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Edited by P.M. Hickey, M.D.
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THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor, P. M. Hickey, M. D., Detroit

Associate Editor, F. C. Zapffe, M. D., Chicago

VOL. I

NEW SERIES, JANUARY, 1914

No. 3

A POWERFUL ROENTGEN RAY TUBE WITH A PURE ELECTRON DISCHARGE*

By W. D. COOLIDGE

1. INTRODUCTION

A consideration of the limitations of a Röntgen tube of the ordinary type showed that they were for the most part incident to the use of gas and that they could therefore be made to disappear if a tube could be operated with a very much higher vacuum. In this case, of course, the electrons constituting the cathode ray stream would have to be supplied in some other way than by bombardment of the cathode by positive ions.

The work of Richardson and others on the emission of electrons from hot bodies suggested that the electrons might be produced by simply heating the cathode. But the values of the thermionic currents obtained by different observers had varied between wide limits, so much so as to suggest that a Röntgen tube based upon this principle might be as unstable in resistance as is the standard tube. Moreover, the fact that the substances usually worked with, platinum and carbon, are so difficult to completely free from gas, suggested strongly that with the cleaner conditions (greater freedom from gas) that could be realized by the use of tungsten, the thermionic currents might cease altogether. Some experiments of Dr. Irving Langmuir, however, on the thermionic currents between two tungsten filaments in a highly evacuated space,

were very reassuring. According to his observations, after a certain high degree of exhaustion had been reached, the thermionic currents increased, up to a certain limiting value, as the tube became freer and freer from gas.

The idea of using a hot cathode in a Röntgen tube was not new, but, so far as the writer could learn, the principle had never been successfully applied in a vacuum good enough so that positive ions did not play an essential role.

Wehnelt and Trenkle had used a hot lime cathode for the production of very soft Röntgen rays, working with voltages from 400 to 1000. Wehnelt, in another article, describes the use of his lime cathode in a Braun tube, and here he says that it is not advisable to employ more than 1000 volts, as otherwise cathode rays come off from that part of the platinum which is bare, giving bad disintegration. As the platinum is heated only to dull redness, this obviously means that there is sufficient gas in the tube to furnish positive ions which bombard the platinum and so cause it to emit electrons. For it has been shown that platinum, unless heated almost to its melting point, will not

*An abstract of a paper published in the December number of the Physical Review.

yield an appreciable thermionic current.† Apart from this fact, of course, the Röntgen rays produced by voltages as low as 1000 are too "soft" for the ordinary applications.

Lilienfeld and Rosenthal had described a Röntgen tube whose penetrating power is, they say, independent of vacuum. Their main aluminum cathode and their platinum anticathode are shaped and located like the electrodes in the ordinary Röntgen tube. Besides these, they have an anode and an auxiliary hot cathode. Current from a low voltage source passes from the hot cathode to the anode, and this current furnishes the positive ions which, by their bombardment of the main cathode, liberate electrons from it. Their tube is dependent for its operation on the presence of positive ions, for without these there is no means provided for getting electrons out from the main, aluminum, cathode. Lilienfeld concludes from his extended experiments in tube exhaustion that the complete removal of all gas from tube and electrodes would not do away with positive ions. There would, according to this view, be no such thing as a pure electron discharge. Lilienfeld's work in exhausting the gas from the tube itself and from the glass, seems to have been excellent, but according to the experience of the writer, none of his electrodes were sufficiently freed from gas to justify the conclusions drawn. Working even with tungsten electrodes in a tube so designed that the electrodes could be heated in place to very high temperatures, the writer has had the positive ion effects persist for hours, disappearing completely, however, as the electrodes become sufficiently freed from gas.

The work of Dr. Langmuir had shown that a hot tungsten cathode in a very high vacuum could be made to continuously yield a supply of electrons at a rate determined by the temperature.

Further work showed that very high voltages, up to at least 100,000, in no wise

affect this rate of emission. For application to the fields of radiography and fluoroscopy, it was necessary to develop a satisfactory method of focusing. And, finally, the large amounts of energy transformed into heat in a Röntgen tube render imperative the use of a very heavy target, and this made it necessary to develop methods for sufficiently freeing from gas large masses of metal.

The result of efforts in this direction has been entirely successful, and tubes have been made, based upon this principle, which are free from most of the limitations of tubes of the ordinary type.

2. GENERAL DESCRIPTION

The structural features of the new tube which differ from those of a tube of the ordinary type are the following:

The pressure, instead of being, as in the ordinary tube, a few microns,† is as low as it has been possible to make it; that is, not more than a few hundredths of a micron.

The cathode consists of a body which can be electrically heated (such as a tungsten or tantalum filament) and, suitably located with reference to this portion, an electrically conducting ring or cylinder, consisting preferably of molybdenum or tungsten or other refractory metal. The ring or cylinder is connected either to the heated portion of the cathode, or to an external source of current by means of which its potential may be brought to any desired value with respect to the heated portion. The heated portion of the cathode serves as the source of electrons, while the ring or cylinder assists in so shaping the electrical field in the neighborhood of the cathode that the desired degree of focusing of the cathode-ray stream upon the target shall result.

The anticathode, or target, functions at the same time as anode.

The operation is satisfactory only when the vacuum is exceedingly high, so high that the ordinary tube would carry no current even on 100,000 volts.

†A micron is 0.001 mm.

†H. A. Wilson concluded a paper upon this subject, in 1903, with the following statement: "It is probable that a pure platinum wire heated in a perfect vacuum would not discharge any electricity at all, either positive or negative, to an extent appreciable on a galvanometer."

3. THEORY OF OPERATION

As will be seen from the characteristics of the tube, in §5, it gives no evidence of positive ions. This makes the theory of its operation exceedingly simple.

The discharge appears to be purely thermionic in character.

The rate of emission of electrons from the filament appears to be in accord with Richardson's Law, which says that the maximum thermionic current which can be drawn from a hot filament is

$$i = a\sqrt{T} e^{-\frac{b}{T}},$$

where T is the absolute temperature, e is the base of the natural system of logarithms, and a and b are constants.

In the particular tube described in detail in this paper, over the range of temperatures and voltages included in the curves shown in Figs. 1, 2 and 3, this simple law accounts perfectly for the conductivity of the tube.

4. DETAILED DESCRIPTION OF TUBE No. 147

This description relates to tube No. 147, which was used in getting the data for the following curves. Fig. 4 shows a complete assembly, while Fig. 5 shows an enlarged detail of the cathode and of the front end of the target.

THE CATHODE.

In the diagram, 25 is a tungsten filament in the shape of a flat, closely wound spiral. It consists of a wire 0.216 mm. in diameter

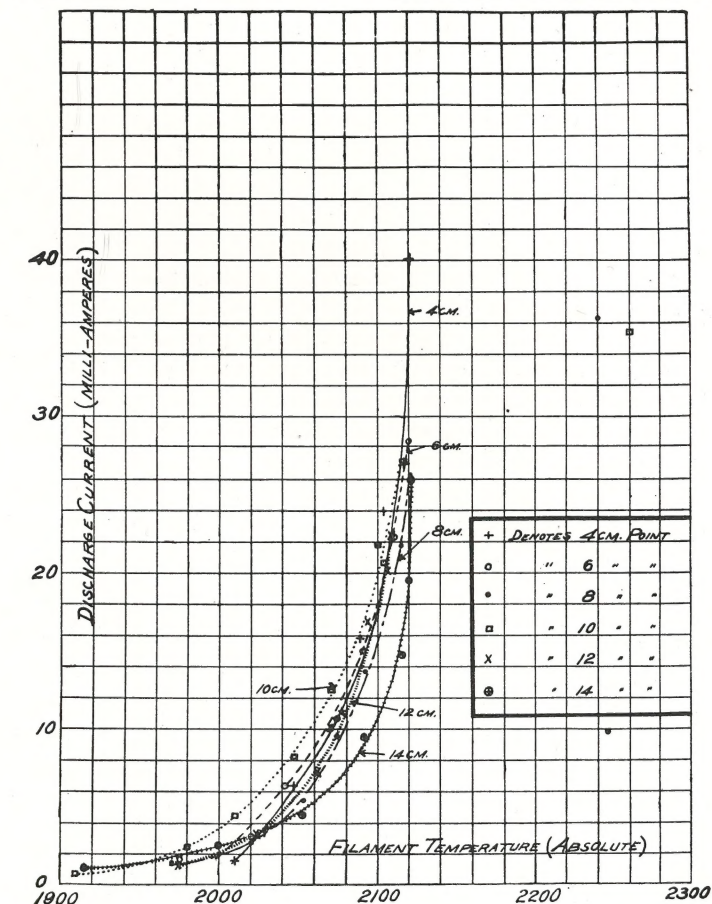


FIG. 1

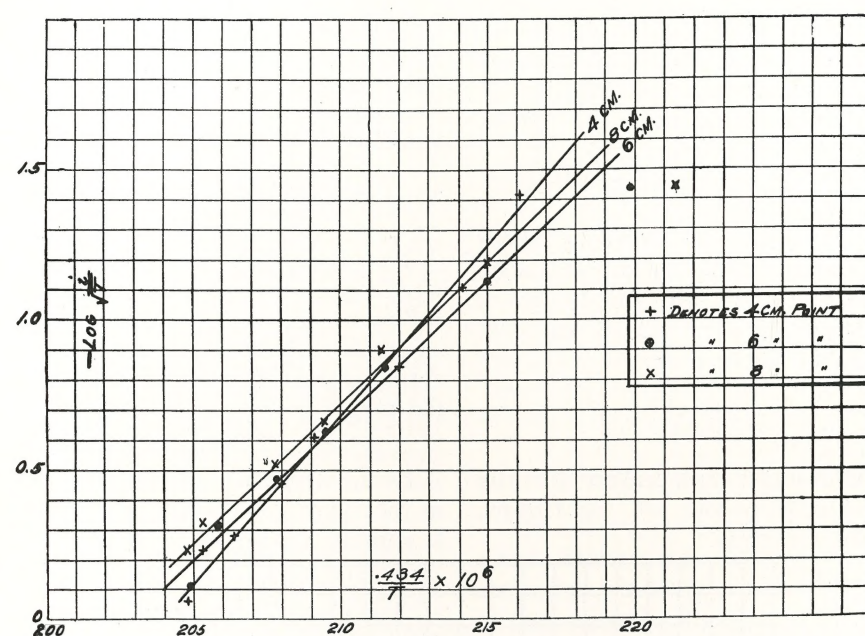


FIG. 2

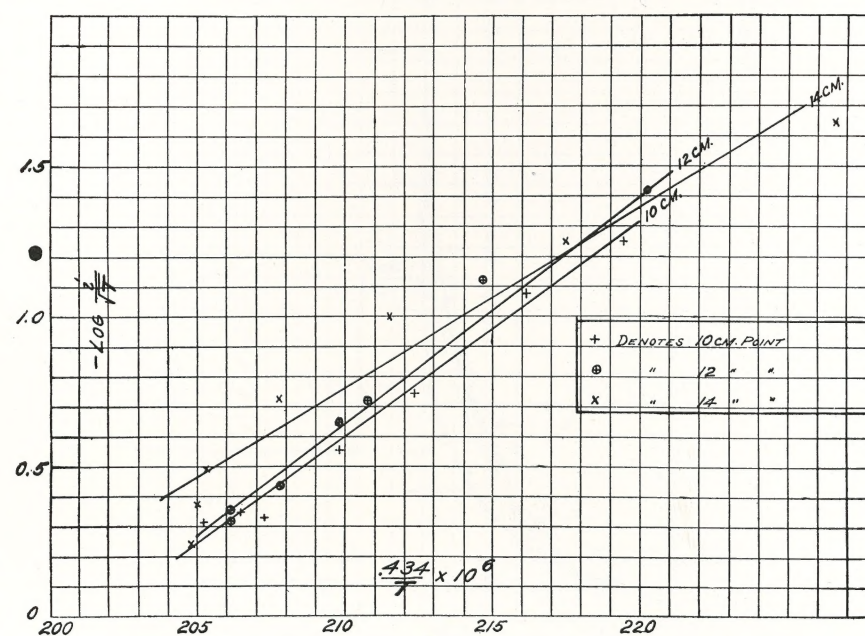


FIG. 3

and 33.4 mm. long, with $5\frac{1}{2}$ convolutions, the outermost of which has a diameter of 3.5 mm. It is electrically welded to the ends of two heavy molybdenum wires 14 and 15, to the other extremities of which are welded the two copper wires 16 and 17. These in turn are welded to the platinum wires 18 and 19. The molybdenum wires are sealed directly into a piece of special glass, 12, which has essentially the same temperature coefficient of expansion as molybdenum.

eter and is mounted so as to be concentric with the tungsten filament, and so that its inner end projects about 0.5 mm. beyond the plane of the latter. It is supported by the two stout molybdenum wires, 22 and 23, which are sealed into the end of the glass tube, 12. It is metallically connected to one of the filament leads, at 24.

Besides acting as a focusing device, it also prevents any discharge from the back of the heated portion of the cathode.

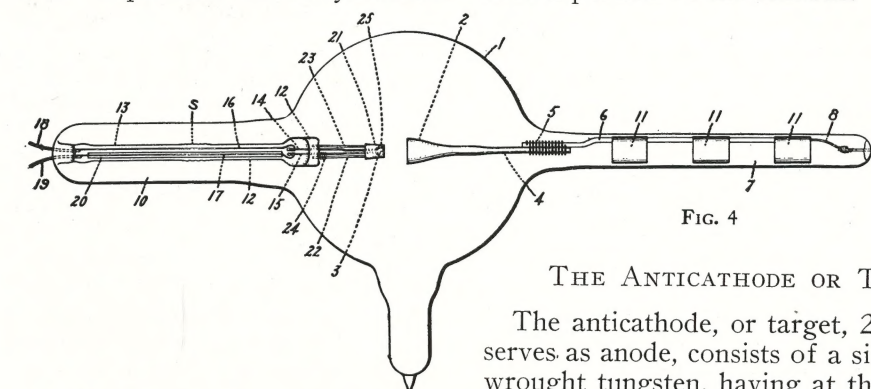


FIG. 4

THE ANTICATHODE OR TARGET.

This first seal is simply to insure a rigid support for the hot filament, the outer seal being the one relied upon for vacuum tightness. The outer end, 13, of the support tube, is of German glass, like the bulb itself, and it is therefore necessary to interpose at S a series of intermediate glasses to take care of the difference in expansion coefficients between 12 and 13. The small glass tube, 20, prevents short-circuiting of the copper wires, 16 and 17.

The filament is heated by current from a small storage battery which is, electrically, well insulated from the ground. In the circuit are placed an ammeter and an adjustable rheostat and, by means of the latter, the filament current can be regulated, by very fine steps, from 3 to 5 amperes. Over this current range, the potential drop thru the filament varies from 1.8 to 4.6 volts and the filament temperature from 1890 to 2540 degrees Absolute.

THE FOCUSING DEVICE.

This consists of a cylindrical tube of molybdenum, 21. It is 6.3 mm. inside diam-

The anticathode, or target, 2, which also serves as anode, consists of a single piece of wrought tungsten, having at the end facing the cathode a diameter of 1.9 cms. (Its weight is about 100 gms.) By means of a molybdenum wire, 5, it is firmly bound to the molybdenum support, 6. This support is made up of a rectangular strip, and, riveted to this, three split rings, 11, 11, 11, all of molybdenum. The split rings fit snugly in the glass anode arm, 7. They serve the double purpose of properly supporting the anode and of conducting heat away from the rectangular strip, and so preventing too much heat flow to the seal of the lead-in wire, 9.

THE BULB.

This is of German glass and is about 18 cm. in diameter.

THE EXHAUST.

This is as thorough as possible.

For the earlier tubes, mercury pumps were used, with a liquid-air trap between tube and pump to eliminate mercury vapor. The whole tube, while connected to the pump, was in an oven and was heated at intervals to 470°C. Between heating op-

erations, the tube was operated with as heavy discharge currents as the condition of its vacuum would permit. For hours the tube would show the characteristics of an ordinary Röntgen tube, and in many cases a several days' application of the above treatment was required to entirely eliminate these characteristics and to realize an essentially pure electron discharge.

The exhaust time has been greatly reduced in two ways. The massive tungsten anode is given a preliminary firing to a very high temperature in a tungsten-tube vacuum furnace¹. The molybdenum support is also fired, to a somewhat lower temperature, in the same manner. In the second place, a Gaede molecular pump has been substituted for the mercury pumps and, at the same time, a very large and short connection has been adopted between tube and pump.

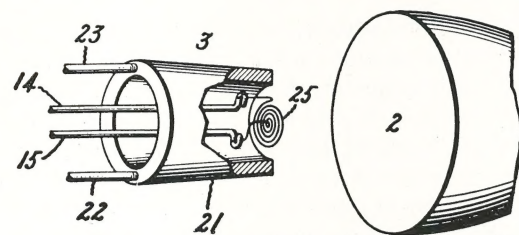


FIG 5

In the later stages of the exhaust, a very heavy discharge current is maintained continuously on the tube for perhaps an hour, the temperature of the bulb being kept from rising too high by the use of a fan.

The pressure in the finished tube is very low, certainly not more than a few hundredths of a micron and probably much less than this.

The tube was connected as shown in the diagram, Fig. 6, in which T is the tube; B is a small storage battery; A is an ammeter; R is an adjustable rheostat which can be controlled from behind the lead

¹A description of this furnace will be published in the near future. The heating element consists of a tungsten tube 2.5 cm. inside diameter and 30 cm. long. This is fastened in an upright position and, by means of suitable terminals, is connected to a 100 K. W. transformer. The heating element is placed in a water-cooled metal cylinder, and the space within connected to a pump which maintains, with the furnace at its highest temperature, a vacuum of a few microns.

screen which shields the operator from the Röntgen rays; S is an adjustable spark gap with pointed electrodes, which can also be operated from behind the lead screen; and M is a milliamperemeter which can be read from behind the screen.

CONNECTIONS AND METHOD OF OPERATING.

As the high potential is connected to the battery circuit, it is necessary that the latter shall be thoroughly insulated from the ground.

As a high potential source, a 10 K. W. Snook machine, made by the Röntgen Apparatus Co., was used. This consists of a rotary converter driven from the direct current end and delivering alternating current at 150 volts and 60 cycles per second to a closed magnetic circuit step-up transformer with oil insulation. From the secondary of this transformer the high voltage current is passed through a mechanical rectifying switch (which is direct connected to the shaft of the rotary) and the milli-ampere-meter, M, to the tube. The output of the transformer is controlled by a variable resistance in the primary circuit.

5. CHARACTERISTICS OF THE TUBE

A. NO DISCHARGE CURRENT UNLESS FILAMENT IS HEATED.

Unless the filament is heated, the tube shows no conductivity in either direction, even with voltages as high as 100,000.

B. TUBE ALLOWS CURRENT TO PASS IN ONLY ONE DIRECTION.

The tube suppresses any current in the direction which does not make the hot filament the cathode. It is therefore capable of rectifying its own current when supplied from an alternating source.

In the case of a focusing tube, however, the use of alternating current will very considerably lower the maximum allowable energy input. For as soon as the target becomes heated at the focal spot, to a temperature approximating that of the filament,

the tube will cease to completely rectify and, as the temperature of the focal spot rises, will allow more and more current to pass in the wrong direction. This, to be sure, will not cause either a harmful vacuum change or a metallic deposit on the bulb, as it would in the case of the ordinary tube, but it will give rise to needless heating of the bulb where it is bombarded by the cathode rays from the target, and to disturbing Röntgen rays emanating from the glass at this point. In the case of a tube which does not focus, but in which the cathode rays bombard the entire surface of the anode, the allowable energy input, which the tube will completely rectify, can be increased to any desired amount by simply increasing the surface of the anode.

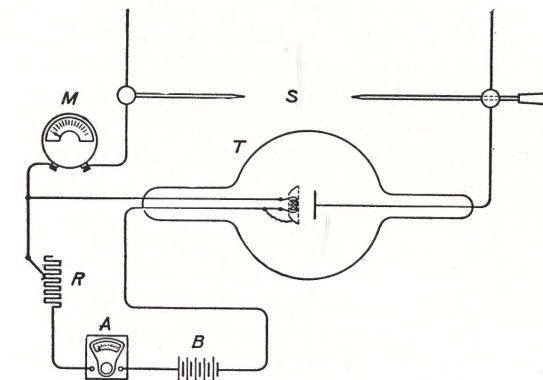


FIG. 6

C. DISCHARGE CURRENT DETERMINED PRIMARILY BY FILAMENT TEMPERATURE.

With a given design, the amount of discharge current which can be passed through the tube is determined primarily by the temperature of the filament, and responds instantly to changes in the same in either direction.

The effect of both temperature and voltage on the discharge current, in the case of the tube illustrated in Fig. 1, may be seen by referring to Fig. 4. The different curves obtained for different voltages, expressed in terms of the equivalent parallel spark gap,

are seen to lie very close together showing that over the range of voltages employed, the magnitude of the discharge current is practically independent of voltage. This shows that the current in these experiments was always the saturation value.

Richardson's Law, stated in §3, may also be written in the following form:

$$\log_{10} \frac{i}{T} = b \frac{.434}{T} - \log_{10} a,$$

which is the equation of a straight line.

If, then, the values of $\log \frac{i}{T}$ and $\frac{.434}{T}$, corresponding to the curves in Fig. 4, are plotted, they should lie along straight lines, provided conduction in the tube, between the voltage limits used, follows Richardson's Law.

Reference to the plots, Figs. 5 and 6, will show that the points are clearly represented by straight lines.

If the temperature of the filament is low, only a small number of electrons escape from it and, consequently, only a small discharge current (the saturation current) can be sent through the tube. Increasing the impressed voltage above that needed for this current value causes no further increase in current. It simply increases the velocity of the cathode rays and hence the penetrating power of the Röntgen rays.

D. PENETRATING POWER OF RÖNTGEN RAYS DETERMINED BY VOLTAGE ACROSS TUBE TERMINALS.

The penetrating power of the Röntgen rays coming from the tube increases with the potential-difference between tube terminals.

With the tube excited from a variable potential source, such as the transformer, it did not seem safe to predict that, with the same equivalent spark gap, the rays would show, photographically, the same penetrating power as those from a standard tube. But upon making the experiment, using a Benoist penetrometer, it was found that they did.

E. CAPABLE OF CONTINUOUS OPERATION WITHOUT CHANGE OF CHARACTERISTICS.

That the tube may be operated continuously without showing an appreciable change in characteristics, is shown by the following experiment on Tube No. 47, illustrated in Fig. 1.

The filament current was set at 4.1 amperes. This gave a discharge current of 25 milliamperes. The impressed voltage was then set at a point where the tube showed a 7 cm. equivalent spark gap.

The tube was then run continuously, with no adjustment of any kind, for 50 minutes. The readings of discharge current and equivalent spark gap, taken every two minutes, are given in Table I.

TABLE I.

Time	Discharge Current (Milliamps.)	Equivalent Spark Gap (CM.)
11:48 A.M.	25.	7.0
:50	25.	7.0
:52	25.	6.9
:54	25.	6.5
:56	25.	6.5
12:00 P.M.	25.	6.7
:02	25.	6.9
:04	25.	6.5
:06	24.	6.4
:08	24.	6.5
:10	24.	6.5
:12	23.	6.6
:14	25.	7.0
:16	25.	6.8
:18	24.	6.8
:20	25.	6.9
:23	23.	6.7
:26	23.	6.9
:28	25.	6.9
:30	25.	6.9
:32	25.	7.0
:34	24.	6.9
:36	25.	7.0
:38	24.	7.1

F. SHARPNESS OF FOCUS.

Other conditions remaining the same, the greater the distance between the filament and the front (end facing the target) of the molybdenum tube, the sharper will be the focus.

G. FIXITY OF POSITION OF FOCAL SPOT.

The focal spot on the anode does not wander, but remains perfectly fixed in position. This is in sharp contrast to the ordinary Röntgen tube in which the focal spot does move about, and often so rapidly as to be noticeable even during the shortest radiographic exposures. The effect of movement of the focal spot is, of course, to cause in the radiograph or on the screen, a blurring of all lines except those parallel to the direction of motion. In the earlier stages of exhaustion, while the new tube is being operated with a relatively poor vacuum, the focal spot may dance about, but as the electrodes and the glass become freer from gas the motility of the focal spot decreases and finally disappears completely. Its disappearance goes hand in hand with the disappearance of fluorescence of the glass, discussed in section J. Movement of the focal spot appears to be due to the action of positive ions in disturbing the distribution of static charge on the glass walls of the tube.

H. TUBE NOT SENSITIVE TO CONSIDERABLE CHANGES IN GAS PRESSURE.

The gas pressure within the tube is so low that it can increase several-fold, and apparently decrease without limit, without appreciably affecting the other characteristics.

I. CAPABLE OF CONTINUOUS OPERATION WITH HIGH ENERGY INPUT.

Owing to the fact that the tungsten target can run at such a high temperature, large amounts of energy can be continuously radiated.

J. NO FLUORESCENCE OF GLASS.

When operating properly the tube shows no fluorescence of the glass at any point. Corresponding to this, there is an absence of the usual strong local heating of the anterior hemisphere. The absence of fluorescence and of local heating seem to point to the fact that there is no bombardment of the glass by secondary cathode rays sent

out from the target. This is in striking contradistinction to what takes place in an ordinary Röntgen tube, where, in the case of a platinum target, it has been found that there are about three-fourths as many electrons leaving the target, and going to the glass, as secondary cathode rays, as there are bombarding it, in the form of primary cathode rays. This elimination of secondary cathode ray bombardment prevents the production of a large part of the useless and disturbing Röntgen rays which emanate from the glass in the case of the ordinary tube.

The simple explanation appears to be based upon the fact that the large number of positive ions present in an ordinary Röntgen tube is here lacking. The inner surface of the glass becomes strongly negatively charged, when the tube is first operated, and, not being able to attract an appreciable number of positive ions, remains so. The presence of this negative charge upon the glass prevents further electrons, either in the shape of primary or secondary cathode rays, from going there.

K. IDENTITY OF STARTING AND RUNNING VOLTAGE.

The starting, or break-down, voltage of the tube is the same as the running voltage. This is very different from the state of affairs in the ordinary tube in which the break-down voltage is much the higher of the two. The explanation of this difference is as follows: In the ordinary tube the number of ions present when the circuit is closed is exceedingly small, being only that due to natural ionization causes, such as radioactive matter in the surroundings. After the discharge circuit is closed, the number of ions increases, by collision, very rapidly, and the voltage across the tube terminals falls in consequence. In the case of the new tube, on the other hand, the full supply of electrons is there the instant the discharge circuit is closed, and even before this, and the available number is not changed by the discharge current.

L. PERMITS OF REALIZATION OF HOMOGENEOUS BUNDLE OF PRIMARY RÖNTGEN RAYS.

The tube must permit of the realization of a strong homogenous bundle of primary Röntgen rays of any desired penetrating power. For this purpose it should clearly be excited from a source of constant potential. The result should be attained even though the discharge is intermittent.†

M. NO HEATING OF CATHODE BY DISCHARGE CURRENT AND NO EVIDENCE OF CATHODIC DISINTEGRATION.

At the high vacuum and with the relatively gas-free electrodes of the new tube there is no evidence of any bombardment of the cathode. On the pump, in the earlier stages of gas removal, when a discharge can be made to pass through the tube without the heating current in the filament, the latter is seen to be strongly locally heated by the discharge current, as from bombardment by positive ions. But when the exhaustion has been completed and the tube is operated with the cathode hot, a voltmeter and ammeter in the filament circuit show no change even when a very heavy discharge is sent through the tube. Positive ion bombardment, if it existed to an appreciable extent, would raise the temperature and, hence, the resistance of the tungsten filament and would therefore be indicated by the instruments. If it were very local and considerable, it would be further indicated by a melting through of the filament at the point in question. The resistance change and local disintegration of the filament have been observed in only those cases where the vacuum, as shown by other effects, such as fluorescence of the glass, has been poor.

Disintegration of the cathode would also manifest itself in blackening of the bulb. Even after running for several hours, the deposit on the bulb is very slight, and what

† For fluoroscopic work with the ordinary tube, it seems preferable to use an interrupted discharge so as to reduce heating of the tube and danger to patient and operator. The phosphorescence of the fluoroscopic screen makes possible frequent interruptions without appreciable loss of light.

there is may well be entirely accounted for by vaporization of tungsten at the focal spot on the target.

N. THE SIZE OF FOCAL SPOT ON THE TARGET THE FACTOR LIMITING ALLOWABLE ENERGY INPUT.

Of the many factors limiting the allowable energy input in the ordinary tube, but one remains in the case of the new tube. With sharp focusing and above a certain energy input, the tube resistance is unstable, dropping suddenly to perhaps a small fraction of its original value, returning instantly to the old value, however, upon stopping the discharge or upon lowering it to the limiting value. The cause of this phenomenon appears to be as follows:

With a very high energy input and sharp focusing, the surface of the target melts at the focal spot and volatilizes. Owing to the fact that this tungsten vapor is produced at the focal spot, all of the primary cathode rays pass through it and, by collision, ionize it. This, of course, decreases the tube resistance. The larger the focal spot the greater is the allowable current. The design of the target also has a great deal to do with the allowable current value, as the face of a thin target is vaporized with a much lower energy input than a relatively thick one. For very short excitation of the tube, the allowable energy input is somewhat larger than for longer periods; but an input which can be carried for a few seconds can be carried indefinitely.

6. DANGER CONNECTED WITH USE OF TUBE

There has been in the old tube a certain element of safety in that it could not be run continuously with a very heavy energy input. The new tube, even when focusing sharply, can be operated, for example, on a 7 cm. parallel spark gap with currents as high as 25 milliamperes for hours at a time, and without the slightest attention.

For most purposes, other than fluoroscopic or radiographic work, there is no

advantage in having the tube focus. In case it does not, the above mentioned energy input limitation falls away and the tube can apparently be designed for any energy input whatsoever. This permits, in this field, of the use of much greater Röntgen ray intensities than have heretofore been realized.

7. SUMMARY

In the light of the above, it will be seen that the precautions which have been shown by years of experience to be sufficient for work with the old tube are not necessarily sufficient for the user of the new one.

In the foregoing, a new and powerful Röntgen-ray tube has been described. It differs in principle from the ordinary type in that the discharge current is purely thermionic in character. Both the tube and the electrodes are as thoroughly freed from gas as possible, and all of the characteristics seem to indicate that positive ions play no appreciable role.

The tube allows current to pass in only one direction and can therefore be operated from either direct or alternating current.

The intensity and the penetrating power of the Röntgen rays produced are both under the complete control of the operator, and each can be instantly increased or decreased independently of the other.

The tube can be operated continuously for hours, with either high or low discharge currents, without showing an appreciable change in either the intensity or the penetrating power of the resulting radiations.

The tube in operation shows no fluorescence of the glass and no local heating of the anterior hemisphere.

The tube permits of the realization of intense homogenous primary Röntgen rays of any desired penetrating power.

It is a pleasure to me, in closing, to express my appreciation of the services of Mr. Leonard Dempster, who has assisted me throughout this work.

Research Laboratory of the General Electric Co., Schenectady, N. Y.

A PRELIMINARY REPORT ON THE DIAGNOSTIC AND THERAPEUTIC APPLICATION OF THE COOLIDGE TUBE

By LEWIS GREGORY COLE, M. D.

Professor of Roentgenology at Cornell University Medical College

INTRODUCTION

PRINCIPLE OF THE ORDINARY TUBE

The powerful Roentgen ray tube with a pure electron discharge, designed by Dr. Coolidge, is undoubtedly the most important contribution to Roentgenology since the birth of that science. Except for slight changes made from time to time in the construction of the tube and various methods that have been devised for regulating its vacuum, all Roentgen ray tubes have been fundamentally alike, that is to say, the penetration has always been controlled by regulating the vacuum of the tube.

PRINCIPLE OF THE NEW TUBE

In the new tube, designed by Dr. Coolidge, which unquestionably should be known as the Coolidge tube, an entirely new principle is involved. The tube and the phenomena it exhibits when excited have been fully described in the December (1913) number of the Physical Review. The limitations of the ordinary tube have been overcome by devising a tube the vacuum of which is about 1000 times as great as the vacuum of the ordinary tube. The tube is capable of being excited only when the cathode is heated. When the tungsten filament, which forms the cathode, is heated by an electric current, the electrons are liberated, or as Dr. Coolidge says, "stewed out" of the cathode and propelled across the space between the cathode and anode by the high potential current from the coil, transformer, or static machine.

The penetration of the tube depends upon the rapidity with which the electrons are liberated from the cathode. This speed is

controlled by regulating a low potential current from a storage battery in circuit with the tube.

THE ADVANTAGES OF THE COOLIDGE TUBE

The advantages of the new tube are manifold and include:

1. Accuracy of adjustment.
2. Stability.
3. Exact duplication of results.
4. Flexibility.
5. Tremendous output.
6. Long life of the tube.
7. Absence of indirect rays.

ACCURACY OF ADJUSTMENT

It is not until one uses the Coolidge tube that he realizes the limitations of the ordinary tube with regard to accuracy of adjustment. Self-regulating devices have proved disappointing even when the tube is used on a coil, and entirely unsuccessful when the tube is excited by the high milliamperage ordinarily used with a transformer, because the shunt of a large current through the regulator reduces the vacuum to a greater degree than is desirable. The most careful adjustment of the ordinary tube has therefore been merely guess-work, for when the tube has been reduced to a desired penetration with a small amount of current, the penetration will materially increase again when more resistance in the rheostat is cut out, and the tube excited by more current.

In the Coolidge tube the penetration is regulated *up* or down by the amount of heat generated in the cathode filament, and this in turn is controlled by regulating the amount of current from a storage battery connected with the secondary circuit from the transformer or coil, as described by Dr. Coolidge in his abstract.

STABILITY

The stability of the tube is no less remarkable than the accuracy with which it may be adjusted. Dr. Coolidge states that the present tube, crude as it is, may be excited continuously with 25 milliamperes for 50 minutes without perceptibly changing the

(Foot, Walter Bell. Test
Plate No. 1)

Fig. 1.

Detail in soft tissues. No structure of bone visible.
Parallel Gap, 2 ins.; Current, 10 m. a.; Exp., 5 secs.; m. a. secs., 50; Benoist reading, 2.

(Foot, Walter Bell. Test
Plate No. 2)

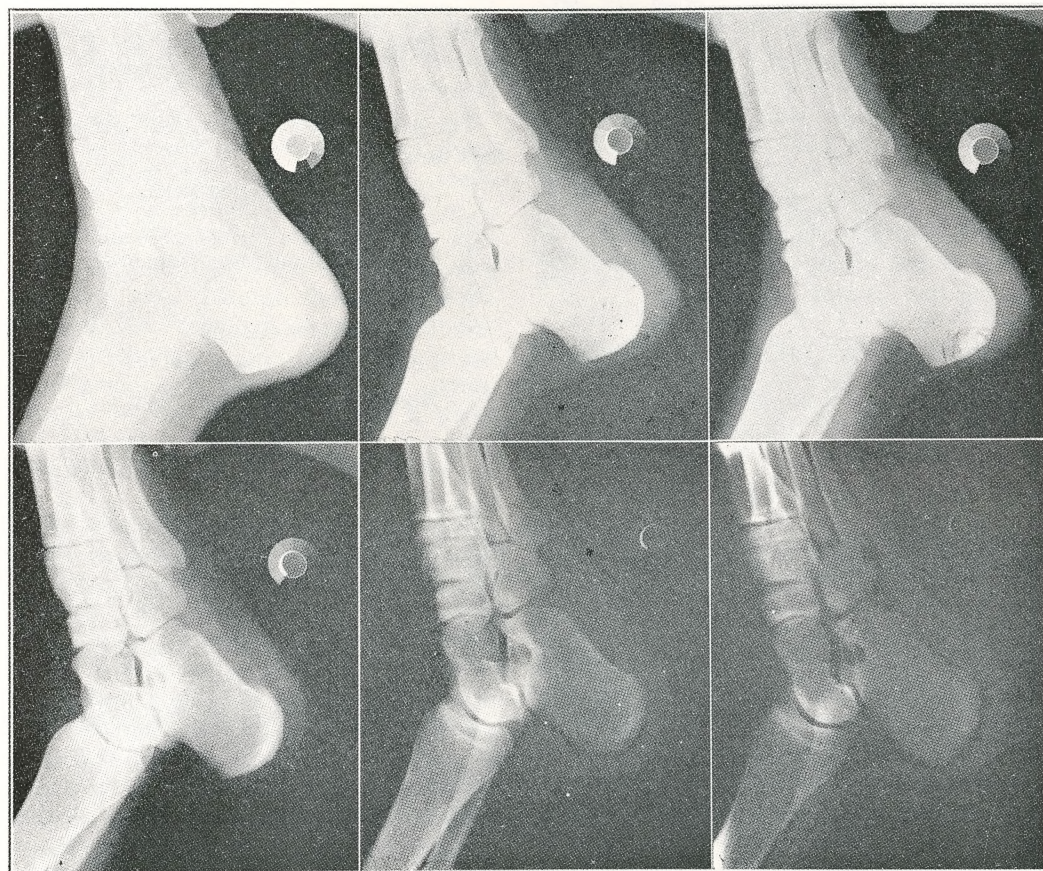
Fig. 2.

Structure in soft parts shows very distinctly. Some detail begins to appear in the structure of the bone.
Parallel Gap, 3 ins.; Current, 10 m. a.; Exp., 5 secs.; m. a. secs., 50; Benoist reading, 4.

(Foot, Walter Bell. Test
Plate No. 3)

Fig. 3.

Exact duplicate of roentgenogram illustrated in Fig. 2, showing the ability to produce exactly the same characteristics in two different roentgenograms.



(Foot, Walter Bell. Test
Plate No. 4)

Fig. 4.

Structure of soft parts disappearing. Increasing detail in structure of bone.
Parallel Gap, 5 ins.; Current, 10 m. a.; Exp., 5 secs.; m. a. secs., 50; Benoist reading, 8.

(Foot, Walter Bell. Test
Plate No. 5)

Fig. 5.

Soft tissues almost entirely obliterated. Very minute detail in structure of bone.
Parallel Gap, 6 ins.; Current, 10 m. a.; Exp., 5 secs.; m. a. secs., 50; Benoist reading, 9.

(Foot, Walter Bell. Test
Plate No. 6)

Fig. 6.

Soft parts entirely obliterated. Structure of bone beginning to be obliterated.
Parallel Gap, 7 ins.; Current, 10 m. a.; Exp., 5 ins.; m. a. secs., 50; Benoist reading, 10.

penetration. For Roentgenographic work such prolonged stability is unnecessary; but stability for the length of time required to make an exposure of any part of the body produces Roentgenograms with a uniformity of excellence which has been the hitherto unattained ideal of every Roentgenologist. Having determined the amount of penetration required for any given part of the body, the tube is readily adjusted for that degree of penetration, and may be excited with any desired milliamperage from 1 to 200 milliamperes, for a sufficient length of time to make a correct exposure. The number of milliamperes multiplied by the length of exposure gives the milliampere seconds. The few tests that I have made indicate that it is immaterial whether one uses 1 milliampere for 50 seconds or 50 milliamperes for 1 second. If this be true, and one can accurately control the penetration during the entire exposure, then it is a very simple matter to obtain uniform results in all roentgenographic work by following a scale of the milliampere seconds required for each part of the body. During the short time that we have been privileged to test this tube the different degrees of penetration required for the various parts of the body were perfectly sustained during every exposure.

EXACT DUPLICATION OF PREVIOUS RESULTS

It is the experience of every operator that occasionally he obtains a roentgenogram of admirable brilliancy, but personally I have never been able to obtain such results with any degree of certainty. On a few occasions I have made roentgenograms showing really remarkable detail. My experience with the Coolidge tube leads me to believe that these exceedingly brilliant roentgenograms, hitherto obtained only occasionally, may be made quite uniformly with the new tube, as soon as we have determined the exact penetration required and the amount of milliampere seconds necessary for each part of the body. The apparatus can be set for a given penetration, and by using the

same milliamperage through the tube, a hundred roentgenograms can be made so nearly alike that it is impossible to tell them apart.

FLEXIBILITY OF THE TUBE

Flexibility as a characteristic of Roentgen tubes has been an almost unknown quantity. Raising the vacuum has never been successfully accomplished. It has been possible



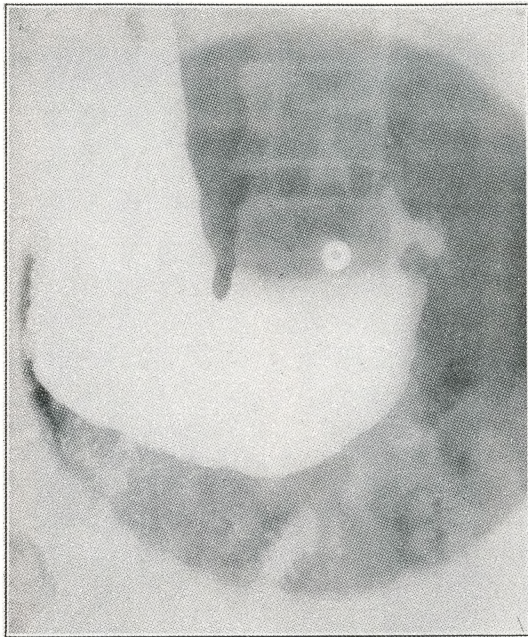
(Arm, Leone Cottrell, Plate No. 39721)

Fig. 7.

Bones, muscles, blood in veins, and even small lobules of fat show distinctly.
Parallel Gap, 3½ ins.; Current, 70 m. a.; Exp., ¼ sec.

to reduce the vacuum and therefore the penetration to any desired degree, but the instability of the vacuum made results very uncertain. In the Coolidge tube flexibility is one of the strong points. The tube may be operated one instant at a penetration so

slight as to show the anastomosis of the blood vessels of the extremities and the next instant, without leaving his seat in the operating booth, one may operate the tube at a penetration far exceeding anything possible with the ordinary tube. Therefore the same tube may be used for all kinds of roentgenographic and therapeutic work.



(Stomach, Mr. Prendergast, Plate No. 4580)
Fig. 8.

One of a series of 10 roentgenograms. Aggregate time consumed in making the series of 10 plates was 4/10 second, or 6/100 second for each plate.

Parallel Gap, 5½ ins.; Current, 110 m. a.; Exp., .06 sec.

TREMENDOUS OUTPUT

The tremendous output of Roentgen rays from the Coolidge tube, the penetration of which is accurately adjustable and absolutely stable for an unlimited time, and moreover can be exactly duplicated at any subsequent time, places in the hands of the roentgenologist a diagnostic and therapeutic agent of immeasurable value.

LONG LIFE

The life of this tube is estimated by Dr. Coolidge to be at least a thousand hours of constant running. In fact he says that instead of wearing out, the tube is more likely to meet its fate by being dropped or accidentally broken in handling. He believes it will not be punctured by any ordinary usage.

INDIRECT RAYS

Indirect rays, generated in the wall of the anterior hemisphere of the tube by secondary or deflected cathode streams, have played a villainous role in the ordinary tube. The indirect rays are not only useless for Roentgenography, but they are positively detrimental, for they blur the image and generate secondary rays in the tissue of the body interposed. A long time ago I determined that one-half of the radiation from the ordinary tube emanated in the form of indirect rays. Other observers have made this percentage much higher. Although various screens and hoods encircling the anode have been devised, the most practical method for eliminating their disturbing influence has thus far been to cut them off with a diaphragm outside of the tube, without trying to prevent their generation. In the Coolidge tube indirect rays do not exist, as is indicated by an absence of green fluorescence of the anterior hemisphere, and as has been proven by the pin point camera obscura tests. Their absence eliminates the necessity for a small diaphragm and compression blend near the tube, with the result that the compression blend may be located independently of the tube-holder, and is used only for compression and localization of the area of the body to be exposed.

APPLICATION OF THE NEW TUBE TO ROENTGENOGRAPHY AND ROENTGENOTHERAPY

Having briefly referred to the remarkable practical advantages of this tube, let us consider its application to Roentgenography and Roentgenotherapy. A comparison of roentgenograms of various parts of the body

made with known sustained penetration and milliamperage and with different lengths of exposure, has enabled us to compile a table or scale, which is based on penetration of the tube and milliampere seconds. This scale undoubtedly will be improved by refinement in gradation of penetration, and amplified for patients of various sizes. However, as it has proved a great help in the routine work of the office and has enabled us to duplicate results with great accuracy, the following crude table is submitted as a guide to those who may wish to use the tube as soon as possible.*

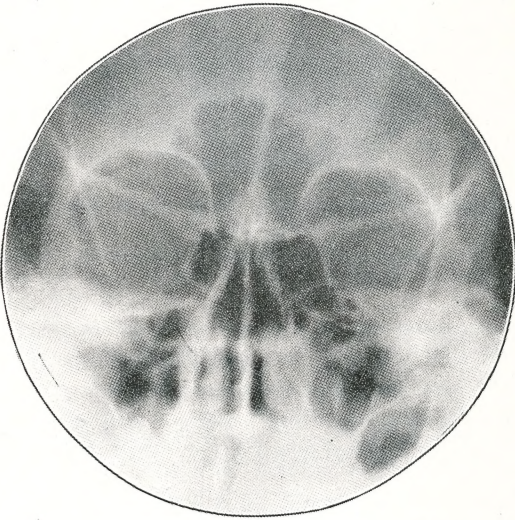
Part of the body.	Length of sparks gap in inches.	Milliamperage.	Time in seconds.	Milliamperage seconds.
Hand—Soft parts....	1½-2	25	2	50
Hand—Bone	2	25	2	50
Foot—Soft tissues, lateral	2	25	3	75
Foot—Bone, lateral..	3	25	3	75
Knee—Soft parts....	3	25	4	100
Knee—Bone and soft tissues	4	25	4-5	125
Knee—Bone only....	4½	30	5	150
Shoulder—Soft tissues	4	30	8	240
Shoulder—Bone	4½-5	30	10	320
Hip—Bone	5	30	15	450
Kidney	4	30	15	450
Spine—Bone detail...	5	30	15	450
Head—Lateral	5	30	15	450
Head—A. P.....	5½	40	15	600
Lungs	3	40	10	400
Stomach (screen)....	5	100	.06	6

From our experiments, the number of milliampere seconds seemed to be greater than the amount we have been accustomed to use with the ordinary tube. To test this, an exposure was made with the ordinary tube with as nearly a stable vacuum as possible. The same procedure was then repeated with a Coolidge tube. The result was that no variation could be detected in either density or detail between the two exposures. It therefore appears that the increased crispness obtained with the new tube is due, at least in part, to a full exposure, without variation, in vacuum and without fogging by indirect rays.

*The milliampere seconds may be obtained with any amount of amperage or any length of exposure, but a moderate milliamperage and an appreciable length of exposure is desirable if the part to be roentgenographed can be kept at rest.

ADVANTAGES FOR ROENTGENOGRAPHY

The tremendous amount of milliamperage that may be used for a short time is of great advantage in gastroduodenal roentgenography. By the use of a time switch we were able to determine accurately the aggregate time required to make ten roentgenograms of the stomach of a moderate-sized man. The aggregate time required for the ten exposures was 4/10 second, making the time required for each exposure about .06 second, and the contrast and detail is all that could be desired. This rapidity is especially valuable for Roentgencinematography, and may make possible the production of cinematographs direct from the fluorescent screen.

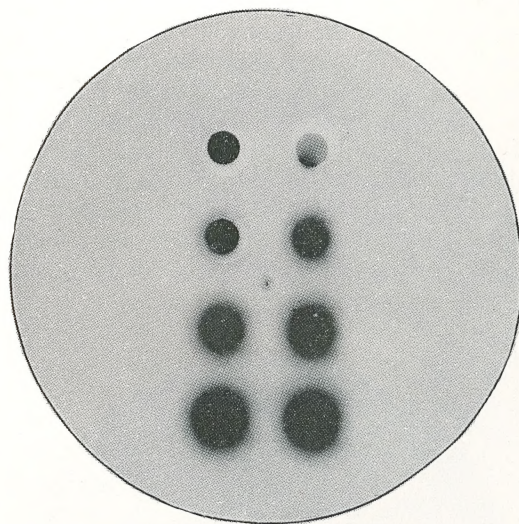


(Frontal Sinuses, Hazel Hill 39593)
Fig. 9.
Parallel Gap, 5½ ins.; Current, 30 m. a.; Exp., 15 secs.

ADVANTAGES FOR FLUOROSCOPY

For fluoroscopy, the Coolidge tube offers great advantages also, because any degree of penetration can be obtained with a minimum amount of milliamperage, generated from the same source, which at the next moment can be used through the same tube for mak-

ing instantaneous roentgenograms of the gastro-intestinal tract. It will be seen, therefore, that its value is incalculable for combined serial and Cinematographic Roentgenography and Roentgenoscopy, which is the ideal method for gastro-intestinal examination.



(Walter Penetrometer, Test Plate No. 10)

Fig. 10.

Roentgenograph of Walter Penetrometer, showing a plus reading of an 8 Walter, and the fact that the rays readily passed through the lead screen surrounding the platinum discs.

Parallel Gap, $7\frac{1}{2}$ ins.; Current, 10 m. a.; Exp., 10 secs.

APPLICATION OF THE COOLIDGE TUBE TO ROENTGENOTHERAPY

The great demand for a more efficient Roentgenotherapeutic tube caused me to urge Dr. Coolidge to announce the success of his tube while it was still in what he considered a crude form. At that time only three roentgenograms had been made with the tube, and its therapeutic value was wholly untried. Nevertheless, laboratory tests, showing the stability of the tube during its excitement with a tremendous milliamperage, had already suggested its usefulness in the field of Roentgenotherapy, and certain experiments recently carried out are a proof of the extraordinary therapeutic efficiency of

the Coolidge tube compared with standards to which Roentgenologists are accustomed. For these experiments, the Kienboeck and Hampson radiometers were used.

A piece of beef two inches thick was placed with its surface $5\frac{1}{2}$ inches from the focal point of the tube. Three millimeters of aluminum was interposed between the tube and the beef. A Hampson pastille and Kienboeck strip were placed on the surface of the beef, a second pastille and strip were placed one inch below the surface, and a third pastille and strip were placed behind the two inches of beef.

Experiment I: The tube was regulated so that it backed up $7\frac{3}{8}$ inches on the parallel gap. The Bauer penetrometer read far beyond the registered scale. The Walter penetrometer registered 8+.* An exposure of $3\frac{1}{2}$ minutes was made. During this time the milliamperage varied from 10 to 8 and back to 9. The Hampson pastille on the surface read 12 H, or 3 times an erythema dose. The Kienboeck strip on the surface was spoiled. The Hampson pastille one inch deep read 6 H or 16 K, or $1\frac{1}{2}$ erythema dose. The pastille two inches below the surface read 3 H and 8 K, respectively, or about $\frac{3}{4}$ of an erythema dose.

A second experiment was made, repeating the previous test.

Experiment II: The same degree of penetration was maintained in the tube, i. e., the gap remained at $7\frac{3}{8}$, the Bauer penetrometer read off the scale, the Walter penetrometer registered 8+, and the milliamperage varied from 8 to 10. Three millimeters of aluminum was interposed. A series of four one-minute exposures and one two-minute exposure was made.

After the first exposure of one minute, the pastille and strip on the surface read 4 H and 12 K, respectively. The pastilles and strips one inch and two inches deep were not read.

*Note—A later experiment showed that when the Walter penetrometer was laid on a plate and roentgenographed, the rays readily passed through the thickest aluminum disc, and even through the surrounding lead.

After the second exposure of one minute, making a total exposure of two minutes, a new pastille and strip on the surface read 4 H and 18 K. The pastille one inch deep, exposed for a total of two minutes, read 3 H. The Kienboeck strip was not read.

After the third exposure of one minute, a new pastille and strip on the surface read 4 H and 15 K. The pastille one inch deep, exposed for a total of three minutes, read 4 H. The Kienboeck strip was not read.

After the fourth exposure of one minute, a new pastille and strip on the surface read

strip two inches deep read 4 H and 15 K.

The following table is a condensed form of the above experiments:

The above tests indicate that through six ports of entry one may obtain a full erythema dose two inches below the surface in six minutes. With this tremendous amount of highly penetrating rays, any amount of screening desirable may be used and yet the treatment need not be prolonged beyond a reasonable time. Dr. Coolidge believes that with a large focal point on the anode these milliamperages may be increased up to 2000, and transformers or other exciting

Spark Gap.	Milliamperage.	Length of Exposure in Minutes.	Filter.	Reading (Hampson and Kienboeck).
$7\frac{3}{8}$	Varied from 10 to 8 to 9	$3\frac{1}{2}$	3 mm. of aluminum	Surface: 12H-K (spoiled) 1 in. deep: 6H-16K 2 in. deep: 3H-8K
"	9	1	"	Surface: 4H-12K 1 in. deep: not read 2 in. deep: not read
"	$8\frac{1}{2}$	1	"	Surface: 4H-18K 1 in. deep: 3H-K (not read)
"	9 to $8\frac{1}{2}$ to 8	(total 2) 1	"	Surface: 4H-15K 1 in. deep: 4H-K (not read)
"	9 to $8\frac{1}{2}$ to 8 to $9\frac{1}{2}$	(total 3) 1	"	Surface: 4H-15K 1 in. deep: 6H-15K 2 in. deep: 3H-K (not read)
"	10 to 8	(total 4) 2	"	Surface: 8H-K (black) 1 in. deep: not read 2 in. deep: 4H-15K
"		(total 6)		

4 H and 15 K. The pastille and strip one inch deep, exposed for a total of four minutes, read 6 H and 15 K, respectively. The pastille two inches deep read 3 H. The Kienboeck strip two inches deep was not read.

After a fifth exposure of two minutes, the surface pastille read 8 H. The Kienboeck strip was black. The pastille and strip one inch deep were not read. The pastille and

apparatus may be designed which will increase the penetration.

With these forces under control, there is no limitation to the amount of ray at our command, and with the cross-fire method of application, and the screen materially increased, there is every reason to hope that we may be able to apply to internal cancers the same amount of X-Ray which, when applied to superficial cancers, has caused their immediate disappearance.

THE ROENTGEN DIAGNOSIS OF LESIONS IN THE REGION OF THE MEDIASTINUM

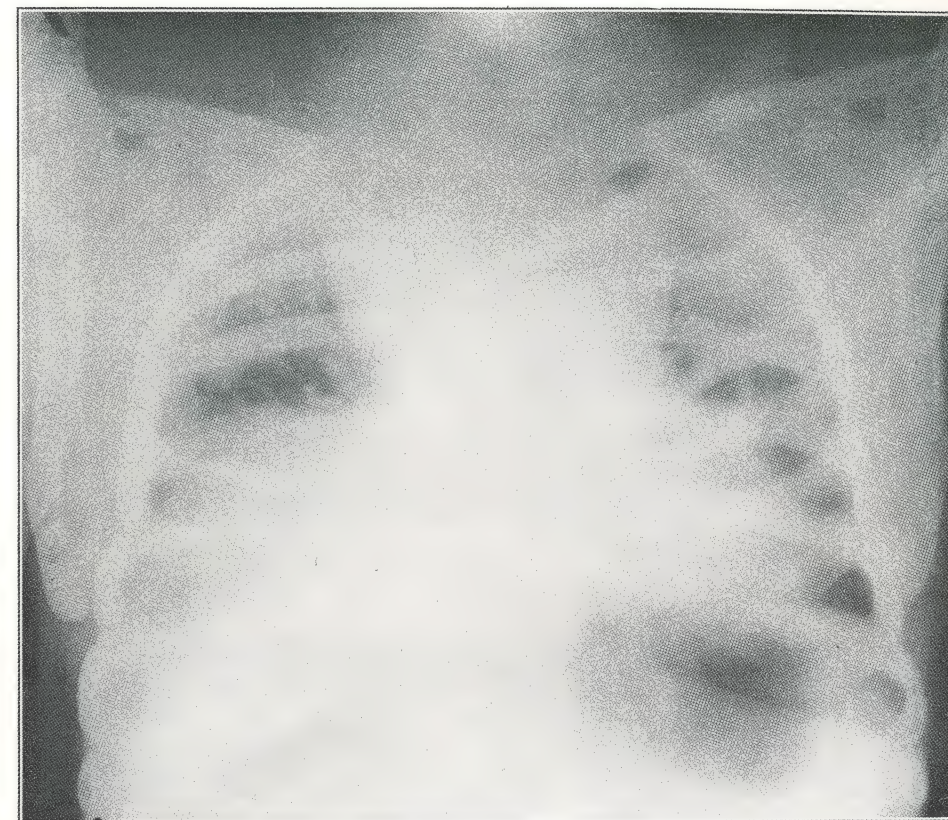
By GEO. F. THOMAS, Ph. B. M. D., Cleveland

The pre-eminent symptoms of disease in the region of the mediastinum are those produced by pressure. This is true in the early as well as the more advanced stages of all lesions commonly found in this space. Although in some instances, e. g. in some cases of mediastinal tumor, the process may be quite advanced before the symptoms become of sufficient importance to cause the patient to seek medical advice, it is more often true that patients will present themselves with suggestive symptoms at a time too early for the physician to determine the nature of the cause; frequently before he can even determine the presence of a cause, by physical examination. In many of these cases, a competent X-Ray examination will save the physician from an incomplete or incorrect diagnosis. The symptoms that indicate mediastinal investigation are: (1) Feeling of oppression, or sense of weight or pressure on the chest; (2) Dyspnoea; (3) Dysphagia; (4) Pain anywhere in the region of the mediastinum, or pains radiating to shoulders, arms, sides of the chest, or upper abdomen; (5) Tickling in the throat, cough or inability to cough; (6) Aphonia or hoarseness, due to complete or partial paralysis of the vocal cords; (7) Enlargement of the veins of the face and neck; (8) Unilateral flushing of the face or unilateral dilatation of the pupils; (9) Tachycardia or bradycardia. Any one or any combination of the above symptoms should arouse suspicion of a mediastinal lesion as the cause unless there is definite evidence to the contrary. They may be the indications of pressure on the structures adjacent to the mediastinum, namely the sternum, the dorsal vertebrae or the lungs; or on the contents of the mediastinum, namely, the recurrent laryngeal,

vagus, phrenic, cardiac or sympathetic nerves; the trachea; the oesophagus; the roots of the lungs; or the circulatory system especially the venous. *Physical signs are, for obvious reasons, often difficult to obtain especially in deep chested or deformed individuals, and frequently even more difficult to properly interpret.*

It does not lie within the province of this paper to detail the nature of these difficulties; the frequent absence of pathognomonic signs and the apparently contradictory indications of those present. I simply wish to emphasize the fact that after the family physician has inquired into the anamnesis, made his physical examination, and made his statement as to the probable diagnosis (the whole of which proceeding is apt to occur months after the patient has made his original complaint), and then the whole of this proceeding repeated as various consultants are called in, I simply wish to emphasize the fact that after all of this history taking, examining and consulting, the diagnosis is frequently undetermined, whereas a competent Roentgenologist in most of the cases could have made an accurate diagnosis at the time of the patient's first complaint.

Of all the excuses given for the delay in submitting the patient to the X-Ray examination, that of ignorance is the least blameworthy; that of attempted economy the most mistaken and the most reprehensible. The extravagance of repeated unnecessary consultations, and the fearful waste of valuable time during the period of uncertainty, both from a financial and a therapeutic standpoint, are individually enough to counteract the frequently heard remark that Roentgen examinations are too expensive to be extensively resorted to. The



Large substernal thyroid. Patient very corpulent. Note position of liver from intra-abdominal pressure.

fact is that few patients can afford the expense of not having an X-Ray examination and surely, from the viewpoint of the patient, it would seem that a Roentgen illumination intra vitam should be preferable to an exploratory investigation post mortem.

Although in many of these cases, a simple antero-posterior, or postero-anterior radiograph will present enough information upon which to make an accurate diagnosis, in some of them it is necessary to make a fluoroscopic examination in addition to the radiographs from the different angles, including the oblique through the left posterior right anterior. Instantaneous screen plates are of great value because of their sharp outlines. Visualization of the oesophagus with bismuth may often be of service.

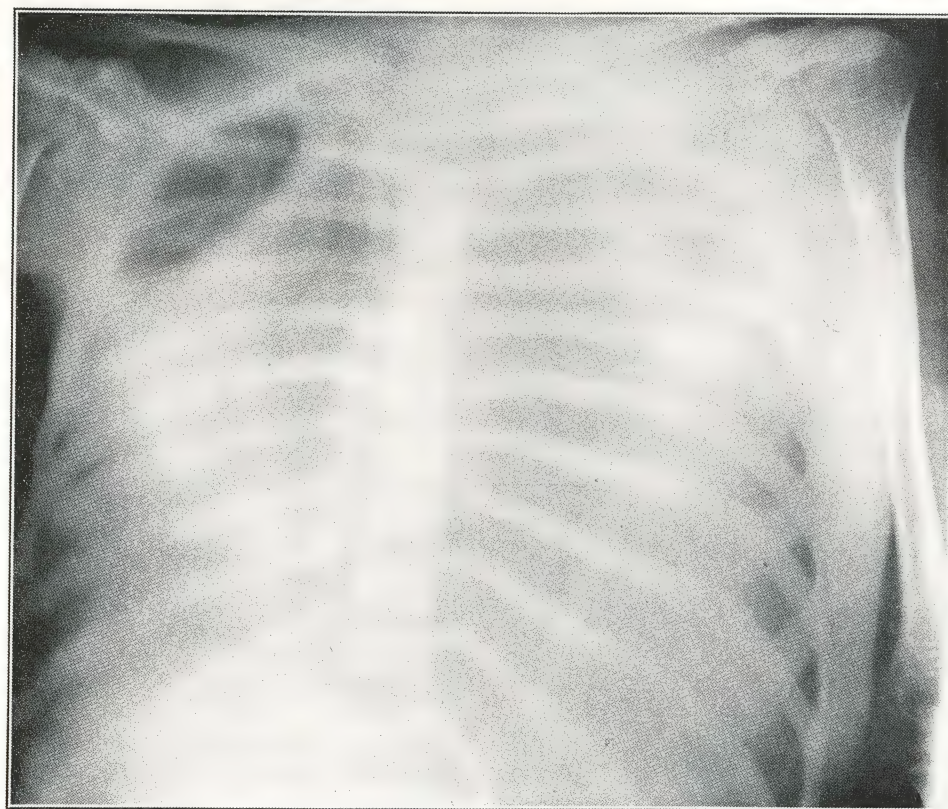
In the examination, the position of the mediastinum in general, and of the heart in particular, should be observed. The mediastinal shadow may be normal in position or it may be displaced in toto to the left or right, or suspended in the median line, displaced upward or downward or congenitally transverted to the right side. The heart shadow in addition to being displaced with the mediastinum may show rotation of the base to the right and downward, or to the left. The apex, though moved with the mediastinum, is not usually displaced in reference to it. Furthermore, the shape and size of the heart should be noted, as also should the outline of the aorta, the position and appearance of the trachea, and the width of the superior mediastinal shadow. All of

the above points may need be considered in the differential X-Ray diagnosis, as I expect to illustrate later on in this paper. They may be the result of conditions within or without the mediastinum, the normal position of which depends on the maintenance of a normal tension in both sides of the thorax and a normal equilibrium between the intrathoracic tension and the intraabdominal pressure, the latter of which varies according to the tone of the abdominal muscles and the amount of intraabdominal contents, e. g. abnormal fat, tumors, or fluid or gas either inside or outside the gastrointestinal tract.

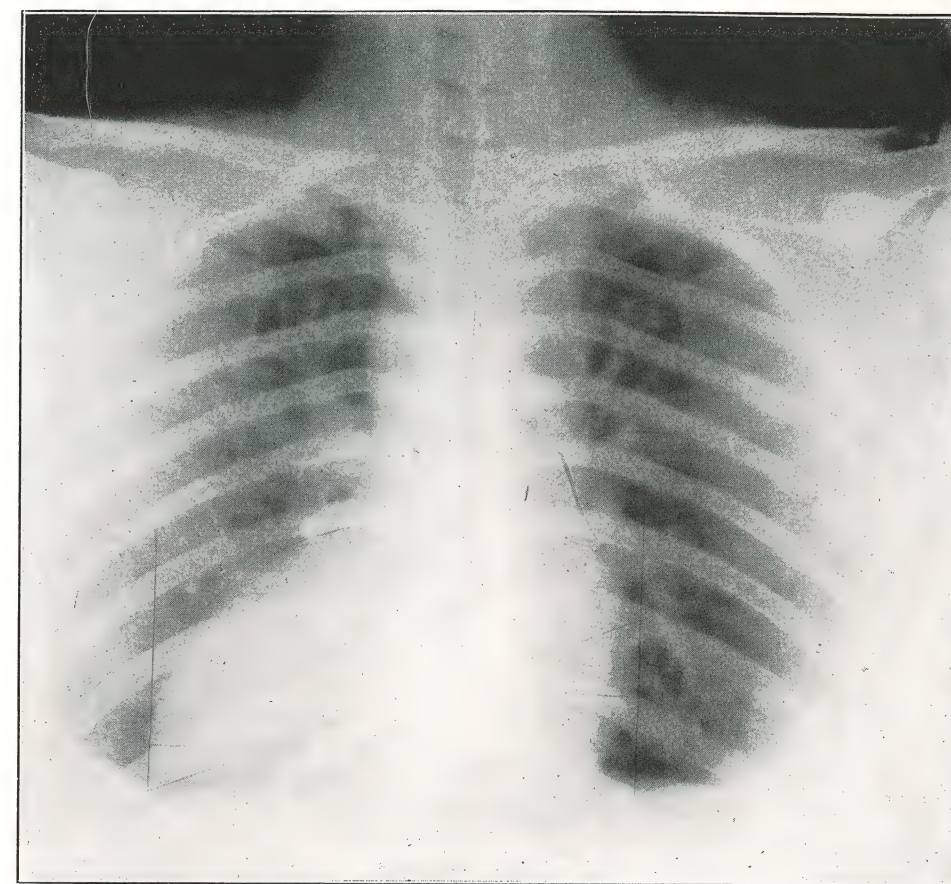
In cases of general visceroptosis, the diaphragm is low and the heart assumes a vertical position in the median line. This condition is frequently to be noted in thin people with long narrow chests. In very cor-

pulent individuals the opposite condition may be noted, the heart assuming a more transverse position than normal, due to mechanical elevation of the diaphragm from intraabdominal pressure. I recall an unusually corpulent patient in whom we found an enormous substernal thyroid. The heart was lying in a transverse position. The diaphragm, especially on the right side, occupied a position some 3 inches higher than normal. The lung space on both sides was enormously decreased. I think this mechanical intrusion upon the lung space accounted to a great extent for the patient's extreme shortness of breath.

Further causes of displacement of the mediastinum other than that of congenital situs transversus and that due to deformities of the chest are: pleural effusions, adhesions, compensatory emphysema, pneumo-



Mesial pneumothorax with thickened pleura. Mediastinal contents displaced to left.



"Transverse heart" due to lengthening of aorta without dilatation. Diagnosis Aortitis.

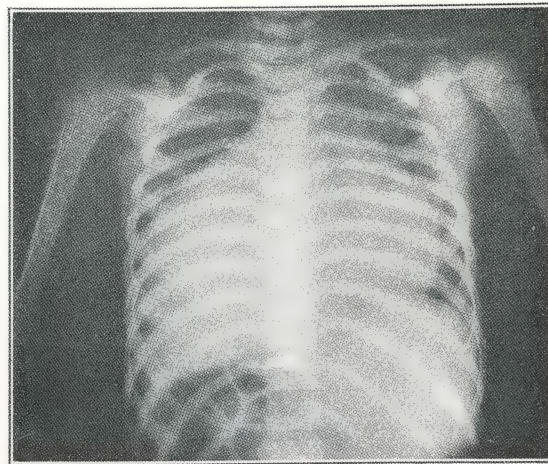
thorax and lung tumors. In this connection it is interesting to note the great reliance placed on displacement of the heart as a sign of pleural effusion, when we consider that in many cases the heart is not displaced away from the involved side, even in some cases being pulled over into the shadow of the effusion by the contraction of old adhesions.

In regard to the displacement due to pneumothorax, I recall two interesting cases, in one of which the pneumothorax was centrally confined by adhesions between the median border of the collapsed right lung and the mediastinum, with the mediastinum so markedly displaced to the left that the radiograph showed a very detailed picture of

the dorsal spine, unobstructed by the cardiac shadow. In the other case, the pneumothorax was situated externally on the left side, the heart was displaced markedly to the right, the left diaphragm was markedly depressed and the affected area gave a dull note upon percussion. The diagnosis of pleural effusion was made. When the radiograph, made simply to complete the demonstration to the students of an unusually typical case, showed the condition to be a pneumothorax under extreme pressure, there was considerable consternation. In this case and a couple of others where dullness was elicited by percussion over a pneumothorax, the pleura was quite thickened.

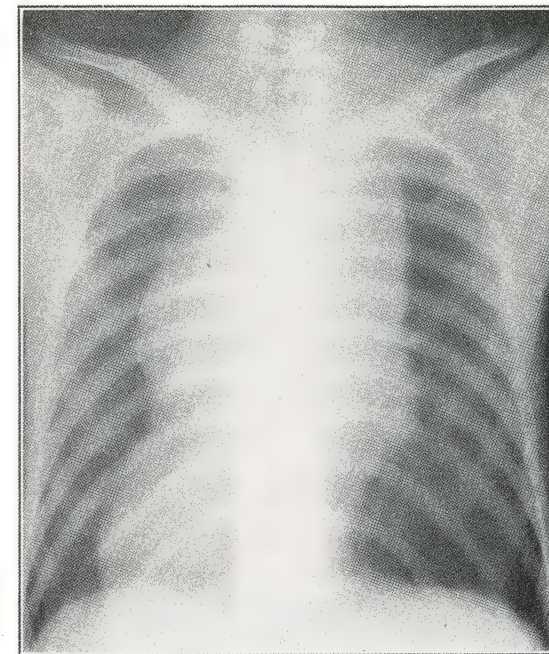
The downward displacement of the base of the heart due to the presence of mediastinal growths or aneurisms is, of course, well recognized. I think, however, that I have never seen any reference to the significance of a transverse heart which could not be accounted for by the above mentioned causes, namely, increased intraabdominal pressure or the presence of an aneurism or tumor of the superior mediastinum. I have noticed that the heart assumed a horizontal position in some cases where dilatation of the aorta was present, and furthermore in some cases where a clinical diagnosis of aortitis was justifiable, but in which the radiograph did not show aortic dilatation. In one of these cases, which presented, as usual, a positive Wasserman reaction, antiluetic treatment was accompanied by a relief of symptoms, and subsequent radiographs showed a return of the heart to nearly the normal angle. It seems, therefore, that in the absence of other demonstrable causes, the rotation downward of the base of the heart is evidence of lengthening of the aorta, the result of aortitis. When associated with dyspnoea and pain, the diagnosis of aortitis is indicated.

In the diagnosis of lesions of the heart, the chief value of the X-Ray is to show definitely the size and shape of the heart. The relative prominence of the shadow of the left auricle and of the right heart is of some importance in indicating the presence of valvular insufficiency. With the screen the character of the cardiac pulsation is observable. This may at times help to differentiate between pericardial effusion and dilatation of the heart, the differential diagnosis between which is usually easy with the X-Ray. In a couple of cases, I have been able to see definitely the outline of the heart shadow within the shadow of the surrounding effusion. In one of the most marked of these cases, the fact that the cardio-hepatic angle, though displaced markedly to the right, was not altered, or made less acute than normal, was of great interest to me. In certain cases of chronic pericardi-



Pericardial effusion. Note shadow of heart inside of shadow of effusion. No obliteration of cardio-hepatic angle.

tis, the thickening of the pericardium and the density of the fibrinous exudate render impossible the differentiation of the cardiac shadow. In these cases, the evidence of adhesions and inflammatory thickening in the surrounding tissue is of value. These findings, together with the physical findings indicating impeded heart action, especially during sustained deep inspiration, should clear up the diagnosis. The recognition of aneurism is, as a rule, a simple procedure. The presence of a definite, regular clean-cut outline, which can be demonstrated as continuous with the aortic shadow is unmistakable, and there is no further difficulty. But there are a good number of cases where the diagnosis is not so easy. It may be necessary, then, to make examinations in the oblique positions before one can eliminate the diagnosis of aneurism. This will occasionally demonstrate an enlargement otherwise not shown. In practically all cases of aneurism the base of the heart is displaced downward. When this displacement is not present, the diagnosis of aneurism must be guarded. When it is present, and the large shadow above does not present sufficient characteristics to positively indicate aneurism, the sign is of value, although tumors and abscesses may occasion-



Dissecting aneurism.

ally produce similar displacement. When, however, there is no evidence of an aneurism or other tumor, I consider a transverse position of the heart as very indicative of a dilated aorta or a lengthened, undilated syphilitic aortitis as above stated.

I have frequently noticed in chest plates a peculiar bulging of the aortic arch to the left, due to the tipping or rotation of the transverse aorta. This is marked enough in some cases to cause some hesitation in stating that a localized saccular aneurism is not present. In these cases a careful examination of the plate or a stereoscopic pair will demonstrate that the ascending aorta is displaced to the left and forward, thus rotating the arch in a horizontal plane to a more antero-posterior position and tipping the apex of the arch to the left of the descending portion.

This condition may be produced by a lengthening of the aorta (due to aortitis) without downward displacement of the base of the heart, by the contraction of adhesions

surrounding the mediastinum, or by pressure from a tumor or enlarged mediastinal glands. I have seen it in some cases where I could not determine any cause.

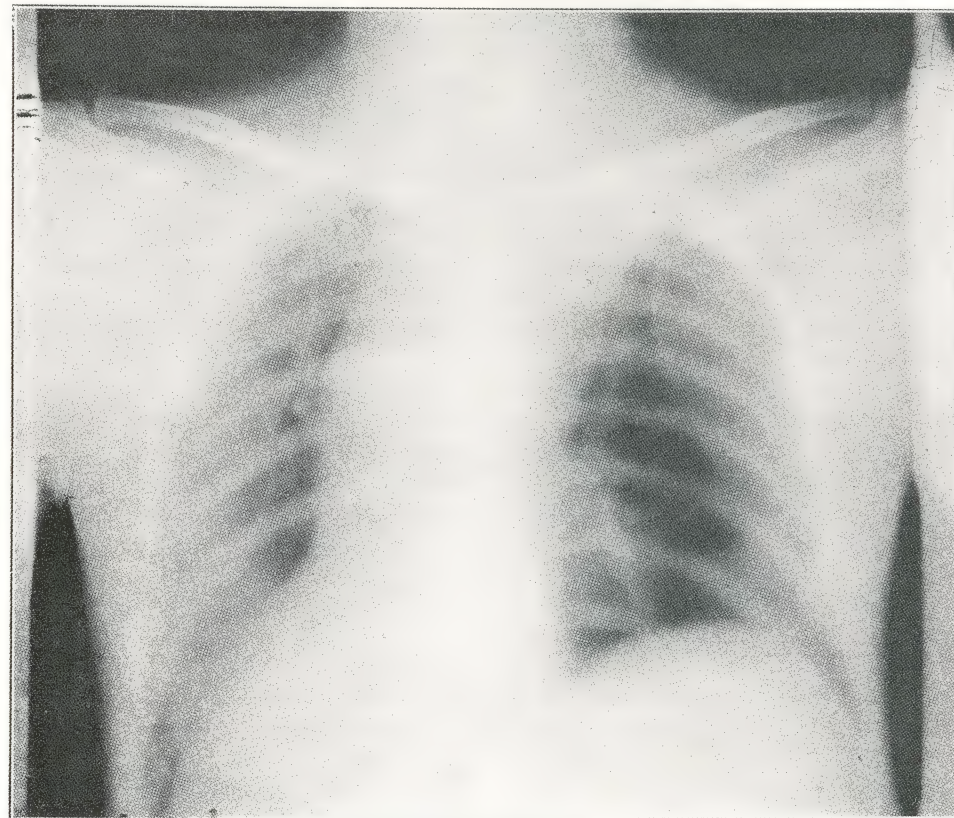
In the examination of aneurism, it is of interest to determine what portion of and to what extent the aorta is involved, and to observe the pressure effects upon the trachea and oesophagus, the latter points being of obvious value as an indication of treatment and prognosis. In this connection, it may be mentioned that dysphagia may indicate aneurism, and that the stomach tube should not be passed until the possibility of aneurism is eliminated. The size of an aneurism is not a true index to the gravity of the case; and a guarded prognosis is always justifiable. I recall a case of a very large aneurism of the innominate, with also a marked dilatation of the arch. The trachea could be seen displaced far to the left and almost completely collapsed. Of course, the patient was suffering from extreme dyspnoea, with the cyanosis constant and at times so extreme as to presage complete suffocation. This patient was a prominent, unmarried clergyman who claimed a negative venereal history. After heroic antiluetic treatment and a few months of absolute rest, the patient was able to get about quite comfortably.

The differential diagnosis between aneurism, mediastinal tumor and a pulsating mediastinal abscess is sometimes impossible from the clinical history and the physical examination. In most of these cases, the X-ray examination will determine the diagnosis. As a rule, the shadow of the aorta can be definitely distinguished through the tumor mass. If not, then one must depend upon the character of the outline of the shadow under inspection, upon the nature of the cardiac displacement in reference to the size and position of the tumor shadow and upon the fluoroscopic observations regarding pulsation. An irregular, hazy border instead of a sharp fairly regular outline; a lateral or downward displacement of

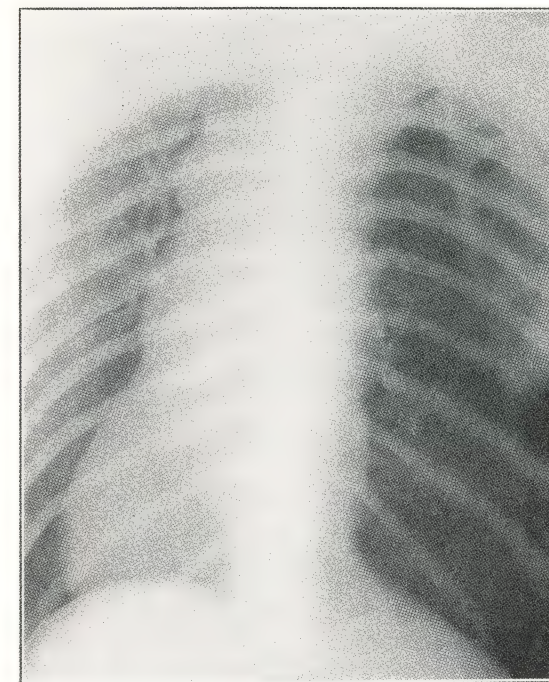
the heart rather than a rotation of the base downward; the presence of a pleural effusion, are indications in favor of a mediastinal tumor. On examination of the bismuth visualized oesophagus, the presence of a primary oesophageal carcinoma may be shown with the characteristic irregular compression of the lumen. In aneurism the oesophageal pressure is usually most marked at the level of the aortic arch. A correlation of the radiographic and physical signs, and the clinical history should enable one to give the correct diagnosis. The mere determination of the exact size of the mass may eliminate the probability of aneurism when considered in conjunction with the symptoms; it is possible to have a very large

mediastinal growth with very few symptoms. This can rarely be said regarding aneurisms.

With mediastinal abscesses, other than those from spinal caries, I have had no experience, nor have I seen any radiographs showing them. A careful correlation of all available data, together with thorough fluoroscopic examinations should assist one, as a rule, to make the diagnosis by elimination. But in an occasional case, it is impossible to give a definite opinion. The following description concerns a case of this type. The radiograph showed an enormous irregular mass in the superior mediastinum. The heart was rotated downward. The outline of the tumor was ragged. The mass was too dense to show an aortic



Aneurism of innominate, also of aorta. Plate shows compression of trachea by innominate heart displacement downward.



Mediastinal lympho-sarcoma.

shadow through it. The patient had been up and around, at the time of the examination, but had lost considerable weight, had coughed for some months and had been expectorating pus. He had an afternoon temperature of $99\frac{1}{2}$ to 100—his white count was about 12,000. Physical examination revealed pulsation, but no bruit or diastolic impact. It and the history pointed more to abscess than to aneurism. An exploratory needle was introduced and a small amount of pus withdrawn. This seemed final, although the radiographic findings were more in favor of aneurism. Upon opening the chest, a small amount of pus was found, but further exploration with the finger resulted in a terrific hemorrhage that revealed the true nature of the condition. The post mortem showed that the aneurism had eroded through the right bronchus. The tracheitis and subsequent infection of the surrounding tissues explained the recorded indications of pus, as well as the peculiar ragged outline of the radiographic shadow.

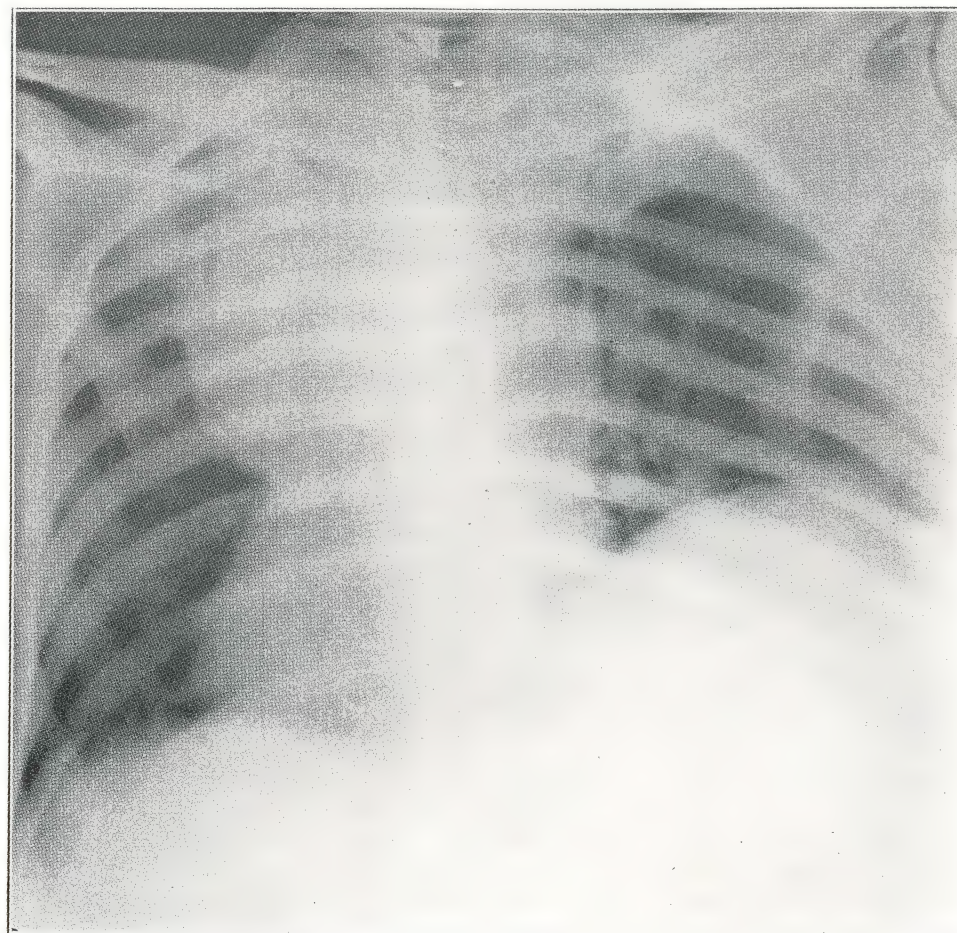
In regard to abscesses from tuberculous spinal caries, those I have observed were fusiform, bilateral, and narrowed gradually down to the diaphragm. The semi-lateral radiograph shows up the diseased spine most satisfactorily. In this connection, I wish to emphasize the occasional occurrence of caries of the lower dorsal vertebrae as the cause of severe pain in the upper abdominal region, without local pain or kyphosis to give intimation of the seat of trouble. I recall a case in which there was severe tenderness over the right kidney area with sharp pains which came on especially when the patient stood up. These pains radiated to the anterior abdominal region, and were associated with pus in the urine and pain on micturition. These symptoms naturally caused the attending physician to suspect renal calculus, and he referred the case to us for an examination of the right kidney and ureter. The radiographic findings were negative. About a month later, the patient was sent back again with the request for us to make a diagnosis, covering both kidneys and whatever else seemed advisable. The patient now complained of occasional pains on the left side. The radiographs of the left genito-urinary tract as well as those of the right were negative. After considering the various possibilities, including tabetic crises, we decided to radiograph the lower dorsal spine. The plates showed spinal caries, with only the slightest trace of kyphosis. The pains were due to pressure upon the spinal nerves. Extension of the spine and immobilization relieved the patient of pain. The urinary findings were simply due to a co-incident cystitis.

The most frequent mediastinal growth is a lympho-sarcoma. The primary indication may be simply a complaint of a feeling of substernal pressure. The radiograph may show a very extensive growth. The differentiation between malignant mediastinal neoplasm and enlarged mediastinal glands will depend somewhat upon the anamnesis, though usually the X-ray will give definite information. In cases of mediastinal sar-

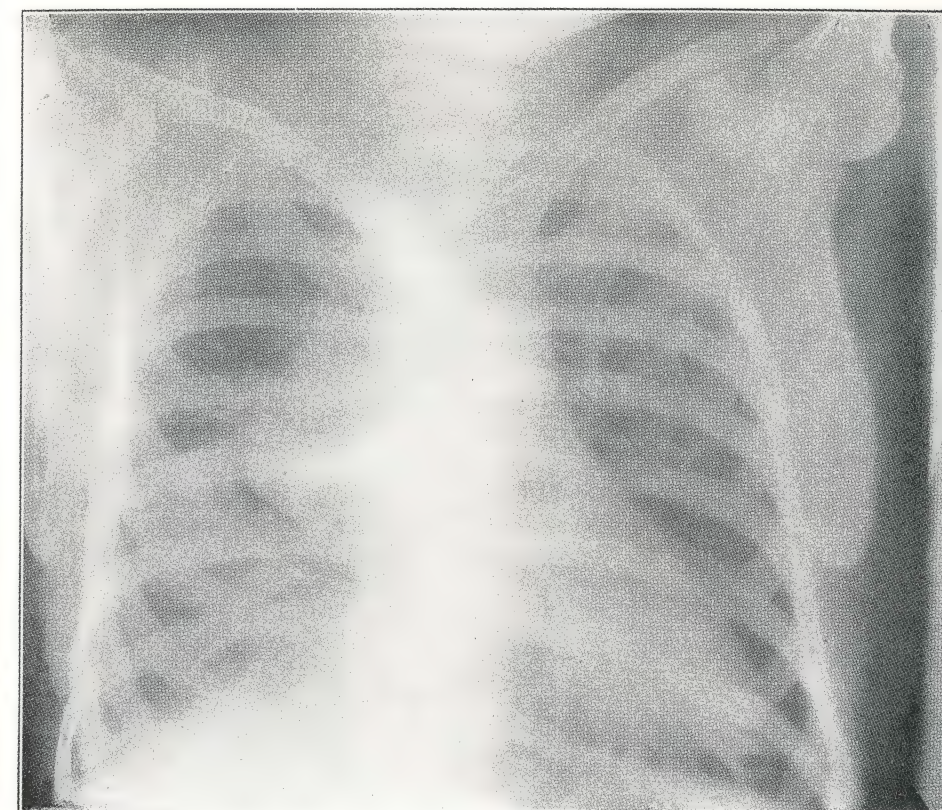
coma, there may be observed distinct indications of irregular involvement of the adjacent tissues. Another indication is the finding of a pleural effusion, or the large rather undefined shadows of metastatic deposits in the lung tissue. The differentiation of tuberculous mediastinitis is sometimes possible from the peculiar mottled appearance of the posterior mediastinum, with numerous small calcified foci. This may be found without any definite evidence of pulmonary involvement. Syphilitic involvement occasionally may be diagnosed by the extensive density of the hilus and mediastinal tissues, associated with aortic dilata-

tion or lengthening. The lack of calcification of the small glands may be noted. The effect of antiluetic treatment may give a therapeutic diagnosis if comparative plates are made. In doubtful cases, when no history is obtainable and the Wasserman reaction negative, this method may be of value. In Hodgkins disease, the involved glands are apt to be quite large and discrete.

A marked broadening of the superior mediastinal shadow, regular and clearly defined, usually bilateral, even if not symmetrical, with narrowed or displaced tracheal shadow suggests substernal thyroid. The radiographic appearance of an intrathoracic



Mediastinal tumor. Shadow of aorta can be seen through tumor mass. Enlargement of liver shadow.



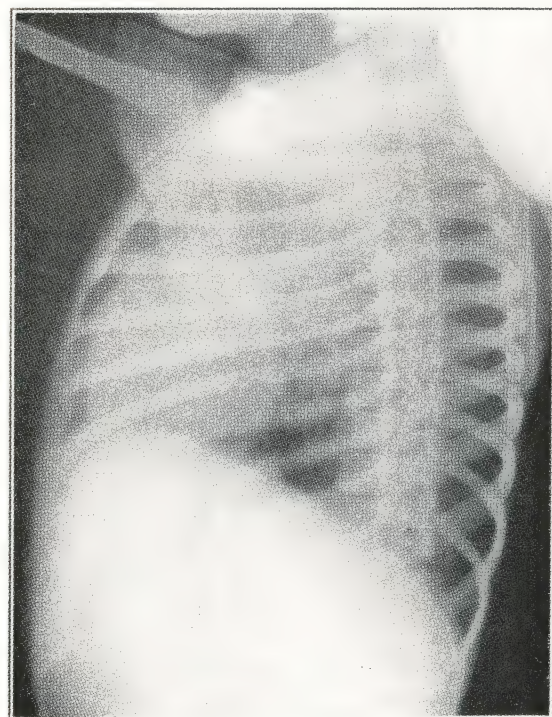
Mediastinal tumor. Irregular border on right side. Heart displaced.

goitre depends upon whether the substernal thyroid is the extension downward of the supraclavicular gland, or the development of a substernal lobe or accessory thyroid. In the first case the substernal shadow broadens as it approaches the clavicular level and continues into the less distinct supraclavicular shadow. In the second type, wherein the growth is primarily that of an intrathoracic gland, the shadow converges to the median line as it approaches the upper level of the sternum and extends downward convexly, in marked cases overlapping the upper part of the heart shadow. The shadow may be distinctly median and symmetrical, or it may be laterally unsymmetrical depending upon which and to what extent the lateral lobes are enlarged and furthermore upon their respective levels. When

the lateral lobes are particularly involved, the shadow of the compressed and possibly laterally displaced trachea should be observed. If the lateral enlargements are at different levels, the trachea may be flattened and squeezed into an elongated S-shape. If the median lobe is especially enlarged, the compression of the trachea may be observed in the semi-lateral view. The contour is sharply outlined and regular if the mass is not malignant. The heart is displaced downward in proportion to the size of the tumor. The aortic shadow may show displacement to the left. Upon fluoroscopic examination, it should be possible in most cases to differentiate the aortic shadow from that of the tumor by observations during deglutition which raises the thyroid shadow, or during deep respiratory efforts in which "the goitre

goes downward with deep inspiration and upward with expiration," according to Dr. Bowen in his paper before the last session of this Society. At the same time he brought out the fact that fluoroscopy during deep respiration might bring into view a small tumor otherwise not demonstrable. Altogether, either by fluoroscopic or thorough radiographic methods, it should be possible in practically every case to demonstrate the shadow of the aorta as a continuous entity separate from that of the tumor.

The shadow of a persistent thymus is not apt to extend so high, but more apt to extend lower, onto the cardiac shadow and is usually less dense than that of a thyroid though occasionally the antero-posterior dimension may be enough to cast a very dense shadow. The lateral boundaries are parallel or divergent from above downward with the edge quite distinct and regular. Upon



Enlarged mediastinal glands.

a semilateral view, the shadow can be definitely located in the anterior mediastinum.

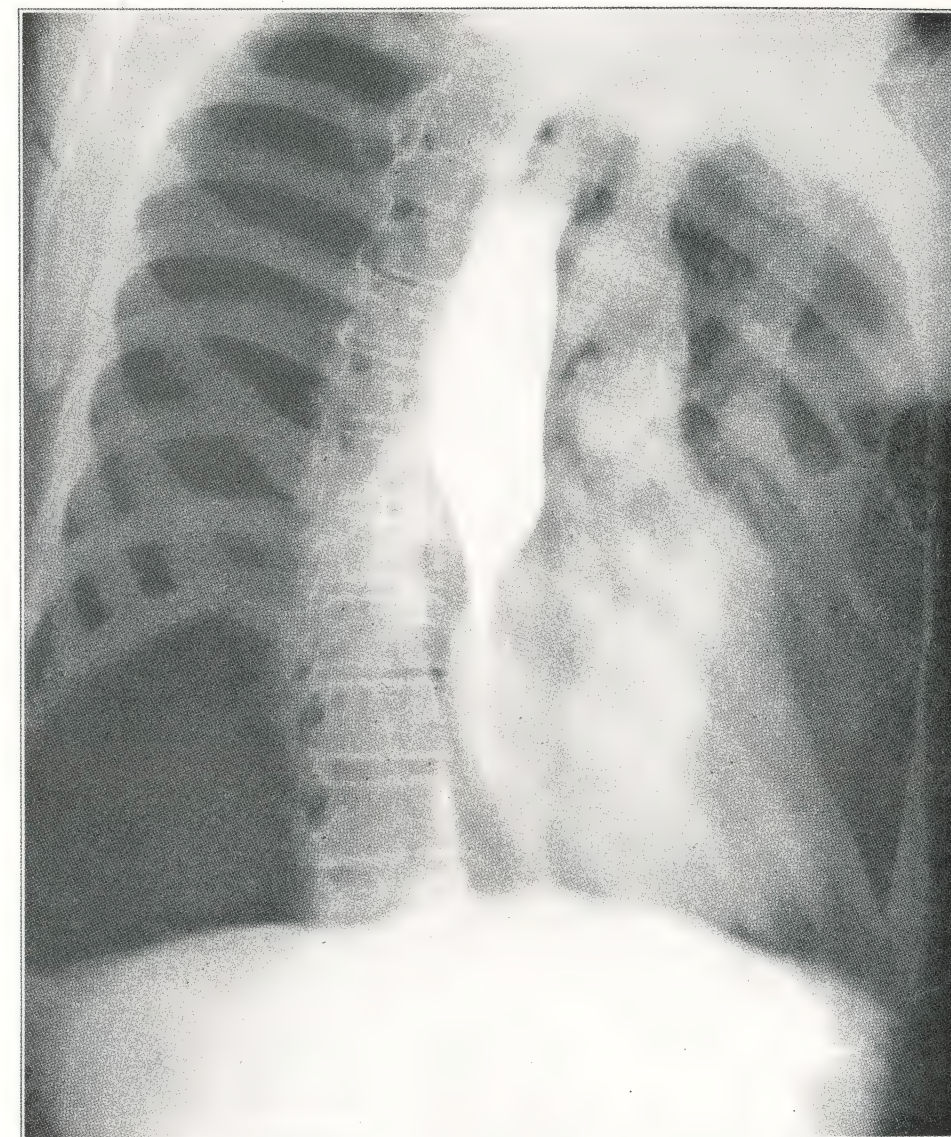
The lesions of the oesophagus that must be considered are:

1. Stricture by outside pressure such as aneurism or tumors.
2. Stricture from primary oesophageal growth, i.e. malignant.
3. Stricture from non-malignant causes, such as ulcer.
4. Oesophagospasm or cardiospasm.
5. Diverticula.

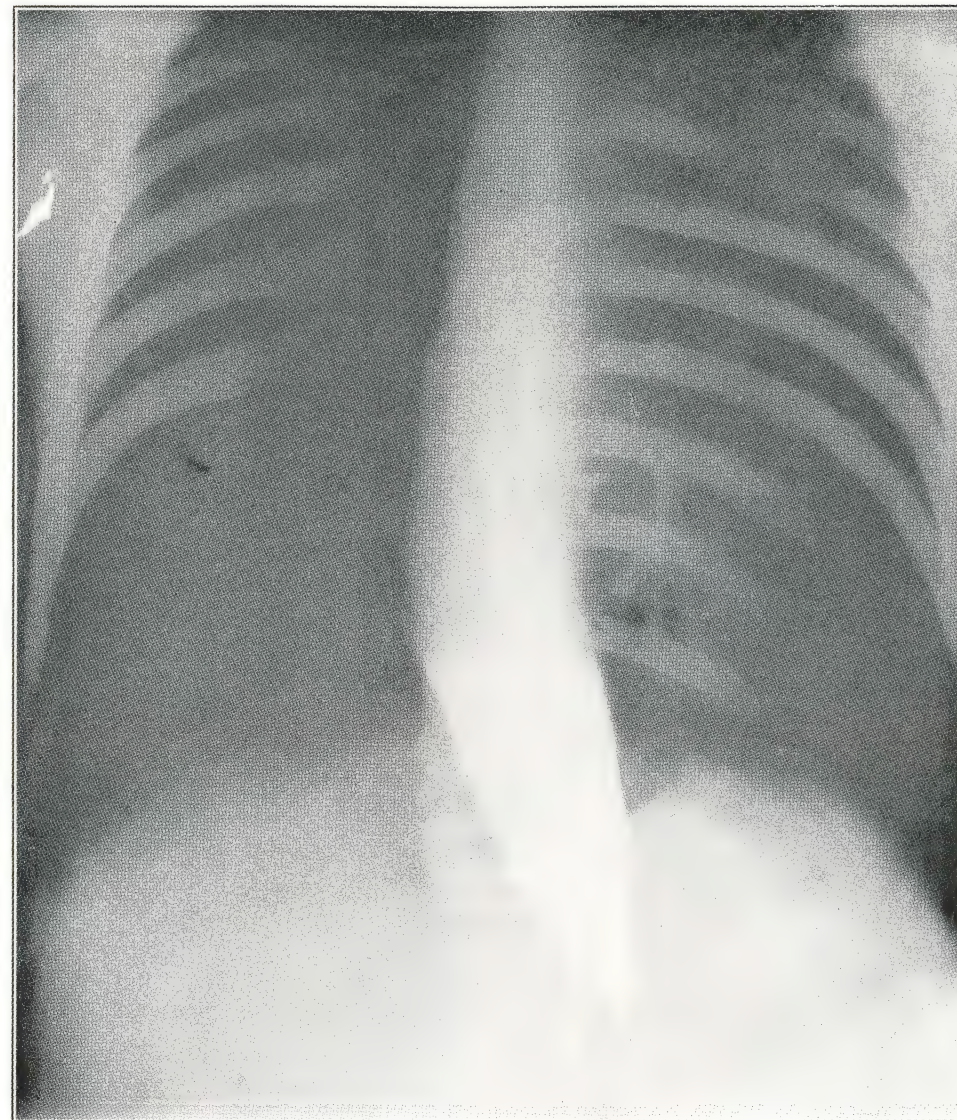
In aneurism, dysphagia may be the first symptom. The compression is at the level of the aortic arch, at which point there is normally a slight amount of indentation of the oesophageal wall. In primary oesophageal carcinoma, the bismuth can be seen seeping, in an irregular line, through the shadow of the tumor of the oesophageal wall. If the tumor is primarily a sarcoma of the lymph-glands, the tumor mass itself can be observed and occasionally the unilateral, irregular compression of the oesophagus. In oesophagospasm or cardiospasm, the marked dilatation of the oesophagus is seen, with the clear, regular and concentric contraction of the bismuth shadow, which is characteristic. The appearance of diverticula is usually typical, and not to be mistaken, if examined from the angle that shows its saccular shape.

Other lesions that may be found in the mediastinum are dermoid and echinococcus cysts. In regard to dermoid cysts, the finding of a tooth or a piece of bone in the tumor would make a positive diagnosis.

In conclusion, I wish to emphasize a few points that seem of value, and to repeat the dictum that a correlation of the anamnesis, the physical, and laboratory findings and the X-ray examination constitute the proper method of procedure, with the added statement that the X-ray examination is the method of choice to detect or eliminate the presence of intrathoracic pathological processes, the others being occasionally neces-



Carcinoma of oesophagus. Bismuth can be seen trickling through the lumen in the tumor mass. Irregularity of lower end of bismuth shadow.



Marked symmetrical dilatation of oesophagus from cardiospasm.

sary to determine the nature of the process, and always necessary in corroborating and amplifying the diagnosis.

The points that seem worthy of being included in a summary of the value of X-ray examination of the mediastinum are:



Side view Front view
Diverticulum of oesophagus.

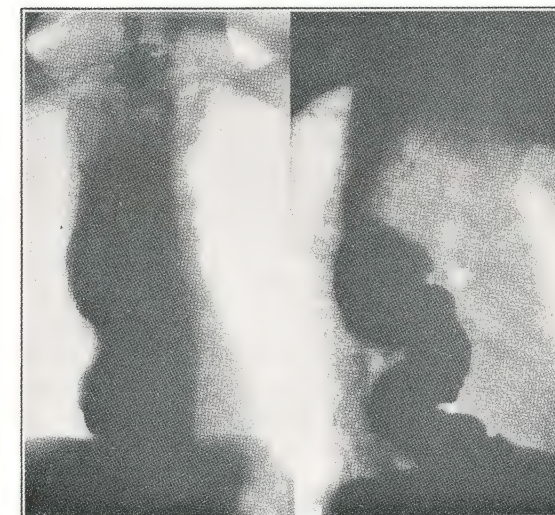
1st. The position of the mediastinum gives information of the presence of extra-mediastinal conditions.

2nd. The semi-lateral projection is of distinct value, to study the bodies of the thoracic vertebrae, to study the anterior and posterior mediastinal contents.

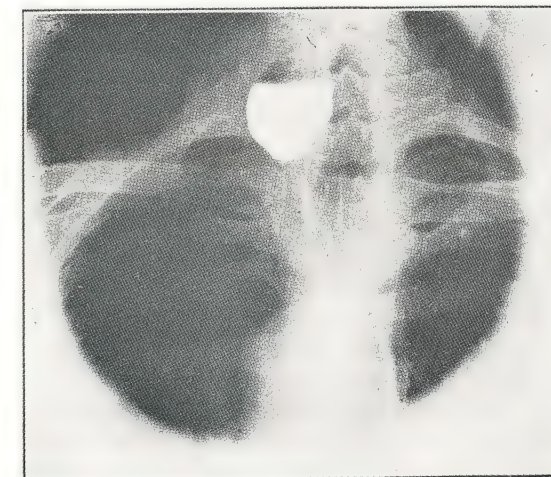
3rd. The outline of the aorta should show up in most cases, even through a superimposed shadow, enough to differentiate between aneurism and other mediastinal tumors.

4th. A careful study of the visualized oesophagus will often help to clear up an obscure diagnosis.

5th. The rotation of the heart toward a transverse position without evidence of any definite mass to produce this displacement indicates lengthening of the aorta, due to aortitis, practically always specific.



Marked dilation and lengthening of oesophagus
from cardiospasm.



Diverticulum of oesophagus.

X-RAY WORK IN THE ARMY WITH STATIONARY MACHINES

CAPT. ARTHUR B. CHRISTIE, U. S. A.

The immense value of the X-ray to the military surgeon was recognized at an early date. During the English-Boer war it was used extensively at stationary hospitals and on hospital ships, and in all of the other great wars down to the present time it has played an important part. In war time in the field of active operations the use of the X-ray will necessarily be limited quite closely to the investigations of gunshot fractures and the localization of foreign bodies. In time of peace, on the other hand, and even in the time of war at the base and general hospitals, X-ray work in the army covers about the same field as in civil practice.

So far as equipment is concerned, the army has passed through the same gradual evolution and series of changes that have marked the general advance of the art. The static machine, only a few of which were installed, was soon replaced by the coil. When the transformer began to come into general use all of our important posts and many of the smaller ones were equipped with some form of coil apparatus. These machines were of many different makes, some operating on direct, others on alternating current, and occasionally at posts not having an electric supply, the coil was actuated by a gas engine and dynamo. Many of these coils with electrolytic or mercury interrupters are still in use and it is believed that they will be found perfectly satisfactory for many years to come at small posts where nearly all the X-ray work consists in examination of the extremities for fractures.

During the past two years the Surgeon General has been purchasing transformers and at the present time about twenty-five of the most important posts are equipped with these machines. It is the intention of the Surgeon General to furnish machines

of the transformer type to all of the important posts, but this will necessarily take some little time, since the amount of money available each year for this purpose is limited. The machines already installed are standard makes of three different well-known manufacturers and all of them have been found to do satisfactory work. It has been found possible to obtain an alternating current supply at the majority of posts, but even with direct current the transformers do good work, especially on the 220 volt current. It is not believed that the newer type of machine with three transformers giving the triphase current will be found practical in the army, not only because of its high initial cost and large size, but also because of its complicated construction and consequent liability to get out of order. Simplicity of construction is a very important desideratum in X-ray machines intended for army use. The special reason for this is that the Army Medical Corps is small and the number of officers constantly on foreign service make frequent changes of station necessary. That which seems so desirable to you—a specialist at each post who would have only X-ray work to do is absolutely impossible in the army in time of peace, both because of the small number of medical officers, and because of the fact that there are only a few hospitals at which there is sufficient X-ray work to occupy all of a man's time. It seems, therefore, that the only way in which it is possible to have enough doctors trained in X-ray work so as to provide for the large number needed in time of war is to give every one who enters the Army Medical Corps a course of instruction in this work. The object is to give every man in the corps a thorough knowledge of the fundamentals of the work so that when called upon he will be able in a comparatively short time to do

satisfactory work in the diagnosis of fractures and the location of foreign bodies.

To enter the Army Medical Corps it is necessary for a candidate to take a course of instruction at the Army Medical School and one of the subjects taught at that school is X-ray work. The course in this subject covers a period of five months, one and one-half hours per week. During this course the student becomes thoroughly familiar with the construction of the various forms of apparatus used in X-ray work, including coils and high potential transformers, as well as the special apparatus used in field work. Each student constantly takes and develops radiographs of all parts of the body, the aim being to make the course as practical as possible.

The final month of the course is given to the study and interpretation of radiographs. There is now being established at the Army Medical School a very extensive library of stereoscopic and lantern slides of radiographs covering all lesions in which radiographs are of use. These slides have been contributed by prominent radiologists of this country who have done notable work along certain lines. A study of these slides and of the plates on file at the school gives the student considerable facility in inter-

pretation of radiographs. The student leaves the school with a good basic knowledge of the use of the X-ray in diagnosis, and although he may not be stationed where he can do special work along this line he will still have sufficient knowledge of it to be able to do the limited work that is necessary in time of active service or the necessary work at a small post. Some few men who show special inclination for X-ray work will find opportunity at the larger hospitals to perfect themselves in it, but as I stated before, the desirable thing in the army service is to have as large a number of men as possible trained in the essentials of X-ray work so as to provide a sufficient number to do the necessary work in time of war.

In conclusion, I wish to thank the members of this society for their kindly interest in the progress of X-ray work in the army. Army medical officers, interested in this work, have been given a most cordial reception by you, and through the personal assistance of many of the members of this society, have been enabled to keep abreast of the advances in radiology. It gives me great pleasure to thank you in behalf of all the members of the corps who have profited by observing your work and who have been benefited by your larger experience.

THE STOMACH AS A REFLEX ORGAN

By A. W. CRANE, M. D., Kalamazoo, Mich.

No achievement of the X-ray since its discovery by Roentgen has made so strong an impression upon surgeons and internists alike as the examination of the stomach by the bismuth method. The subject has grown rapidly in importance notwithstanding numerous startling errors in interpretations revealed at operations and autopsy.

Barclay, in his recent and masterly monograph on the stomach, candidly stated:—"I have been present at as many operations as possible X X X. The opinions I gave as the result of the X-ray examinations were as often wrong as right, and in many of the failures of diagnosis it seemed that I was hopelessly beside the mark; so much so, that at times I had little confidence in the work and little hope of ever becoming successful, the results were seemingly so contradictory."

He finally gained a high degree of accuracy in the interpretation of X-ray findings by looking for causes of gastric phenomena outside as well as within the stomach walls. Monahan has expressed himself as believing that most of the stomach pathology is secondary to causes beyond the stomach. In one of my own cases, the slide of which I will show you, Dr. Wm. J. Mayo, at the operation a few days ago developed at some length the view that the stomach is the alarm box of the abdomen, that the fire is often elsewhere in the peritoneal cavity, and that the water is too often turned upon the alarm box instead of upon the real conflagration. The particular case which called forth this clinical lecture was a case of pylorospasm with marked stomach distress after meals, daily regurgitation of food, constant six hour residue, hypertonus and tenderness in epigastrium. Operation showed a stomach free from all pathology, but an appendix buried in adhesions and showing unresistable involvement. The post opera-

tive diagnosis was Appendiceal Pylorospasm. At the same time Dr. Mayo paid the X-ray examination of the gastro intestinal tract a most glowing tribute, and said that it was becoming a means of inestimable value in diagnosis.

The stomach as a reflex organ responds to many pathologic foci within the body. The most important of these concern the appendix.

The gall bladder, the bile ducts and the duodenum. Also abscess of liver, constipation, taxatemias, partial or complete stenoses, and in women, gynaecologic and obstetric affections bring about marked gastric disturbances.

Barclay gives some most remarkable instances of persistent hour-glass contractions with distressing symptoms which, on operation, were non-existent, yet which recurred after operative recovery, and proved to be due to decayed teeth and oral sepsis. We all know the temporary susceptibility of the stomach to reflexes from the eyes, ears and nose; the sight of disgusting food, certain remarks, or odors of various kinds being potent to set up gastric contraction pylorospasm and relaxation of the cardia.

The reactions of the stomach to reflex influences from without are manifested by cardiospasm, pylorospasm, hour-glass contraction, increased and decreased peristalsis, incisura, change in stomach outlines, changes in position of pyloric antrum and alterations in the character and quantity of the gastric juice. For example, in chronic cholecystitis with or without gall stones, it is common to find the pylorus antrum advanced to the right so as to overlies the gall bladder. At the same time there will be found a hyperchlorhydria with hypertonus, increased peristalsis and rapid emptying of stomach.

As a sequel a gastric ulcer may form, with a six-hour residue, etc., or duodenal ulcer may form with greatly accelerated peristalsis and very rapid emptying. In two cases of liver abscess and one case of sarcoma of liver in my own practice marked pylorospasm was induced with fractional vomiting after meals, so that all three patients came in for relief of stomach symptoms.

Examples could be multiplied, but the point is made that as Roentgenologists we must be careful to differentiate between true organic diseases of the stomach and the reflex manifestations of disease located outside of the stomach. The examination by the Roentgen Rays of the gastro intestinal tract is thus clearly indicated in the diagnosis of many extrinsic abdominal affections.

The Roentgenologist is made a true clinician whether he would be or not, and must bring to bear in the interpretation of his findings all the knowledge and experience which he can gather.

Reflex stomach disturbances long enough continued finally give rise to actual organic

stomach disease. La Roque, in the October, 1913, number of the *American Journal of the Medical Sciences*, gives a wonderful survey of the work on chronic ulcer of the pylorus duodinal and gastric secondary to appendicitis colitis, bile-tract infection and other foci of infection within the area drained by the portal vein. In this same number of this journal is also found the splendid article by Baetjer and Friedenwald on the X-ray diagnosis of ulcerated stomach and duodenum.

MacCarty (in 1910) Mayo clinic found 26.9 per cent of gastric ulcer associated with chronic appendicitis. In the Augustina Hospital during 1910 and 1911 out of 79 cases of gastric ulcer 35 had chronic appendicitis and 14 had bile-tract infection. Mitchell found 19 out of 48 cases of pyloric ulcer associated with chronic appendicitis. In 1910 and 1911 Moynihan, out of 62 cases of gastric and duodenal ulcer, found 25 with chronic appendicitis, 6 with bile-tract infections and 2 with both appendicitis and cholecystitis. Out of another of Moynihan's series of 34 cases of ulcer 21 had chronic appendicitis.

THE VALUE OF ROENTGENOGRAPHY IN THE PROGNOSIS OF TUBERCULOUS BONE LESIONS

By ROLAND HAMMOND, M.D.,
Providence, R. I.

When we are dealing with a disease of such long duration as bone tuberculosis, it is necessary to employ every means at our command to ascertain the progress of the disease, whether favorably or otherwise. In a general way the clinical symptoms offer a fairly accurate guide to the condition within the joint. In tuberculosis of bone, as in pulmonary tuberculosis, improvement is noted in the general condition of the patient, before any change is apparent in the specific body tissues in question. Thus improvement in a case of tuberculosis of the hip-joint, for example, is shown by a diminution of the spasm in the muscles adjacent to the hip, by a lesser degree of pain, by increased excursion of movement in the joint, and by improvement in the general condition, as denoted by increased weight, color, appetite and sleep.

Following these changes in the patient's condition, at an interval of several weeks, an improvement in the bone may be observed by Röntgen examination. Islands of bone are seen in the diseased area, the appearance of atrophy is being lost, the lime salts are coming back.

In favorable cases this condition continues until we have the dense healing osteitis with which you are all so familiar. On the contrary, the cases which go on to an unfavorable termination, show a progressive increase of radiability, until, in many cases, the shadow of the bone is hardly to be differentiated from that of the surrounding soft parts.

In these two classes of cases, the Röntgen examination merely confirms the clinical findings, and we proceed in the treatment of the case with more confidence, from having

at our command a valuable laboratory aid in the shape of the Röntgen ray to guide us in the right direction.

There are other cases, however, in which the Röntgen examination is indispensable in helping us to form an accurate idea of the probable outcome of the case. I well re-



Fig. 1—Case 2—Tuberculosis of right hip. The neck of the femur is wasted to a stem, and is an insufficient support for weight bearing.

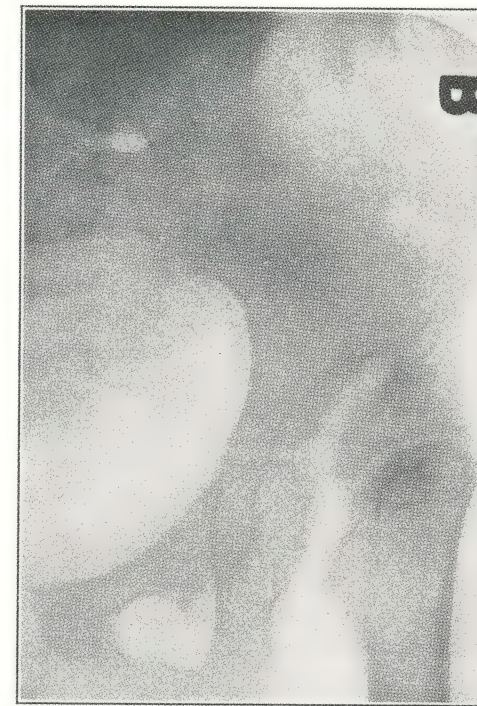


Fig. 2—Case 2—Tuberculosis of right hip. Condition one year later than Fig. 1. The neck of the femur has become rounded off, and weight bearing may safely be allowed.

member a case of tubercular hip in a girl of 15, which had run a severe course for three years, but seemed about to terminate favorably. The general condition of the patient had improved greatly, and the examination of the joint itself showed every symptom usually associated with healthy repair processes. As a precaution before omitting apparatus, a röntgenogram was made. The bone was marked atrophied, and in places could hardly be distinguished from the surrounding soft parts. The apparatus was continued, the girl was sent to the seashore, and every precaution used to prevent further unfavorable progress. She continued to fail, however, and died three months later. Had the apparatus been omitted, and the patient allowed to walk on the badly diseased limb, we should have blamed ourselves unjustly for precipitating fatality. With the knowledge obtained by

the Röntgen method, we know the condition was already progressing to an unfavorable outcome.

In another patient (Case 2) with tuberculosis of the right hip, the neck of the femur had wasted to a mere stem. Before allowing weight bearing, we followed the repair process over a period of months by a series of plates, until the trochanter was seen to approach the acetabulum, and a cure resulted. This patient is now walking without pain, but, of course, with a short leg.

Case 3, a girl of ten, shows extensive disease of the femur and acetabulum, extending quite a distance into the wing of the ilium. A röntgenogram one year later shows the repair process well advanced in the ilium, as well as in the hip-joint itself.

Case 4, a boy of eight with tuberculosis of the hip, shows the condition a few weeks before a fatal termination. The

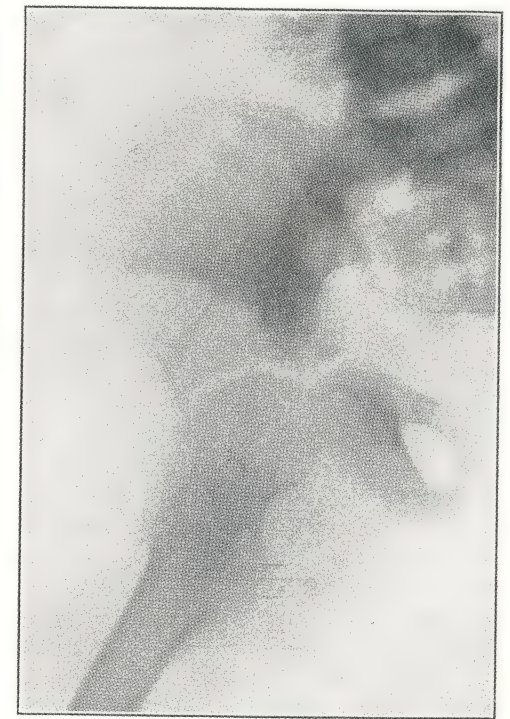


Fig. 3—Case 3—Tuberculosis of left hip, acetabulum and ilium. Condition in 1911, showing extent of disease.



Fig. 4—Case 3—Tuberculosis of left hip, acetabulum and ilium. Condition one year later than Fig. 3, showing healing ostitis especially well marked in the ilium.

bone shadow is but slightly denser than the surrounding soft parts. Cases 3 and 4 were accompanied by abscess and sinus formation. They confirm the clinical findings, favorable in Case 3; unfavorable in Case 4.

Similar observations have been made on other joints, but the hip has been selected in this case because of the abundance of material and the accessibility of this joint to frequent Röntgen examination during the course of tuberculous disease.

Conclusions: In many cases of tuberculous bone disease, the Röntgen ray, used at frequent intervals, gives us an accurate idea of the progress of the disease, and confirms the clinical findings, whether the disease be progressing towards a favorable or an unfavorable termination.

In other cases it reveals conditions unsuspected from the clinical condition. We are thus enabled to proceed more intelligently in the treatment of the case than would have been possible if this laboratory aid were not employed.

THE INFLUENCE OF THE ROENTGEN RAY UPON RAYNAUD'S DISEASE

By WM. S. NEWCOMET, M. D.

Clinical Professor of Roentgenology and Radiology at the Temple University, Philadelphia, Pa.

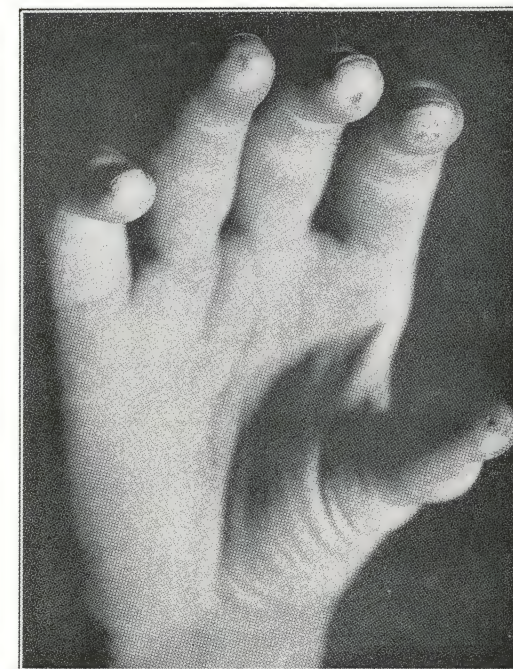
A little over five years ago, when the first patient of this disease came under observation for treatment, the prompt relief from pain as well as the healing of the ulcers was regarded as one of those fortunate accidents that we now and then observe in the practice of radiotherapy. Just why the X-Ray should have any influence upon this disease would be like many more in our field—extremely hard to answer.

The pathology, to be sure, is obscure. Some believe it to be due to some influence from the ductless glands, while others the actual condition of the capillaries: either a vaso motor disturbance or an actual degen-

eration of the walls of the vessel. However, the nature of this disease is not understood and furthermore the diagnosis is often doubted, especially if the patient recovers.

For the reasons stated, very little thought was given to the first case until the early part of the present year, when the second case was referred for treatment and the result was just as prompt and equally gratifying.

Unfortunately, the notes of the first case are rather meagre. On December 28th, 1908, Mrs. T., wife of a well known physician of our town, was referred to me by her husband for X-Ray treatment of the tips of her fingers, for the relief of pain. The patient had been a sufferer for several years and the ordinary treatment failed to give any relief; narcotics were employed, with the usual discomfort. From time to time these ulcers would heal, but there was always more or less discomfort which was (more or less) aggravated by cold. Treatment was given with the full understanding of the risks, but both the patient and her husband were anxious to assume all responsibility for the sake of the relief from pain. One or two fingers were treated at a time with a very mild old tube. After the fifth treatment considerable relief from pain was manifested, and then another was treated in the same manner until all the ulcerated spots were covered. At no time was there any reaction and in about two months most of the ulcers had healed. Then the patient insisted upon the treatment of all her fingers, stating that those healed under the influence of the X-Ray felt so much better; even when the hand was placed



Dr. R. Right hand. Showing ulcers upon the finger tips, before treatment.

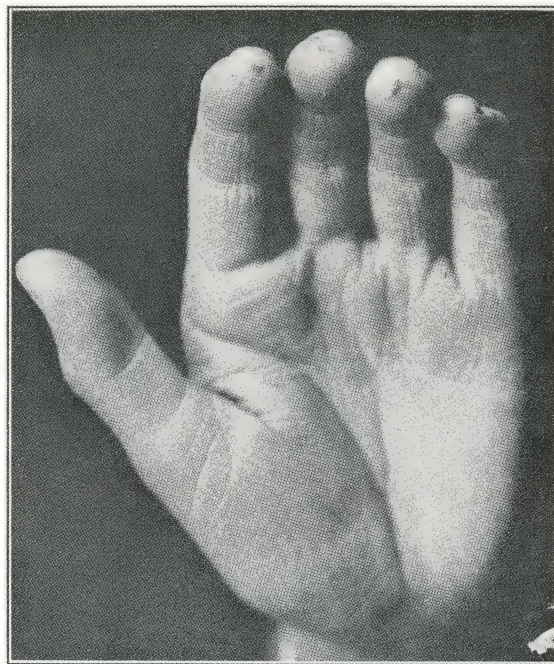
in cold water, there was not the tingle as in those that, as she expressed it, were only temporarily healed. The treatment was continued for a period of six months at irregular intervals, and then stopped; since that time there has been no recurrence.

The second case differs somewhat from the first in its clinical history, age and sex, and while there has been some doubt cast upon the diagnosis since the ulcers have healed, it was not considered before, although he had traveled over several states and was considering the suggestion of one of our western surgeons for cutting the nerve supply to the suprarenals; happily, the operation was not carried to an issue for since he has so greatly improved the diagnosis has been changed to scleroderma, which to some extent must be admitted, as can be seen from the history. This, however, is not the point at issue and the ulcers that at least resembled those of Raynaud's healed promptly and the hope is that his subsequent history will be as agreeable as the first instance.

On March the 12th, of this year, Dr. R. reported for X-Ray treatment. The condition of his hands was most peculiar; from above the wrists to the tips they were stony, all of the joints were fixed and the general feeling was that of a wooden model. The tips of the fingers were elevated somewhat, very white and on the apex of this dome-like elevation was a deep ulcer extremely indolent in its character. The usual history of spontaneous healing, with subsequent breaking down, was given and at that time the tips of first, second and third fingers of the left hand were ulcerated with the pit-like scars upon the thumb and little finger on the right hand. The thumb, second, ring and little finger were ulcerated while the crusts had just fallen from the index finger. The condition was painful, but there did not seem to be the same neuralgic condition as in the first instance.

His family history is negative: general health always good, and while at the Uni-

versity of Pennsylvania during '91 and '92 was a member of the crew. The present illness began in March, 1912, when he complained of a pain in the muscles of the chest and thought it was due to an intercostal neuralgia induced by exposure and overwork. About a month later he noticed that his hands were stiff and swollen; this gradually increased, and three months after the onset the ulcers developed upon the tips of the fingers. The condition continued with more or less regularity, modified at



Dr. R. Left hand. Showing ulcers upon the finger tips, before treatment.

times with the involvement of different joints and a change in the location of the stiffened areas over the body. The condition of his bowel, urine and blood were normal. Treatment began on Nov. 12, '12, by the exposure of the hands and wrists, the tips being held toward the tube. Two or three treatments a week were given and continued until May 2, '13, and while no record was made of the amount of radi-

ation at that time it was equal to about one Kienboch unit at each sitting. Healing was prompt and at the time there was some diminution in the swelling.

Considering the radical nature of the operations that are advised for the relief of this condition it would seem that before such procedures are recommended at least a trial of the X-Ray under proper conditions should be given. If we are to believe that

this disease is due to a disturbance of the vasomotors it would seem that the arterio venous anastomosis or the resection of the nerves of the suprarenals could be of sufficient value to relieve the condition. Radiation given in these cases was extremely mild, there was no discomfort and no sequelae. But the unfortunate part of radiotherapy is that those who often give it are the least qualified to carry out such procedure.

INTENSIFYING SCREEN AND SCREEN TECHNIQUE

By H. THRELKELD EDWARDS, M. D.
South Bethlehem, Pa.

Although the intensifying, or reinforcing screen has become such an exceedingly important item in the equipment of the modern roentgenological operating room—its use being absolutely indispensable in gastro-intestinal radiography and in all cases where instantaneous exposures are necessary—and in spite of the fact that nowadays screens are used in some way by nearly every Roentgen worker, I venture to say that the average roentgenologist knows less about the construction, mechanics, modus operandi and care of his intensifying screen than of any other instrument in his possession.

In my correspondence with colleagues regarding screen technique this fact has become very evident. Quite recently one writer remarked, "I am afraid you forget that most of us know nothing at all about intensifying screens, at least I don't, so begin at the beginning."

In order to comply with this reasonable and sensible suggestion which seems apropos of the present occasion, we must briefly consider the physics of the subject, starting with the phenomena of fluorescence and phosphorescence.

FLUORESCENCE AND PHOSPHORESCENCE

The general term "luminescence" has been applied to light which is independent of incandescent heat, and it is divided under numerous headings, according to its nature and origin.

One of these headings is "Radio-Luminescence," which applies to light that is emitted by certain substances under the stimulation of other light, or in some cases of electric radiations, such as cathode rays, etc. Under this heading we find the tran-

sient effect known as fluorescence, which if it persists *after* the exciting cause is cut off, is called phosphorescence.

All substances when exposed to the irradiations from a Roentgen tube emit rays of more or less penetrating power which are of different character than those of the exciting or primary radiation. These secondary radiations, when they occur in the body tissues, Barkla calls "Fluorescent X Radiations." Every chemical element gives out its own peculiar and individual fluorescent X radiation when it is excited by the rays from a Roentgen bulb, just as it has its own peculiar spectroscopic character.

Only a few elements, however, are capable of emitting rays that are visible to our eyes—although the list of chemical compounds possessing visible fluorescent radiation is constantly increasing since expert synthetic chemists have turned their attention to this important subject—one in which roentgenologists are deeply interested.

The actual mechanism involved in creating fluorescence and phosphorescence is still unknown, although a number of plausible theories have been suggested to account for the phenomena.

Probably the arrangement of the molecule and the chemical composition of the element itself is largely concerned in their production, while in the case of the so-called "solid solutions," fluorescence may be caused by the vibration of certain atoms of the solvent which are excited by ether waves to vibrate in unison to the frequencies of the light waves producing the principal color.

Some observers have suggested that fluorescence and phosphorescence may be caused by a certain decomposition of the compound itself, with the forming of

"double salts" which themselves decompose and are again reformed. These changes in atomic arrangement being evidenced by luminescence.

Although we do not know *how* fluorescence is caused, we know that its production depends upon certain conditions and that a constant factor governs the quality of all fluorescent X radiation.

We know that the exciting or primary energy must be of higher frequency and therefore of shorter wave length than that of the fluorescent light it produces.

We also know that the quality and penetrating power of the radiation emitted by any element is in direct proportion to its atomic weight. The higher the atomic weight the more penetrating the fluorescent radiation from it, the shorter its wave length and higher its frequency.

Knowledge of this rule is of the greatest importance to roentgenologists. It supplies us with a working theory and suggests an accurate and scientific method for selecting the proper focus tube for certain therapeutic uses; for instance—a tube with a tungsten target if we desire to use a deeply penetrating ray—or one with a copper one if we wish a superficial effect. In the same way this rule might guide us in selecting a tube for screen work—a Tungsten target tube for *intensifying screens*, or when heavy parts are to be fluoroscoped; a target of lighter metal for the B. P. C. screen, and when examining thin parts of the body.

As before stated, comparatively few chemical elements at present known to us possess *visible* or actual fluorescent radiations when excited by Roentgen rays, and very few of these are useful in roentgenology because the luminescence emitted is either too weak, or the predominating color is not suited for our purpose. Practically we are confined to three elements:

1st—The platinum salts—barium platino cyanide,

2nd—The calcium salt of tungsten—calcium tungstate,

3rd—The zinc salts—zinc silicate, etc., etc.

The first and third—B. P. C. zinc silicate—fluoresce with a yellow-green luminescence under the X-rays, the former has no phosphorescence, while the zinc salts have both fluorescence and phosphorescence. Both of these salts are extensively used for making fluoroscopic screens, but the yellow color of their fluorescence makes them useless, of course, for intensifying screens.

Calcium tungstate, on the other hand, when excited by X-rays, gives a blue-white fluorescence which possesses considerable actinic power, and for this reason it is used in some form or another as the basis of all intensifying screens. Different specimens of calcium tungstate, or CaWO_4 , vary greatly in fluorescent power, and it is exceedingly difficult to prepare a really good fluorescent salt.

I will pass around a small vial of CaWO_4 which is nearly absolutely pure and brilliantly fluorescent. Please notice how exceedingly heavy this small quantity of material is—I have found it to be a fact that the heavier the salt the brighter the fluorescence of that particular specimen. This small specimen of stonelike appearance is a piece of natural CaWO_4 , or wolframite. It is also exceedingly heavy, but is contaminated with iron and other minerals.

INTENSIFYING SCREEN CONSTRUCTION AND MECHANISM.

Intensifying screens are made by mixing some form of CaWO_4 alone, or combined with other chemicals to increase its fluorescent brilliancy, with an adhesive or agglutinant solution, and spreading the mixture upon cardboard, so that it will dry with a smooth surface.

The finished screen is then placed in contact with the glass negative in a light-proof container, and exposed to the rays, with the part to be radiographed between the tube and the screen. The screen re-

ceives the impact of X-rays and is able in some way to appropriate and transmute them into another form of energy. Their velocity is checked, their wave length reduced and frequency lowered—and they reissue from the surface of the screen as blue-white luminescence.

The silver salts in the negative were not able to respond to the bombardment of the original X-ray electrons, but when the screen returned them in the shape of blue-white rays of light, the silver atoms responded immediately, and an instantaneous picture of the tissue penetrated by the X-rays en route to the screen is the final result.

We see from the above that the action of the screen was exactly that of a step-down transformer, in fact, that is what it really is. It absorbs the rapidly moving and short waves of the X-ray, and transforms them into the longer and slower moving waves of visible and actinic light.

This conception of the intensifying screen will, I think, give you the best idea of its mechanism and simplify a correct understanding of the entire subject.

Passing now to the composition of the screen itself, we note a great improvement in construction since the first intensifying screens appeared in this country—imported from Germany several years ago.

The first screens were made from the crystalline salts of CaWO_4 , and were unsatisfactory because the tiny crystals on the surface emitted the fluorescence radiations unevenly, giving a mottled appearance to the resulting picture. At present the amorphous salt is alone used and grain is not so noticeable. This amorphous salt of calcium tungstate must be reduced to the very finest powder, practically impalpable—no small task in itself!

As I stated before the fluorescent quality of every specimen of calcium tungstate depends *absolutely* upon its method of production.

Different chemists use different synthetic methods—producing salts that are identical as far as chemical composition and physical appearance is concerned, but differing vastly in their fluorescent brilliancy.

Except in the preparation of the salt itself, all intensifying screens are practically made in about the same way, viz.: a layer of the fluorescent material held together, and to the cardboard backing, by some agglutinant. They differ, however, very much in the amount of the fluorescent powder used in their construction, some of the imported screens having, relatively, a very small quantity of the expensive ingredient—calcium tungstate.

INTENSIFYING SCREEN TECHNIQUE

A picture made by the aid of an intensifying screen is not, strictly speaking—a Roentgenogram, but a photograph, since the silver salts are not affected directly by the rays from the Roentgen bulb, but are reduced by actinic rays from the screen surface. It may properly be called a radiogram, however, for it is made by radio-luminescence.

In my experience better screen pictures result if the negatives are treated as photographs—landscape pictures, say, rather than roentgenograms, when they reach the dark room.

The best screen plates are those that are rather under-exposed. An over-exposed plate of this kind is an abomination, since it is certain to show more or less grain, no matter how good the screen may be. Moreover, an over-exposed screen negative cannot be developed fully, whereas an under-exposed one will remain in the developer for twenty to thirty minutes and come out full of detail and with clear shadows. Tank development is best for screen-plates and a long sojourn in the fixing bath is absolutely essential for good results.

CASSETTES

Intensifying screens should always be permanently mounted in holders, or cassettes—only in this way can accurate alignment of the plate and screen be secured and the screen surface protected from injurious scratching from the glass negatives, or from contact with objects in the dark room, during the loading and unloading of plates. Moreover, a loose screen is certain to be stained by chemicals and developing materials from contact with the fingers while they are soiled with these solutions, and such stains are, of course, indelible.

The cassette should really be considered an integral part of the intensifying screen. It is impossible to do good work—no matter how perfect the screen may be—if the holder is of wrong design or badly constructed—a good many of the cassettes now upon the market are both.

A good cassette should possess all of the following attributes: It should be light-proof and strong, but not unnecessarily heavy or cumbersome, not more than $\frac{3}{4}$ of an inch in thickness, or $2\frac{1}{2}$ inches over plate diameters in the other dimensions.

The two sections of the cassette should be connected by flexible hinges. If the parts are not thus connected and the screen is fastened to the under part of the holder, it is impossible in the dark room to correctly position the two sections, one to the other, without scratching the surface of the screen against the metal sides of the upper part of the cassette.

The “front” or top—must be of material easily penetrated by the rays and without granular effect upon the plate. If sheet aluminum is used, it should be thin, otherwise detail will be lost and exposure prolonged.

By my tests, black celluloid gives the best results. It is much more transparent to the rays than even the thinnest aluminum, and is without secondary radiations. I consider that celluloid is the ideal covering

for the smaller size cassettes, but with large ones it is difficult to prevent warpage in hot weather.

One of the sections should contain a recess for the plate; this should be well defined so that correct alignment of the negative will be automatic.

Adequate compression must be provided between the two sections so that adjacent surfaces of the screen and plate will be in absolute optical contact at all times. This may be accomplished by springs inside the cassette, or outside—attached to the back.

Provision must be made for variance in the thickness of the glass negative. A layer of felt $\frac{1}{8}$ " or more in thickness is best for this purpose—the felt being attached to the lower section of the cassette—with the screen itself permanently fixed to the felt. If the cassette is made of aluminum, a sheet of lead or “X-ray metal” the size of the plate should be mounted behind the screen in order to prevent fogging of detail by secondary radiations which the aluminum back fails to intercept and which in consequence are returned to fog the negative.

Cassettes should be made for only one size plate: if small plates are used with large screens, the sharp edges of the former will surely cut and scratch the surface of the screen.

In case of emergency, however, one may construct from cardboard of the same thickness as the plate a frame to surround the latter. The plate with its cardboard frame is placed in the plate section of the cassette and both are covered by a sheet of very thin transparent celluloid, cut to the size of the screen. The holder can then be closed without danger of scratching the surface of the screen and a good picture can be made in this way if the card and plate are of one thickness and the celluloid is free from opacities and wrinkles.

MANIPULATION OF PLATES AND SCREENS IN THE DARKROOM

If possible a separate apartment, or at least a separate corner of the dark room, should be set aside for this purpose. In my experience developer stains figure at about 65 per cent in screen "mortality tables," with surface scratches and abrasions at 25 per cent, and all other causes, including black specks, finger marks, etc., 10 per cent.

If a separate place cannot be provided and it is necessary to use the general dark room, the exposed plate should be removed from the cassette *before development begins*—when no solutions are exposed in trays, etc., within the room—placing the negative in a black envelope, or in a special light-proof box or drawer, for subsequent development.

Plates should not be put in the cassette until just before exposure, otherwise detail will be sacrificed and the plate will lack crispness and clarity in the shadows, due to the fact that the fluorescent salts in the screen emulsion are slightly radio-active—or rather—perhaps, because they store up part of the energy from former exposures and emit it later as invisible radiations. For the same reason exposed plates should be removed from the cassettes as soon as possible after the picture is made—to remain in lightproof containers for later development.

REMOVAL OF DUST, ETC.

It is essential that every particle of dust and other foreign material be removed from the surface of the screen and from the negative before the plate and screen are placed in contact, otherwise the dust specks will produce "pin holes" in the picture by intercepting the rays from the fluorescent surface; moreover, if any of the specks are hard and gritty, they will be forced into the sensitive surface of the screen by the pressure of the springs when the cassette is closed up, to remain embedded therein forever.

Of course the film side of the plate should be in contact with the sensitive surface of the screen.

Some workers prefer to use a wide and soft camel's hair brush for the removal of dust. I find that a square foot of soft "outing" or "Domet" flannel (really cotton with a downy surface on both sides) is far better.

It must not be forgotten that vigorous rubbing of screen and negative, especially in the winter months, will electrify both and cause them to attract dust as a magnet attracts iron filings.

In my opinion the ideal method of removing dust is by means of compressed air—supplied from a small tank. One may use a regular air tank and pump like those made for nose and throat specialists. Instead of using the metal hand cut-off provided with those outfits for use with the atomizer bottles a valve should be arranged at the tank end of the delivery tube to operate by the pressure of the foot. The current of air is then delivered from the tank through a rubber hose of suitable length. No nozzle is needed at the free end of the tube; instead it is advised that it be wrapped with several layers of soft flannel secured by adhesive plaster and a few stitches, so that the air may be carried directly to the surface of the plate and screen without any fear of scratching these delicate surfaces. Air may be pumped into the tank with the usual double action hand-pump—or at moderate cost—a small electric pump may be purchased, fitted with an automatic arrangement which can be adjusted so that the tank is always full of air at constant pressure.

Those of you who have occasion to use a large number of screens will find an outfit of this kind extremely useful and it will soon pay for itself by the saving effected in screens alone.

RELATIVE POSITION OF SCREEN AND PLATE WITHIN THE CASSETTE

In my opinion the only rational method of taking screen pictures is with the screen *behind* the plate, so that the rays pass through the glass negative before they reach the screen. I am aware, however, that some radiologists, especially abroad, prefer to reverse these positions—the rays going through the screen first—claiming that this arrangement obviates the necessity of reversing the pictures when examining them afterwards.

It seems to me that this advantage is more apparent than real, since only a neophyte is likely to be misled because of the reversed images in screen negatives, whereas there are very real and substantial objections against the method of filtering the rays through the screen *before* they reach the plate.

In the first place, calcium tungstate and all other salts used in the construction of intensifying screens are very opaque to the rays. You remember how heavy the small vial of powder was, so judge for yourselves how opaque a layer of it is likely to be!

Of course the glass negative and its sensitive film are somewhat opaque in themselves, but if the glass is up to standard, and free from lead, as it should be, and usually is, this opacity is as nothing compared to that of the screen. Then again, it is impossible to pass the rays through a properly made intensifying screen without producing "grain" in the picture itself. Think again of the weight of the powder in this connection—is it to be expected that a grain-free plate can be made through a layer of this material?

Certainly a screen *can be made* that will pass the rays without much absorption or obstruction, but that screen will be found to contain mighty little of the expensive CaWO_4 ! These screens are made with a very thin layer of fluorescent material and at a proportionately low cost, and my experiments show that they are *always rela-*

tively slow—as is to be expected, since one does not get *something from nothing*!

Now an intensifying screen is used for *one purpose*, and one purpose only, namely; to cut down the time of exposure; therefore, other things being equal, the screen possessing the greatest amount of actinic radiations—in other words, the *fastest screen*—is the *best screen*!

As Dr. Connor says, the salts of the metals are as opaque and the rays of the metal distinct.

We know that calcium tungstate is both heavy and opaque to the rays: Ergo, a *good* screen must be too opaque to the rays to be used between the tube and the plate. Per contra—only a light weight, transparent, cheaply made screen can be used in this position, and a longer exposure will of necessity be demanded.

Before removing the loaded cassette from the dark room it is a very good plan to slip it into a bag of black outing flannel. Such bags may be made to snugly fit the different size cassettes and will prove extremely useful in many ways—for instance, in preventing fogging around the edges of the plate from light that may leak in around the sides of the cassette if the operating room is very light. Also, the bag protects the cassette and operating table from scratches, etc.

Patients find it very comfortable too, especially in cold weather, when contact of bare metal against the skin of back or abdomen is pretty sure to cause a remonstrance! The covering also reduces to a large extent the chance of the patient getting "shocked" by static discharges.

For use with children this bag is most desirable. When the cassette is thus enclosed it looks more like a soft pillow than "an instrument," and the little ones do not hesitate at all to rest upon it!

CARE OF SCREENS.

Intensifying screens should not be left locked up in air tight cassettes for any length of time. They should be exposed to

the air at frequent intervals—the cassette being opened up and stood on edge in the shape of a letter "V" and kept in this position, in a dry place, for several hours, every few days, or for several days in succession if the screen is not used often.

"Airing" is especially necessary with *newly purchased* screens and it is strongly advised to expose all new screens in the above manner for several days, before they are used. If the screen is needed at once, then the cassette should be left open "between times," and during the night.

It is good practice to continue this for the first month or two; after that an occasional airing will be all that is necessary—say at night, once or twice a week.

If these precautions are not taken the surface of the screen will become softened, and if the screen is not used frequently it may ultimately become ruined because of surface abrasions of the soft surface, and the embedding therein of dust, specks, etc.

The reason for this softening is that nearly all intensifying screens contain pyroxylin, which is used as an agglutinant or adhesive after being dissolved with amyl-acetate, fusel oil, etc. It is impossible to entirely eliminate these solvents from the finished screen without a process of "seasoning," extending over many months, or even a year.

Even a minute quantity of the above solvents will soften the surface of a new screen if the latter is kept in an air-tight cassette, or in a cardboard carton, for many days at a time without being exposed to the air so that evaporation may take place.

Frequent "airing" of the screen is all that is needed to prevent this softening, and that is a small premium to pay for a reduction of nearly 25 per cent in screen mortality.

The surface of the screen may be cleaned of superficial soiling and ordinary stains by gentle rubbing with damp absorbent cotton—or even by breathing on it as one cleans eye-glasses and spectacles—polishing with the outing flannel at the same time.

Only the soiled areas should be rubbed with the wet cotton—and the screen should always be exposed to the air for a day or two before cleaning, in order to harden the surface as much as possible. After cleaning the screen should be exposed to the air for twenty-four hours before it is used.

Of course the ideal screen is one with a hard, china-like surface, invulnerable to abrasions and scratches, and capable of being washed with soap and water and afterwards polished with a cloth. I am glad to say that experiments now under way seem to promise such a screen in the near future.

Time of Exposure, Etc.

The time of exposure for screen plates is dependent upon so many varying factors connected with the current generator and tube circuit—type and vacuum of focus tube—speed of plate—construction of cassette, etc.—that it is quite impossible to formulate any useful rule governing the matter.

In general, however, it may be said that a good intensifying screen should reduce the time of exposure more than ninety per cent. If a transformer of 4 K. W. or more capacity is used, all exposures should be instantaneous, or as nearly so as the present automatic switches will permit them to be. If a hand switch is used, it should be arranged so that the secondary circuit is closed and opened by one motion of the hand, since a knife-switch cannot be operated rapidly enough with heavy currents.

If a screen is used to back-up or reinforce a weak coil, it will be necessary to experiment until the proper exposure is found for that particular apparatus.

If the screen is used for pictures, of this part, or for children, etc. the milliamperage of the secondary circuit should be reduced, since even instantaneous exposures are apt to give an over-exposed negative in these cases.

Vacuum of Tube

Personally, I see no reason for either increasing or diminishing the vacuum of a tube because a screen is used—certainly you cannot influence penetration by using a screen, therefore there seems to be no occasion to change the technique. The vacuum

should be sufficient to properly penetrate the tissues in every case—that is all.

A simple rule for beginners in screen radiography is to expose a plate and to develop it for a stated time in a standard tank developer. If it over-develops at the expiration of the proper time, it is over-exposed and vice versa.

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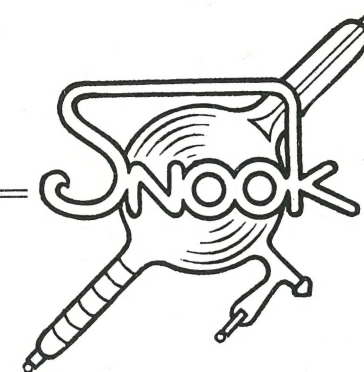
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EDITORIAL

The mid-winter meeting of the Western Section will be held in Detroit at the Hotel Cadillac on the 21st of February, 1914. The committee in charge of arrangements are: Dr. Rollin Stevens (chairman), Dr. Geo. Chene, and Dr. P. M. Hickey. The success which has attended these mid-winter meetings will serve to stimulate interest in the Detroit meeting. The program thus far arranged is somewhat informal but will perhaps on that account be all the more interesting. All those who are contemplating coming are invited to bring lantern slides, plates, reports of interesting cases and new apparatus.

Dr. Gray, Richmond, Va., chairman of the executive committee, announces that the next annual meeting, which is to be held in Cleveland, will take place on the days of Sept. 9 to 12, 1914. Dr. Gray also desires to announce that the applications of candidates for membership should be immediately sent in to the executive committee for their consideration and calls their attention to the rule which requires their publication in the Journal of the Society at least six months before the annual meeting. Not only should the application blanks be properly filled out but they should be accompanied by letters of recommendation as prescribed by the constitution. At the last annual meeting, held in Boston, a number of applications had to be refused by the executive committee because they were not properly filled out according to the requirements adopted two years ago.



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