), enables the tissues to be completely immersed in Ringer's solution. The simplicity of adjustment, and the accessibility of the parts, render the apparatus suitable for use by elementary students. The Trough is made out of solid ebonite ; two adjustable platinum electrodes are provided. A vertical arm, forming part of a bell crank lever, projects into the middle of the Trough and is pivoted to a carrier which can be moved horizontally along the outside of the Trough and clamped in position. The other arm of the lever extends horizontally along the side of the Trough, and can be provided with a writing point for recording the movements of the muscle or nerve under examination. Weights can be applied to the horizontal arm to load the muscle. When experimenting on a gastrocnemius-sciatic preparation, a pin, thrust through the knee-joint between the bones, is fixed to a boss on the floor of the Trough, and a short loop of thread, tied to the tendon, is attached to a hook on the vertical arm. The electrodes can be applied either to the nerve at any part of its length, or to any part of the muscle. The method is applicable to any muscle of suitable size, or to the hearts of small animals. The Trough can also be adapted for experiments on the electric response of muscles and nerves.

Further particulars will be given on request.

CO_2 INDICATOR
for Alveolar Air

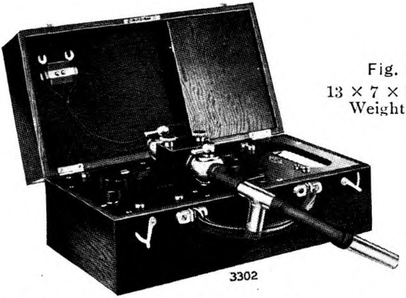


Fig. 10.
13 × 7 × 6 inches.
Weight 14 lbs.

TO physiologists and physicians working on respiration and on the respiratory functions of the blood, it is important to be able to measure the carbon dioxide content of alveolar air. In diabetes, for example, a lowering of the CO_2 percentage is an indication of danger, and the percentage figure is therefore a valuable guide to prognosis and treatment. The instrument shown in Fig. 10 has been developed from a suggestion by Prof. A. V. Hill. It is electrical in operation, and has the advantages that it requires no absorbents, is quick reading and simple to use. The patient breathes out in the ordinary way, and then, by an effort, expels the residue of the gas that has been in actual contact with the blood system, through a tube with a glass mouthpiece connected to a katharometer of the Shakespear type. On either side of the katharometer are cocks that may be closed immediately after expiration, thus retaining a small quantity of the residue, or alveolar air, in the katharometer chamber. After an interval of about one minute, to permit proper diffusion of the gas, the percentage of CO_2 in the sample is shown on the indicator scale, which is calibrated to read from 0 to 10 per cent. CO_2. The apparatus is sometimes used to give an indication of the basal metabolism of a patient by determining the CO_2 output. The outfit is portable and is immediately ready for use.

Further particulars will be given on request.

MACKENZIE-LEWIS POLYGRAPH

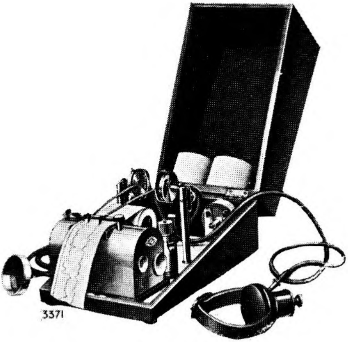


Fig. 11.
9 × 5 × 5 inches. Weight $4\frac{1}{2}$ lbs.

THE Polygraph shown in Fig. 11 is an improved form—due to Sir Thomas Lewis—of an instrument originally designed by the late Sir James Mackenzie for recording the venous and arterial pulsations of patients. It incorporates modifications which considerably increase the accuracy of the records, and render the instrument more reliable and more convenient in use. By its means two simultaneous records of any length may be taken. The moving parts are made as light as possible to ensure a quick response and to reduce inertia effects, while the small dimensions of the tambours and receiving chambers prevent undue lag and distortion of the wave form. These improvements also increase the relative sensitivity, enabling records of readable amplitude to be obtained from feeble pulses. The venous and apical receivers are simple cups, while the radial (or brachial) receiver is a glycerine pelotte which in practice is fixed to the arm of the patient by a leather strap and is provided with a fine pressure adjustment. A valve enables the pelotte to be opened to the atmosphere while being

MACKENZIE-LEWIS POLYGRAPH

Typical Record

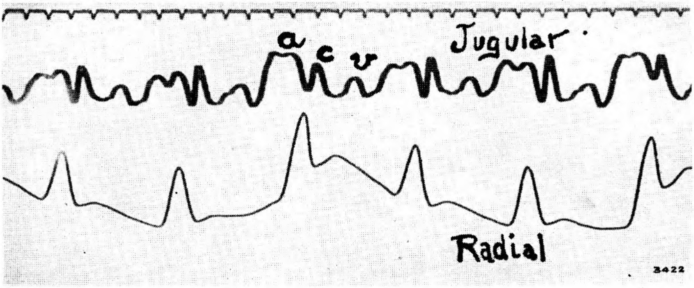


Fig. 12.

strapped to the patient, thus avoiding violent movement of the pen and the likelihood of danger to the tambour. The receivers are connected to the transmitting tambours by moderately thick-walled rubber tubing. The two tambours are attached to vertical posts at the rear of the instrument by ball and socket joints, which permit of adjustment in all directions. The movements of the tambours are recorded on a continuous paper chart (38 mm. wide), which is driven by clockwork at a speed which can be varied from 9 to 21 millimetres per second. The paper roll is carried on a drum beneath the tambours, thus economising space, and enabling the paper to travel away from the writing points, an arrangement which tends to assist the ink flow. A time marker is fitted, giving one-fifth second marks at the side of the record. The instrument is compact, and can be closed and carried about while still ready for use. The ink bottle and two spare rolls of paper are contained within the case. A simple device enables the rubber membrane in the tambours to be replaced without difficulty. Fig. 12 is a full-size reproduction of a record obtained with the instrument. The time marks will be clearly seen along the upper edge of the record.

Further particulars are given in List No. 181.

ELECTRO-CARDIOGRAPHS

Galvanometer

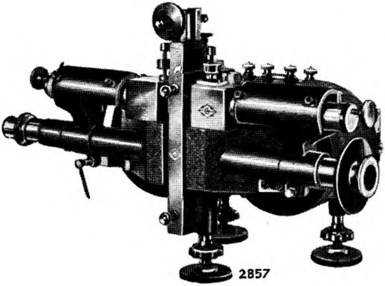


Fig. 13.
17 × 10 × 10 inches.

THE Electro-Cardiograph has been developed for pathological investigations in connection with the study of the human heart. It enables the extremely minute electrical currents set up by the auricular and ventricular contractions to be measured and their fluctuations recorded upon a photographic plate or on a strip of photographic paper. Derangements in the heart's action can thus be detected, the results providing a check upon diagnosis, and forming a valuable aid to prognosis and treatment. Accurate records are easily and quickly obtained—a complete series of three curves can be taken from a patient's heart in a few minutes. The apparatus comprises an Einthoven string galvanometer, connected to the patient through the intermediary of suitable electrodes, together with illuminating and optical devices, whereby the movements of the galvanometer fibre are photographically recorded on a moving sensitized surface. The Einthoven string galvanometer is illustrated in Fig. 13. The moving system is a fine conducting fibre which is stretched in the narrow gap between the poles of a powerful electro-magnet. When the minute electrical currents from the heart are passed through the fibre it is deflected at right angles to the magnetic field and to the direction of the

ELECTRO-CARDIOGRAPHS

Fibre Case

fibre by an amount proportional to the strength of the current. The field coils are wound for either 110 and 220 volts D.C. or for 10 and 20 volts D.C. respectively. The fibre is suitably illuminated and its movements recorded micro-photographically. The magnified image is projected on to a cylindrical prism in front of the camera, and is thus focussed on the sensitized photographic surface, the shadow of the fibre forming a sharply defined break in a horizontal band of light. The sensitized surface is moved at a definite variable speed in a vertical plane at right angles to the plane of the band of light, and the deflections of the fibre are thus recorded in the form of an unexposed line. Some typical records are reproduced (approximately half full-size) on pages 23 and 25.

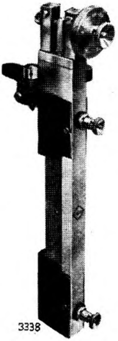


Fig. 14.
3 × 4 × 9 inches.

The galvanometer fibre, which is generally of glass covered with a thin metallic coating, is completely enclosed in an air-tight case (Fig. 14), which gives efficient protection against draughts, dust and dirt, and guards against accidental mechanical breakage. The tension on the fibre can be adjusted, and hence the sensitivity controlled. The fibre and case can be readily replaced. When it is desired to take two simultaneous electro-cardiograms, or to take a phono-cardiogram simultaneously with an electro-cardiogram, the single fibre case is replaced by a double fibre case, in which two fibres are mounted side by side. A record of this type is shown in Fig. 23.

Further particulars are given in List No. 180.

ELECTRO-CARDIOGRAPHS
Control Board

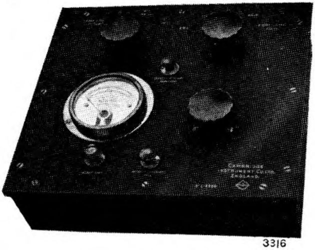


Fig. 15.
13 × 12 × 5 inches.

WHEN taking electro-cardiograms, electrical connections to the patient are made through the extremities of the limbs. Connections made through the two upper limbs give a different aspect of the heart's movements from that given from the two lower limbs, and in practice it has been found that the most complete information is obtained from a series of three electro-cardiograms taken with the following connections :—The right arm and left arm, the right arm and left leg, and the left arm and left leg (termed leads I, II and III respectively). The three limbs are connected to the Control Board shown in Fig. 15, upon which is mounted a switch enabling any one of the leads I, II and III to be readily connected in circuit with the galvanometer.

The Control Board also provides a means of compensating for the " skin current " due to a potential difference caused by the glandular activities of the skin. In addition, the sensitivity of the galvanometer can be standardised, the body resistance of the patient measured and the resistance of the galvanometer determined. All the contacts are enclosed, and the various switches readily operated.

Further particulars are given in List No. 180.

ELECTRO-CARDIOGRAPHS

Electrodes

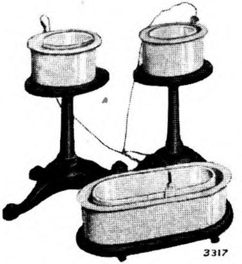


Fig. 16.

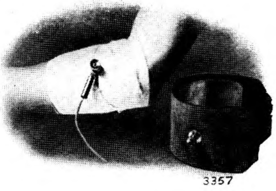


Fig. 17.

THE apparatus is connected to the limbs of the patient by means of non-polarisable Electrodes. The immersion Electrodes illustrated in Fig. 16 are particularly suitable for hospital work, and are recommended for use wherever practicable. Each consists of an inner porous vessel, which is filled with a warm 20 per cent. salt solution, and an outer stoneware vessel filled with a half-saturated zinc sulphate solution and containing an electrode of zinc. It is usually advisable to have a quantity of cotton wool in the inner porous vessel which is thoroughly saturated with the tepid saline solution. The wool breaks up any movement of the liquid, and also helps to steady the patient's hand or foot. Suitable insulated iron stands are supplied.

Alternatively, for bedside or other work where the use of immersion Electrodes is not practicable, the non-immersion Electrode illustrated in Fig. 17 can be supplied. This Electrode, devised by Dr. A. E. Cohn, of the Rockefeller Institute, consists of a flexible zinc plate with a rubber covering and fitted with a connecting terminal. The inner surface of the metal sheet is dampened with a 50 per cent. saline solution and the Electrode firmly bound to the limb of the patient (see Fig. 17).

Further particulars are given in List No. **180.**

ELECTRO-CARDIOGRAPHS
Outfit with Pointolite Lamp

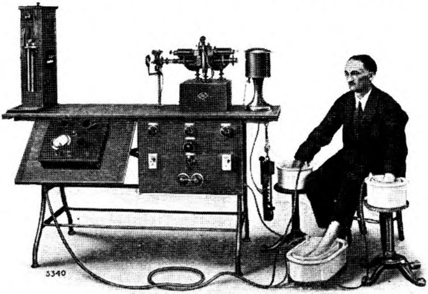


Fig. 18.
65 × 30 × 62 inches.

A COMPLETE Electro-Cardiograph Outfit for use where a suitable D.C. supply (110 or 220 volts) is available, is illustrated in Fig. 18. It comprises an Einthoven string galvanometer with single fibre case, a Pointolite lamp and focussing lenses, plate camera, time marker, and immersion type electrodes. Alternatively, Cohn electrodes, as illustrated in Fig. 17, may be employed. If there is no suitable direct current supply, the Pointolite lamp is replaced by a 50 candle-power half-watt lamp, as illustrated in Fig. 20, and the Outfit run from a 12-volt battery. The complete Outfit, with the exception of the electrodes, is mounted on a table which also carries the control board and the necessary switches. This tables simplifies the setting up of an outfit, by defining the relative positions of the parts. The amount of wiring is reduced to a minimum, the only external connection required being a wall plug and socket for connecting the flexible cable provided to the D.C. supply. The plate camera consists of a light-tight box with a horizontal slit, in front of which is mounted a cylindrical lens; past this lens travels a photographic plate. Fitted in front of the lens is a shutter enabling any one-third, two-thirds, or the whole of the plate to be exposed at one time. The speed of the plate movement is accurately controlled, and

ELECTRO-CARDIOGRAPHS
Typical Record

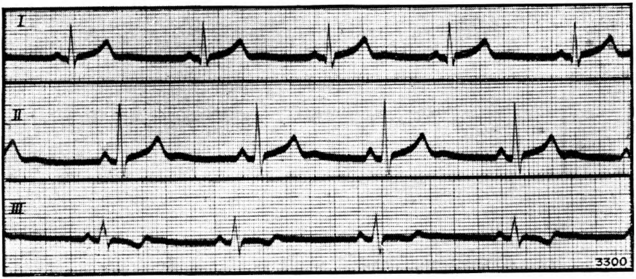


Fig.19

can be varied from zero to 500 millimetres per second. If it is desired to take continuous records of longer duration than is possible with the plate camera, the paper camera described on page 24 can be added to the Outfit. The time-marking mechanism comprises a rotary time marker as described on page 9, controlled by a vibrating bar having a periodicity of 50 per second. This bar, which will be seen suspended from the table beneath the Pointolite lamp in Fig. 18, is electrically maintained in vibration by means of a small electro-magnet. The electrical energy required to operate the Outfit is from 40 to 80 watts according to the voltage.

A typical electro-cardiogram is reproduced (approximately half full-size) in Fig. 19. It shows a series of three records (Leads I, II and III) of a normal heart. The vertical lines on the record are obtained with the rotary time marker, the space between two adjacent lines representing a time interval of 0·04 second. Every fifth line (representing 0·2 second) is broader than the others, thus facilitating interpretation. The horizontal lines are formed on the record in the manner described on page 25, the space between two adjacent lines corresponding to a potential difference of 0·1 millivolt. In the record shown, the speed of the plate was about 315 millimetres per second.

Further particulars are given in List No. 180.

ELECTRO-CARDIOGRAPHS
Outfit with Half-Watt Lamp

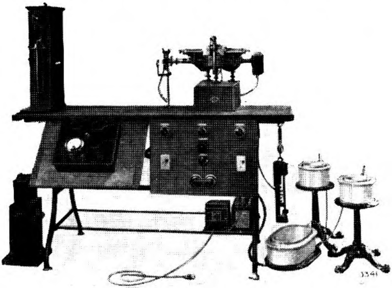


Fig. 20.
65 × 30 × 62 inches.

WHEN a suitable direct current supply (110 or 220 volts) is not available, the Pointolite lamp shown in Fig. 18 is replaced by a 50 candle-power half-watt lamp, as illustrated in Fig. 20, and the Outfit is run from a 12-volt battery. The electrodes may be either of the immersion type, as illustrated, or of the Cohn type shown in Fig. 17. When an electro-cardiograph is required for use in a research laboratory or in a hospital, it is often desirable to include a paper camera in the outfit, in addition to the standard plate camera. In Fig. 20 a plate camera is shown in position while a paper camera is standing on the floor. Either camera can be quickly placed in position. The paper camera enables a record to be obtained of longer duration than is possible with the plate camera, and will be found particularly serviceable for experimental work. A continuous record (say, three metres long), may be obtained on a roll of bromide paper, six cm. wide, which is made to travel past a cylindrical lens mounted in front of a slit in a light-tight box. The camera is provided with a shutter, which carries a scale for calibrating purposes. The paper is contained in two removable light-tight boxes, one containing the unexposed paper, and the other the exposed portion. The opening through which the paper enters the latter box can be

ELECTRO-CARDIOGRAPHS
Typical Record

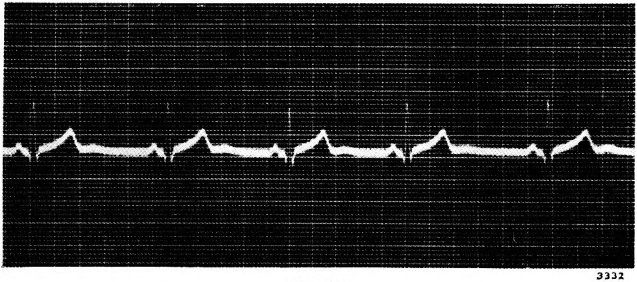


Fig. 21.

closed by a sliding shutter which severs the exposed length from the roll. On the camera base is mounted an electric motor which drives the paper through speed-reducing gear. The speed of the paper is varied by means of cone pulleys or by varying the speed of the motor; the average speeds are approximately 20 to 60 mm. per second. A suitable rectifier, which enables the 12-volt battery to be recharged on an A.C. supply, can be added to the Outfit. The rectifier and battery are shown beneath the switchboard in Fig. 20.

A portion of a typical electro-cardiogram obtained with a paper camera is reproduced (approximately half full-size) in Fig. 21. It shows a record obtained from a normal heart (Lead No. 1). The horizontal lines on the record are formed by the shadows of equally-spaced lines engraved on the plane surface of the cylindrical lens in front of the camera shutter. Each division represents a difference in potential of 0·1 millivolt. The vertical lines are formed by the time marker; each division represents 0·04 second, while the broader lines mark intervals of 0·2 second. When phonocardiograms or pulse records are required in addition to electro-cardiograms, the accessory apparatus described on pages 26 or 28 is added to the electro-cardiograph outfit.

Further particulars are given in List No. 180.

HEART SOUNDS APPARATUS

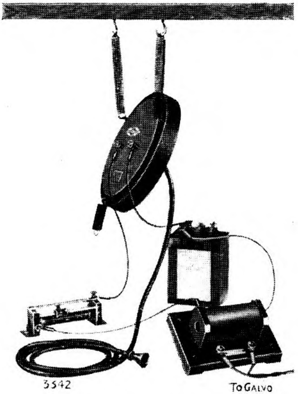


Fig. 22.

Microphone
10 × 10 × 3
inches.

THE apparatus illustrated in Fig. 22 is used in conjunction with a string galvanometer to produce records showing the relationship of heart sounds to the electro-cardiogram, thus providing an indication of the small intervals of time which may occur between the contraction of the various chambers and the sound produced. The duration of prolonged movements may be accurately measured. The apparatus consists of a sensitive microphone mounted in a heavy iron ring, which is suspended by means of springs. The microphone is connected by rubber tubing to a stethoscope. A transformer, a rheostat and a 4-volt accumulator complete the outfit. When in use, the microphone is connected to the primary winding of the transformer, with the rheostat and the accumulator in series. The secondary winding of the transformer is connected direct to the galvanometer. Sound waves impinging on the diaphragm of the microphone cause the latter to vary in resistance by an amount corresponding to the volume of the sound. This rapid variation in resistance, the frequency of which is governed by the tone of the murmur, produces corresponding variations in the current in the primary circuit

HEART SOUNDS APPARATUS

Typical Record

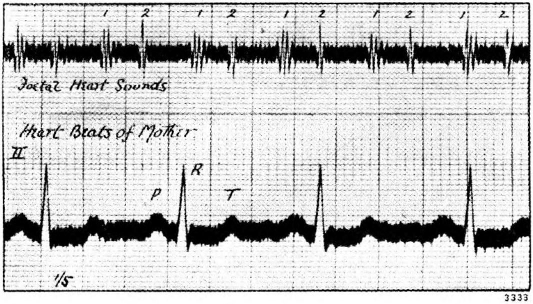


Fig. 23.

of the transformer, thus inducing simultaneous currents of higher potential in the secondary circuit. These currents in the secondary circuit cause corresponding movements of the galvanometer fibre, which can be recorded in the same manner and with the same apparatus as is employed for obtaining electro-cardiograms (see page 19). When it is desired to obtain an electro-cardiogram and a phono-cardiogram simultaneously, the apparatus shown in Fig. 22 is added to the electro-cardiograph outfit (see pages 22 to 25). The Einthoven galvanometer is then fitted with a double fibre case and a double prism attachment, by means of which the shadows of the two fibres are brought sufficiently close together to fall on the same photographic plate or paper. A typical record is reproduced (approximately half full-size) in Fig. 23. The lower curve is an electro-cardiogram of the pregnant mother, while the upper curve is a phono-cardiogram showing the foetal heart sounds. If it is desired to take phono-cardiograms only, the Einthoven string galvanometer can be replaced by the simple form of string galvanometer illustrated in Fig. 24.

Further particulars are given in List No. 180.

HOT WIRE SPHYGMOGRAPH

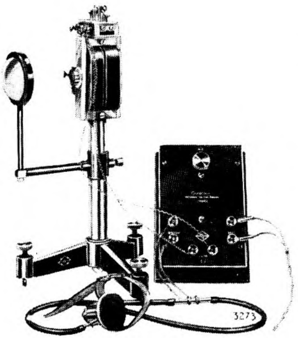


Fig. 24.
Bridge Box 8 × 5 × 3 inches.
Galvanometer 8 × 8 × 16 inches.

THE outfit illustrated in Fig. 24 has been suggested by Professor A. V. Hill (see *Proc. Physiol. Soc.*, Oct., 1920, *p.* lii.) for recording volume and pressure changes in the human arterial and venous system. It is of value for investigating the velocity of the pulse wave, and thus determining the elasticity of the arterial walls (see *Heart*, **1923**, x. (iii.), **233**). The apparatus is useful for teaching work, as wave forms of large amplitude may readily be obtained. A cup receiver of the type used in the polygraph (page 16) is connected by flexible tubing to a small copper spiral enclosed in an ivory tube mounted between two metal flanges. These flanges are electrically connected to a bridge box so arranged that the spiral forms one arm of a Wheatstone bridge, the out-of-balance in which is indicated on a small string galvanometer of the Einthoven type.

A 4-volt battery is connected across the bridge, thus heating the spiral ; the consequent alteration in its electrical resistance is balanced by means of a rheostat. The receiving cup is placed over the patient's artery or vein, the small pulsations in which cause fluctuations in the internal capacity of the cup, which in turn cause a current of air to flow backwards and forwards in the tube, thus periodically cooling the hot spiral and lowering its electrical resistance. The consequent movements of the galvanometer fibre may be recorded by means of a camera in the way described on page 19. By using two Sphygmographs, the receiving cups of which are placed on a single artery at two points some distance apart, an accurate determination of the length of time taken for the pulse wave to pass along this length of artery may be obtained. Owing to the small dimensions (10 μ) of the wire forming the hot spiral,

HOT WIRE SPHYGMOGRAPH

Typical Record

Fig. 25.

the lag in the heating and cooling is not sufficient to affect the curve to any appreciable extent. The natural frequency of the small string galvanometer is approximately 500 at the working sensitivity.

It is sometimes desirable to obtain an electro-cardiogram simultaneously with a pulse record. The small string galvanometer, to which the Sphygmograph is connected, is then used in conjunction with an electro-cardiograph outfit, the eyepiece of the Einthoven galvanometer being removed, as its function is effectively served by the lens which is fitted to the small galvanometer. The objective of the larger instrument forms a magnified image of the string in the plane of the two strings of the smaller instrument. Images of these two strings and the image of the string of the larger galvanometer are formed simultaneously in the camera by the lens of the smaller instrument, all three images being in focus together and having different magnifications. A typical record obtained in this manner is reproduced (approximately half full-size) in Fig. 25. It shows the normal electro-cardiogram together with curves taken from the radial pulse and jugular vein respectively.

Further particulars will be given on request.

PHOTOGRAPHIC OPHTHALMOSCOPE

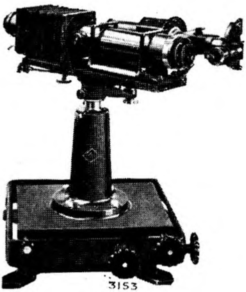


Fig. 26.
22 × 16 × 21 inches.

THE Ophthalmoscope shown in Fig. 26 is similar to that designed by the late Prof. Wertheim Salomonson (see *Proc. Kon. Akad. van Wetenschappen te Amsterdam*, xx., No. 2, 326, and *Trans. Opt. Soc.*, 1920-21, xxii., 53). It enables a large proportion of the total fundus to be viewed and photographed at one setting, both the optic disc and the macula lutea being shown on one plate (see Fig. 27). The photographs obtained are capable of considerable enlargement. The Ophthalmoscope consists of two optical systems, one for illuminating and the other for viewing and photographing the fundus. The source of light is a small carbon arc lamp (4-5 ampere). The illuminating beam passes through a condenser, which forms an image of the arc in the plane of an instantaneous shutter of modified design ; the beam is then reflected at right angles through a prism, is rapidly converged through an aplanatic aspherical lens, and finally reflected from a small front surface mirror into the eye. The illuminated fundus is viewed and photographed through a separate optical system comprising an aplanatic-aspherical lens, a collector field lens, and a photographic lens, which can be adjusted to obtain images covering larger or smaller portions of the fundus. All secondary reflections from the ophthalmoscope lens and the cornea are practically eliminated. For viewing the image, an eyepiece is inserted at the rear of the camera. This eyepiece can be quickly and easily replaced by a ground glass focussing screen, or by a photographic plate. The instantaneous shutter in the illuminating beam is so designed that when the eye is being examined, and its image focussed, the intensity of the beam is reduced so that the patient experiences no discomfort. When the shutter is released to

PHOTOGRAPHIC OPHTHALMOSCOPE

Typical Record

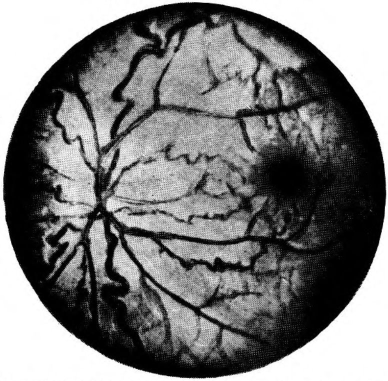
Fig. 27.

take a photograph, the eye is momentarily exposed to the full beam of light for a period which may be varied from 0·05 to 0·2 second. An exposure of 0·1 second (or slightly less) is generally sufficient. A standard clip for astigmatic or other corrective lenses is fitted in front of the ophthalmoscope lens. The apparatus is mounted upon a short pedestal, relative to which slow rotational and vertical adjustments can be made, while the pedestal is further provided with slow motion adjustments in two directions at right angles to each other. These four adjustments facilitate setting the apparatus into close proximity to the patient's eye. A novel device enables the apparatus to be turned over through an angle of 180° without removing it from the pedestal, thus facilitating the photographing of the retina of either left or right eye. A chin-rest and head-steady ensure stability on the part of the patient. Fig. 27 is a full-size reproduction of a photograph obtained with the instrument, showing the normal fundus oculi.

Further particulars are given in List No. 185.

PHOTOGRAPHIC OPHTHALMOSCOPE
Typical Record

Fig. 28.

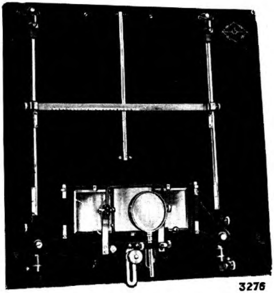


ON looking through the dilated pupil of a normal eye with the Ophthalmoscope, an orange-red surface is seen, upon which can be distinguished the optic nerve, blood vessels and macula region. The papilla, or entrance of the optic nerve, is seen as a pale yellow-red disc or plaque surrounded by a narrow white ring (the scleral ring) and framed by an irregular darkly pigmented edge. The central artery and vein of the retina divide upon the surface of the disc into upper and lower branches, which again divide into temporal and nasal branches ; smaller branches are given off which do not anastomose. The macula lutea, which is the most sensitive part of the fundus, is a uniform pink in colour, with the fovea centralis flashing brightly from its centre. It is surrounded by a bright halo which marks out the macula region. The photographic records are exceptionally distinct and clearly defined. In Fig. 27, which is a record of the normal fundus oculi, the optic disc is shown on the left (nasal side), and the macula lutea on the right (temporal side). Fig. 28 is a view of the fundus oculi showing arterio-sclerosis of the retinal vessels. The blood vessels are thick and tortuous, showing a decided white streak in the centre.

Further particulars are given in List No. 185.

RECORD MEASURING MACHINE

Fig. 29.



24 × 24 × 7 inches.

THE instrument illustrated in Fig. 29, the design of which is primarily due to Capt. B. H. Elliott, R.A., facilitates the analysis of photographic records such as those obtained with the electro-cardiograph. The apparatus dispenses with actual measurements and slide-rule calculations, does not entail marking of the records, and is direct-reading, no microscope or vernier scales being employed. It can be applied to records on photographic plates, films, or paper, or to pen-recorded charts. In effect, the instrument collates the movement over the record of a fine line on a glass cursor with that of a scale past a reading line, the movement of the scale being, say, ten to fifty times that of the cursor line. The ratio is instantly adjustable so that the full length of the scale, which is divided into 100 equal parts, can be arranged to fit exactly between any two points on the record, no matter what the distance between these points may be. Measurements can be obtained easily and quickly to within 0·1 millimetre. When measuring a record including time-marked datum lines, such as is reproduced in Fig. 19, the instrument can be adjusted so that the 100 scale divisions represent the distance between two time markings; the time interval between any two peaks on the record can then be measured directly in units of time by setting the cursor first to one peak and then to the other. A lens or eyepiece facilitates the viewing of the records.

Further particulars will be given on request.

HYDROGEN-ION APPARATUS
Complete Outfit

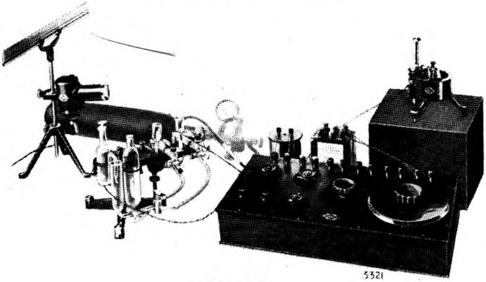


Fig. 30.
36 × 18 × 18 inches.

THE usefulness of electrometric methods in analytical operations has become increasingly recognised within recent years. The Hydrogen-Ion Apparatus illustrated in Fig. 30 has many practical applications in bacteriological, biochemical, and physiological research work, where measurements of high precision are required. It can be used, for example, to determine the pH value, or hydrogen-ion concentration, in blood and in bacteriological media and sera. With the apparatus illustrated, readings can be obtained directly to 0·2 millivolt and, by estimation, to within 0·02 millivolt. The principle upon which the apparatus is designed depends upon the fact that if a hydrogen electrode be immersed in a solution, the potential difference between electrode and solution is a measure of the hydrogen-ion concentration. In order to facilitate the measurement of this potential difference, it is customary in practice to employ a standard half-cell, usually a calomel electrode, and to complete the cell by a solution of potassium chloride having a definite concentration. The hydrogen-ion concentration in the solution under test is then readily deduced by subtracting the constant electromotive force due to the calomel electrode from the electromotive force of the complete cell. The outfit consists of a potentiometer,

HYDROGEN-ION APPARATUS

Blood Electrodes

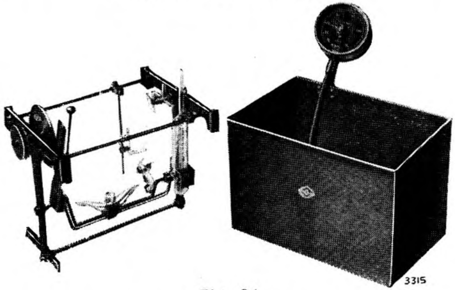


Fig. 31.

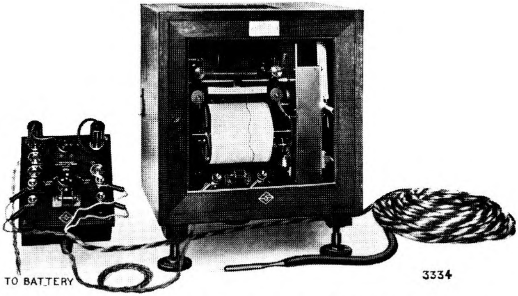
12 × 12 × 14 inches.

D'Arsonval galvanometer, Weston normal cell (for standardising the potentiometer), lamp and scale outfit, and two-volt accumulator, together with suitable electrodes. The potentiometer is of the slide-wire type, having all the moving parts inside the case, thus eliminating corrosion and other deteriorating effects. To minimise thermo-electric errors, the resistances are made of manganin, hard soldered to copper. For some biochemical studies, for example, when dealing with actively fermenting culture, it is sometimes essential that equilibrium be rapidly attained. Hasselbalch found (1911) that a constant potential can be quickly reached by shaking the hydrogen electrode vessel, and also that by periodically immersing and exposing the platinum electrode, only a thin film of liquid has to be penetrated by the hydrogen before absorption by the platinum black. These principles have been adopted in the Clark system of electrodes supplied with the standard outfit.

The Electrodes illustrated in Fig. **31** have been designed for blood work. The complete system of Electrodes is carried on a frame which is given a rocking motion by a pulley-driven crank pin working in a vertical slot. The frame and the Electrodes are completely immersed in a thermostatically-controlled water bath.

Further particulars are given in List No. 908.

RECORDING CLINICAL THERMOMETERS



Control Board, 8 × 6 × 5 inches. · Recorder, 14 × 12 × 15 inches.
Fig. 32.

IT is sometimes important, not only to take the temperature of a patient at certain periods of the day, but to obtain full knowledge of the diurnal variations in the body temperature. The apparatus illustrated in Fig. 32 has been developed as a result of the investigations of the late Sir G. Sims Woodhead and Dr. P. C. Varrier-Jones (see *Lancet,* 1916, Jan. 22 to March 4), and enables a continuous and automatic record extending over a considerable period to be obtained. It is reliable and easy to manipulate, and is of ample sensitivity for the requirements of ordinary medical practice. The recording apparatus may be erected at some distance from the patient. The Outfit comprises an electrical resistance thermometer connected by a length of leads to a thread recorder through a form of control board. The standard thermometer consists of a coil of fine platinum wire enclosed in a silver tube, which is inserted in the rectum of the patient, and is constricted at a point above the termination of the coil, so that it may not irritate and thus stimulate the contraction of the sphincter muscle. The thermometer coil forms one arm of a Wheatstone bridge, the opposite arm of which is made equal in resistance to that of the thermometer at the minimum temperature which it is

RECORDING CLINICAL THERMOMETERS

Typical Record

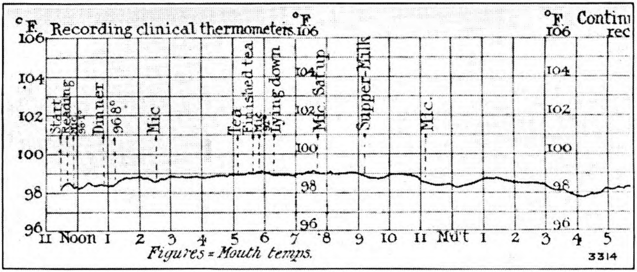


Fig. 33.

designed to measure. Compensating leads are also connected in this arm to balance the resistance of the connecting leads and to eliminate the effect of variation in the temperature of these leads. The galvanometer of the thread recorder, which is of the suspended moving coil type, is connected across the arms of the bridge. Variations in the temperature of the thermometer coil cause changes in its resistance, and the galvanometer pointer is correspondingly deflected. The recorder is calibrated to give readings directly in degrees of temperature, the standard chart being 95 mm. wide, with a range of 96°F. to 106°F., or an equivalent Centigrade range. Current is obtained from a 4-volt accumulator, a rheostat being provided, so that variations in the electromotive force of the battery can be compensated. A portion of a typical record is illustrated in Fig. 33.

A skin thermometer has been designed for use instead of the rectum thermometer. It comprises a non-inductive spiral coil of platinum attached to the surface of a small, flat, glass vacuum bulb mounted in an ebonite holder. The construction practically eliminates errors due to conductance and moisture. An outfit is also made by us for indicating the difference in the skin temperature at two adjacent parts of the body, by means of thermo-couples.

Further particulars are given in List No. **183.**

NEEDLE THERMO-COUPLE OUTFIT

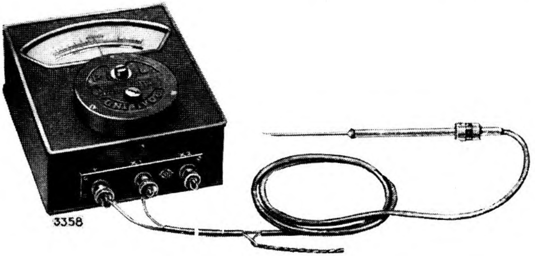


Fig. 34.
Galvanometer 6 × 4 × 3 inches.

THE Outfit illustrated in Fig. 34 has been suggested by Drs. E. D. Adrian and C. F. Watts (*Proc. Physiol. Soc.*, Dec., **1923**, *p*.xi.), for determining intra-venous temperatures or the temperature within the substance of a muscle or a gland. It comprises a thermo-couple made in the form of a hypodermic needle, and a Unipivot galvanometer. The thermo-couple can be introduced without undue discomfort into any part of the body which can be reached by an exploring needle. The needle (Parke Davies, No. 24) has a thin insulated constantan wire passed down its centre ; the end of the wire is soldered to the tip of the needle. Steel and constantan wires are taken from the needle to a second thermo-junction immersed in a thermos flask (not shown in Fig. 34), which is fitted with a mercury thermometer, and is filled with warm water at approximately the temperature it is desired to measure. The circuit through the galvanometer is completed by suitable leads. The galvanometer is a pattern I Unipivot (see Booklet No. III.), calibrated for two ranges, 1·2 – 0 – 1·2 millivolts for accurate work, and 2·4 – 0 – 2·4 millivolts for approximate observations ; a calibration table giving the equivalent temperature readings is provided. When the 2·4 – 0 – 2·4 range is used, the water in the thermos flask may be approximately at air temperature.

Further particulars will be given on request.

BEMROSE. 10,000/10/25.