Conclusion.

Since no fixed boundary line can be determined between normal and abnormal size of the red blood corpuscles for any given individual, I think that the regular comparison of blood films in suspicious cases of pernicious anaemia is of much greater value than attempting to fix a definite point judged by any scale on any instrument. Therefore I submit as worthy of consideration the value of the

"direct comparative diffraction" method of observing the onset and progress of any increase in the size of the red blood corpuscles, which has been shown to be diagnostic of pernicious anaemia and the blood changes of subacute combined degeneration of the spinal cord.

REFERENCES.

¹ *British Medical Journal*, April 6th, 1929, p. 635. ² *Ibid.*, July 13th, 1929, p. 48. ³ *Ibid.*, October 26th, 1929, p. 785. ⁴ *Price's Textbook of the Practice of Medicine*.

MEASUREMENT OF THE DISTRIBUTION OF GAMMA RAYS AROUND A FOUR-GRAM MASS OF RADIIUM.

REPORT FROM THE PHYSICS DEPARTMENT, WESTMINSTER HOSPITAL,

BY

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This paper describes an attempt to measure accurately the gamma radiation field, in air, of the radium "bomb" in use at Westminster Hospital Annexe. The bomb is shown, in section only, in Fig. 3; four separate grams of

connected by a long wire to a distant electroscope—led us to believe that many difficulties would be avoided at the outset by combining ionization chamber and electroscope into one small instrument, thereby dispensing with connecting leads altogether. It is, for example, impracticable to use lead screening to prevent ionization losses from the connecting wire on account of the thickness required; the alternative plan of embedding the wire in paraffin wax gives trouble from the static charging-up of the insulation immediately round the wire when exposed to the radiations. The capacity of such a connexion also becomes undesirably large compared with that of the ionization chamber.

Accordingly, a tiny gold leaf electroscope was made up as shown in Fig. 1 (a). The leaf was attached to a brass plate 15 by 6 mm., which was mounted on a sulphur plug, and encased by a thin brass cylinder of radius 10 mm. and length 20 mm., furnished with a transparent circular window back and front. To slow down the movements of the gold leaf to a measurable rate in the intense fields which were being dealt with it was found necessary to add in parallel with the electroscope a small condenser consisting of two co-axial brass cylinders separated by a thin film of sealing-wax (Fig. 1 (b)), whose electrostatic capacity was of the same order as that of the electroscope itself.

To ward off stray beta rays the electroscope and con-

FIG. 1.

radium were placed one at each corner of a 4 inch horizontal square, and so disposed in a lead container* that the issuing radiation was confined to two fairly narrow beams, one above and the other below the container.

An ionization method was chosen for investigating the field. A few preliminary trials with the usual type of apparatus—namely, a small exploring ionization chamber

* For a complete account of the bomb see an article on "Radium Teletherapy" by Francis Rock Carling, in the *British Medical Journal* of February 8th, 1930 (p. 232).

FIG. 2.

denser were assembled one above the other in a cylindrical lead sheath 3 mm. thick (Fig. 1 (c)), which was closed by a circular disc of lead 3 mm. thick; this was located in position by the spike B fixed to the top of the electroscope; the spike also served to indicate the middle of the instrument. The only beta rays which could enter the ionization chamber directly were those which passed in through the narrow diagonal viewing slots S.

In order that scattered radiation from the electroscope supports might be reduced to a minimum, the lead sheath

and contents were slung on thin steel wires at the centre of an opening 1 metre square, in a light wooden framework, braced with steel wires, which carried at one end a lamp for illuminating the leaf and at the other a telescope for viewing the leaf at a safe distance of 2 metres.

The radium container was too heavy to move about

Fig. 3.

with ease, therefore wheels were fitted to the framework so that it would run on a horizontal rail at each end, each rail being adjustable for height. The electroscope could thus be placed in any desired part of the field and its position recorded by means of horizontal and vertical scales attached to the framework.

The gold leaf system could be connected to a battery of 230 volts by lifting the metal plunger P into contact with the condenser by pulling on a string Q at the operator's end. The plunger was earthed to the electroscope case during measurements.

The relative gamma-ray intensities at various points were determined by timing the fall of the gold leaf over a fixed interval in the eye-piece scale, which corresponded to a potential change in leaf and condenser of from 228 to 142 volts. The accompanying table gives a typical set of readings taken along a horizontal line 4 cm. below the bomb, and intersecting its vertical axis. Fig. 2 shows the same data in graphic form.

Distance (in cm.) to left of centre	9	8	7	6	5	4	3	1	0
Time of leak (seconds)	55.5	35.5	23.0	16.3	9.2	6.2	5.4	4.9	4.8
Distance (in cm.) to right of centre	1	2	3	4	5	6	7	8	9
Time of leak (seconds)	5.0	5.0	5.8	6.4	8.5	15.3	25.6	38.7	56.5

Further series of measurements were taken at different levels, in all about 500 readings, covering a vertical area 25 by 20 cm., each series giving a curve of the same general character as that of Fig. 2.

The strongest field observed, corresponding to a time

of leak of 5 seconds, was taken as 100 in arbitrary units of intensity. The isometric lines (curves of equal times of leak, "isodoses") for 100, 95, 90, etc., arbitrary units were drawn by linking up the points on the various levels for which the times of leak were 5 sec., 5.26 sec., 5.55 sec., etc., these numbers being inversely proportional to 100, 95, 90, etc. Fig. 3 shows, on a reduced scale,

the gamma-ray isometrics taken in a vertical diametral plane parallel to the bomb supports; it is accurate on the whole to within 5 per cent. The chart enables skin doses to be read off in arbitrary units.

At the present time there is no general agreement as to the best absolute unit to be used in connexion with the measurement of dosage in gamma-ray therapy. Various units have been employed in radiation therapy, and two of these which could be applied to this work are the international R unit and the absorption unit (energy absorbed per cubic centimetre per milligram hour). The calculation of the dose in terms of these units is not without difficulty, especially in the case of the R unit. The electrostatic capacity of our measuring instrument has been determined by direct substitution in an oscillating circuit, which completes the data required for computing the total charge set free per second in the ionization chamber, but in order to separate the wall effect from the true gas ionization effect by means of which the R unit is defined much further research is necessary.

The arbitrary units adopted here form the basis of an accurate measurement of the dose given in any case, and it will be possible to convert them to whatever scientific unit is ultimately adopted in work of this kind. The depth dose in the tissue may be expected to differ somewhat from that indicated on the chart by reason of scattering and absorption.

It is interesting to note in passing how clearly the lateral bulges of the isometrics mark the boundary of the geometrical shadow cast by the lead tunnels which confine the radium. Evidently the spreading of the field may be controlled by altering the depth of the lead channel.

LATEST MODIFICATION OF WESTMINSTER TELETHERAPY APPARATUS.

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The apparatus to be described was designed to enable those engaged in the treatment of patients to perform their work more safely and easily.

Two patients can be treated simultaneously, one above the radium, the other beneath it. The bomb itself is designed to tilt only about one axis, so placed that the direct radiation cannot enter the main building, the directions being either towards the sky and ground, or the garden and the road, which are safe by reason of distance. Thus the necessity for protecting the main building is largely removed. In order, however, to err on the side of over-precaution, barium plaster was added to a 24-inch wall. Each stretcher can be so approached to the bomb that the axis of tilt of the latter is either parallel to the stretcher or at right angles to it. Each stretcher can also be raised or lowered, tilted about its long axis, and traversed longitudinally or laterally. Thus the radiation from the bomb can be brought to any position on a patient with the minimum of inconvenience. All the movements