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WAR DEPARTMENT

TECHNICAL MANUAL

ROENTGENOGRAPHIC TECHNICIANS

July 3, 1941

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TECHNICAL MANUAL
No. 8–240

WAR DEPARTMENT,
WASHINGTON, July 3, 1941.

ROENTGENOGRAPHIC TECHNICIANS

Prepared under direction of
The Surgeon General

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SECTION I

GENERAL

Paragraph
Purpose and scope 1

1. Purpose and scope.—This manual is intended to serve a twofold purpose: a general outline for a course of instruction of student X-ray technicians; and a reference text for the technician, particularly with respect to exposure factors and reminders of the gamut of precautionary measures which should lead to perfection of their practice of roentgenography. Necessarily the descriptions and explanations have been limited to fundamentals. Detailed descriptions as to the construction features of various auxiliary parts which might be found on the equipment of one or another manufacturer have been avoided. It is believed that inclusion of such details would have led to too much

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confusion. Variations in designs and construction features of X-ray apparatus are today so numerous that for these aspects it is necessary to refer to descriptive literature as issued by the manufacturers and to texts which deal essentially with X-ray physics.

SECTION II

X-RAYS; THEIR NATURE AND ORIGIN

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Nature	2
Origin	3
Types	4

2. Nature.—X-rays are radiant energy. They simulate light rays, ultraviolet rays, heat rays, and even radio waves. Like them, X-rays travel at the rate of 186,000 miles per second. Names have been applied to these several types of radiant energy, from time to time, as man has become somewhat familiar with the effects of one or another group. Intricate physical testings indicate that there should be no sharp demarcation separating one band of wave lengths from another that precedes or follows it. There is an actual merging or gradation of the wave lengths and frequencies, and one type is to be distinguished from another merely in an arbitary manner. The range of wave lengths which have been assigned to the several arbitrary band limits is indicated in figure 1.

The shortest wave lengths shown in figure 1 are designated "gamma" rays. Some scientists believe that "cosmic rays" are similar to these gamma rays but even shorter. Gamma rays are emitted from radium. As indicated in figure 1 some of the gamma rays are identical with some of the waves included in the X-ray band. The longer gamma rays are identical with the shortest X-rays. With the development of apparatus capable of performing at higher and higher kilovoltages, shorter and shorter wave lengths of X-ray energy are being produced, and more and more of this gamma band is being duplicated by the artificial accomplishments of man—versus the natural physical effects which occur in the element radium and other radioactive substances.

3. Origin.—When using the term "X-ray" (i. e., roentgen ray), we are inclined to consider those rays which are produced by the bombardment of a stream of electrons upon a metal target in an evacuated tube. The stream of electrons constitute what was formerly described as cathode rays. It was thought that these cathode rays were actually reflected from the target and that they constitute the X-ray energy. This was a misconception. Electrons are not ordinarily reflected from the face of the target nor are they changed into X-ray

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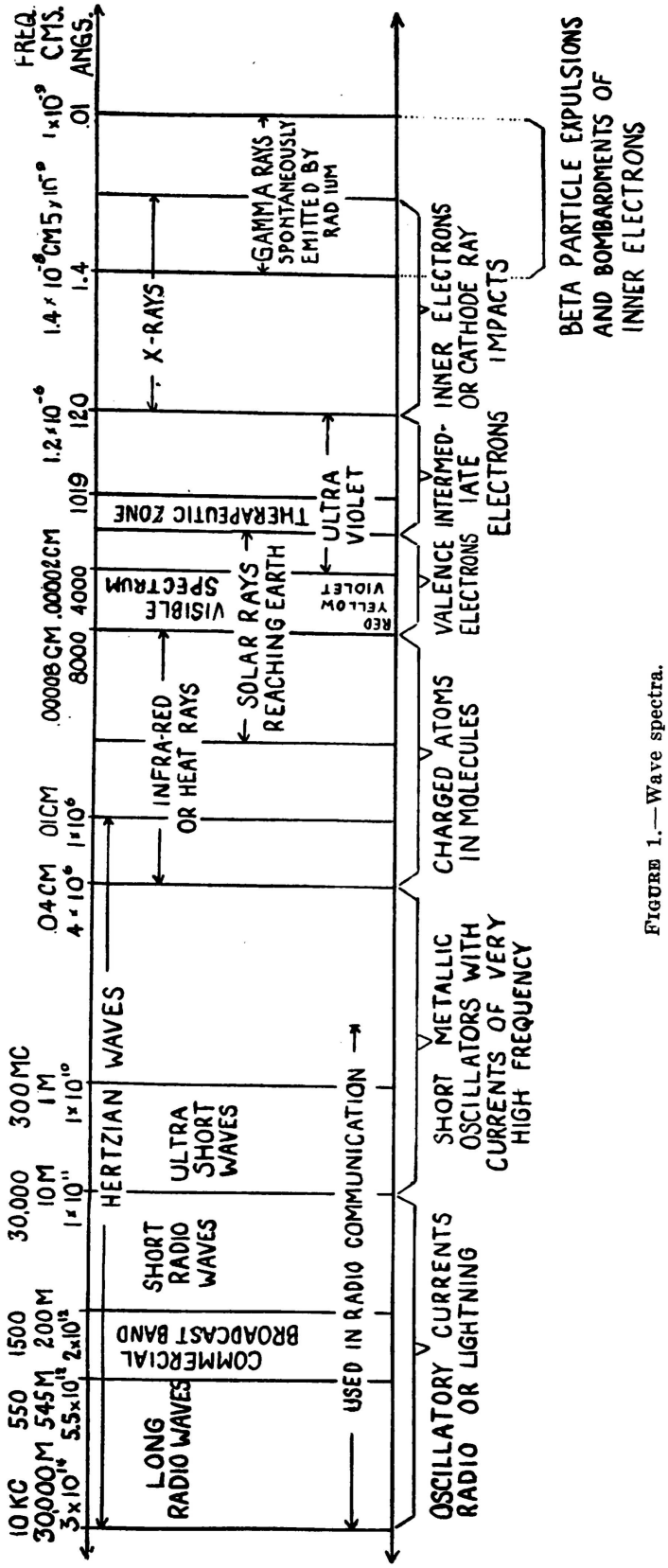


FIGURE 1.—Wave spectra.

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energy. They produce the X-ray energy simply because of their deceleration of movement or impact upon the target. The electrons continue to move on through the target to complete an electrical circuit. X-rays are energy, whereas electrons which produce them constitute a form of matter. The production of X-ray energy might be considered analogous to the production of heat which is developed because of friction when two surfaces are rubbed together. As a matter of fact, a very great deal of heat is produced simultaneously with the production of X-rays. Heat is also a form of energy. It is a form of radiant energy, and actually its wave lengths are those described in the infrared band as shown in figure 1. When generating X-ray energy within an evacuated tube, much heat is produced. In fact, when operating X-ray apparatus, besides generating radiant waves of the X-ray band and of the infrared band, there are also generated the various gradations of wave lengths which constitute ultraviolet rays and even light rays. A gamut of rays is produced.

4. **Types.**—*a.* There are three general types of X-rays to be considered:

Primary.
Stray.
Secondary (scattered).

(1) *Primary X-rays* are those X-rays which are produced by the impact of primary electrons within the area of the focal spot of the target of the X-ray tube. Primary electrons are those electrons which are driven from the filament of the X-ray tube to the target.

(2) *Stray X-rays* are distinguished as those X-rays which are produced by the impact of primary electrons upon other than the focal spot of the X-ray tube.

(3) *Secondary X-rays* are those X-rays which are produced because of the release of, and the bombardment by, electrons which belong to atoms of a substance affected either by the primary electrons, secondary electrons, or X-rays. With this consideration, secondary X-rays might be produced in the target of the X-ray tube; they might be produced in other portions of the X-ray tube; but of much greater importance than either of these two possibilities is the third possible location of their development—within substance outside of the X-ray tube, including the tissues of the body.

b. These three types of X-rays are more graphically distinguished in the section concerned with the discussion of grids.

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SECTION III

THE ELECTRON; ITS RELATION TO THE ATOM, TO MAGNETISM, AND TO ELECTRICAL CURRENTS

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Magnetism ---------- 6
Electricity ---------- 7

5. General.—*a.* Electrons are minute particles of matter (in contradistinction to energy). When flowing in very great quantities, the path of electrons can be seen, but the single electron is so infinitesimally small that it cannot be seen even by the most powerful ultra microscopes that man has been able to construct. However, on the basis of tangible physical and chemical phenomena, scientists recognize the electron to be an actual particle of matter.

b. Its relationship to matter can best be understood by reviewing several basic definitions. Matter must be considered to include gases, liquids, and solids. It might be defined as anything that occupies space (and has weight). Any type of matter might be subdivided by physical means until there is uniformity in the characteristics throughout all portions of it. Such would be a break-down into a "pure substance." It is conceivable that division upon division of any such pure substance might be made until there would be left the very smallest particle of that pure substance which still maintained all the characteristics of it. This small particle would be called a molecule. A pure substance or a molecule might be composed of a single element such as hydrogen (H_2), or it might be composed of a stable combination of two or more components such as hydrogen and oxygen, as in the case of water. Thus, when pure substances are compounds, their molecules contain more than one element. Compounds may be broken down into their constituent elements. Today it is difficult to define an element. Chemists are inclined to consider only those pure substances which maintain their characteristics regardless of mechanical or chemical influences. They recognize substances which are relatively stable, describing 96 elements. Physicists include in their considerations many transient or unstable simple-pure substances and they describe well over 300 of them. This confusion has led to such terms as "isotopes," "isomers," etc. However, if one were to consider dividing any simple pure substance into its very smallest particles, eventually there would be obtained a unit which would be the smallest possible division of the element still maintaining all the characteristics of that element. This unit would be an atom. To distinguish further these two units, we might consider a

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molecule of hydrogen (H_2) versus an atom of hydrogen (H). A molecule of water (H_2O) contains two atoms of hydrogen and one atom of oxygen. An intact atom is an electrically neutral particle. However, with the gain or loss of one or more electrons, an atom devolps an electrical charge, and it is then called an "ion." This relationship is more graphically demonstrated in the section concerned with electricity.

c. All atoms are composed of a nucleus and one or more circulating electrons. The nucleus may be composed of a single proton (as in the case of an atom of hydrogen), or it may contain one or more neutrons plus one or more protons. No atom is large enough to be

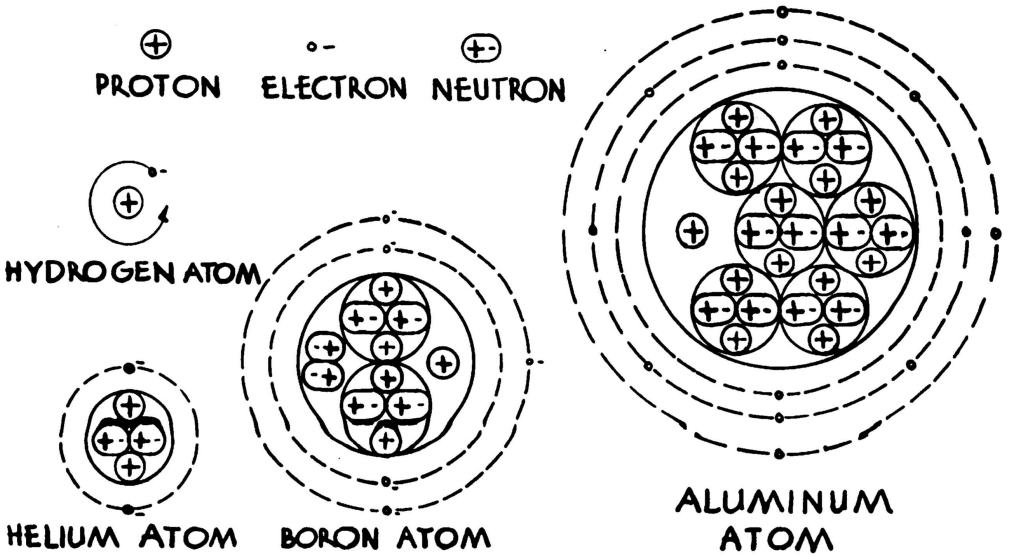


FIGURE 2.—Atomic structures.

seen by any means, and yet physicists tell us that a proton has a mass which is 1,800 times the mass of an electron. We might think of a proton as being analogous to our sun, while an electron might be considered analogous to our earth, revolving about it. Following such a theme, a neutron consists of a proton and an electron (the latter being fixed in relation to the former). All electrons are identical, one with another. All protons are identical, one with another. All neutrons are identical, one with another. One element differs in characteristics from another element merely because of the number and arrangement of the protons, electrons, and (perhaps) neutrons contained in their respective individual atoms. Thus all elements are composed of the same essential "building blocks."

6. Magnetism.—*a.* The exact nature of magnetism is unknown. It is believed to be due to an arrangement of the individual atoms

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whereby their circulating electrons become fixed into uniform positions with relation to their respective nuclei. Each atom might be considered as an individual magnet having two poles (extremities); its nucleus versus its electrons bearing potentials opposite, one to the other. The magnet as a whole is considered to be a composite of literally millions of these atomic magnets as shown in figure 3.

b. The earth itself is a very large magnet, having a magnetic north pole and a magnetic south pole. The magnetic field of force extending between these poles explains the positioning and alinements

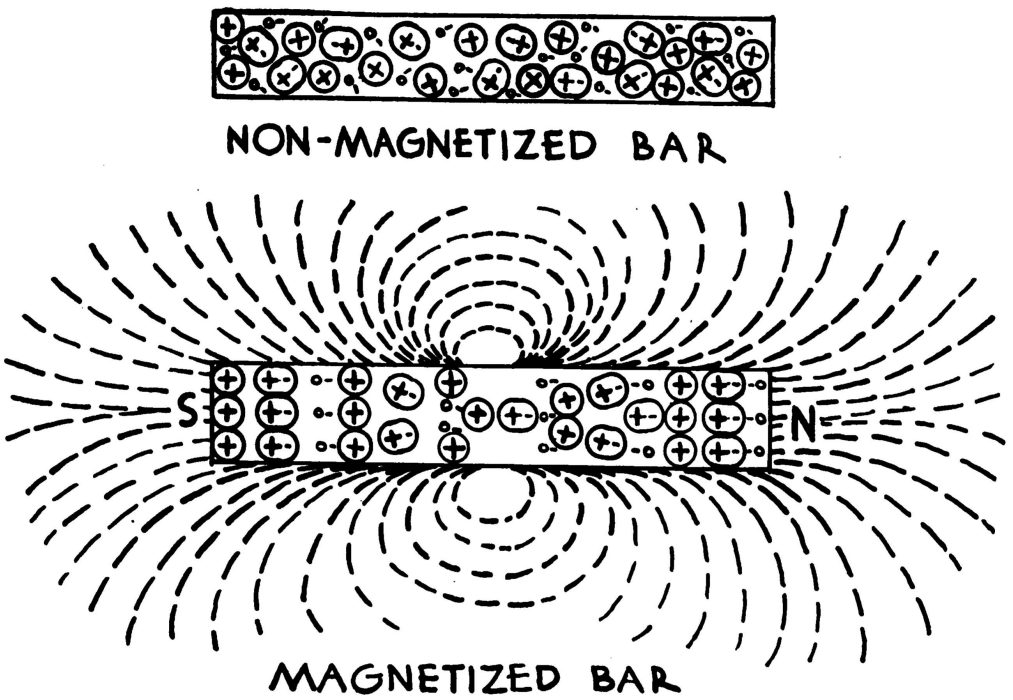
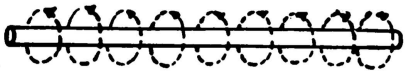


FIGURE 3.

of the floating needle of a compass (the latter being a very small permanent magnet). Certain substances such as loadstone (iron oxide) possess magnetic properties even as they are found in nature. When these properties of magnetism are not lost by ordinary degrees of impact or the application of moderate temperatures of heat, these substances are called permanent magnets. There are combinations, such as aluminum, nickel, and cobalt, which by themselves do not possess magnetic properties, but which after being influenced by a magnetic field of force develop into very powerful magnets. This combination (trade name "alnica") maintains magnetic properties indefinitely after becoming magnetized. It is an artificial magnet but one which is also a permanent magnet. There are other sub-

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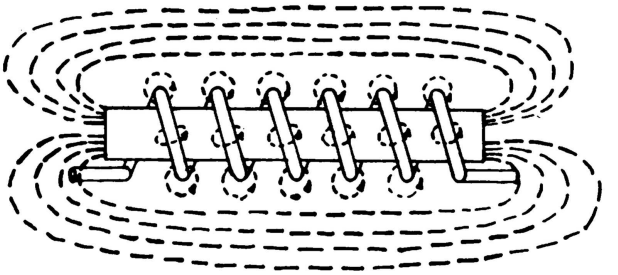
stances, such as soft iron, which do not possess the properties of magnetism, as they are found in nature, but which develop magnetism when influenced by a strong magnetic field. Such substances are called temporary magnets. Silicon steel is another example of such a substance. It may transiently develop the characteristics of a magnet but lose those qualities when not influenced by a field of force. When the properties of magnetism are maintained by a temporary magnet for some length of time following the influence of a field of force, there is considered to be a lag of magnetic effect. For



A FIELD OF FORCE IS BUILT UP ABOUT A CONDUCTOR WHEN ELECTRONS FLOW THRU THAT CONDUCTOR.



THE FIELD OF FORCE IS INTENSIFIED BY CONCENTRATING THE PATH OF THE ELECTRONS BY MEANS OF LOOPS.



AN ELECTROMAGNET CONTAINS A CORE, SURROUNDED BY A SERIES OF LOOPS

FIGURE 4.—Electromagnet.

certain performances, such as those of a core of a transformer, this lag is detrimental. It is called "hysteresis."

c. When electrons move through a conductor, there is developed about that conductor a magnetic field of force. The magnetic field of force might be intensified by concentrating the path of the current of electrons. This can be accomplished by making a series of loops in the conductor and approximating the loops. This concentration of the magnetic field of force might further be intensified by inserting a substance, such as soft iron or silicon steel, into the field. There is developed thereby an electromagnet, as shown in figure 4.

7. Electricity.—*a.* The term "electricity" should connote electron mobilization. In this broad sense, there would be included the activities of photoelectrons, recoil electrons, the electron rearrangements

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concerned with fluorescence, phosphorescence, magnetism, and ionization. However, the term usually implies the activity of an electric current. An electric current is simply the flow of electrons from one location to another. Usually, an electric current flows through a metal conductor. In such conductor, it should be considered that the electrons actually move out beyond the limits of one atomic structure and into an adjoining atom; that there is a constant release of one or more electrons from individual atoms; but an almost immediate reinstatement of them from succeeding atoms. It is believed that only the most peripherally located circulating electrons are concerned in this excitation movement. Because of replacements of the mobilized electrons (except in instances such as the chemical battery described below), ionization and disintegration of the conductor itself does not result. This result is counteracted when the electrons move in true circuits, as they usually do.

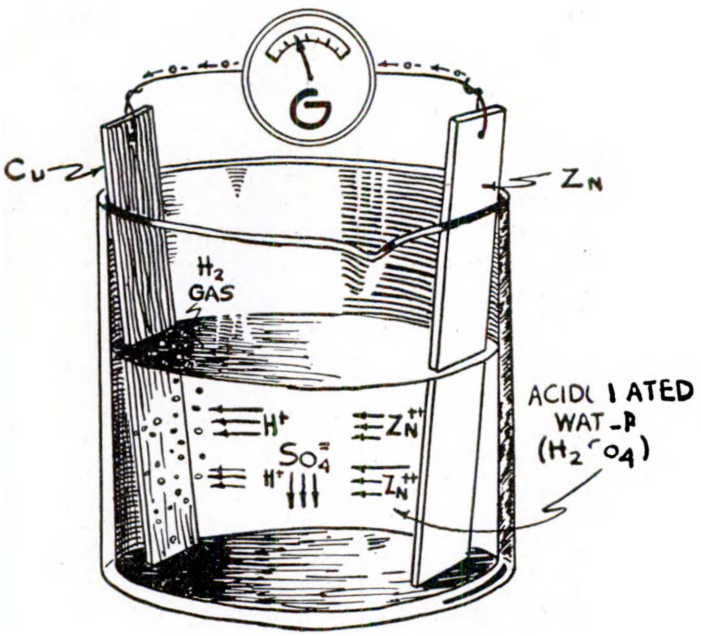


FIGURE 5.—Chemical battery.

b. An understanding of the relationship of the electron to the development of X-rays requires a consideration of the excitations and movement of electrons when actuated by a magnetic field of force. Just as it is true that when certain substances, such as soft iron or silicon steel, are subjected to the influence of a magnetic field of force, there results a rearrangement of the electrons concerned with the individual atoms to the extent of the development of magnetic properties in that substance itself, so also it is true that when a

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metallic conductor, such as copper, is placed within the sphere of influence of a magnetic field of force, there result an agitation and movement of the electrons concerned with individual atoms. If a circuit of such a conductor is provided, the electrons will move through such a circuit, but they will do so only *provided* there be movements either of the field of force or of the conductor.

SECTION IV

X-RAY MACHINES; FUNCTIONING PRINCIPLES, FUNDAMENTAL COMPONENT PARTS, AND TYPICAL WIRING ARRANGEMENTS

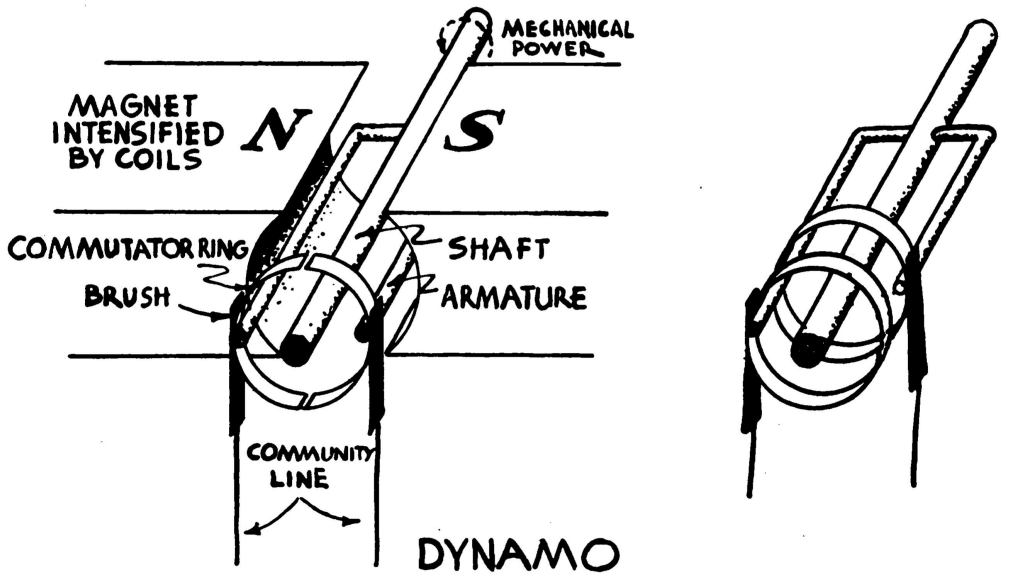
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8. Dynamos and motors.—*a.* The factor of movement, either of the magnetic field of force or of the electrons, is particularly well demonstrated by the functioning of a dynamo (electrical generator) or the principles of a motor.

b. One might consider a dynamo as a device designed to convert mechanical energy into electrical energy. Such a definition is of course fallacious for today we do not think of electrical energy, but instead we realize that actual particles of matter, the electrons, are induced to flow. The mechanical energy referred to in this widely used definition is the energy which causes the armature of the dynamo to revolve. Falling water, steam, or even electrical devices may be utilized. The essential consideration is that a portion of a metallic conductor, forming an open loop (the armature) and a small segment of a complete circuit, is mechanically revolved in a magnetic

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field. This open loop is positioned so that with revolution of it there results the maximum cutting across the lines of force concerned with the magnetic poles. Having movement and the field of force, electrons contained in the individual atoms of the armature are excited to move, and with the provision of completion of a circuit, they travel through the commutator to the community line.



① Half-ring commutator suitable for pulsating direct current. ② Two-ring commutator suitable for alternating current.

FIGURE 6.—Dynamo.

As indicated in figure 6, either alternating current or pulsating direct current might be generated by a dynamo, depending upon the design of its commutator. When one pole of the magnet constantly influences one terminal of the external circuit, while the other pole of the magnet constantly influences the other terminal of the external circuit (as shown in fig 6①), there will result a pulsating direct type of electron flow in the external circuit. If each terminal is influenced first by one pole and then by the other pole of the magnet (as indicated with the type of construction of the commutator shown in fig. 6②), there will result an alternating type of electron flow in the external circuit.

c. In contrast to the principles concerned with the functioning of a dynamo, a motor might be considered as a device designed to convert electrical energy into mechanical energy. More definitely, because of movements of electrons, there is developed a field of force; and because of alternations in the direction of movements of electrons, there is an expansion and collapse of this field of force. Thus,

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in the case of a motor, the movement of the electrons produces movement of the field of force; and the movement of the field of force produces revolution of the armature—which in the case of the motor consists of magnetic poles.

d. Just as dynamos may develop either alternating or pulsating direct types of current flow, depending upon the construction features of their commutators, so also motors may be designed for operation on either alternating or pulsating direct types of current flow, depending upon the construction features of their commutators.

9. Types of electrical currents.—Four types of electrical currents might be considered:

a. A continuous direct current is one in which the electrons travel steadily in one direction. This type of current has been called a galvanic current. It is the type of current produced by batteries.

b. A pulsating direct current is one in which the electrons move in one direction but not quite as steadily, as in the case of a continuous direct current. Instead, in the case of a pulsating direct current, some electrons begin to move and very quickly more and more of them are moving but then, after reaching a peak (considering the number of electrons moving), less continue in motion, and then there follows a repetition of this acceleration and deceleration. This is the type of electrical current produced by a dynamo having a commutator of the design shown in figure 6①.

c. An alternating current is one in which the electrons move first in one direction and then in the opposite direction. There are increment and reduction as to the number of electrons flowing, as considered in the case of pulsating direct current. However, in the case of alternating current, the accelerations and decelerations of electron movements extend all the way from and to the base line; and moreover these waves are directed first in one direction and then the opposite, changing with every alternation.

d. The term "unidirectional" is applied to those currents where there is conversion of an alternating current (rectification) so that all pulsations of electron flow move in the same direction—full wave, or there may be an inhibition of every other pulsation (i. e., alternation)—half wave. With the use of valve tubes (thermionic rectification), full wave rectification is productive of wave forms which extend practically from the base line to peak levels, comparable to those of pulsating direct current. Prior to the use of valve tubes, this rectification was accomplished by the use of a rotating disk or cross arm terminals, in which instances only a portion of each wave became effective. These comparisons are shown in figure 7.

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10. Electrical cycle.—The design of the dynamo and the speed of rotation of its armature govern its cycle performance. A cycle might be considered as the electron movement induced by the full effect of each of two magnetic poles (of opposite potential). The term is usually applicable to alternating current, in which case one cycle is equal to two alternations. With the same considerations, in the case of pulsating direct current, one cycle is equal to two pulsations. Today most communities are supplied with 60-cycle current. With such, there are 60 cycles per second; 60 episodes wherein the

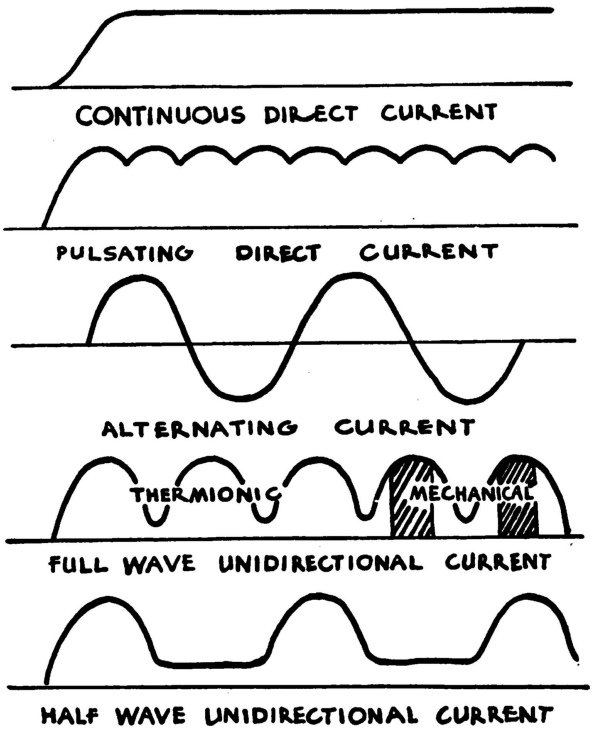


FIGURE 7.—Electrical currents.

electrons are excited to movement by the full effects of each of two magnetic poles, and therefore 120 alternations. Some communities are supplied with 50-cycle current, in which case there would be 50 episodes of magnetic pole influences or 100 alternations per second. A few communities in the United States still utilize 30-cycle current while in such places as the Canal Zone 25-cycle current is used. Transformers and other component parts of X-ray equipment are designed and constructed to function on a particular cycle. Usually, when equipment is designed to function on a relatively low cycle current, it will also function with current of higher cycle, though not as efficiently. When equipment is designed to function with a relatively high cycle (i. e., 60-cycle), and it is connected into a line of relatively

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low cycle (i e., 25-cycle), it is likely to burn out, particularly because the impedance in the cores of the transformers is insufficient. It is therefore important that the cycle of the electrical supply be known and that the design of the X-ray equipment be proper.

11. Electrical phase.—The design of the dynamo also controls the phase performance. The term "phase" is used to signify the relative number of magnetic pole effects with relation to each cycle. It might be considered as a particular electrical time degree of a segment of a cycle. For most X-ray equipment single phase current is used. It is produced when the entire electron movement over the period of a cycle can be accounted for on the basis of only two

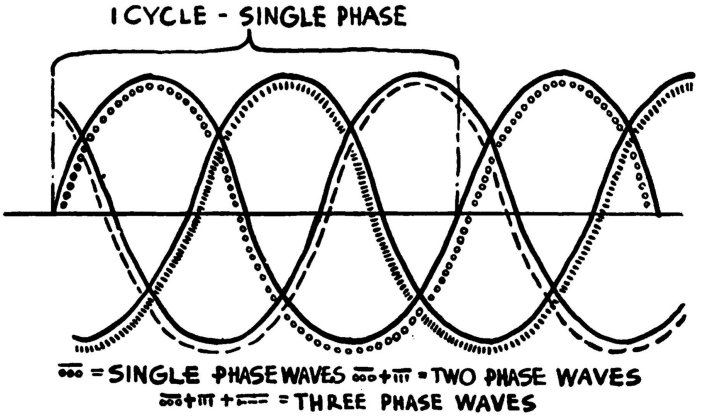


FIGURE 8.—Three phase alternator waves.

magnetic pole effects. During this same time interval it is possible that other pairs of magnetic pole effects may be superimposed as shown in figure 8.

12. Circuits.—The term "circuit" really refers to a complete path of electron movement from and to the site where the excitation of movement developed. When devices are connected into a circuit so that they constitute a portion of this path, they are said to be connected in series. When these devices are connected as a bridging across a portion of this path, they are said to be connected in parallel. This latter relationship must necessarily be relative to other components in the circuit.

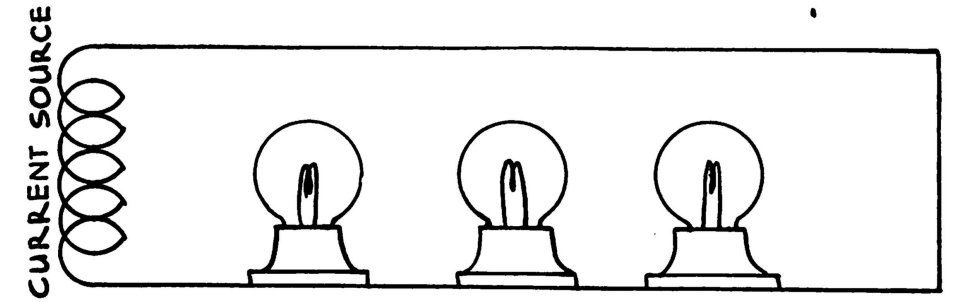
13. Electrical units.—*a.* The term "ampere" as used in roentgenography might be considered as the unit of quantity of electron movement. Actually it is the unit of intensity; it signifies quantity of current per unit of time. For instance, it is that quantity of current which will deposit silver from a silver nitrate solution at the rate of 0.0011182 gram per second. The actual unit of quantity

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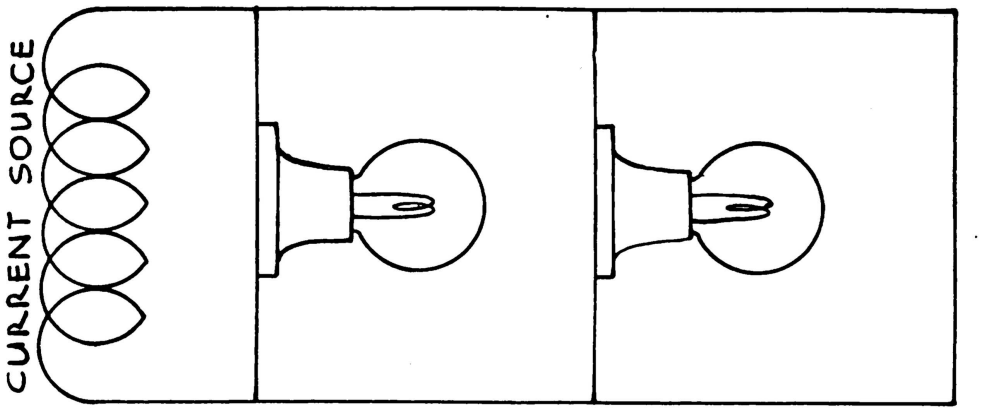
is the coulomb, but this term is not used in roentgenographic parlance, ampere being generally used synonymously for it.

b. A milliampere is 1/1000 of an ampere. The current of the high tension circuit of roentgenographic equipment is measured in terms of milliamperes.

c. The volt is the unit of electrical pressure. It is the unit of force which causes electrons to move against resistance. Actually, it is that amount of potential (energy) required to overcome a resistance of 1 ohm in a conductor carrying 1 ampere of current.



① Series.



② Parallel.

FIGURE 9.—Circuits.

d. A kilovolt is equal to 1,000 volts. The potential of the high tension circuit of roentgenographic equipment is measured in terms of kilovolts. The values are commonly described in terms of Kv. P. (kilovolts peak) or P.Kv. (peak kilovoltage), since these high potentials are usually measured with sphere gaps, and the peak values are the ones considered. For a more complete discussion of these expressions, see the descriptions of average, effective, and peak values (par. 15*b*).

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e. The ohm is the unit of electrical resistance. It is the resistance provided by a column of mercury 106.3 cm. long and having a mass of 14.4521 grams at 0°C.

f. A megohm is equal to 1,000,000 ohms. The intratubal resistance of a valve tube is in the order of megohms.

g. The watt is the unit of electrical power. Watts measure the product of the volts times the amperes; 746 watts are equivalent to a horsepower.

h. A kilowatt is equal to 1,000 watts. It is equal to 1⅓ horsepower.

14. Measuring instruments.—*a.* Most instruments for measuring electrical units are constructed on the basic principles of a galvanometer. A galvanometer consists of a freely rotating coil of wire, mounted on a pivot and encircling a pointer. The movement of the pointer depends upon the intensity of a field of force which is developed because of the flow of electrons within the coil.

b. An ammeter is designed and calibrated to measure amperes. It is constructed with very little internal resistance, and it must be connected in series relationship to the circuit as a whole.

c. A milliammeter is of design and construction very similar to that of an ammeter but calibrated for the measurement of milliamperes. It also must be connected in series.

d. A voltmeter differs from an ammeter or a milliammeter by having constructed into it a high internal resistance and being calibrated to record volts. Since it is designed to measure pressure or the difference in potential, it must be connected "across the line." This explains why a high internal resistance must be incorporated into it. Figure 10 is intended to distinguish these differences in construction features.

e. A watt meter is used to measure watts. To connect it into a circuit, four connections are required for it is actually a combination ammeter and voltmeter. It is very important that the ammeter binding posts be connected in series relationship, while the voltmeter binding posts be connected across the line.

f. A ballistic meter is an instrument designed to measure ampere values in terms of duration of time (to extent of 1 second or less). The principle of operation of ballistic meters invokes inertia and momentum.

g. Sphere gaps are used to measure kilovolts peak. Kilovoltmeters are used for this same purpose in some experimental laboratories, but the internal resistance required in such meters is so large they are not practical for use with radiographic equipment in the

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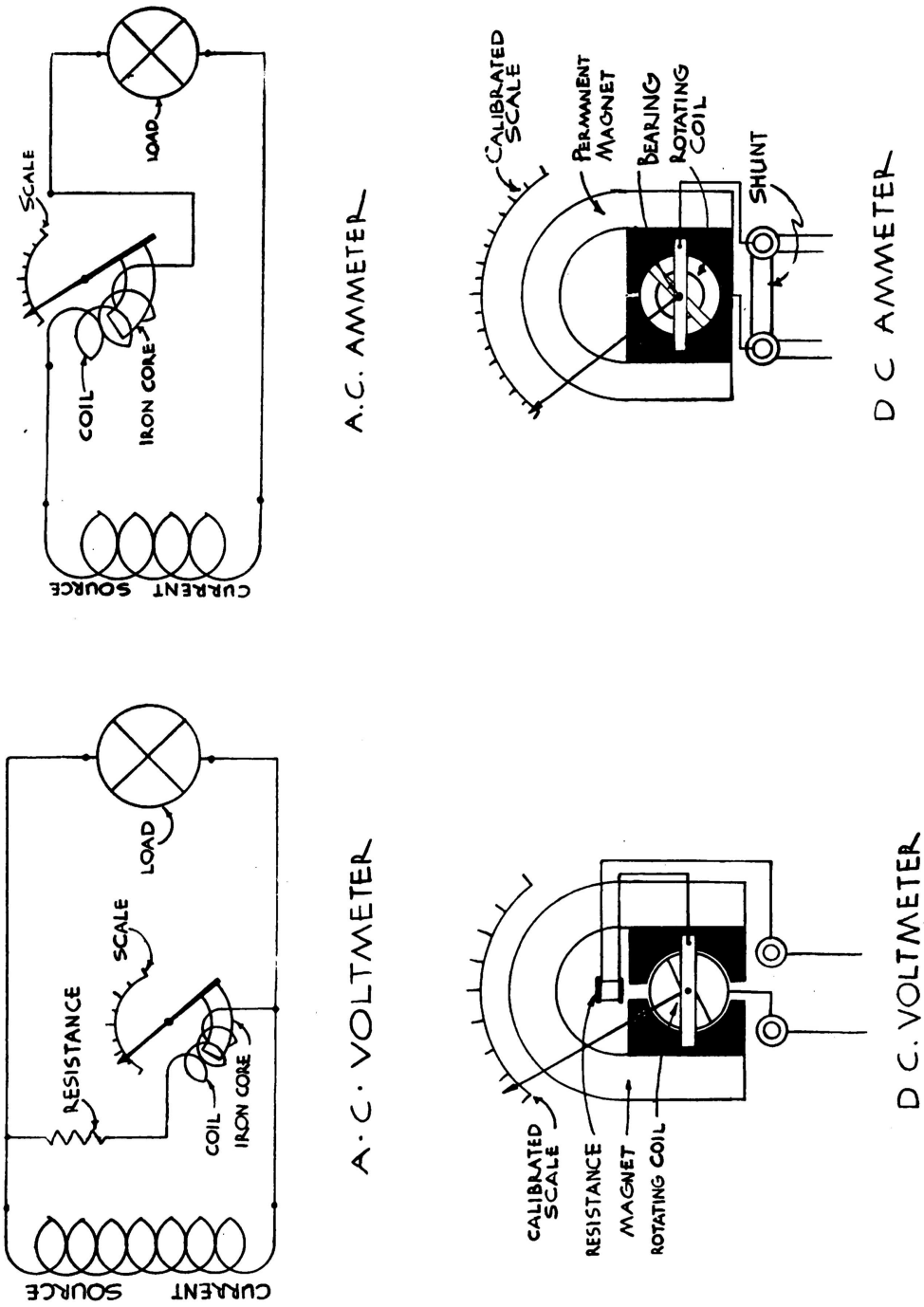


FIGURE 10.—Measuring instruments.

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average laboratory. Oftentimes the voltmeter which is mounted on the control stand is referred to as a kilovoltmeter, but it is not. It is connected across the primary circuit of the high tension transformer; it actually measures volts though it may be calibrated in terms of kilovolts.

15. Wave form.—*a.* Various types of electrical currents have been discussed. Continuous direct current has been distinguished from pulsating direct, and each of these has been compared with alternating and unidirectional types.

b. The plotting of a continuous direct current indicates constancy of current flow and therefore a single measurement value. In contrast to this, the plottings of each of the other three types indicate variations in current flow from moment to moment. They are pulsating currents and for them the question arises as to what value

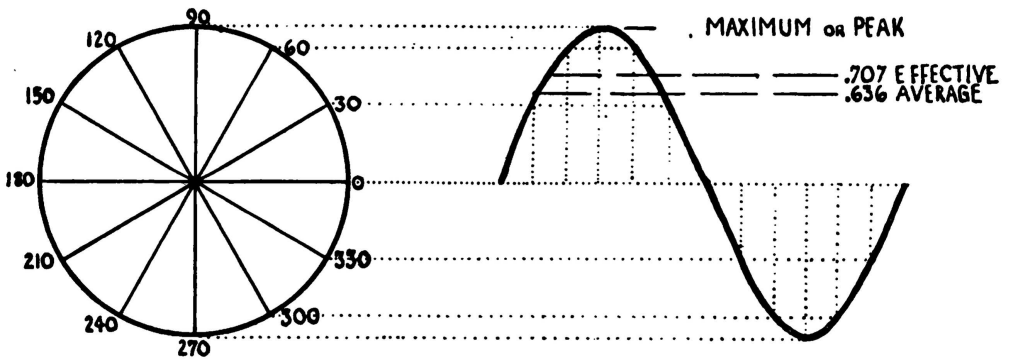


FIGURE 11.—Pure sine wave showing projection from segments of a circle and relative planes representing measurement values.

should be measured. One might consider the maximum or peak value—representing the value at the peak of the pulsation. This is actually the value measured with proper use of sphere gaps. However, since this value does not represent the total summation, taking into consideration all moments of the cycle or half cycle, another measurement may be preferred. This is called the effective value and is described as the root mean square value. It is the value recorded by meter readings. Still another value is to be considered—the average value or continuous direct current equivalent. These three measurement values are indicated in the plotting of a sine wave. (See fig. 11.)

(1) Knowing one of these values, in the case of a pure sine wave, it is possible to compute either of the other two. The maximum value is equal to 1.41 times the effective or 1.57 times the average. The effective is equal to 0.71 times the maximum or 1.11 times the average. The average is equal to 0.64 times the maximum or 0.90 times the effective.

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(2) These wave forms apply both to the amperage and to the voltage. It is only under ideal conditions that the actual functioning wave (the combination of the amperage wave and the voltage wave) is a true sine wave. Considerable distortion of wave form is likely to prevail in the wave form of circuits having an inductive type of load, such as produced by transformers. Because of such loads, in the case of X-ray apparatus, the voltage wave may not coincide either as to time or shape with the amperage wave, in which case there would result distortion of wave form. Each unit might be considered to have its own particular wave form. This explains some of the variations in radiographic performances. As much as 30 to 40 percent difference has been found in comparing the X-radiation performance of one unit with that of another, using identical technical factors and correcting for meter variations, etc.

16. Line requirements.—One of the first considerations should concern the line supply and wiring into the building. High capacity equipments have been purchased without the realization that their loads would be more than could be tolerated either by the pole transformer or by the dimensions of wire used for leads into the building. These requirements will vary according to the particular efficiencies of transformer designs, but average requirements are as indicated in table I.

17. Solenoids.—In order to understand the functioning of various essential parts of an X-ray machine, it is necessary to consider the principles involved in a solenoid or helix. As mentioned elsewhere in this text, when electrons flow through a conductor. because of their movement there is built up about that conductor a magnetic field of force. This magnetic field of force can be concentrated by making a series of loops. This constitutes a solenoid.

18. Choke coils.—The magnetic field of force which is developed about a conductor when electrons flow through it tends to restrain the movement of the electrons. There is actually the paradoxical effect of a force tending to inhibit the very cause of its origin. If this field of force is sufficiently intensified—by means of concentrated loops and a core, there may be accomplished almost complete inhibition of electron flow. This arrangement of utilizing an adjustable core (temporary magnet) within the magnetic field of force provided by a solenoid is called a choke coil. Choke coils are used particularly in the primary circuit of the filament transformers. There they serve as filament regulators.

19. Rheostat.—Oftentimes a rheostat is used as a substitute for a choke coil. A rheostat, essentially, is nothing more or less than a poor

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TABLE I.—*Power supply requirements*

(1) Machine capacity (milliamperes)	(2) Peak kilovoltage	(3) Nominal line voltage	(4) Transformer load (Kv.-A.)	(5) Wire size (B. & S.), transformer to switch	(6) Wire size (B. & S.), switch to control	(7) Ground wire	(8) Fuse capacity (amperes)	(9) Line switch capacity (amperes)
Self-rectified:								
10	85	100–130	1. 5	8	----	8	15	Base reception.
30	85	100–130	5. 0	6	----	8	40	60.
100	85	208–240	15. 0	4	6	8	70	100.
Full wave:								
200	85	208–240	15. 0	4	6	8	70	100.
500	85	208–240	25. 0	00	3	6	180	200.
1,000	85	208–240	50. 0	300, 000	0	4	350	400.
Three phase:								
500	85	208–240	3–15	3	4	8	100	200.
1,000	85	208–240	3–25	00	3	6	200	200

NOTES

1. The above specifications are the minimum requirements for a single X-ray machine of the rating specified.
2. They are based on a normal line regulation of 2 percent when the X-ray machine is not in operation.
3. The wire sizes in column (5) are based on a run of 100 feet. If the run is 200 feet, double the wire size.
4. The wire sizes in column (6) are based on a maximum run of 10 feet.
5. If more than one X-ray machine is to be used, or additional load is contemplated for the future, larger wire and transformer sizes must be specified for satisfactory operation.

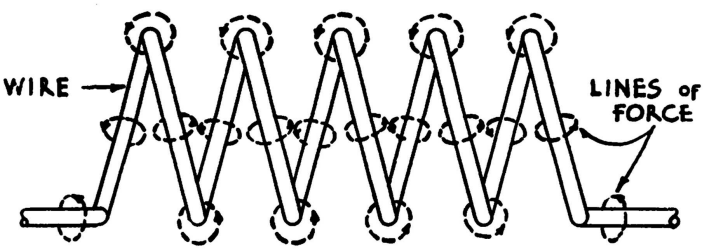


FIGURE 12.—Solenoid.

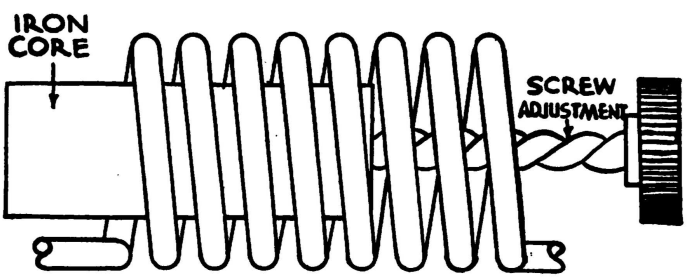
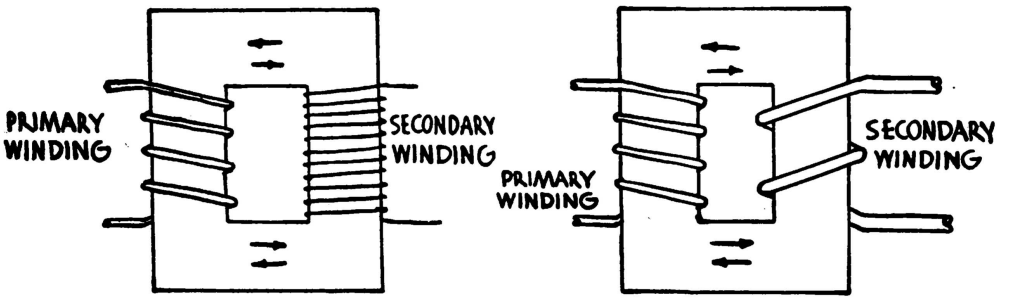


FIGURE 13.—Variable choke coil.

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conductor of electricity. It offers resistance to the flow of electrons. Ordinarily some means of adjustment is provided so that more or less of this resistant conductor can be introduced into the circuit. In this respect a rheostat differs from a true resistor. Rheostats may be used as filament regulators in either the primary or the secondary filament circuits. For roentgenotherapeutic equipment they are usually incorporated into the primary circuit of the high tension transformer.

20. Transformers.—*a. General.*—The physical effects described in the case of the choke coil are utilized in the functioning of transformers. A transformer serves as a functional connecting link between two entirely independent electrical circuits. Actually there is no electrical connection provided between these two circuits. The design of a transformer is very much as if a choke coil connected into one



① Step-up. ② Step-down.

FIGURE 14.—Transformers.

circuit were approximated to a choke coil connected into another circuit. The approximation of these two choke coil arrangements must be such that the field of force produced by the electrons moving in the one circuit will excite the movement of electrons in the second circuit. The strength and influence of the field of force of the primary circuit are intensified by utilizing a closed core—a temporary magnet such as soft iron or silicon steel which is constructed not as a bar but, instead, usually of thin strips arranged in laminations in the form of a rectangle or doughnut.

b. Step-up.—When the number of turns in the secondary winding is greater than the number of turns in the primary winding, the transformer is described as being a step-up transformer. This term refers to the increase in voltage. The voltage of the secondary circuit bears a relationship to the voltage of the primary circuit approximately as the number of turns in the secondary winding bears a ratio to the number of turns in the primary winding.

c. Step-down.—When the number of turns in the secondary circuit is less than the number of turns in the primary circuit, the result

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is the opposite. There are then fewer turns of conductor (i. e., actually less length of it) in the secondary circuit to be influenced by the fluctuating field of force of the primary, and as a consequence there is a reduction in voltage. This is the arrangement in a step-down transformer. The term refers to a decrease in voltage.

d. Windings.—In the case of a step-up transformer, the primary winding consists of relatively large copper wire because it must accommodate relatively large current capacities. The secondary winding is constructed of very small gage copper wire because it is intended to accommodate much less current. The very opposite relations as to gage of copper wire used for the primary and for the secondary windings, respectively, in the case of a step-down transformer hold true; namely, the primary winding ordinarily consists of relatively small gage wire, while the secondary winding consists of relatively large gage.

e. Performance.—The design and construction of transformers are very complicated engineering problems. There are numerous factors which govern their efficiency of performance. By efficiency is meant the current consumption (in terms of wattage) of the primary circuit as compared with the total current induced (i. e., available) in the secondary circuit. Most transformers designed for functioning with X-ray apparatus are of relatively low efficiency; they show an efficiency or power factor from as low as 38 percent to barely more than 48 percent. The efficiency of transformer function might be gaged in terms of wave form. Transformers incur inductive types of loads which tend to alter the wave form of the current. With roentgenographic equipment these alterations (distortion of wave form) are directly concerned with X-radiation performance. Though P.Kv. (peak kilovoltage) values be controlled, for the very same milliampere second values, the X-radiation performance of one unit may differ considerably from the X-radiation performance of another unit. Moreover, in the case of a poorly designed transformer the wave form is likely to be altered when it is operated at a high milliamperage setting as compared with operation on a low milliamperage setting. A load which exceeds the ideal capacity of the transformer will cause distortion of the wave form so that even though identical milliamperage-second values may be imposed, and even though the peak kilovoltage values may be the same, the X-radiation performance will be less than that obtained at a lower milliamperage setting—one that is easily accommodated without distortion of the wave form. However, even though the load (milliamperage setting) is well within reasonable capacity limits, there will

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occur some voltage drop for an increase in the load (i. e., milliamperage) of the secondary circuit. This fact makes it important that kilovoltage calibrations be accomplished in terms of the useful milliamperages.

21. Autotransformer.—*a.* An autotransformer consists of a single winding or series of loops of copper wire which provide a common path for two independent circuits. Usually this copper wire is of large gage in order to eliminate the production of heat which would otherwise result from resistance to the flow of an appreciable quantity

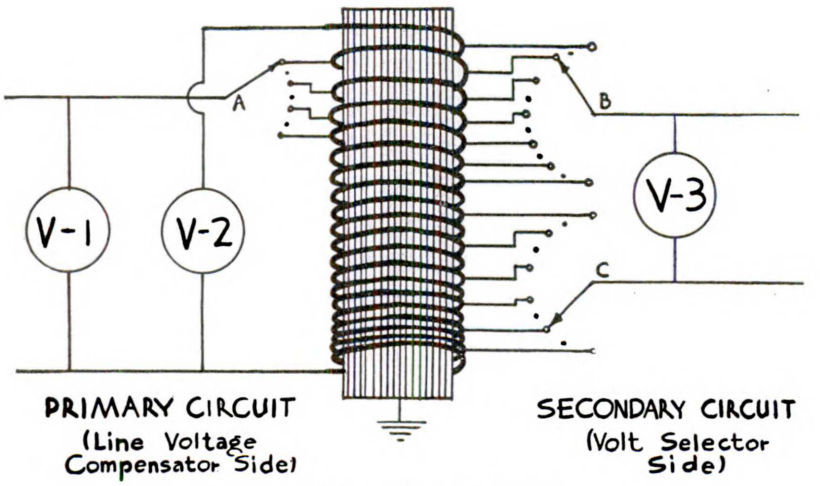


FIGURE 15.—Autotransformer.

of electrons in it. Autotransformers are connected across the line, and if it were not for the intense field of force provided by their large core there would result an actual short circuiting. The field of force is so great that electrons concerned with atoms of the copper winding itself are excited to flow in a direction opposite to that of the electrons of the primary current. All that is necessary for actual current flow of these secondary electron mobilizations is that leads be provided and that a secondary circuit be completed. The voltage of this latter circuit bears a relationship to the voltage of the primary circuit as the number of turns utilized in the secondary circuit bears a ratio to the total number of turns incorporated in the entire autotransformer.

b. It has been said that an autotransformer is always a step-down transformer in effect. This is not necessarily true, for as shown in figure 15, it is possible to utilize in the primary circuit less than the total number of turns incorporated in the autotransformer.

It will be noted that this figure takes into consideration 3 voltmeters, V1, V2, and V3. When the control at *A* is adjusted as indicated so that less turns are utilized in the primary than are incorporated in the

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entire autotransformer, the voltage across the entire number of turns, as indicated on voltmeter 2, will be greater than the voltage recorded on voltmeter 1, and the relationship will be approximately a proportion consistent with the number of turns utilized in each instance. If the controls *B* and *C* should be adjusted so as to utilize the entire number of turns of the autotransformer, the end result would be a step-up in voltage. It will be noted that the control *B* is such as to utilize steps of a single winding or loop, whereas the control *C* is such as to utilize steps of a number of windings or loops. In this way, the control *B* represents the minor control of the autotransformer, whereas the control *C* represents the major control. It is practical to consider the secondary circuit of an autotransformer as the volt selector side of it, for by making adjustments in this circuit by means of controls such as *B* and *C*, there can actually be selected the desired voltage value for application to another component part of the equipment, such as to the primary winding of the step-up transformer. When adjustments are provided in the primary circuit of an autotransformer, as indicated with the use of the control *A*, this instrument will also function as a line voltage compensator. The voltmeter V2 then becomes a line voltage indicator.

22. X-ray tubes.—*a. General.*—X-rays have been produced with tubes of various designs and with various types of generating apparatus. The discovery of X-rays in 1895 by Wilhelm Conrad Röntgen

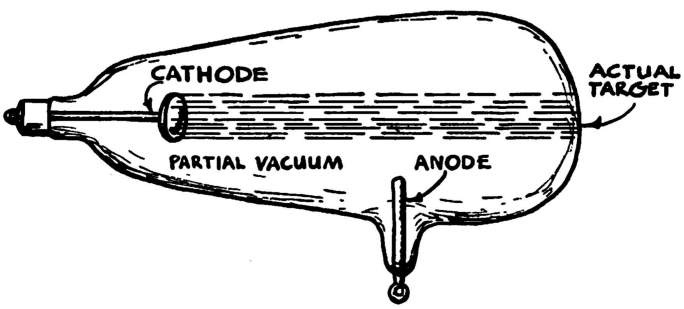


FIGURE 16.—Roentgen's tube.

was accomplished with the use of a Hittorf tube which was a modification of a Crookes tube. Such tubes contained a partial vacuum. Partially evacuated tubes were in common usage for several decades following the discovery of the X-rays. The main objection to these partially evacuated tubes was that they were not consistent in performance. This was due to the fact that the resistance which existed between the terminals within the tube varied according to the degree of ionization of the gas contained. Conduction of the electrons (cathode rays)

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took place as soon as ionization was produced because of the potentials (negative, at the cathode; positive at the anode) developed at the two terminals. The ease of this conduction increased as ionization progressed, and since ionization of the gases progressed with continued usage of the tube, the resistance between the terminals (i. e., the intratubal resistance) progressively decreased and thereby the degree of impact of the electrons became less and less. As a consequence the production of X-radiation varied both as to quantity and quality. Some of these tubes had one degree of vacuum; some another. It was necessary to have a collection of tubes in an X-ray laboratory; tubes of various degrees of hardness (referring to the shortness of wave length of the X-rays produced in relation to one or another degree of vacuum). One tube was used for one thickness of the body, another tube for another. Unfavorable as this might seem, it was even more annoying that the performance of any one tube was not steady.

b. Modern.—In 1912, Coolidge invoked two important principles which even today are used in the construction of an X-ray tube. These principles include a complete vacuum and provision for thermionic control of current flow. A perfect vacuum offers complete resistance to the flow of electrons. Modern X-ray tubes are therefore as completely evacuated as man can accomplish. Even the metal parts which are to be contained within the tube are degassed. When using these tubes the resistance of this vacuum is reduced by heating one of the terminals, the cathode, for with a certain quantity of heat applied to a conductor (approximately 500° C. in the case of tungsten), mobilized electrons will move out beyond the limits of the conductor. Coolidge selected tungsten for this purpose because of its very high melting point. To provide for its heating, the tungsten was drawn to wire-like dimensions, as in the case of modern electric lamps, and a separate heating circuit was supplied. This is called the filament circuit. It is completed through the filament itself without involving the target or anode terminal of the tube at all. These relations are indicated in figure 17. It is important to realize that the quantity of electrons permitted to flow across the gap and between the cathode to the anode terminals of this X-ray tube is dependent upon the degree of heating of the filament of the cathode. Thus, regulation of the filament circuit actually controls the quantity of electrons flowing across the tube—the high tension circuit. To this extent, the filament regulator might be said to control the quantity of X-ray production.

c. Capacities.—(1) However, even with the support of valve tubes, there is a limit to the amount of heat that can be tolerated. This limit is described as the tube capacity. In general, the larger the

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dimensions of the actual focal spot of the tube, the greater will be its heat unit capacity per unit of time, and the greater will be its milliamperage tolerance. With a smaller actual focal spot dimension, this same tube will tolerate the same total number of heat units, but it will not tolerate as high a milliamperage setting. As mentioned in describing the types of X-rays, the focal spot of an X-ray tube is that limited portion of the target designed to receive the impact of the primary electrons (the cathode rays). The relationship between the actual focal spot and the effective focal spot is

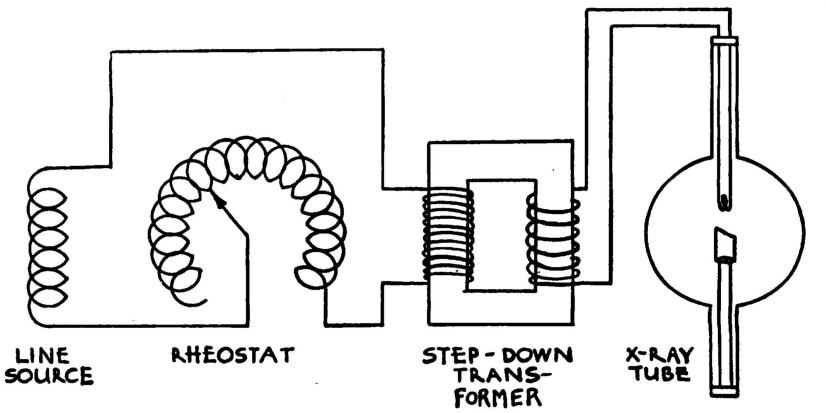


FIGURE 17.—Filament circuit.

shown in figure 18. Many radiographic tubes contain a double focus arrangement whereby one or the other focal spot dimensions may be utilized. The dimension of the effective focal spot is an important factor in relation to the detail which can be obtained on the roentgenogram, as discussed in the section concerned with technical factors which govern quality.

(2) (*a*) For diagnostic tubes, there are two kinds of capacity:

1. The maximum load (i. e, milliamperage) for any one individual exposure.

2. The summation of heat units—represented by all the exposures made by a tube during a given working period.

(*b*) The individual exposure load ratings are determined largely by the size of the focal spot of the tube regardless of other features of the design of the target. Rotating anode tubes are exceptions. They have much higher ratings for a given focal spot size than do stationary anode tubes. However, within their own category, the individual load ratings of rotating anode tubes are also determined largely by focal spot size. It is customary to establish

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technique factors for exposures of any given part of the body in terms of a fixed milliamperage and time. For certain cases, notably chest exposures, it is desired to make the milliamperage as high as possible so that the time may be as short as possible. For most other exposures, a greater amount of X-ray energy is required, and a longer time factor is usually employed with a lower milliamperage factor. In tables II and III, milliamperage tolerances for each focal size

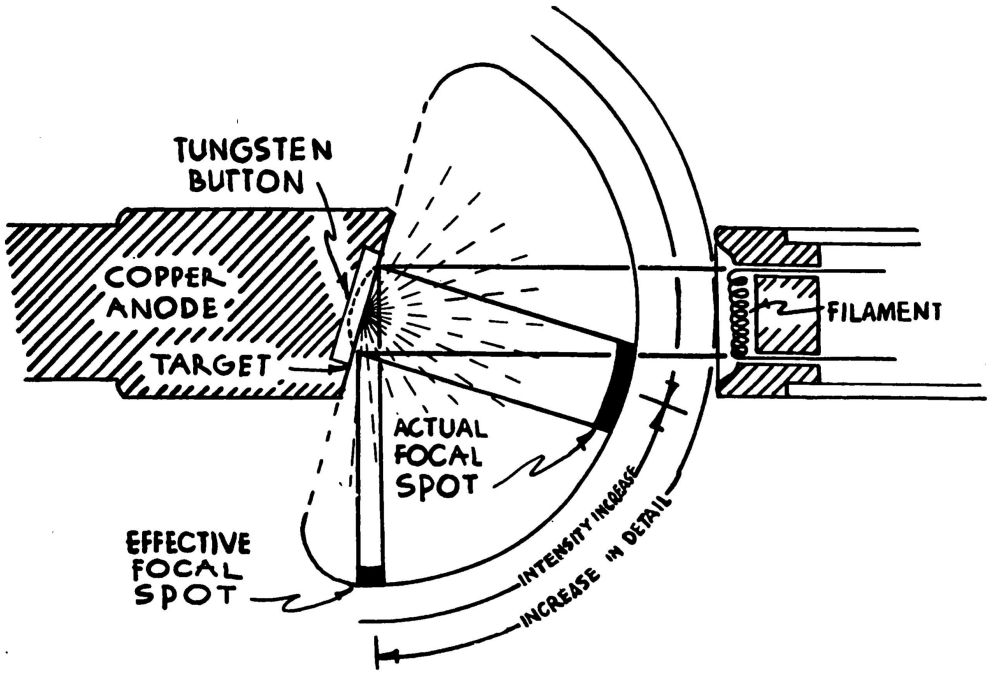


FIGURE 18.—Heat storage capacity.

are indicated. Four different figures are given in each case: two for cases requiring very short exposures, as for chests; and two for the routine requirements of the longer exposures, as with the use of grids. Under each heading the figures in column (A) represent the *maximum* milliamperage that it would be safe to employ routinely where it is desired to cut exposure times as much as possible, and exceptional care should be taken to set the currents accurately, etc. The figures in column (B) represent normal working values to insure good tube life and allow a certain amount of leeway for errors. Since these tolerances differ when half wave (including self-rectification) is utilized rather than full wave, two tables are given, one for full-wave rectified generators and one for half-wave generators. These values might serve as a general guide in the selection of focal spot size. However, in actual operation, the technique factors to be employed should always be checked against the

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rating charts supplied with the tube to make sure that the tube ratings are never exceeded.

TABLE II.—*Full-wave generator, milliamperage* vs. *focal spot size*

Focal spot size—mm.[2]	Chest exposures		Bucky exposures	
	(A)	(B)	(A)	(B)
Stationary anode:	*Milliamperes*	*Milliamperes*	*Milliamperes*	*Milliamperes*
1.5	25	20	20	15
2.3	75	60	40	30
3.2	120	100	60	40
3.8	200	150	75	50
4.2	250	200	80	60
5.0	350	250	100	60
Rotating anode:				
1.0	200	150	75	50
2.0	500	400	100	60

TABLE III.—*Self-rectified generator, milliamperage* vs. *focal spot size*

Focal spot size—mm.[3]	Chest exposures		Bucky exposures	
	(A)	(B)	(A)	(B)
	Milliamperes	*Milliamperes*	*Milliamperes*	*Milliampere*
1.5	----------	----------	15	10
2.3	40	30	30	25
3.2	60	50	40	30
3.8	100	75	50	40
4.2	100	80	60	50
5.0	100	100	60	60

Courtesy Machlett Laboratories, Inc., Springdale, Conn.

(*c*) The heat which is generated by an X-ray exposure is almost immediately removed from the focal area by conduction into the body of the anode structure, where it is stored while being gradually dissipated. This dissipation of heat is by means of radiation into the surrounding medium and by conduction in air, water, or oil which may be used as a cooling medium. The anode structure of the tube may become overheated if a number of exposures are made which represent a total amount of heat in excess of the heat storage capacity of the anode. To avoid this condition, it is necessary to know the heat storage capacity of the anode and the heat-dissipation characteristics of the tube. These properties of the tube are usually published by

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the manufacturer. The amount of heat involved in an exposure is usually expressed in terms of arbitrary units described as heat units (the product of the peak kilovoltage times the milliamperage times the time in seconds). If the total number of heat units involved in a series of exposures to be made in rapid succession exceed the heat storage capacity of the anode, it will be overheated unless sufficient cooling intervals are allowed between exposures to allow for the dissipation of the excess amount of heat. A study of the heat-dissipation characteristics is necessary to indicate the length of cooling intervals required.

23. Self-rectification.—With this arrangement, as long as the target of the tube remains relatively cool (i. e., less than 500° C.), and when alternating current is supplied to the terminals of this tube, only

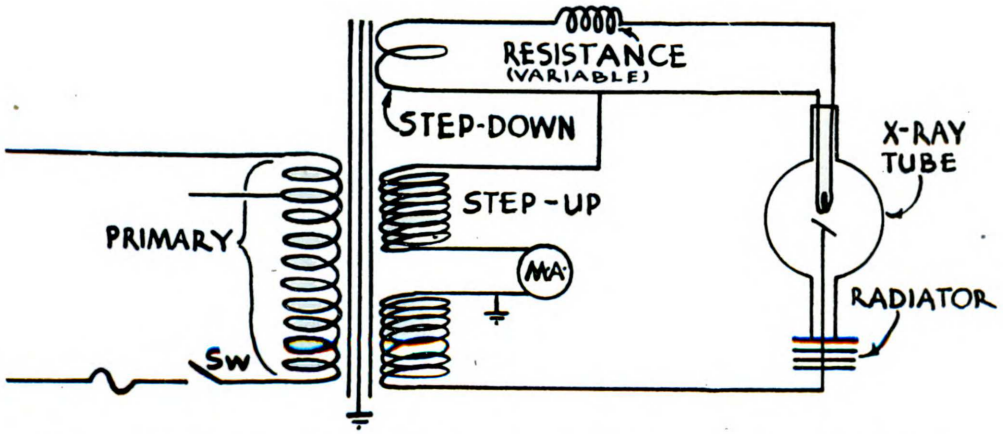


FIGURE 19.—Simple self-rectified X-ray circuit (with combination transformer).

those alternations which are directed to the filament terminal are able to get across the gap. Those alternations which are directed to the target terminal are inhibited. The result is self-rectification. A half-wave unidirectional current is produced. With provision for this type of function on the part of the X-ray tube, an X-ray machine unit may consist of no more than a main switch, a combination (step-up and step-down) transformer, a resistance wire (serving as a rheostat), and the X-ray tube.

This is the design of the mobile unit used in the World War. When self-rectification is imposed upon an X-ray tube, special construction features are ordinarily provided for dissipation of heat which is produced in the target. Even though various construction features are incorporated into X-ray tubes, such as radiator fins, water or oil circulation, etc., nevertheless because of this danger of excessive heat accumulating in the target, the capacity of any tube must necessarily

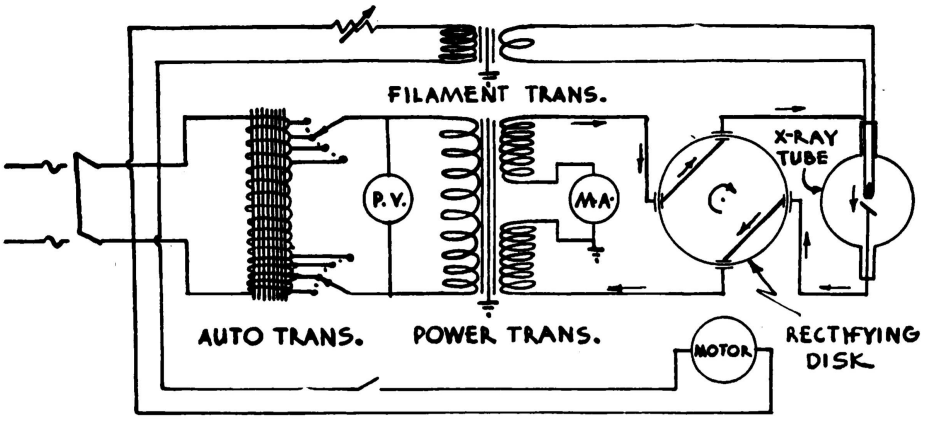
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be less when self-rectification is imposed upon that tube. Unfortunately, when electrons bombard a target, not only X-rays are produced but there is a great production of heat rays (it is estimated that only about 0.4 percent of the energy is of the nature of X-rays, while more than 99 percent of the energy is converted into heat). The result is that before very long sufficient heat accumulates in the target of the tube to force electrons into space beyond the limits of the target structure, and thereby the resistance of the vacuum is counteracted in both directions. The filament of the tube cannot tolerate the bombardment by the electron stream. It is rather delicate and quickly destroyed.

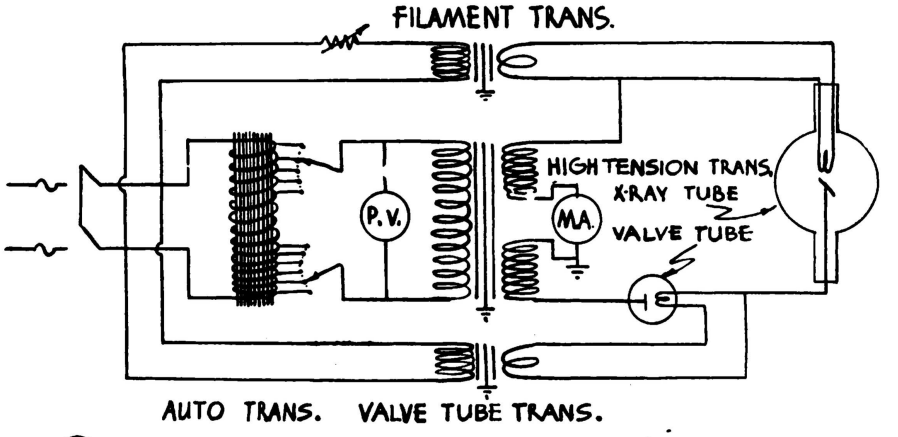
24. Valve tube rectification.—That portion of the target normally receiving the impact of the electron stream is usually constructed of tungsten. In the case of some X-ray tubes the *entire* target is constructed of tungsten. Since tungsten is not as efficient in conducting heat as copper, the latter is used by several of the manufacturers for the construction of much of the target (i. e., anode) terminal. The accumulation of heat is detrimental regardless of whether or not the X-ray tube is required to provide for its own rectification. In some equipment, as shown in figure 20, additional tubes called valve tubes are inserted into the circuit to incur the action of rectification. These tubes are not constructed exactly as are X-ray tubes, but they are designed on thermionic principles, and thereby serve to protect the X-ray tube.

25. Inverse suppressor.—In the case of certain relatively low milliamperage capacity units (10 to 30 milliamperes), instead of incorporating valve tubes in the high tension circuit for the purpose of rectification, an inverse suppressor may be connected into the primary circuit (concerned with the high tension transformer). The purpose of inverse suppressors is to limit partially the amplitude of voltage effective upon the target terminal of the X-ray tube. Inverse suppressors may be constructed on the principle of a thermionic tube or on the principle of crystal rectification. In either instance, there is provided a shunt resistance in a position parallel to the rectifying component. This shunt resistance provides for the flow of a small quantity of current in the unfavorable direction so as to provide for demagnetizing the core of the high tension transformer (i. e., offsetting transformer lag), and thereby increasing the amplitude movement of the magnetic field of force and the efficiency of the transformer over that which would be obtained in case a true half-wave pulsating unidirectional current were supplied in the primary circuit. This performance is indi-

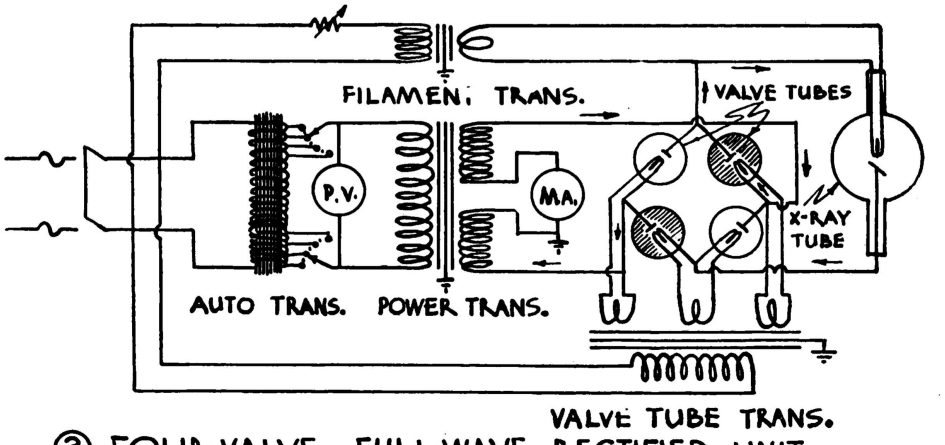
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① MECHANICAL FULL-WAVE RECTIFIED UNIT



② SINGLE-VALVE HALF-WAVE RECTIFIED UNIT



③ FOUR-VALVE FULL-WAVE RECTIFIED UNIT

FIGURE 20.—Valve tube rectification.

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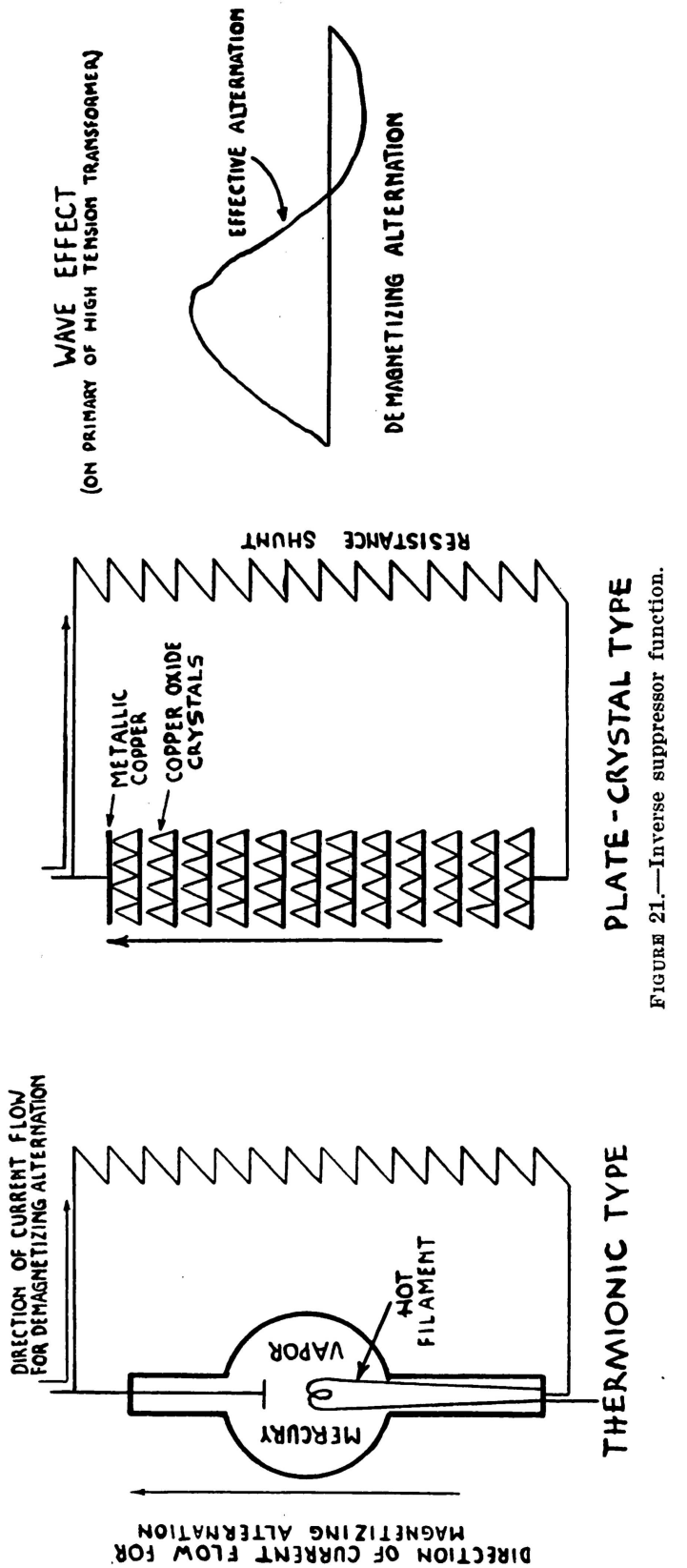


FIGURE 21.—Inverse suppressor function.

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cated in figure 21. Inverse suppressors are usually used when it is necessary to reduce the bulk and weight of the high tension transformer to a minimum, as for instance when the high tension transformer is contained with the X-ray tube. Small transformers necessarily have relatively poor regulation. In performance, the difference between the voltage for the alternations carrying the load versus the voltage developed by those alternations not carrying the load may be as great as 15 to 20 P.Kv. for load considerations of 25 to 30 milliamperes. The construction features in the tube head (i. e., spacing, oil content, etc.) may not tolerate such no-load potentials. It is to compensate for these construction features or to protect shockproof cables that inverse suppressors are utilized.

SECTION V

CALIBRATIONS

	Paragraph
General	26
Kilovoltage calibrations	27
Milliamperage	28
Timer	29
Distance	30
Dimensions of the effective focal spot	31
Quantity of X-radiation	32
Grids	33
Cassettes	34

26. General.—There are certain performance characteristics which must be considered individual to any one unit. The design and construction features of high tension transformers are not consistent. To a lesser degree, this also holds true for filament transformers and for autotransformers. Even when constructed by any one company and regardless of large scale line production, these variations prevail. Of course the differences in performances are considerably greater when the product of one manufacturer is compared with that of another. There are, therefore, a number of questions to which even an expert X-ray technician is entitled when faced with strange equipment. Certain questions would indicate intelligence on his part rather than ignorance. For instance, he should inquire as to calibrated settings concerned with kilovoltage values in relation to usable milliamperage loads; he is entitled to know the radius of the particular grid; what its ratio is and therefore what milliamperage-second requirement is necessary when using the grid as compared with roentgenographic factors without the use of it; and he is entitled to know the sensitizing speed of the particular intensifying screens (contained in one or another cassette).

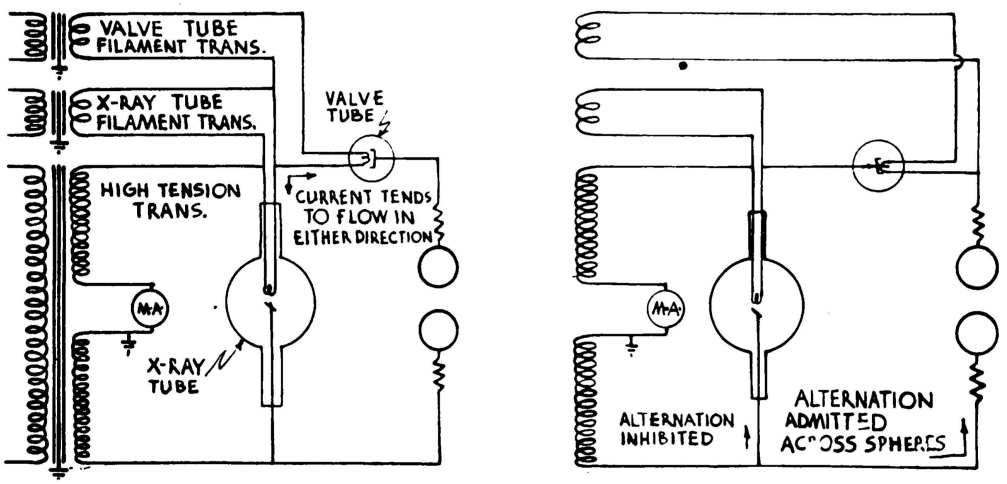
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27. Kilovoltage calibrations.—*a.* When a certain voltage is applied through the primary of the high tension transformer, the voltage in the secondary winding is amplified in accordance with the ratio of the number of turns of the secondary to the number of turns in the primary, as previously described. However, the actual voltages concerned with both the secondary circuit and the primary circuit depend not only upon the voltage selection in the primary but also upon the current load in the secondary circuit. Even though there is no actual load, as long as the primary winding is energized, a certain potential is developed in the secondary winding. This potential is described as the no-load potential. In relation to any given setting which might pertain to one or another useful voltage, this no-load potential is called the inverse voltage. It is especially important with consideration of half-wave performance (either self-rectification or where valve tubes are used in the secondary circuit). Regardless of inhibiting unfavorably directed alternations of current flow by means of valve tubes, no-load or inverse potentials become effective. If these potentials are excessive, there may result a break-down with short circuiting to the housing (if a tube unit) or through the insulation of shockproof cables. These dangers are less likely in the case of full-wave rectified units. In either case, though, with heating of the filament whereby a certain milliamperage of current is allowed to flow through the X-ray tube, there will result a certain reduction in the intratubal (X-ray tube) resistance, and because of this there will be a reduction in the kilovoltage of the circuit. This reduced kilovoltage is called the "useful." With every increase in heating of the filament of the X-ray tube, and resultant increase in the milliamperage load, the useful voltage will be reduced, regardless of the no-load potential remaining constant. It is the useful kilovoltage that is concerned with the production of X-rays, their quality, and the resultant radiographic density; hence the importance of knowing the useful kilovoltage values in relation to milliamperage settings. These values are usually recorded on the meters of modern X-ray equipment. However, with certain machines, arbitrary numbers or letters are used to designate the button settings, particularly of the autotransformer, and for them, especially, sphere gap calibration may be necessary. For this, leads must be extended from the high tension terminals and connections provided so that the spheres are placed in a circuit and parallel with the X-ray tube itself. In the case of half-wave performance, a valve tube should be connected into this parallel circuit. When this valve tube is positioned as indicated in figure 22 ①, the sphere gap calibration will measure the useful voltage; whereas when the valve tube is posi-

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tioned as indicated in figure 22 ②, there will be measured the no-load voltage.

b. A slight error is incurred by this method because of the resistance through the valve tube itself. This error is usually in the order of 1 to 2 kilovolts, but as far as the relationship between the useful kilovoltage and the no-load kilovoltage is concerned, this error is canceled as long as the valve tube is used in both instances and the connections to it merely changed. With full-wave rectification it is not necessary to include a valve tube in the sphere gap circuit. The useful kilovoltage is measured with the filament of the X-ray tube heated



① Measuring useful voltage. ② Measuring inverse voltage.

FIGURE 22.—Wiring diagram for calibration of half-wave (including self-rectified) equipment.

sufficiently to provide for the particular milliamperage load, while the no-load value is measured with the filament circuit open so that the filament is not heated. Useful kilovoltage values should be determined for at least three zones for each of the milliamperage loads. For radiographic equipment, it is practical that these three zones be in the neighborhood of 40, 60, and 80 P.Kv. Each of these settings should be carefully checked at least three times. Having obtained trustworthy values in this manner, it is then possible to plot them on coordinate paper so as to obtain information as to all other intervening values, as indicated by a calibration chart (fig. 23).

28. Milliamperage.—Today the values indicated on the scale of a standard milliammeter are usually reliable to within 5 percent of their full-scale deflexion. In case the recording by any one milliammeter should be doubted, it is usually practical to connect in series with it a second milliammeter of known trust. It is not unusual to depend upon two milliammeters (twin milliammeters) when using apparatus for

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X-ray therapy, but this is not practical in the case of roentgenographic equipment. As described in the discussion pertaining to wave form, the radiographic performance of any one piece of equipment may not be proportional to the milliamperage merely because of distortion of the wave form, particularly under conditions of high capacity loads. Moreover, due to inherent filtration factors, the X-radiation performance by one tube may differ markedly from that of another, and for this reason radiographic calibrations (using penetrometers, aluminum

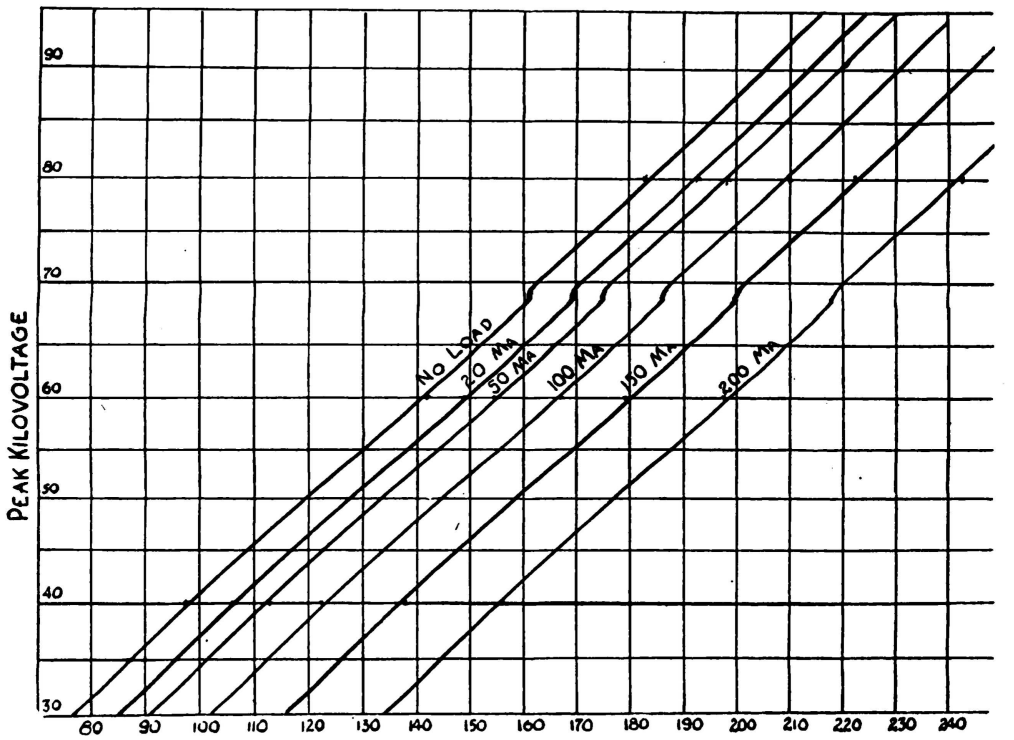


FIGURE 23.—Primary voltmeter reading.

ladders, etc.) of milliamperage and/or of kilovoltage values, as oftentimes recommended, are not truly indicative.

29. Timer.—Prolonged exposure times may be checked with the use of a reliable stop watch. Exposure of less than 1 second might be checked with the use of a spinning top. This device is simply an X-ray opaque top containing a perforation or notch so that when the top is made to spin, the perforation or notch will rotate through a plane parallel to the film over which it is positioned. If an exposure is made, the X-ray tube being positioned above the top, provided the top be truly X-ray opaque, there will be projected a series of outlines of the perforation or notching. These should indicate the number of pulsations of X-radiation coincident with the pulsations of the high

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tension current. In the case of full-wave rectification, with a 60-cycle current, there are 120 pulsations per second. In such a case, the number of dots of radiographic density indicated by the top test, divided by 120, will indicate the fraction of a second exposure. In the case of half-wave currents, provided the cycle be 60, the divisor should be 60 rather than 120.

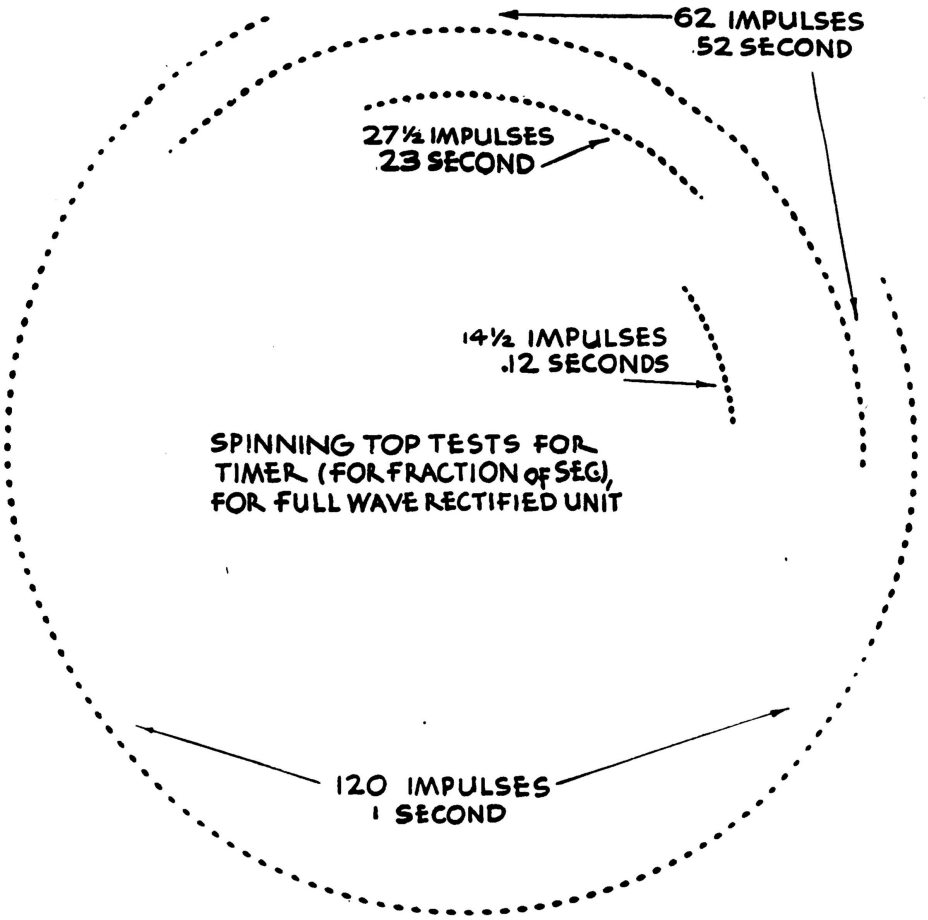


FIGURE 24.—Spinning top tests for timer (for fraction of second) for full-wave rectified unit.

30. Distance.—Occasionally it may be necessary to measure the position of the focal spot of the X-ray tube in relation to the plane of the exit portal of the primary bean. This may be indicated when dealing with foreign body localizations or when troubled by a cut-off in the area of coverage by the primary beam. With modern equipment the entire tube is likely to be concealed either within a tube unit or a tube housing. Should it be necessary to determine the exact location of the focal spot, a simple procedure is to place an 8- by 10-inch film (contained in a cardboard holder) on its side, the

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middle of it positioned across the exit portal and approximately at right angles to it. After making an exposure, such as 60 Kv.P. for 40 Ma.S., this film should be processed in the usual manner and then laid upon a white background. By projecting the converging borders of the semitriangular density on the film, there will be obtained a fairly accurate measurement of the position of the focal spot beneath the plane of the exit portal. It should be realized that a slight error will be incurred because of "penumbra." This error will be greater when a large focal spot is used rather than a small one. The penumbra can be identified and eliminated to a considerable extent provided the radiographic density is proper.

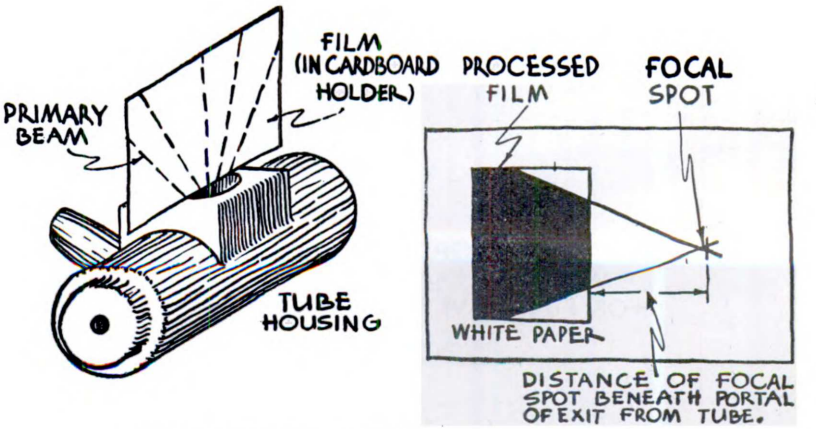


FIGURE 25.—Determination of focal spot level.

31. Dimensions of the effective focal spot.—When the roentgenographic detail is consistently hazy and lacking in sharpness, it may be desirable to measure the dimensions of the focal spot. This can be done with the use of a lead diaphragm having an 0.5 mm. pin point opening. After placing this diaphragm beneath the portal of the X-ray tube, and at one-third the distance between it and a dental film, make an exposure sufficient to produce a density on the film (if the focal film distance be 30 centimeters, 60 Kv.P. for 40 Ma.S. should suffice). Using calipers, measure across the area of uniform density (ignoring the peripheral lesser densities—produced by penumbra). With this measurement apply the following formula:

$$\frac{\text{projected dimension}}{2} - \frac{3 \times \text{aperture dimension}}{2} = \text{effective focal spot dimension}$$

32. Quantity of X-radiation.—The quantity of X-radiation delivered may be measured with the use of an r-meter (Victoreen dosimeter). This calibration is seldom indicated for roentgenographic equipment, though very important with therapy equipment.

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When the ordinary r-meter is used for calibration of radiation performances, at the relatively low kilovoltage values used for roentgenography, a certain error is incurred. However, such an error is canceled when the calibrations are made to obtain comparative data, as for instance in the testing of constancy of radiation performance at high versus low milliamperage settings. Provided the kilovoltage values be controlled, for the same milliampere-second values, in the case of a good transformer, the quantity of X-radiation delivered

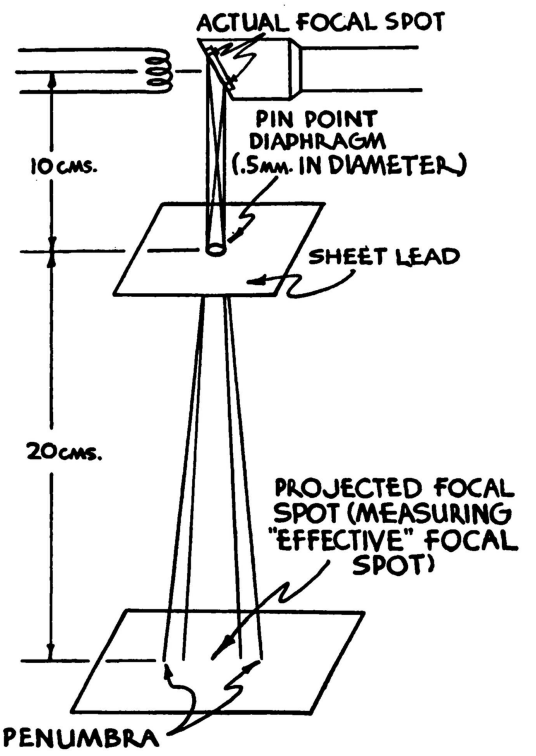


FIGURE 26.—Measuring focal spot.

at a low milliamperage setting will coincide (within 5 to 6 percent) with that delivered at a high milliamperage setting. This will not be true in case the milliamperage load exceeds ideal limits of capacity of the transformer. In the case of the latter, the r-performance will be reduced at the high milliamperage settings. Such evidence is indicative of distortion of wave form.

33. Grids.—Well-constructed grids (Bucky diaphragms) are designed with a definite radius and grid ratio. Depending upon its radius, the X-ray tube should be positioned within a certain limited range of distance from it. Depending upon its ratio, appropriate compensation in the X-radiation exposure will be required. These requirements are described in the paragraph devoted to the description of grids (par. 42).

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34. Cassettes.—Until individually understood, the characteristics of any one cassette (mainly because of the characteristics of its intensifying screens) should be considered as unknown and yet as important as any of the performance factors described above. It is essential to realize that the fluorescence by intensifying screens varies with the kilovoltage and that their sensitizing speeds vary accordingly. Hence, the importance of calibrating each individual cassette as described in the paragraph pertaining to cassettes (or at least allowing an approximate speed factor consistent with the kilovoltage range).

SECTION VI

TROUBLE ANALYSES; MAINTENANCE AND REPAIR OF X-RAY EQUIPMENT

Paragraph
General ---------- 35
Manifestations of trouble ---------- 36

35. General.—Before attempting to remedy X-ray equipment difficulties, the approach to the trouble must be systematic and analytical. The wiring diagram should be studied and above all else, common sense must be utilized to the highest degree. Consider the trouble possibilities in relation to each circuit. In most instances the difficulty is of minor nature. Hesitate before proceeding to dismantle intricate and expensive components. Practically all electrical troubles are caused by open circuits or short circuits (including grounded circuits).

36. Manifestations of trouble.—*a. Inconstancy of performance.*—In fluctuations of milliamperage, consider the possibilities of a gassy X-ray tube, or if valve tubes are used, this same condition with respect to one or more of them. These fluctuations may be indicated by repeated opening of the circuit breaker. If sputtering is concurrently noted, test the performance at lower kilovoltage settings—consistent performances at lower kilovoltage settings may indicate an intermittent shorting about the X-ray tube due to a low oil level.

b. Partially dead equipment.—A range of possibilities is to be considered:

(1) In case the filament of the X-ray tube is not lighted (considering that it is visible by means of a transparent window), or in case X-rays are not produced, even though the prereading voltmeter indicates energization of the high tension transformer, consider the possibility of a short circuit in the filament circuit or a burned-out filament in the X-ray tube. If the X-ray tube is of double

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focus design, change the adjustment to the other focal spot and test an exposure. If no milliamperage is recorded by the milliammeter with either setting, and if there is no evidence of X-radiation with either setting, test the several circuits concerned with the filament. Check rheostat for broken or burned-out sections.

(2) Failure of X-ray production with or without registration of milliamperage but associated with sputtering in the high tension transformer during operation. Consider a shorting either around the X-ray tube or through the case of the transformer—due to low oil level; perhaps there is a content of air admixed with the oil; or perhaps the high tension leads have become detached.

(3) Lack of registration of prereading voltage and of milliamperage, regardless of evidence that filament circuits are intact. Consider dead button setting on autotransformer or detached leads concerned with it. (Never vary settings when high tension switch is closed.) Check potential across the voltmeter. Connections or components on it may have been burned out. Check all external connections; consider short circuiting possibilities which might result from dust or accumulation.

c. Completely dead equipment.—This evidence is likely to indicate burned-out fuses. Use a test lamp (220-volt lamp or 110-volt lamp, depending upon the voltage of the incoming line used), checking across the line, ahead of the fuses, and beyond them, and then eliminating one or another fuse. Replace burned-out fuses with new ones. They may have been burnt out because of an overload due to careless adjustment of controls; therefore before proceeding with subsequent trial exposures, it is important to set all controls at low values and then to readjust to higher settings. In case the new fuses are immediately burned out, even at low settings, it is likely that short circuiting exists (due either to wear or abuse of the apparatus). Disconnections might then be accomplished, separating first the high tension transformer and opening the primary circuit concerned with it. Using the test lamp, check the several low tension circuits.

d. Precautionary measures.—Repair problems naturally prompt precautionary measures. Some of these include—

(1) Routine cleaning and dusting of equipment. This should be practised at least weekly with particular care of all exposed high tension leads.

(2) Routine checking of all external connections.

(3) Prompt repair of all minor defects.

(4) Strict adherence to calibrated values and capacity limits.

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SECTION VII

PROTECTIVE MEASURES

	Paragraph
General	37
Electrical dangers	38
X-radiation hazards	39

37. General.—In dealing with X-ray equipment, two types of hazards must be respected: electrical dangers and X-radiation dangers.

38. Electrical dangers.—*a.* The use of shockproof equipment is now so prevalent that electrical dangers have been almost eliminated. However, the safety provided by this type equipment is of itself a danger because it is likely to relieve too completely the mind of the operator. After handling trustworthy shockproof equipment, there is considerable likelihood that our younger X-ray technicians may fail to recognize the electrical hazards which exist as far as the operation of nonshockproof equipment is concerned. Moreover, everyone should realize that regardless of self-contained tube heads (i. e., when the X-ray tube is immersed in oil and contained in the same tank which accommodates the high tension transformer), or with the use of shockproof cables, one is still handling currents of exceptionally high voltage which under certain conditions might resist the protective provisions. Therefore, even with modern shockproof equipments, the possibilities of electrical hazards should be respected.

b. Death may result from any one of four physiological effects:

(1) The ventricles of the heart may be thrown into fibrillation from which, in the human, they seldom or never recover.

(2) Tetanic convulsion of the respiratory apparatus may result, with resultant fixation of the muscles of the thorax and the diaphragm into the phase of deep inspiration.

(3) The brain centers concerned with constriction of blood vessels may be so stimulated as suddenly to produce extreme blood pressure with resultant hemorrhages.

(4) The resistance on the part of the tissues to the flow of the electrical current may be so great as to produce extreme accumulations of heat with the result of actual charring.

c. Contrary to general belief, voltage is not the factor directly responsible for any of these effects. It is amperage that causes fatalities, and of greatest importance is the volume of current which is effective upon the heart. It has been estimated that for the frequencies of current utilized with most roentgenographic equipment (60-cycle), the human heart will tolerate no more than 6 to 15 milli-

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amperes. The heart is involved to the greatest extent when the electrical contacts include one upper extremity and the opposite lower extremity, for with such a contact, approximately 10 percent of the total current involves the heart. Interpreted as total current flowing through the body, by such a route, a minimal lethal value would amount to between 60 and 150 milliamperes. Some individuals have idiosyncrasies (either because of defects in their heart or because of an overly excitable nervous mechanism), and they cannot tolerate even the lower of these values. It is estimated that approximately 90 percent of maleffects incident to electrical shock are those concerned with the heart—hence the importance of these considerations. With high voltage and very low amperage (i. e., milliamperage), there is a tendency for an individual to be thrown for a distance. With lesser voltage and sufficient current to stimulate muscle contraction, a complete gripping contact is likely. A certain amount of voltage is required to overcome the resistance of the skin and superficial tissues. This value varies, depending upon the dryness of the skin, the thickness of it, and the amount of fat contained in the subcutaneous tissues. With very moist skin and a thin individual, it has been estimated that only 65 volts are required to overcome all body resistance.

d. Regardless of the unfavorable possibilities, every effort should be made to restore a victim from electrical shock. However, one should never directly grasp the individual, because by so doing the result will most likely be suicide with the accomplishment of no aid whatsoever to the first victim. Instead of plunging to one's own death, the first objective should be to break the electrical circuit by opening a switch. Perhaps the victim might be disentangled by throwing over him, a sheet or rope or some other nonconductor and then forcibly removing him from his contacts. Thereafter he should be treated as a victim of shock. He should be placed in the lying position, prone, with his face turned to one side and chin resting on the back of one of his hands—to provide for freedom of breathing. His collar and other clothing should be loosened and then the Schaeffer method of resuscitation (as used for the semidrowned) should be instituted. The chest manipulations should be continued at a rate of about 12 to 15 times per minute, without despair, for as long as 2 to 4 hours—awaiting the arrival of a doctor.

e. This treatment is effective in only a small percentage of cases. However, one should not despair in attempting to revive a victim of this sort. The poor results of treatment should emphasize the importance of avoiding the possibilities of electrical shock. Conspicu-

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ous warnings should be posted wherever dangers exist. With roentgenographic equipment, exposed condensers are examples of such dangers. It should be realized that these condensers may discharge even though the machine is not in operation. They may discharge hours and even days later.



FIGURE 27.—Schaeffer method of resuscitation.

39. X-radiation hazards.—X-radiation hazards are to be considered both in relation to the technician and to the patient. Ordinarily, the technician receives only a minimum of primary X-radiation at any one time, though he may receive considerable secondary X-radiation—from the patient as well as from adjoining materials (such as the examining table, chair, etc.). Even small dosages, if repeated often, become injurious. The maleffects are mainly concerned with the blood cells and those tissues which produce them. Ultimately an anemia may result. The blood cells become so reduced in numbers that the individual may not only become pale and weak, actually lacking in vitality, but he may succumb easily to all types of infections because of his lack of resistance. Occasionally, the blood-forming tissues become overly stimulated in reaction to these depletions, and as a consequence there may result a wild growth of these cells in the form of one or another type of leukemia. This is actually a form of cancer which is usually fatal within a period of 3 to 6 years. The importance of precautions cannot be overemphasized. These precautions should include protective measures necessary to avoid unnecessary X-radiation exposures; they should include proper hygienic care, regularity of exercise in the open, proper dietary, and periodic blood examinations. The recommendations of the Advisory Committee on X-ray and Radium Protection, as published in the National Bureau of Standards Handbook HB20, should be observed. In addi-

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tion to the general systematic effects, as produced by repeated small dosages of X-radiation, injury to the skin (of either the technician or the patient) is to be considered. A single prolonged exposure is sufficient to do this. Hair follicles may be injured and the hair thereby caused to fall out or the skin may actually be burned—though these effects may not become evident for as long as 10 days to more than 2 weeks later. The intensity of effects is the greatest when short distances (focal-skin distances) are used; 12 inches should be the minimum. Though the inherent filtrations of X-ray tube arrangements vary, table IV should serve as a rough guide as to maximum safe tolerances.

TABLE IV.—*Filtrations with voltages of 90 Kv.P. and less*

Focal-skin distance	Tolerance limits (summation values)
Inches	*Milliampere-seconds*
15	1, 200
16	1, 365
17	1, 541
18	1, 728
19	1, 925
20	2, 133
21	2, 352
22	2, 581
23	2, 821
24	3, 072
25	3, 333
26	3, 605
27	3, 888
28	4, 181
29	4, 485
30	4, 800
72	27. 648

These values are based upon an inherent filtration in the X-ray tube unit, or added filter to the equivalence of at least 1-mm aluminum. For roentgenography about the head, reduce the milliampere-second allowances to half those listed.

SECTION VIII

AUXILIARY RADIOGRAPHIC EQUIPMENT

Paragraph
General ---------- 40
Diaphragms, cones, and cylinders ---------- 41
Grids ---------- 42

40. General.—*a.* With the passage of a beam of X-rays through a substance, a large percentage of the rays traverse the substance

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while some of them become absorbed. Absorption occurs when an X-ray directly strikes the nucleus of an atom. There results a mobilization of electrons (atomic). Mobilization of the electrons, *per se*, as well as subsequent bombardments by them, are productive of a new order of X-ray energy. The X-ray energy produced in this manner is called secondary radiation. The secondary rays are generated from any point source within the substance pervaded. The result is very much as if there were not merely the one X-ray tube functioning but, instead, numerous X-ray tubes and these located at various levels and positions. Since the X-radiation is generated from numerous point sources, there results a multiplication in the projection of any one density which might be positioned between the X-ray tube and a film. The primary beam of X-rays serves to project such a density onto one position of the film, while the secondary rays serve to project it onto other locations. The effect of the secondary rays is much more feeble than that of the primary beam but sufficient to result in blurring of outlines. This blurring is described as secondary fog.

b. The degree of secondary fog is proportional to the mass of tissue affected by the primary beam or other X-radiation, and it is increased with increases in kilovoltage. These effects are decreased by reduction in kilovoltage; reduction in the mass of substance traversed by the primary beam—as accomplished with the use of diaphragms or cones; and absorption of tangentially directed rays—by the use of grids.

41. Diaphragms, cones, and cylinders.—Limitation in the development of secondary radiation with the use of a diaphragm, cone, or cylinder is illustrated in figure 28. It should be emphasized that when using a diaphragm it must be placed either beneath the X-ray tube or upon the part that is being studied. It should serve to limit the diameter of the primary beam. A diaphragm positioned between the part and the film serves merely as a mask. It does not serve to reduce the amount of secondary radiation produced in the part. Grids, though, are positioned between the part and the film. They serve to absorb rather than to limit the production of secondary rays.

42. Grids.—*a.* A moving grid is called a Bucky diaphragm or a Potter-Bucky diaphragm. It was Dr. G. Bucky who developed the idea of utilizing strips of lead, arranged in parallel positions, to absorb the tangentially directed rays. The thickness of the lead strips of the earliest types of grids was such that the densities of these strips as projected onto the films were annoying to the roentgen-

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ologist. For this reason Dr. Hollis Potter invoked the principle of moving the strips of lead. If the exposure time is coordinated properly in relation to the grid travel time, the individual strips of lead are not visualized on the film. The lead strips serve the purpose of filtration but at the expense of some radiation absorption. Therefore when using grids it is necessary to increase the milliam-

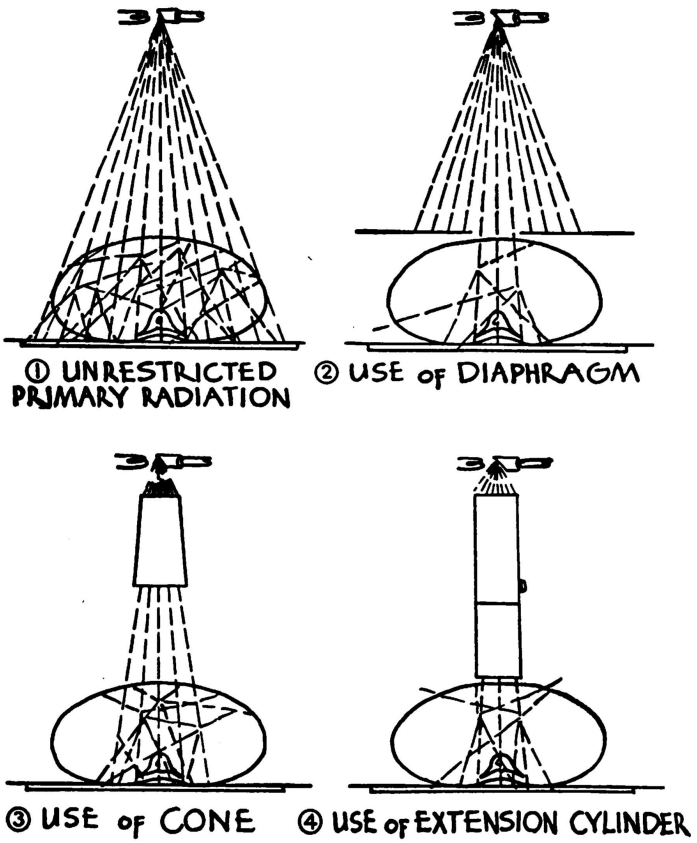


FIGURE 28.—Development of radiation.

pere-seconds or kilovoltage. The construction features of the curved type of grid as compared with the flat type are shown in figure 29.

b. Grids possess individual characteristics which should be understood in order to provide for proper handling. Some grids are constructed with approximately 20 lead strips per inch width; others with approximately 30; while others contain 40 to 55 lead strips. The greater the number of lead strips per inch, naturally, the less is the thickness of each individual lead strip. The less the thickness of each individual lead strip, the less tendency there is to produce grid marks or wooliness on the roentgenogram.

c. Grids also differ as to ratio. The grid ratio might be defined as the proportion between the width of each individual lead strip

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(i. e., thickness of the grid itself) in relation to the spacing between the lead strips. A common grid ratio is 5 to 1, but grids are constructed with a 3 to 1 ratio, 6 to 1, 8 to 1, and occasionally even 12 to 1 ratio. The higher the ratio the greater is the efficiency of absorption of the secondary rays, but at the same time the greater is the milliampere-second compensation requirement.

d. Grids also differ as to radius. The grid radius might be defined as that distance at which the X-ray tube should be positioned so as to obtain to the greatest extent a parallel relationship of the rays

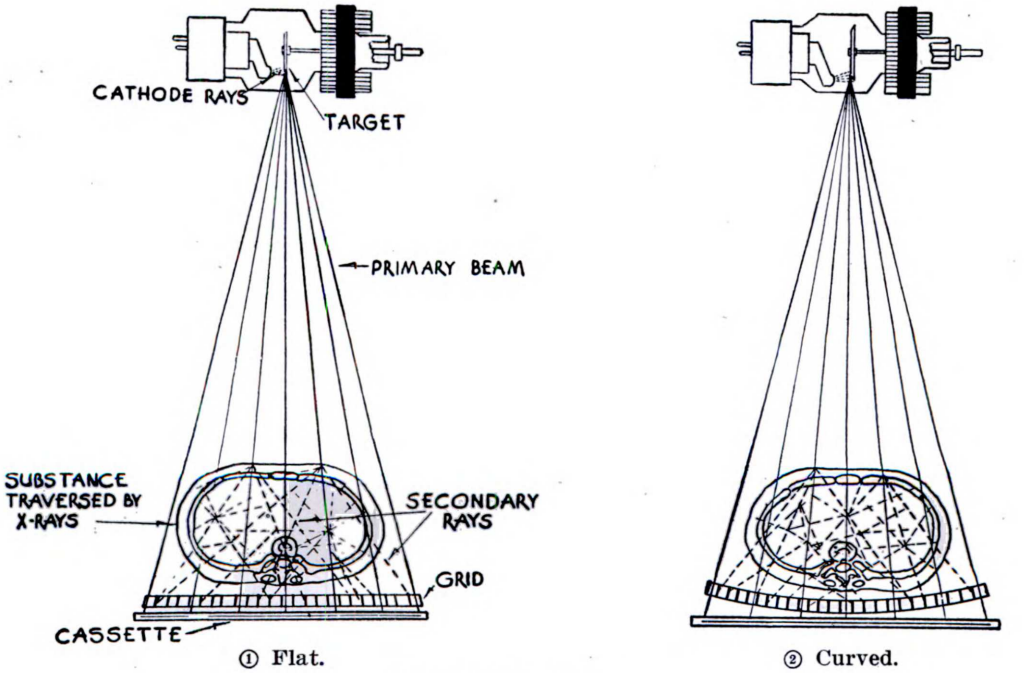


FIGURE 29.—Grids.

of the primary beam to the lead strips. With consideration of a curved grid, the grid radius is actually the radius of a circle of which the grid itself would constitute an arc. It is important to use grids with the X-ray tube properly positioned, otherwise there results absorption of primary X-rays as well as of the secondary. On the film this is evidenced by sections of underexposure. It is described as cut-off. Most grids are constructed with a radius of 30 inches, but some are constructed with a 25-inch radius while others have a 36-inch, 48-inch, or even a 72-inch radius. With some the radius would be infinity, for the lead strips are exactly parallel to one another.

e. The radius of a grid is usually described on the side of its housing, but it can be determined by positioning the grid beneath the

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X-ray tube and making a number of exposures at different distances. That distance which serves to project each individual lead strip uniformly (i. e., as of uniform thickness) upon the film can be considered to be the grid radius. The grid ratio might be determined by positioning the X-ray tube off center to the extent of the geometric base as considered in relation to the similar triangles showing in figure 30. For example, if it is thought that the ratio is 5 to 1 and the radius is 30 inches, the geometric relationship would be—5:1 :: 30:x—indicating that a shift of the X-ray tube to the extent of 6 inches should result in a complete cut-off (of radiation effect).

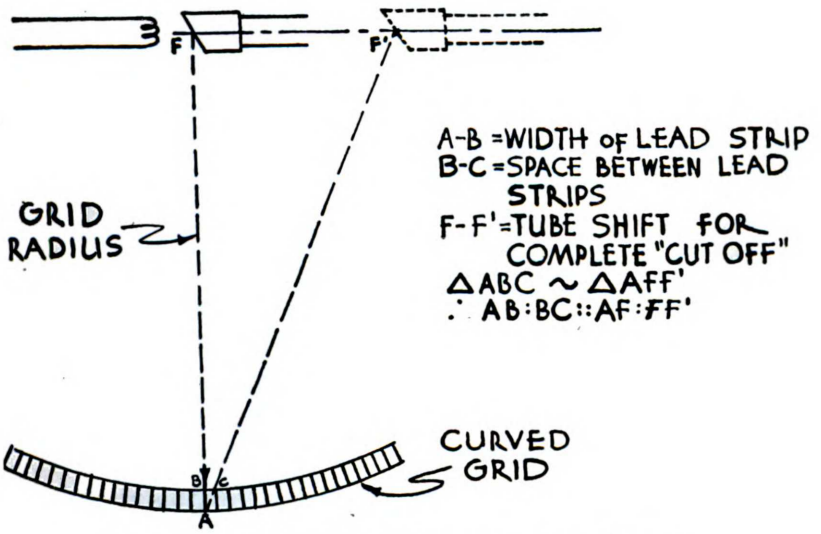


FIGURE 30.—Relation between cut-off and grid ratio.

f. Grid lines or wooliness may result even with the use of moving grids. The following possibilities are to be considered:

(1) Failure of the grid to move.

(2) The exposure occurring ahead of the time of initiation of grid movement (or pretravel time being too short to provide for smooth movement of the grid at the time when the exposure begins).

(3) The exposure time continuing beyond the period of grid movement (or the post-travel time being too short and allowing jerky movement of the grid before termination of the exposure).

(4) Jerky movements of the grid during the ideal travel period.

(5) Uneven thickness of grid strips.

(6) The composite travel (i. e., pretravel, effective travel, and post-travel) being more than twice the exposure time.

(7) The X-ray tube being positioned off center, laterally or vertically in relation to the proper radius centering.

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(8) The exposure time being so short as to produce synchronization—i. e., exposures of $\frac{1}{10}$ of a second or less, where self-rectification is utilized and the exposure is dependent upon as few as six impulses.

g. Grid lines must be expected when using stationary types of grids. With modern construction, having very thin lead strips and as many as 50 or more lead strips per inch, these lines are so thin as to result in very little annoyance. The advantages of a stationary grid of this sort are two fold: they provide for minimal part-film distance, thereby lessening the degree of distortion; and the milliampere-second compensation requirement by them is not great.

SECTION IX

DARKROOM EQUIPMENT

	Paragraph
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Films	44
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43. Processing room.—The first essential of a processing room is that it should be sufficiently light and X-ray proof so that films contained therein will not become fogged. The temperature of the room should not exceed 90°F. This fact emphasizes the importance of not having too great an area of heating surfaces and seeing that these are not located in close proximity to the sites of film storage. The darkroom should be located on a side of the building where, during the summertime, the heat of the sun will not become too intense. Thus an eastern exposure is to be preferred or a side of the building protected by shade, particularly during the afternoon. Certain construction features are desirable. For instance, a film bypass should be constructed in a convenient location into an inside wall. Rather than use a door, a labyrinth or maze should be provided for ingress and egress. The walls of this labyrinth should be painted a dull black, and its design and dimensions (i. e., width of the passageway in relation to total length) should be such as to inhibit the entrance of light into the room in amounts which would cause fogging of uncovered films. It is practical to have an air circulating fan. This might be constructed into an outside wall so as to provide either for ingress or egress of the air. It should be of lightproof construction. Properly filtered lighting sources should be provided, preferably mounted onto the ceiling. Since the filtering characteristics provided by these may not be sufficient to protect the particular emulsions of the X-ray films, it is important to make the film tests

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mentioned above under actual working conditions. It should not be necessary that the ceiling and walls of a processing room be painted black. They may be of a relatively light color, a peagreen, for instance, provided other protective measures prevail, as described. It is practical to have the film loading bin and loading bench on one side of the room and the processing tanks within handy reach of them, but at a sufficient distance to counteract splashing of chemicals onto sites where films or intensifying screens might be exposed or later come in contact. Racks for film hangers should be provided and located within handy reach of the loading bench. (See fig. 31.)

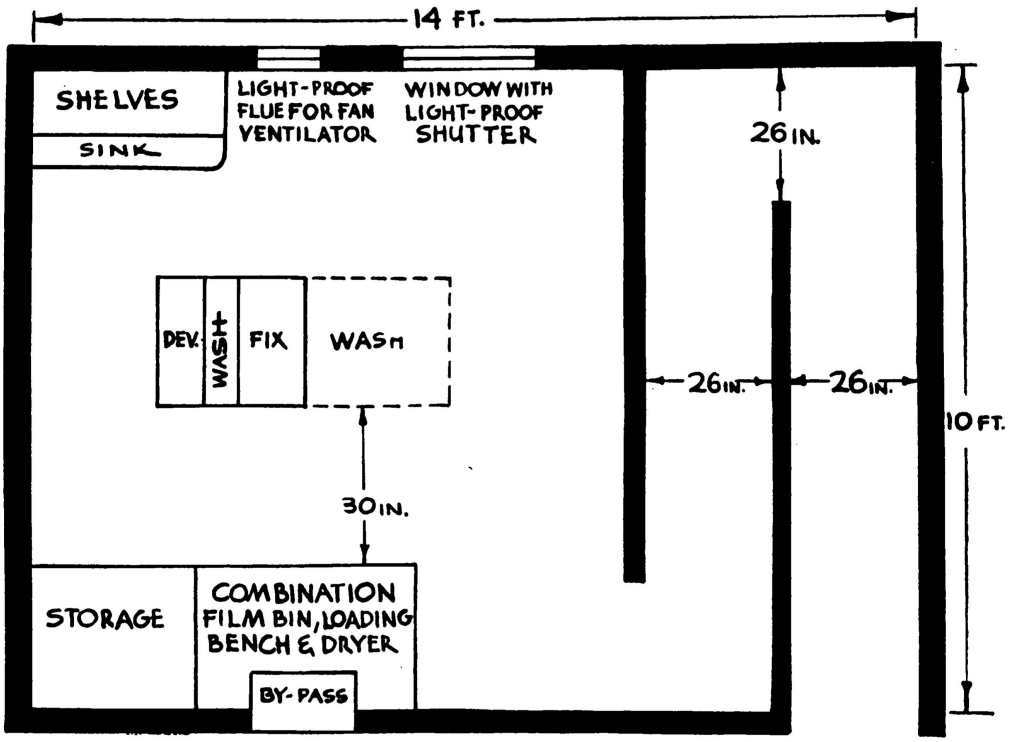


FIGURE 31.—Processing room.

44. Films.—*a.* The appearance of an X-ray film is well known. Standard dimensions, as used for medical purposes, include 35-millimeter film (in roll), dental, 4- by 5-inch, 4- by 10-inch, 5- by 7-inch, 6½- by 8½-inch, 8- by 10-inch, 10- by 12-inch, 7- by 17-inch, 11- by 14-inch, 14- by 17-inch, and 14- by 36-inch.

b. All of these films are composed of a light transparent base covered on one or both sides with a gelatinous emulsion containing a suspension of a silver halide. Double coatings are found on all except the 35-mm roll film and some of the dental films. The base of modern X-ray films contains less than 3 percent nitrocellulose. It

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is mainly composed of cellulose acetate. Nitrocellulose is still used in small percentages to provide for pliability and to improve the light transparency. It is an unfavorable constituent because of its avidity for combustion. The burning rate of the cellulose acetate base is much less than that of the nitrate. It is compared to the burning rate of paper, but some of the modern bases are even less ignitible than paper. Though they will burn, unless the flame is repeatedly renewed it becomes self-extinguished. These slow burning characteristics have developed for this film the name of safety film. Safety film may be distinguished by one or more small rectangular notches cut into one border of each individual film.

c. Film emulsions vary markedly not only with consideration of differences in composition, as produced by one manufacturer versus another, but also as far as any one manufacturer is concerned. For instance, among X-ray films produced by any one manufacturer there are two types: a screen film which is especially sensitive to the fluorescent light of intensifying screens and not so sensitive to the direct action of X-rays; and a direct exposure film, which is sensitive to the action of X-rays and not so sensitive to the wave lengths of fluorescent lighting as emitted from intensifying screens. This latter film emulsion may be identified by a double rectangular notch cut into one of its borders, as distinguished from the screen film containing a single notch. These notches provide for identification while handling the films in the darkroom, but they are further identified by printed information which is readable after processing. The screen film is the one most commonly used.

d. Film emulsion becomes sensitized when subjected to energies such as ordinary light, ultraviolet light, or X-rays. Unfortunately, sensitization also occurs to some extent by the effects of heat, static discharges, and rough handling. The result of any of these is an intermediary stage of oxidation of the silver salts contained in the emulsion. When subjected to the chemicals contained in the developer, those granules of the silver salts which have been so affected are first changed from the salt combinations into metallic silver. With further oxidation, these particles of metallic silver develop a black color. When a part is interposed between the X-ray tube and the film, there results a varying degree of sensitization because of varying quantities of X-ray energies becoming effective upon one or another portion of the film. With proper control of such an exposure there results an inverted shadowgraph (a negative) which is actually a positive (photographically speaking).

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e. Film emulsions differ as to size of grain (of the silver salts) as well as to the degree of their sensitization. Ordinarily the smallest possible grain size is desirable since sharper detail is obtainable with it. It is generally true that the faster the sensitizing characteristics, the larger is the grain size. The steeper the slope of sensitization (i. e., the shorter the gradation of it), the greater will be the contrast on the roentgenogram for any set of technical factors.

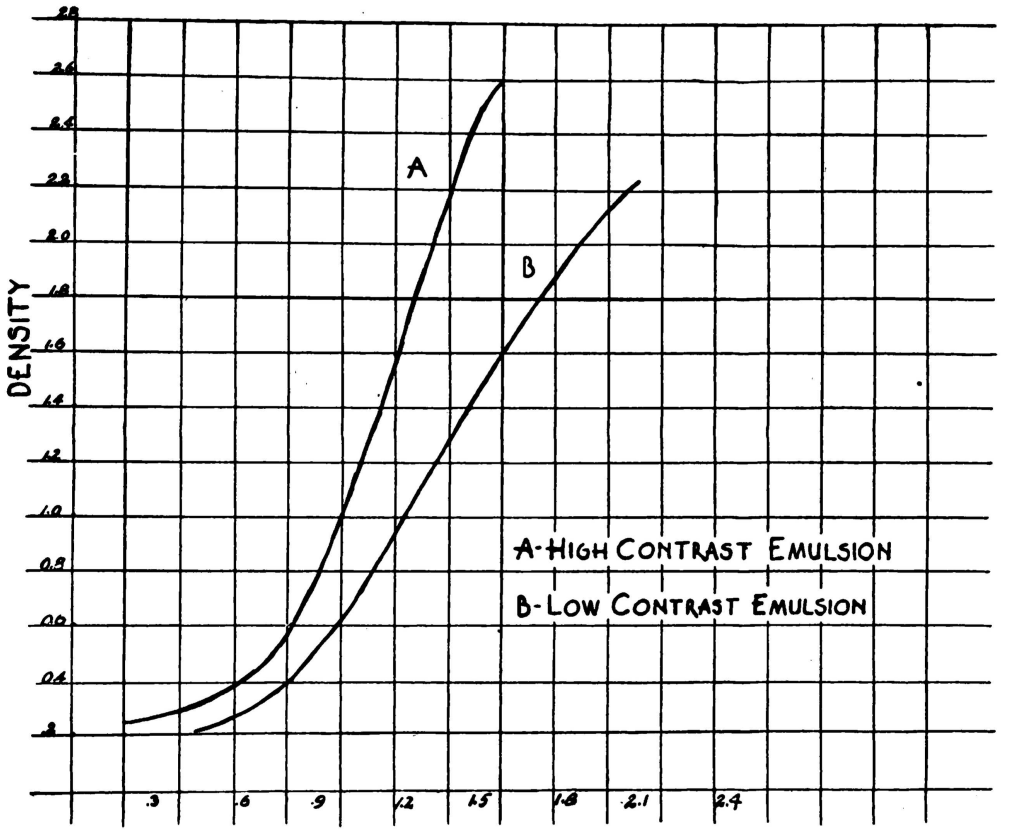


FIGURE 32.—Sensitization curves.

f. The steps of gradation might be demonstrated with the use of an aluminum ladder. This may be of 1 to 3 or more millimeters in thickness (aluminum) per step, each step having area dimensions of approximately 1½ by 3 inches. Such a ladder might be placed over a film (contained in a cardboard holder) and subjected to a slight X-ray exposure, depending upon the thickness of the steps (using factors such as 60 K.v.P. 10 Ma.S. at a distance of 30 inches). In order to obtain more complete information in this regard, it is advisable to repeat this test, having the film contained between intensifying screens in a cassette (for this testing, the Ma.S. factors should be re-

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duced in accordance with the speed of the intensifying screens). It must be remembered that the speed of intensifying screens varies with the kilovoltage. It is desirable to obtain testings of the film at

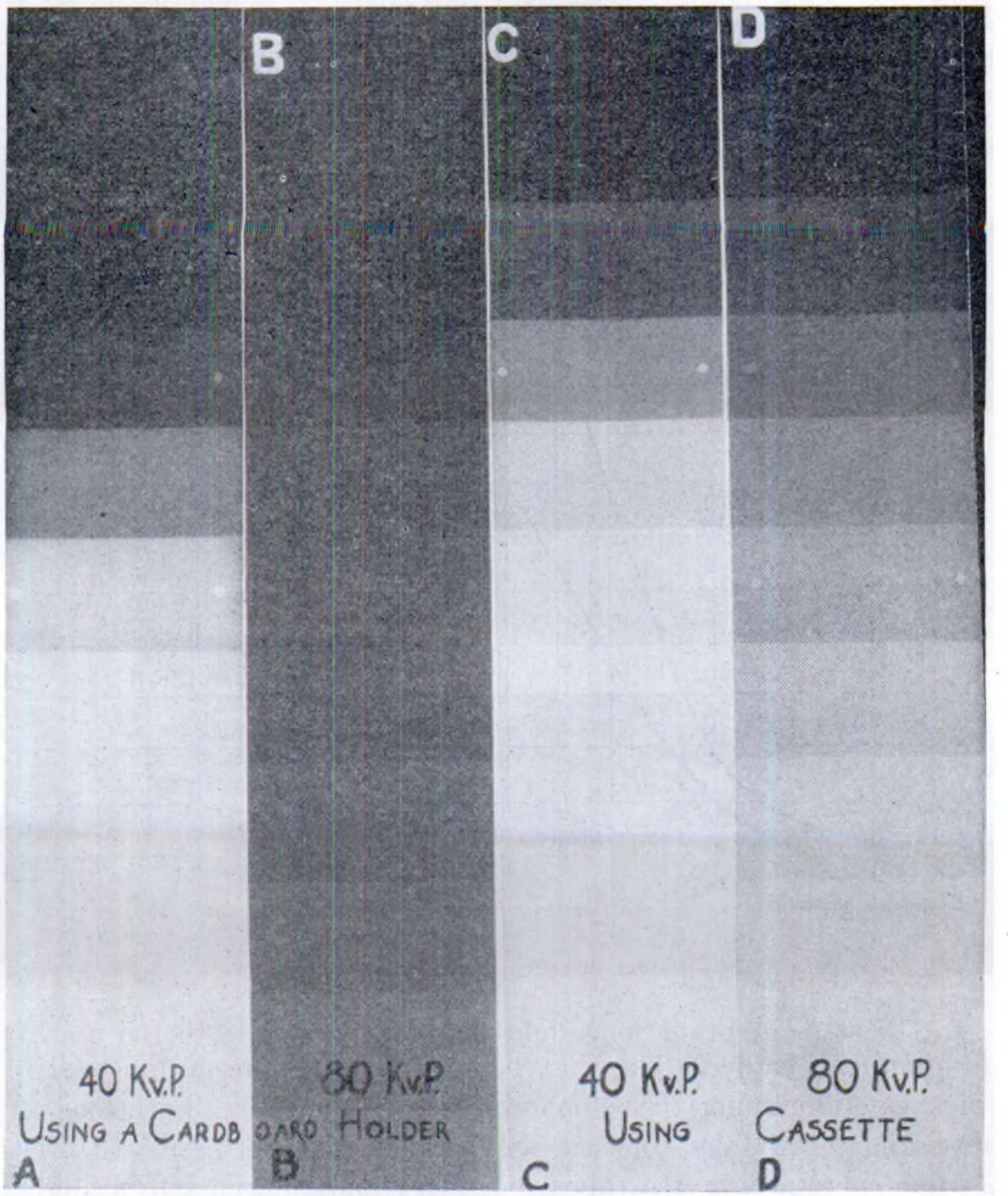


FIGURE 33.—Ladder tests.

kilovoltages of 40 as well as at 80. The comparative scale of gradation is shown in figure 33.

g. Many roentgenologists insist upon high degrees of contrast while others favor considerably less. The amount of contrast obtained with roentgenography can be controlled to a large degree by heeding

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the relationships of the technical factors discussed in the succeeding paragraphs. However, it should be realized that the inherent quality of the emulsion is a very important factor.

45. Film handling.—*a.* Films should be stored on end and in a cool, dry place. It is important to protect all unexposed films not only against the effects of light but also from heat and X-radiation. The cardboard cartons in which they are supplied are protective merely against light. The possibilities of X-radiation coming from an adjoining room or from rooms above or below the site of storage should be considered. The use of sheet lead may be necessary. It might be used to line one or more walls of the film bin. To protect against the wave lengths utilized in roentgenography, 1.5-mm thickness of lead should suffice.

b. Unexposed films should be removed from their cartons *only in a darkened room.* With the use of proper light filters, complete darkness is not required. The emulsion of X-ray films is sensitive to the blue violet portions of the light spectrum. The wave lengths of light concerned with the red, orange, and amber portions of the light spectrum are not injurious to the emulsion, and since they provide for considerable visual accommodation, it is favorable that the processing room be provided with lighting filtered accordingly. However, light filters should not be trusted without testing, and for this it is suggested that an exposed film covered by an object of some sort be placed in one or another working position and left there for a period of time, such as 5 minutes, and then processed. Sensitization of the emulsion will of course indicate escape of sensitizing wave lengths of light or the admission of X-radiation into the room.

c. For the making of exposures, films might be carried in a cardboard holder or in a cassette. Cardboard holders function in much the same manner as do ordinary envelopes. In loading a film into either of the latter, the protective black paper should be left about the film. In the case of a cardboard holder, it is important to fold the apron portion of the flaps first, then the sides, and finally the end, as shown in figure 34. The top cover of these holders is impregnated with small amounts of lead (to filter secondary radiation which would otherwise provide back-scattering and fogging of the film), and for this reason the base portion of this holder should be placed up toward the X-ray tube during the exposure. Cassettes usually contain intensifying screens, though for nonscreen films cassettes are available which serve the same purpose as provided by cardboard holders. Actually, a very small percentage of the X-radiation which traverses a part becomes absorbed by or is effective upon the film

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emulsion. It has been estimated that less than 1 percent of the X-radiation which passes through a film actually sensitizes the emulsion. It is to increase the efficiency of the X-rays that intensifying screens are used.

d. Intensifying screens are composed of a special cardboard base having a coating of calcium tungstate crystals held together in a binder. X-radiation produces fluorescence when striking calcium tungstate. This fluorescence is used to sensitize the emulsion in conjunction with the X-radiation itself, and therefore the black separating paper used in packing should be removed before placing films in cassettes which contain intensifying screens. Ordinarily, two intensifying screens are contained in a cassette, and the calcium tungstate surfaces of these are positioned in immediate contact with the

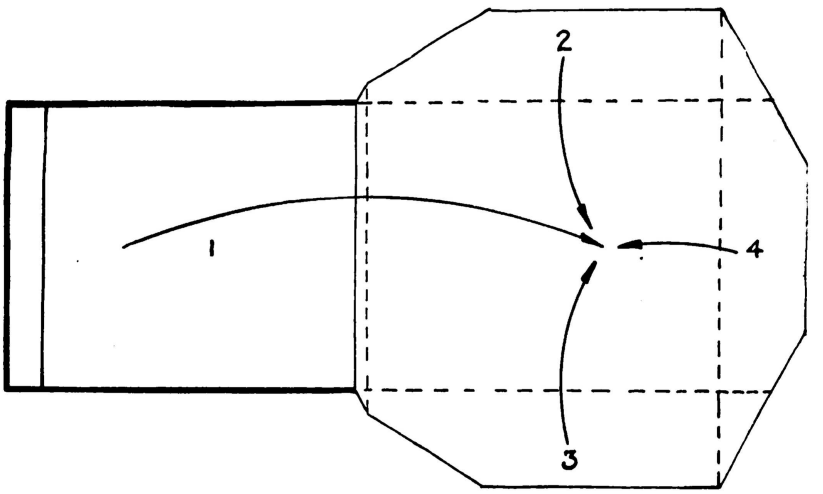


FIGURE 34.—Proper folding of cardboard holder.

film, one screen being above and one below. Intensifying screens may vary markedly as to their degree of fluorescence. Some screens contain one thickness of calcium tungstate crystals, some another. Moreover, the crystals of the calcium tungstate may be of one diameter or another. The larger the diameter of the crystal and/or the thicker the layering of the calcium tungstate crystals, the faster (i. e., the more intensely fluorescent) the screen. Intensifying screens are produced by several manufacturers in the United States. They are identified as to relative speeds by means of trade names. In general, there are three grades: slow, medium, and fast. However, the speed of any intensifying screen varies, depending upon the wave length of the X-ray energy. The shorter the wave length of X-rays, the greater is the fluorescence produced by them upon the screens. Expressed in terms of kilovoltage, this relationship might

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be indicated by curves. (See fig. 35.) Since no one speed factor can be considered to apply to any one type of screen or even to any one screen (because of this relationship to kilovoltage), it is practical to calibrate each individual cassette. This calibration curve should be recorded on the back of the cassette and consulted before making an exposure,

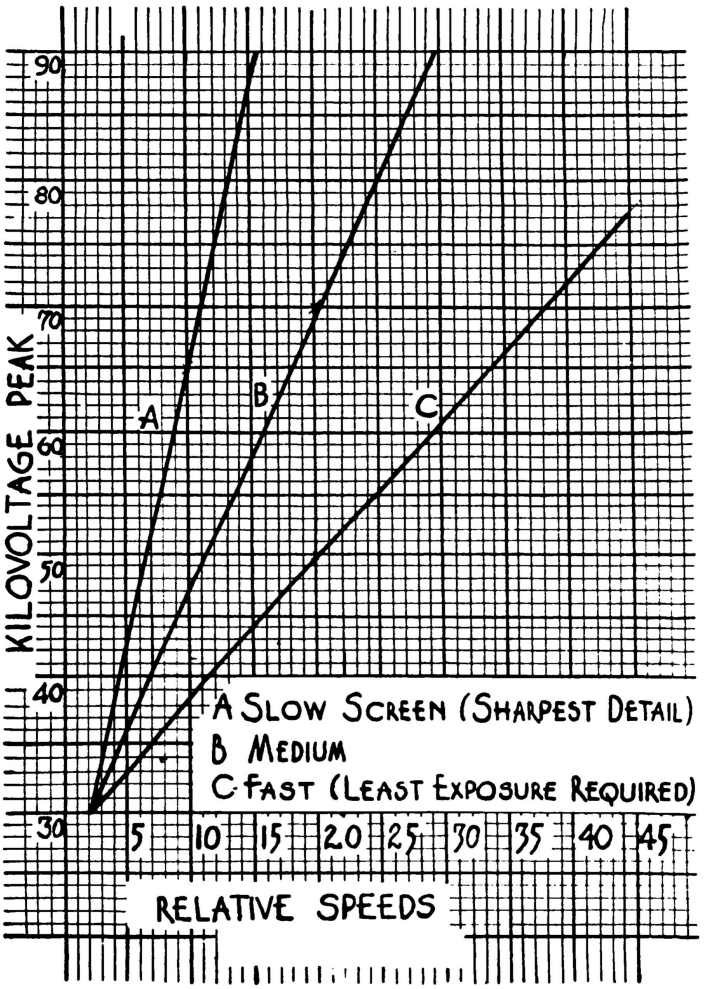


FIGURE 35.

referring to the particular kilovoltage effect in each instance. The procedure of calibration might be outlined as follows:

(1) Equipment and items necessary:

Cassette to be calibrated.
Unexposed (14- by 17-inch) X-ray film.
14- by 17-inch cardboard holder.
Scissors to cut film.
Lead letters and numbers for identification of film strips.
Lead sheets sufficiently large to cover a 14- by 17-inch cardboard holder.

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One X-ray unit.
Graph paper (square).

(2) The focal-film distance for all exposures is 10 feet. A 1-mm aluminum filter should be used throughout. The actual steps of procedure are as follows:

(*a*) Cut an unexposed 14- by 17-inch film lengthwise into four strips as shown in figure 36.

(*b*) Place strip A–1 in one corner of the cassette to be calibrated; make the first exposure using factors listed in A–1, after placing lead numbers A–1 in a position appropriate for identification.

(*c*) Unload the cassette in the darkroom; reload with strip A–2 and make the second exposure using factors listed in A–2, after providing lead numbers for identification.

(*d*) Again unload the cassette (in the darkroom); reload with strip A–3; make third exposure using factors in A–3, again identifying by lead numbers.

(*e*) Load strip B into cardboard holder (maintaining black paper about film). Delineate 8 block divisions on the exposure side of this cardboard holder and number these 1, 2, 3, etc., as indicated in figure 36. Place lead figure B in the position of block 8. Make an over-all exposure using 40 Kv.P. for 80 Ma.S. Place sheet of lead (1.5-mm in thickness) so as to cover all except block 1. Repeat exposure of 40 Kv.P. and 40 Ma.S. Then move lead sheet so as to expose blocks 1 and 2 and repeat this same exposure. Thereafter, expose one block at a time, repeating the exposures so that finally each block will have received the Ma.S. exposure listed in figure 36.

(*f*) Repeat this same procedure for strips C and D using the factors listed. Be sure to identify each strip by placing letters C or D in the respective positions for block 8.

(*g*) Process all portions of strips A, B, C, and D at the same time.

(*h*) After drying films compare densities of A–1 with various blocks of strip A, densities of A–2 with various blocks of strip B, and the densities of A–3 with various blocks of D.

(*i*) With consideration of the relative requirements of Ma.S., plot relative speeds in terms of the three kilovoltage values and extend curve.

e. This relationship of speed factor to kilovoltage is very commonly ignored. If for some reason calibration of individual cassettes cannot be accomplished, at least factors should be considered for each of several ranges of kilovoltage. For instance, with con-

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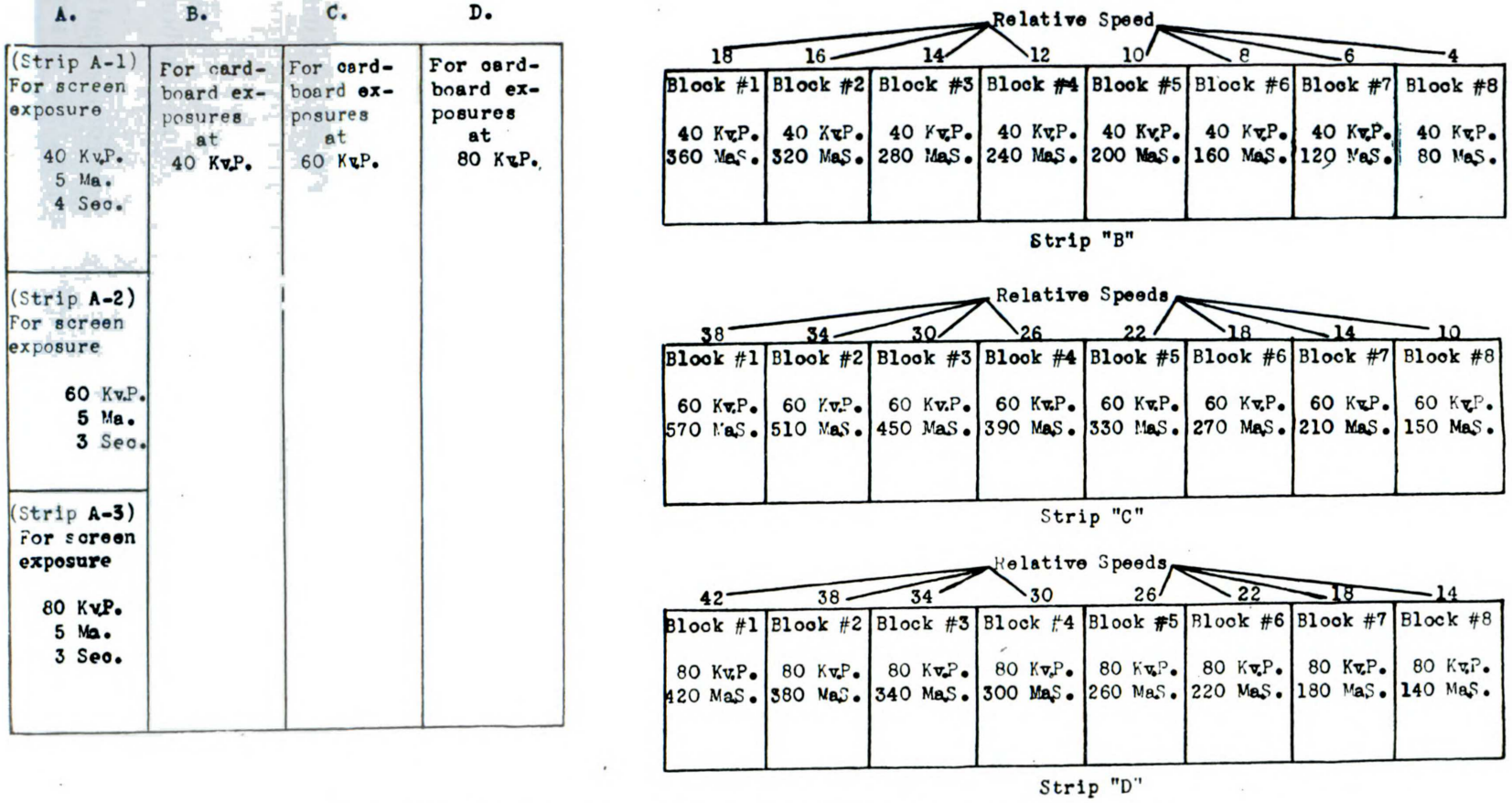


FIGURE 36.—Calibration of cassettes—technical factors and relative speed values.

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sideration of medium speed intensifying screens, a number of individual calibrations have indicated the following averages:

Kv.P:	30–40	40–50	50–60	60–70	70–80	80–90
Average speed:	4	10	14	18	21	25

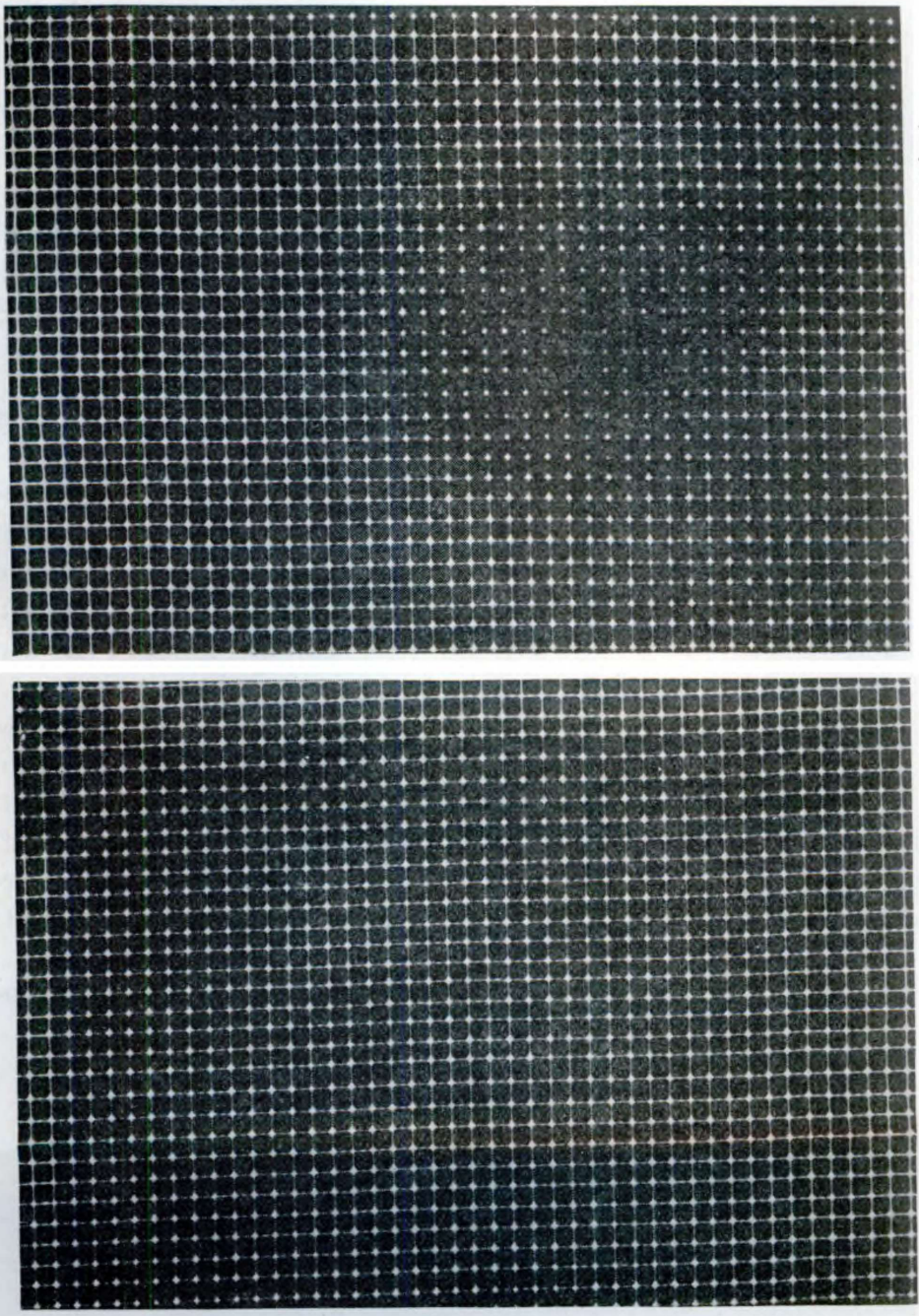
f. Intensifying screens may be purchased separately and subsequently mounted into cassettes. Not infrequently the mountings are defective. Sometimes slightly X-ray opaque bindings are used. Repeated visualizations of such binders may be seen upon the roentgenograms. Moreover, foreign substances might fall behind the screens or even between them and upon the film, and because of them "artefacts" may result. In case a certain portion of roentgenograms repeatedly show a fuzziness—an unsharpness of detail—there is to be considered the possibility of irregularities in the contact surfaces of the intensifying screens in apposition to the film surfaces. Testing as to this possibility might be accomplished by making a roentgenogram of a wire mesh.

46. Chemical processing.—*a.* This should be accomplished on the basis of time and control of temperatures. Repeated viewing of the film during its development is too likely to result in streaked development—due to the close proximity of the film to viewing lights which might be used, and also to uneven contact between the chemicals and the emulsion. Temperature control for the developer is especially important. The ideal temperature is 65°F. With most developers, insufficient reduction is accomplished when the temperature is below 60°F., while the process is too rapid and uneven, with the result of chemical fog, when the temperature is above 70°F. At greater temperatures swelling of the emulsion is likely to occur. The essential constituents include elon (metol, or pictol, etc.) and hydroquinone. These are the reducing agents which, under proper conditions, select those granules of the silver halide which have been sensitized by the X-rays (or other factors), and they convert these granules into metallic silver. The elon is not very penetrating. It acts on the superficial layers of the emulsion while the hydroquinone, though acting more slowly, is more penetrating. Other constituents include sodium sulphite, which serves to counteract oxidation of these agents; bromids, which serve to restrain the reducing agents and thereby provide for more uniform effects, lessening the likelihood of chemical fog; and an alkalizing agent, such as sodium carbonate, which serves as a catalyst for the reducing agents.

b. Having a fresh developer, the ordinary time requirement for development is 4 to 6 minutes, provided the temperature is within a few degrees of 65°F. With old developer, a longer time should

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be allowed. Following this, the film should be washed for 10 or 15 seconds in circulating water and then placed into the hypo or fixing bath. There are two reasons for this intermediary washing:



② Poor intensifying screen contact.

① Good intensifying screen contact.

FIGURE 37.—Roentgenogram of wire screen.

(1) The developer is of alkaline reaction while the fixing bath is acid. Rapid changeover, in the case of fresh solutions, is likely to produce surface heating (and fogging) of the emulsion.

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(2) A large film may carry over as much as one ounce of solution. Repeated admixtures of the developer into the fixing bath will not only result in diluting the latter but also directly weakening it.

c. When leaving the developer the gelatinous emulsion of the film is soft, both because of effects of the water and because of the alkalinity. The purposes of the fixing bath are to—

(1) Remove those granules of the silver halide which were not sensitized and therefore not acted upon by the developer.

(2) Harden the emulsion.

The first of these functions is accomplished by sodium thiosulphate, while the second function is performed by the alum contained. In addition, the fixing bath also contains sodium sulphite—again serving to counteract oxidation, and an acid (such as glacial acetic or sulphuric) which serves to stop all further development.

d. Ordinarily, films should be left in the fixing bath for as long as 10 to 20 minutes. They should then be placed in a bath of circulating water. Usually, 15 minutes or more are required for adequate washing. With incomplete washing, the film when dry will show either a thin coating of white crystalline material or it will appear foggy. Drying may be facilitated with the use of a fan and a draft of warm air (as provided with the aid of a heater). Should the air be too hot, the emulsion will become crinkled.

e. The importance of the film processing room is too seldom appreciated. It has been estimated that 80 to 90 percent of the trouble which occurs in an X-ray department can be found there. It is there that intensifying screens are frequently rendered defective because of foreign materials falling upon their surfaces, improper fixations, or because of nicks imposed upon their surfaces, etc. With frequent replacements they become a most expensive item in the department. Other troubles which might be attributed to the film processing room are given in table V.

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TABLE V

Defect in roentgenogram	Factors attributable to—		
	Processing room	Storage room	Exposure room
Localized blurring of detail.	Warping of the surface of intensifying screens—careless mounting or handling.		
Repeated outlines of hairs, dust particles, etc.—decreased radiographic densities.	Accumulations of such on the surfaces of the screens — failure in routine cleaning. Pitted or torn surfaces of intensifying screen.		
Mottled areas of blackness, usually extending centrally from borders.	Light leak into film loading bin. Light leak through worn edges of cardboard holder or cassette.	Careless opening of film carton in lighted room. Prolonged storage in flat position with sensitizations of emulsion due to impacts.	Careless handling of cardboard holder or cassette with light admission into either.
Widespread fogging.	Leakage of X-radiation into processing room. Sight development. Hot chemicals. Excessive heat in storage bin.	Films stored too close to radiator or hot pipes; excessive heat in storage room. X-radiation leakage in the storage room (also possibility of gamma ray exposure from nearby radium).	Minimal X-radiation exposure before or after the roentgenographic procedure. Excessive secondary radiation—need for grid, cone, or diaphragm.
"Christmas tree-like," or circular densities with feathery margins.	Static discharges (especially incident to rough removal of film from protective black paper). Impacts.	Impacts; rough handling.	Impacts; rough handling of cardboard holders and cassettes.

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TABLE V—Continued

Defect in roentgenogram	Factors attributable to—		
	Processing room	Storage room	Exposure room
Moon-shaped or V-shaped areas of decreased density	Bending of film incident to fingernail pressure or creasing of the film.		
Fusiform areas of decreased density.	Close contact of buckled portions of two films in developer.		
Transfer of image from one film to another.	Slight contact of emulsion surfaces of two films in developer		
Streaky densities.	Sight development.		
	Hot solutions.		
Insufficient densities.	Old (oxidized) developer.	----------	Underexposure.
	Cold developer.		
Strip of transparent base at one end of film with sharp demarcation or bubble outline.	Level of developer too low—not covering entire film.		
Greyish yellowish strip at one end of film.	Level of hypo too low—not covering entire film.		
Yellowish discoloration throughout roentgenogram.	Old (oxidized) hypo.		
Fusiform area of grayish yellow or yellow	Close contact of emulsion surfaces because of buckling of films in hypo.		
Rough, whitish, or crystalline surface—noted after drying.	Inadequate washing of film after hypo fixation of it.		
Crinkled surface.	Excessive heating of wet emulsion—likely during processive drying.		

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TABLE V—Continued

Defect in roentgenogram	Factors attributable to—		
	Processing room	Storage room	Exposure room
Bubble or track bucklings.	Dropping of water or chemicals onto dried film.		
Unsharpness of detail.	Defective intensifying screens; fast screens with large fluorescent crystals.	----------	Movement of patient or of film or of tube during exposure. Use of large focal spot of tube. Distortion—associated with short focal film distance in relation to large part film distance.
Excessive density throughout film.	Hot developer----------	----------	Overexposure.
Wooliness of actual grid markings.	----------	----------	Improper action of grid (see under description of grid function).
Grayness—long scale of gradations of density—lack of contrast.	Use of cardboard holders instead of cassette with intensifying screens. Shortening of development time because of hot developer.	----------	High kilovoltage. Secondary fog—need for grid. cone. or diaphragm.
Excessive contrast—short scale gradation.	Use of fast intensifying screen—rather than medium or slow screens or cardboard holders. Prolonged development in cold developer.	----------	Low kilovoltage.

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SECTION X

RADIOGRAPHIC QUALITY

Paragraph
Photoroentgenographic quality 47

47. Photoroentgenographic quality.—This quality might be analyzed in terms of four main characteristics:

a. Distortion.—The perversion of true shape of the part of the object studied. Roentgenographically speaking, distortion may be of two types:

(1) *Magnified.*—The equal magnification of all portions of a plane of the part. This type of distortion results when the part film distance (i. e., the distance between a plane of the part under consideration and the film) is great in proportion to the focal film distance (i. e., the distance between the focal spot of the X-ray tube and the film).

(2) *True.*—The unequal magnification of various portions of a plane of the part under consideration. This type of distortion may be produced because of malalinement of the tube in relation to the film and/or the part.

b. Detail.—The sharpness of contour and structural lines. Detail is decreased by—

(1) Distortion.

(2) Movement of the part, the film, or the tube.

(3) Use of large effective focal spot.

(4) Use of an intensifying screen—the larger the crystal of the fluorescent substance or the thicker the layer of it, the less sharp is the detail obtainable.

(5) Poor intensifying screen-film contact.

c. Contrast.—The relative degree of blackness of the black portions of the film as compared with whiteness of the white portions, that is, the abruptness of change in the gradation of densities. Contrast is decreased by—

(1) Use of a film of which the emulsion has a long scale gradation.

(2) Increasing the kilovoltage.

(3) Using slow types of intensifying screens or cardboard holders rather than screens.

(4) Secondary radiation, which is increased in proportion to the thickness of the part and increases in kilovoltage. The maleffects of secondary radiation might be reduced by the use of grids, cones, or diaphragms.

(5) Overexposure and shortening in the time of development or the use of cold developer.

d. Radiographic density.—The generalized blackness of the exposed portions of the film.

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(1) Radiographic density is increased by—

(*a*) Time and milliamperage—which bear an almost direct proportion to the density. Therefore, time and milliamperage are interchangeable (provided the wave form is not changed).

(*b*) Kilovoltage—in proportion approximately as the squares of the relative kilovoltages.

(*c*) Excessive developing time or hot developer.

(2) Radiographic density is decreased by—

(*a*) Distance—in proportion approximately as the squares of the relative distances.

(*b*) The use of grids, cones or diaphragms—*unless* milliamperage, time, or kilovoltage is increased.

SECTION XI

TECHNICAL PROCEDURE

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Roentgenographic technique 49
Roentgenographic procedure 50

48. Preparation.—Before actually making a roentgenographic exposure, the following factors should be considered:

a. Film size.—This should be no larger than required to cover the field for study; yet a reasonable expanse of tissues should be visualized beyond the actual site where pathology is suspected. Two or more views might be accommodated on one film by protecting certain portions of the film with lead while making one or another exposure.

b. Film container.—A cardboard holder, nonscreen cassette, or a cassette. The use of a cardboard holder or nonscreen cassette is recommended when the thickness of the part is 10 cm or less and when the sharpest of detail is required. It is also recommended when reduction of contrast is desired. It provides for a wide latitude of acceptable exposures. With modern film emulsions, the milliampere-second factor may be as much as 50 percent plus or minus from the ideal and still obtain a readable roentgenogram. This same latitude pertains to the use of cassettes with intensifying screens provided the individual cassette has been calibrated for speed factors in relation to kilovoltage, as described in paragraph 45*d*. When the exposure time must be reduced to the minimum, particularly with consideration of the possibilities of movement, the use of intensifying screens is recommended. They are recommended for all parts of thickness greater than 10 cm because of the large amount of secondary radiation (and secondary fog) which would be developed in case of utilizing the increased milliampere-seconds or higher kilovoltage required for the use of cardboard holders.

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c. Positions.—At least two positions are ordinarily indicated, providing for visualizations of planes at right angles one to the other. Oblique views should be considered. Stereoscopic pairs may be indicated. More elaborate procedures such as planigraphy, serialscopy, kymography, etc., are ordinarily special studies, either specifically requested or accomplished at a reexamination. Particularly when concerned with infants and children, it is advisable to include studies of the opposite side as well as that of the part requested.

d. Use of a cone, diaphragm, or grid.—This should be considered for any part the tissues of which are solid and not air-contained, or where there is edema or accumulation of fluids, and particularly when the thickness of the part is 12 cm or greater.

e. Captioning.—This should include identification of the patient and the date of the examination. It is also advisable to identify the side as to R or L and give the name of the hospital or clinic.

f. Technical factors.—These factors are milliamperage, time, distance, and kilovoltage.

(1) Milliamperage must necessarily depend upon the capacity of the unit (including the tube capacity) and the requirements of focal spot dimensions. High milliamperage imposes the requirement of relatively large focal spot dimensions which detract from the sharpness of detail. Generalities pertaining to this relationship are described in paragraph 22. The tube rating charts supplied by the manufacturer should be consulted. Ordinarily, it is said that there is a direct ratio relationship between radiographic density and the milliamperage which is used (other factors being constant). This is generally true, provided the performance capacity of the transformer be not taxed. The design of some X-ray transformers is such that the wave form is distorted when operating at high milliamperage settings. In such cases, the radiographic density cannot be expected to be proportionate to the milliamperage. This may explain the reason why a certain technique may be unsatisfactory when used with one unit even though that same technique was found to have been ideal when used with another unit. Moreover, with some X-ray apparatus, a. c. milliammeters are used whereas with others d. c. meters are used; a. c. meters are calibrated in terms of effective values whereas d. c. meters are calibrated in terms of average values. This difference, too, may account for difficulties in duplication of results. A number of other factors might also be mentioned, such as differences in the inherent filtration of X-ray tubes, changes in the performance of any one tube because of pittings of its target and the resultant filtrations by the substance of the target itself.

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as well as by tungsten which may have become impregnated into the glass wall of the tube. Such factors as these account for the statement that "the milliamperage of one unit may not be identical with the milliamperage of another unit." However, a large percentage of these variations in performance can be overcome by the use of an ideal technique, invoking compensation factors which might concern a particular cassette, a particular grid, cone, or other auxiliary device.

(2) Time of exposure should be reduced to the minimum to counteract the effects of motion. For all practical considerations, the time of the exposure and the milliamperage are interchangeable. The greater the milliamperage the less will be the time of exposure required and vice versa. Two types of motion are to be considered: voluntary and involuntary. Voluntary motion includes the movement of muscles which ordinarily would be controlled (even though these movements may not have been intentional). Involuntary motion includes the pulsation of arteries and movements of veins as well as of the heart. For roentgenography of the chest, the exposure time should be no greater than $\frac{1}{10}$ second (if these pulsation movements are to be counteracted for the majority of cases).

(3) *Distance*, with reference to roentgenography, usually implies the focal-film distance, which is the distance between the focal spot of the tube and the film. The focal-skin distance is to be distinguished as the distance between the focal spot of the tube and the skin of the patient. It is to be considered when calculating the summation dosage of X-radiation received by the patient. A third type of distance referred to is part-film distance, which is the distance between any level of the part being studied and the film. This last type of distance is of importance with respect to distortion as already described. Because of the thickness of certain parts, such as the chest, their part-film distance must be compensated by using a relatively long focal-film distance. When possible, the focal-film distance for chest roentgenography should be 72 inches or longer. This distance may be necessary for roentgenography where measurements are to be made on the roentgenogram, as for instance, in the case of the "sella turcica." Such work is called teleroentgenography. For most requirements, the commonly used focal-film distance is 30 inches. This latter distance has been chosen because for many parts the thickness is not such as to incur an appreciable amount of distortion at this distance, and the milliamperage requirements in relation to the exposure time are ordinarily easily accommodated by the capacities of the X-ray machine and the X-ray tube. For this reason, the majority of grids have been

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constructed to a 30- or a 36-inch radius. When using a grid (i. e., Bucky), it is necessary to be guided by the grid radius. However, there is some latitude as to the adaptation of modern grids to distances greater and also to distances less than their radius. When having to use a tube with a large focal spot, it is advisable to use a relatively long focal-film distance if sharp detail is essential. Occasionally it is desirable to shorten the focal-film distance to less than that for which a certain technique has been developed. In either instance, it may be convenient to convert the milliampere-second values of the calculated technique as indicated in table VI.

TABLE VI

Known distance (inches) \ Distance desired (inches)	25	30	35	40	45	48	50	55	60	65	70	72
25	1	1. 44	1. 96	2. 56	3. 56	3. 68	4	4. 84	5. 76	6. 76	7. 84	8. 29
30	. 69	1	1. 36	1. 77	2. 24	2. 56	2. 78	3. 36	4	4. 70	5. 44	5. 73
35	. 59	. 74	1	1. 31	1. 65	1. 88	2. 04	2. 47	2. 94	3. 45	4	4. 23
40	. 39	. 56	. 77	1	1. 28	1. 44	1. 57	1. 90	2. 25	2. 64	3. 06	3. 24
45	. 31	. 44	. 61	. 79	1	1. 14	1. 23	1. 49	1. 77	2. 08	2. 42	2. 56
48	. 27	. 39	. 53	. 69	. 88	1	1. 08	1. 31	1. 56	1. 83	2. 13	2. 25
50	. 25	. 36	. 49	. 64	. 81	. 92	1	1. 29	1. 44	1. 69	1. 96	2. 70
55	. 21	. 30	. 40	. 53	. 67	. 76	. 83	1	1. 19	1. 31	1. 62	1. 71
60	. 17	. 25	. 34	. 44	. 56	. 64	. 69	. 84	1	1. 17	1. 39	1. 44
65	. 15	. 21	. 29	. 38	. 48	. 55	. 59	. 71	. 85	1	1. 15	1. 23
70	. 13	. 18	. 25	. 33	. 41	. 47	. 51	. 62	. 73	. 88	1	1. 06
72	. 12	. 17	. 24	. 31	. 39	. 44	. 48	. 58	. 69	. 81	. 95	1

Multiplying factor

Courtesy Westinghouse X-ray Company.
Long Island City, New York.

(4) Kilovoltage must not exceed the capacity limits as rated for the apparatus. For roentgenographic equipment, it is a good rule *never to exceed 90 Kv.P.* Most roentgenographic equipment is not designed for higher kilovoltage values (i. e., with the commonly used

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milliamperage settings which pertain to roentgenography). Moreover, whether the design of equipment be self-contained (i. e., having the X-ray tube mounted with the high tension transformer) or whether shockproof cables are used, for the sake of safety to the patient, this limit of kilovoltage is proper. In general, the higher the kilovoltage the less will be the contrast. Increases in kilovoltage, up to 90 Kv.P., might be utilized for the very purpose of reducing contrast. However, the greater the kilovoltage the greater will be the effect of secondary radiation. To offset secondary fog on the film it might be necessary to use a grid. Roughly, kilovoltage changes might be interpolated with respect to milliamperage-second values as indicated in table VII.

TABLE VII

Decrease	Increase
10 Kv. P.—give 2 times the Ma. S.	10 Kv. P.—give half the Ma. S.
13 Kv. P.—give 3 times the Ma. S.	13 Kv. P.—give ⅓ the Ma. S.
15 Kv. P.—give 4 times the Ma. S.	15 Kv. P.—give ¼ the Ma. S.
18 Kv. P.—give 5 times the Ma. S.	18 Kv. P.—give ⅕ the Ma. S.
28 Kv. P.—give 10 times the Ma. S.	28 Kv. P.—give $\frac{1}{10}$ the Ma. S.

With such modifications, to a large extent it is possible to modify the amount of contrast even though a given technique is otherwise followed.

49. Roentgenographic technique.—A wide variety of composite techniques has been advocated. With some, all four factors are changed, depending upon the part of the body to be studied. Such individualizing is usually a handicap to the extent that either one must remember a great number of values to be used for one or another position or else it is necessary to refer constantly to a text. In order to simplify the problem and lessen the need of referring to "recipes," it has become a prevalent practice that three of the factors be kept constant, insofar as it is practical, changing the fourth factor according to the part of the body which is being studied. Since kilovoltage is concerned with the development of quality (i. e., wave length) of the X-rays, it is practical to vary the kilovoltage according to the thickness of the part. Very casual knowledge of anatomy is sufficient to convince anyone of the differences in density of various portions of the human body. Some parts of the body, such as the knee, are composed almost entirely of bone; whereas other parts of the body, such as the thorax, contain mostly soft tissues, and some of the soft tissues, as the heart, are relatively solid, whereas other soft tissues, such as the lungs, are not. Thus there is considerable variation in the X-ray opacity of tissues as well as differences in thickness of the

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parts. With an allowance of 2 Kv.P. per centimeter, thickness of the part plus a basic Kv.P. for that particular part, it is possible to approximate the necessary settings to a reasonable degree. The basic Kv.P. must depend upon a milliamperage-second value. A practical milliamperage-second value without the use of intensifying screens is 50. Considering 50 milliampere seconds then as a starting value and a distance of 30 inches, it has been found that the basic value for the hand is approximately 40 Kv.P.; for the wrist it is approximately 50; the forearm, 54; the elbow 56; the arm 60; the foot 54; the ankle 60; the shoulder 64; the knee 60, etc. Most of these values can be reasoned merely by considering the relative densities of the part and remembering the one basic value, 40 Kv.P. This fundamental technique is based upon bare film usage without the aid of intensifying screen and without the use of a grid. With certain thicknesses of a part, there would be calculated a kilovoltage requirement which would be greater than 90. Therefore, it is necessary to invoke a formula such as the following: 50 milliampere seconds *divided by* the speed factor of cassette *times* the factor necessary to compensate for the kilovoltage substitute (see table VII) *times* the factor necessary to compensate for the type and ratio of the grid (par. 42) *equals* the milliampere-second requirement at the particular kilovoltage selected and for the focal-film distance, 30 inches. For example, let us consider the requirement of obtaining a roentgenogram of the lumbo-sacral spine. A reasonable basic kilovoltage at a focal-film distance of 30 inches and with consideration of a basic milliampere-second allowance of 50 would be approximately 68. Supposing the thickness of this part measured 22 cm. 22 times 2 equals 44—the Kv.P. allowance for the thickness of the part. Adding 44 to 68 Kv.P. there would be the requirement of 112 Kv.P. Since it is inadvisable to use more than 90 Kv.P., it would be necessary to compensate for 22 Kv.P. This can be done by dropping 28 Kv.P. and therefore increasing the milliampere seconds to 500 Ma.S (as described in paragraph 48*f*(4)) and using 84 Kv.P. Very likely, intensifying screens and also a grid would be used for a part of this thickness. The calibration curve for the particular cassette selected might indicate a speed factor of 20 for the kilovoltage 85. If the ratio of the grid were 5 to 1, it is likely that when using it, the milliampere-second value would have to be increased to the extent of three times that which would be used without it. Thus, for this particular roentgenogram, the above-mentioned formula would be converted as follows:

$$\frac{50\ \text{Ma.S.}}{20} \times 10 \times 3 = 75\ \text{milliampere-seconds}$$

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that is, the requirement with the use of 84 Kv.P. and a distance of 30 inches.

50. Roentgenographic procedure.—*a.* These fundamentals have been applied in the calculation of a concise outline of technique based of course upon modern X-ray films. (See table VIII.)

b. For superior quality, it is recommended that reference be made to the atlas descriptions which follow. It will be noted that two sets of milliamperage-second values are listed. The single value described basic value is that which should be used if calibrated cassettes are available. In such a case, the basic value should be divided by the speed factor of the cassette for the particular kilovoltage. To obviate these calculations, approximate milliamperage-second values are tabulated for one or another kilovoltage range. These pertain to medium speed intensifying screens. In order to provide a range of kilovoltages for accommodations of the smallest expected dimensions of any one part as well as for the thickest dimensions, in some instances, the resultant contrast may be greater than desired. For such cases, it is recommended that higher kilovoltage values be used with appropriate reduction in the milliamperage-second values, as indicated in table VII.

TABLE VIII.—*Approximation technique*
(Army Medical School, Washington, D. C.)

Part	Cms. thickness	Kv.P values									Ma.S.		
		4	8	12	16	20	24	28	32	36	Without screens	With screens [1]	With grid [2]
Extremities		52	62	Over 10 cms use screens							75	----	---
Extremities		32	46	60	72	84	Over 14 cms, grid advisable				----------	15	30
Skull	Use 1-mm Al filter	------	------	62	70	78	86	Grid advisable			----------	20	40
Spine, cervical		------	52	60	68	Grid advisable					----------	20	40
Spine, thoracic		Grid advisable			50	58	66	74	82	90	----------	80	160
Spine, lumbosacral (pelvis)		Grid advisable			60	68	76	84	[3] 82	[3] 90	----------	100	200
Chest (ribs)		30-inch distance			50	58	66	74	82	90	Use grid for ribs	5	10
Chest		72-inch distance			50	58	66	74	82	90	----------	25	---
Abdomen		Grid advisable			50	58	66	74	82	90	----------	100	200

[1] Values based upon *medium* speed screens.
For *fast* screens use 25 percent less. For *slow* screens increase 50 percent.
[2] Based on U. S. Army Wafer Grid.
[3] Double Ma.S. values listed for these measurements (never exceed 90 Kv.P.).

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SECTION XII

ROENTGENOGRAMS

(Figs. 38 to 109, incl.)



FIGURE 38A.—Hand, P. A.

Positioning instructions

Film: 8 x 10 in cardboard holder.
Position: Head of 3d metacarpal to center of film.
Focal spot: Aline to head of 3d metacarpal.
Precautions: Elbow on table, fingers flat and separated.
Additional: sandbag over forearm.

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FIGURE 38B.—Hand, P. A.

Technical factors

Distance: 30".	Cone: Optional			(compensate Ma.S.).		(Measure plane through head, 3d metacarpal.)
Cms. thickness:	2	3	4	5	6	
Variable Kv.P.:	48	50	52	54	56	
				(Basic Ma.S. 35)		

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FIGURE 39A.—Hand, dorso-semilateral.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: As for P. A., then rotating 2d knuckle 4 cms.
Focal spot: Aline to head of 3d metacarpal.
Precautions: Elbow on table; fingers extended and separated.
Additional: Sandbag over forearm.

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FIGURE 39B.—Hand, dorso-semilateral.

Technical factors

Distance : 30''.	Cone : Optional		(compensate Ma.S.).			(Measure plane through head, 3d metacarpal.)		
Cms. thickness :	2	3	4	5	6	7	8	9	10
Variable Kv.P. :	48	50	52	54	56	58	60	62	64

(Basic Ma.S. 35)

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FIGURE 40A.—Wrist, P. A.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: Tips of styloid processes to midlength of film.
Focal spot: Aline to point midway between tips of styloids.
Precautions: Elbow on table, fist clenched.
Additional: Sandbag over forearm.

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FIGURE 40B.—Wrist, P. A.

Technical factors

Distance: 30".	Cone:	Optional	(compensate	Ma.S.).	(Measure	plane	through	tips,	
			styloid	processes.)					
Cms. thickness:	2	3	4	5	6	7	8	9	10
Variable Kv.P.:	58	60	62	64	66	68	70	72	74

(Basic Ma.S. 35)

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FIGURE 41A.—Wrist, lateral.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: Internal styloid to center of film.
Focal spot: Aline 1-cm. distal to tip of radial styloid.
Precautions: Elbow on table; superimpose styloids (slight external rotation).
Additional: Fingers extended and between two sandbags, sandbag over forearm.

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FIGURE 41B.—Wrist, lateral.

Technical factors

Distance: 30''. Cone: Optional (compensate Ma.S.). (Measure plane through tips. Styloid processes, laterally.)

Cms. thickness:	2	3	4	5	6	7	8	9	10
Variable Kv.P.:	64	66	68	70	72	74	76	78	80

(Basic Ma.S. 35)

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FIGURE 42A.—Forearm, A. P.

Positioning instructions

Film: 10 x 12 in cardboard holder, lengthwise.
Position: Center of forearm (supine) to center of film.
Focal spot: Aline to center of film.
Precautions: Elbow on table; arm (humerus) low.
Additional: Sandbags across hand and across arm.

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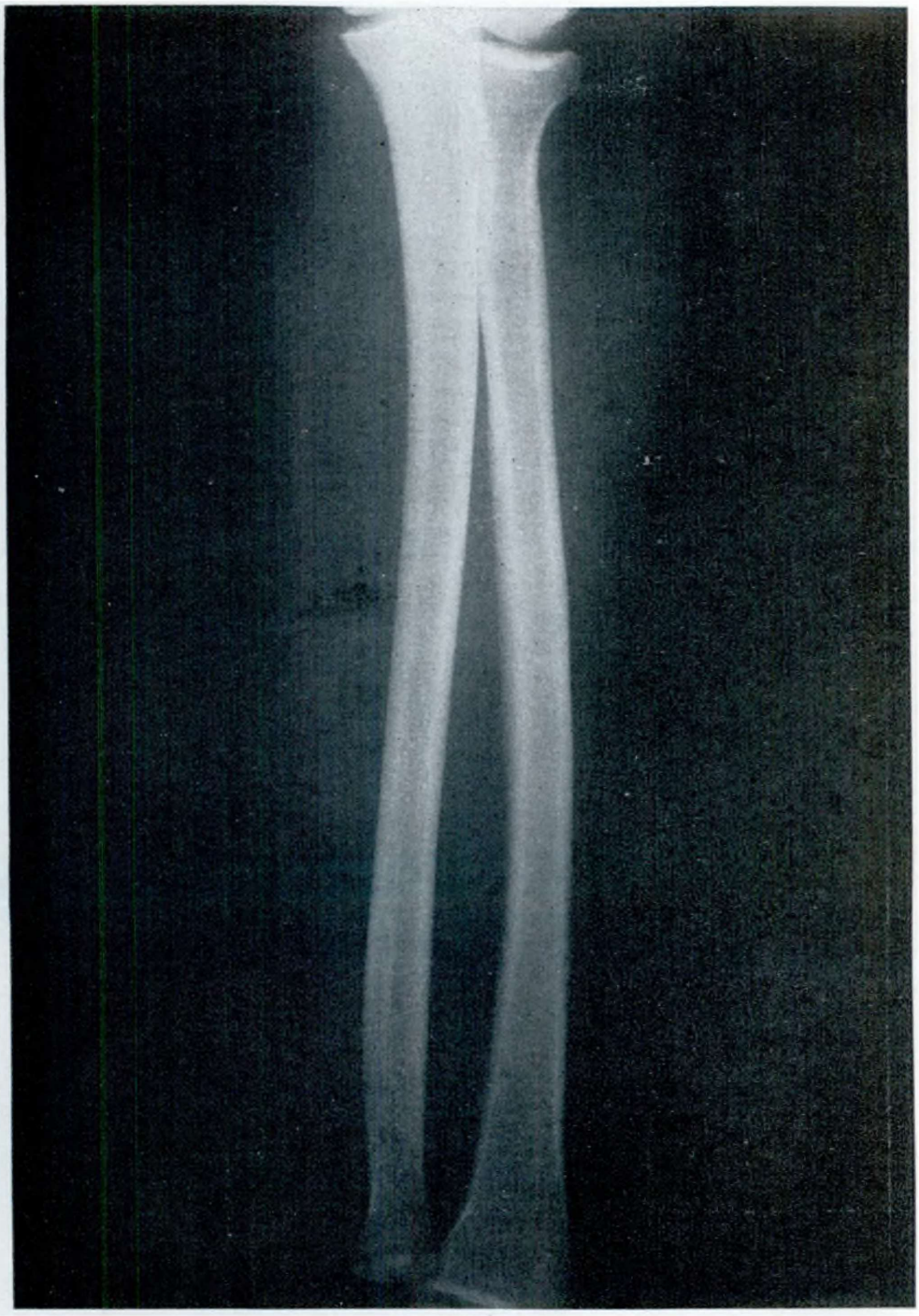


Figure 42B.—Forearm, A. P.

Technical factors

Distance: 30″.	Cone: No.	(Measure plane through midlength, forearm.)						
Cms. thickness:	2	3	4	5	6	7	8	9	10
Variable Kv.P.:	62	64	66	68	70	72	74	76	78

(Basic Ma.S. 35)

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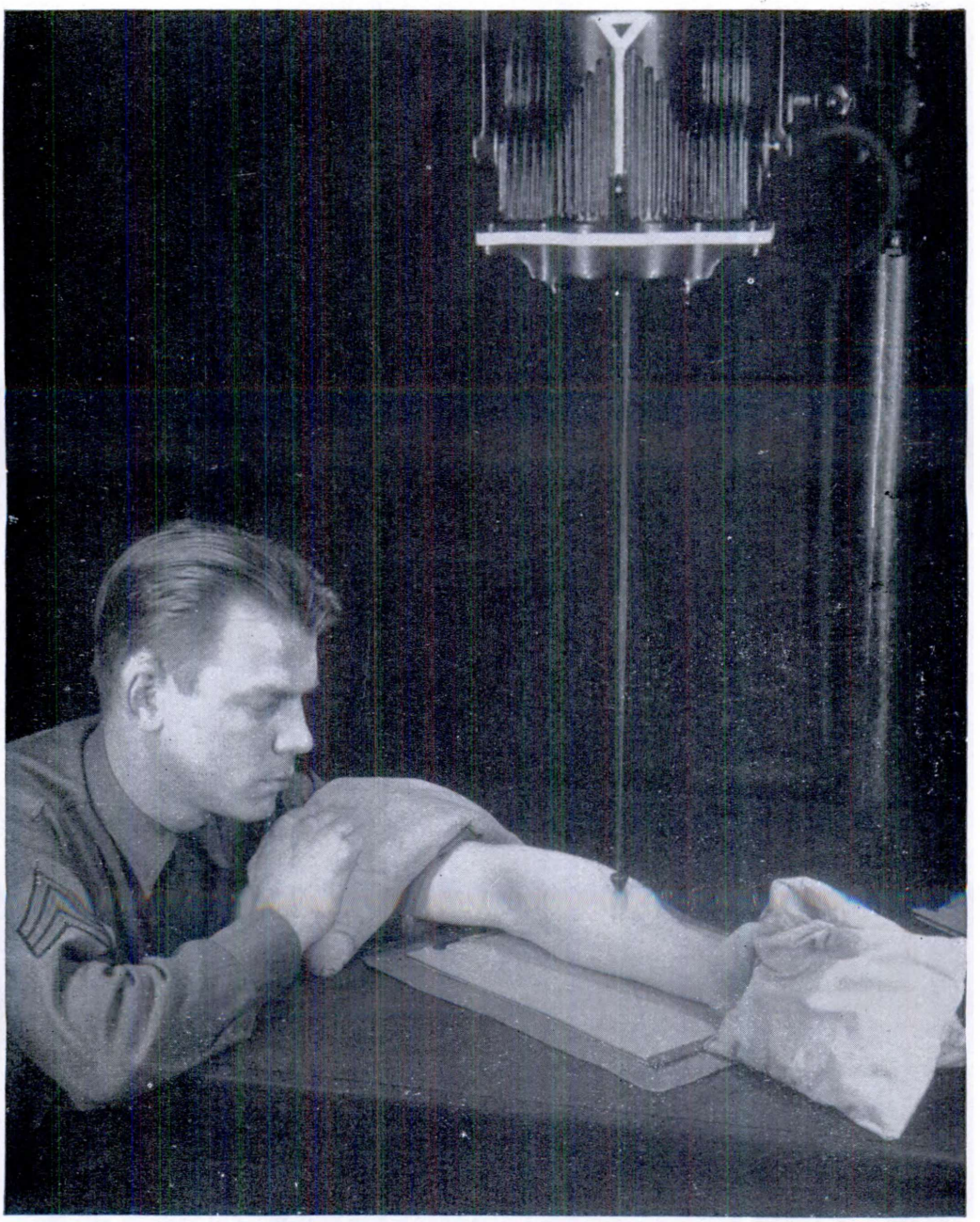


FIGURE 43A.—Forearm, lateral.

Positioning instructions

Film: 10 x 12 in cardboard holder, lengthwise.
Position: Center of forearm to center of film, plane of radius and ulna at right angle to film.
Focal spot: Aline to center of film.
Precautions: Superimpose styloids (slight external rotation); shoulder to level of elbow.
Additional: Fingers extended and between two sandbags; sandbag above elbow.

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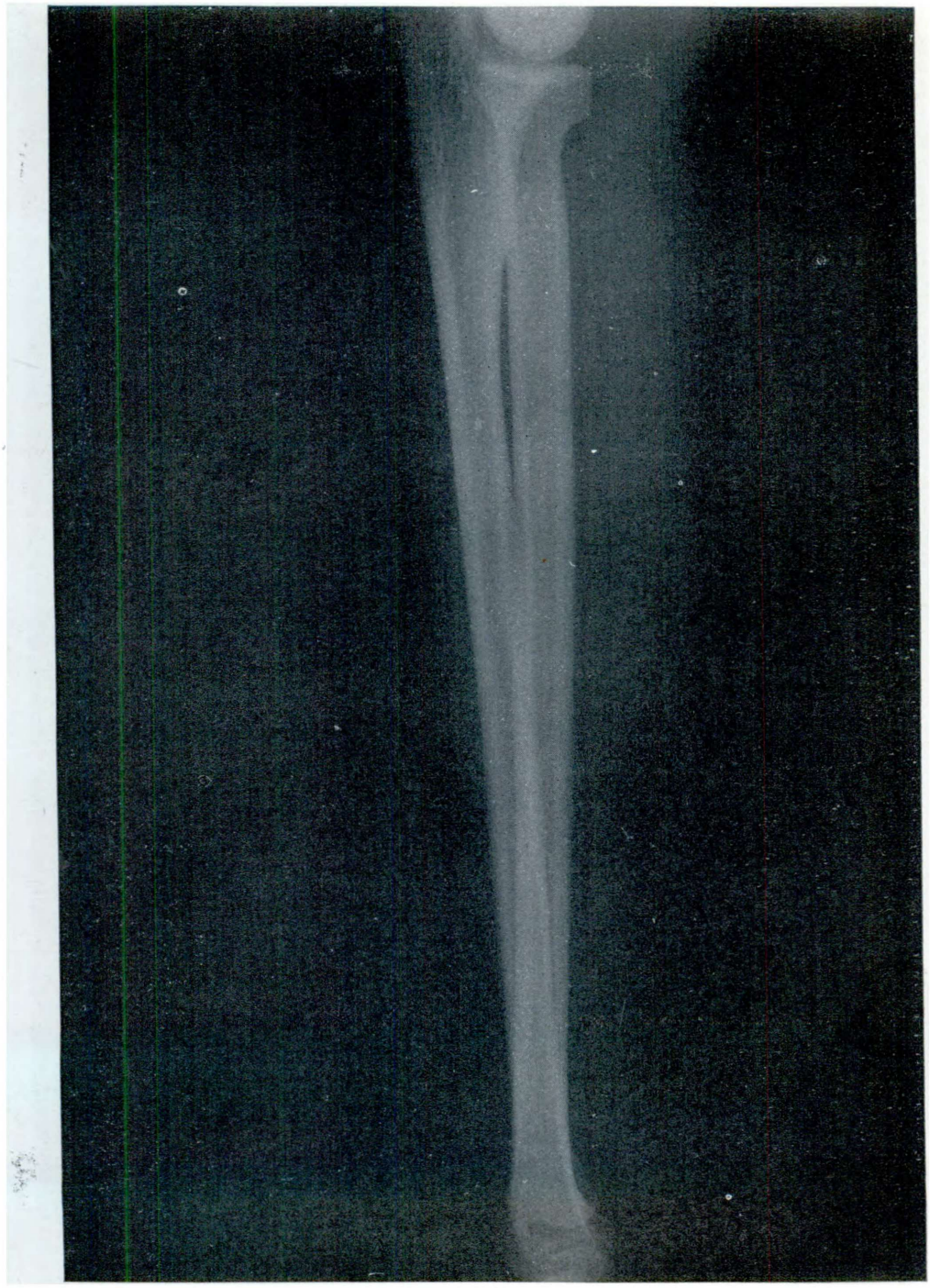


FIGURE 43B.—Forearm, lateral.

Technical factors

Distance: 30″.	Cone: No.	(Measure plane through midlength, forearm, laterally.)						
Cms. thickness:	2	3	4	5	6	7	8	9	10
Variable Kv.P.:	68	70	72	74	76	78	80	82	84

(Basic Ma.S. 35)

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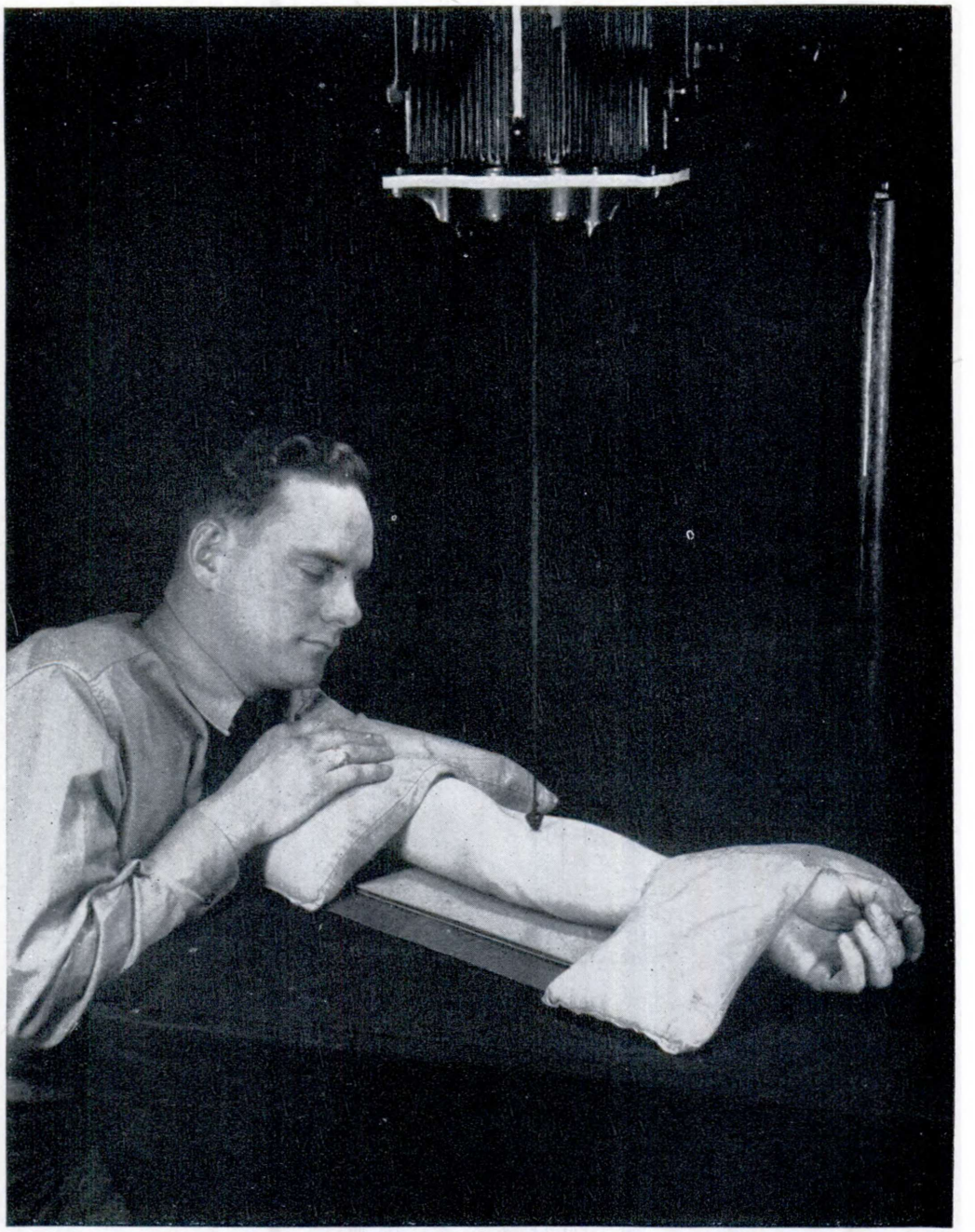


FIGURE 44A.—Elbow, A. P.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: Epicondyles to midlength of film.
Focal spot: Aline to midpoint of plane 3 cms. distal to epicondyles.
Precautions: Shoulder level with elbow.
Additional: Sandbag over forearm and over arm.

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FIGURE 44B.—Elbow, A. P.

Technical factors

Distance : 30″.	**Cone : Optional (compensate Ma.S.).**						**(Measure plane through epicondyles.)**		
Cms. thickness :	2	3	4	5	6	7	8	9	10
Variable Kv.P. :	64	66	68	70	72	74	76	78	80
				(Basic Ma.S. 35)					

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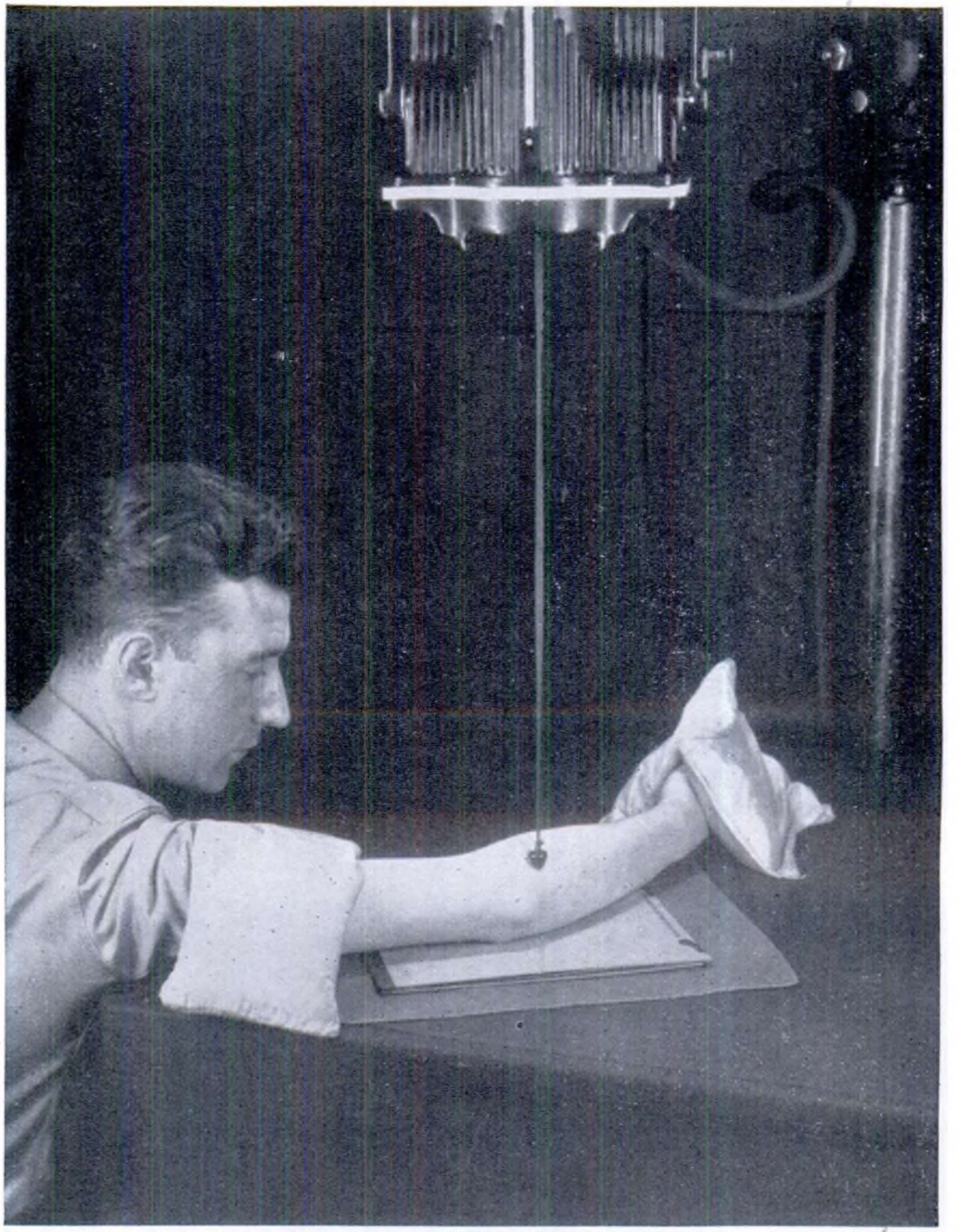


FIGURE 45A.—Elbow, lateral.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: Internal epicondyle to center of film.
Focal spot: Aline 1 cm. distal to tip of external condyle.
Precautions: 45° flexion of forearm; shoulder level with elbow.
Additional: Fingers extended and between two sandbags; weight shoulder.

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FIGURE 45B.—Elbow, lateral.

Technical factors

Distance: 30''. Cone: Optional (compensate Ma.S.). (Measure plane through epicondyles, laterally.)

Cms. thickness:	2	3	4	5	6	7	8	9	10
Variable Kv.P.:	70	72	74	76	78	80	82	84	86

(Basic Ma.S. 35)

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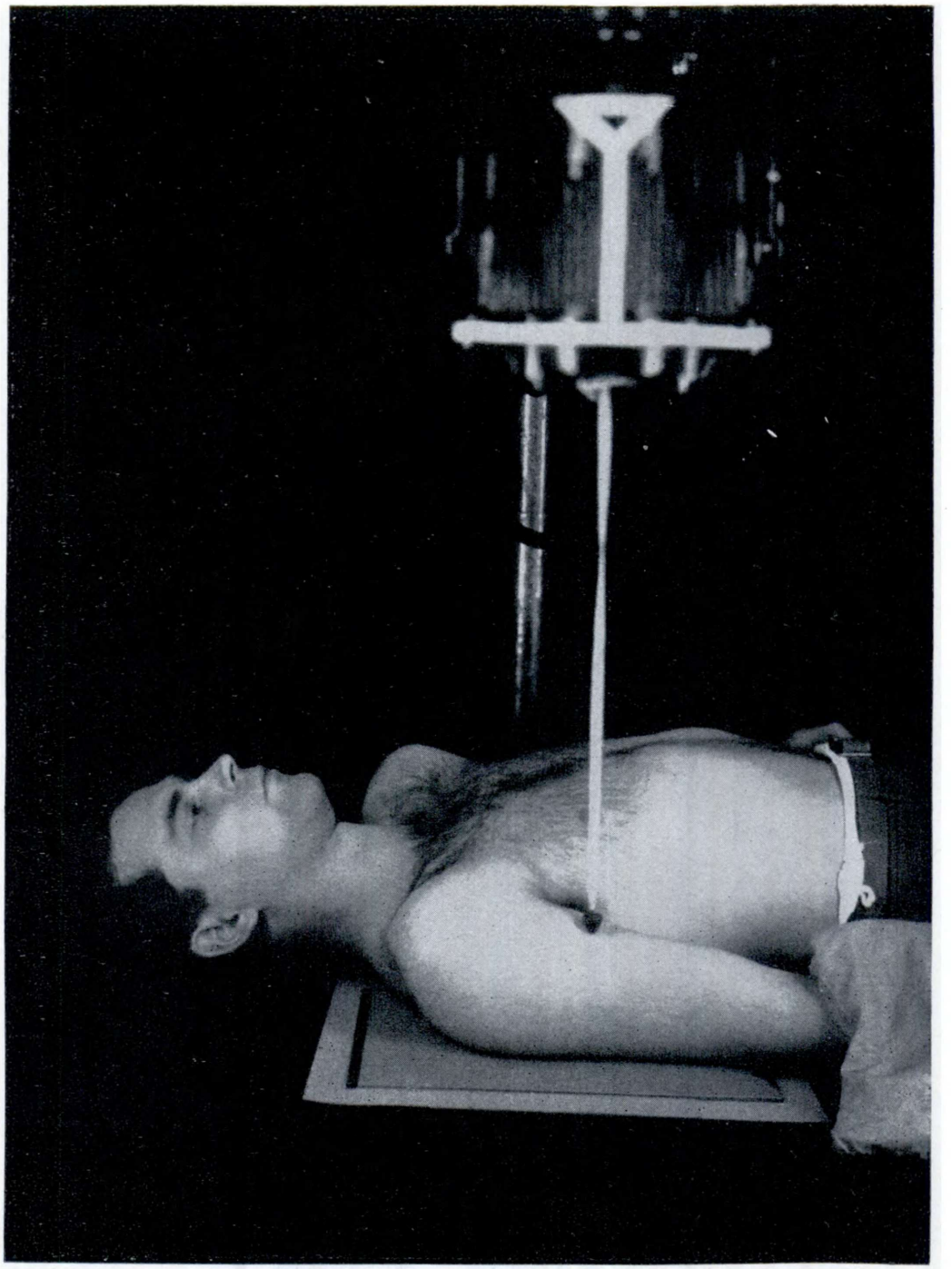


FIGURE 46A.—Arm (humerus), A. P.

Positioning instructions

Film: 10 x 12, lengthwise; cardboard holders if thickness be less than 10 cms., cassettes if greater.
Position: Acromion 2 cms. below middle of upper border of film.
Focal spot: Aline to center of film.
Precautions: Minimal part film distance (sandbag under opposite shoulder); plane of condyles parallel to film—palm up.
Additional: Sandbag over forearm.

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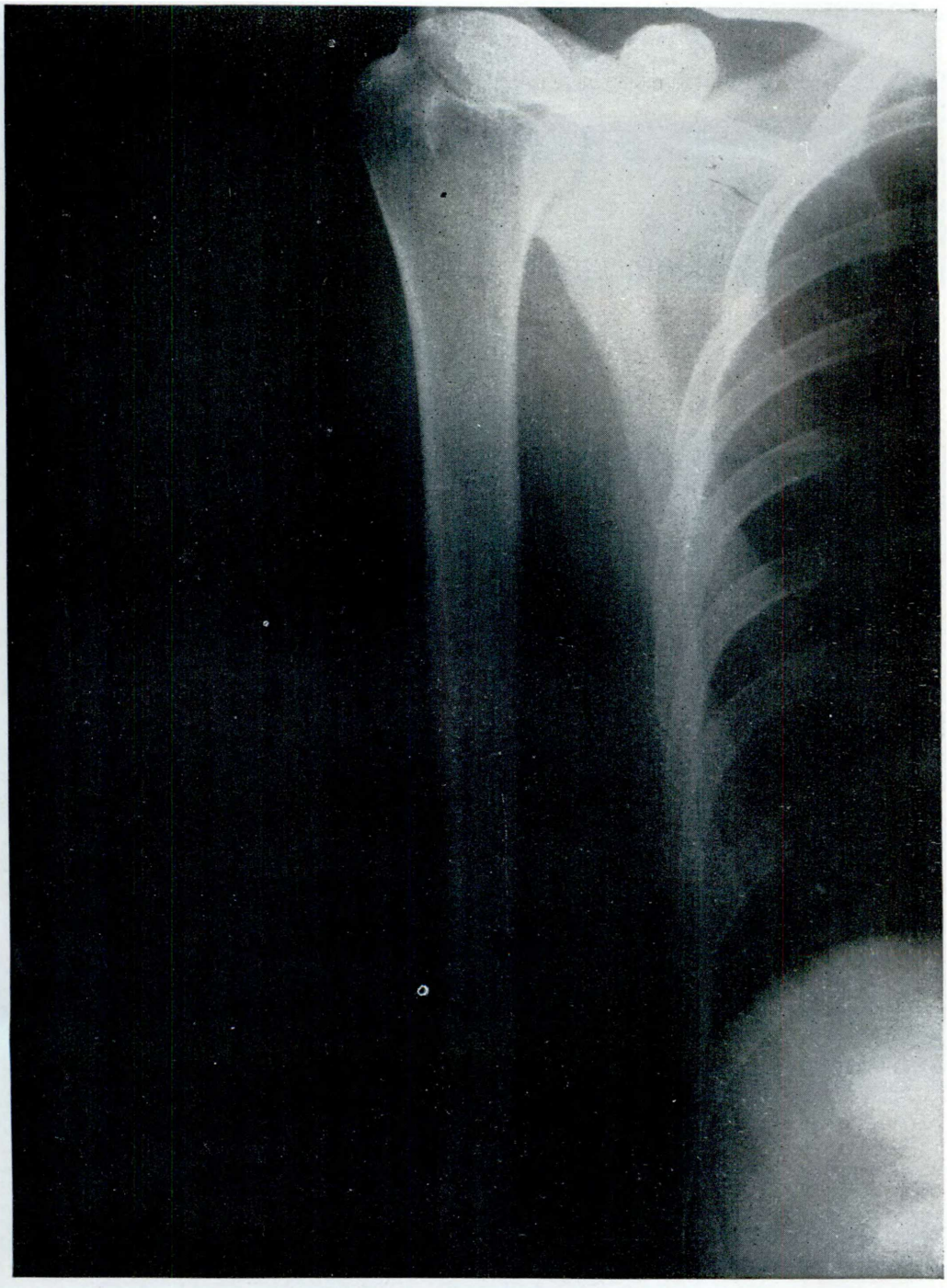


FIGURE 46B.—Arm (humerus), A. P.

Technical factors

Distance: 30''. Cone: No.	(Measure plane through midlength.)									
Cms. thickness:	4	5	6	7	8	9	10	11	12	13
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88
With medium speed screens								3 Ma.S.		

(Basic Ma.S. 75)

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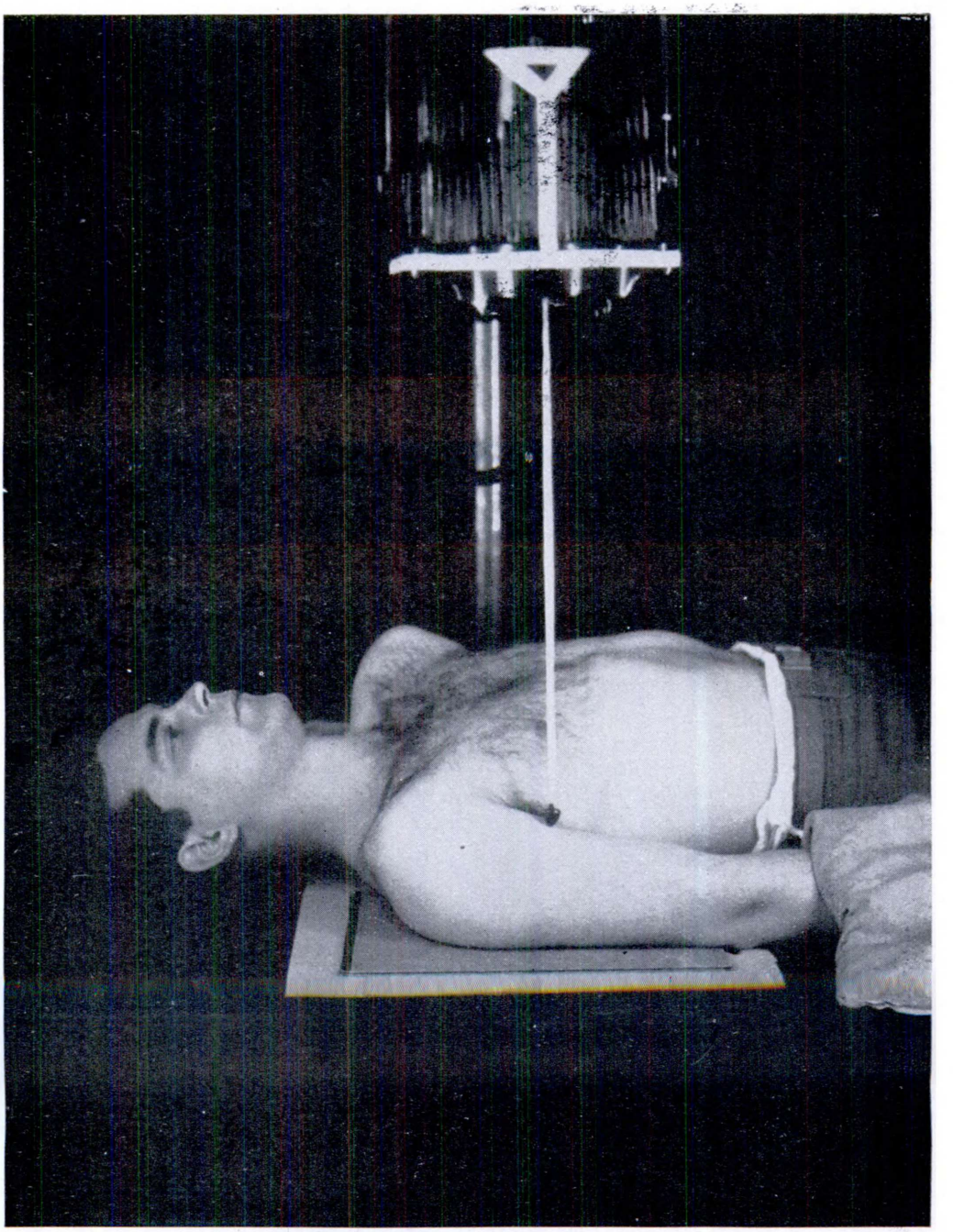


FIGURE 47A.—Arm (humerus), lateral.

Positioning instructions

Film: 10 x 12, lengthwise; cardboard holders if thickness be less than 10 cms., cassettes if greater.
Position: Acromion 2 cms. below middle of upper border of film.
Focal spot: Aline to center of film.
Precautions: Minimal part film distance (sandbag under opposite shoulder); internal epicondyle rotated posteriorly (plane of condyles perpendicular to film)—palm down.
Additional: Sandbag over forearm.

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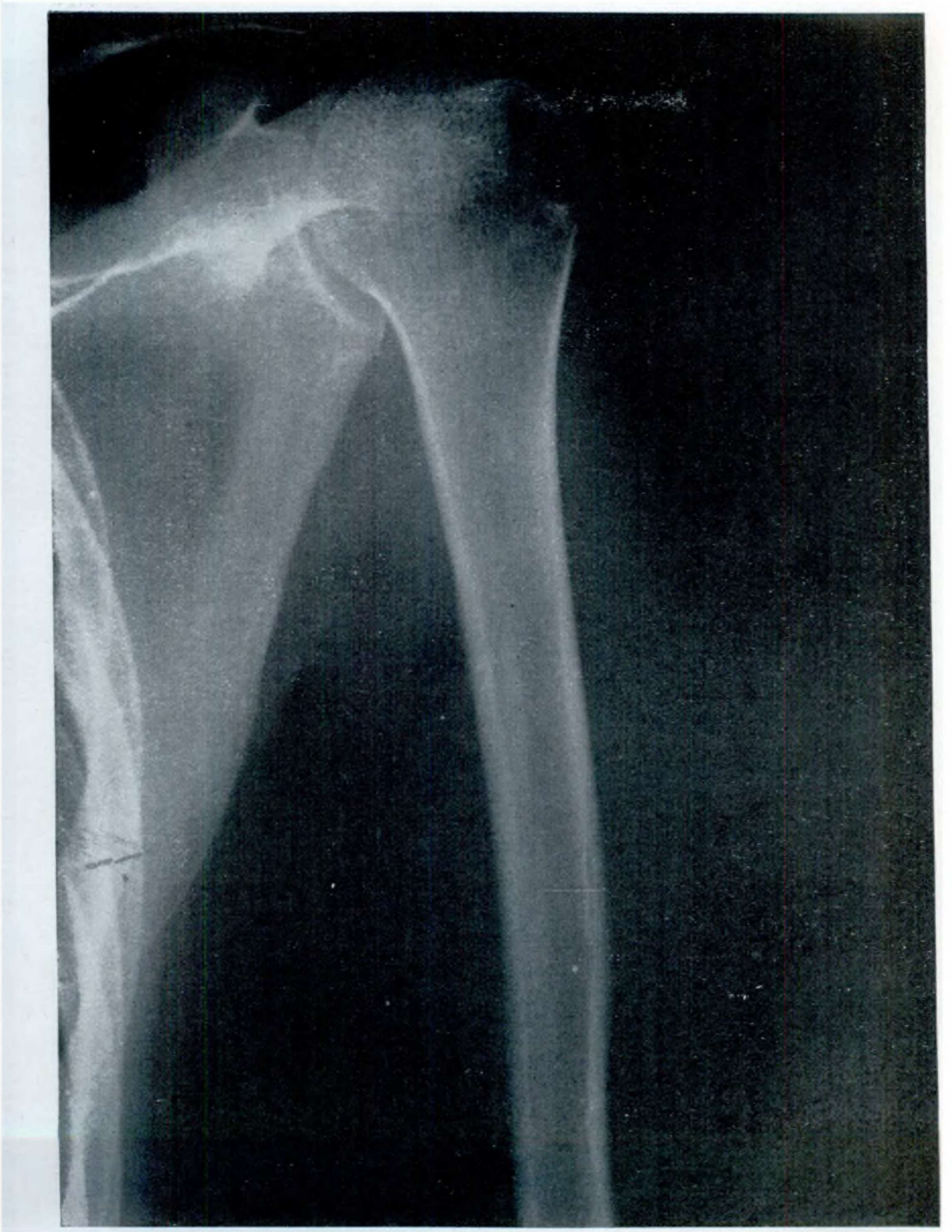


FIGURE 47B.—Arm (humerus), lateral.

Technical factors

Distance: 30″.	**Cone: No.**	(Measure plane through midlength, laterally.)								
Cms. thickness:	4	5	6	7	8	9	10	11	12	13
Variable Kv.P.;	68	70	72	74	76	78	80	82	84	86
								3 Ma.S.		

With medium speed screens

(Basic Ma.S. 75)

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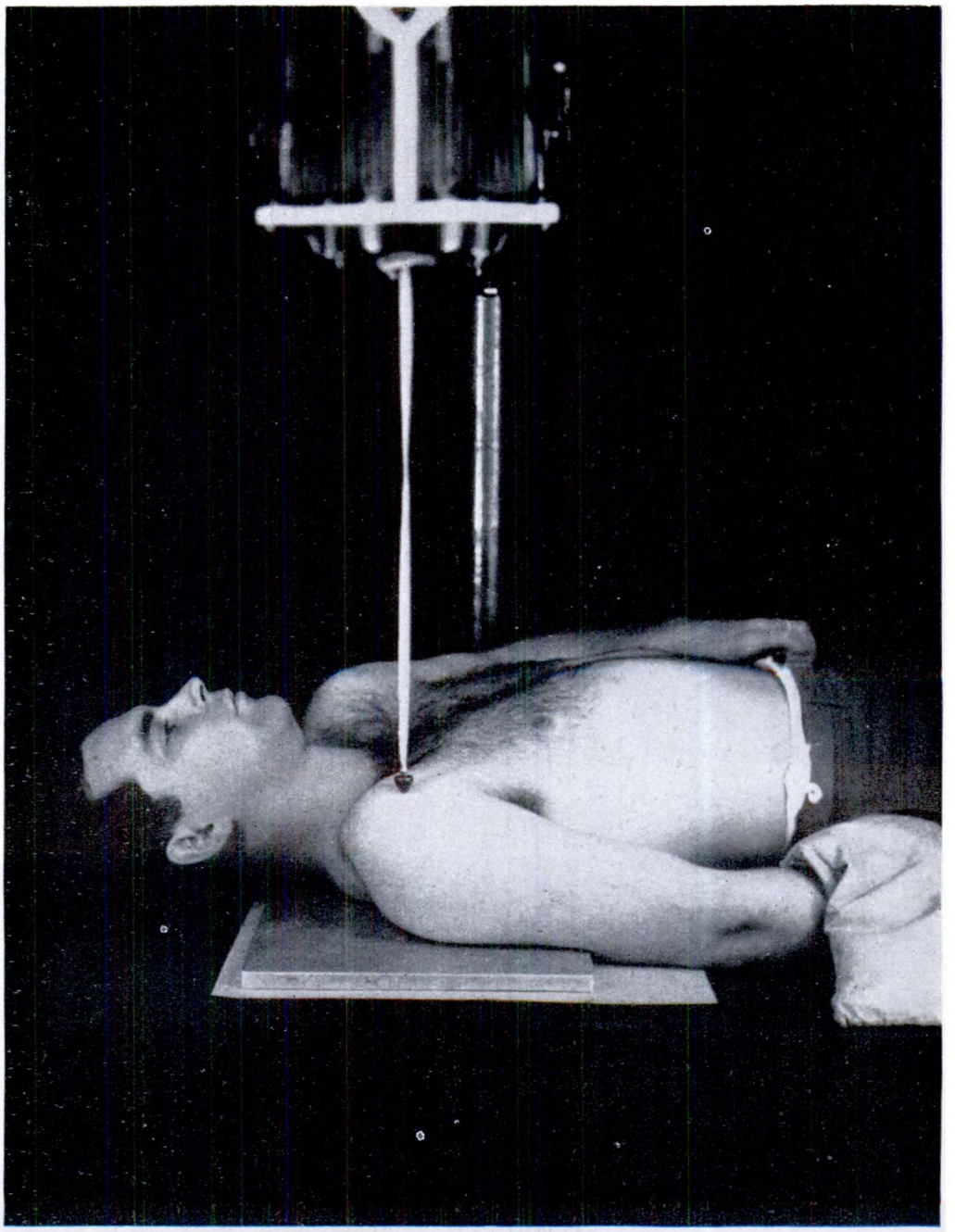


FIGURE 48A.—Shoulder, A. P. (For lateral head of humerus.)

Positioning instructions

Film: 8 x 10, lengthwise; cassette.
Position: Greater tuberosity to center of film.
Focal spot: Aline to center of film.
Precautions: Minimal part film distance (sandbag under opposite shoulder); internal epicondyle rotated posteriorly (plane of condyles perpendicular to film)—palm down, shallow breathing.
Additional: Sandbag over lower third of arm.

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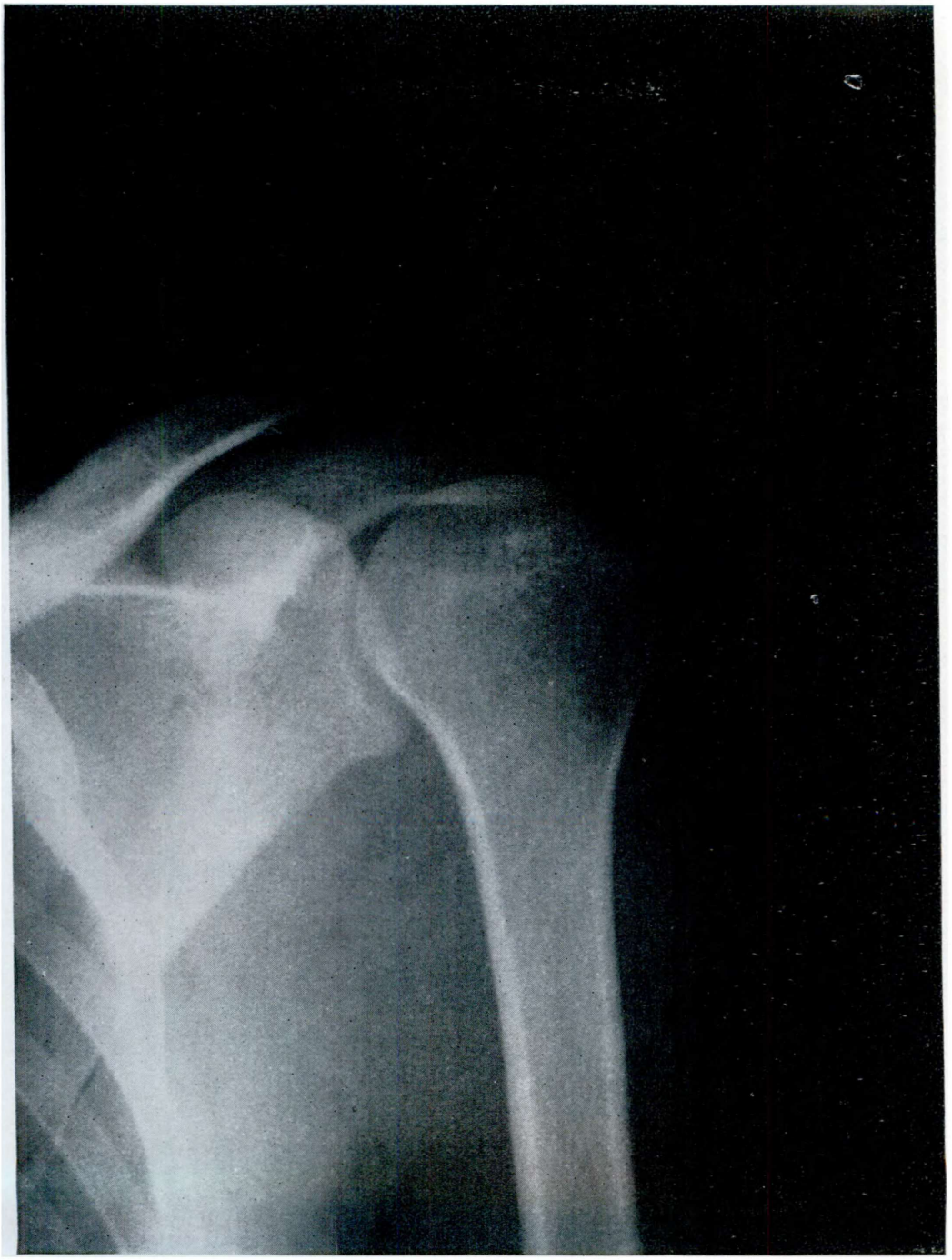


FIGURE 48B.—Shoulder, A. P. (For lateral head of humerus.)

Technical factors

Distance: 30". Cone: Optional (compensate Ma.S.). (Measure plane through greater tuberosity.)

Cms. thickness:	6	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens								3 Ma.S.			
Using grid (5–1 ratio)									9 Ma.S.		

(Basic Ma.S. 75)

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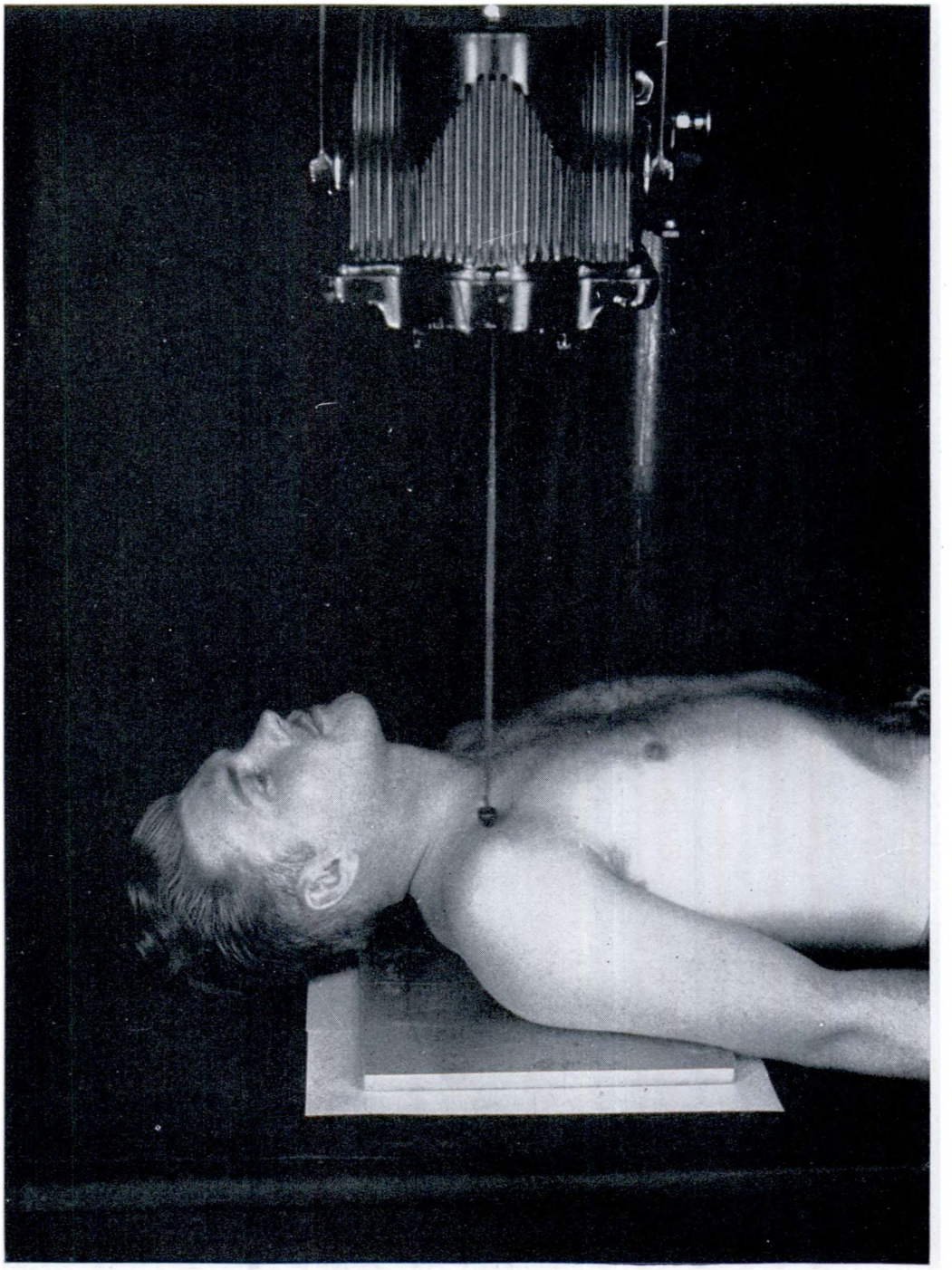


FIGURE 49A.—Shoulder, A. P.

Positioning instructions

Film: 10 x 12, widthwise; cassette.
Position: Greater tuberosity to center of outer half of film.
Focal spot: Aline to coracoid process.
Precautions: Minimal part film distance (sandbag under opposite shoulder); plane of condyles parallel to film—palm up; shallow breathing.
Additional: Sandbag over lower third of arm.

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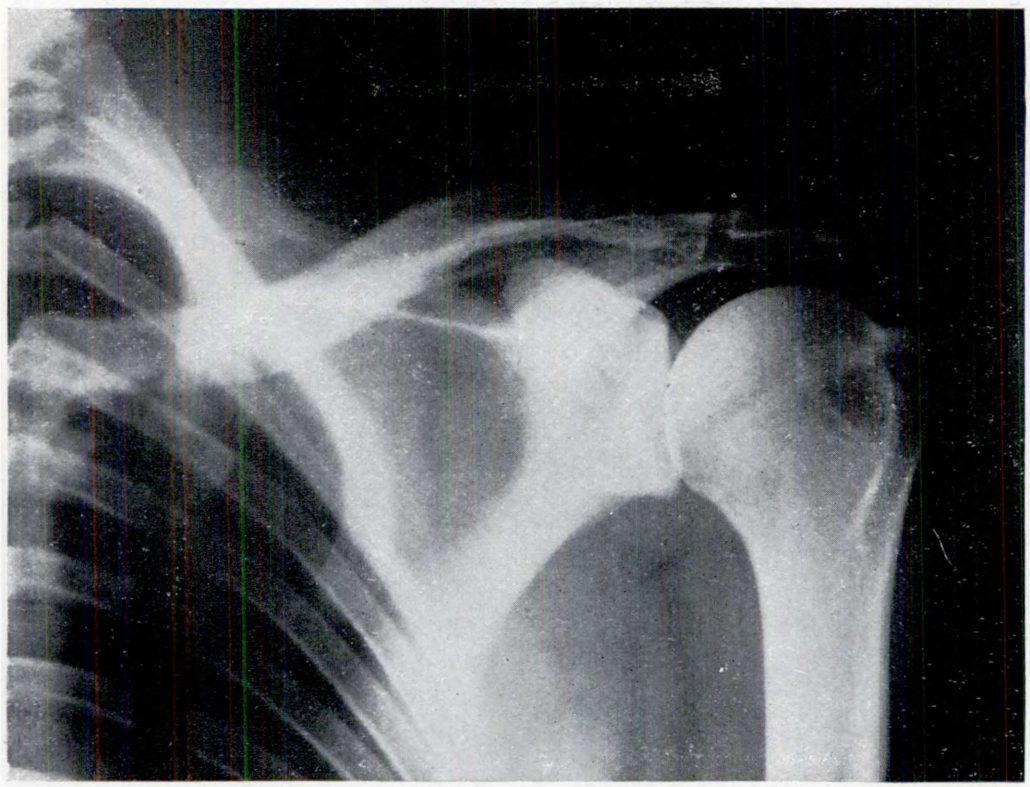


FIGURE 49B.—Shoulder, A. P.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through deltoid. level of coracoid.)

Cms. thickness:	8	9	10	11	12	13	14	15	16	17	18
Variable Kv.P.:	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens				9 Ma.S.				7 Ma. S.			
Using grid (5–1 ratio)							21 Ma.S.				

(Basic Ma.S. 180)

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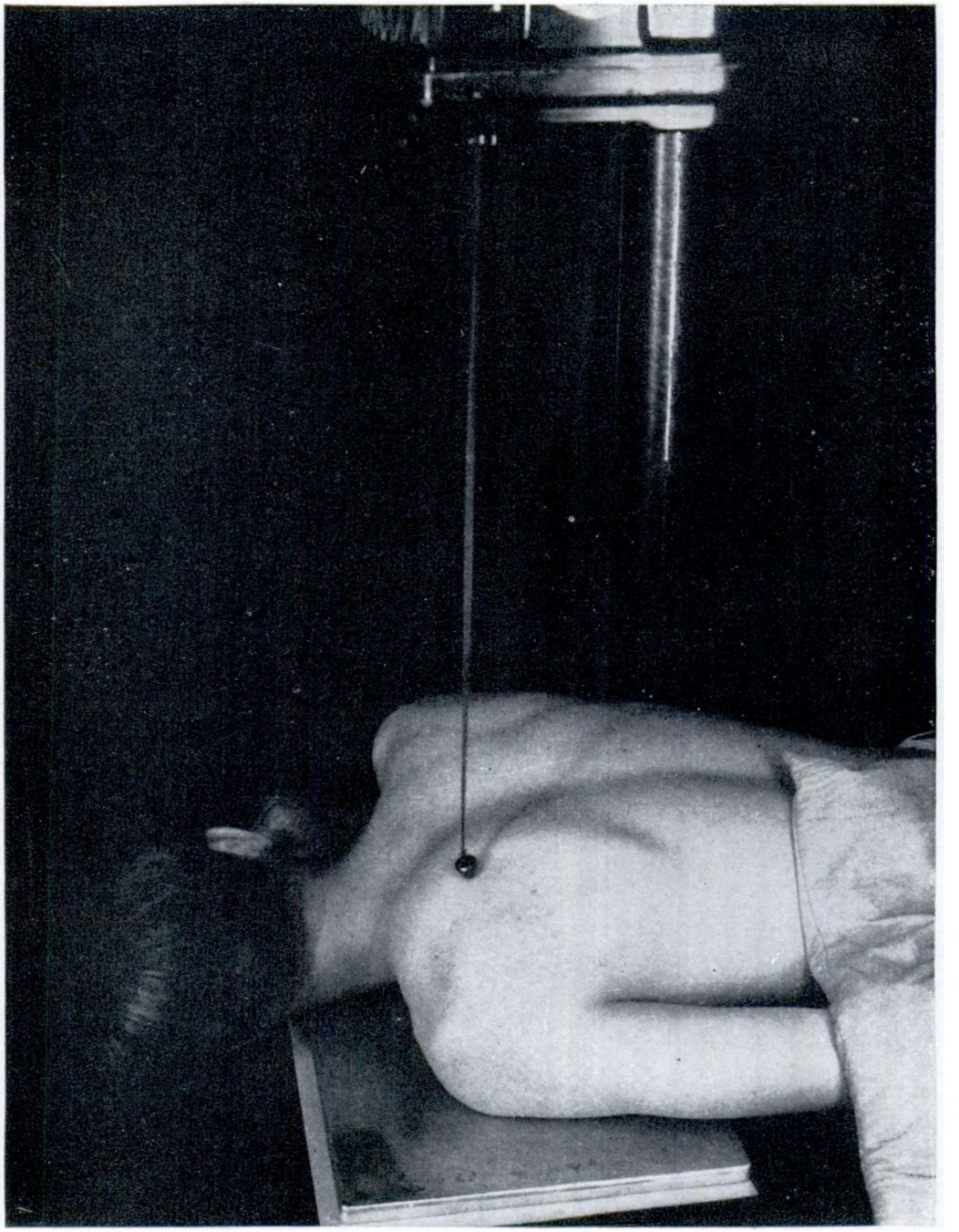


FIGURE 50A.—Clavicle, P. A.

Positioning instructions

Film: 10 x 12, widthwise; cassette.
Position: Greater tuberosity 5 cms. below upper border, outer ¼ of film.
Focal spot: Aline to center of film.
Precautions: Minimal part film distance (sandbag under opposite shoulder); suspend respiration.
Additional: Sandbag over lower third of arm.

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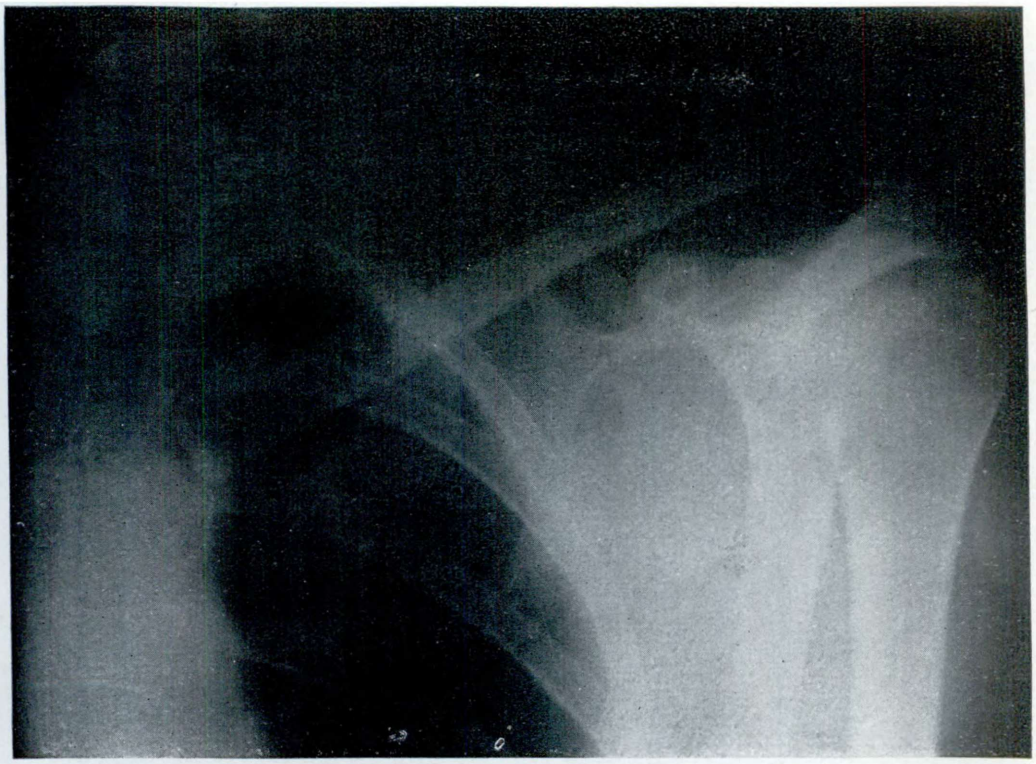


FIGURE 50B.—Clavicle, P. A.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through deltoid to level of coracoid.)

Cms. thickness:	6	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens								3 Ma.S.			
Using grid (5–1 ratio)									9 Ma.S.		

(Basic Ma.S. 75)

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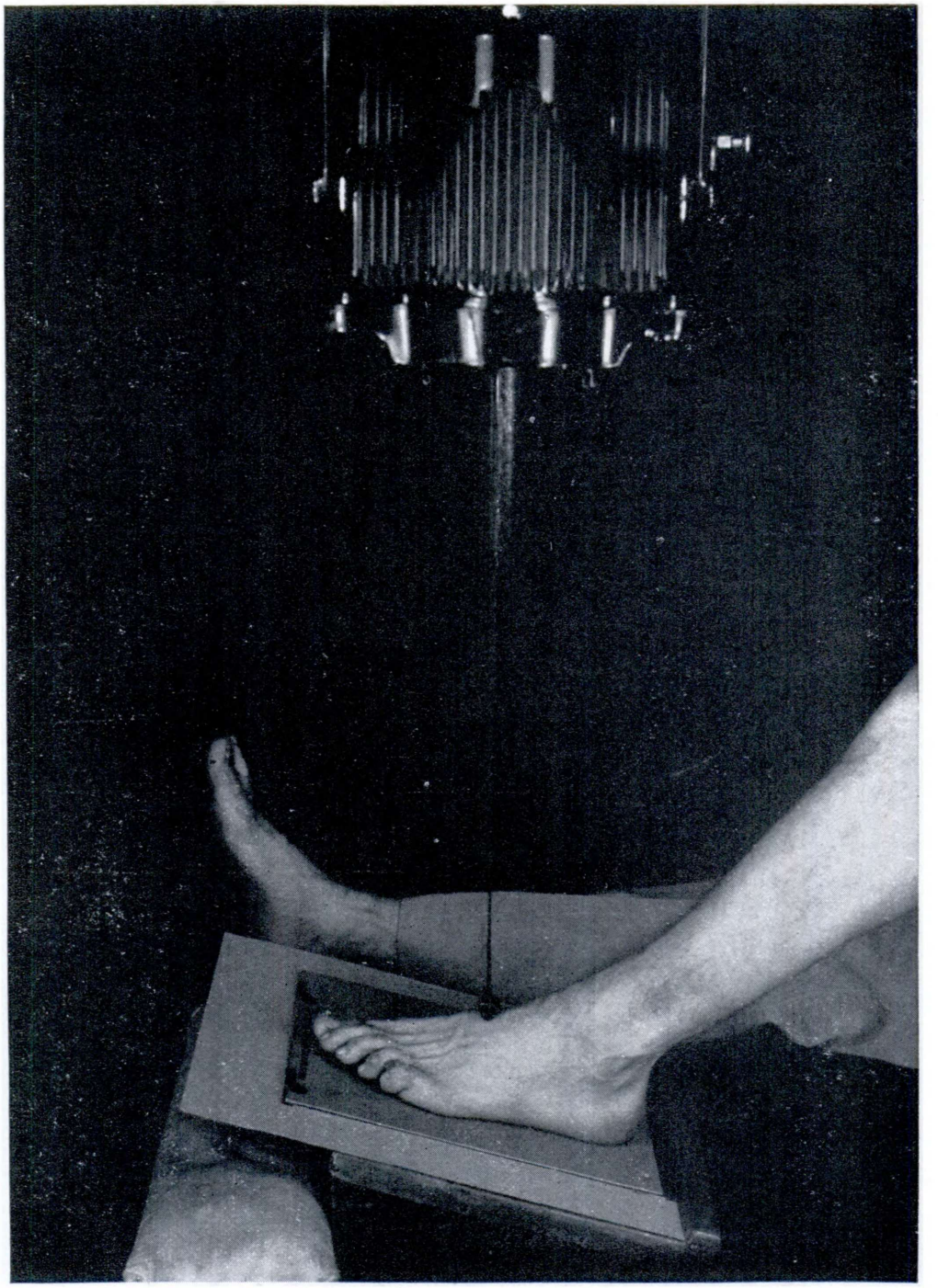


FIGURE 51A.—Foot, dorso-plantar.

Positioning instructions

Film : 8 x 10 in cardboard holder, lengthwise.
Position : Tip of large toe 2 cms. below upper border of film.
Focal spot : Aline to prominence of dorsum.
Precautions : Toes separated (with cotton) and straight.
Additional : 15° angle board (or sandbag substitute).

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FIGURE 51B.—Foot, dorso-plantar.

Technical factors

Distance: 30″. (Measure plane through prominence of dorsum.)	Cone: Optional (compensate Ma.S.).										
Cms. thickness:	3	4	5	6	7	8	9	10	11	12	13
Variable Kv.P.:	58	60	62	64	66	68	70	72	74	76	78
With medium speed screens									2 Ma.S.		

(Basic Ma.S. 30)

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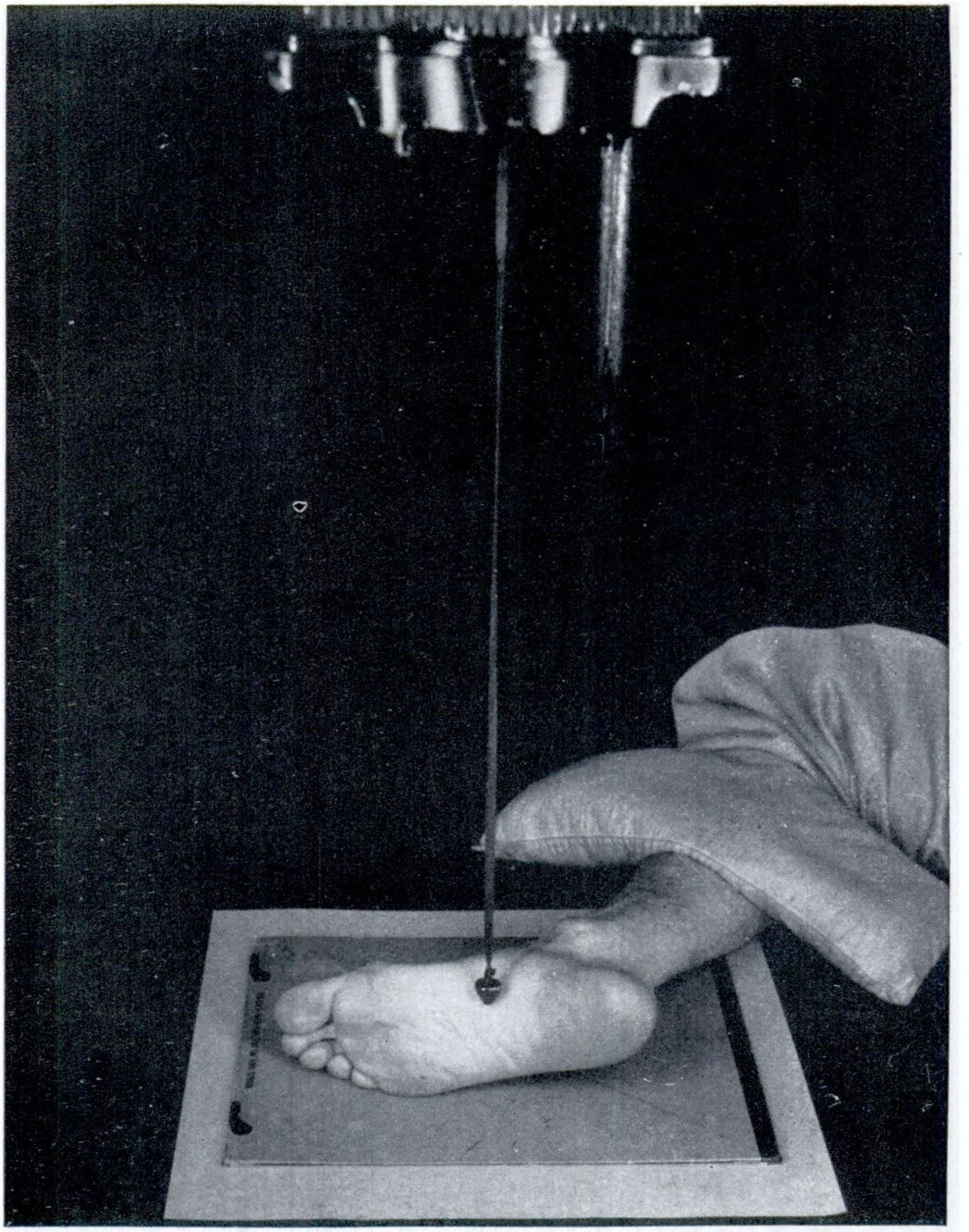


FIGURE 52A.—Foot, lateral.

Positioning instructions

Film: 10 x 12 in cardboard holder.
Position: Patient on side; prominence of dorsum to center of film.
Focal spot: Aline to center of plantar surface.
Precautions: Natural inversion of foot at rest (lying lengthwise on film).
Additional: Sandbag over middle third of leg.

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FIGURE 52B.—Foot, lateral.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through midwidth of dorsum.)											
Cms. thickness:	3	4	5	6	7	8	9	10	11	12	13
Variable Kv.P.:	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens									2 Ma.S.		

(Basic Ma.S. 35)

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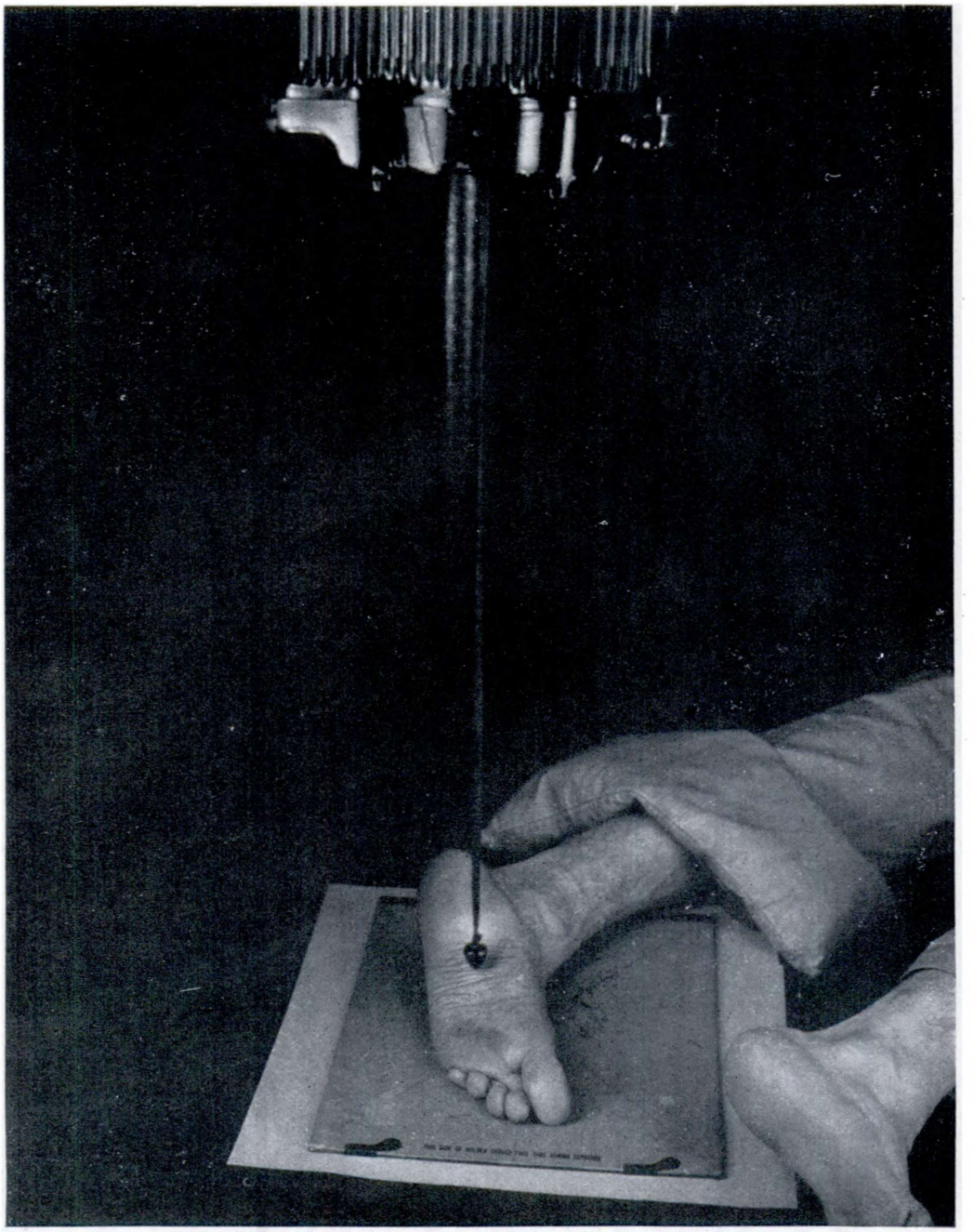


FIGURE 53A.—Foot, plantar-semilateral.

Positioning instructions

Film: 10 x 12 in cardboard holder.
Position: Patient prone; prominence of dorsum to center of film.
Focal spot: Aline to center of plantar surface.
Precautions: Foot inverted and flexed (lying obliquely across film).
Additional: Sandbag over middle third of leg.

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FIGURE 53B.—Foot, plantar-semilateral.

Technical factors

Distance: 30". Cone: Optional (compensate Ma.S.). (Measure plane through midwidth of dorsum.)

Cms. thickness:	3	4	5	6	7	8	9	10	11	12	13
Variable Kv.P.:	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens									2 Ma.S.		

(Basic Ma.S. 35)

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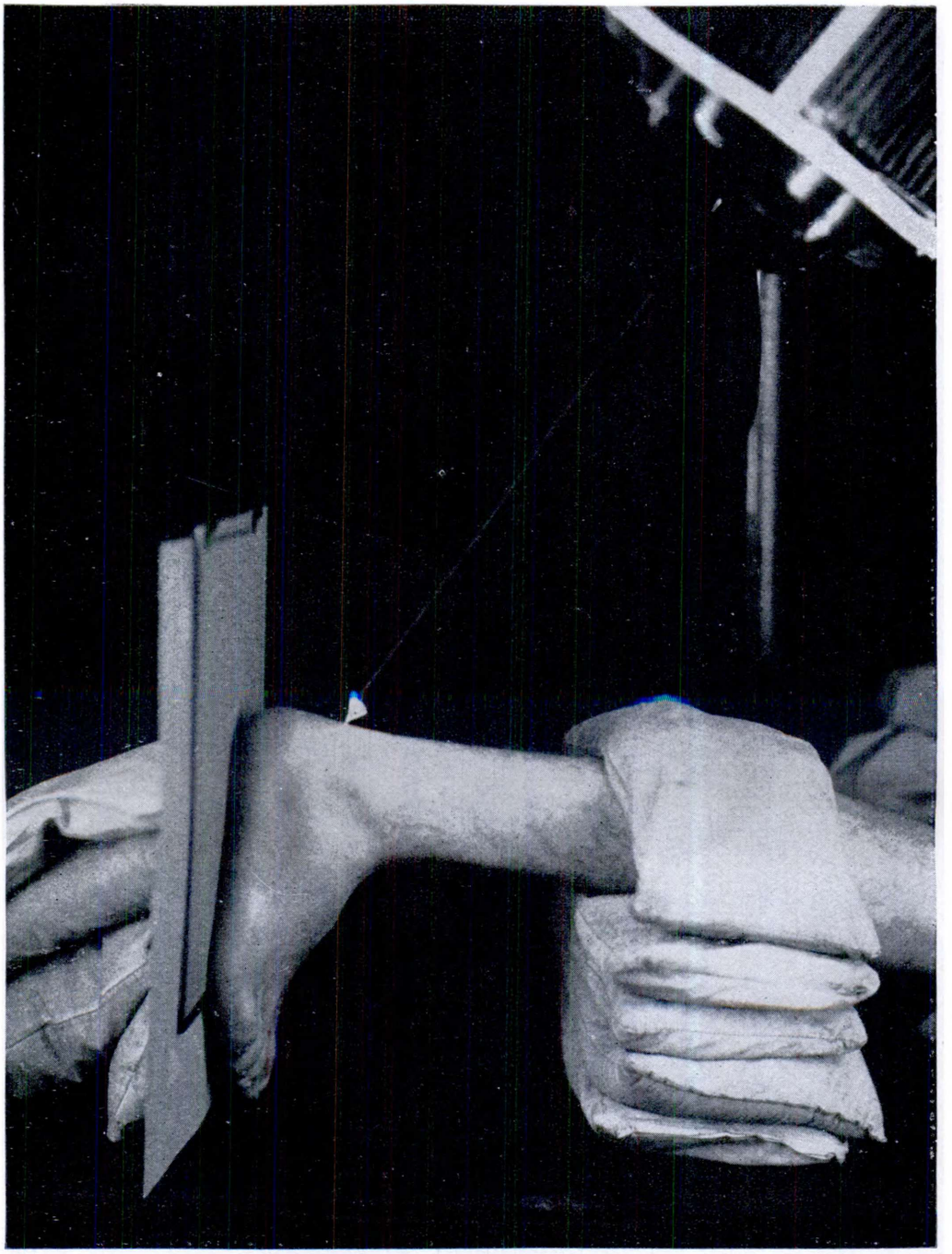


FIGURE 54A.—Heel (os calcis), P. A.

Positioning instructions

Film : 8 x 10 in cardboard holder, upright.
Position : Patient prone ; extremity of heel to center of upper half of film.
Focal spot : Point midway between malleoli (after tilting tube 40° to plane of foot).
Precautions : Ample sandbag support under ankle and leg ; sandbag support of cardboard holder.
Additional : Sandbag over leg.

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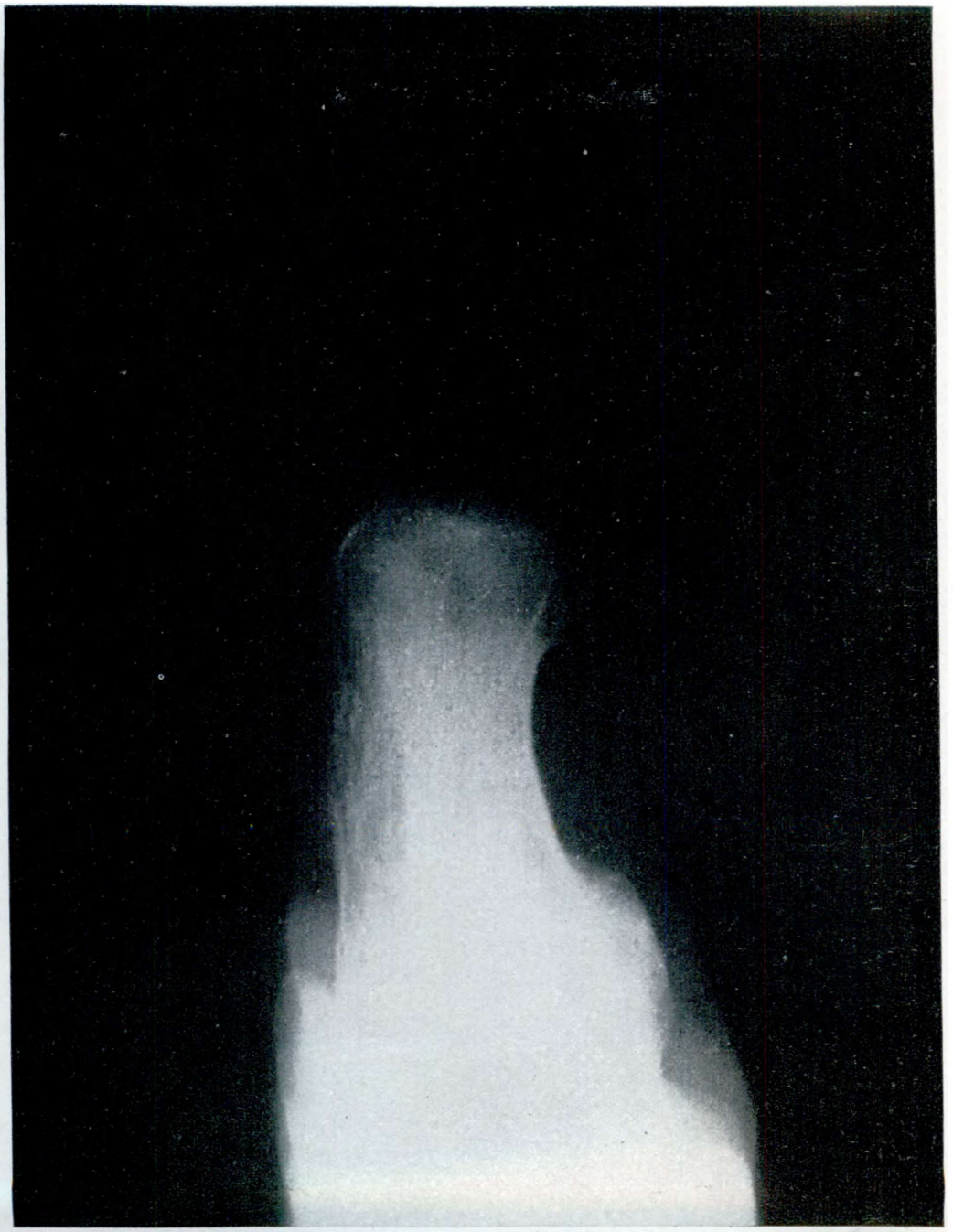


FIGURE 54B.—Heel (os calcis) P. A.

Technical factors

Distance: 30". Cone: Optional (compensate Ma.S.). (Measure obliquely below malleoli.)								
Cms. thickness:	6	7	8	9	10	11	12	13
Variable Kv.P.:	68	70	72	74	76	78	80	82
With medium speed screens						3 Ma.S.		

(Basic Ma.S. 75)

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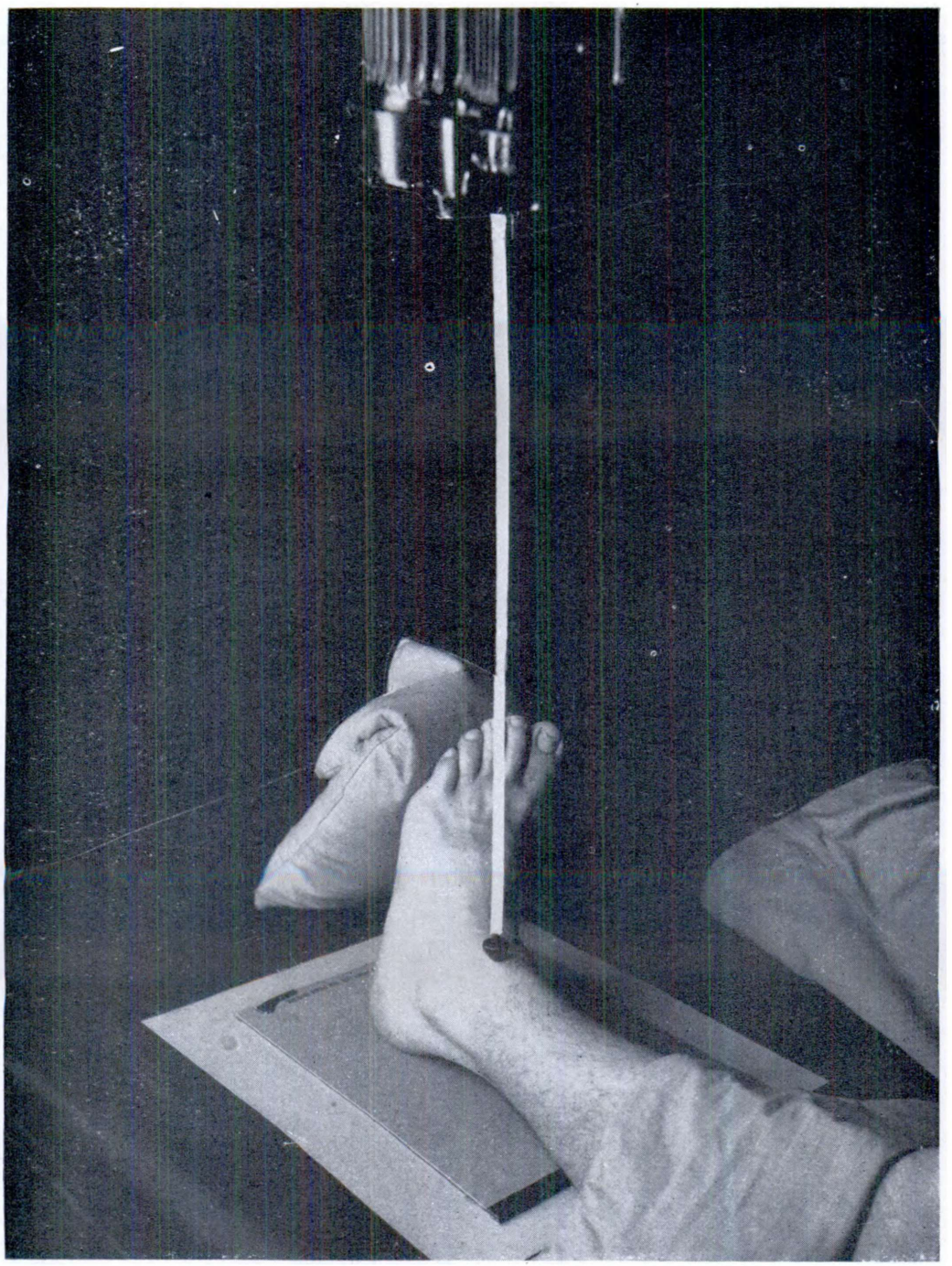


FIGURE 55A.—Ankle, A. P.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: Internal malleolus to midlength of film.
Focal spot: Aline to midpoint between tips of malleoli.
Precautions: Plane through tips of malleoli-parallel to film (internal rotation of ankle); support foot.
Additional: Sandbag over middle third of leg.

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FIGURE 55B.—Ankle, A. P.

Technical factors

Distance: 30".	**Cone: Optional (compensate Ma. S.).**							(Measure plane through malleoli.)		
Cms. thickness:	4	5	6	7	8	9	10	11	12	13
Variable Kv.P.:	72	74	76	78	80	82	84	86	88	90
With medium speed screens								2 Ma.S.		

(Basic Ma.S. 35)

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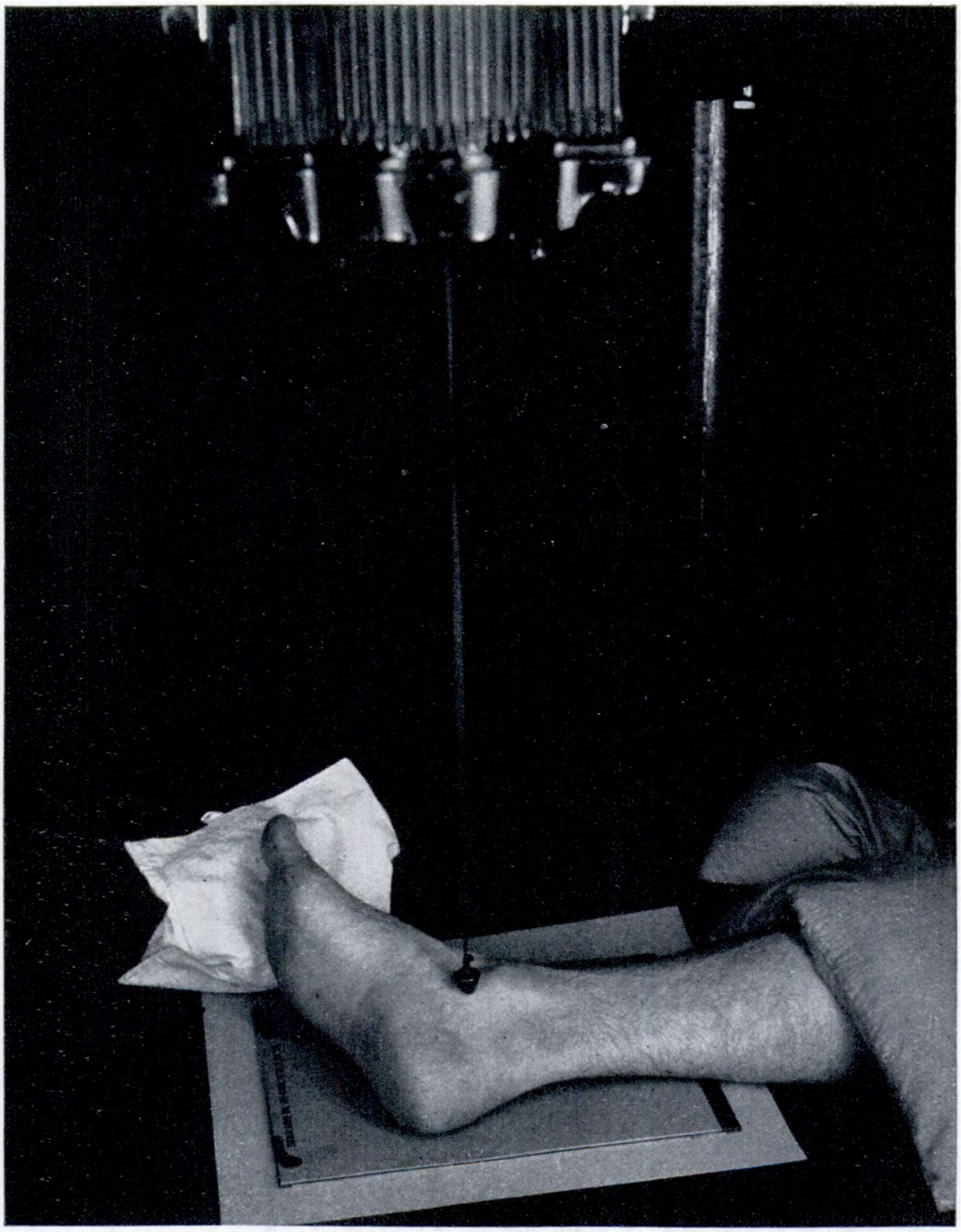


FIGURE 56A.—Ankle, lateral.

Positioning instructions

Film: 8 x 10 in cardboard holder, lengthwise.
Position: External malleolus to center of film.
Focal spot: Aline 1 cm. distal to tip, internal malleolus.
Precautions: Plane through tips of malleoli—perpendicular to film (sandbag under toes and under knee).
Additional: Sandbag over leg.

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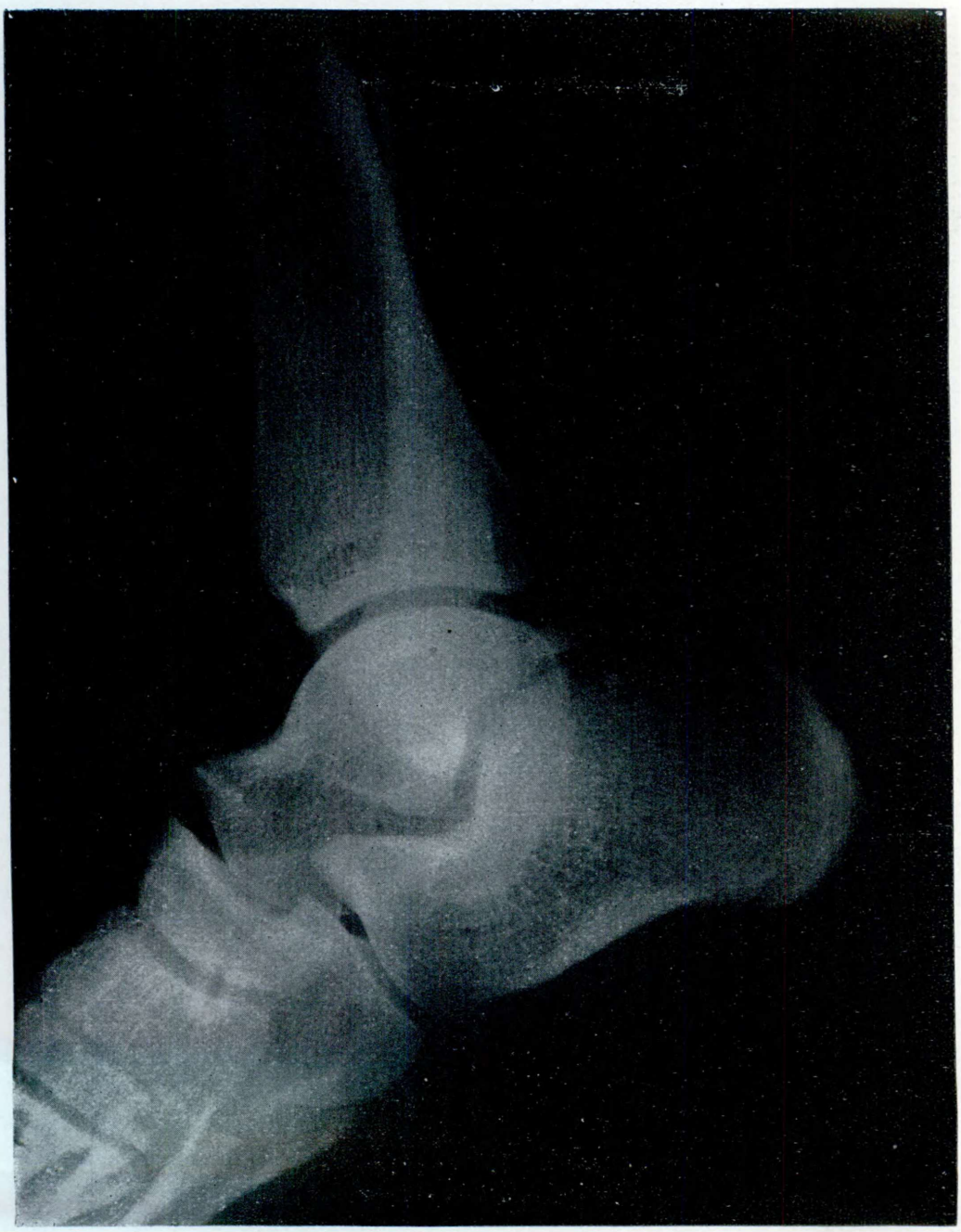


FIGURE 56B.—Ankle, lateral.

Technical factors

Distance: 30''.	Cone: Optional (compensate Ma.S.).							(Measure plane through malleoli.)	
Cms. thickness:	4	5	6	7	8	9	10	11	12
Variable Kv.P.:	74	76	78	80	82	84	86	88	90
With medium speed screens								2 Ma.S.	

(Basic Ma.S. 35)

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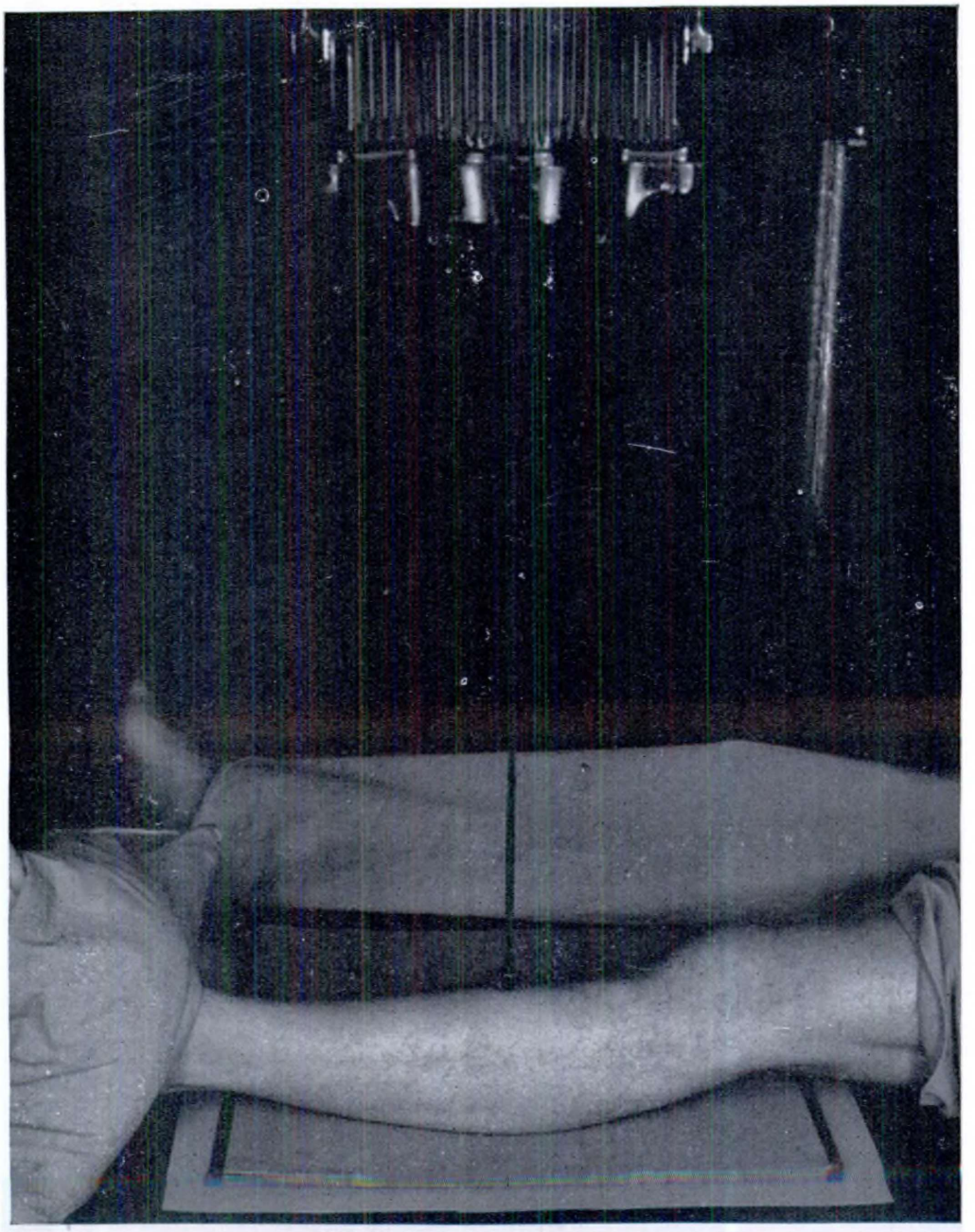


FIGURE 57A.—Leg (tibia and fibula), A. P.

Positioning instructions

Film: 7 x 17 (½ of 14 x 17); cardboard holders if thickness is less than 10 cms., cassettes if greater.
Position: Patient supine; tibial condyles 5 cms. below upper border of film.
Focal spot: Aline to center of film.
Precautions: Plane through tips of malleoli parallel to film (internal rotation of ankle).
Additional: Sandbags over lower third of thigh and supporting foot.

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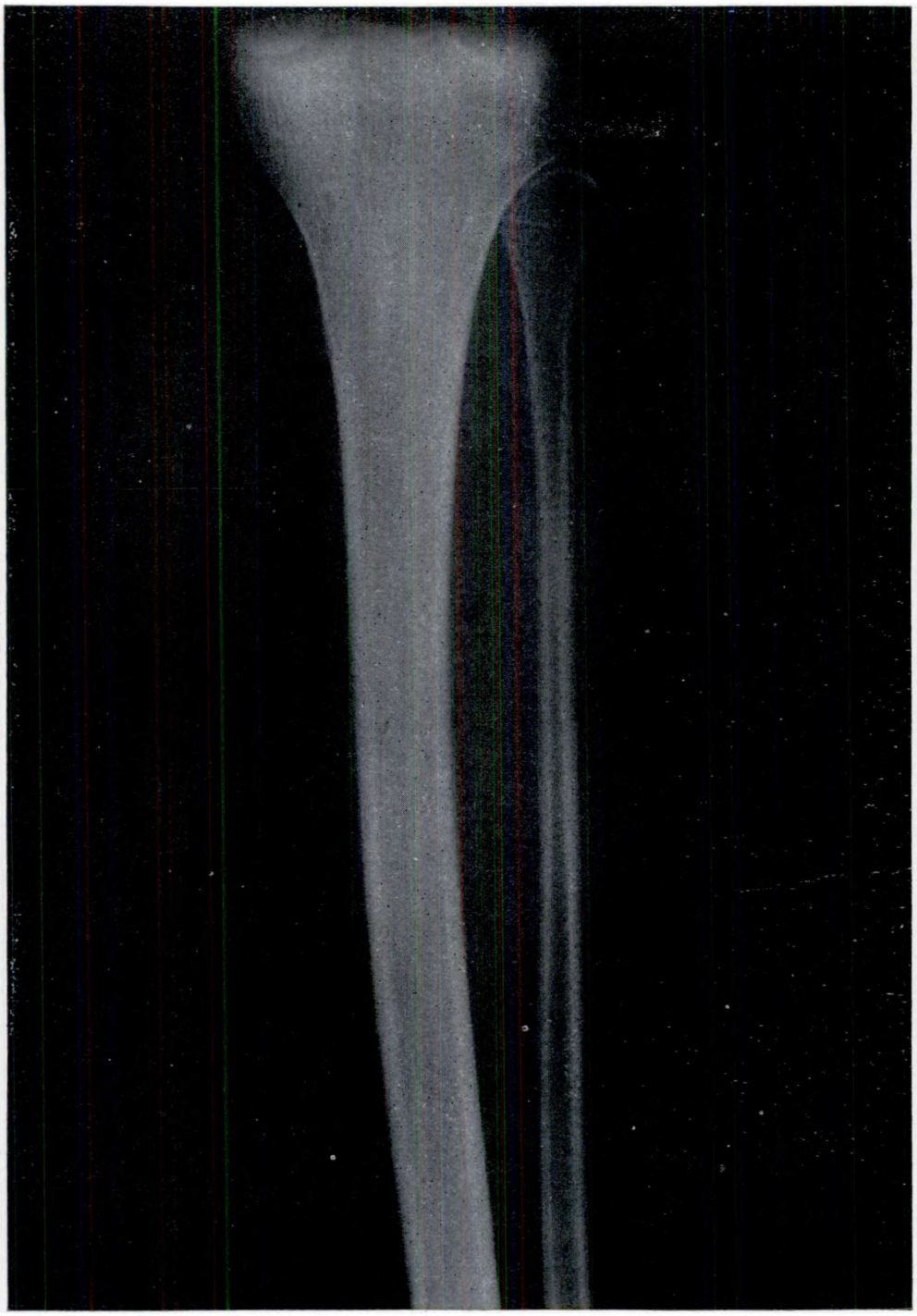


FIGURE 57B.—Leg (tibia and fibula) A. P.

Technical factors

Distance: 30″. Cone: No.	(Measure plane through midlength of leg.)										
Cms. thickness:	6	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens					4 Ma.S.			3 Ma.S.			
Using grid (5–1 ratio)									9 Ma.S.		

(Basic Ma.S. 75)

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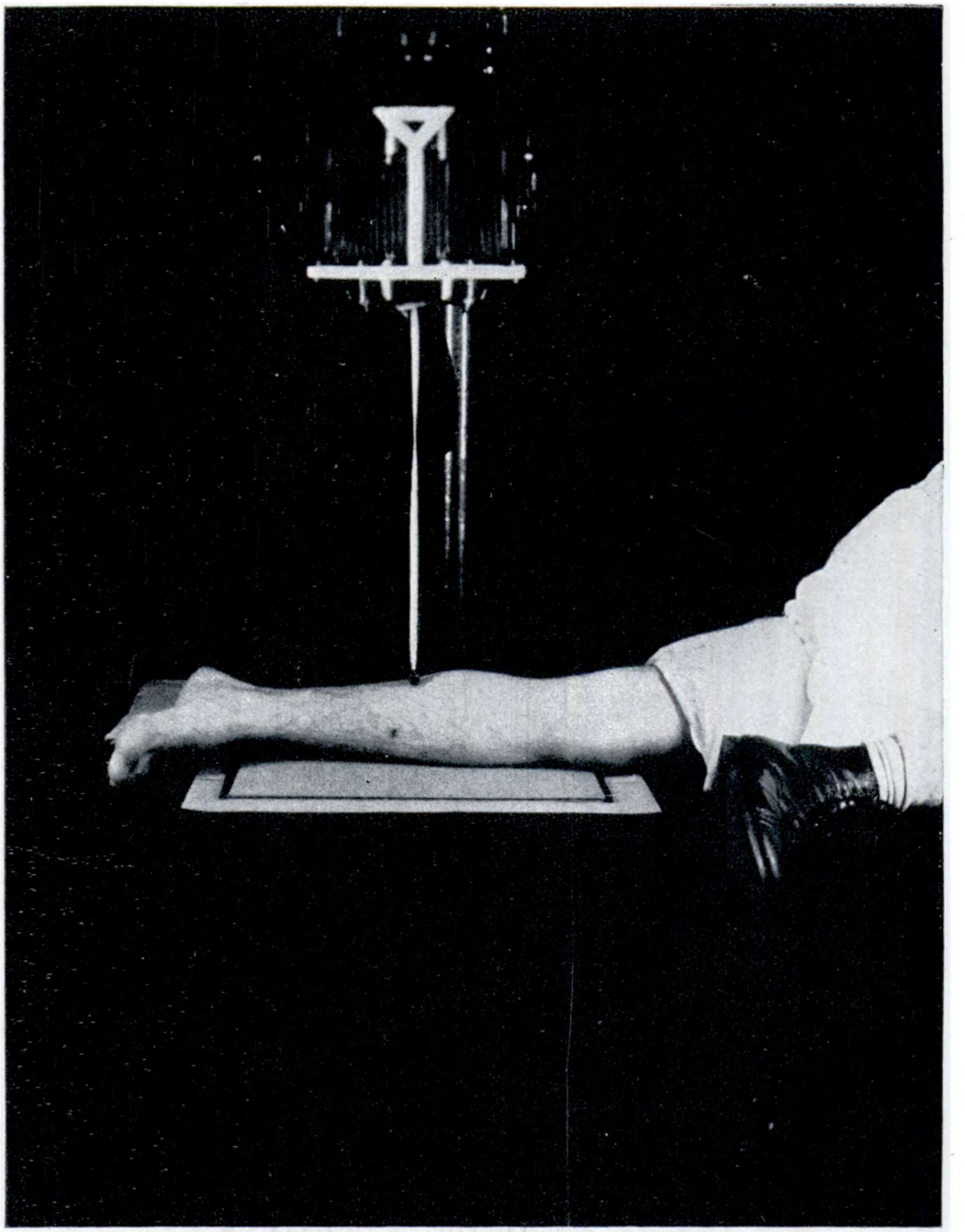


FIGURE 58A.—Leg (tibia and fibula), lateral.

Positioning instructions

Film: 7 x 17 (½ of 14 x 17) as for A.P.
Position: Patient on side, fibula to film; tibial condyles 5 cms. below upper border of film.
Focal spot: Aline to center of film.
Precautions: Plane through tibial condyles perpendicular to film (sandbag under heel).
Additional: Opposite leg flexed forward; sandbag across thigh.

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FIGURE 58B.—Leg (tibia and fibula) lateral.

Technical factors

Distance: 30″. Cone: No. (Measure plane through midlength of leg.)											
Cms. thickness:	6	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens						4 Ma.S.		3 Ma.S.			
Using grid (5–1 ratio)										9 Ma.S.	

(Basic Ma.S. 75)

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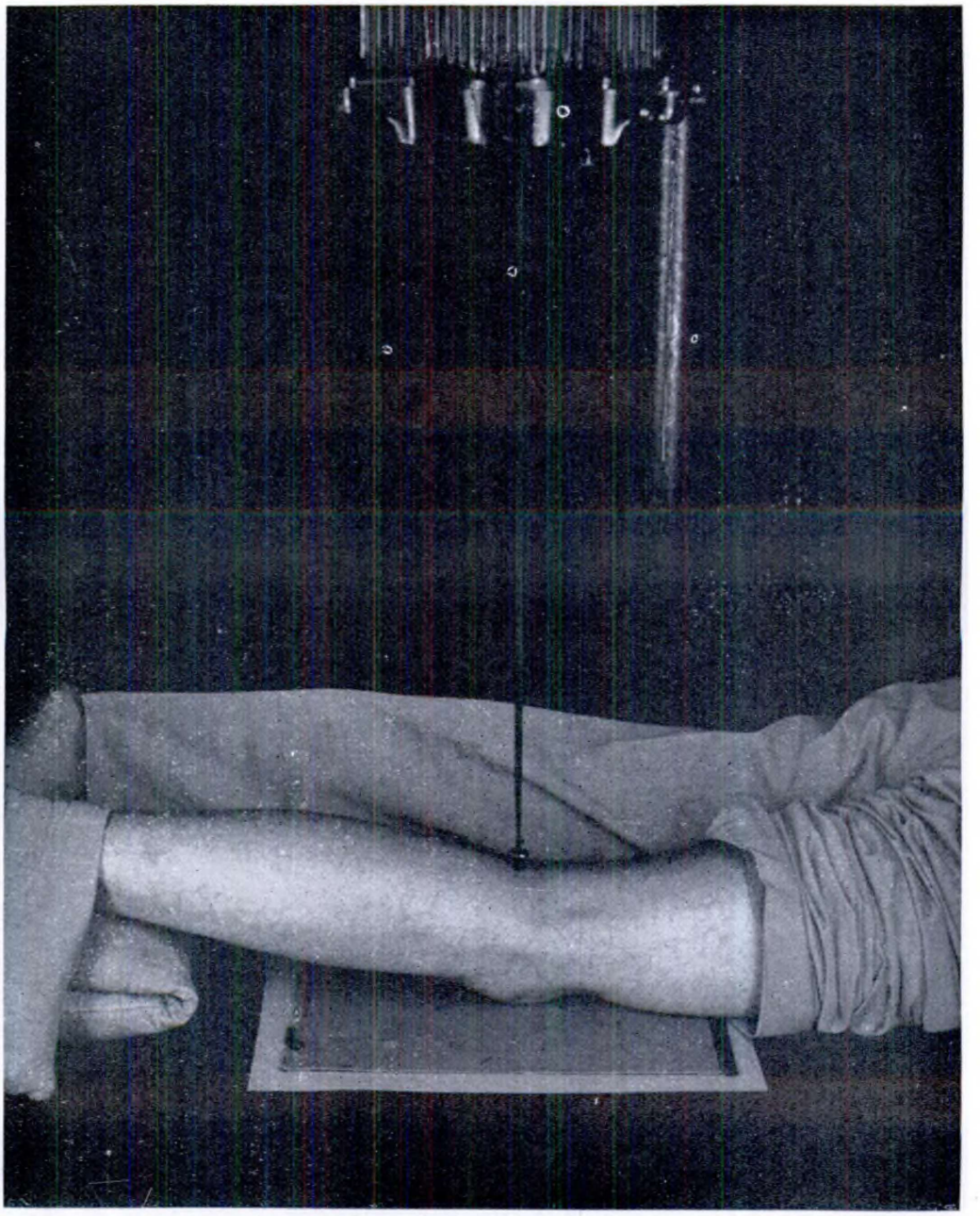


FIGURE 59A.—Knee, P. A.

Positioning instructions

Film: 10 x 12, lengthwise; cardboard holders if thickness be less than 10 cms., cassettes if greater.
Position: Patient prone; tibial tuberosity to center of film.
Focal spot: Aline to plane 2 cms. distal to head of fibula and at midwidth, knee.
Precautions: Leg supported and raised by sandbags (15°).
Additional: Sandbag over leg.

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FIGURE 59B.—Knee, P. A.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through patella.)											
Cms. thickness:	6	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens						4 Ma.S.			3 Ma.S.		
Using grid (5–1 ratio)									9 Ma.S.		

(Basic Ma.S. 75)

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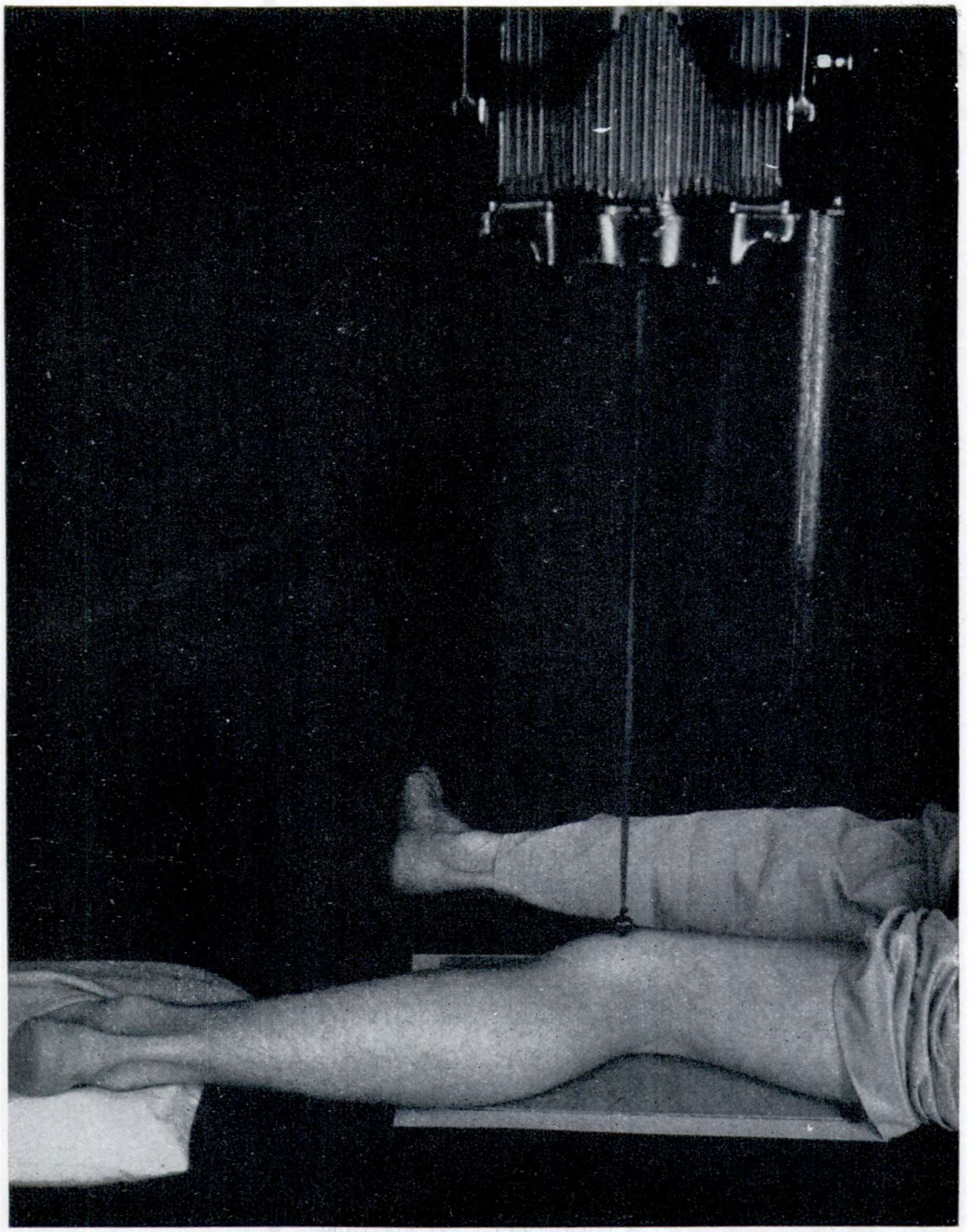


FIGURE 60A.—Knee, lateral.

Positioning instructions

Film: 10 x 12, lengthwise as for P. A.
Position: Head of fibula to center of film; leg flexed 45°.
Focal spot: Aline to plane of upper border, internal condyle and midwidth, knee.
Precautions: Plane of condyles perpendicular to film (sandbag under heel).
Additional: Opposite leg flexed forward (sandbag over toes).

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FIGURE 60B.—Knee, lateral.

Technical factors

Distance: 30″.	Cone: Optional (compensate Ma.S.).						(Measure plane through patella.)				
Cms. thickness:	6	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens						4 Ma.S.			3 Ma.S.		
Using grid (5–1 ratio)									9 Ma.S.		

(Basic Ma.S. 75)

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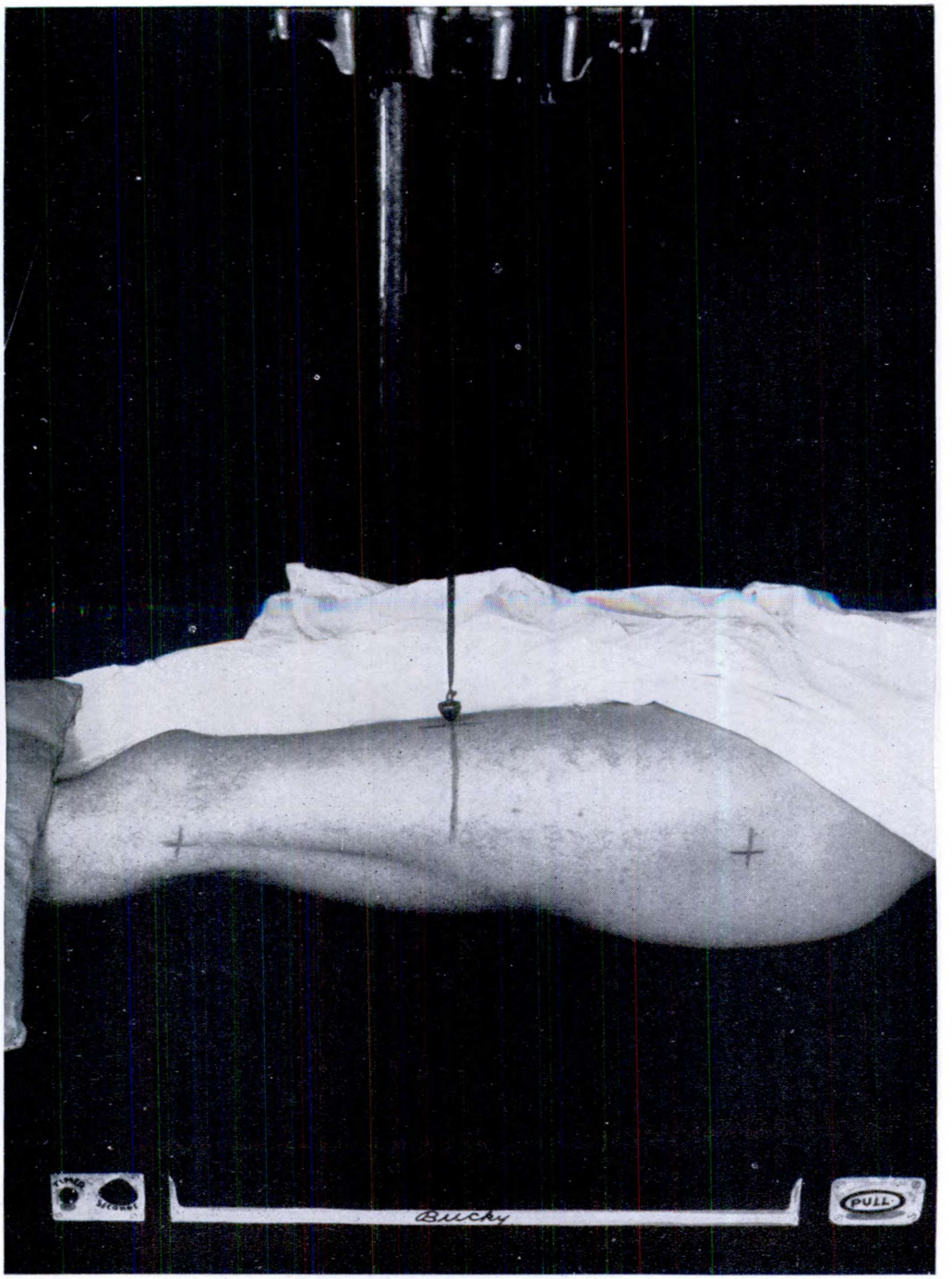


FIGURE 61A.—Thigh (femur), A. P.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient supine; greater trochanter 7 cms. below upper border and at midwidth of film.
Focal spot: Aline to center of film.
Precautions: Plane of condyles parallel to film (slight internal rotation of foot).
Additional: Sandbag over leg; grid advisable.

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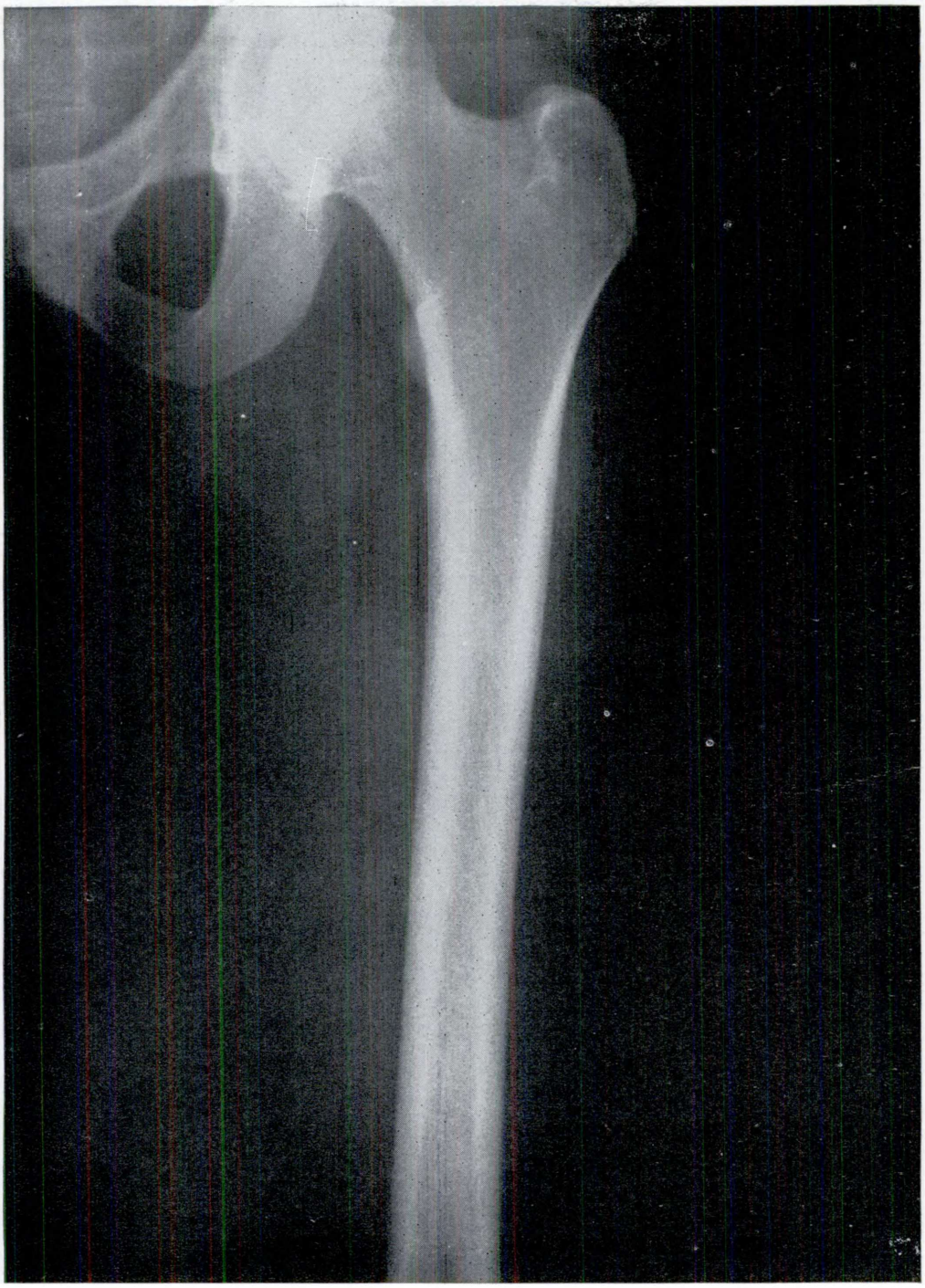


FIGURE 61B.—Thigh (femur), A. P.

Technical factors

Distance: 30″. Cone: No. (Measure plane through midlength, thigh.)														
Cms. thickness:	8	9	10	11	12	13	14	15	16	17	18	19	20
Variable Kv.P.:	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens				10 Ma.S.					8 Ma.S.				
Using grid (5–1 ratio)						30 Ma.S.			24 Ma.S.				

(Basic Ma.S. 200)

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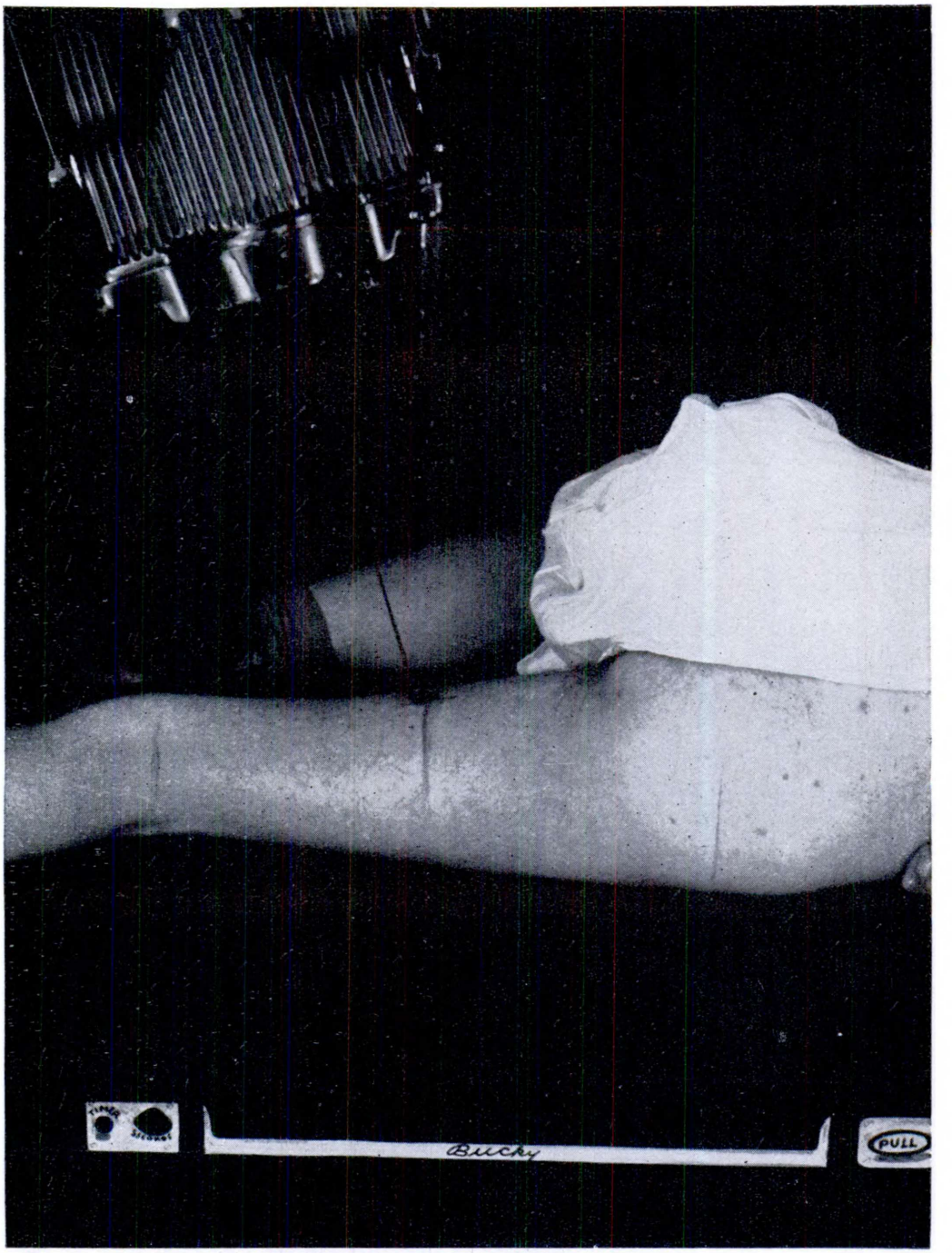


FIGURE 62A.—Thigh (femur), lateral.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient on side; greater trochanter 7 cms. below upper border and at midwidth of film.
Focal spot: Aline to center of film after angling tube so that divergance of primary beam clears top buttock (approximately 15°).
Precautions: Extreme flexion, opposite thigh (for support and clearance of buttocks).
Additional: Sandbag over leg; grid advisable.

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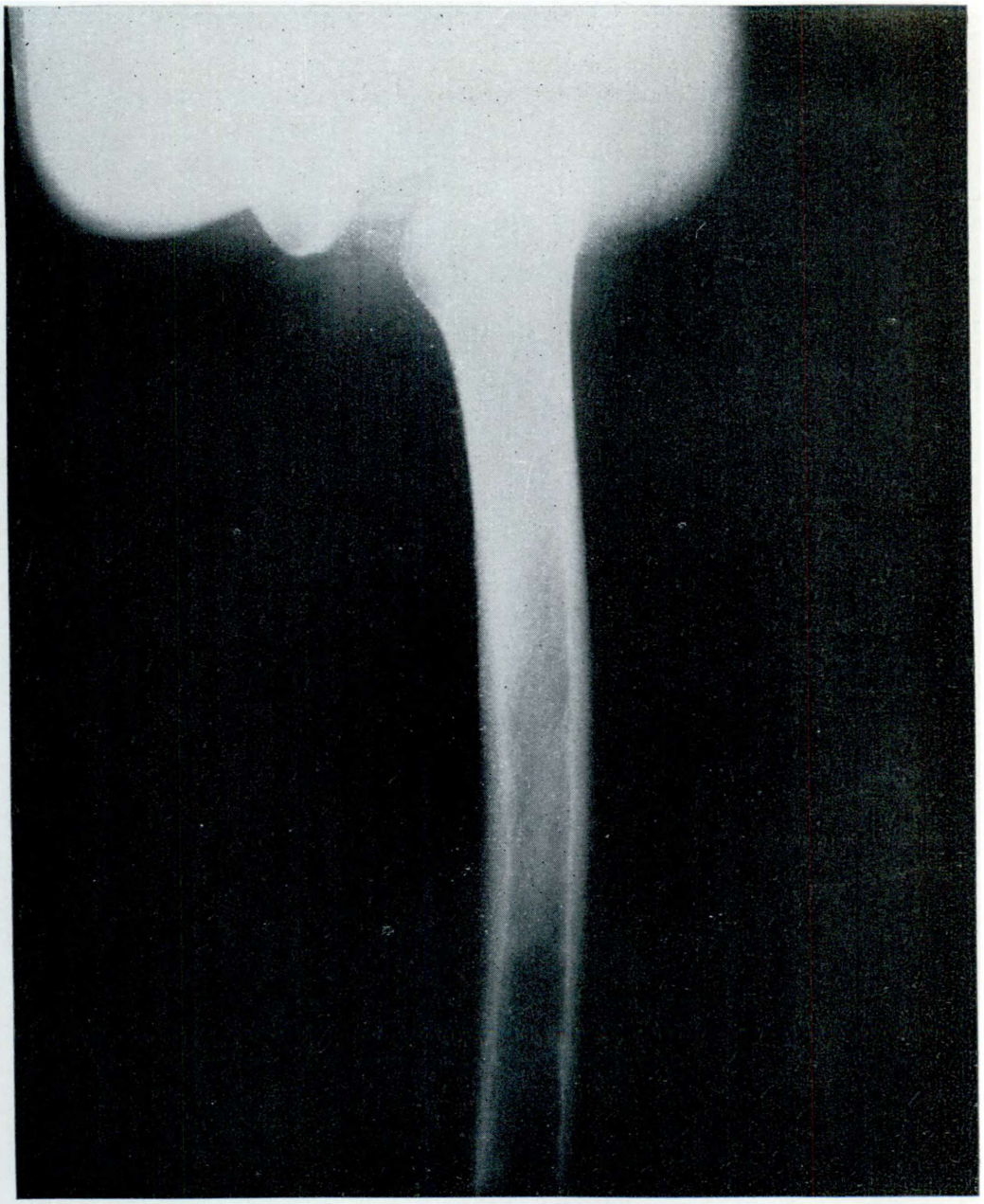


FIGURE 62B.—Thigh (femur) lateral.

Technical factors

Distance: 30″. Cone: No. (Measure plane through midlength of thigh.)

Cms. thickness:	8	9	10	11	12	13	14	15	16	17	18	19	20
Variable Kv.P.:	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens				10 Ma.S.					8 Ma.S.				
Using grid (5–1 ratio)						30 Ma.S.			24 Ma.S.				

(Basic Ma.S. 200)

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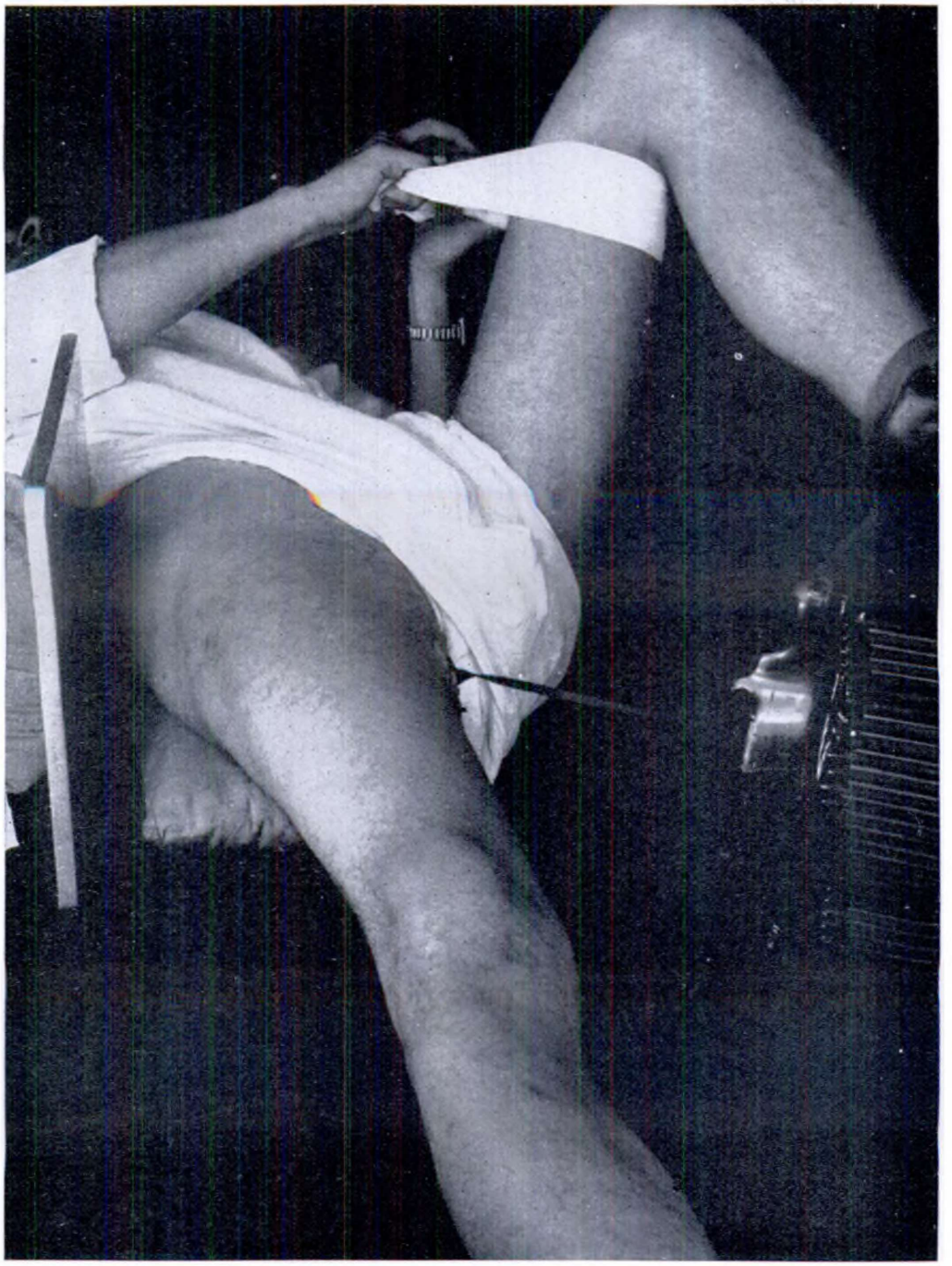


FIGURE 63A.—Hip (for lateral, head of femur).

Positioning instructions

Film: 10 x 12, lengthwise; cassette.

Position: Patient supine; greater trochanter to center, lower half of film (sandbag under buttocks); sandbag supporting cassette—parallel to approximate plane of neck of femur.

Focal spot: Aline to center of film.

Precautions: Opposite leg flexed and raised for clearance of primary beam.

Additional: Wafer grid; cone or diaphragm advisable.

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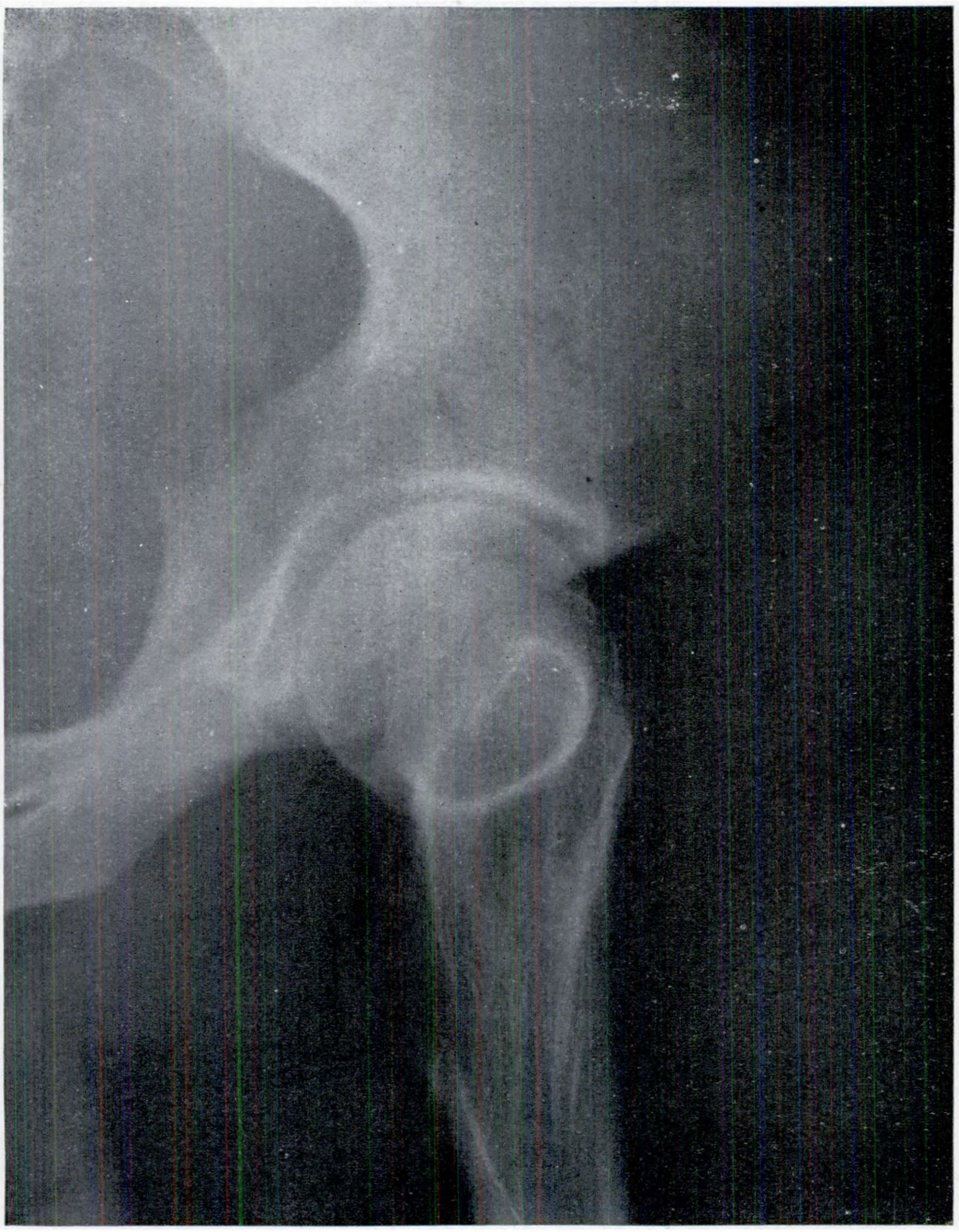


FIGURE 63B.—Hip (for lateral head of femur).

Technical factors

Distance: 30″. Cone: (or diaphragm); advisable—(compensate Ma.S.). (Measure across plane of trochanter.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	50 Ma.S.		40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.		120 Ma.S.					100 Ma.S.					85 Ma.S.				

(Basic Ma.S. 700)

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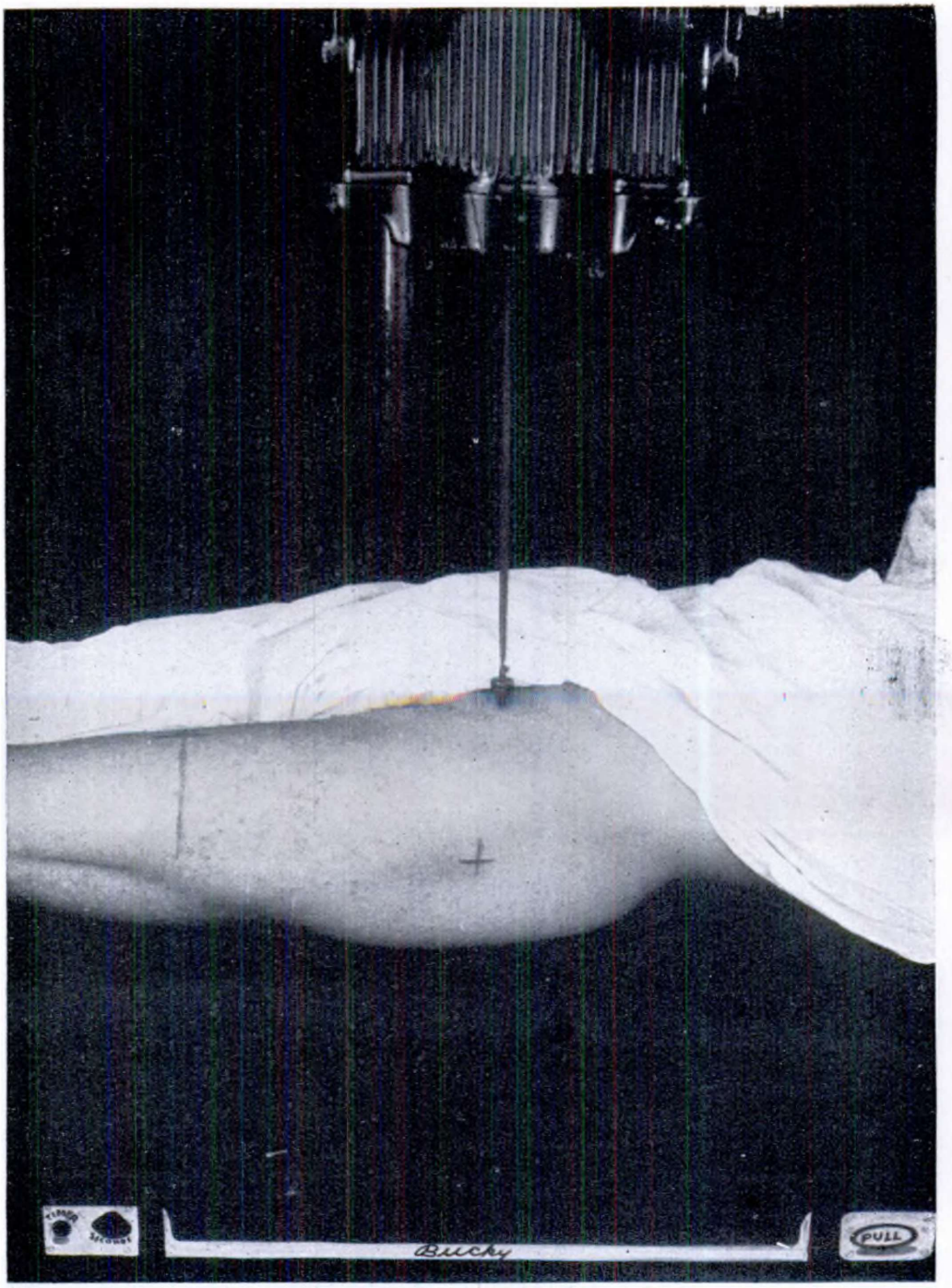


FIGURE 64A.—Hip, A. P.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient supine; greater trochanter to center, outer half of film.
Focal spot: Aline to center of film.
Precautions: Toes up (feet tied together).
Additional: Sandbag over lower third of thigh; grid, cone, or diaphragm advisable.

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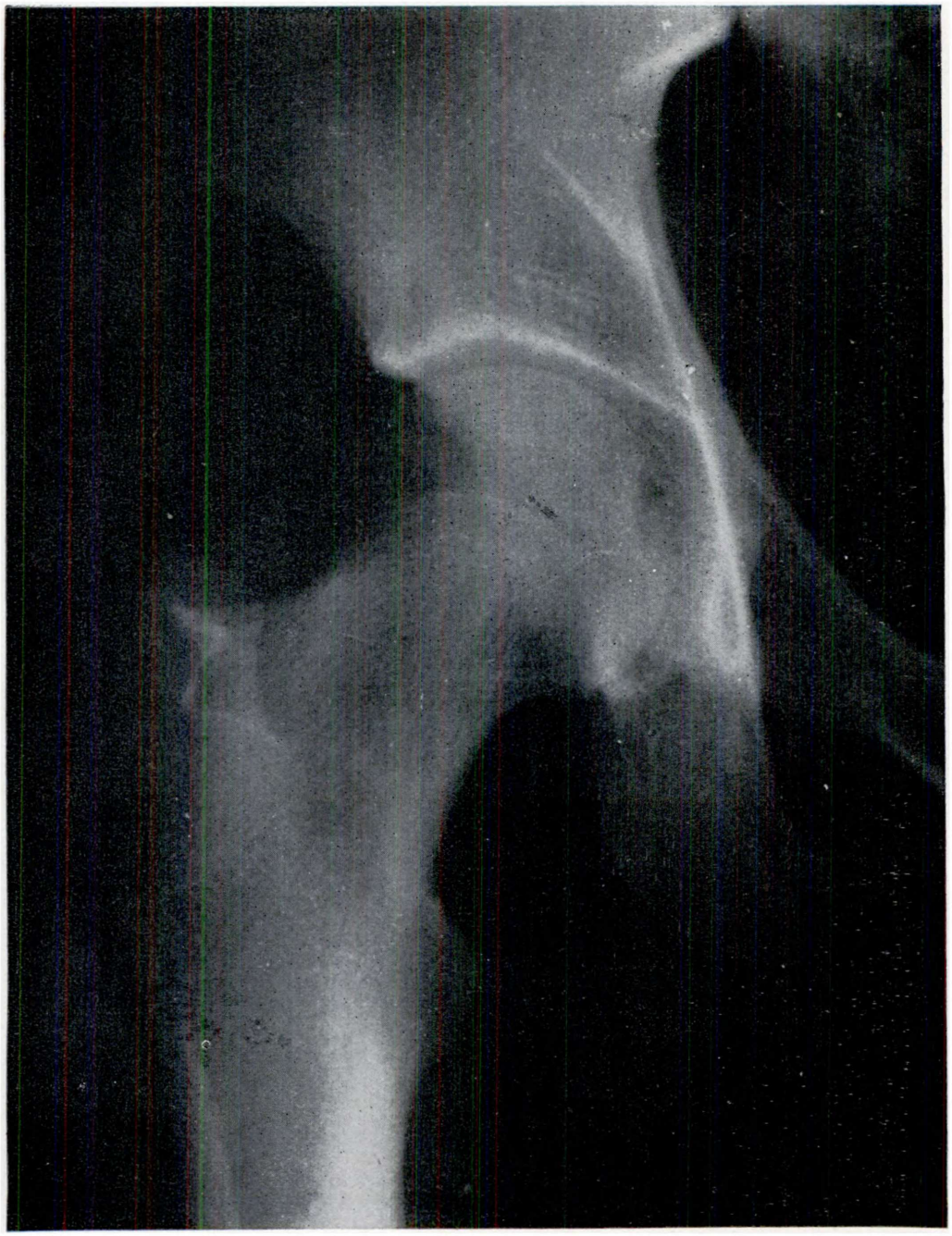


FIGURE 64B.—Hip, A. P.

Technical factors

Distance: 30". Cone: (or diaphragm): Advisable—(compensate Ma.S.). (Measure across plane of trochanter.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium Speed screens	50 Ma.S.		40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.		120 Ma.S.					100 Ma.S.					85 Ma.S.				

(Basic Ma.S. 700)

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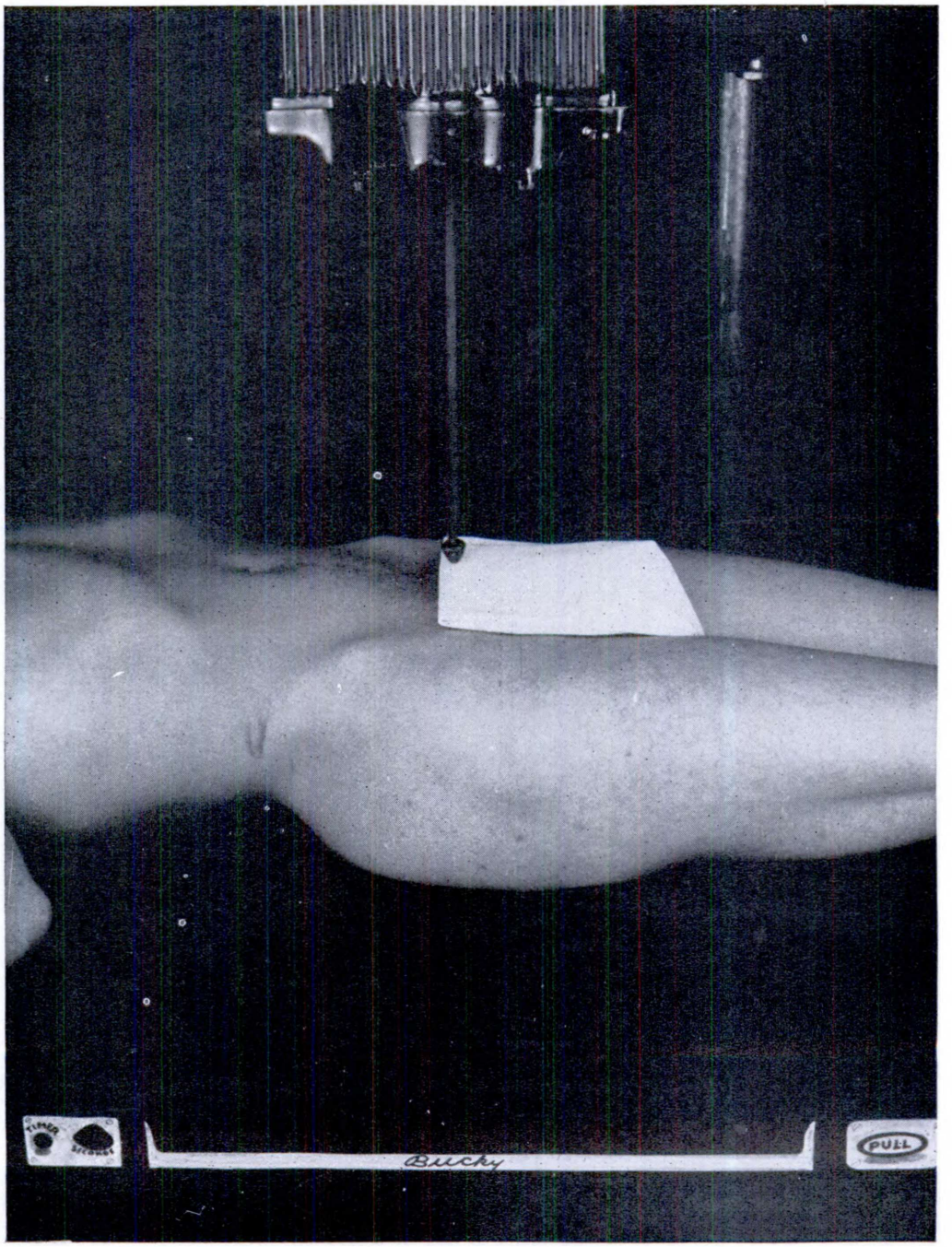


FIGURE 65A.—Pelvis, A. P

Positioning instructions

Film: 14 x 17, widthwise; cassette.
Position: Patient supine; level of iliac crests 5 cms. below upper border of film.
Focal spot: Aline to center of film.
Precautions: Straighten patient to midwidth of film; toes up; feet tied.
Additional: Grid; fixation band.

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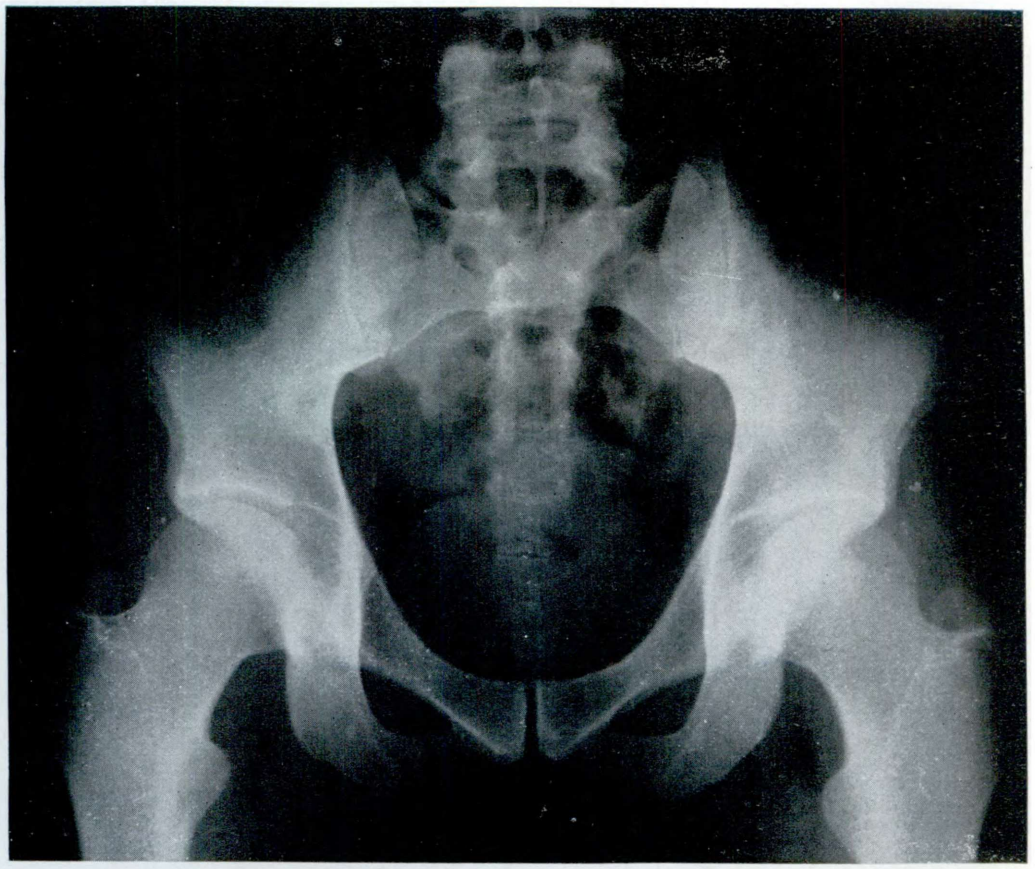


FIGURE 65B.—Pelvis, A. P.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.) (Measure plane through 2d lumbar, A. P.)																				
Cms. thickness:	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	50 Ma.S.					40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.					120 Ma.S.					100 Ma.S.					85 Ma.S.				

(Basic Ma.S. 700)

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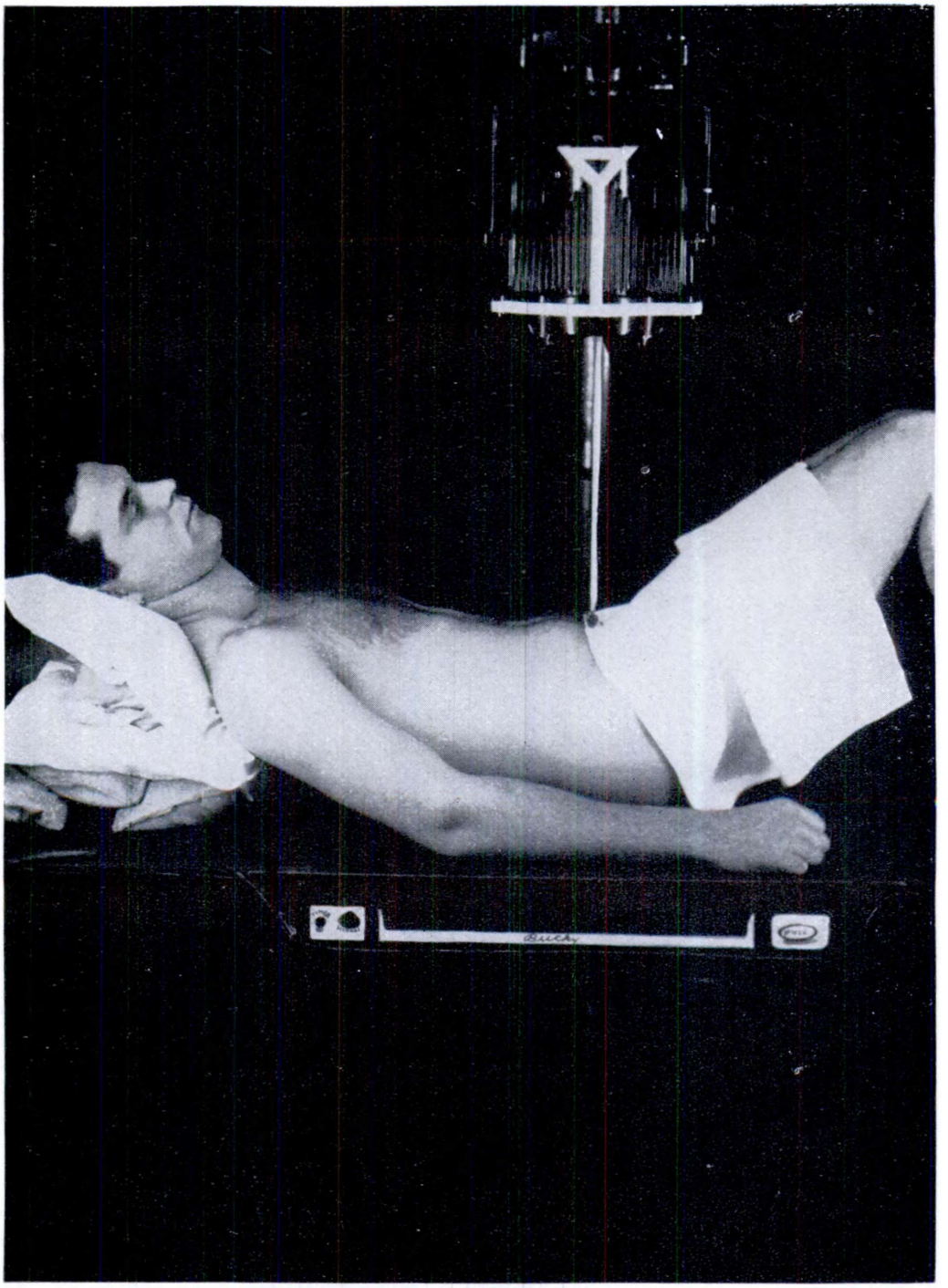


FIGURE 66A.—Spine, lumbo-sacral, A. P.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient supine; crest of ilia to midlength of film.
Focal spot: Aline to center of film.
Precautions: Straighten patient to midwidth of table; flatten lordotic curvature (head on pillow, knees raised and flexed); shallow breathing.
Additional: Grid; fixation band.

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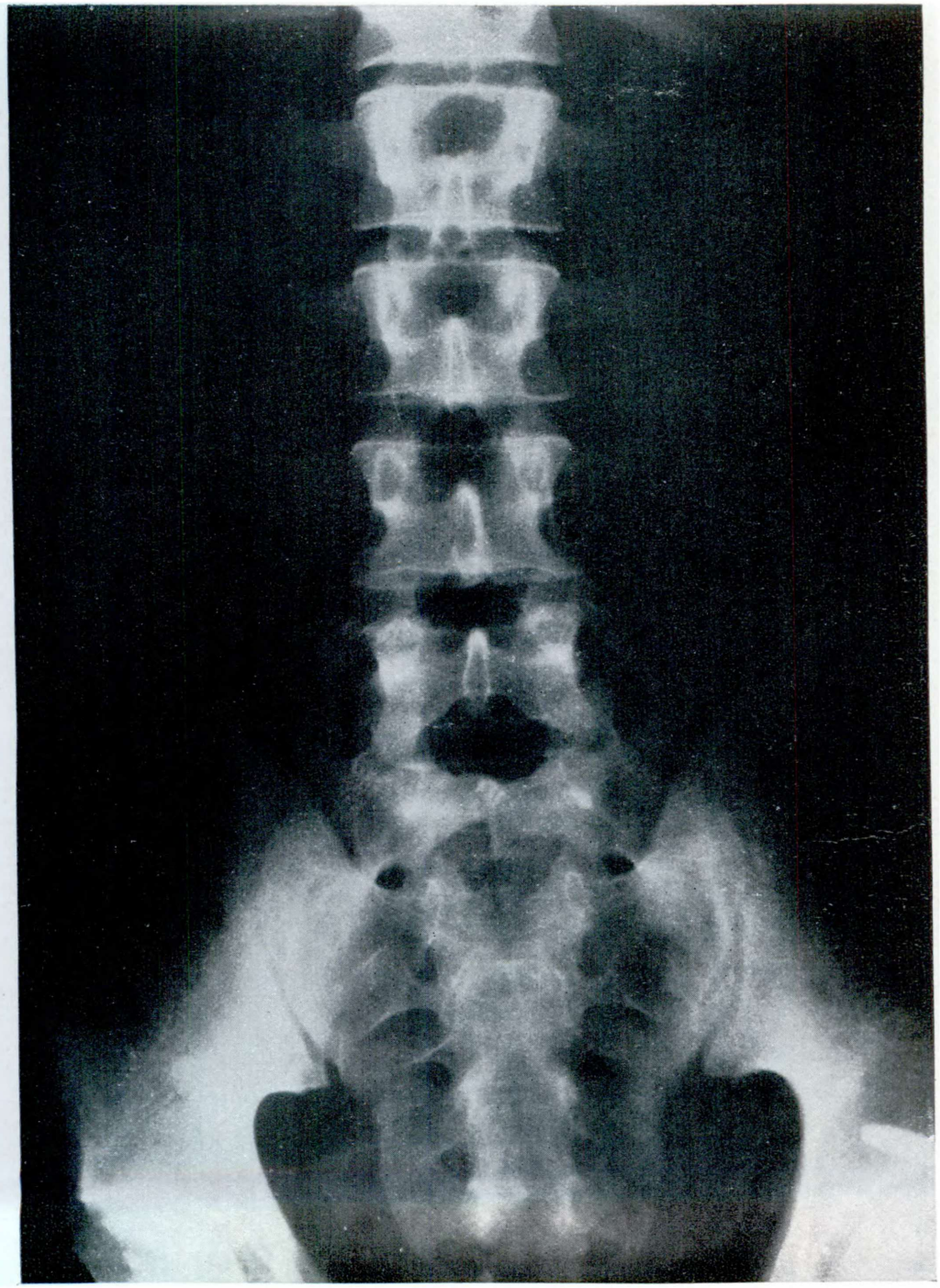


FIGURE 66B.—Spine, lumbo-sacral, A. P.

Technical factors

Distance: 30". Cone: Optional (compensate Ma.S.). (Measure plane through 2d lumbar, A. P.)

Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens	110 Ma.S.		85 Ma.S.					70 Ma.S.					60 Ma.S.			
Using grid (5–1 ratio)	330 Ma.S.		255 Ma.S.					210 Ma.S.					180 Ma.S.			

(Basic Ma.S. 1500)

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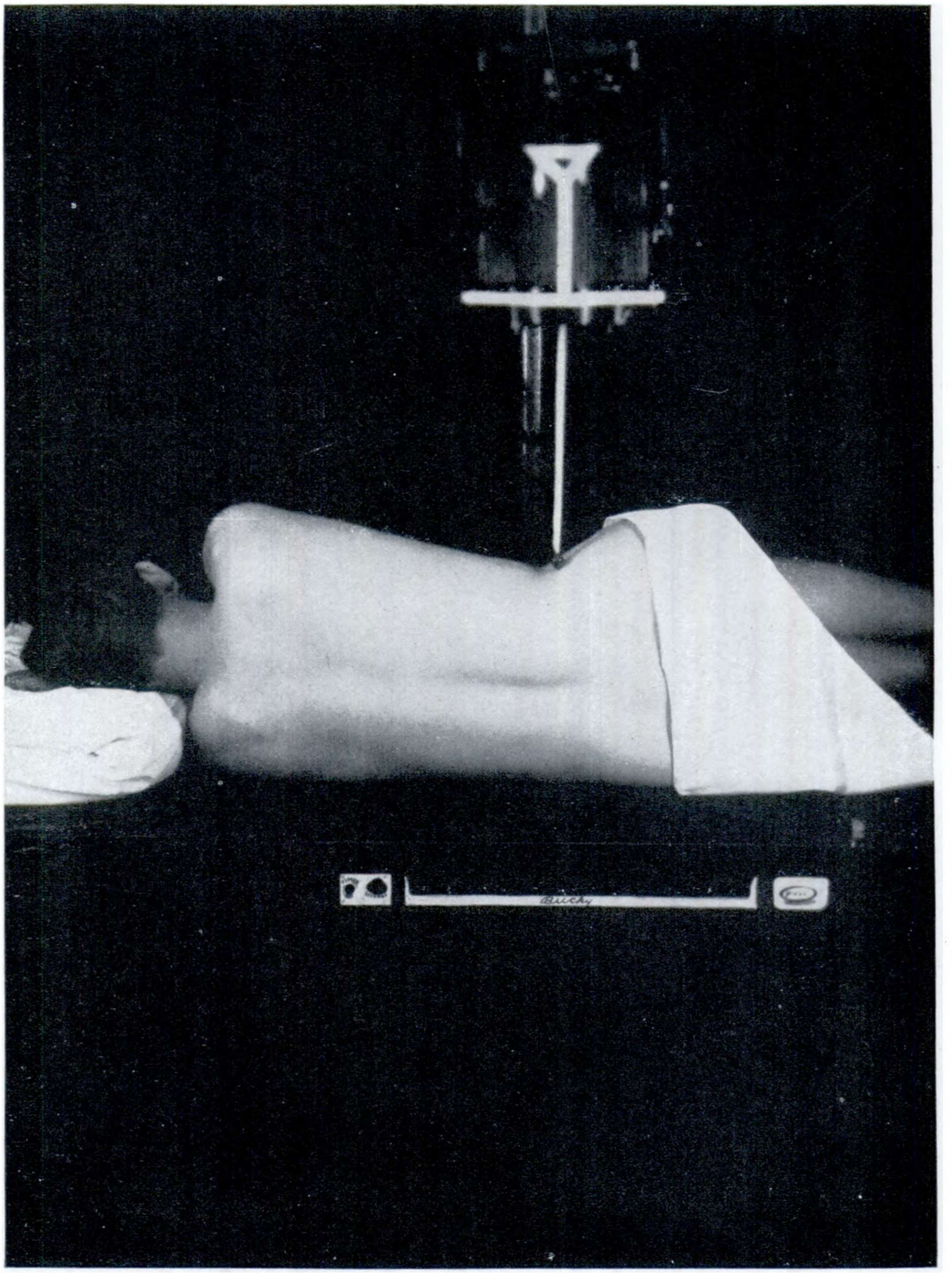


FIGURE 67A.—Spine, lumbo-sacral, lateral.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient on side; iliac crest to midlength of film; plane of back 5 cms. posterior to midwidth of film.
Focal spot: Aline to center of film.
Precautions: Plane of back perpendicular to film; knees forward and flexed; arms extended and flexed.
Additional: Grid; fixation band.

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FIGURE 67B.—Spine, lumbo-sacral, lateral.

Technical factors

Distance : 30″.	Cone : Optional (compensate Ma.S.). (Measure plane through iliac crests.)														
Cms. thickness :	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Variable Kv.P. :	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	160 Ma.S.					130 Ma.S.					110 Ma.S.				
Using grid (5–1 ratio)	480 Ma.S.					390 Ma.S.					330 Ma.S.				

(Basic Ma.S. 2800)

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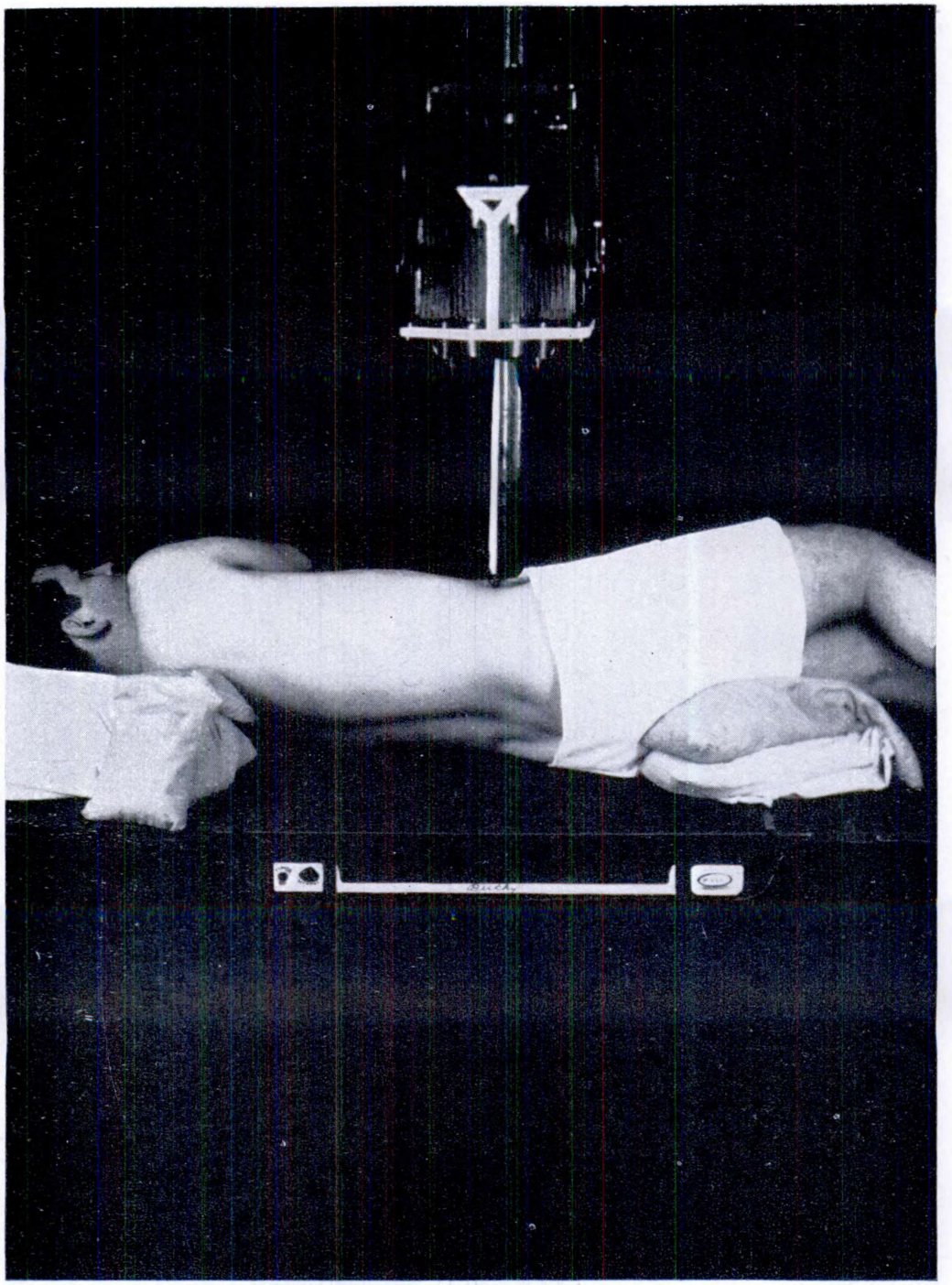


FIGURE 68A.—Spine, lumbo-sacral, oblique.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient supine but rotated 30° to side for study; crest of ilium to midlength of film.
Focal spot: Aline to center of film.
Precautions: Straighten patient to midwidth of table; knees forward and flexed; head raised; sandbags under shoulder and upper thigh.
Additional: Grid; fixation band.

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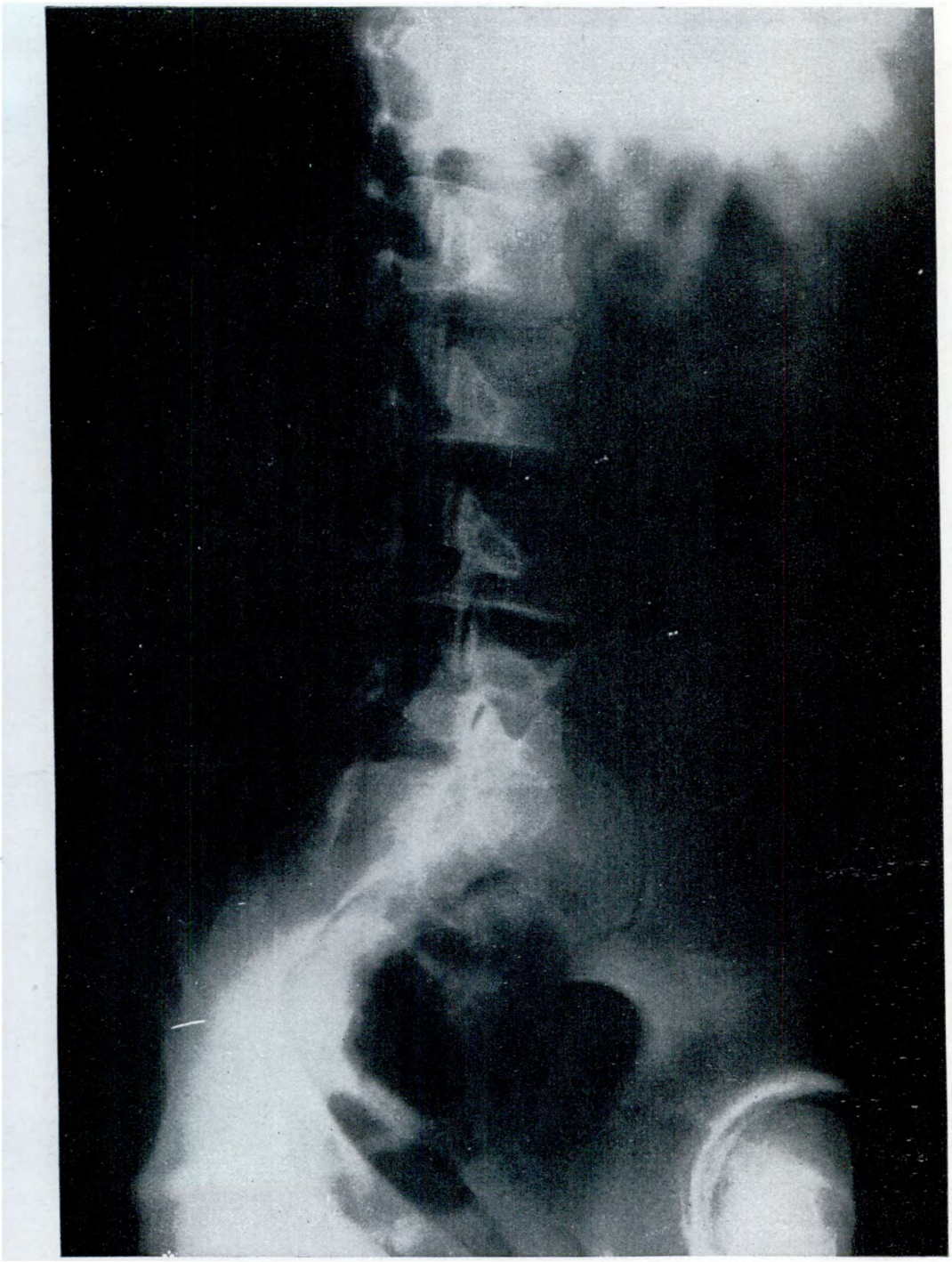


FIGURE 68B.—Spine, lumbo-sacral, oblique.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through level of iliac crests, obliquely.)

Cms. thickness:	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Variable Kv.P.:	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
With medium Speed screens	160 Ma.S.				130 Ma.S.					110 Ma.S.					
Using grid (5–1 ratio)	480 Ma.S.				390 Ma.S. (Basic Ma.S. 2800)					330 Ma.S.					

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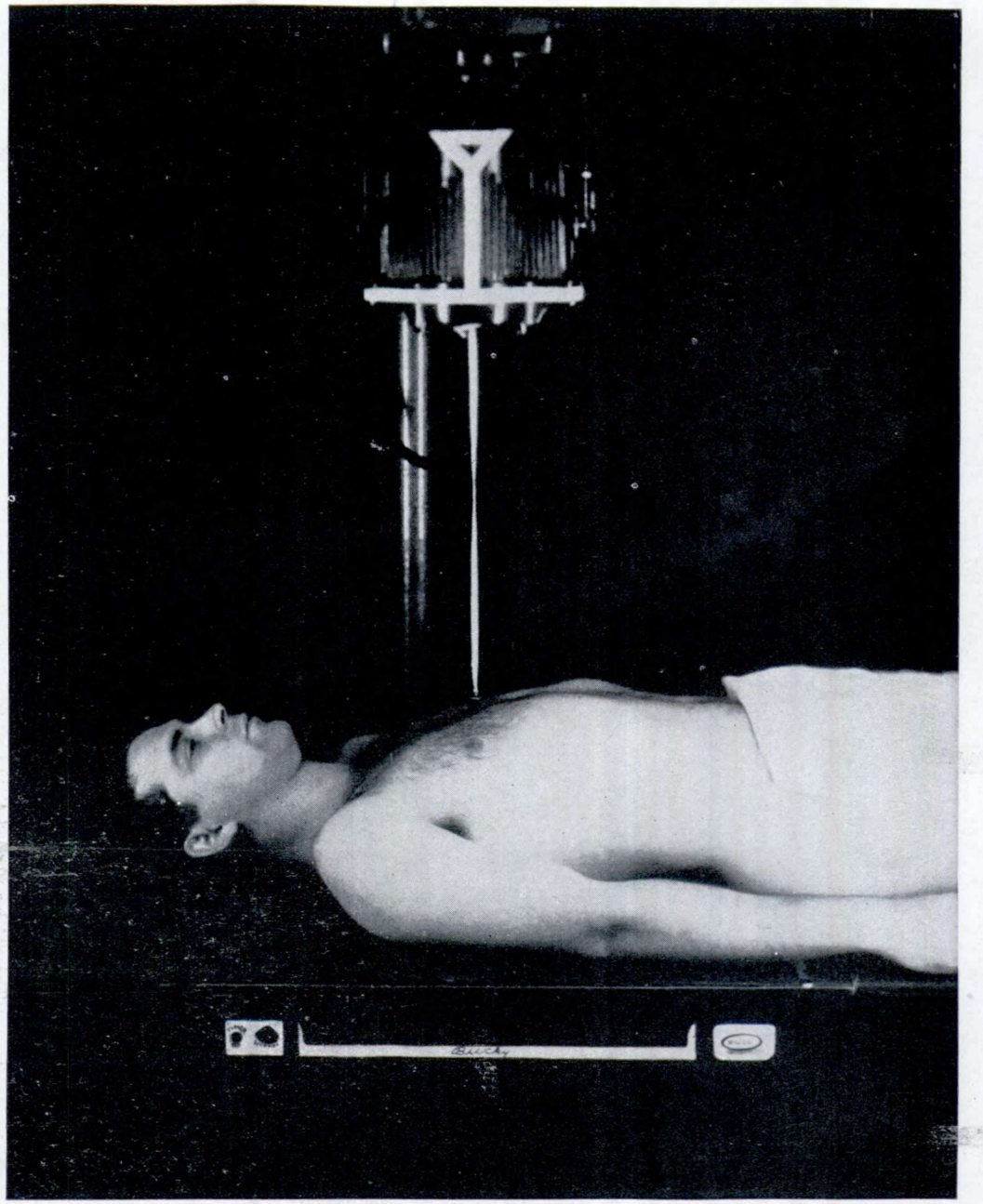


FIGURE 69A.—Spine, thoracic, A. P.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient supine; level of acromial processes 7 cms. below upper border of film.
Focal spot: Aline to center of film.
Precautions: Straighten patient to midwidth of table; shallow breathing.
Additional: Grid; fixation band.

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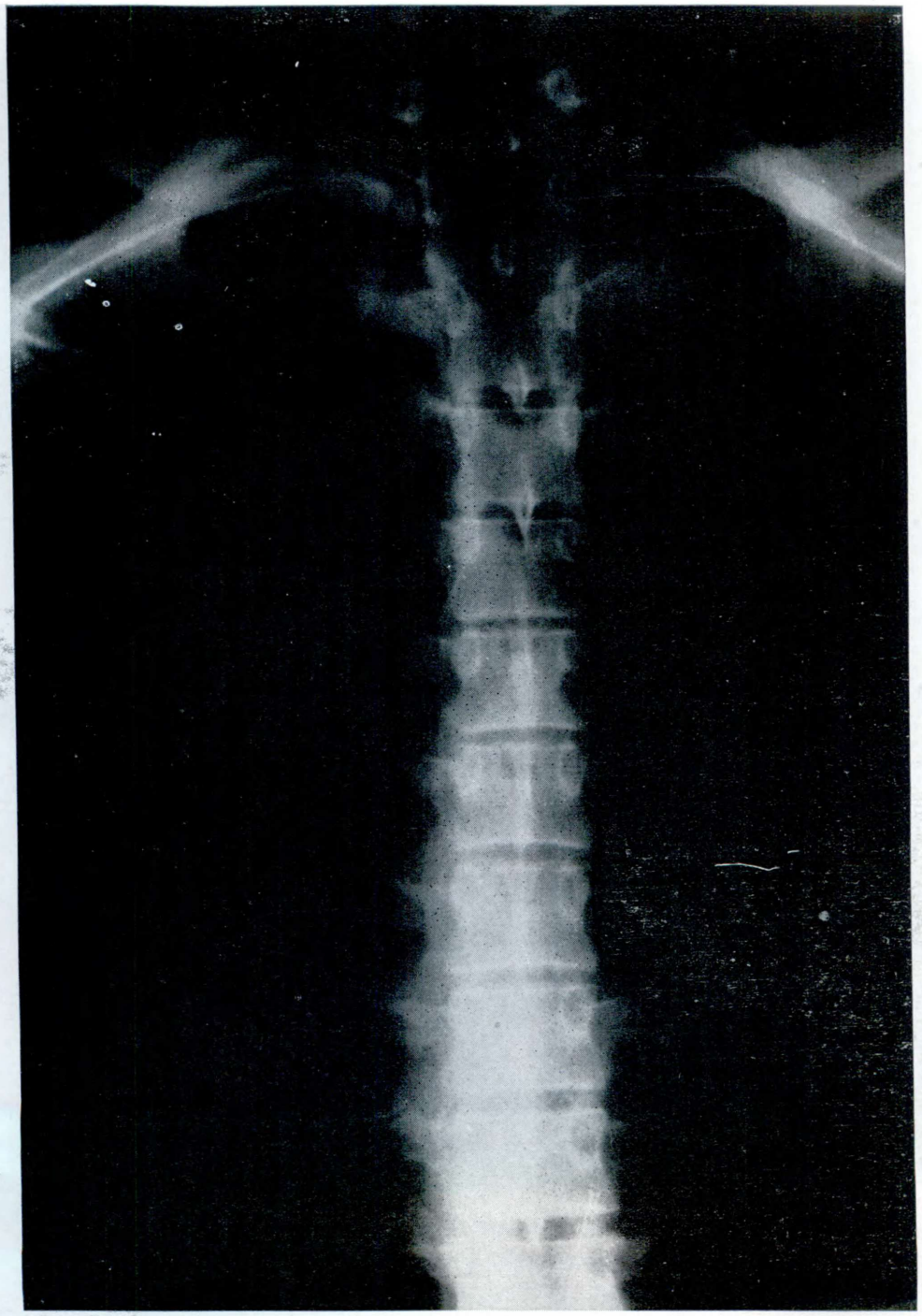


FIGURE 69B.—Spine, thoracic, A. P.

Technical factors

Distance: 30″.	**Cone: Optional (compensate Ma.S.). (Measure plane through manubrium.)**																			
Cms. thickness:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	50 Ma.S.					40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.					120 Ma.S. (Basic Ma.S. 700)					100 Ma.S.					85 Ma. S.				

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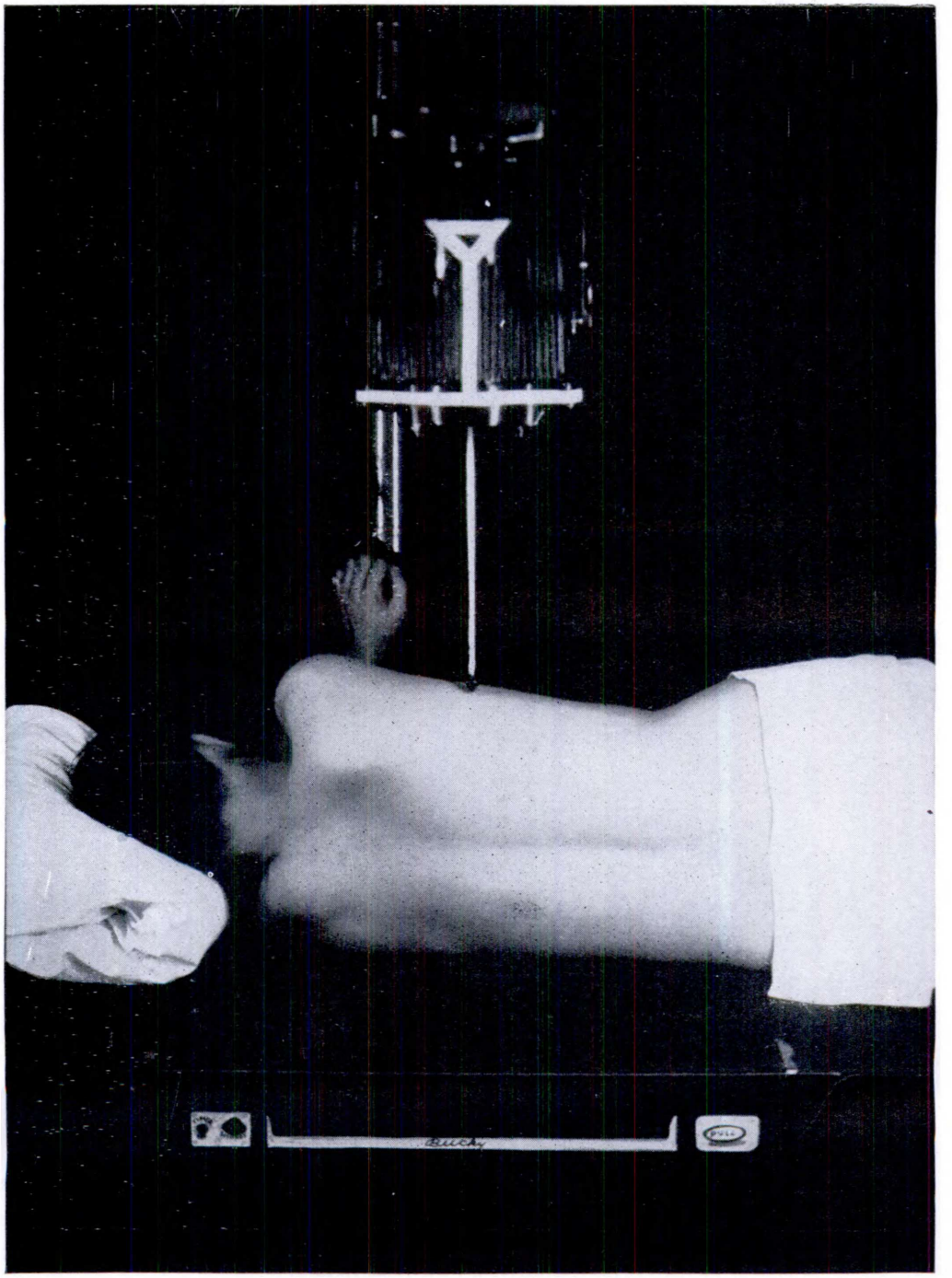


FIGURE 70A.—Spine, thoracic, lateral.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient on side; acromial processes 7 cms. below upper border of film; plane of back 5 cms. posterior to midwith of film.
Focal spot: Aline to center of film.
Precautions: Arms extended forward; knees forward and flexed; plane of back perpendicular to film; shallow breathing.
Additional: Grid; fixation band.

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FIGURE 70B.—Spine, thoracic, lateral.

Technical factors

Distance: 30″. Cone: optional (compensate Ma.S.). (Measure plane through 6th thoracic vertebra, laterally.)

Cms. thickness:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	50 Ma.S.					40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.					120 Ma.S. (Basic Ma.S. 700)					100 Ma.S.					85 Ma.S.				

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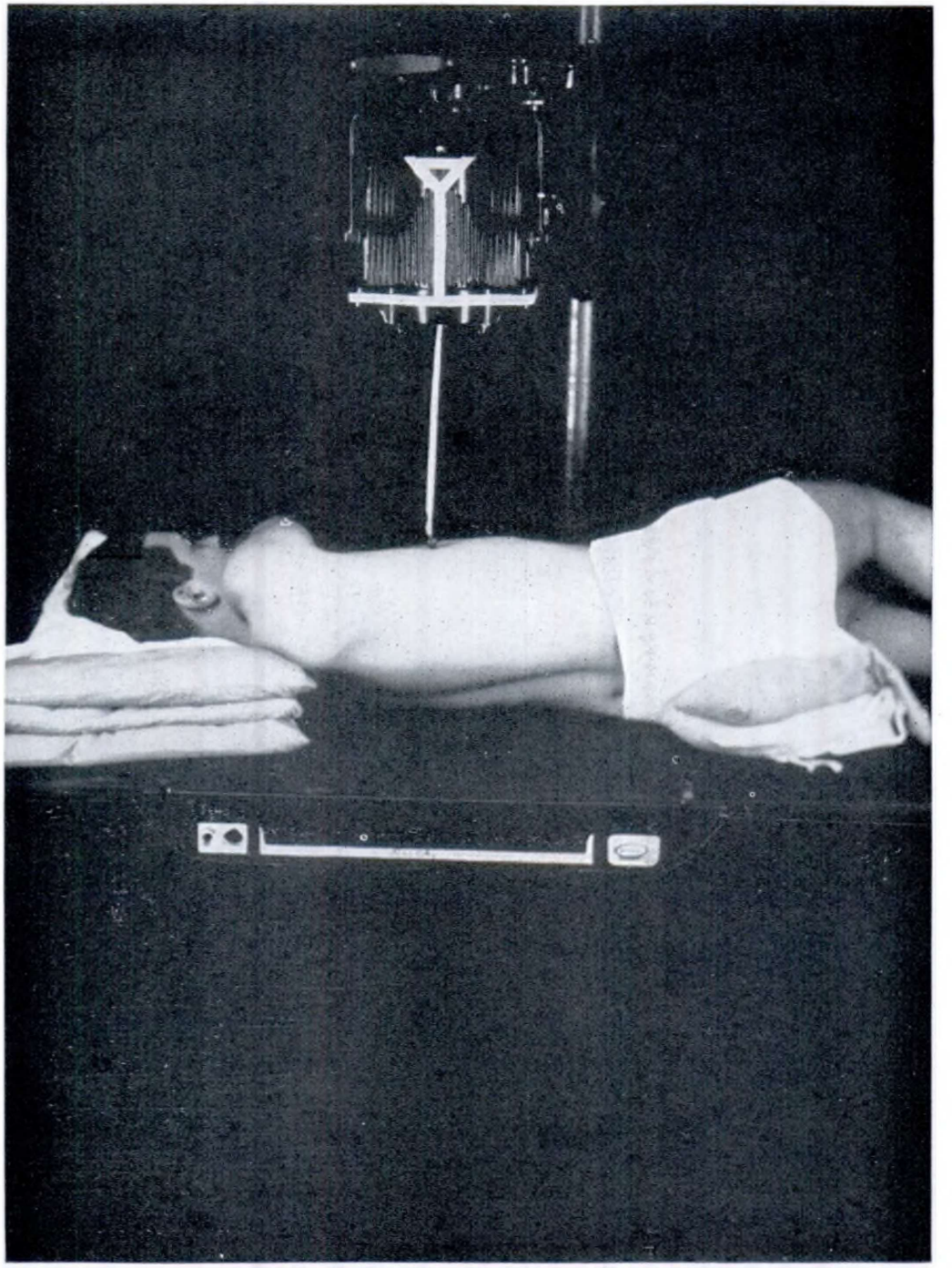


FIGURE 71A.—Spine, thoracic, oblique.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient supine but rotated 30° to side for study; level of acromion 7 cms. below upper border of film.
Focal spot: Aline to center of film.
Precautions: Straighten patient to midwidth of table; arms extended; sandbag supporting shoulder and hip; knees forward and flexed.
Additional: Grid; fixation band.

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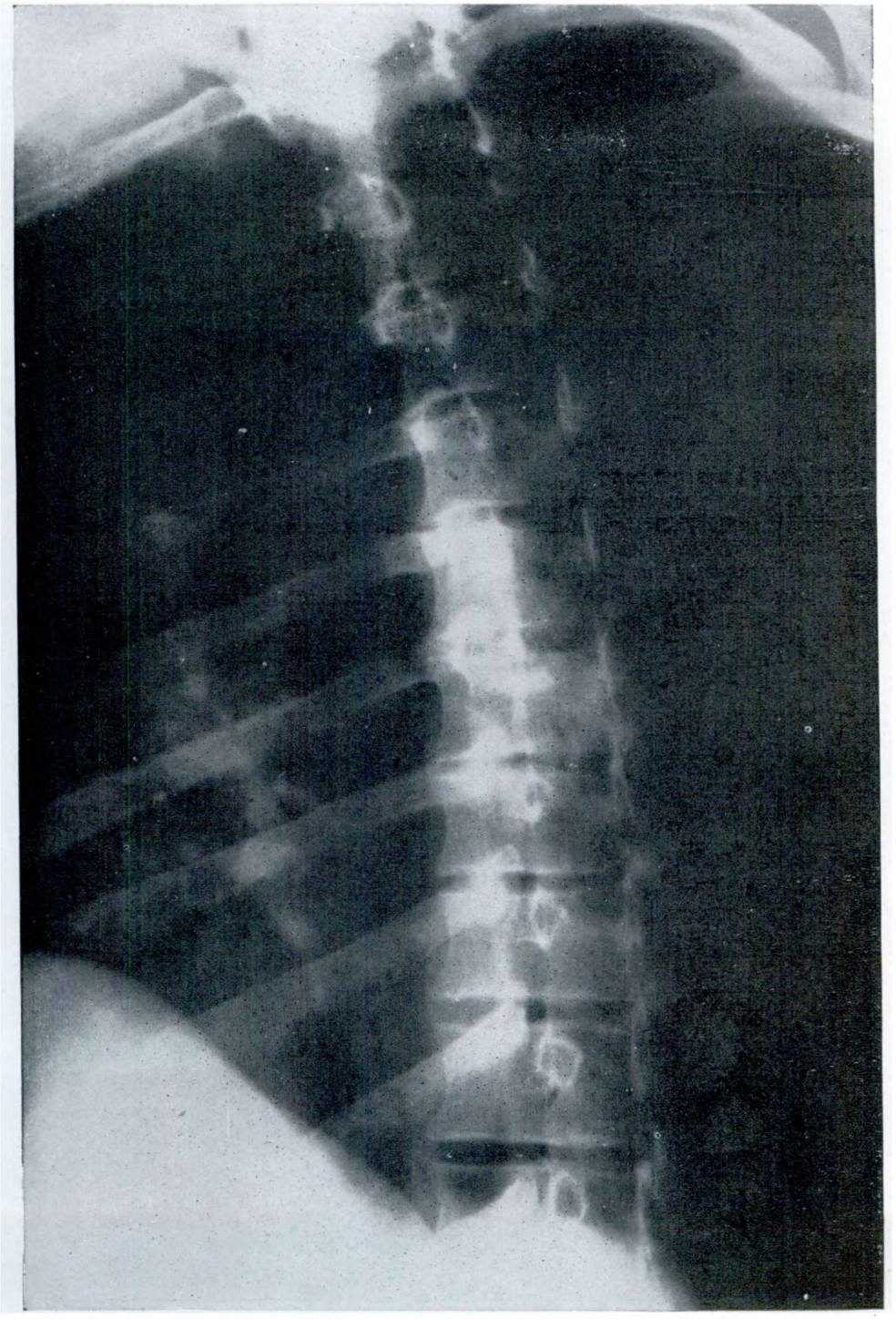


FIGURE 71B.—Spine, thoracic, oblique.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through 6th thoracic vertebra, obliquely.)

Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	50 Ma.S.					40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.					120 Ma.S. (Basic Ma.S. 700)					100 Ma.S.					85 Ma.S.				

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FIGURE 72A.—Spine, cervical, A. P.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient supine; level, upper border of thyroid cartilage to midlength of film.
Focal spot: Aline to center of film.
Precautions: Plane along lower border of mandible to occiput perpendicular to film (head slightly extended).
Additional: Grid; fixation band across chin.

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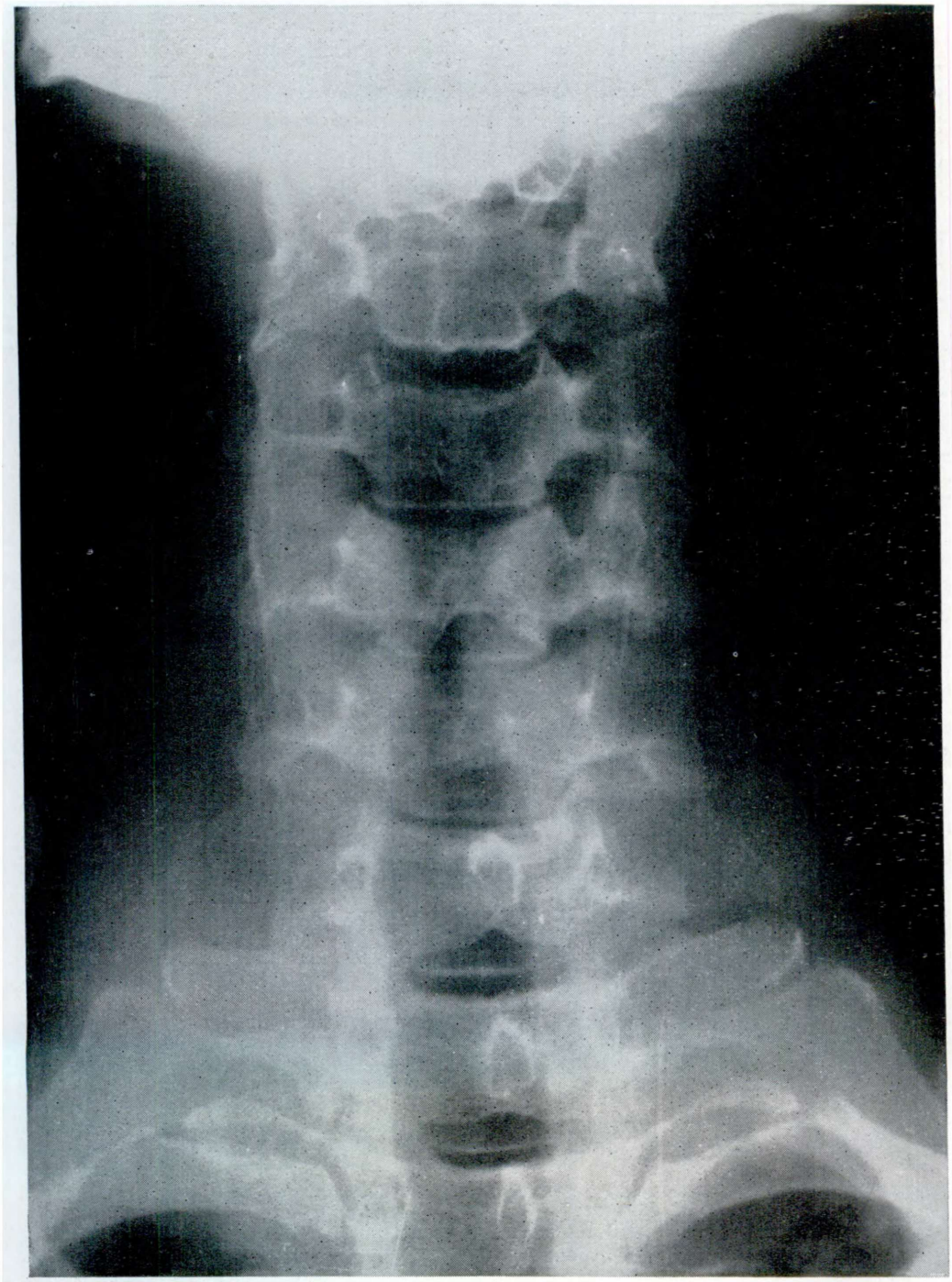


FIGURE 72B.—Spine, cervical, A. P.

Technical factors

Distance: 30″.	Cone: Optional		(compensate Ma.S.).			(Measure plane at level of larynx.)				
Cms. thickness:	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88
With medium speed screens								7 Ma.S.		
Using grid (5–1 ratio)									21 Ma.S.	

(Basic Ma.S. 175)

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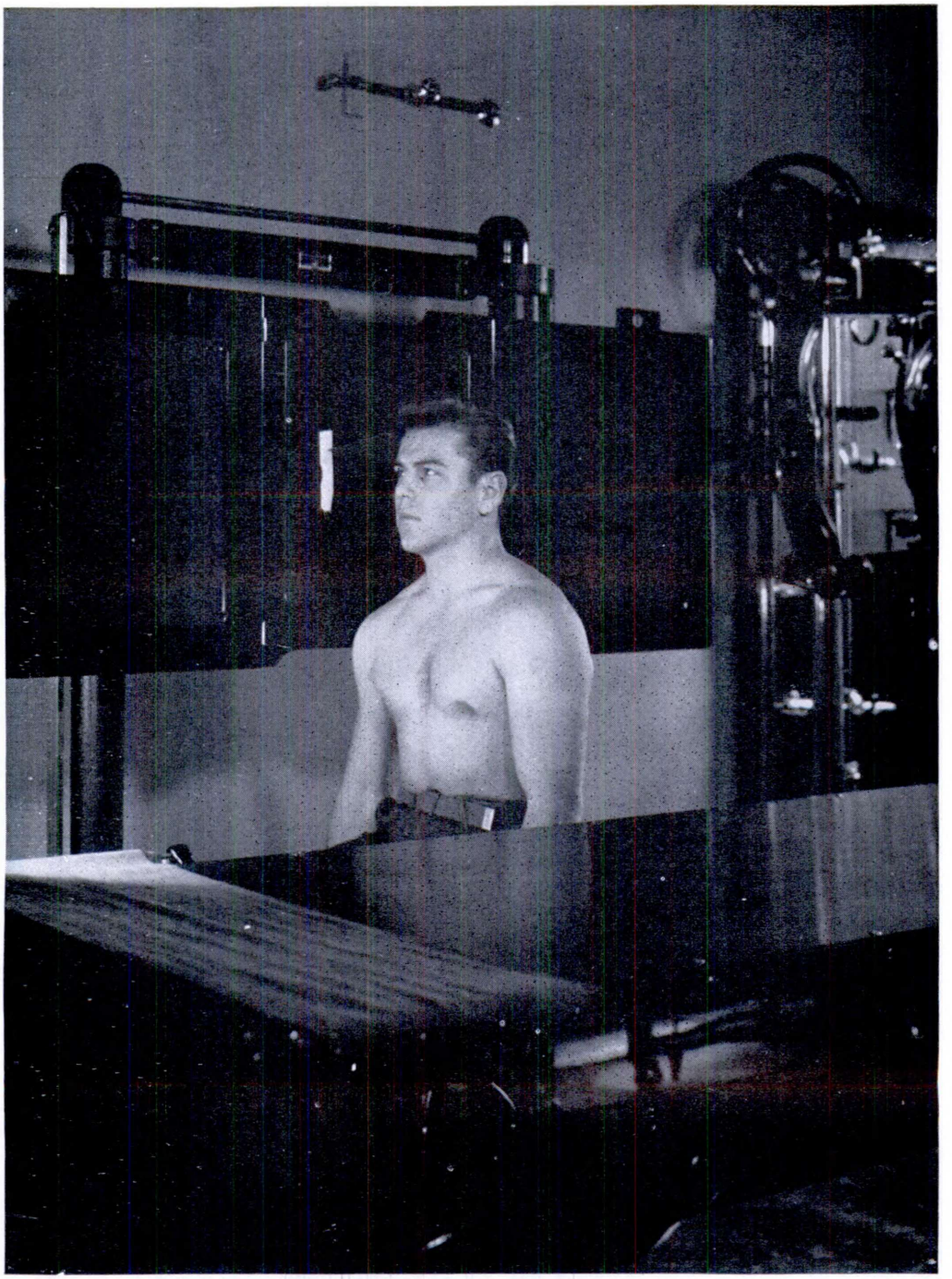


FIGURE 73A.—Spine, cervical, lateral.

Positioning instructions

Film : 10 x 12, lengthwise ; cassette.
Position : Patient sitting ; level, upper border of thyroid cartilage to midlength of film.
Focal spot : Aline to point, midwidth and at level of eyes.
Precautions : Head erect ; chin up ; vertical plane parallel to film ; shoulders drooped (sandbags in hands).
Additional : Cardboard head rest.

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FIGURE 73B.—Spine, cervical, lateral.

Technical factors

Distance: 72″. Cone: Advisable (compensate Ma.S.). (Measure plane through thyroid cartilage, laterally.)

Cms. thickness:	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88
With medium speed screens					28 Ma.S.					

(Basic Ma.S. 700)

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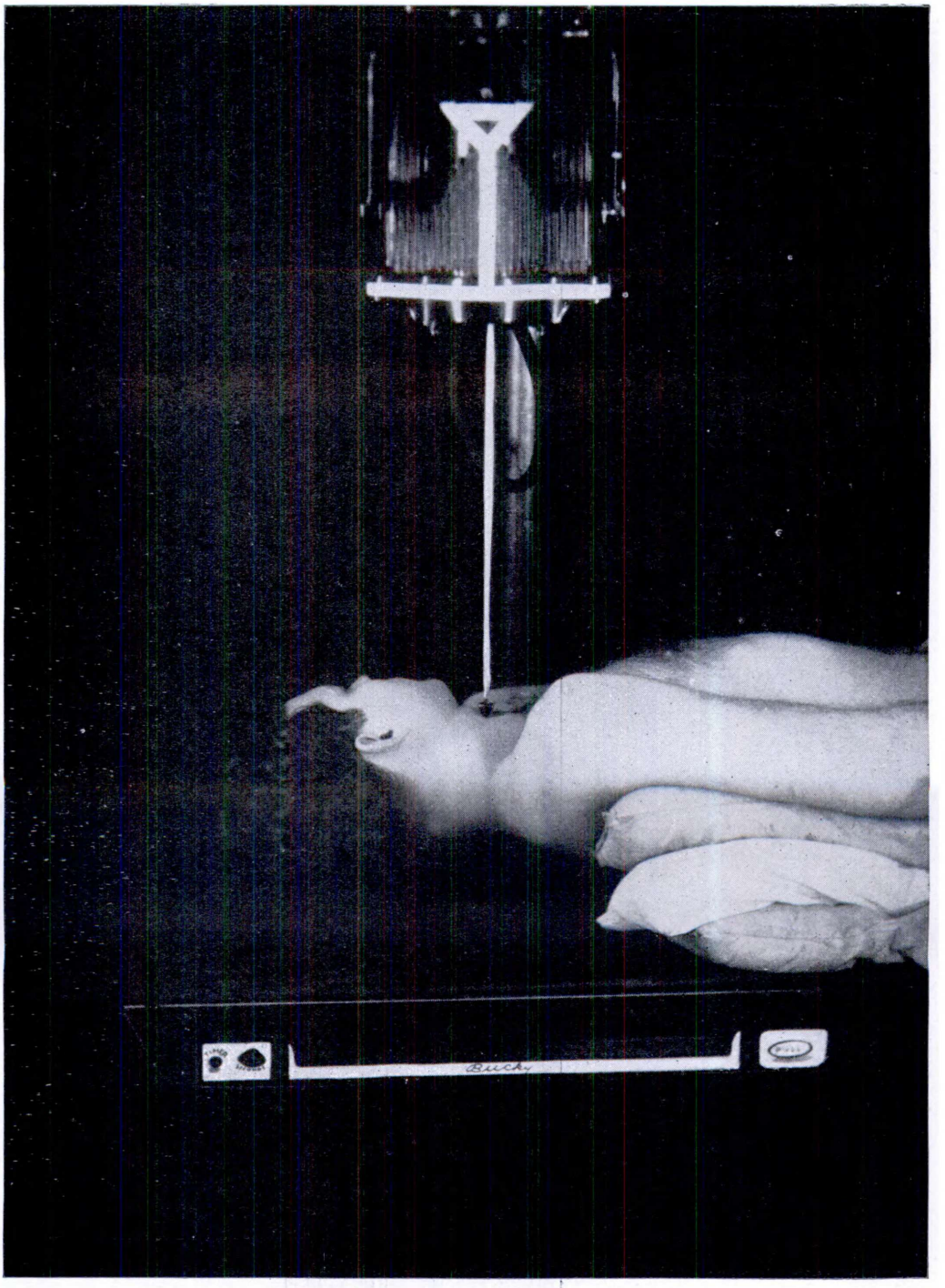


FIGURE 74A.—Spine, cervical, oblique.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient supine; but rotated 30° to side for study; level, upper border of thyroid cartilage to midlength of film.
Focal spot: Aline to point, level of upper border of thyroid cartilage and midwidth.
Precautions: Straighten patient to midwidth of table; head extended; sandbags under shoulder.
Additional: Grid; fixation band.

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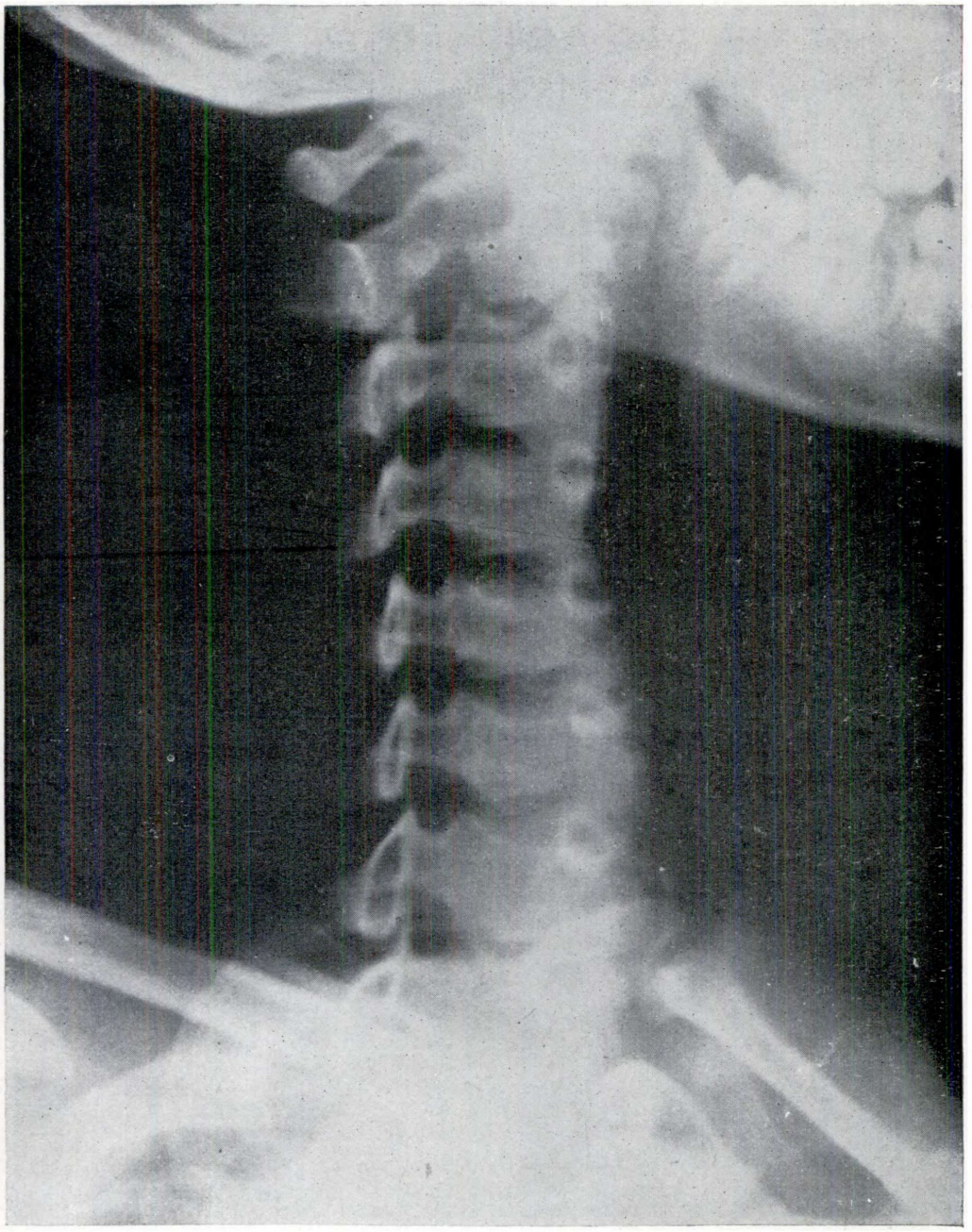


FIGURE 74B.—Spine, cervical, oblique.

Technical factors

Distance: 30″. Cone: upper border—thyroid cartilage.)	Advisable			(compensate Ma.S.).			(Measure plane through level			
Cms. thickness:	7	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88
With medium speed screens Using grid (5–1 ratio)							6 Ma.S.		18 Ma.S.	

(Basic Ma.S. 150)

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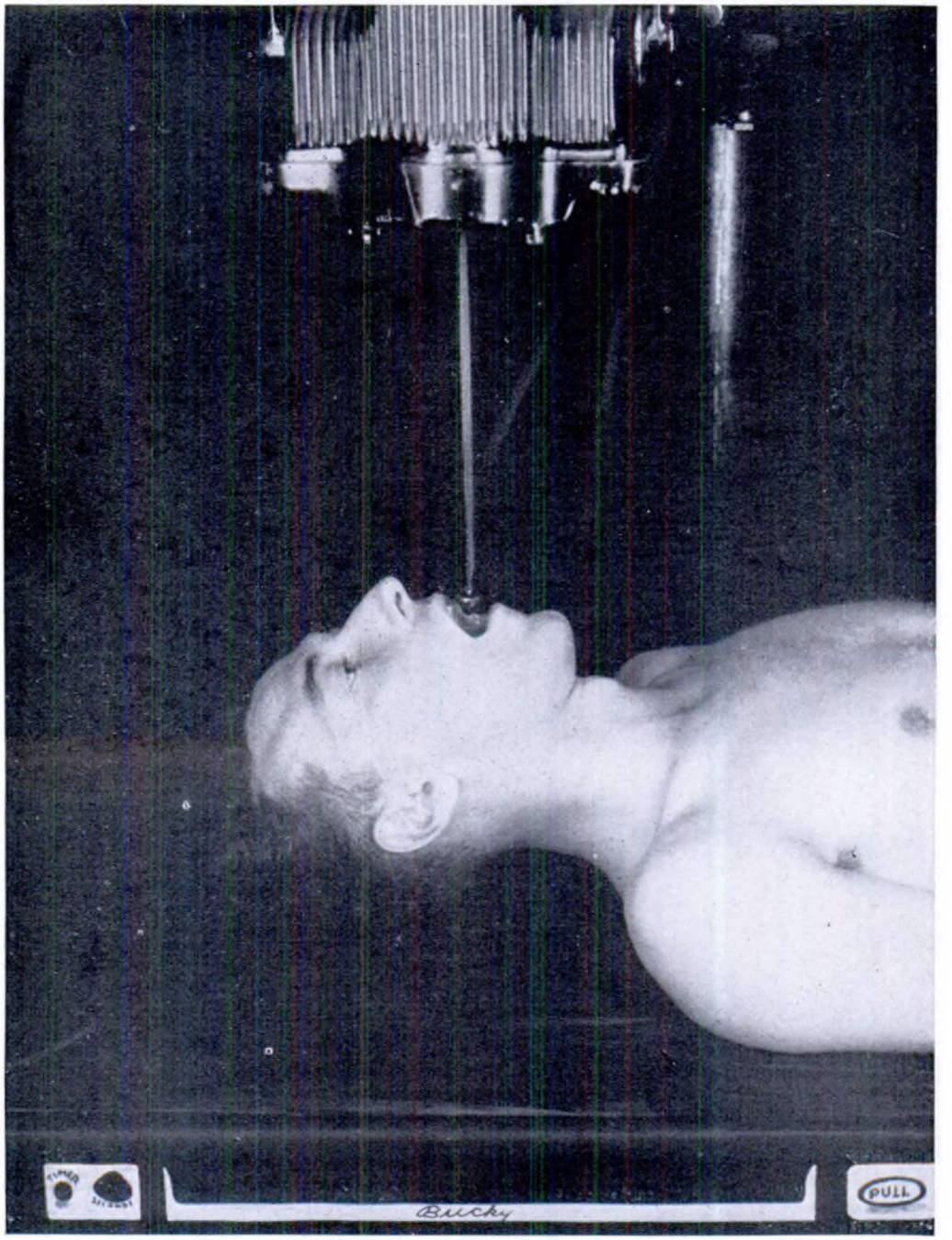


FIGURE 75A.—Spine, cervical, A. P. (for atlas and axis).

Positioning instructions

Film: 8 x 10, lengthwise; cassette.
Position: Patient supine; plane through tips of mastoid processes to midlength of film.
Focal spot: Aline to point, midwidth and 2 cms. below hard palate.
Precautions: Plane of hard palate perpendicular to film (head flexed anteriorly); cork in mouth.
Additional: Grid; fixation band.

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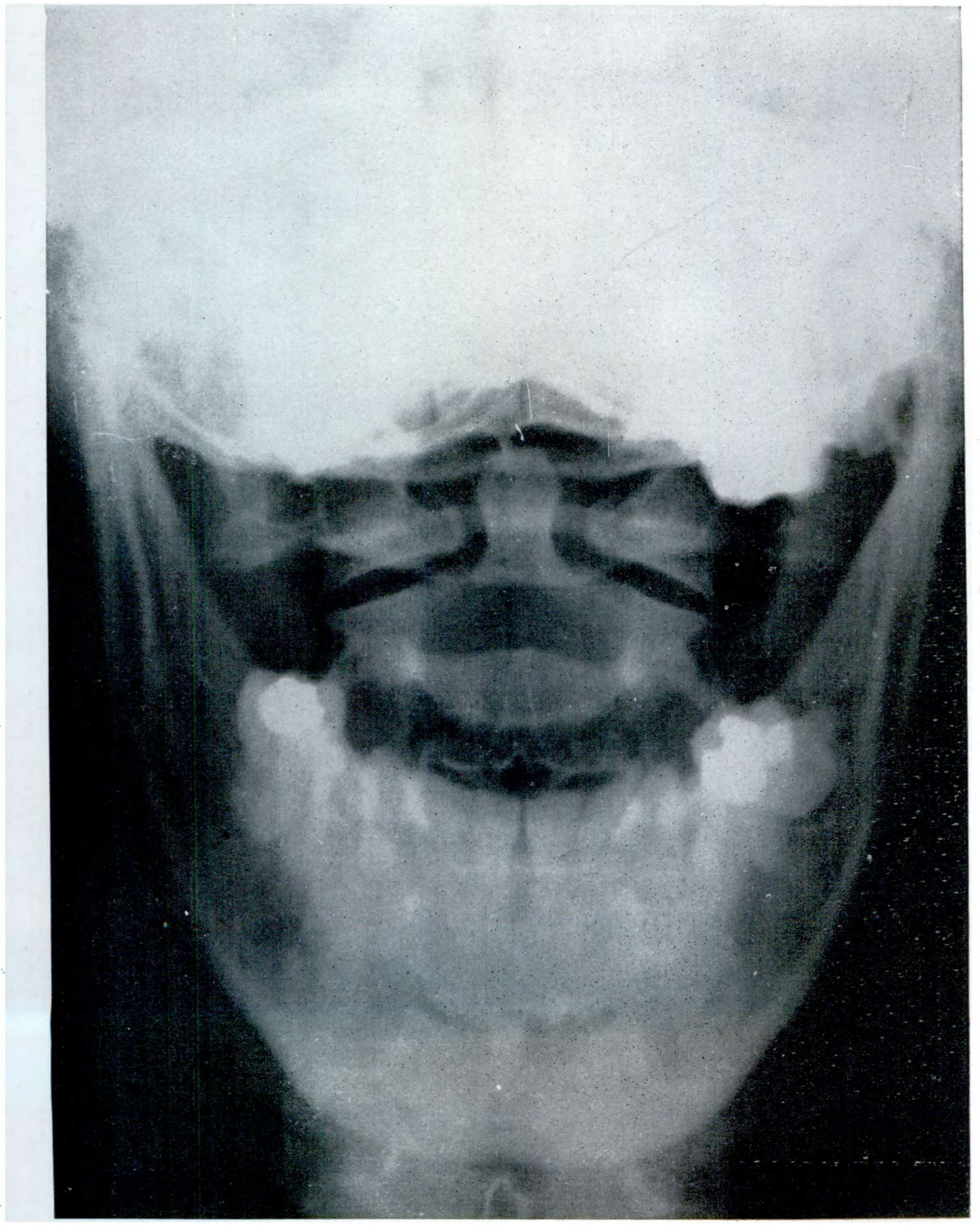


FIGURE 75B.—Spine, cervical, A. P. (for atlas and axis).

Technical factors

Distance: 30″. Cone: advisable (compensate Ma.S.). (Measure plane through occipital condyles and upper lip.)

Cms. thickness:	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
Variable Kv.P.:	72	74	76	78	80	82	84	86	88
With medium speed screens		6 Ma. S.				5 Ma.S.			
Using grid **(5–1 ratio)**		18 Ma.S.				15 Ma.S.			

(Basic Ma.S. 130)

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FIGURE 76A.—Lung fields, P. A.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.

Position: Patient standing to midwidth of film; acromial processes 7 cms. below upper border of cassette.

Focal spot: Aline to 6th thoracic vertebra.

Precautions: 1. Conventional: Rotate scapulae (elbows flexed and forward with knuckles on hips). 2. For apices: Elevate clavicles (arms raised, elbows above level of shoulders). Suspended inspiration; minimal exposure time—high Ma., large focal spot.

Additional: Fixation band; vertical cassette holder.

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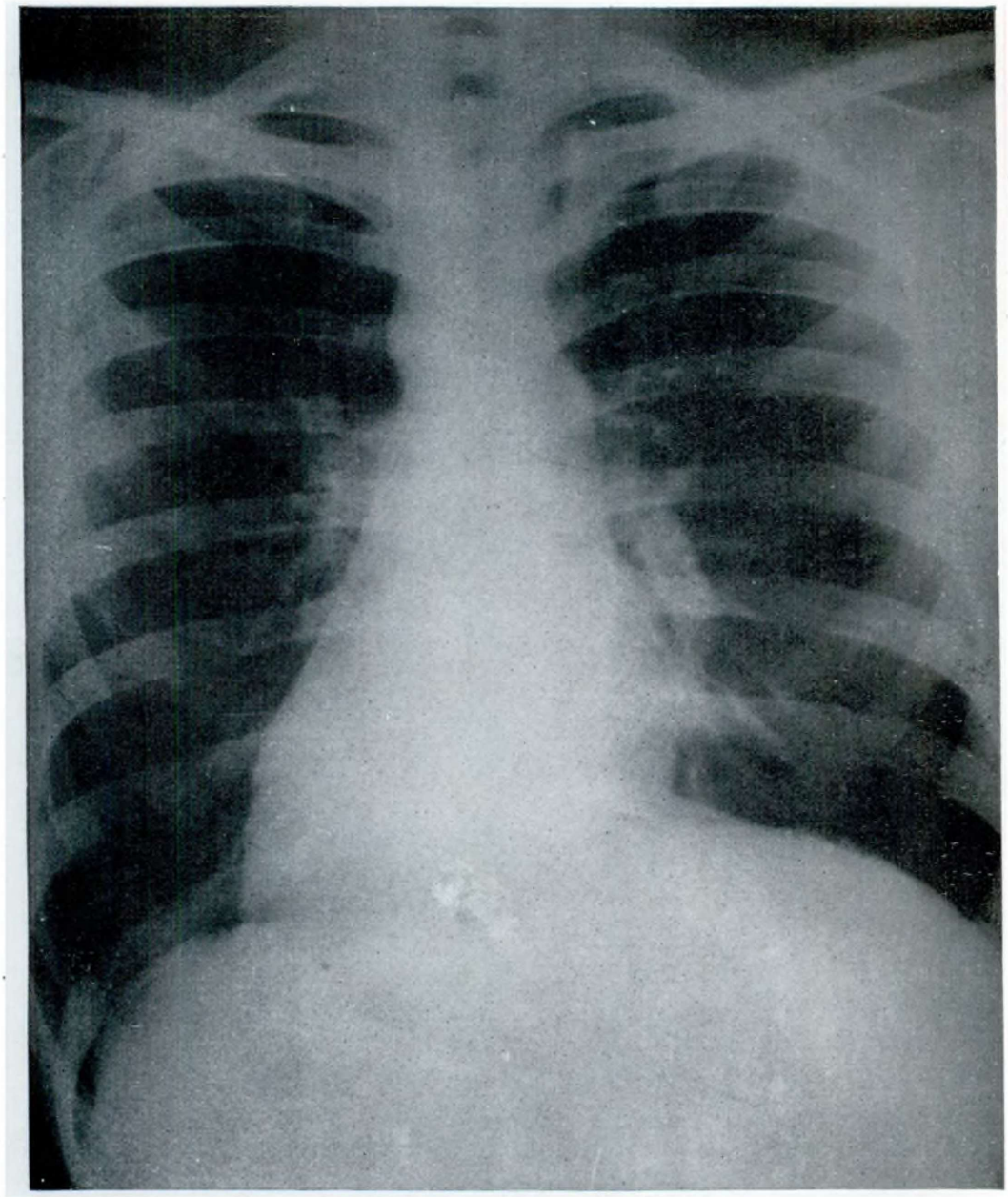


FIGURE 76B.—Lung fields, P. A.

Technical factors

Distance: 72".	Cone: No.				(Measure plane through 6th thoracic vertebra, antero-posteriorly.)															
Cms. thickness:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	24 Ma.S.				20 Ma.S. (Basic Ma.S. 350)					16 Ma.S.					14 Ma.S.					

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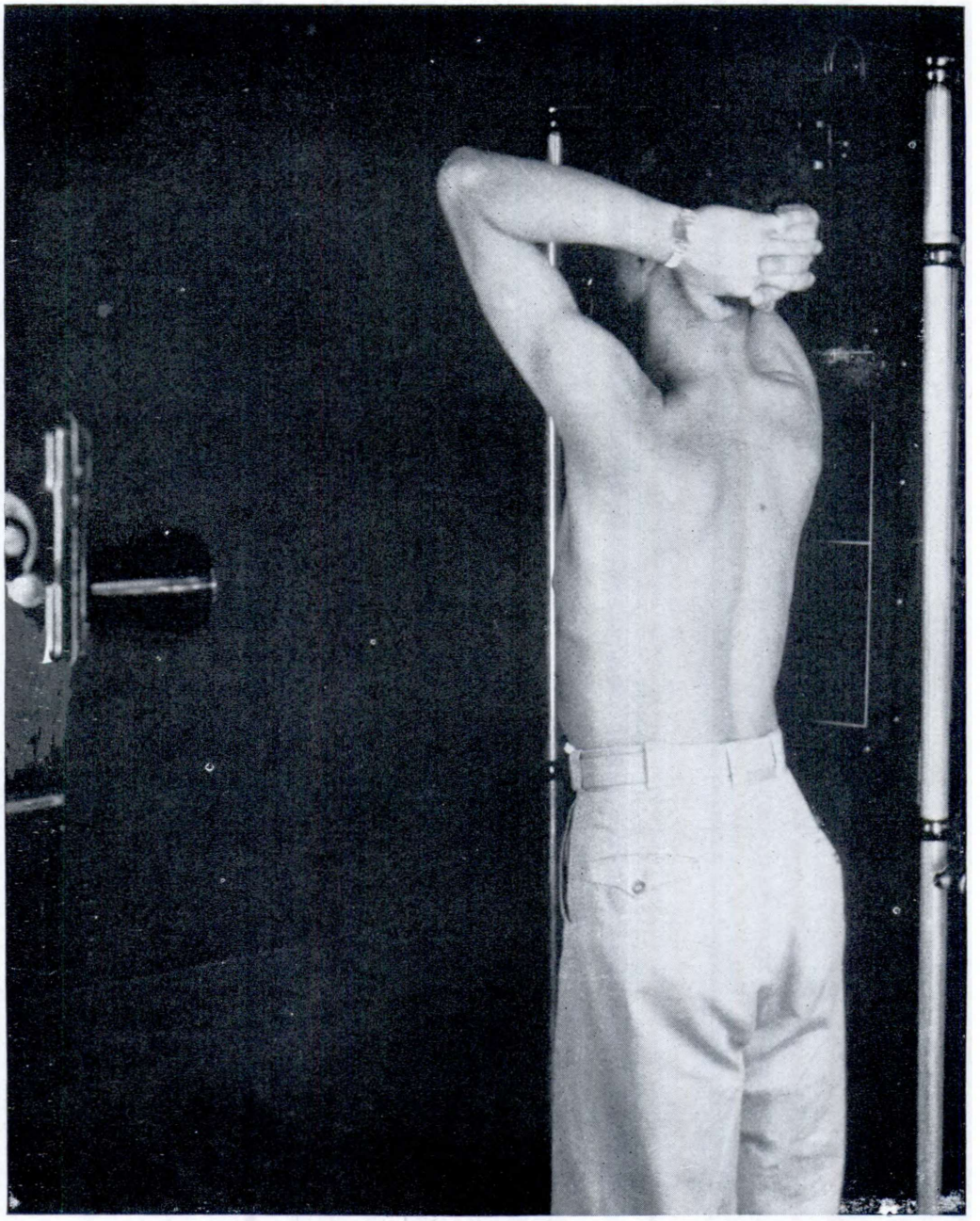


FIGURE 77A.—Lung fields, lateral.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.

Position: Patient standing to midwith of film; side for study in approximation with and plane of back perpendicular to film; acromial processes 5 cms., below upper border of film (with elbows flexed and forearms folded behind head).

Focal spot: Aline to level of 9th thoracic vertebra (if especially interested in apices, or 6th if more interested in bases), midwidth of film.

Precautions: Rotate scapulae posteriorly out of field; minimal part film distance (arms high); suspended inspiration; minimal exposure time-high Ma., large focal spot.

Additional: Fixation band; vertical cassette holder.

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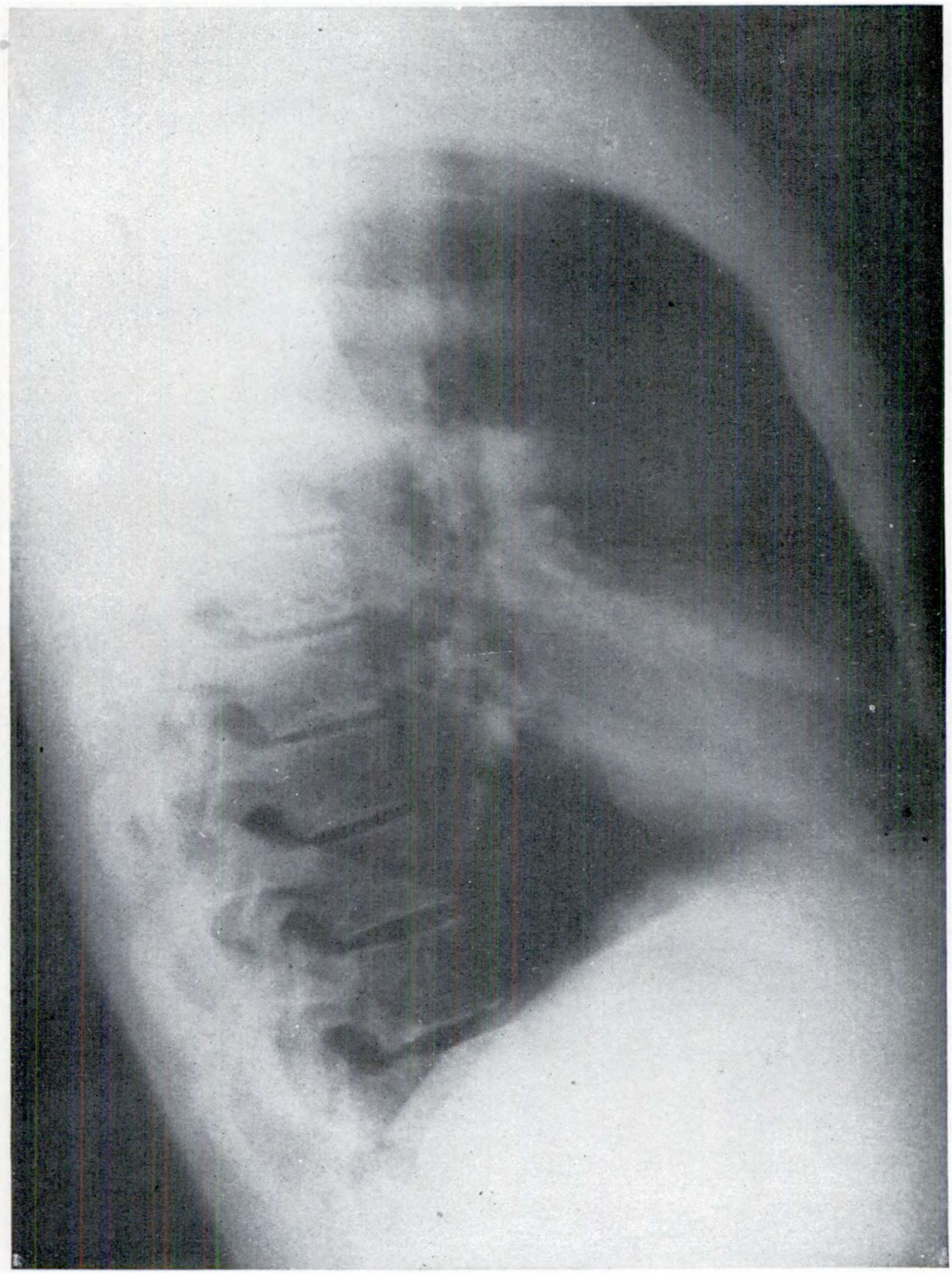


FIGURE 77B.—Lung fields, lateral.

Technical factors

Distance: 72″.	Cone: No.	(Measure plane through 9th thoracic, laterally.)																		
Cms. thickness:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	84 Ma.S.					66 Ma.S. (Basic Ma.S. 1200)					58 Ma.S.					48 Ma.S.				

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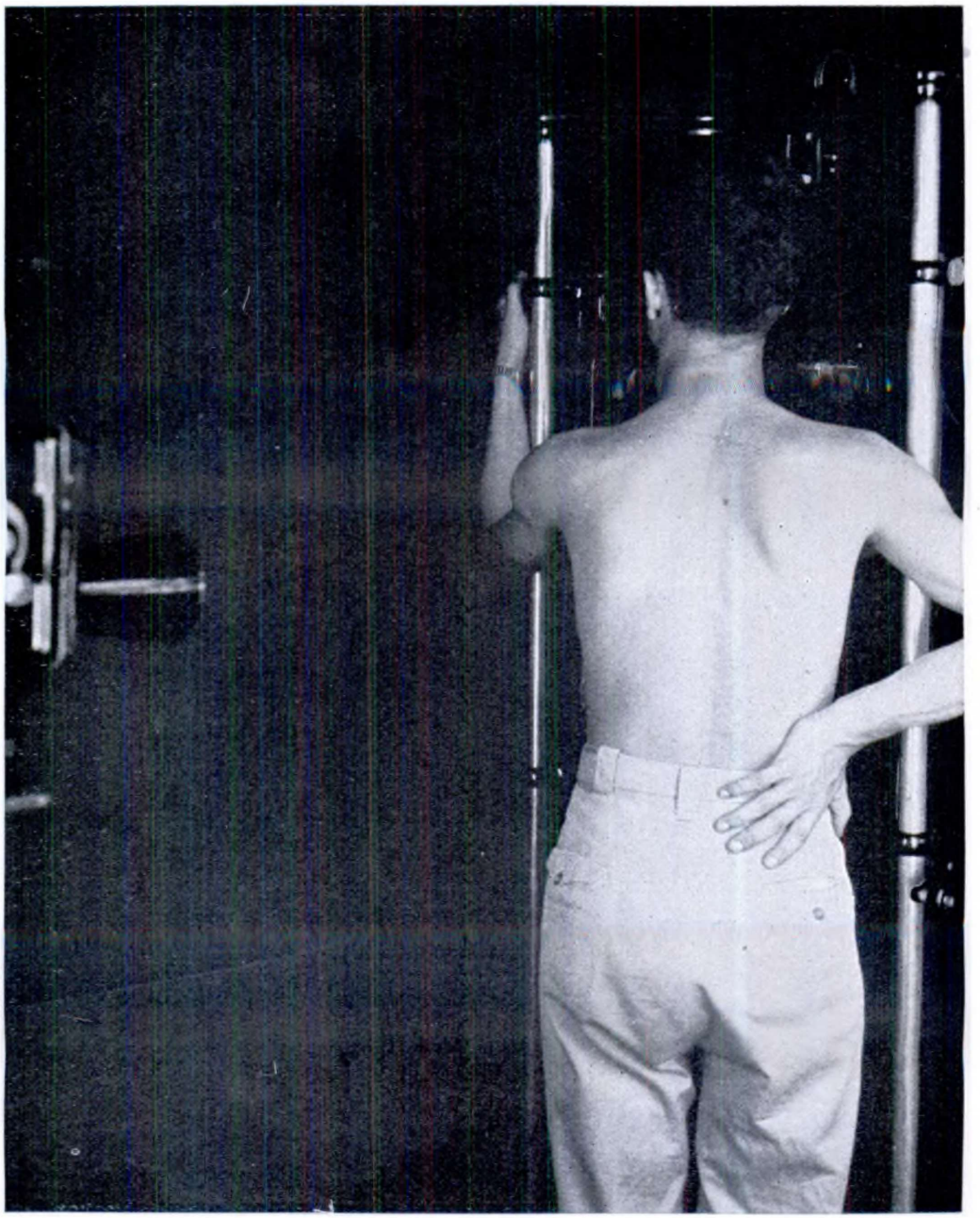


FIGURE 78A.—Lung fields, oblique.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.

Position: Patient standing to midwidth of film; rotation of 45°; acromial processes 7 cms. below upper border of cassette.

Focal spot: Aline to level of 6th thoracic vertebra, midwidth of film.

Precautions: Rotate scapulae out of field (elbow of upper extremity closer to film flexed and forward with knuckles on hip; opposite upper extremity outstretched with hand resting over cassette holder or on head); suspended inspiration; minimal exposure time-high Ma., large focal spot.

Additional: Fixation band; vertical cassette holder.

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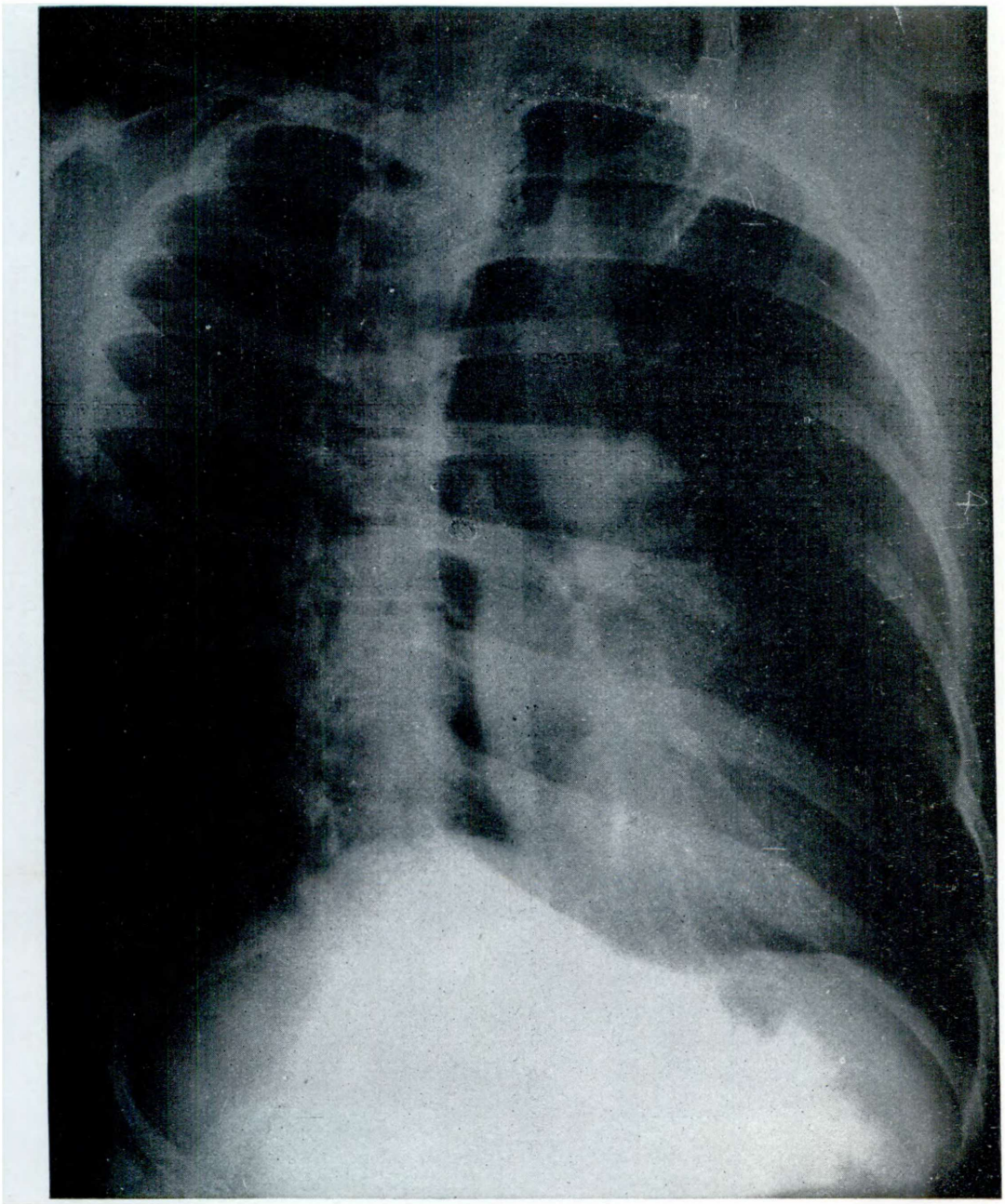


FIGURE 78B.—Lung fields, oblique.

Technical factors

Distance: 72″. Cone: No. (Measure plane through 6th thoracic vertebra, obliquely.)																				
Cms. thickness:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	63 Ma.S.					50 Ma.S. (Basic Ma.S. 900)					43 Ma.S.					36 Ma.S.				

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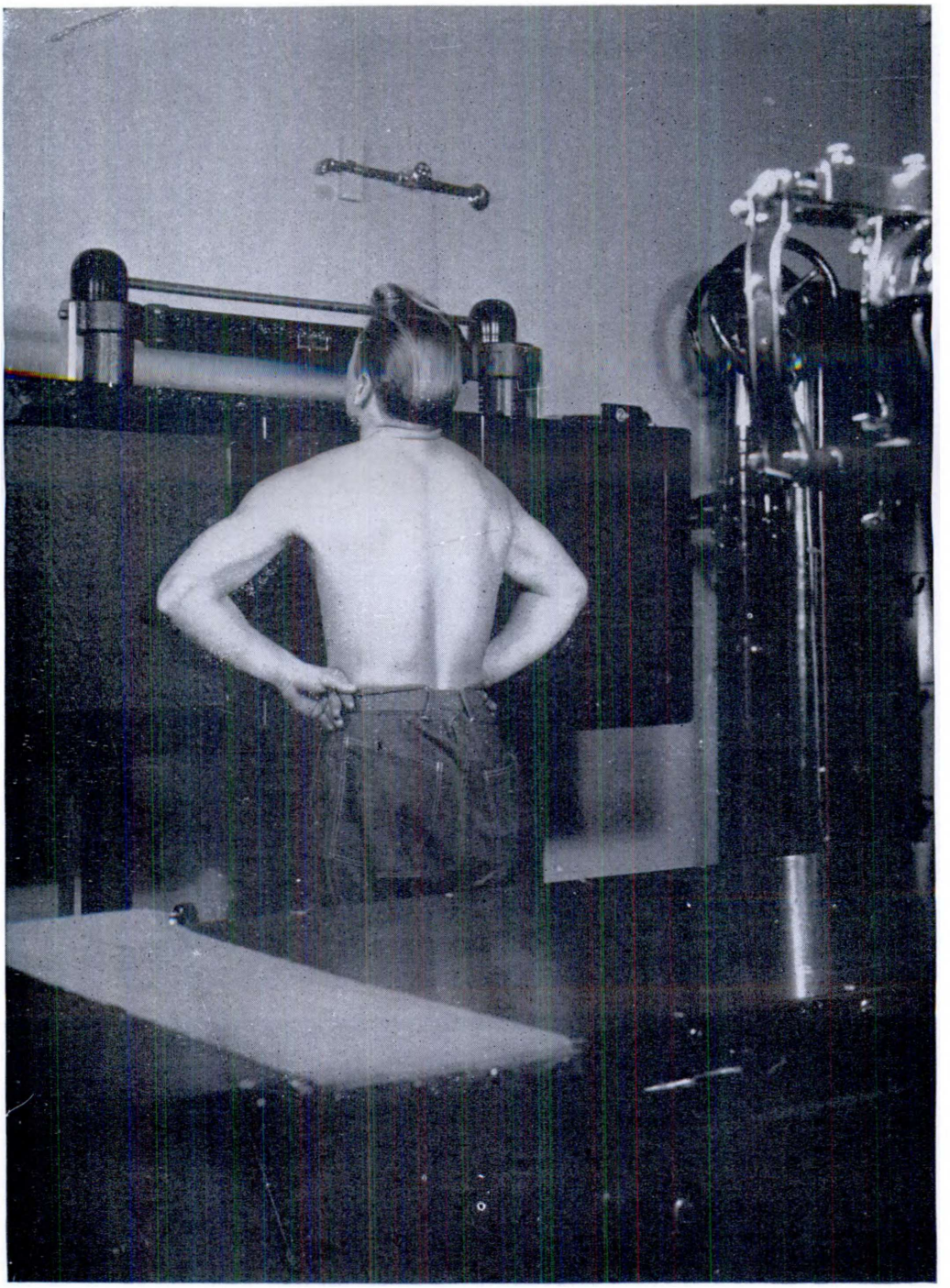


FIGURE 79A.—Heart, P. A.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.

Position: Patient standing to midwidth of film; acromial processes 7 cms. below upper border of cassette.

Focal spot: Aline to 9th thoracic vertebra.

Precautions: Rotate scapulae (elbows flexed and forward with knuckles on hips); suspended inspiration; long exposure time recommended (to produce image in both cystolic and diastolic dilatation).

Additional: Fixation band; vertical cassette holder.

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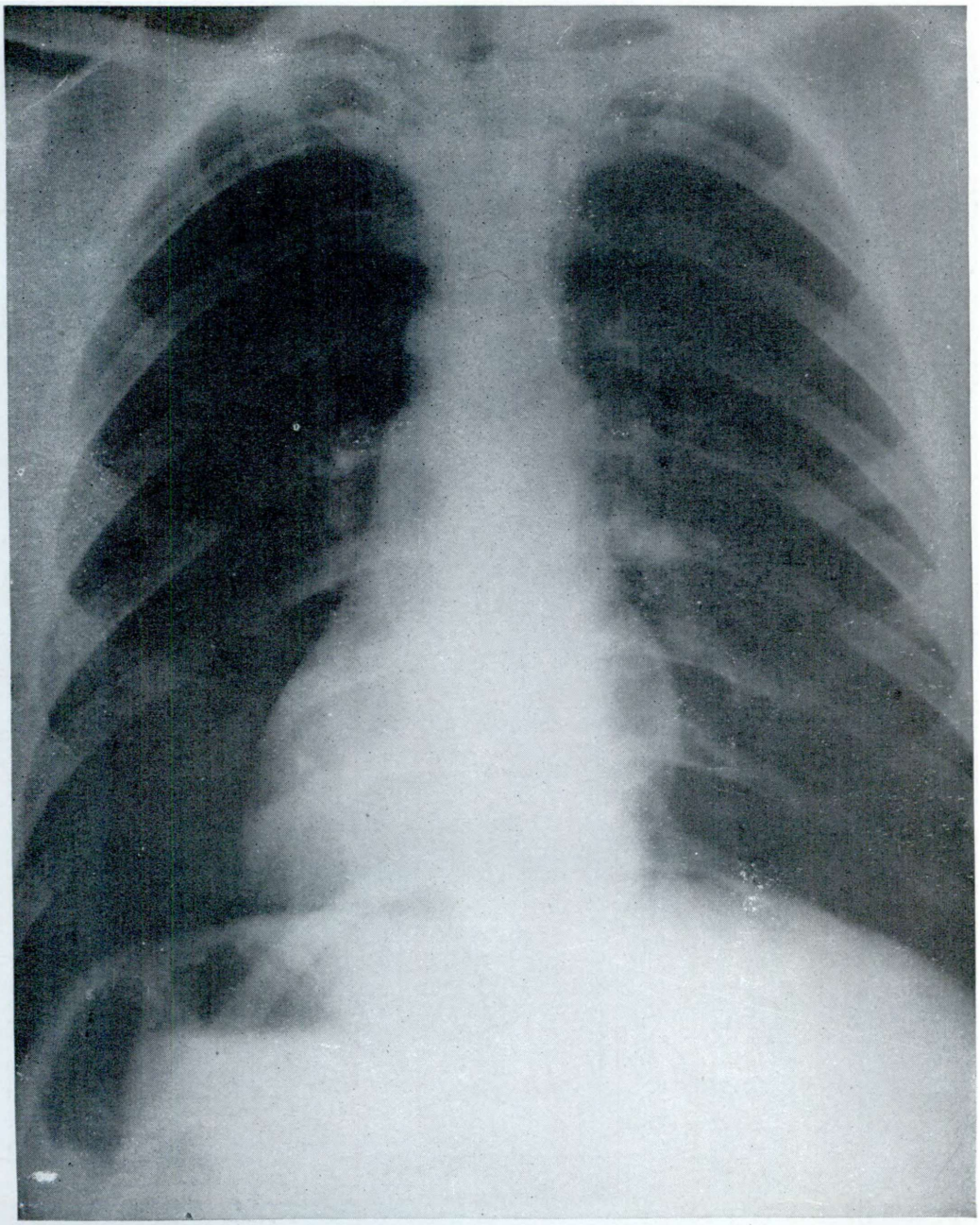


FIGURE 79B.—Heart, P. A.

Technical factors

Distance: 72". Cone: No. (Measure plane through 9th thoracic vertebra, antero-posteriorly.)																				
Cms. thickness:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	48 Ma.S.				39 Ma.S. (Basic Ma.S. 700)					23 Ma.S.					28 Ma.S.					

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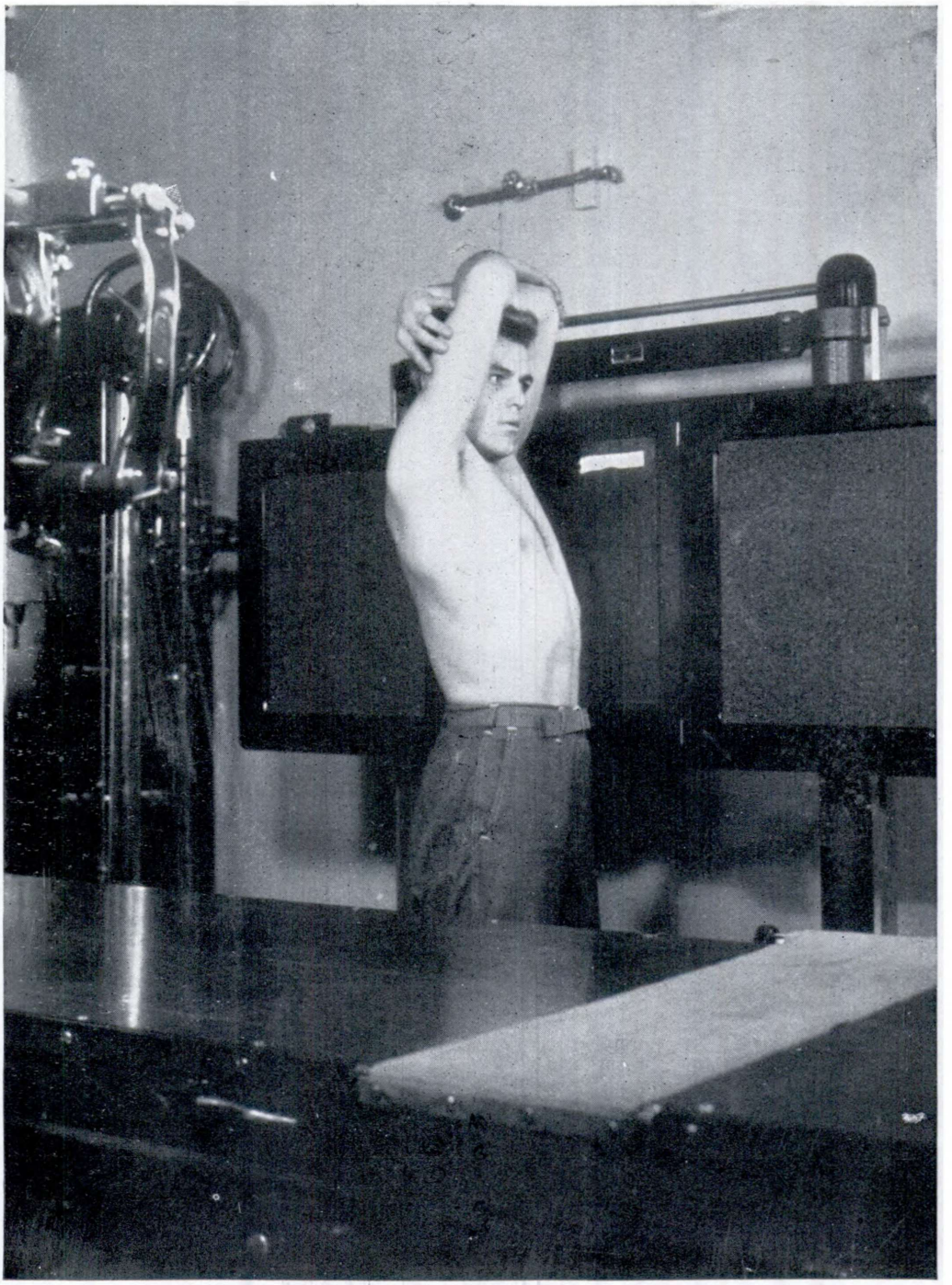


FIGURE 80A.—Heart, lateral (left).

Positioning instructions

Film: 14 x 17, lengthwise; cassette.

Position: Patient standing to midwidth of film; left side in approximation with and plane of back perpendicular to film; acromial processes 5 cms. below upper border of film (with elbows flexed and forearms folded behind head).

Focal spot: Aline to level of 9th thoracic vertebra, midwidth of film.

Precautions: Rotate scapulae posteriorly out of field; minimal part film distance (arms high); suspended inspiration; long exposure time recommended (to produce image in both cystolic and diastolic dilatation).

Additional: Fixation band; vertical cassette holder.

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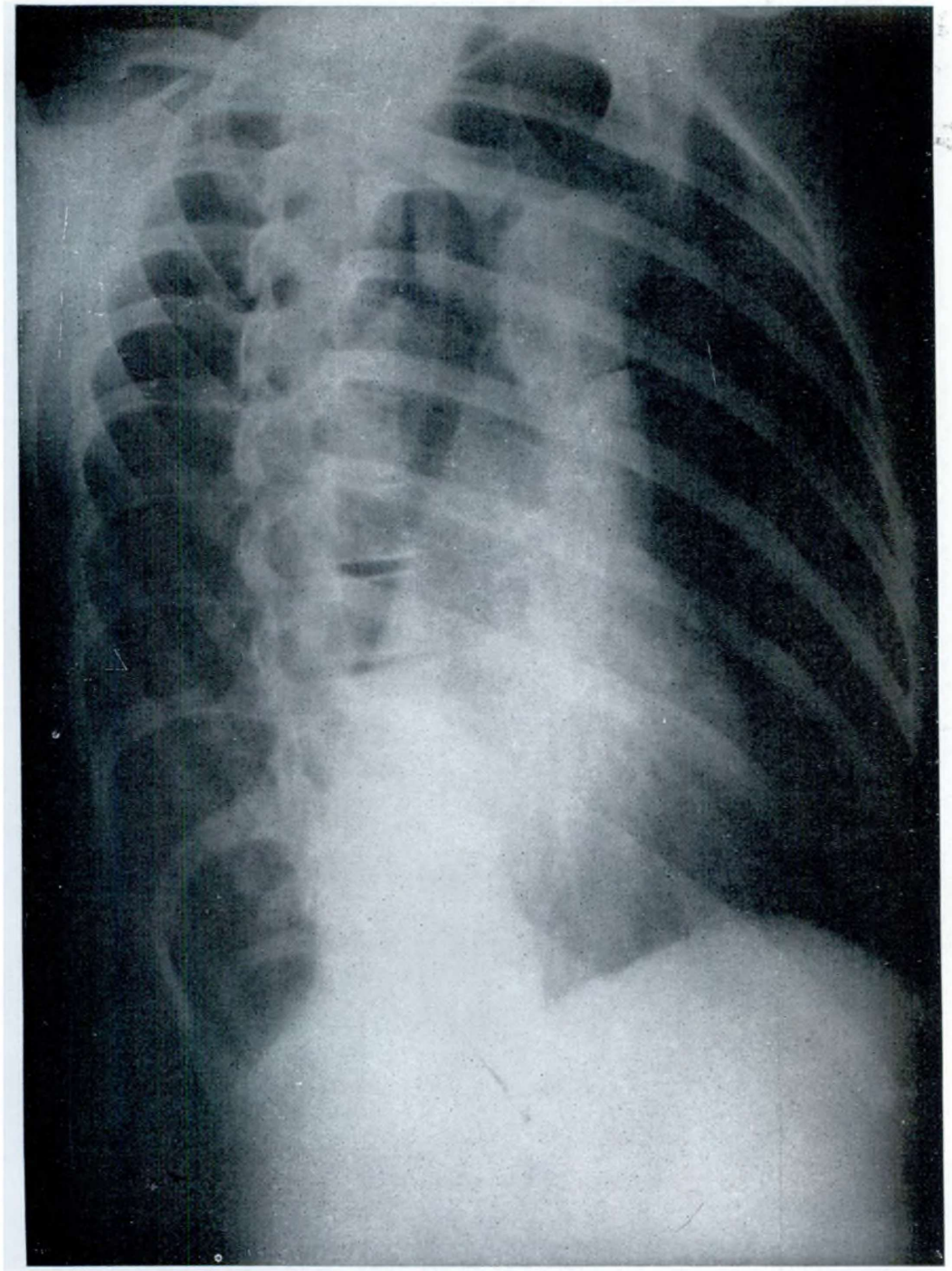


FIGURE 81B.—Heart, oblique.

Technical factors

Distance : 72″.	Cone : No.	(Measure plane through 9th thoracic, obliquely.)																		
Cms. thickness :	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Variable Kv.P. :	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	126 Ma.S.					100 Ma.S.					90 Ma.S.					72 Ma.S.				

(Basic Ma.S. 1800)

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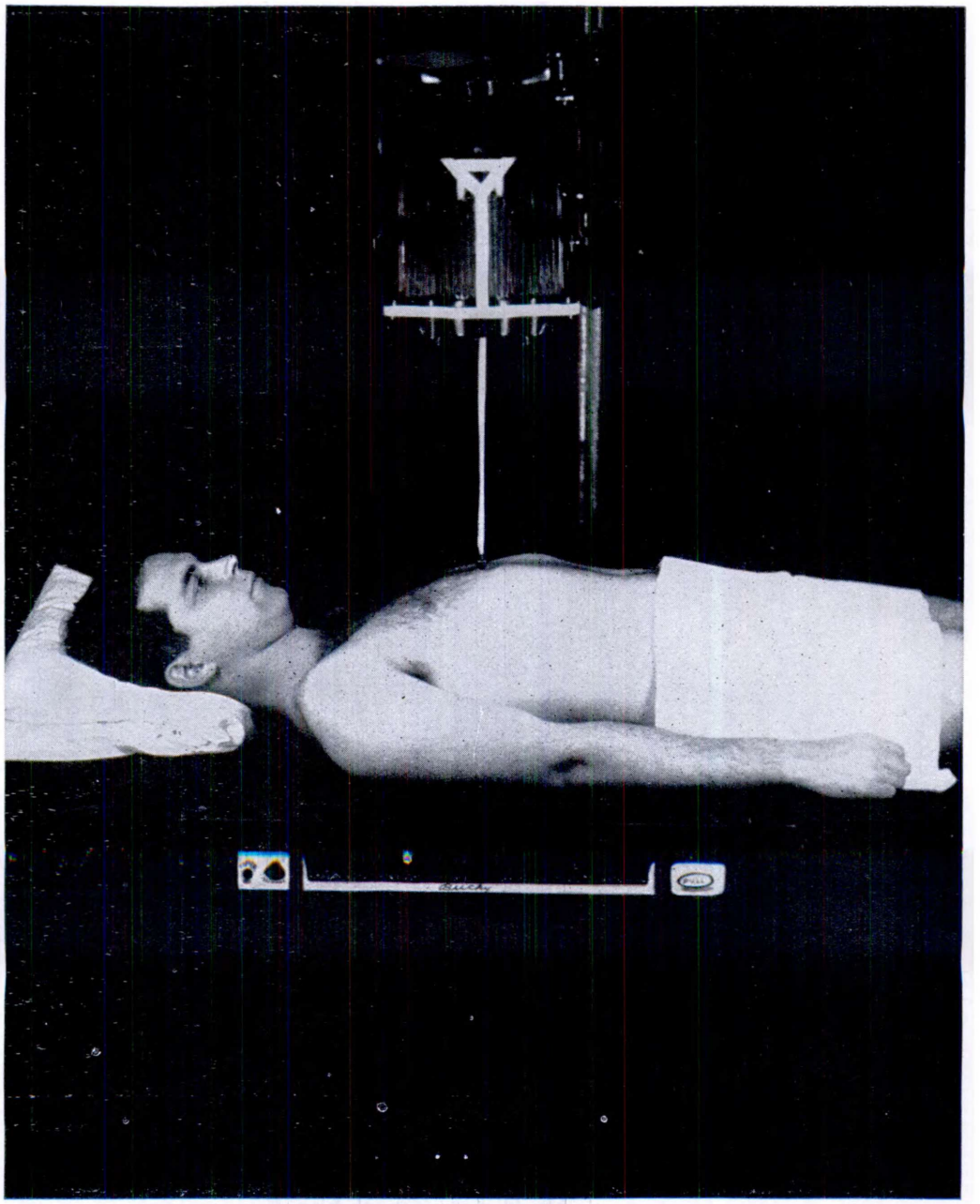


FIGURE 82A.—Ribs.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Portion for study in apposition to film and to center.
Focal spot: Aline to center of film.
Precautions: Persuade shallow breathing during exposure.
Additional: Fixation band.

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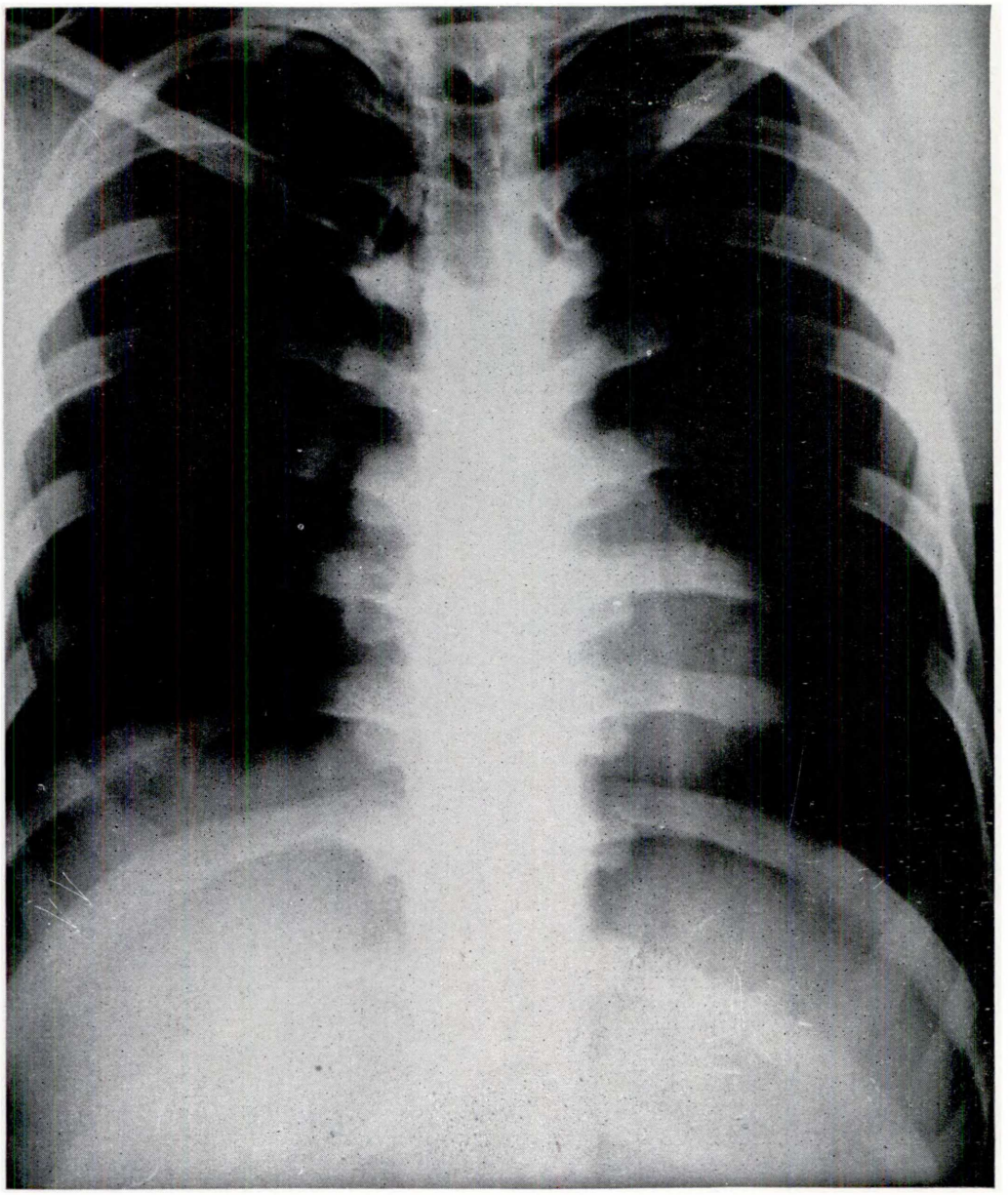


FIGURE 82B.—Ribs.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through portion for study.)					
Cms. thickness:	15 16 17 18 19	20 21 22 23 24	25 26 27 28 29	30 31 32 33 34	35 36 37 38 39
Variable Kv.P.:	40 42 44 46 48	50 52 54 56 58	60 62 64 66 68	70 72 74 76 78	80 82 84 86 88
With medium speed screens	35 Ma.S.	25 Ma.S.	20 Ma.S.	17 Ma.S.	14 Ma.S.
Using grid (5–1 ratio)	105 Ma.S.	75 Ma.S.	60 Ma.S.	51 Ma.S.	42 Ma.S.

(Basic Ma.S. 350)

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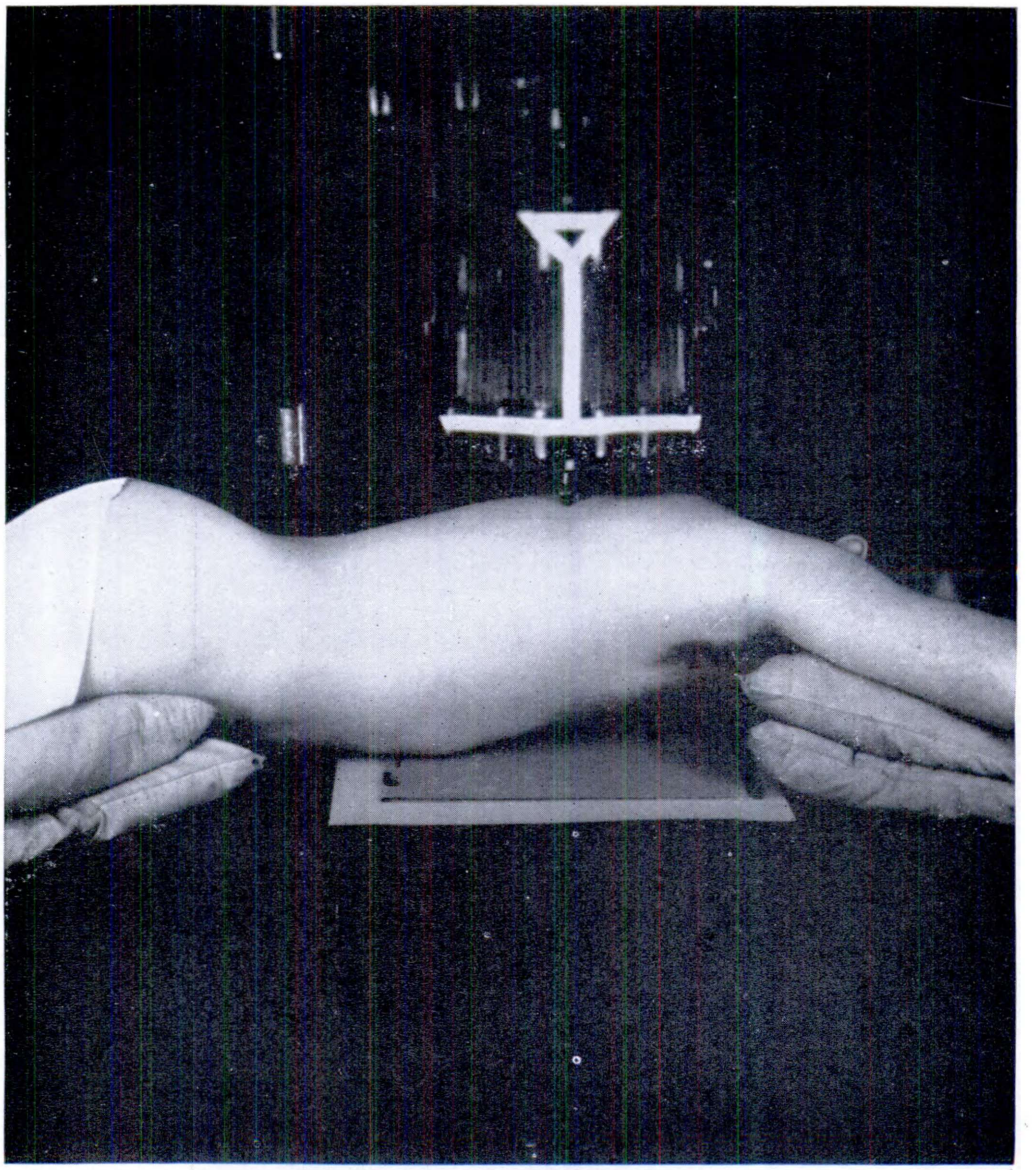


FIGURE 83A.—Sternum, P. A., oblique.

Positioning instructions

Film : 10 x 12 in cardboard holder, lengthwise.
Position : Patient prone but rotated 30° to the left (right side elevated) ; manubrium 5 cms. below upper border and at midwidth of film.
Focal spot : Aline to point 6 cms. to the right of spinous process, 8th thoracic vertebra.
Precautions : Sandbags under right shoulder and hip ; persuade shallow breathing.
Additional ; Fixation band.

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FIGURE 83B.—Sternum, P. A., oblique.

Technical factors

Distance: Tube head ¼'' from skin of patient. Cone: No. (Measure plane through mid-length of sternum, P. A.)

Cms. thickness:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
With medium speed screens		17 Ma.S.				12 Ma.S. (Basic Ma.S. 175)						10 Ma.S.			

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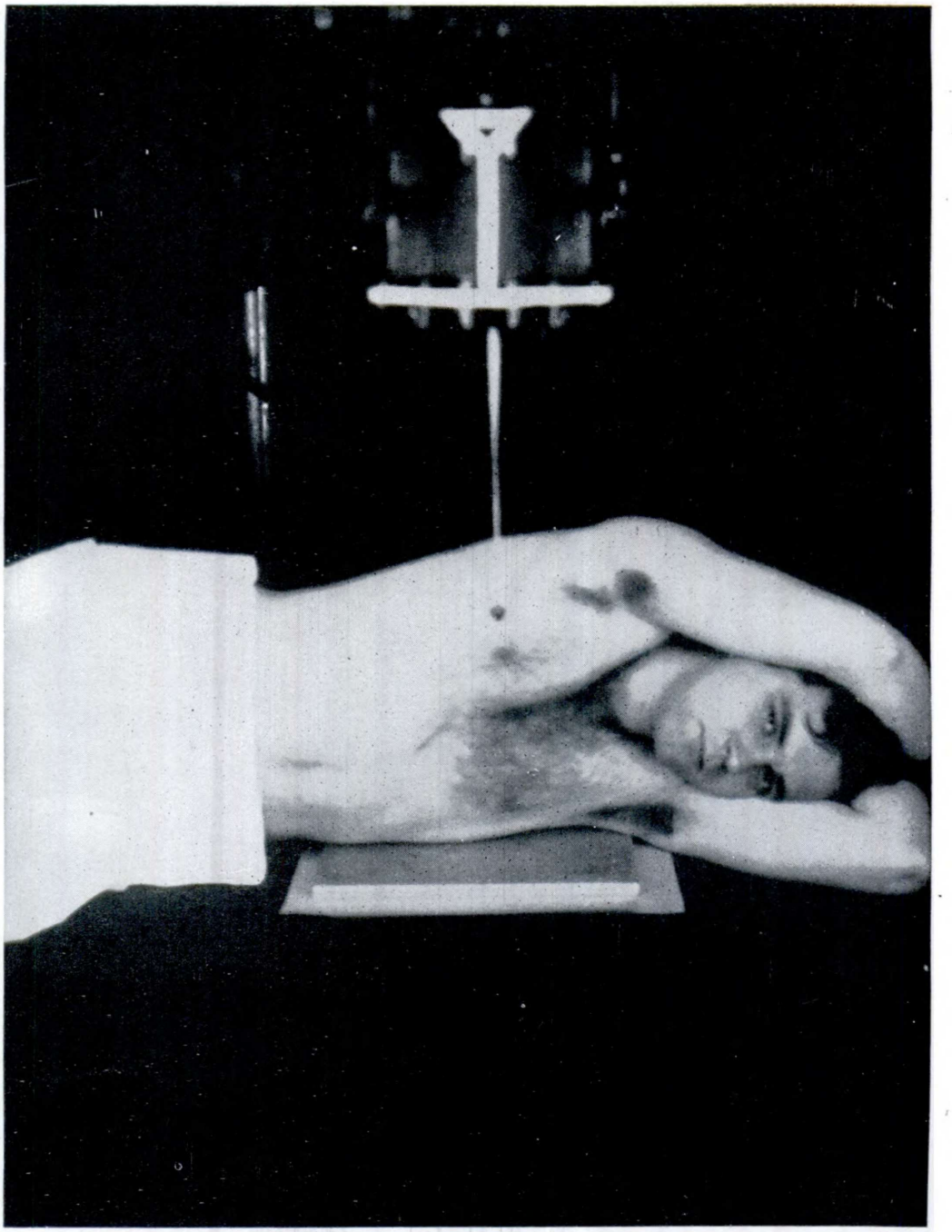


FIGURE 84A.—Sternum, lateral.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient on side; manubrium 5 cms. below upper border and at midwidth of film.
Focal spot: Aline to center of film.
Precautions: Plane of sternum perpendicular to film; suspended inspiration.
Additional: Fixation band.

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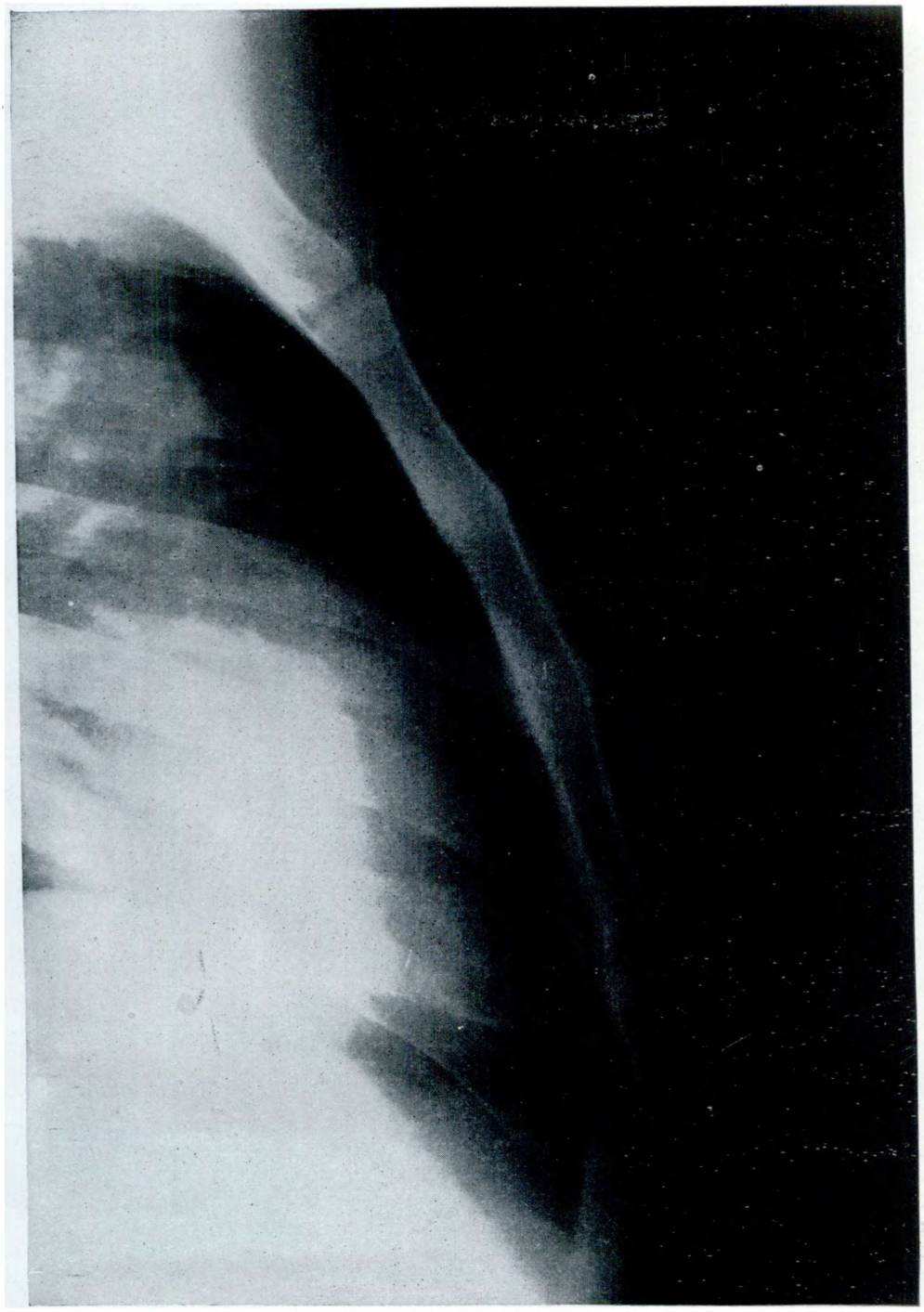


FIGURE 84B.—Sternum, lateral.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through midlength of sternum, laterally.)

Cms. thickness:	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
Variable Kv.P.:	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86
With medium speed screens	29 Ma.S.						22 Ma.S.					19 Ma.S.					16 Ma.S.			
Using grid (5–1 ratio)	87 Ma.S.						66 Ma.S.					57 Ma.S.					48 Ma.S.			

(Basic Ma.S. 400)

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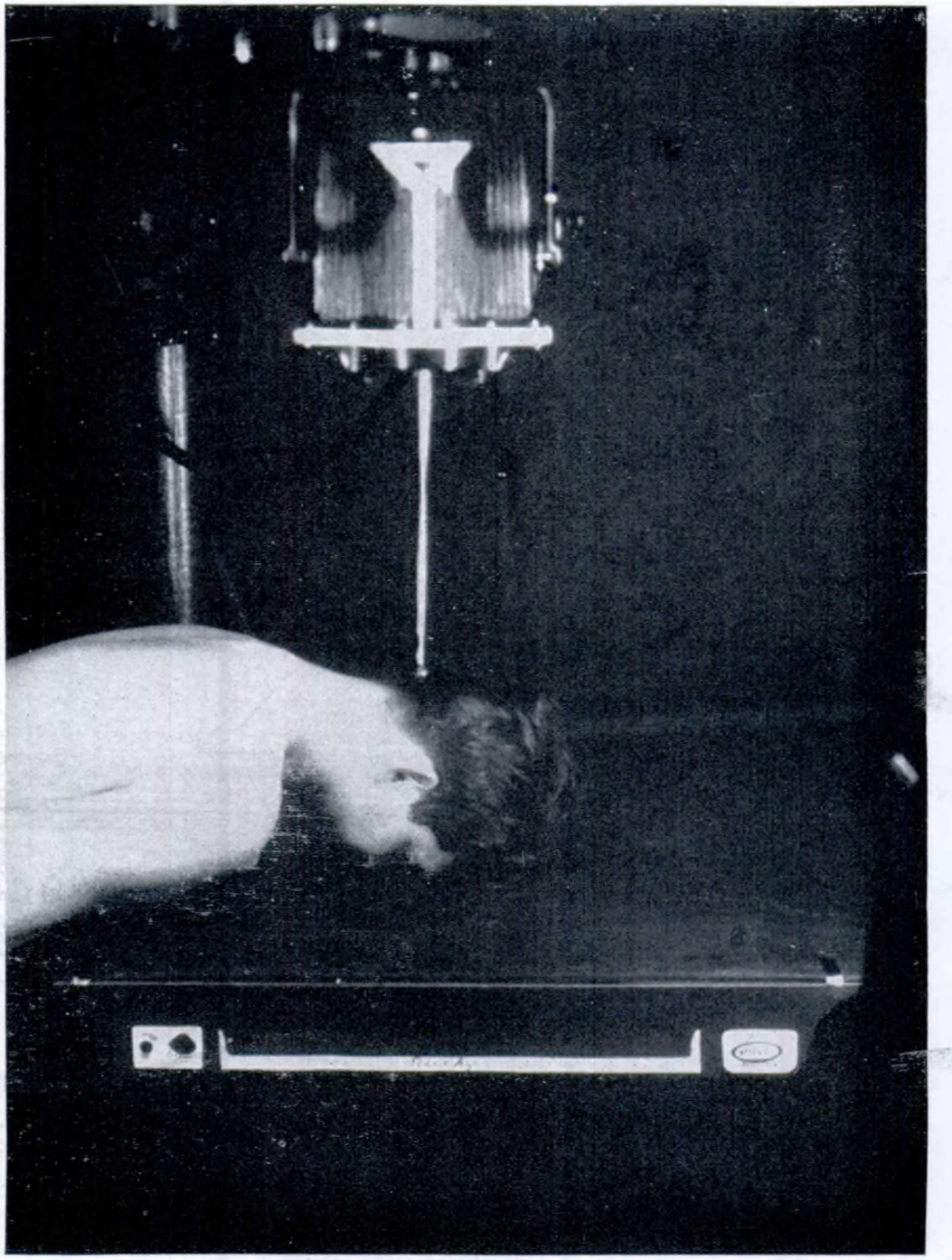


FIGURE 85A.—Skull, P. A.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient prone; forearms flexed under chest; top of head 5 cms. below upper border of film.
Focal spot: Aline to point midway between external auditory meati.
Precautions: Plane through external auditory meati and external canthi perpendicular to film; midsagittal plane perpendicular to film.
Additional: 1 mm. aluminum filter; fixation band; grid.

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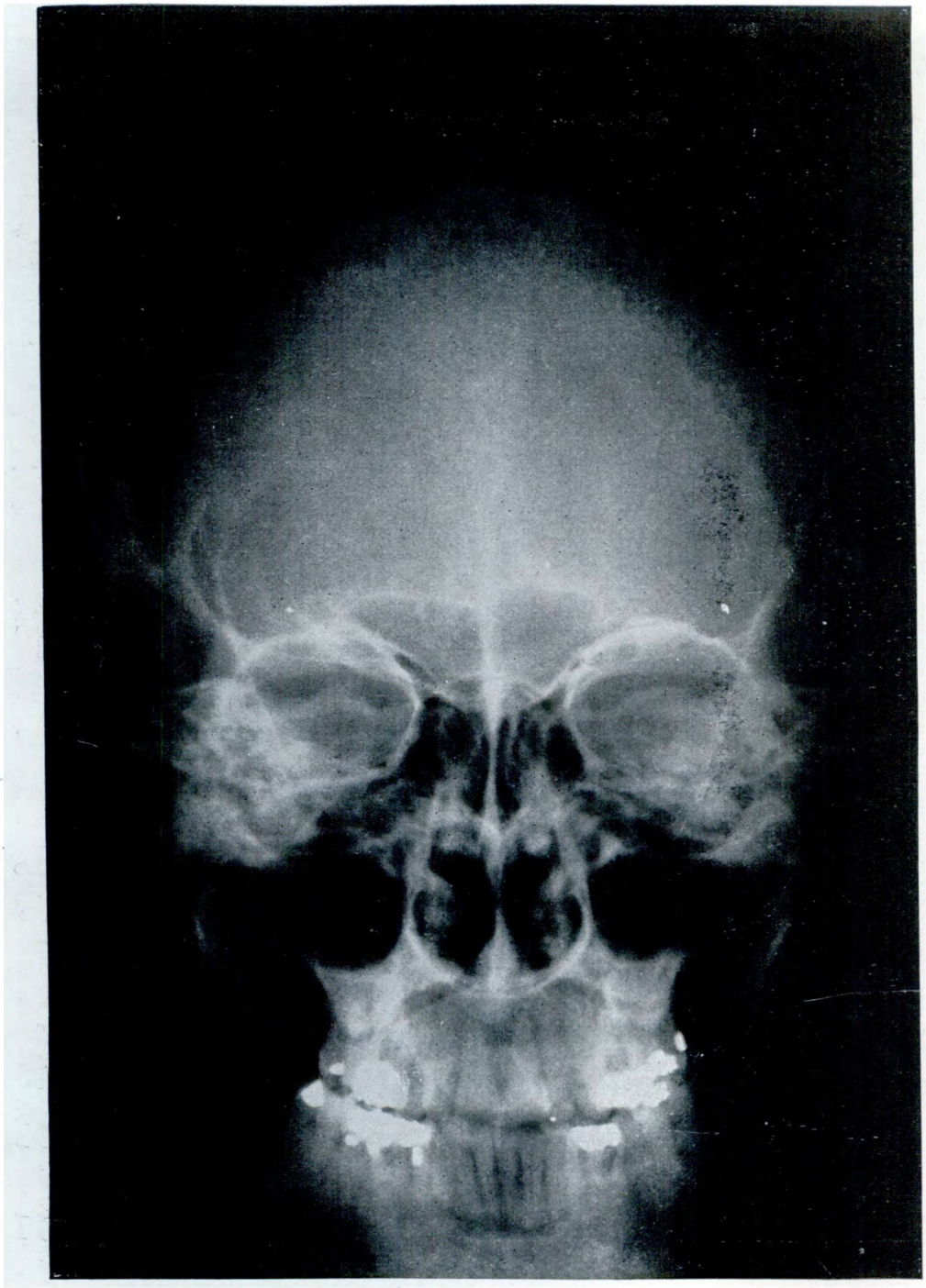


FIGURE 85B.—Skull, P. A.

Technical factors

Distance: 30″. Cone: optional (compensate Ma.S.). (Measure plane through external auditory meatus and external canthus.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24	25
Variable Kv.P.:	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	25 Ma.S.						20 Ma.S.					
Using grid (5–1 ratio)	75 Ma.S.						60 Ma.S.					

(Basic Ma.S. 500)

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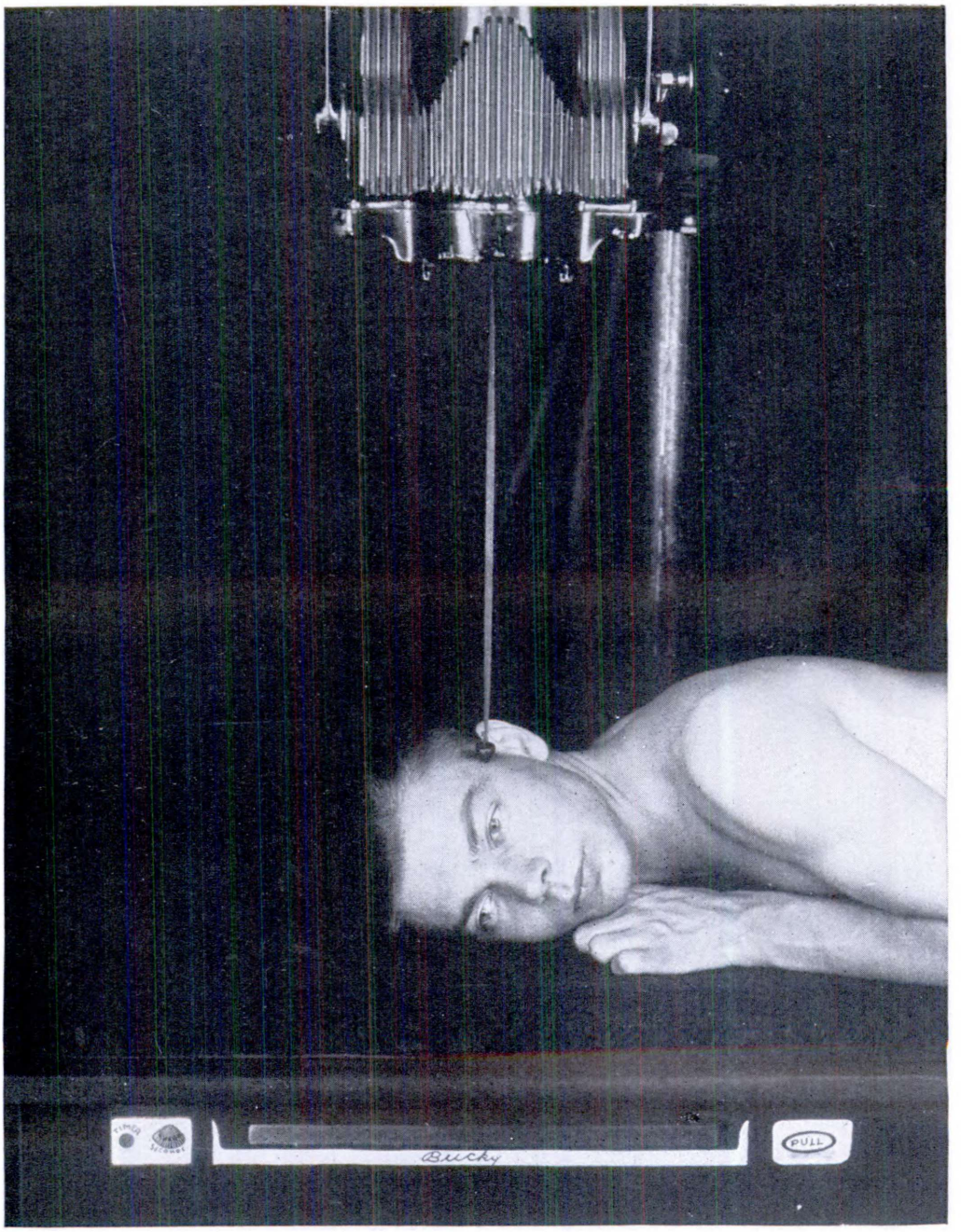


FIGURE 86A.—Skull, lateral.

Positioning instructions

Film : 10 x 12, widthwise ; cassette.

Position : Patient prone ; forearms flexed under chest ; top of head 5 cms. below upper border of film.

Focal spot : Aline to point 3 cms. anterior and 2 cms. above external auditory meatus (shift each way from this point for stereo).

Precautions : Head extended ; midsagittal plane parallel with film (support chin with fist or cork).

Additional : 1 mm. aluminum filter ; weighted or fixation band ; grid.

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FIGURE 86B.—Skull, lateral.

Technical factors

Distance: 30″. Cone: optional (compensate Ma.S.). (Measure plane through external auditory meatus and external canthus, laterally.)

Cms. thickness:	11	12	13	14	15	16	17	18	19
Variable Kv.P.:	62	64	66	68	70	72	74	76	78
With medium speed screens		25 Ma.S.				20 Ma.S.			
Using grid (5–1 ratio)		75 Ma.S.				60 Ma.S.			

(Basic Ma.S. 400)

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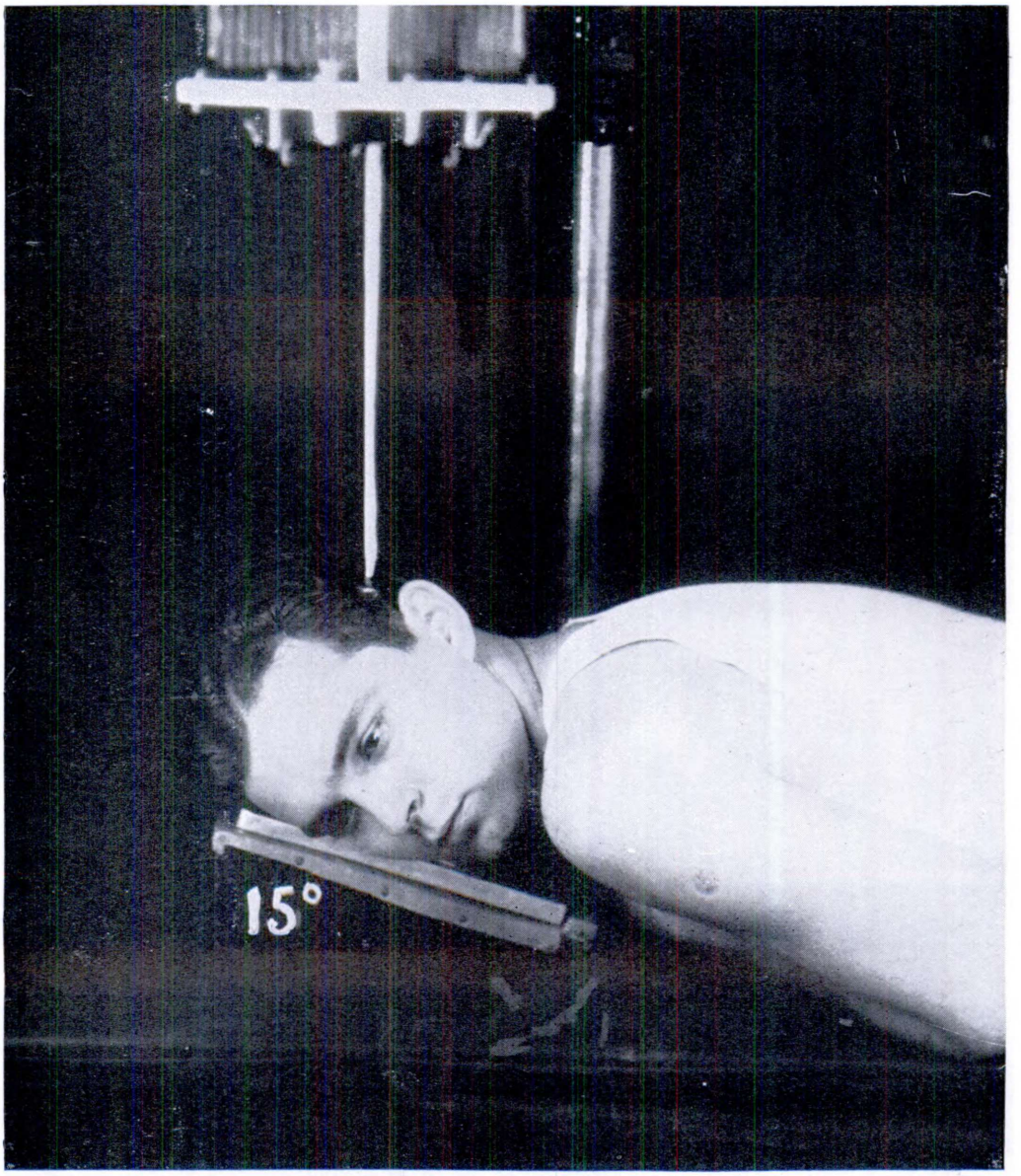


FIGURE 87A.—Mastoids, lateral.

Positioning instructions

Films: 8 x 10, widthwise; cassette—cover unexposed half with 1 mm. lead.
Position: Patient prone; forearms flexed under chest; external auditory meatus (side for study) to center of exposed half of film.
Focal spot: Aline to point 5 cms. above uppermost external auditory meatus.
Precautions: Ear (side for study) folded forward; head resting on 15° angle board; rotated 15° forward (usual contour of face).
Additional: Cone; angle board (15°); 1 mm. aluminum filter.

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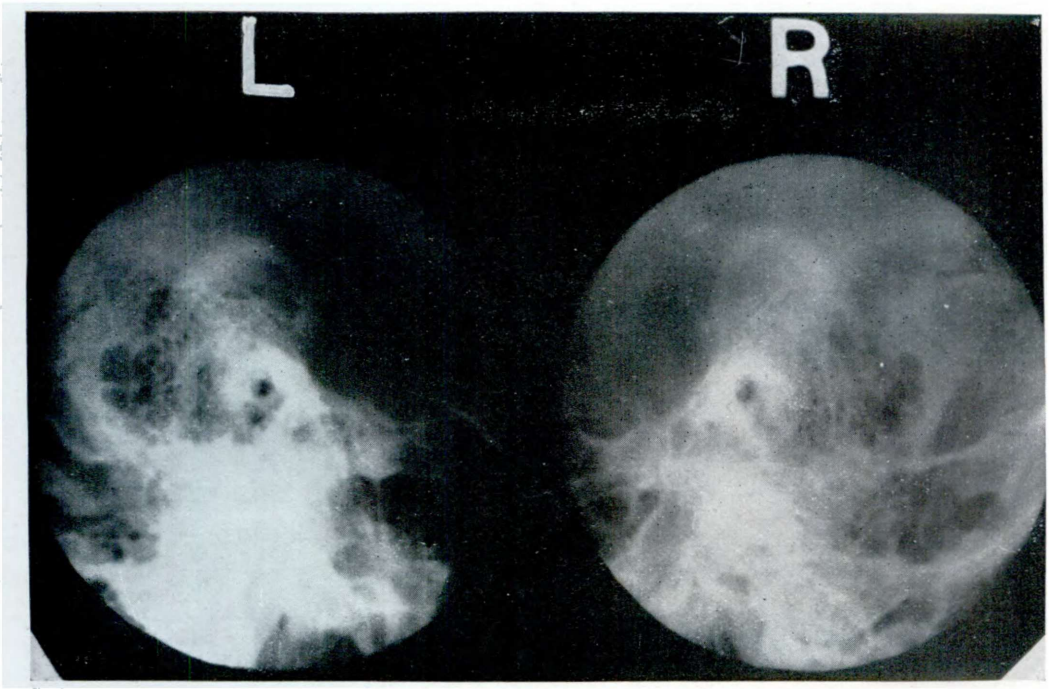


FIGURE 87B.—Mastoids, lateral.

Technical factors

Distance: 30″. Cone: Advisable (compensate Ma.S.). (Measure plane through temporal region, obliquely.)

Cms. thickness:	11	12	13	14	15	16	17	18	19	20
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88
With medium speed screens			14 Ma.S.					12 Ma.S.		

(Basic Ma.S. 300)

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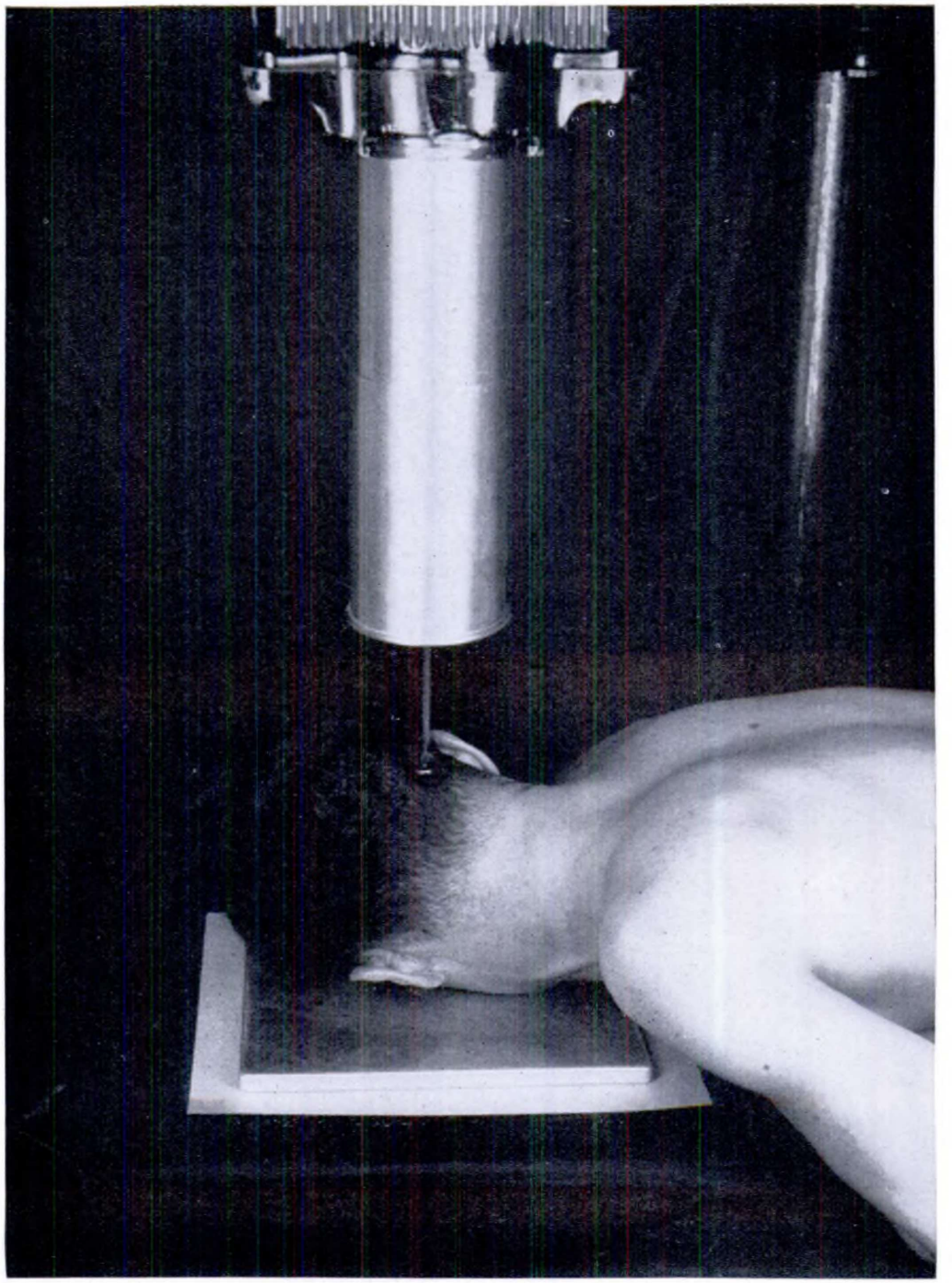


FIGURE 88A.—Mastoids, Stenver's.

Positioning instructions

Film: 8 x 10, lengthwise; cassette.

Position: Patient prone; forearms flexed under chest; eye to center of film; (head resting on nose, supra-orbital ridge and malar).

Focal spot: Aline to point midway between external occipital protuberance and tip of opposite mastoid.

Precautions: Midsagittal plane, head, at 45° angle to film.

Additional: 1 mm. aluminum filter; fixation band; grid advisable.

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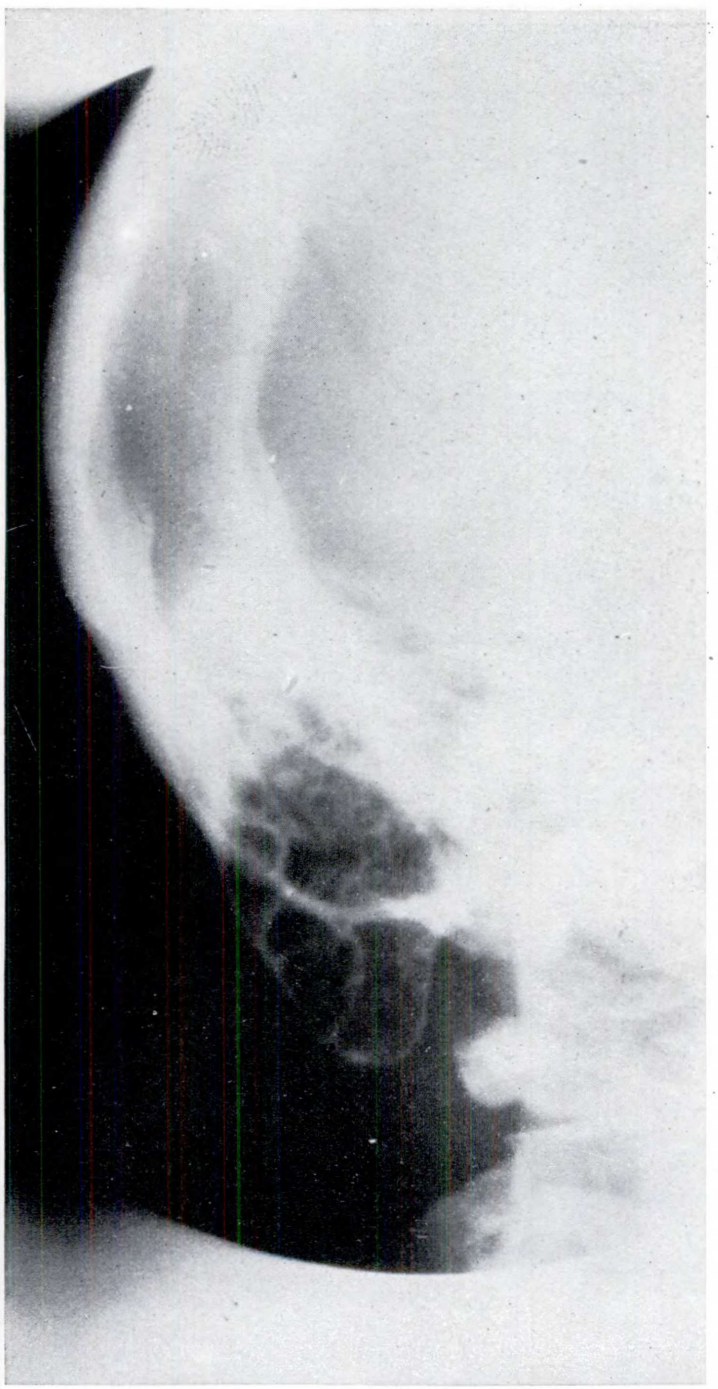


FIGURE 88B.—Mastoids, Stenver's.

Technical factors

Distance: 30″. Cone: optional (compensate Ma.S.). (Measure plane through mastoid process and supra-orbital ridge, obliquely.)

Cms. thickness:	14	15	16	17	18	19	20	21	22
Variable Kv.P.:	70	72	74	76	78	80	82	84	86
With medium speed screens	12 Ma.S.					10 Ma.S.			
Using grid (5–1 ratio)	36 Ma.S.					30 Ma.S.			

(Basic Ma.S. 250)

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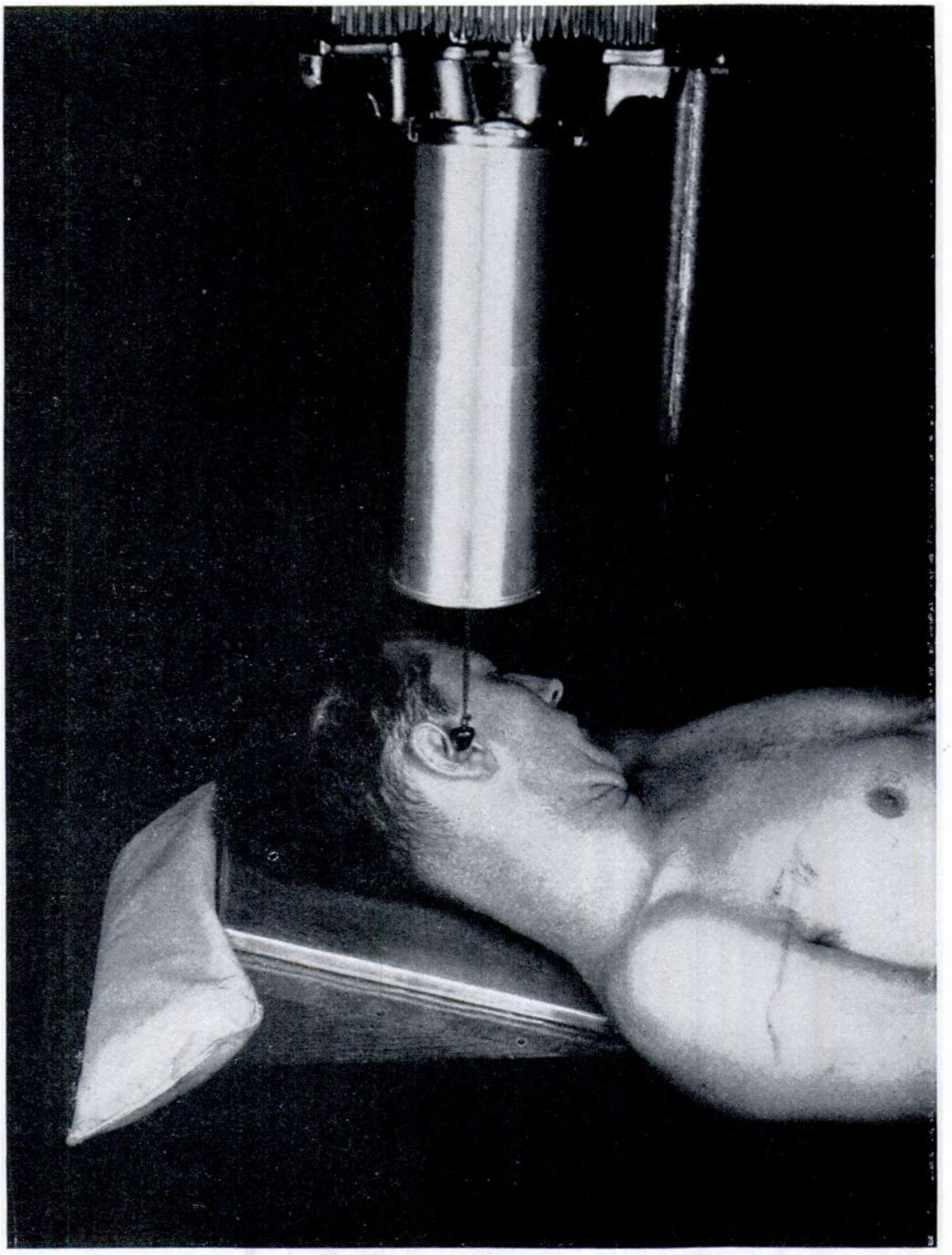


FIGURE 89A.—Mastoid tips, A. P.

Positioning instructions

Film: 8 x 10, widthwise; cassette—cover unexposed half with 1 mm. lead.
Position: Patient supine; tip of mastoid to center of exposed half of film.
Focal spot: Aline to point 2 cms. above mastoid.
Precautions: Rotate head toward opposite side enough to clear mastoid from angle of mandible.
Additional: 15° angle board; fixation band; 1 mm. aluminum filter; cone.

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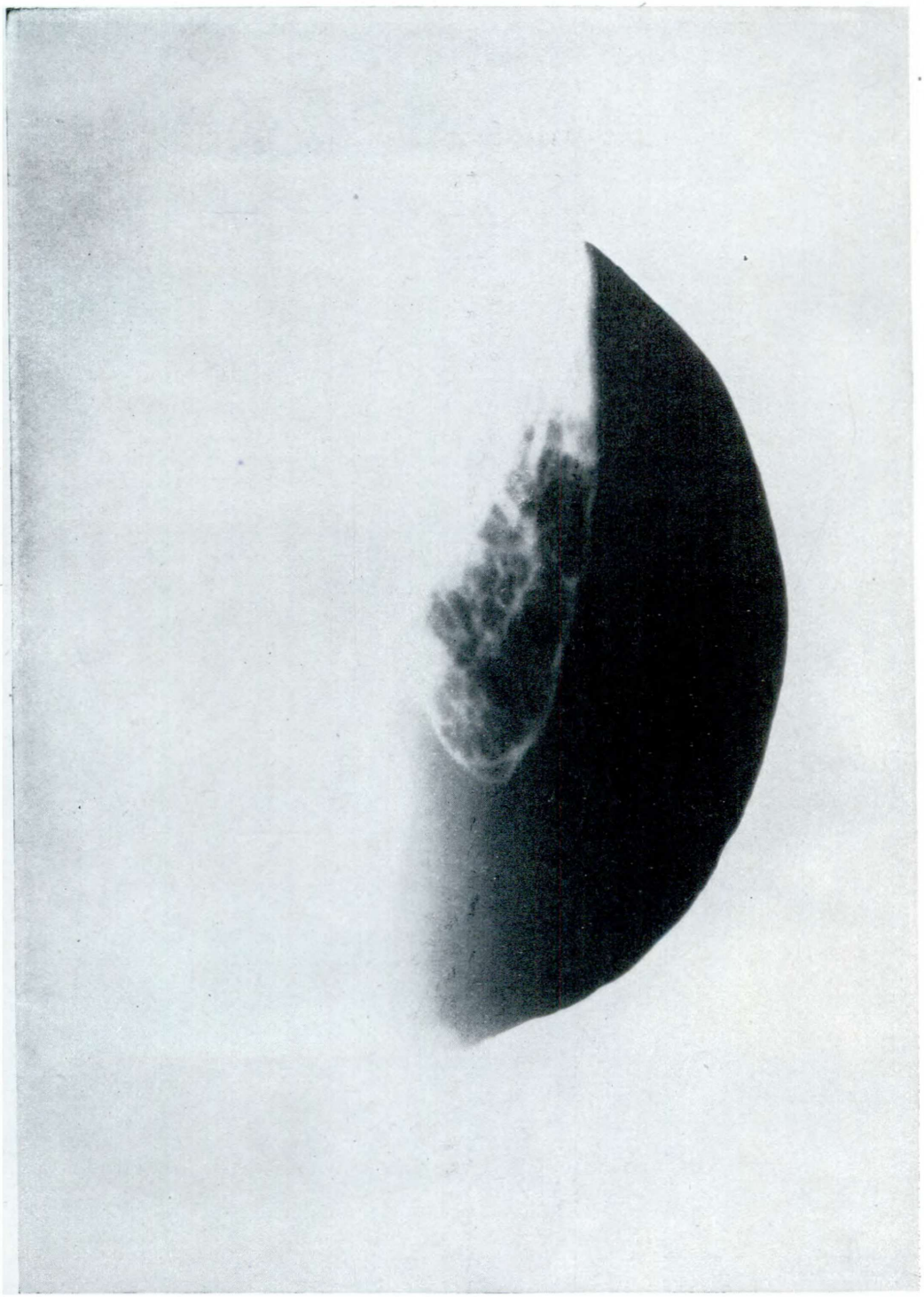


FIGURE 89B.—Mastoid tips, A. P.

Technical factors

Distance: 30″. Cone: Advisable (compensate Ma.S.). (Measure plane through tip of mastoid and supra-orbital ridge.)

Cms. thickness:	11	12	13	14	15	16	17	18	19	20
Variable Kv.P.:	56	58	60	62	64	66	68	70	72	74
With medium speed screens	10 Ma.S.		8 Ma.S.					7 Ma.S.		
Using grid (5–1 ratio)	30 Ma.S.		24 Ma.S.					21 Ma.S.		

(Basic Ma.S. 150)

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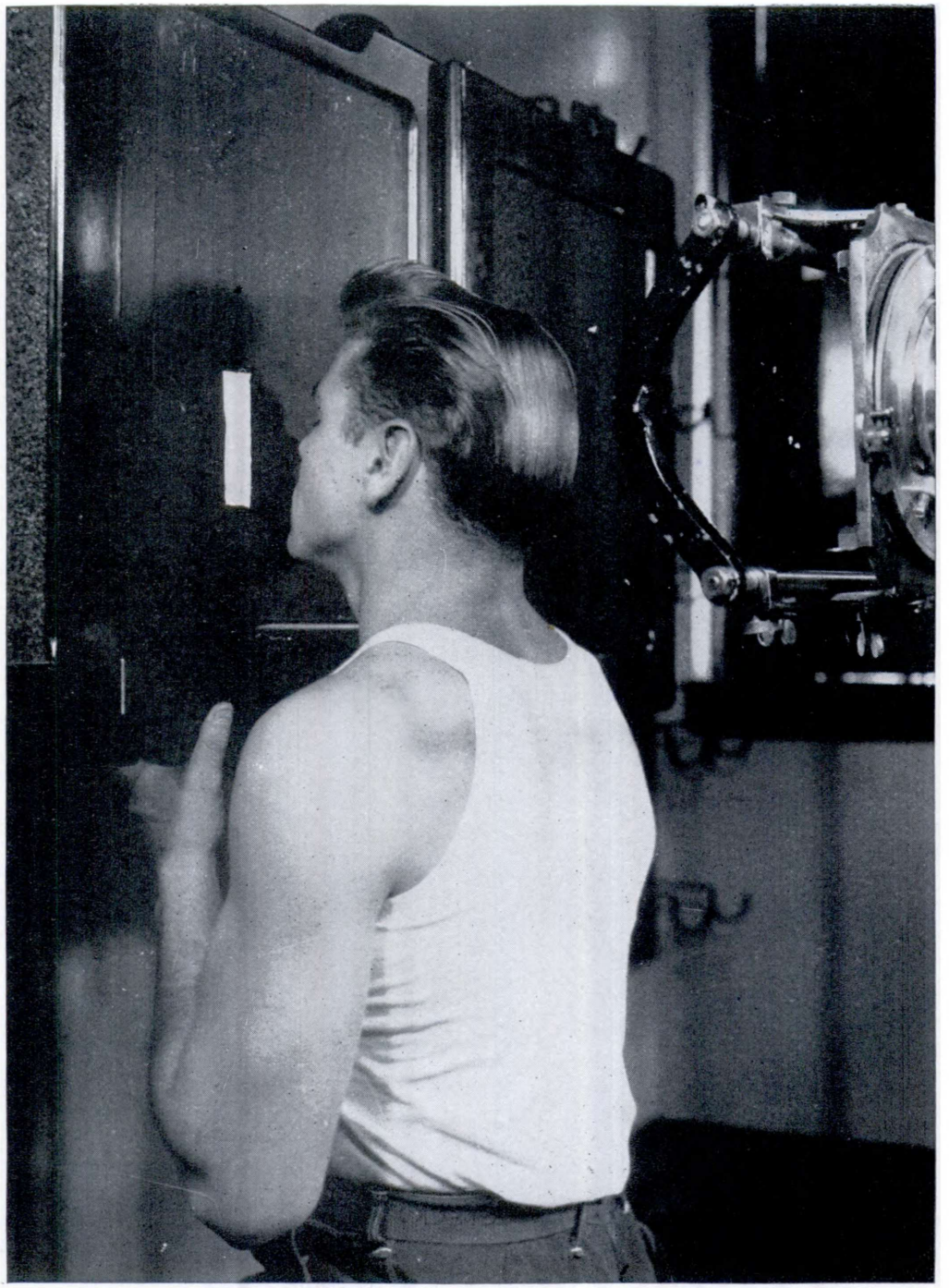


FIGURE 90A.—Para-nasal sinuses, nose-chin position.

Positioning instructions

Film: 8 x 10, lengthwise; cassette.

Position: Patient sitting; head upright with chin resting against cassette and middle of upper lip to center of film.

Focal spot: Aline to tip of nose.

Precautions: Remove hairpins, dentures, etc.; midsagittal plane perpendicular to film; plane through external auditory meatus and external canthus 37° to plane of film (use cardboard angle): suspended respiration.

Additional: Extension cylinder; fixation band; cork rest; 37° cardboard angle; 1 mm. aluminum filter; vertical cassette holder.

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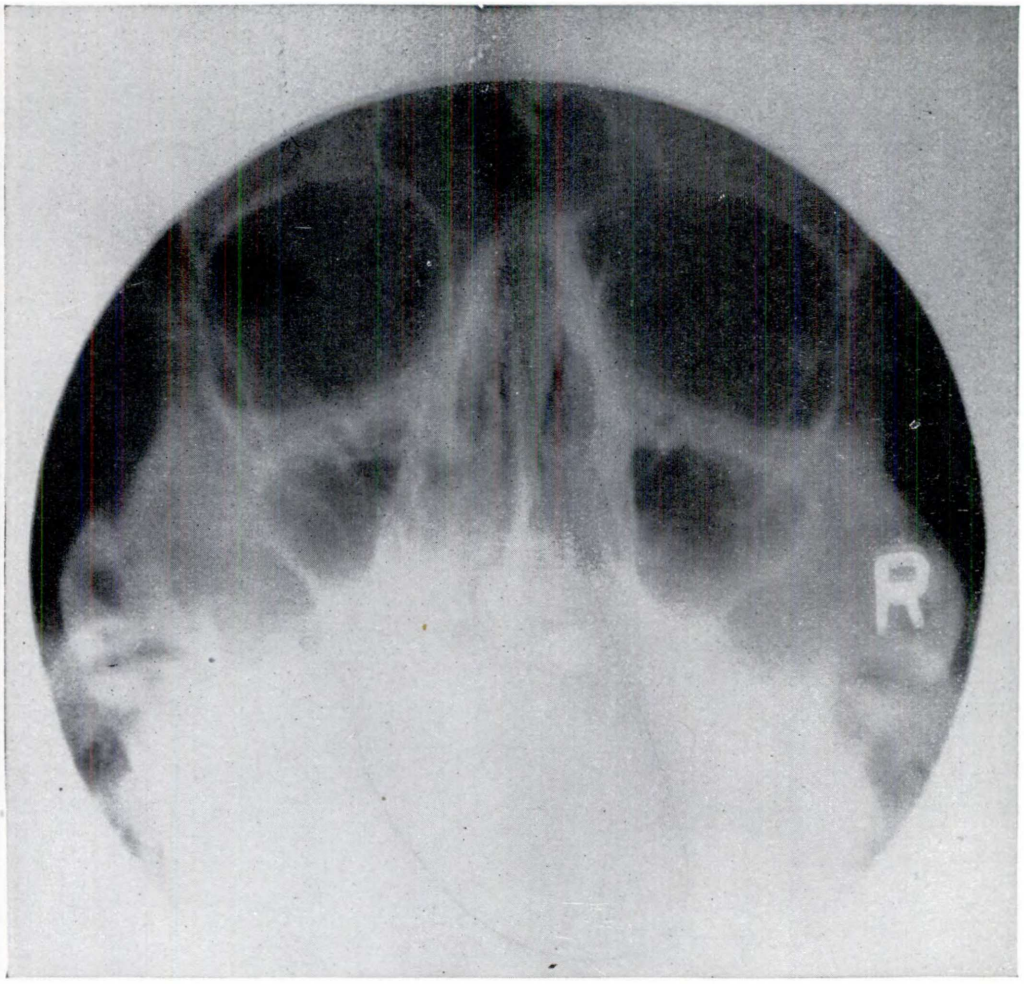


FIGURE 90B.—Para-nasal sinuses, nose-chin position.

Technical factors

Distance: 30″. Cone: advisable (compensate Ma.S.). (Measure through plane, superior occiput and upper lip.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24	25
Variable Kv.P.:	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens			25 Ma.S.						20 Ma.S.			

(Basic Ma.S. 500)

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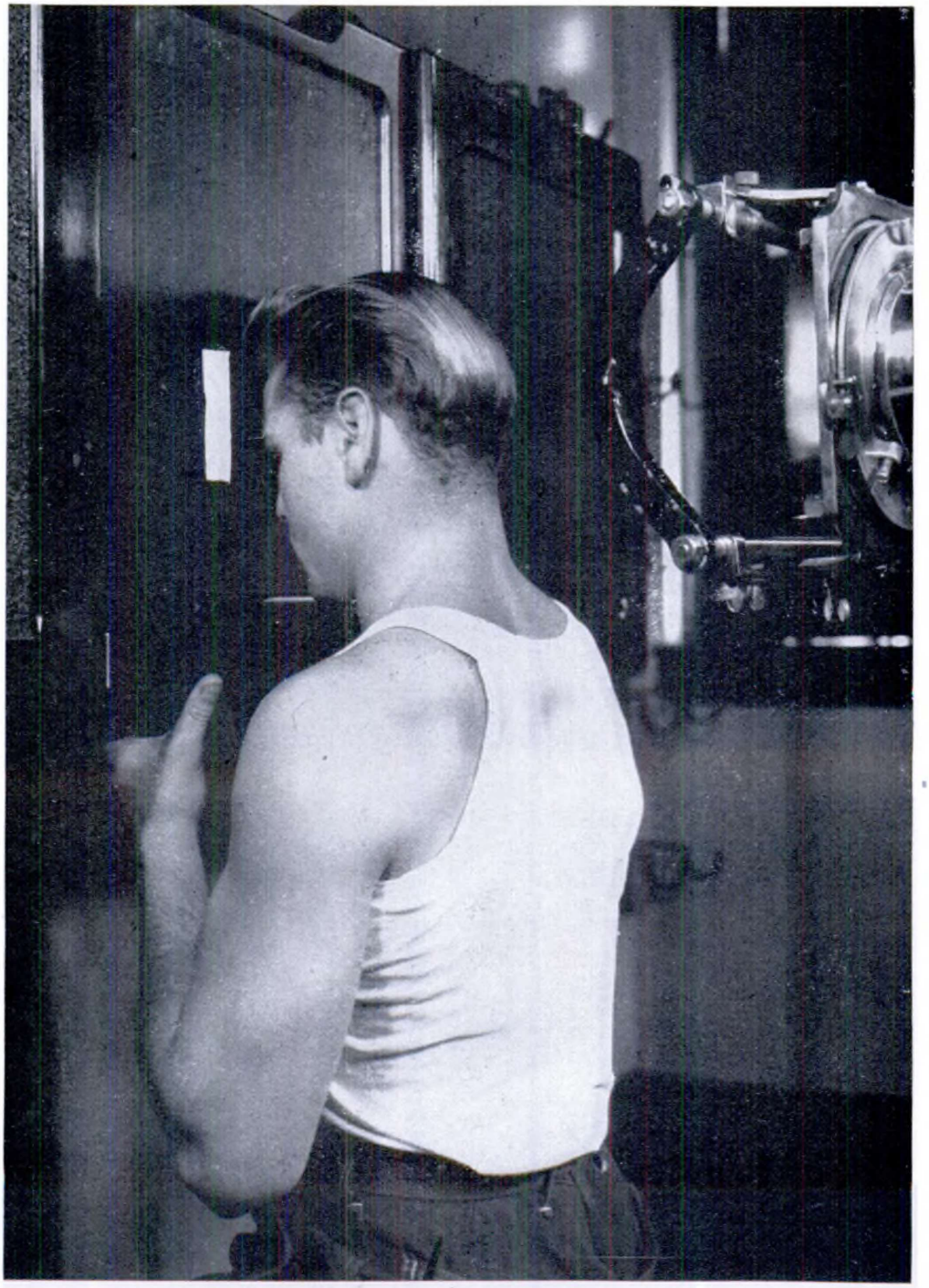


FIGURE 91A.—Para-nasal sinuses, nose-forehead position.

Positioning instructions

Film: 8 x 10, lengthwise; cassette.

Position: Patient sitting; head upright with nose and forehead resting against cassette and glabella to center of film.

Focal spot: Aline to point midway between right and left external auditory meati, after angling tube 15° toward feet.

Precautions: Remove hairpins, dentures, etc.; midsagittal plane perpendicular to film; plane through external auditory meati and external canthi perpendicular to film; suspended respiration.

Additional: Extension cylinder; fixation band; 1 mm. aluminum filter; vertical cassette holder.

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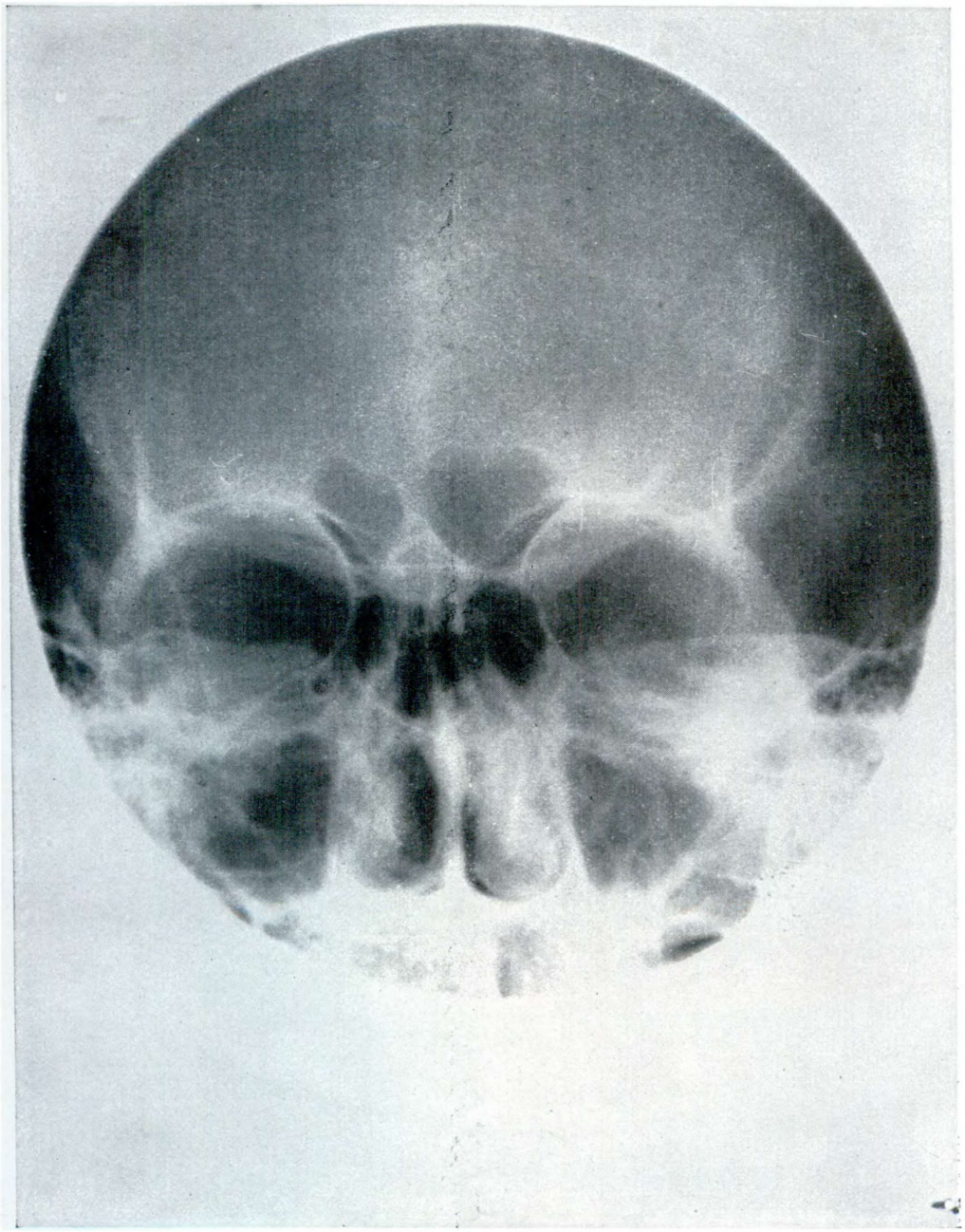


FIGURE 91B.—Para-nasal sinuses, nose-forehead position.

Technical factors

Distance: 30". Cone: Advisable (compensate Ma.S.). (Measure plane through base of occiput and supra-orbital ridge.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens			25 Ma.S.					20 Ma.S.			

(Basic Ma.S. 500)

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FIGURE 92A.—Para-nasal sinuses, lateral position.

Positioning instructions

Film: 8 x 10, widthwise; cassette.

Position: Patient sitting; head upright, laterally, side for special study to film; external canthus to center of film.

Focal spot: Aline to external canthi.

Precautions: Remove hairpins, dentures, etc.; midsagittal plane parallel to film (in both dimensions).

Additional: Extension cylinder; fixation band; 1 mm. aluminum filter; vertical cassette holder.

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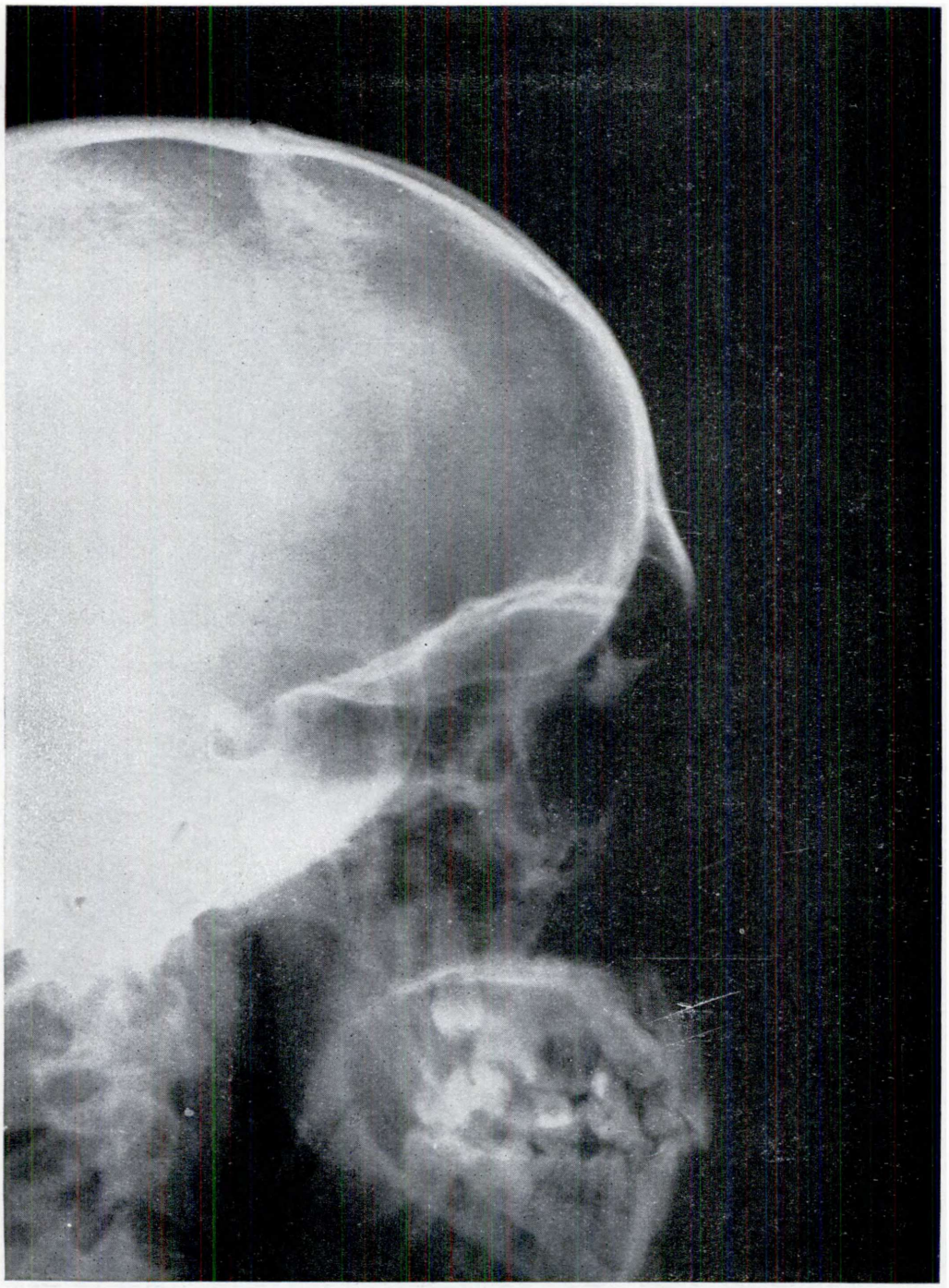


FIGURE 92B.—Para-nasal sinuses, lateral position.

	Technical factors								
Distance: 30″. Cone: advisable (compensate Ma.S.). (Measure plane laterally across temporal fossa.)									
Cms. thickness:	11	12	13	14	15	16	17	18	19
Variable Kv.P.:	72	74	76	78	80	82	84	86	88
With medium speed screens		12 Ma.S.				10 Ma.S.			

(Basic Ma.S. 250)

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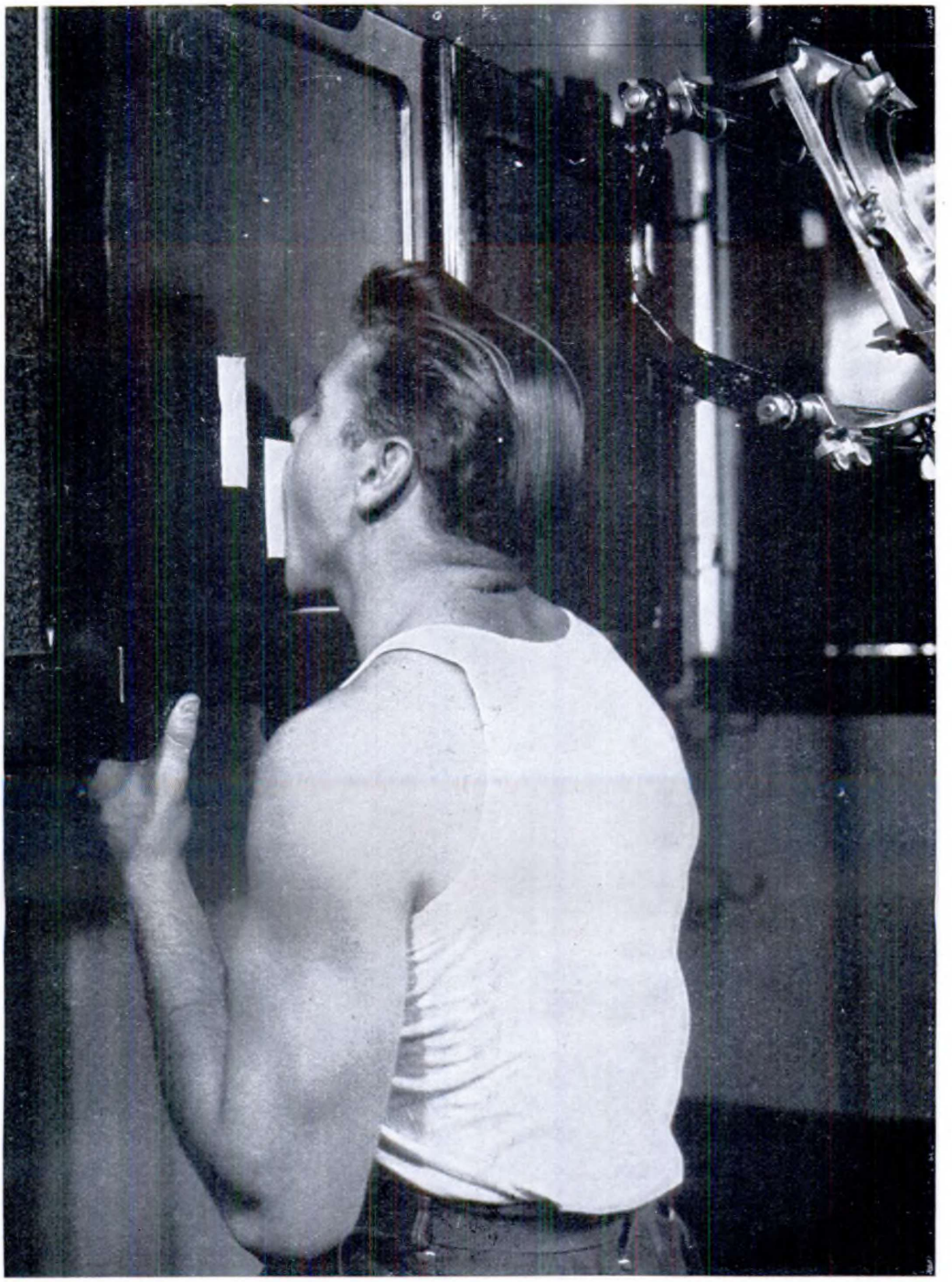


FIGURE 93A.—Para nasal sinuses, sphenoid open mouth.

Positioning instructions

Film: 8 x 10, lengthwise; cassette.
Position: Patient sitting; head upright with chin and open mouth resting against cassette and corners of mouth to midlength of film.
Focal spot: Aline through center of open mouth, after angling tube 30° toward feet.
Precautions: Remove hairpins, dentures, etc.; midsagittal plane perpendicular to film; suspended respiration.
Additional: Extension cylinder; fixation band; 1 mm. aluminum filter; vertical cassette holder.

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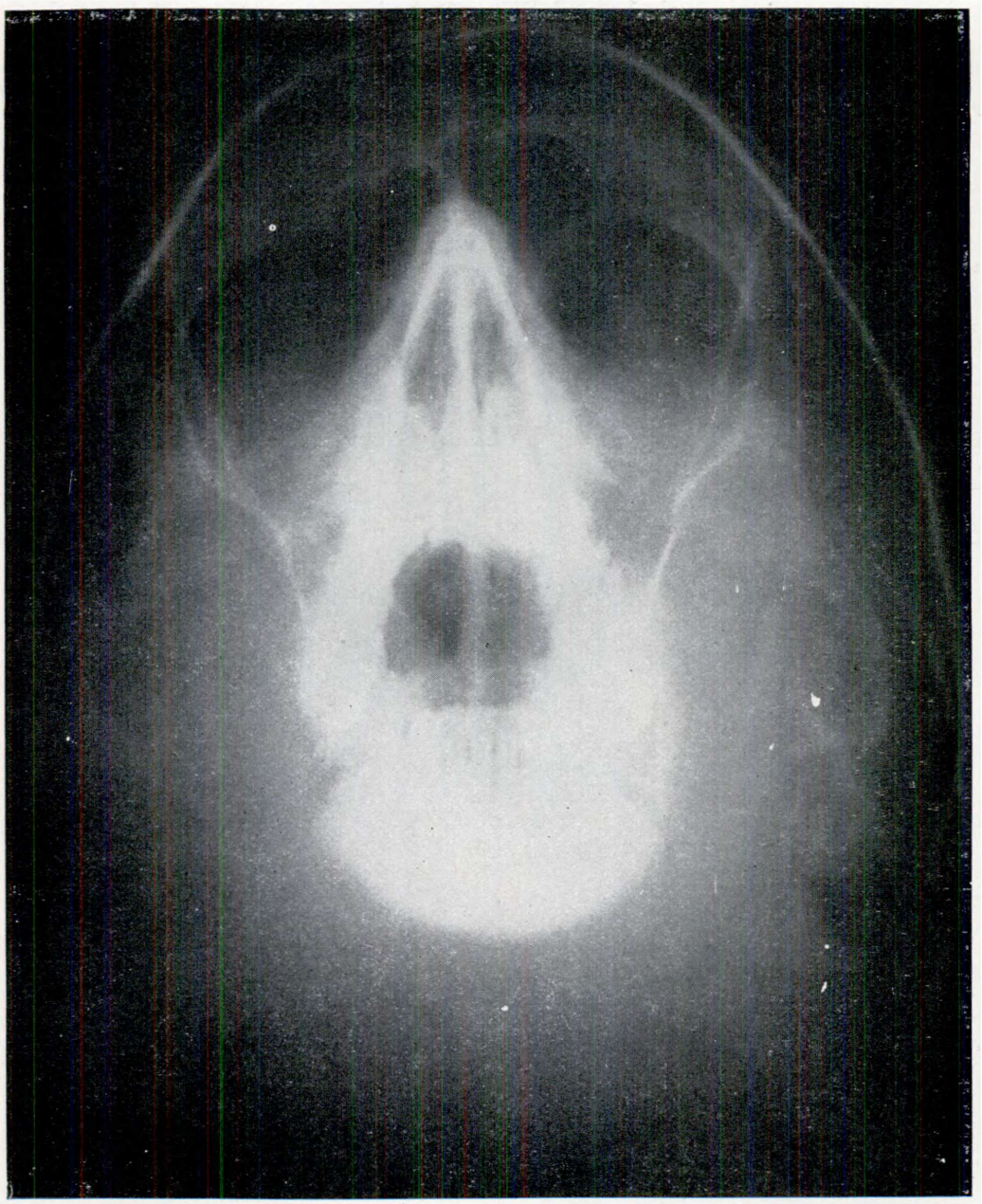


FIGURE 93E.—Para-nasal sinuses, open mouth position.

Technical factors

Distance: 30″. Cone: Advisable (compensate Ma.S.). (Measure plane, superior occiput through corners of mouth.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24	25
Variable Kv.P.:	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	25 Ma.S. (Basic Ma.S. 500)						20 Ma.S.					

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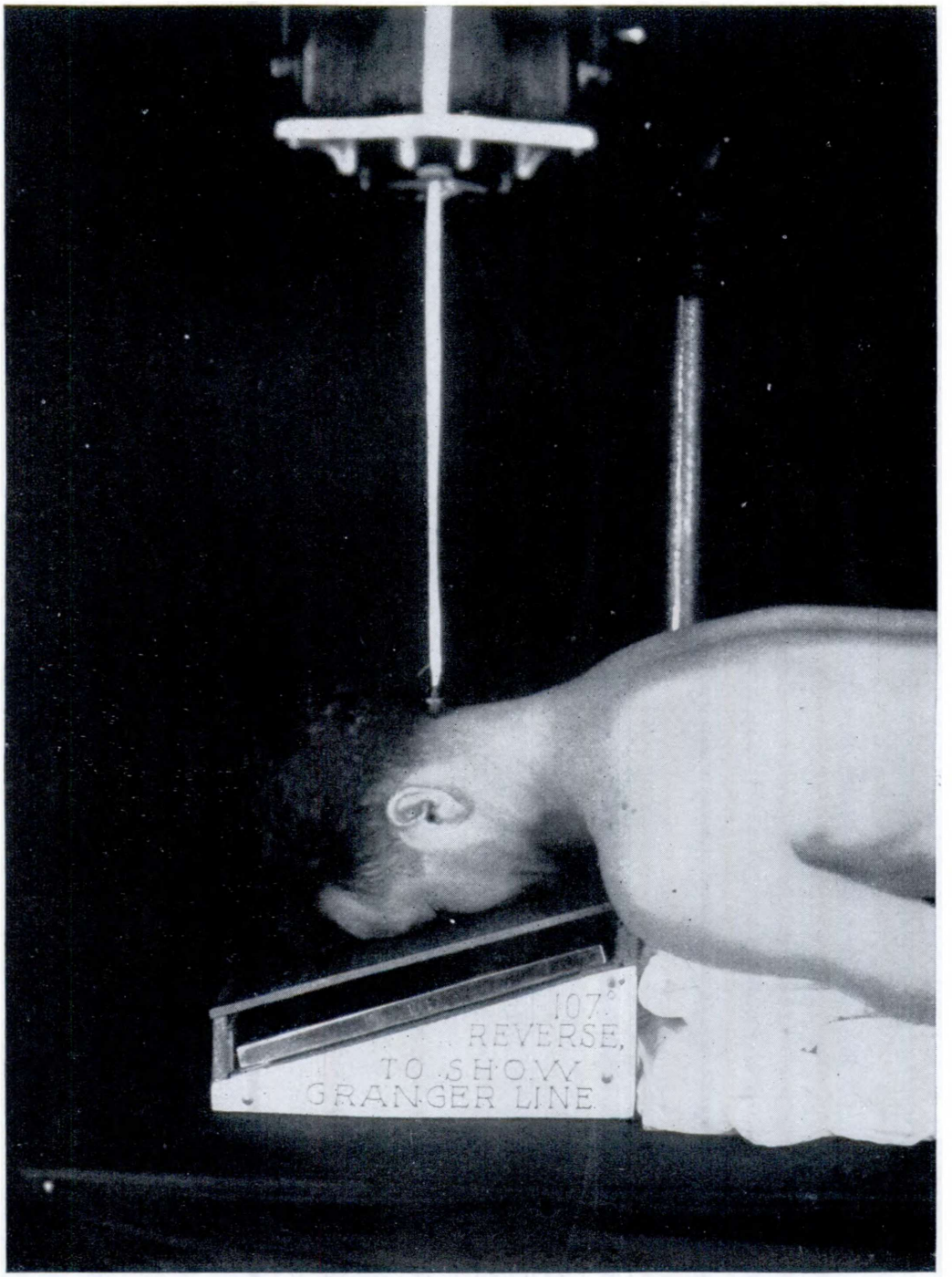


FIGURE 94A.—Para-nasal sinuses, Granger 107°

Positioning instructions

Film: 8 x 10, lengthwise; cassette.
Position: Patient prone; chest raised with pillows; head resting on angle board (reverse 17°) with nose in opening and weight supported by forehead and upper jaw.
Focal spot: Aline to point midway between external auditory meati.
Precautions: Remove hairpins, dentures, etc.; midsagittal plane perpendicular to film; suspended respiration.
Additional: Extension cylinder; 1 mm. aluminum filter; Granger angle board.

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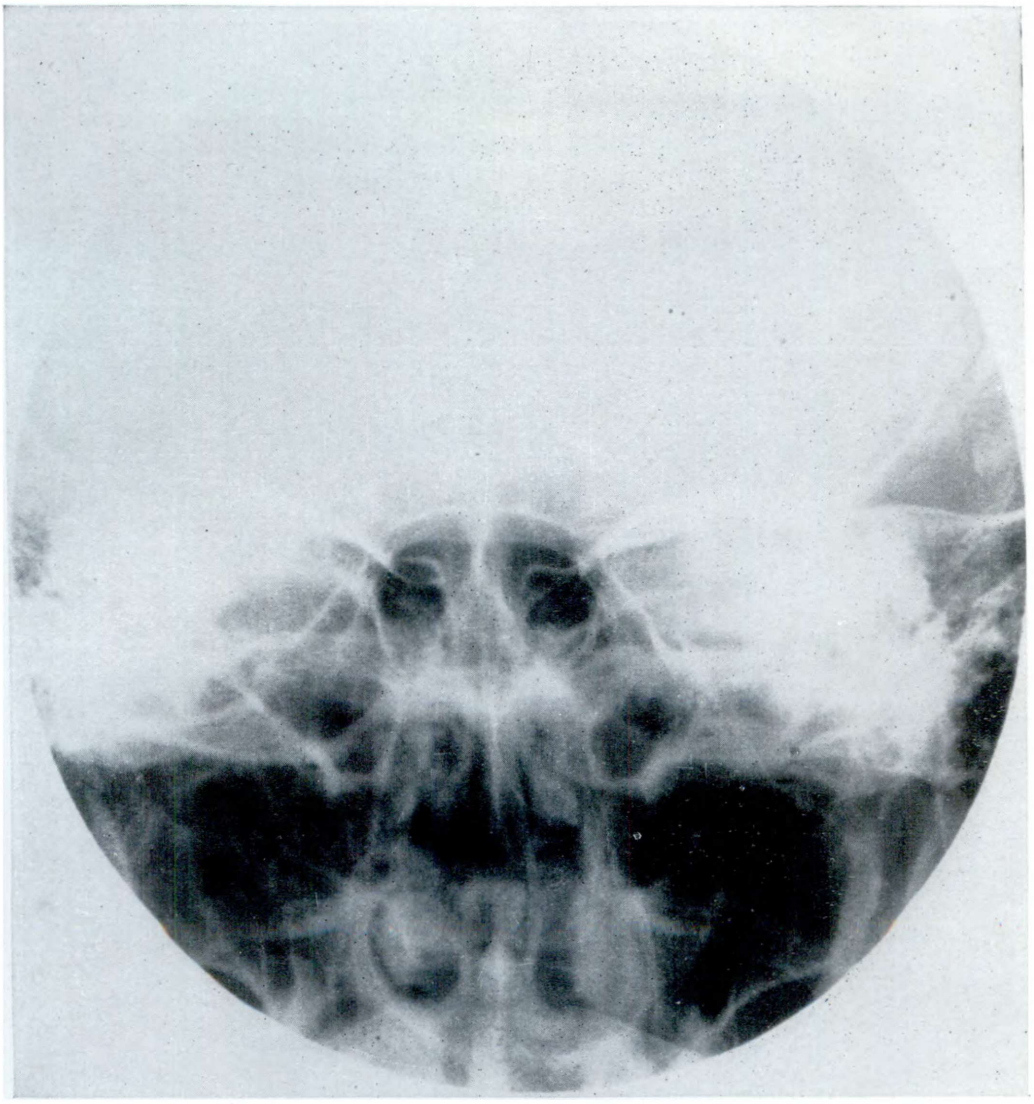


FIGURE 94B.—Para-nasal sinuses, 107° position.

Technical factors

Distance: 30". Cone: Advisable (compensate Ma.S.). (Measure plane through base of occiput and supra-orbital ridge.)

Cms. thickness:	14	15	16	17	18	19	20	21	22	23	24
Variable Kv.P.:	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	36 Ma.S.					30 Ma.S.					

(Basic Ma.S. 750)

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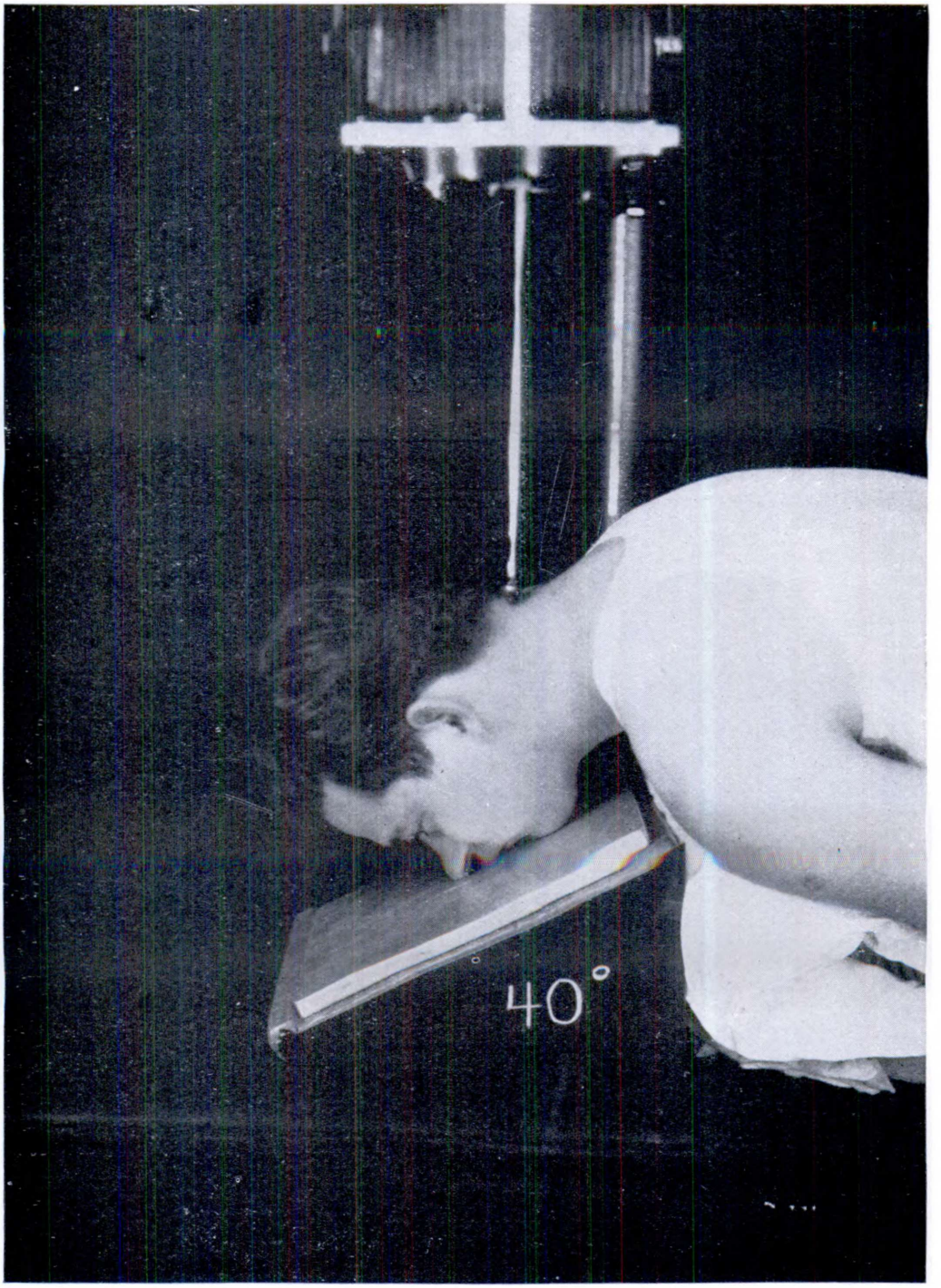


FIGURE 95A.—Mandible, P. A. (for Symphisis).

Positioning instructions

Film: 8 x 10, lengthwise; cassette.

Position: Patient prone; chest raised with pillows; head resting on angle board (reverse 40°) with tip of nose to center of film.

Focal spot: Aline to point midway between angles of mandibles.

Precautions: Remove hairpins, dentures, etc.; midsagittal plane perpendicular to film; suspended respiration.

Additional: Cone; fixation band; 1 mm. aluminum filter; angle board (reverse 40°).

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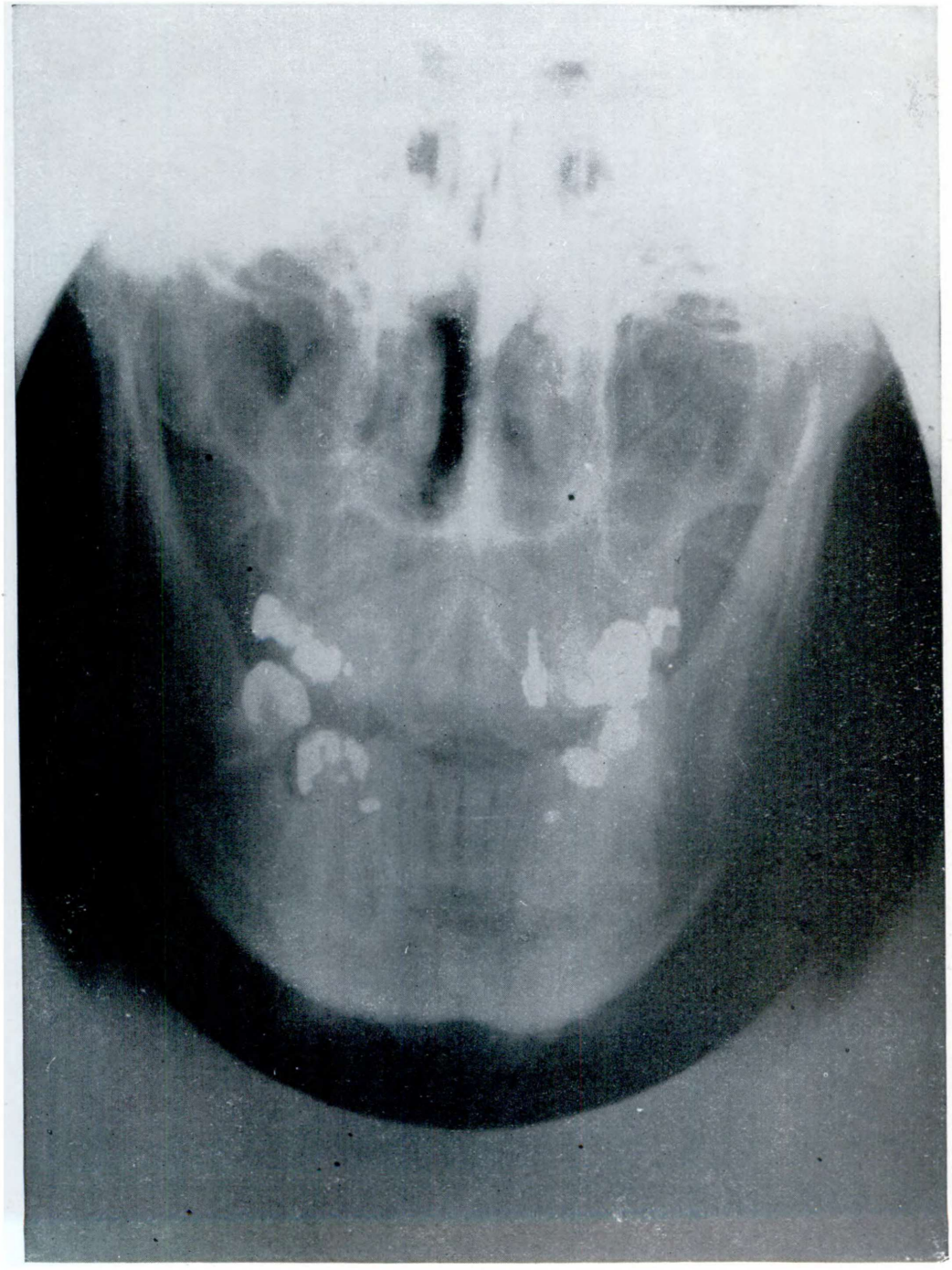


FIGURE 95B.—Mandible, P. A.

Technical factors

Distance: 30". Cone: optional (compensate Ma.S.). (Measure plane beneath occiput extending through symphisis.)

Cms. thickness:	11	12	13	14	15	16	17	18
Variable Kv.P.:	72	74	76	78	80	82	84	86
With medium speed screens		10 Ma.S.				8 Ma.S.		
Using grid (5–1 ratio)		24 Ma.S.						

(Basic Ma.S. 200)

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FIGURE 96A.—Mandible, lateral.

Positioning instructions

Film: 8 x 10, lengthwise; cassette.
Position: Patient prone; chest raised with pillows; head resting laterally on reverse 15° angle board with angle of mandible to center of film.
Focal spot: Aline to point 1 cm. posterior to angle of uppermost mandible (tilt tube 10° toward eyes).
Precautions: Remove hairpins, dentures, etc.; chin extended; head rotated to contour of face; suspended respiration.
Additional: Cone; fixation band; 1 mm. aluminum filter; angle board (reverse 15°).

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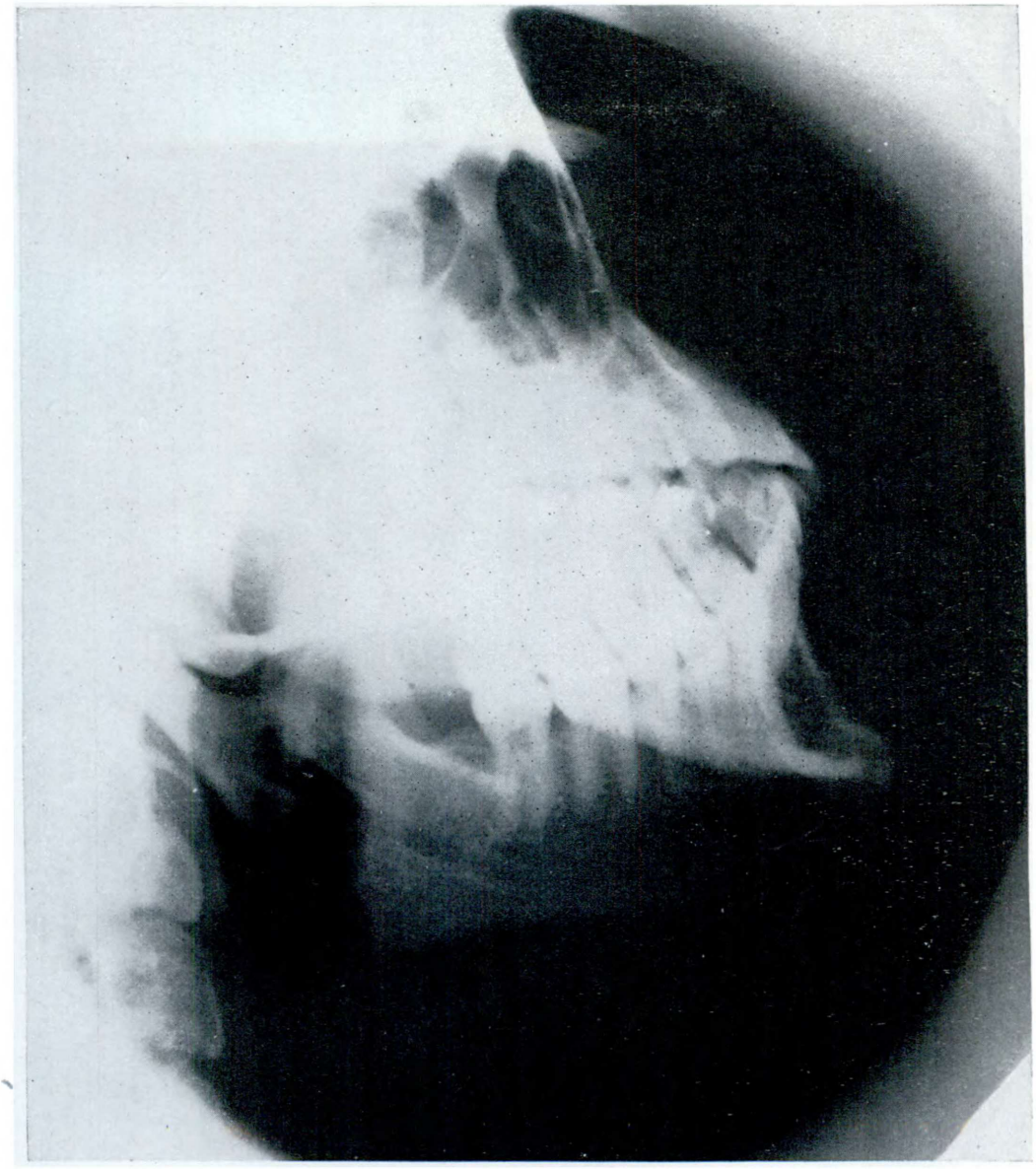


FIGURE 96B.—Mandible, lateral.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through angles of mandibles, laterally.)

Cms. thickness:	8	9	10	11	12	13	14	15	16
Variable Kv.P.:	66	68	70	72	74	76	78	80	82
With medium speed screens				10 Ma.S.				8 Ma.S.	
With medium speed screens Using grid (5–1 ratio)				24 Ma.S.					

(Basic Ma.S. 200)

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FIGURE 97A.—Mandible. Temporo-mandibular articulation.

Positioning instructions

Film: 8 x 10, lengthwise; cassette.

Position: Patient prone; forearms flexed under chest; head resting laterally with external auditory meatus (side for study) to center of film.

Focal spot: Aline to point 5 cms. above uppermost external auditory meatus.

Precautions: Chin extended; head rotated to contour of face.

Additional: Extension cylinder; fixation band; 1 mm. aluminum filter.

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FIGURE 97B.—Mandible (temporo-mandibular articulation).

Technical factors

Distance: 30″. Cone: Advisable (compensate Ma.S.). (Measure plane through external auditory meati and external canthi, laterally.)

Cms. thickness:	11	12	13	14	15	16	17	18	19
Variable Kv.P.:	62	64	66	68	70	72	74	76	78
With medium speed screens		22 Ma.S.					20 Ma.S.		

(Basic Ma.S. 400)

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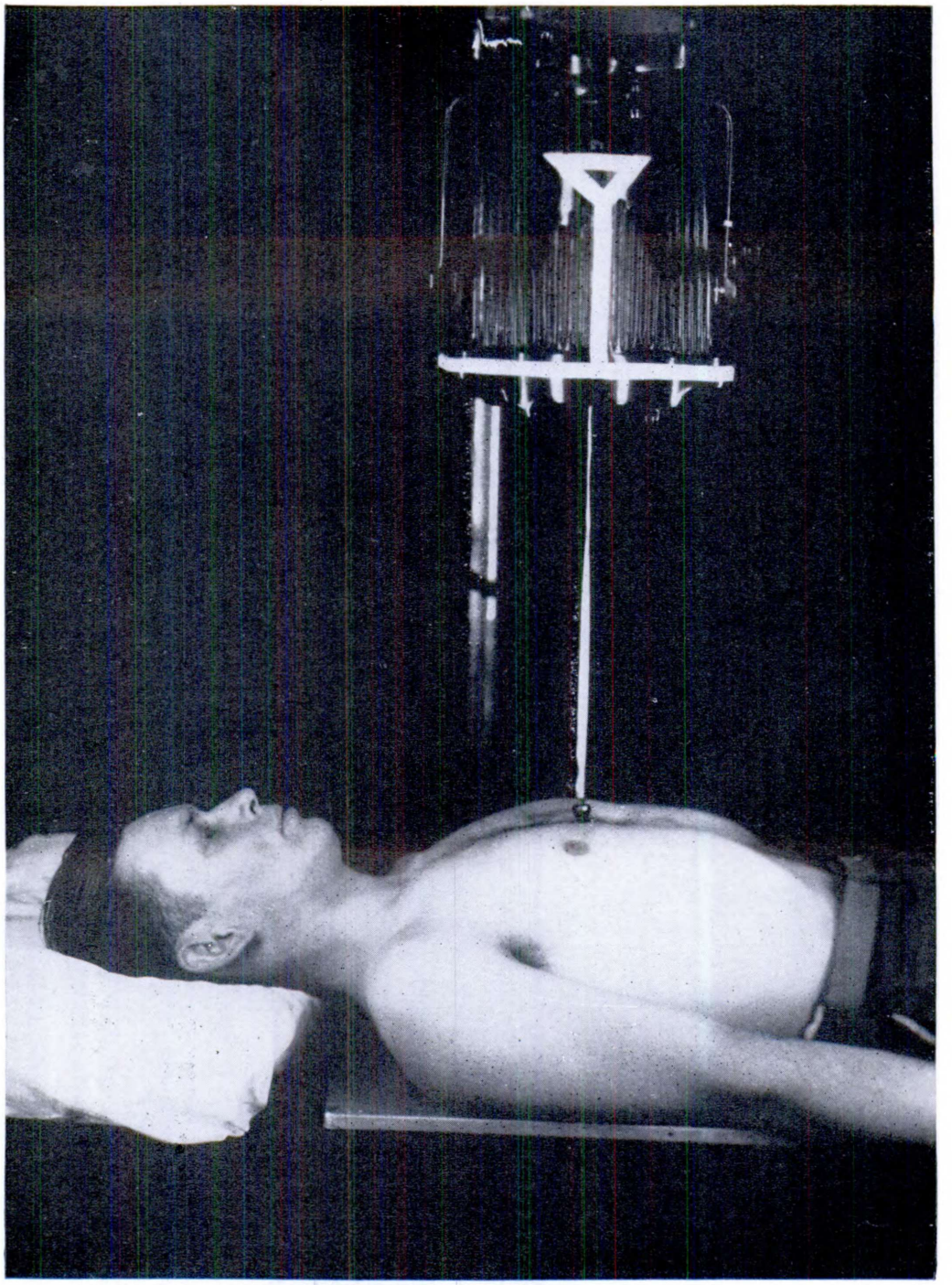


FIGURE 98A.—Chest, bedside.

Positioning instructions

Film : 14 x 17, lengthwise ; cassette.
Position : Patient supine to midwidth of film ; acromial processes 7 cms. below upper border of cassette.
Focal spot : Aline to center of film.
Precautions : Suspended inspiration ; minimal exposure time.
Additional : Mobile X-ray unit (bedside).

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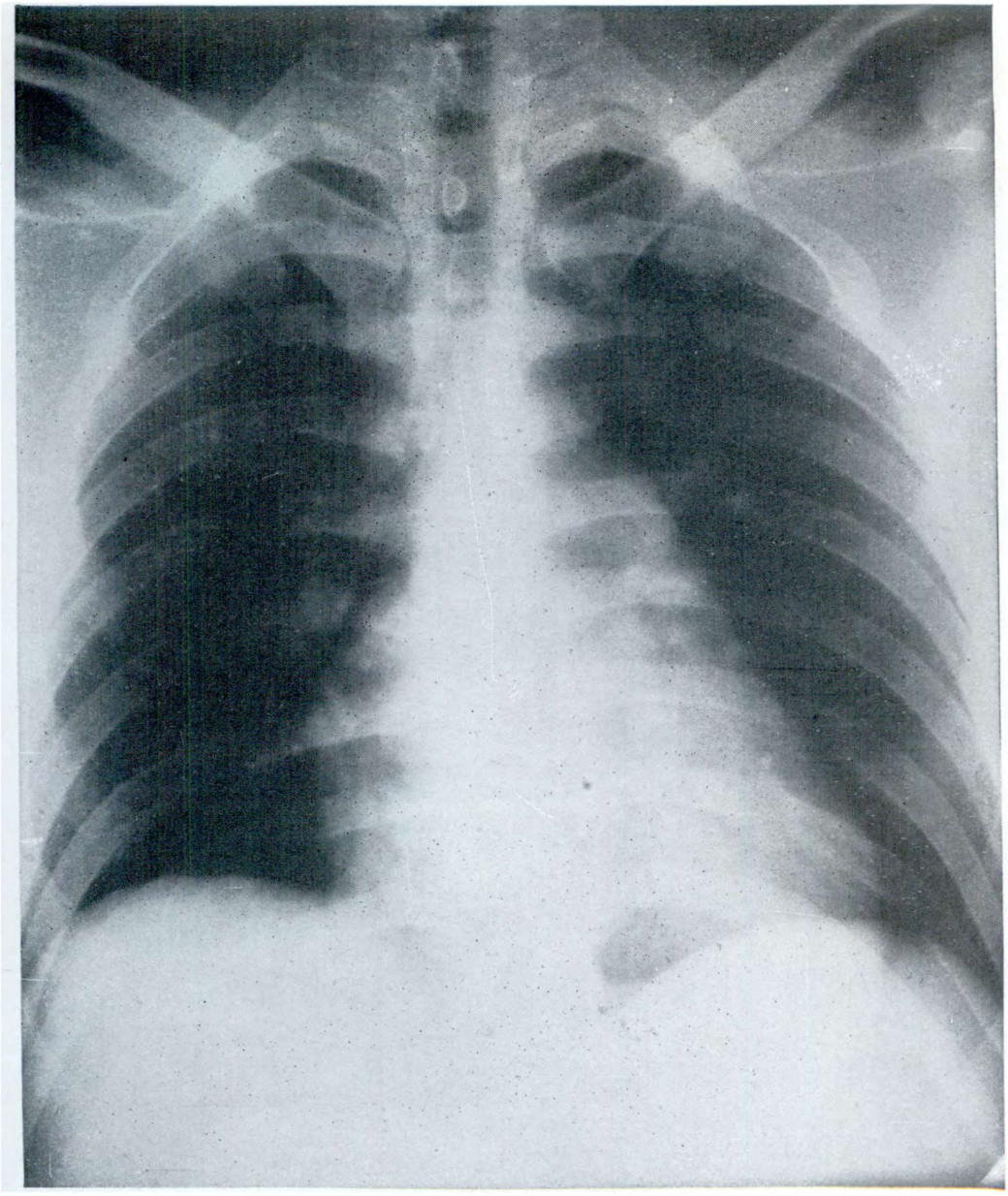


FIGURE 98B.—Chest, bedside.

Technical factors

Distance: 30″. Cone: No. (Measure plane through 6th thoracic, A. P.)																				
Cms. thickness:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	10 Ma.S.				8 Ma.S. (Basic Ma.S. 150)					7 Ma.S.					6 Ma.S.					

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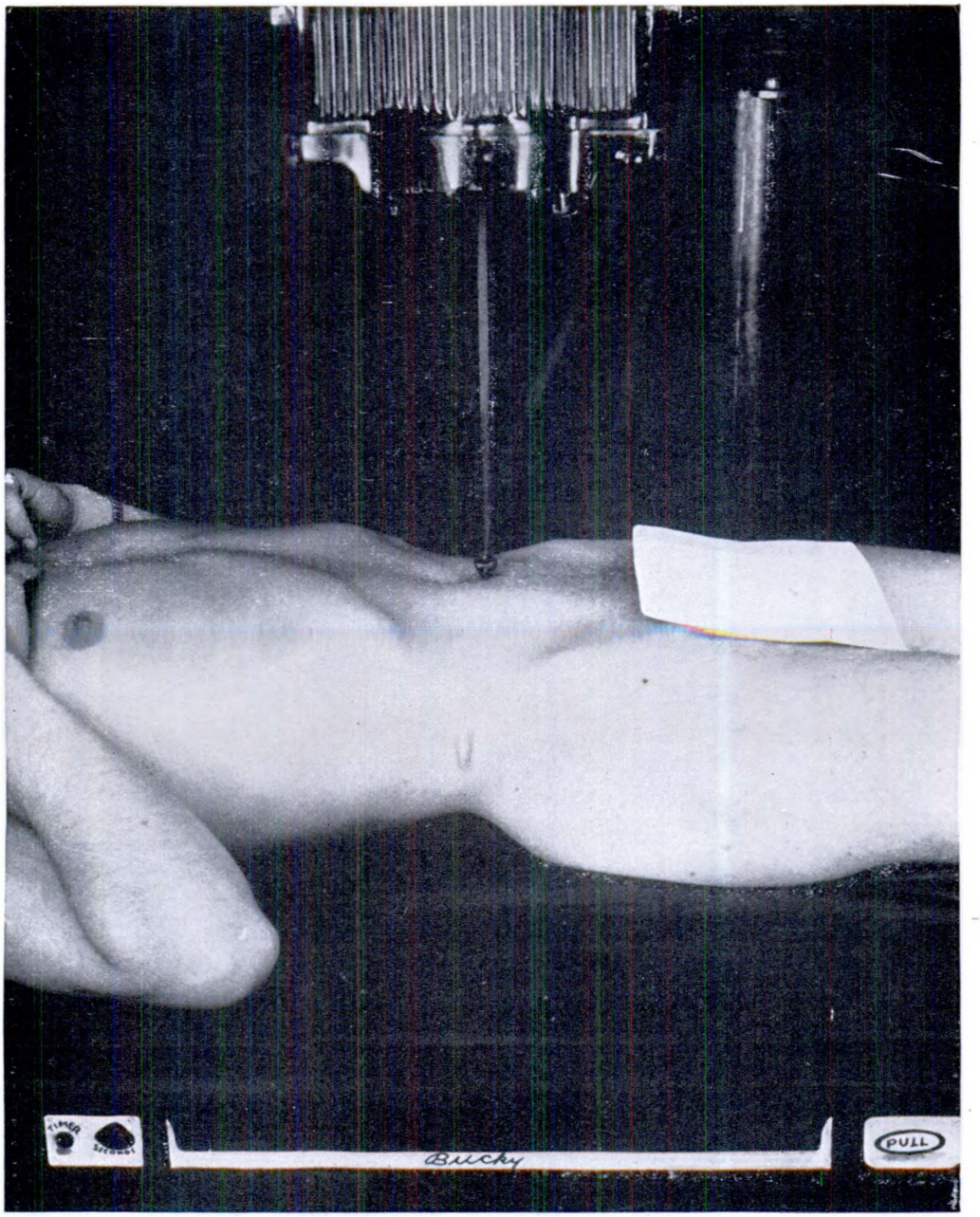


FIGURE 99A.—Kidneys, ureters, and bladder

Film: 14 x 17, lengthwise; cassette.
Position: Patient supine; level of iliac crests to midlength of film.
Focal spot: Aline to center of film.
Precautions: Suspended expiration; minimal exposure time—high Ma., large focal spot.
Additional: Fixation band; pneumatic bag; tilting table; grid.

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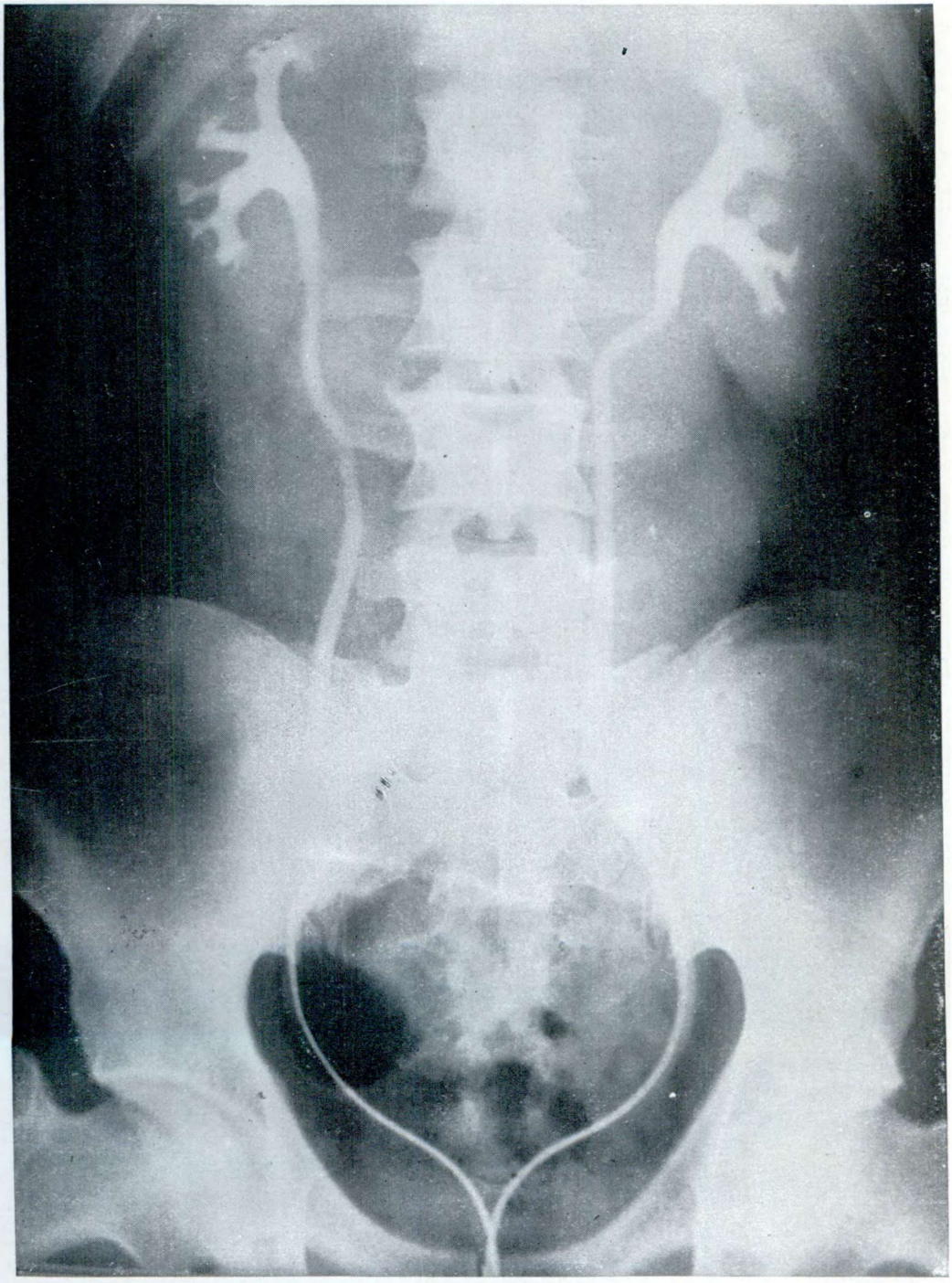


FIGURE 99B.—Kidneys, ureters, and bladder.

Technical factors

Distance: 30''.	Cone: Optional (compensate Ma.S.).								(Measure plane across iliac crests.)							
Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	43 Ma.S.			33 Ma.S.					30 Ma.S.					24 Ma.S.		
Using grid (5–1 ratio)	130 Ma.S.			100 Ma.S. (Basic Ma.S. 600)					90 Ma.S.					72 Ma.S.		

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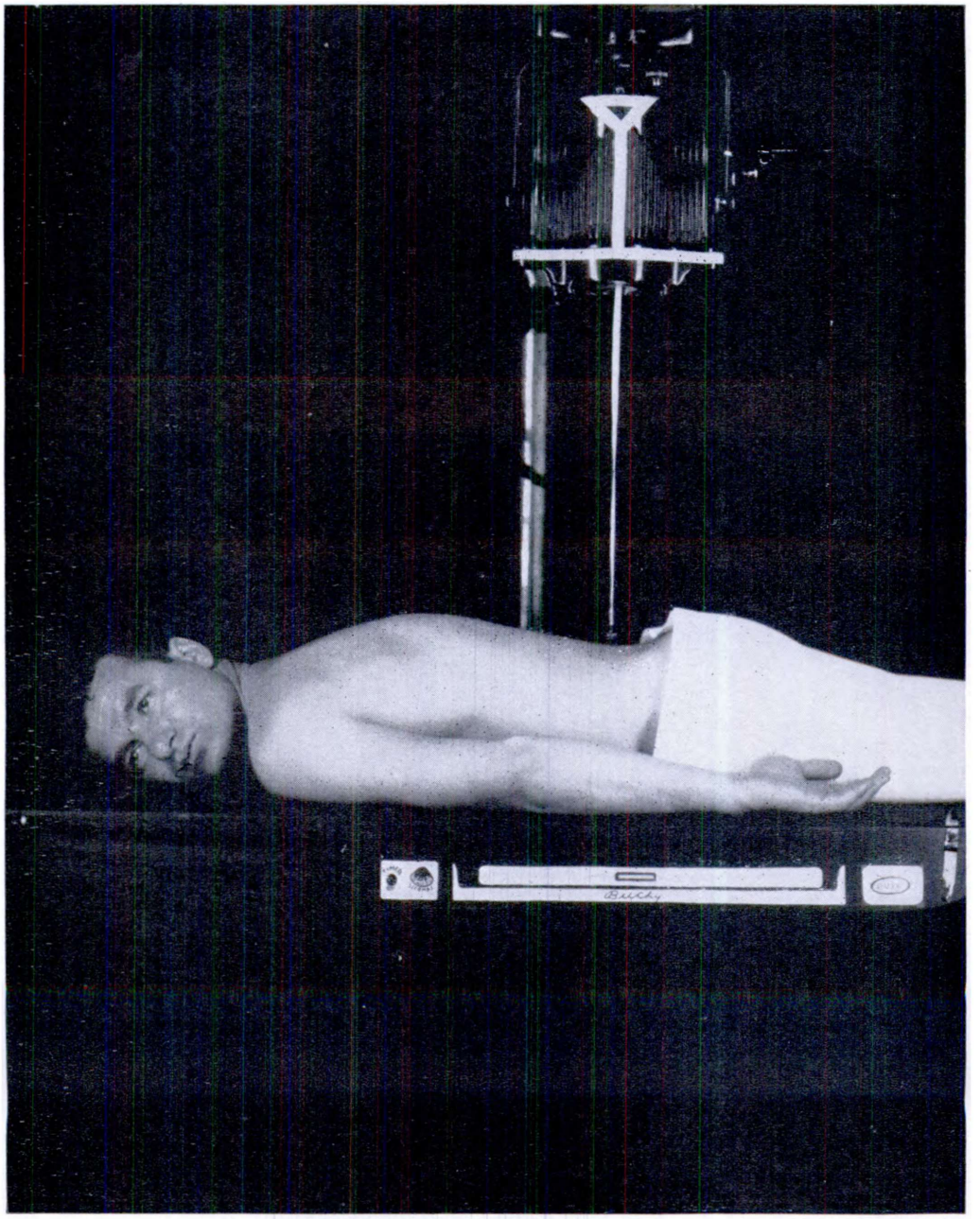


FIGURE 100A.—Barium enema.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient prone; level of iliac crests to midlength of film.
Focal spot: Aline to center of film.
Precautions: Suspended expiration; minimal exposure time—high Ma., large focal spot.
Additional: Grid; bolster under hip.

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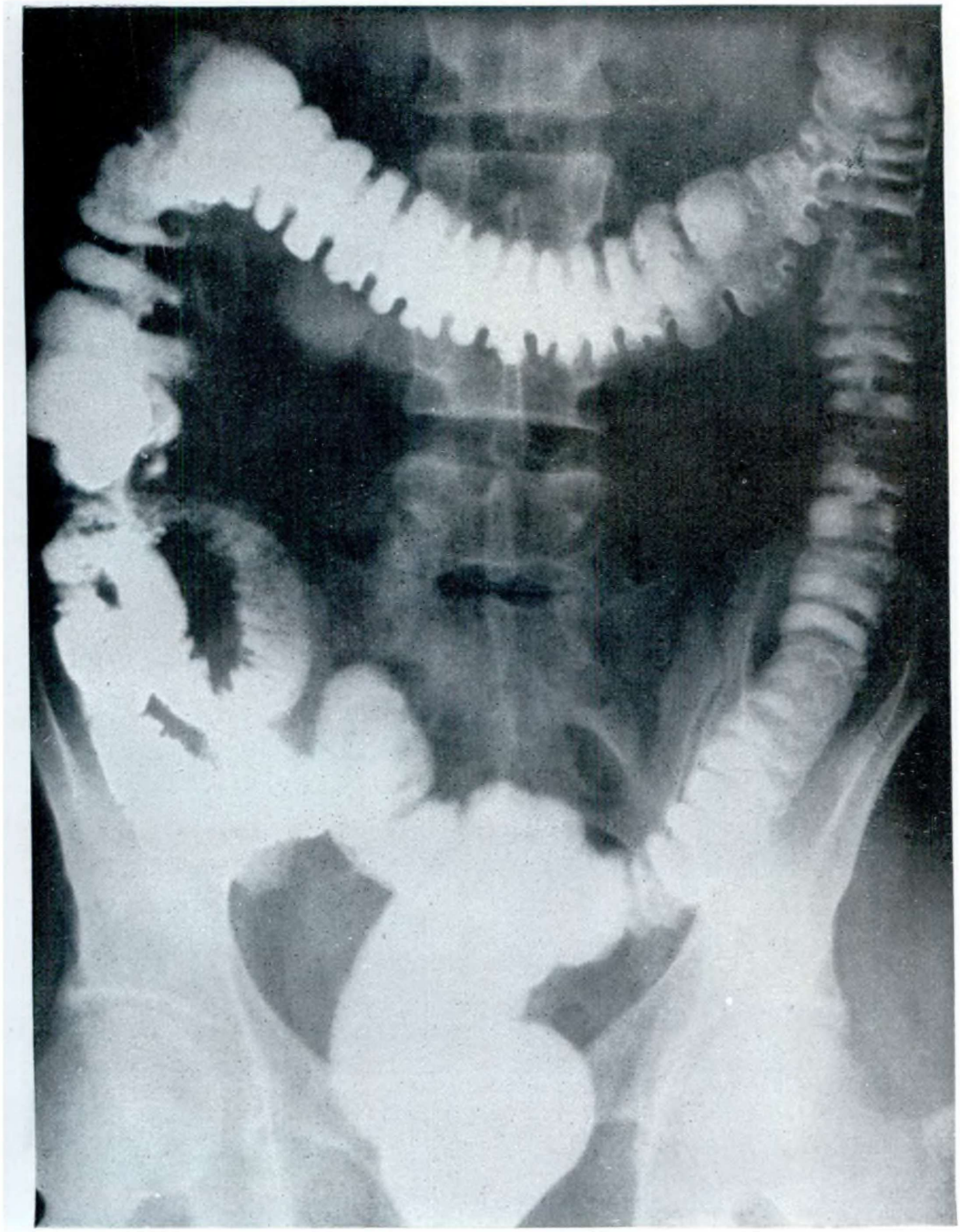


FIGURE 100B.—Barium enema.

Technical factors

Distance: 30″. Cone: No. (Measure plane through iliac crests, intero-posteriorly or obliquely.)																
Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	43 Ma.S.			33 Ma.S.					30 Ma.S.					24 Ma.S.		
Using grid (5–1 ratio)	130 Ma.S.			100 Ma.S. (Basic Ma.S. 600)					90 Ma.S.					72 Ma.S.		

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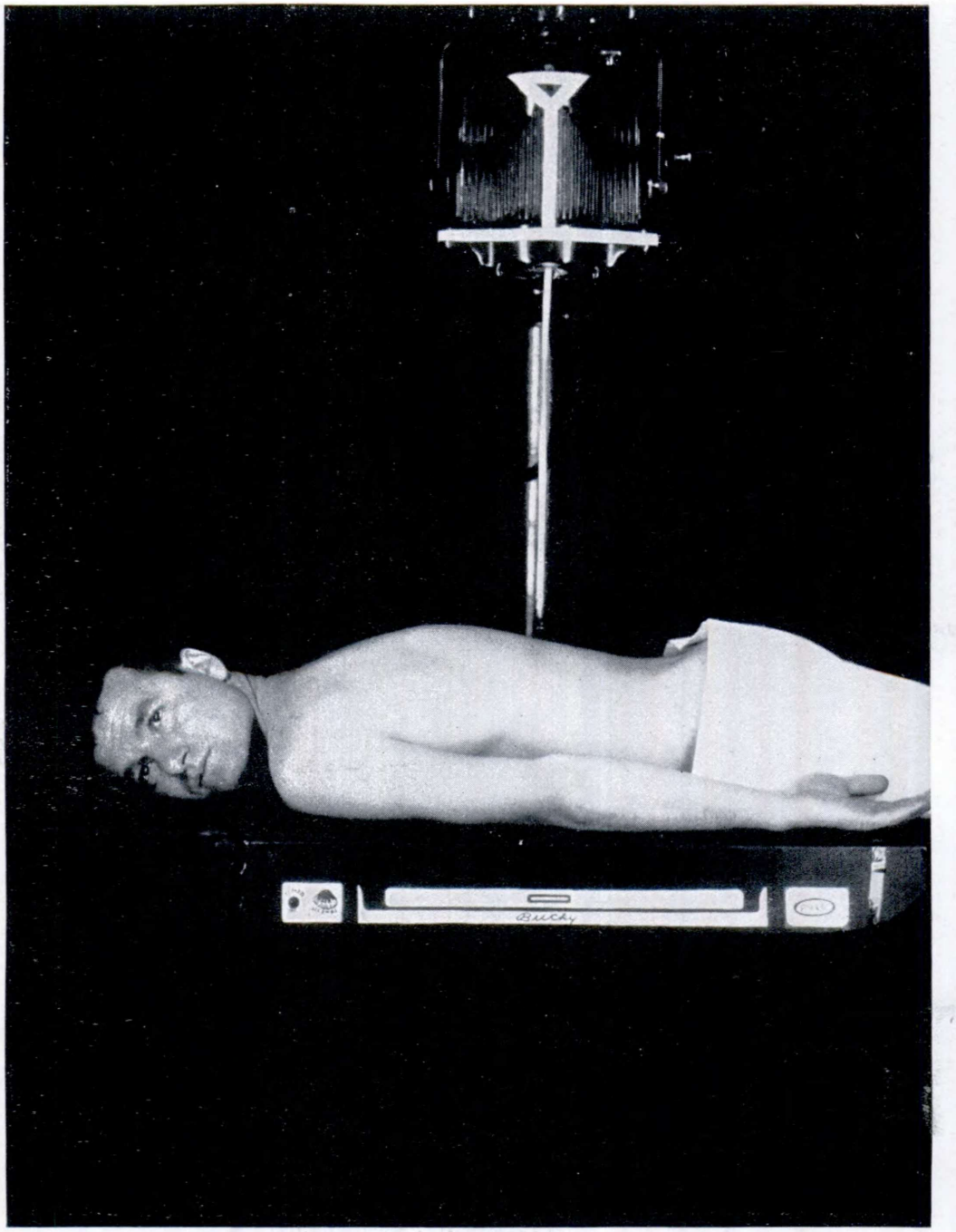


FIGURE 101A.—G. I. tract.

Positioning instructions

Film : 14 x 17, lengthwise ; cassette.
Position : Patient prone (rotated obliquely, if indicated) ; level of iliac crests 5 cms. below midlength of film.
Focal spot : Aline to center of film.
Precautions : Suspended expiration ; minimal exposure time—high Ma., large focal spot.
Additional : Grid ; bolster under hips.

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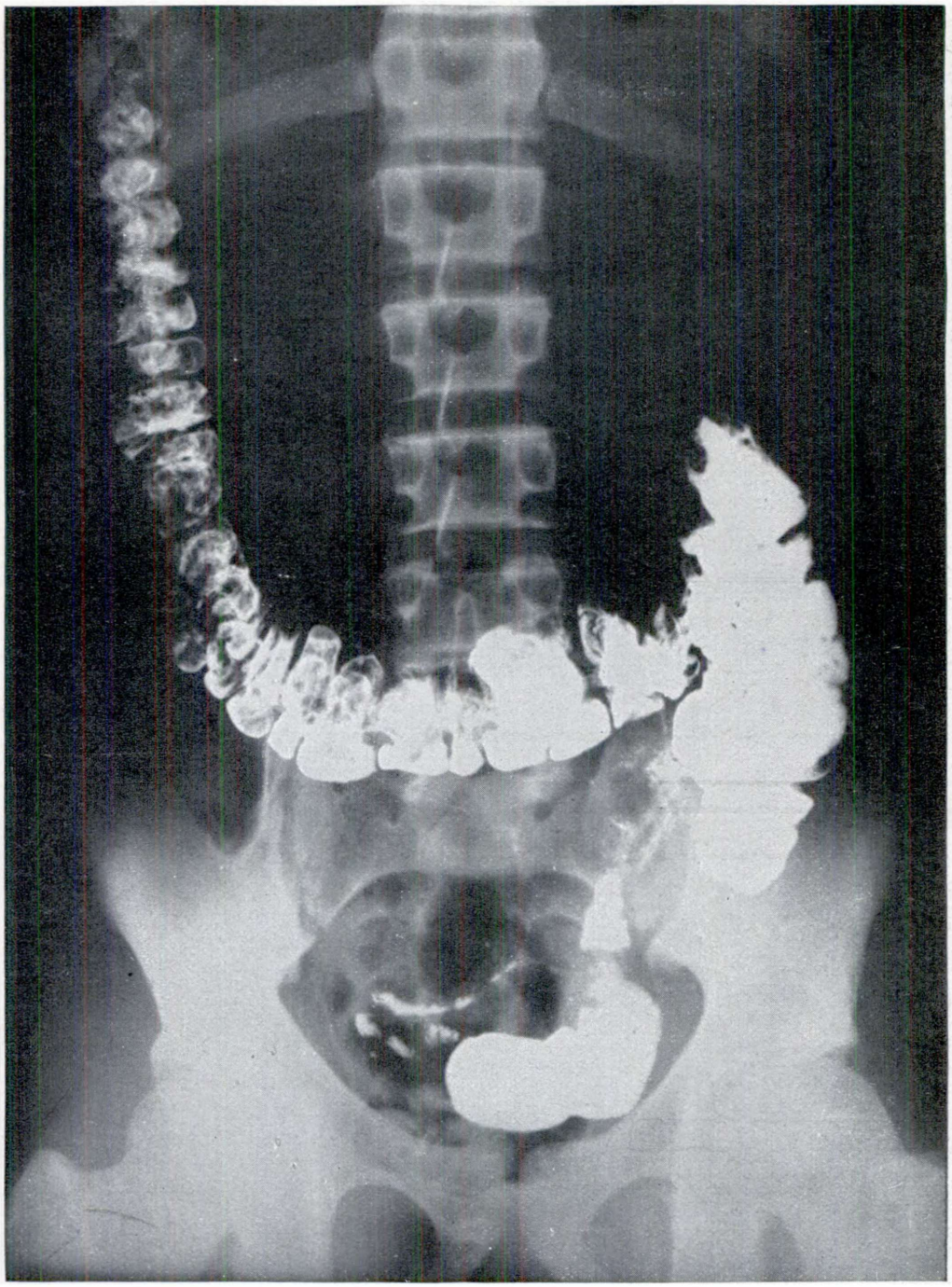


FIGURE 101B.—G. I. tract.

Technical factors

Distance: 30". Cone: No. (Measure plane through iliac crests, antero-posteriorly or obliquely).															
Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	43 Ma.S.			33 Ma.S.					30 Ma.S.					24 Ma.S.		
Using grid (5–1 ratio)	130 Ma.S.			100 Ma.S. (Basic Ma.S. 600)					90 Ma.S.					72 Ma.S.		

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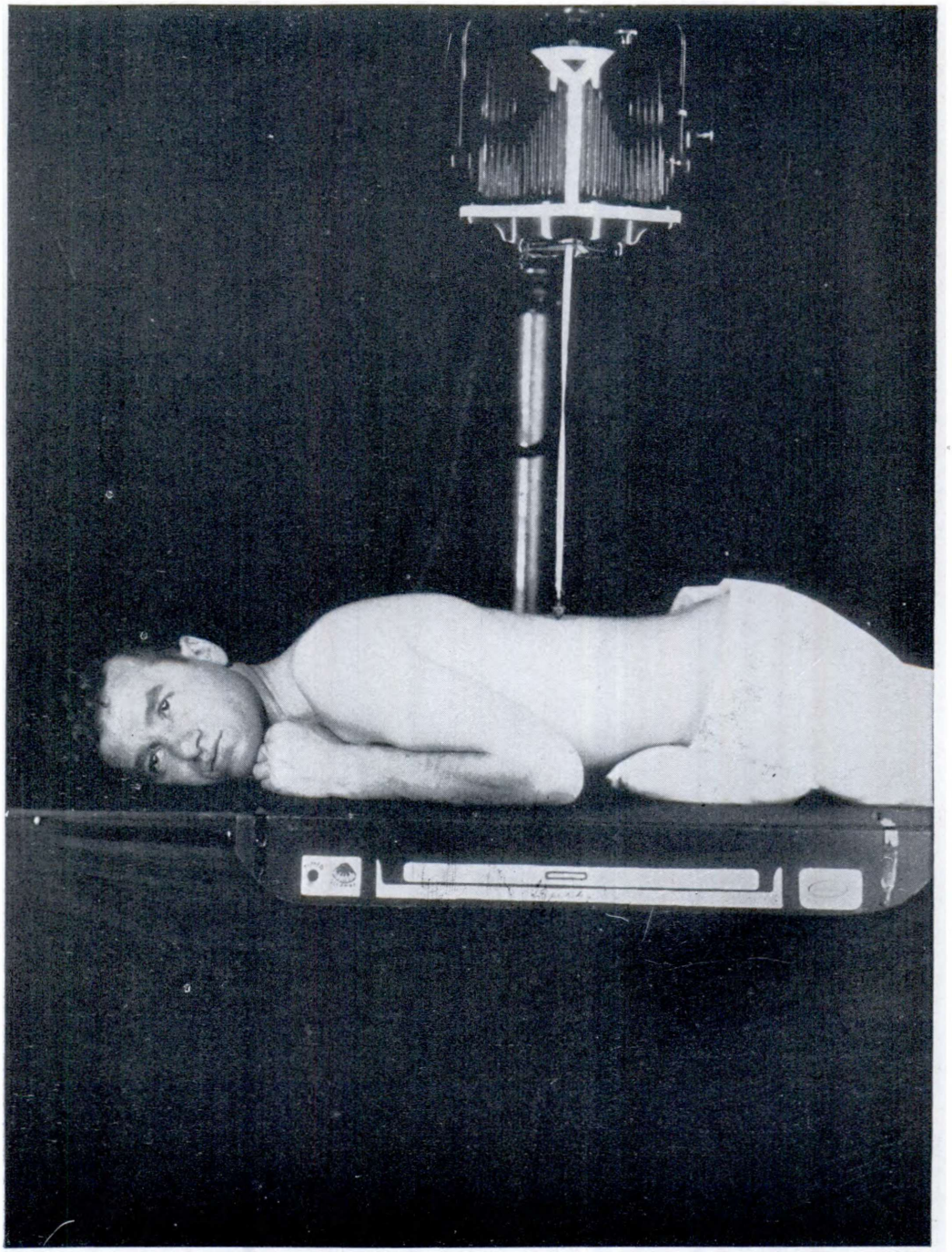


FIGURE 102A.—Stomach.

Positioning instructions

Film : 10 x 12, lengthwise ; cassette.
Position : Patient prone ; cassette under left upper quadrant, its lower border to level of iliac crest—or as indicated by marking at time of fluoroscopy.
Focal spot : Aline to center of film.
Precautions : Suspended expiration ; minimal exposure time—high Ma., large focal spot.
Additional ; Grid ; bolster under left hip.

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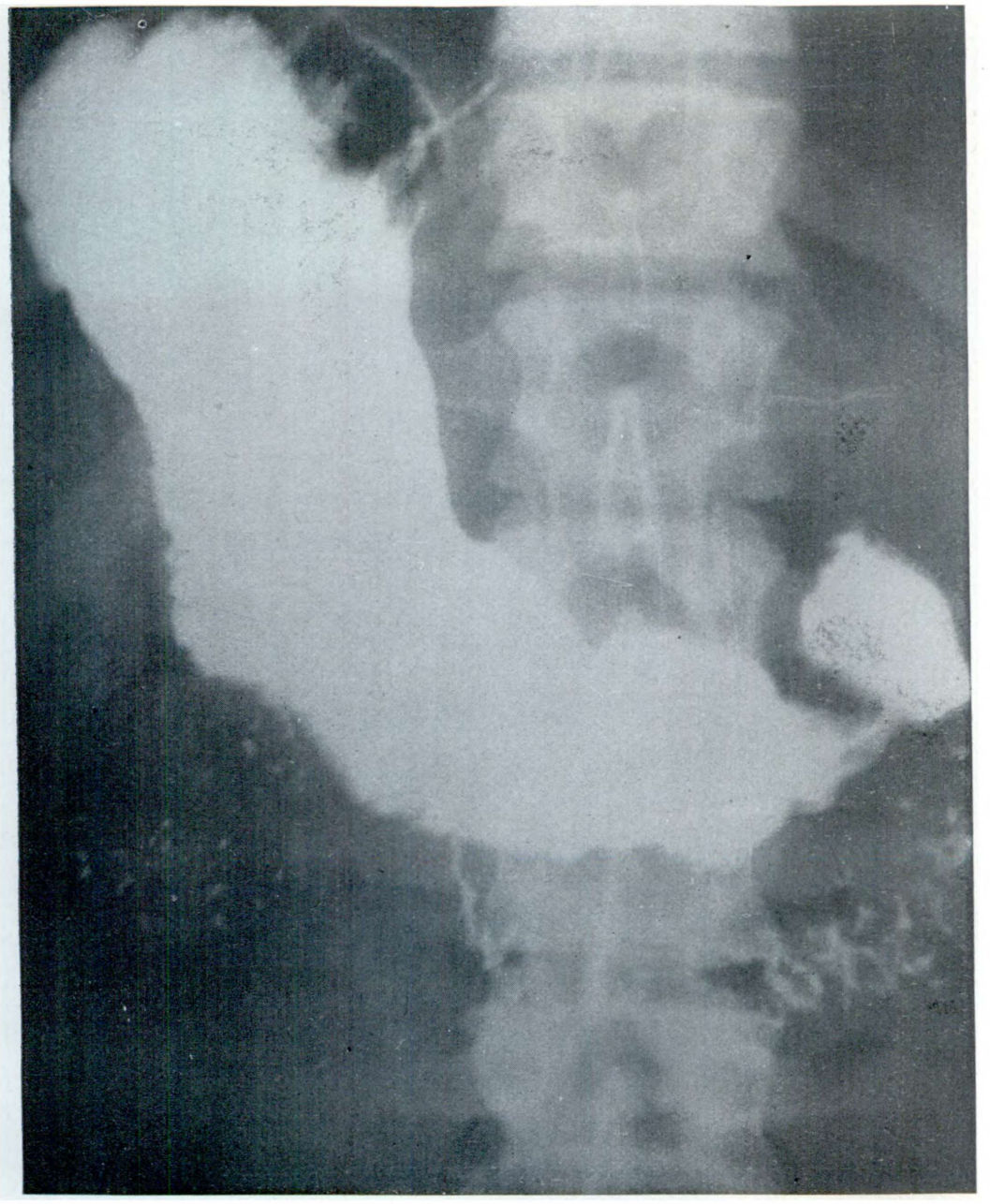


FIGURE 102B.—Stomach.

Technical factors

Distance: 30''. Cone: Advisable (compensate Ma.S.). (Measure plane through 12th thoracic vertebra.)

Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	43 Ma.S.			33 Ma.S.					30 Ma.S.					24 Ma.S.		
Using grid (5–1 ratio)	130 Ma.S.			100 Ma.S. (Basic Ma.S. 600)					90 Ma.S.					72 Ma.S.		

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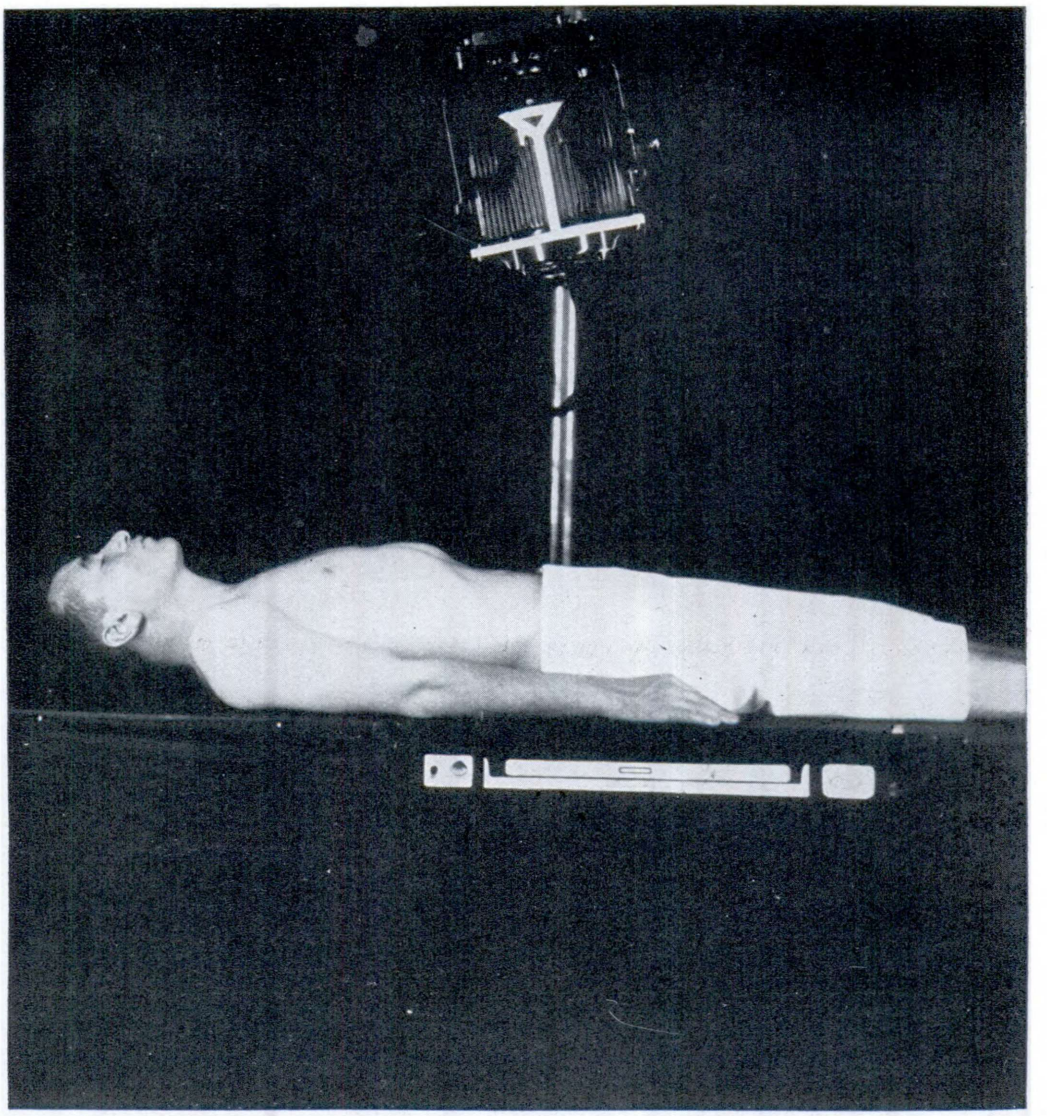


FIGURE 103A.—Urinary bladder.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient supine; level of greater trochanters to midlength of film.
Focal spot: Aline to umbilicus then angle tube toward feet, 15°.
Precautions: Suspended expiration.
Additional: Grid; fixation band.

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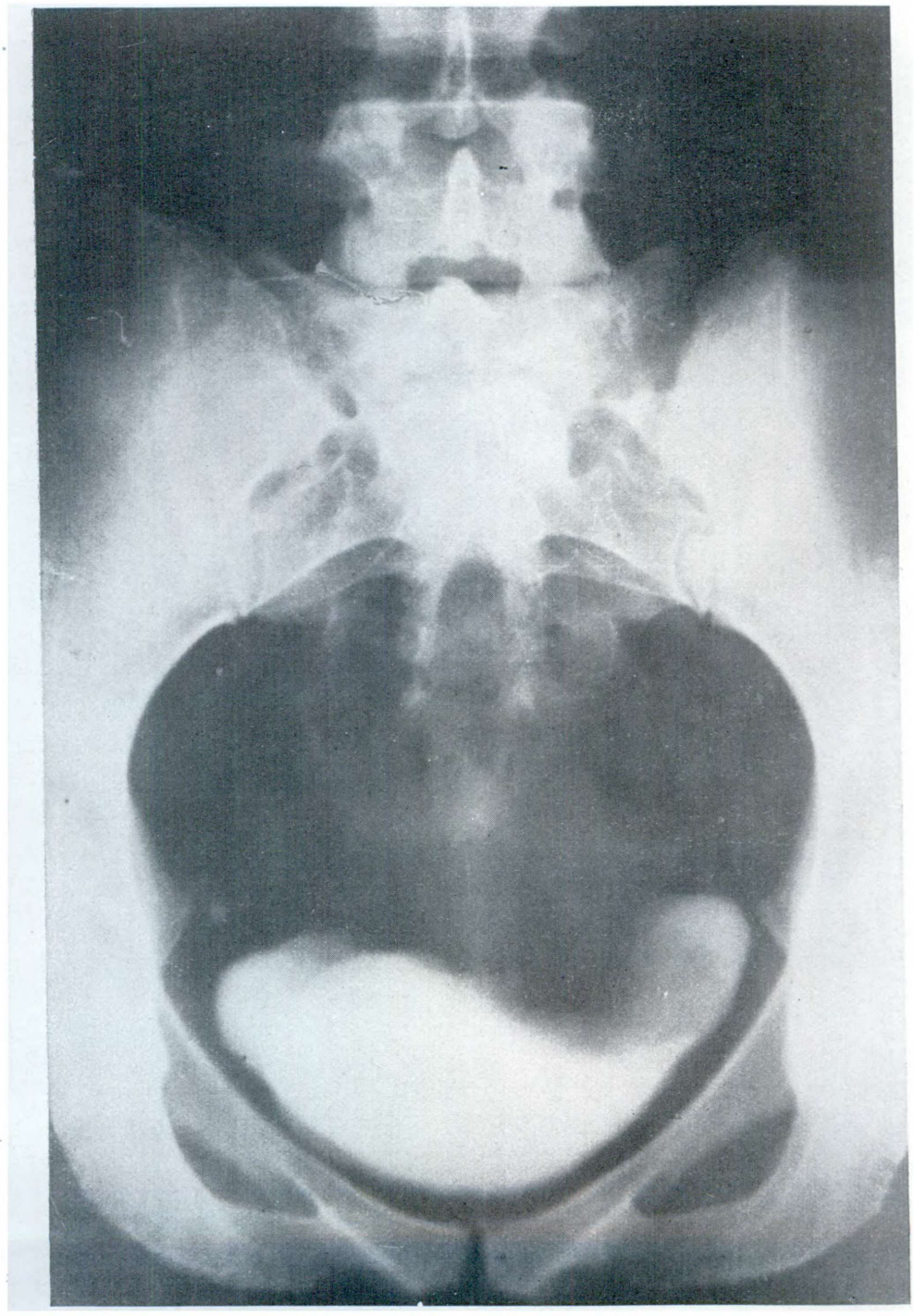


FIGURE 103B.—Urinary bladder.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through greater trochanter, antero-posteriorly.)

Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	43 Ma.S.			33 Ma.S.					30 Ma.S.					24 Ma.S.		
Using grid (5–1 ratio)	130 Ma.S.			100 Ma.S. (Basic Ma.S. 600)					90 Ma.S.					72 Ma.S.		

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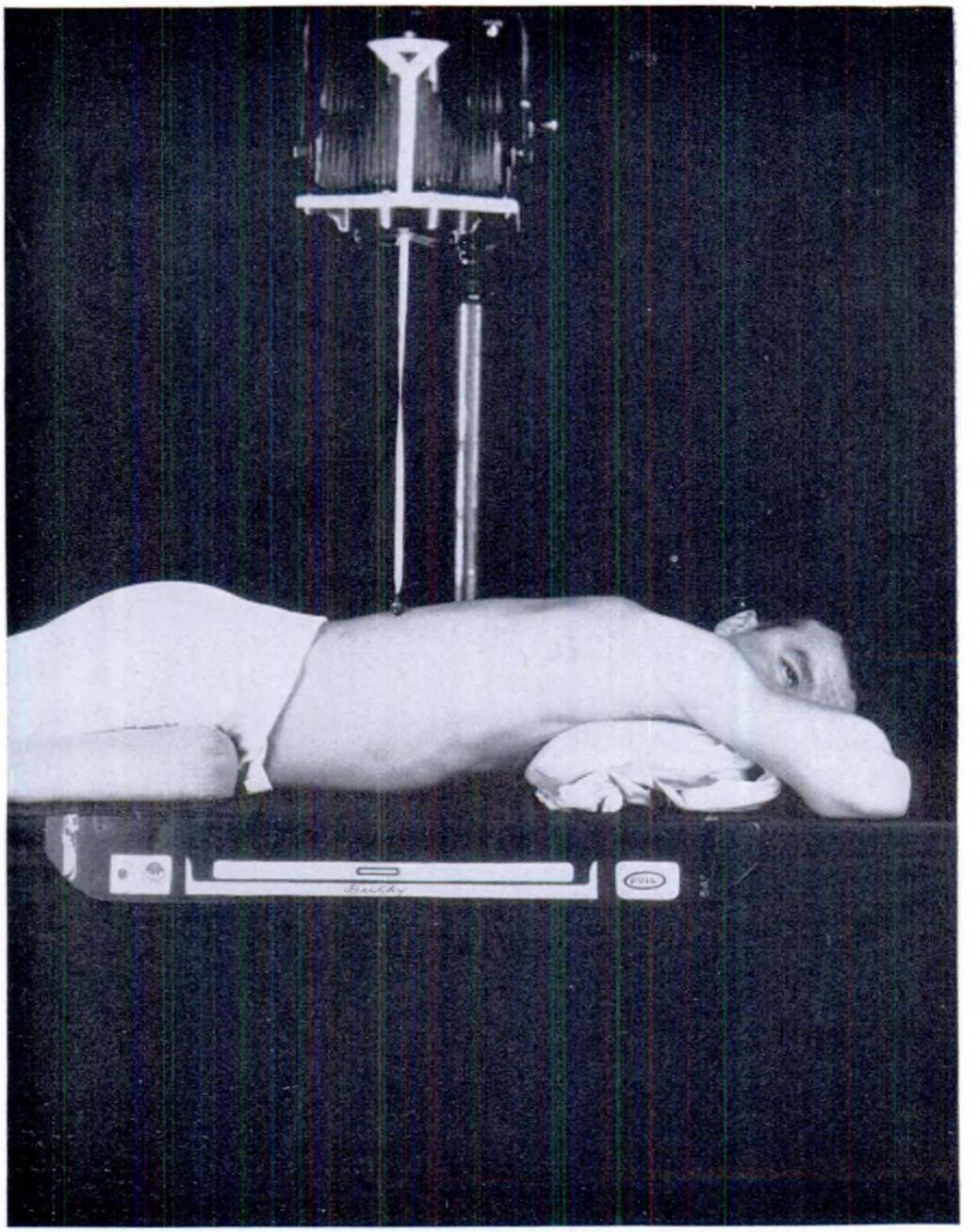


FIGURE 104A.—Gall bladder.

Positioning instructions

Film: 10 x 12, lengthwise; cassette.
Position: Patient prone; head resting on outstretched right forearm; left arm to side (slight rotation to the left); midscapular crossing of 12th rib to center of film. (Preliminary study—subsequently, change to location of gall bladder.)
Focal spot: Aline to center of film.
Precautions: Suspended expiration (as a routine); minimal exposure time—high Ma., large focal spot.
Additional: Sandbag under right shoulder and right hip; fixation band; grid.

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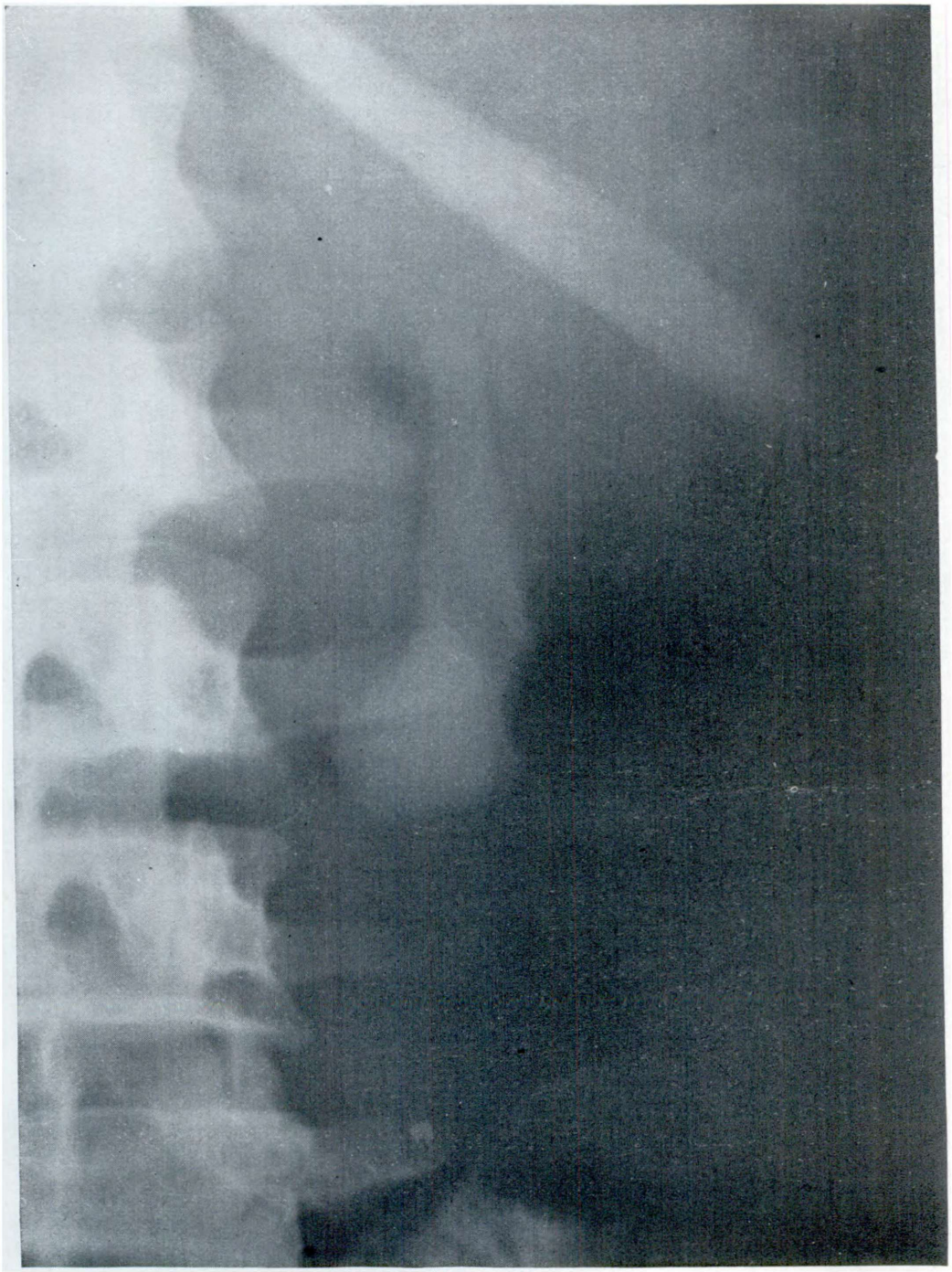


FIGURE 104B.—Gall bladder.

Technical factors

Distance: 30". Cone: Advisable (after preliminary study—compensate Ma.S.). (Measure plane through 12th rib, antero-posteriorly.)

Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	50 Ma.S.			39 Ma.S.					33 Ma.S.					28 Ma.S.		
Using grid (5–1 ratio)	150 Ma.S.			117 Ma.S. (Basic Ma.S. 700)					100 Ma.S.					85 Ma.S.		

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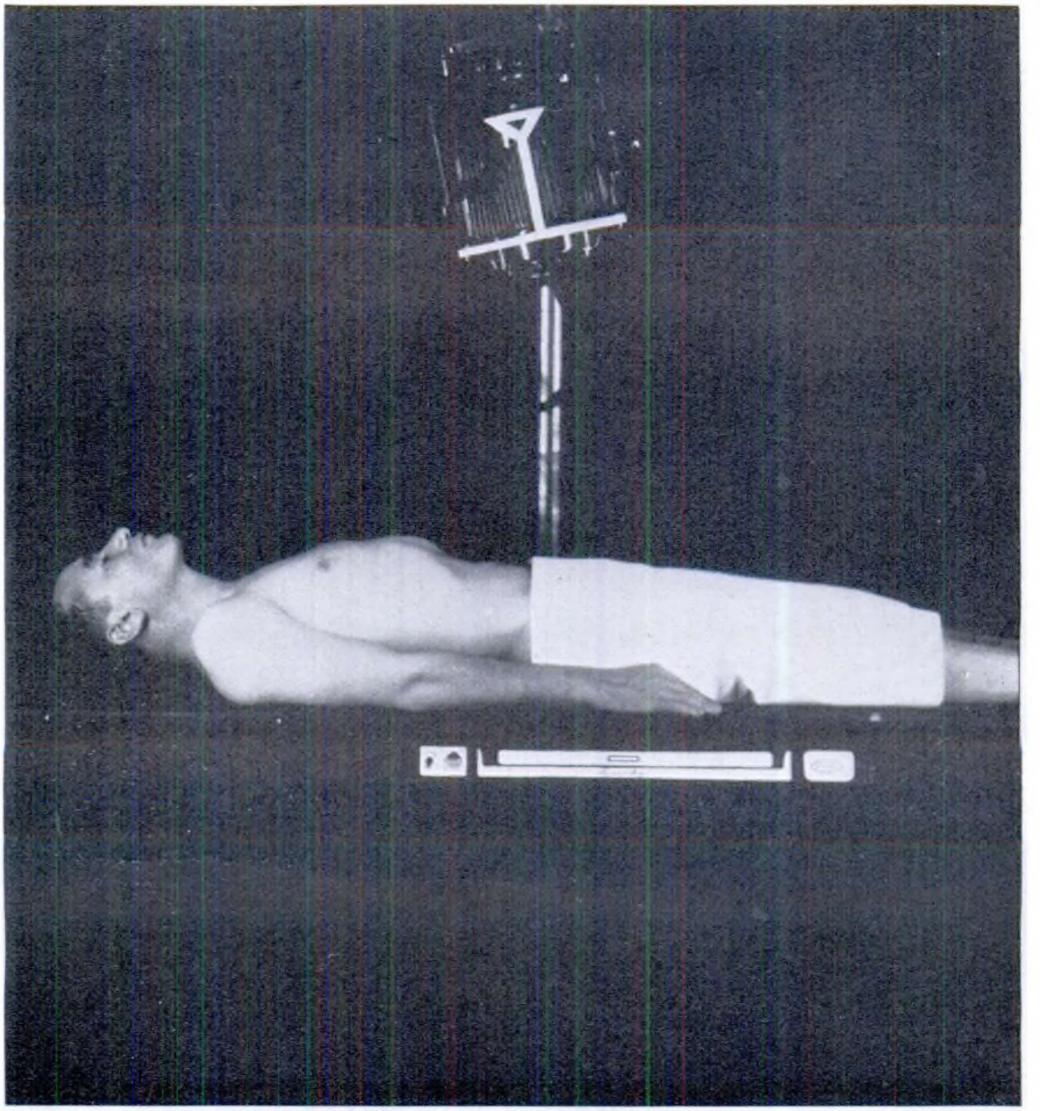


FIGURE 105A.—Rectum.

Positioning instructions

Film : 10 x 12, lengthwise ; cassette.
Position : Patient supine (rotated obliquely, if indicated) ; level of greater trochanters to midlength of film.
Focal spot : Aline to umbilicus then angle tube toward feet, 15°.
Precautions : Suspended expiration.
Additional : Grid.

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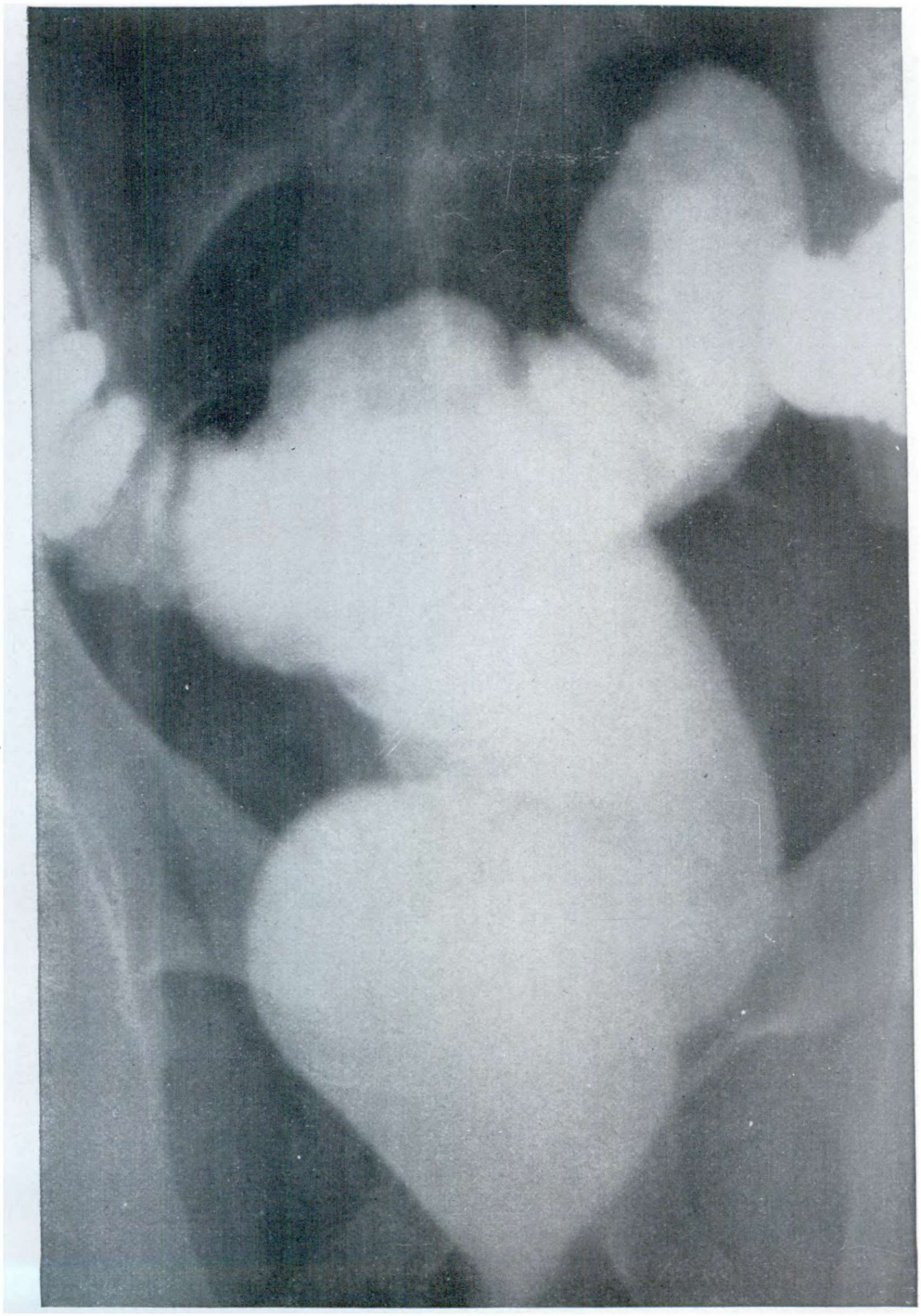


FIGURE 105B.—Rectum.

Technical factors

Distance: 30″. Cone: Optional (compensate Ma.S.). (Measure plane through greater trochanters, antero-posteriorly or obliquely.)

Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84
With medium speed screens	43 Ma.S.			33 Ma.S.					30 Ma.S.					24 Ma.S.		
Using grid (5–1 ratio)	130 Ma.S.			100 Ma.S. (Basic Ma.S. 600)					90 Ma.S.					72 Ma.S.		

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FIGURE 106A.—Skull, lateral (for sella turcica).

Positioning instructions

Film: 10 x 12, widthwise; cassette.
Position: Patient sitting; head resting laterally on cardboard support with top of head 5 cms. below upper border of film.
Focal spot: Aline to center of temporal fossa.
Precautions: Midsagittal plane parallel to film; suspended respiration.
Additional: Vertical cassette holder; cardboard head support.

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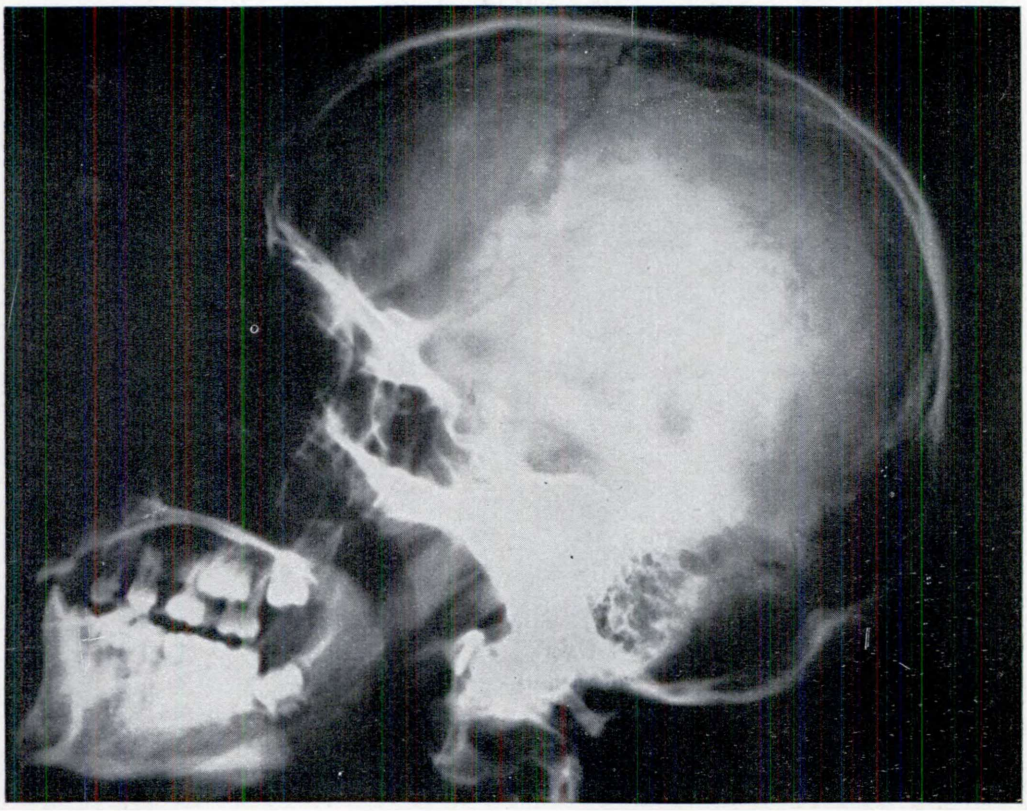


FIGURE 106B.—Skull, lateral (for sella turcica).

Technical factors

Distance: 30″. Cone: Advisable (compensate Ma.S.). (Measure plane through external auditory meati and external canthi, laterally.)

Cms. thickness:	11	12	13	14	15	16	17	18	19
Variable Kv.P.:	62	64	66	68	70	72	74	76	78
With medium speed screens	22 Ma.S.				20 Ma.S.				

(Basic Ma.S. 400)

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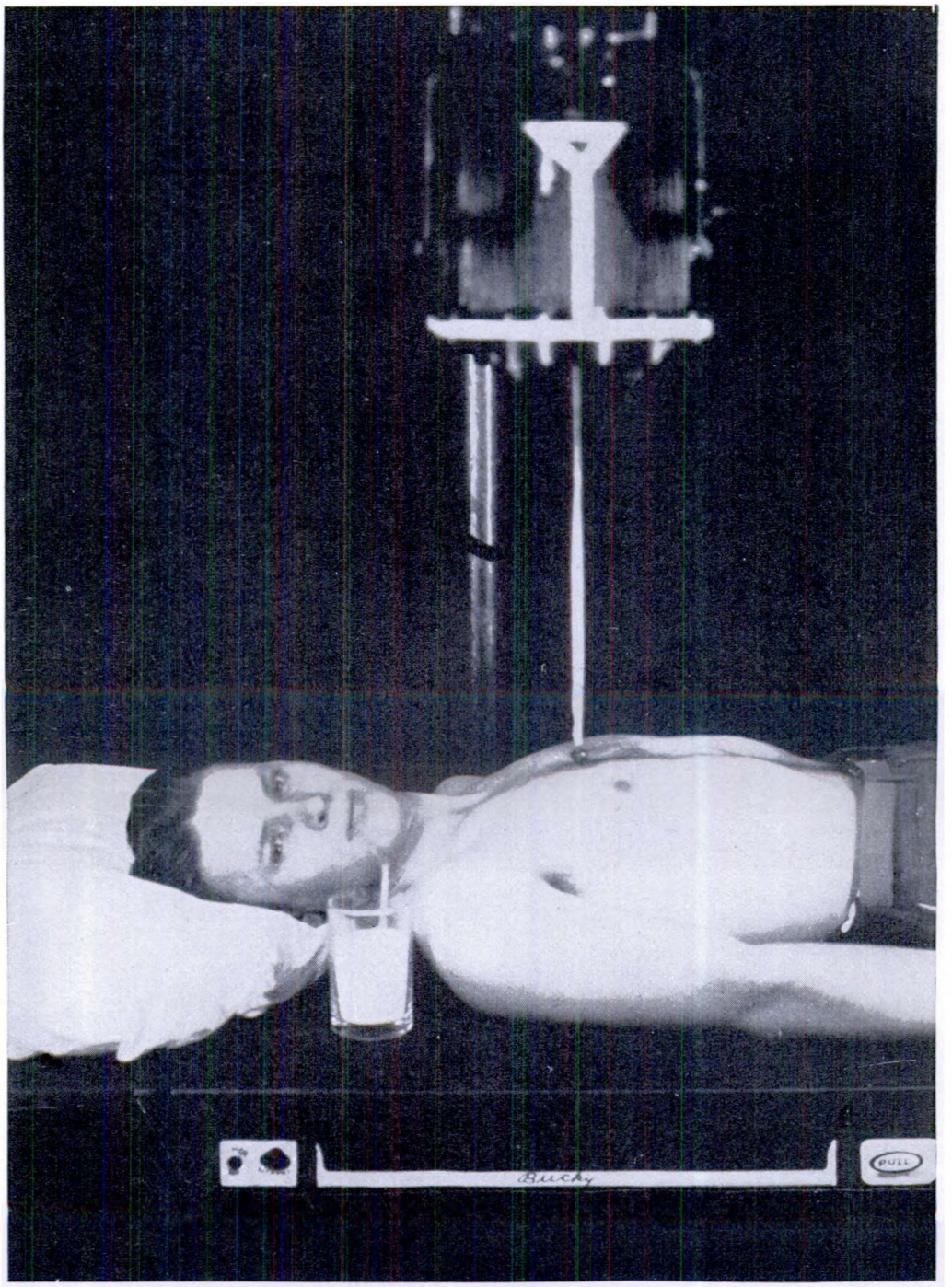


FIGURE 107A.—Esophagus, A. P.

Positioning instructions

Film : 14 x 17, lengthwise ; cassette.
Position : Patient supine, upper border of cassette to level of mandible.
Focal spot : Aline to center of film.
Precautions : Suspended inspiration ; swallowing of medium thick barium during exposure.
Additional : Grid ; drinking tube ; barium mixture.

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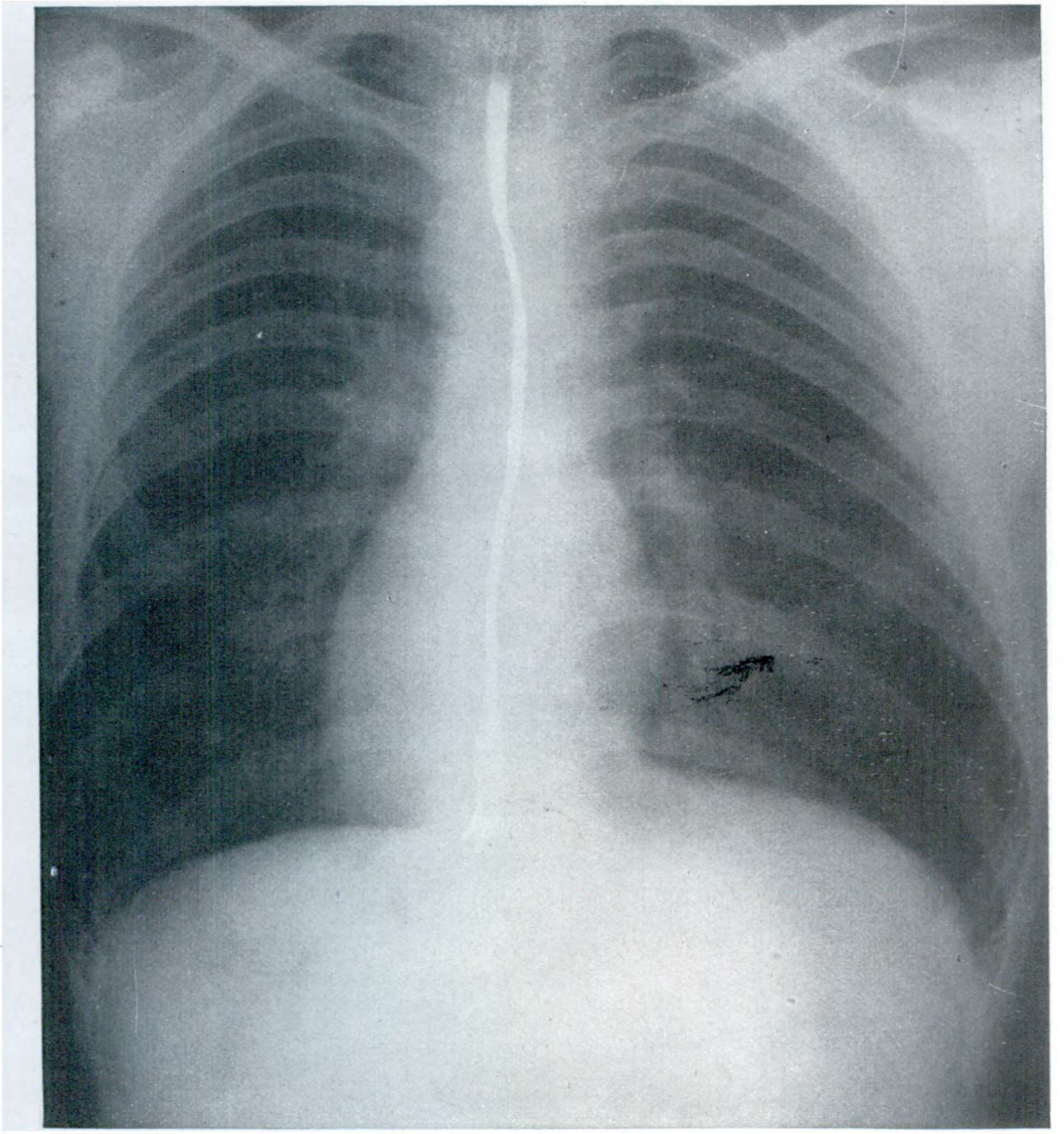


FIGURE 107B.—Esophagus, A. P.

Technical factors

Distance: 30″. Cone: No. (Measure plane through 6th thoracic, A. P.)																				
Cms. thickness:	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Variable Kv.P.:	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90
With medium speed screens	21 Ma.S.				16 Ma.S.					14 Ma.S.					12 Ma.S.					
Using grid (5–1 ratio)	63 Ma.S.				48 Ma.S.					42 Ma.S.					36 Ma.S.					

(Basic Ma.S. 300)

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FIGURE 108A.—Esophagus, lateral.

Positioning instructions

Film: 14 x 17, lengthwise; cassette.
Position: Patient on right side, to midwidth of film; upper level of cassette to level of mandible; arms extended posteriorly.
Focal spot: Aline to center of film.
Precautions: Suspended inspiration; swallowing of medium thick barium during exposure.
Additional: Grid; drinking tube; barium mixture.

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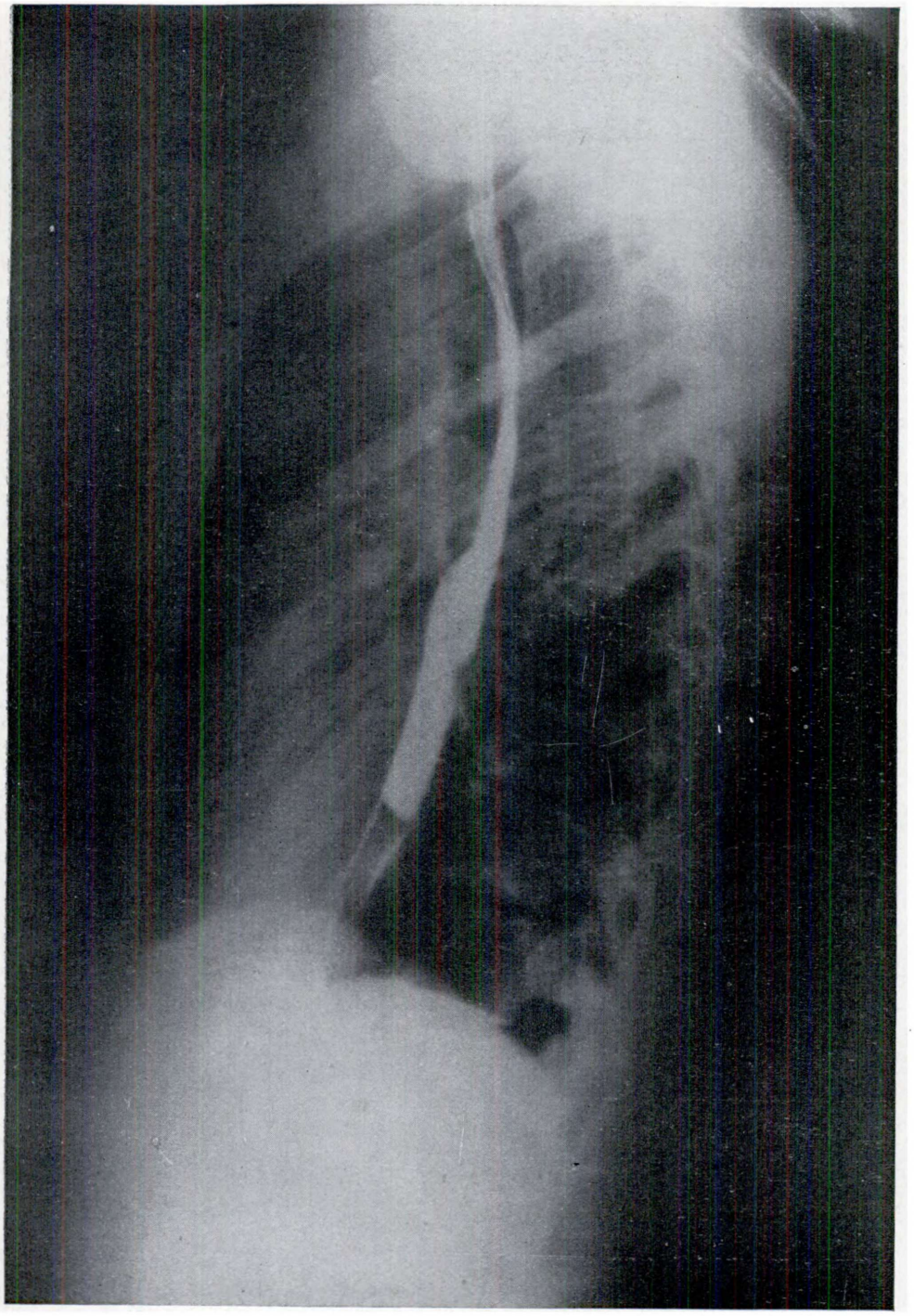


FIGURE 108B.—Esophagus, lateral.

Technical factors

Distance: 30″. Cone: No. (Measure plane through 6th thoracic vertebra, laterally.)																			
Cms. thickness:	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
Withmedium speed screens	50 Ma.S.					40 Ma.S.					33 Ma.S.					28 Ma.S.				
Using grid (5–1 ratio)	150 Ma.S.					120 Ma.S.					100 Ma.S.					85 Ma.S.				

(Basic Ma.S. 700)

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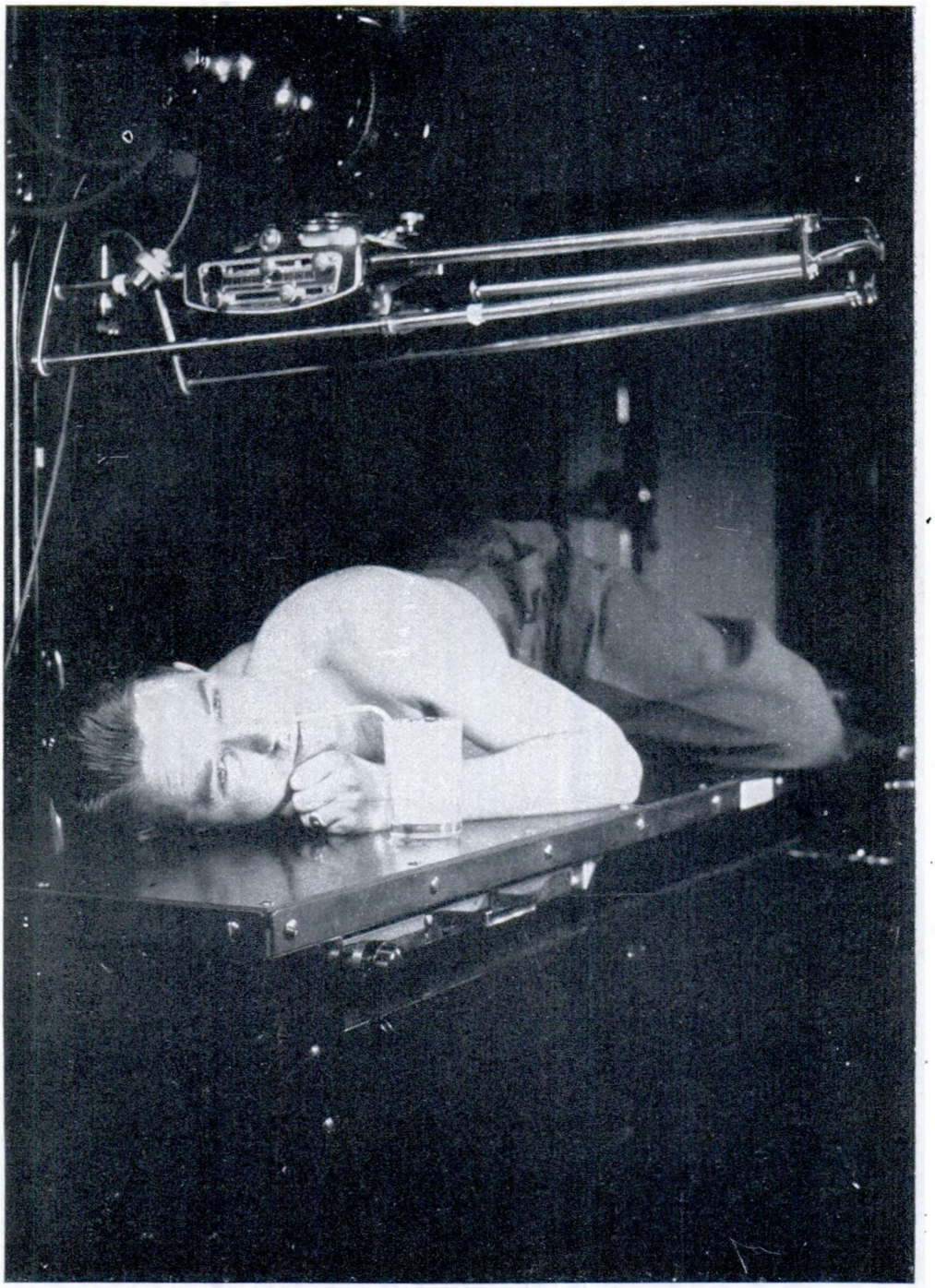


FIGURE 109A.—Esophagus, oblique.

Positioning instructions

Film : 14 x 17, lengthwise ; cassette.
Position : Patient prone but rotated 30° to the right ; right arm to side, left hand under chin ; left knee flexed and supporting oblique position ; upper level of cassette to level of mandible.
Focal spot : Aline to center of film.
Precautions : Suspended inspiration ; swallowing of medium thick barium during exposure.
Additional : Grid ; drinking tube ; barium mixture.

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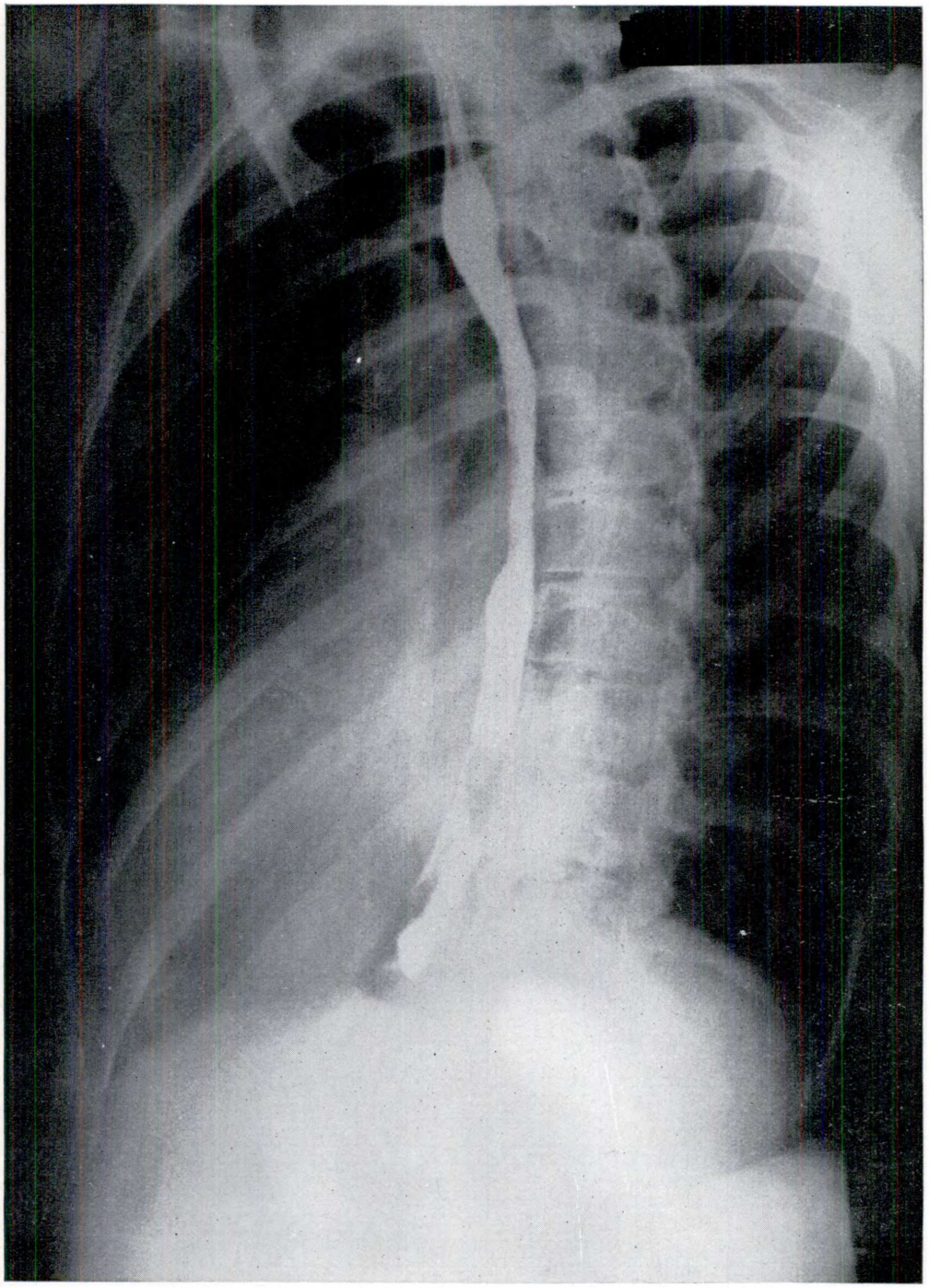


FIGURE 109B.—Esophagus, oblique.

Technical factors

Distance: 30″. Cone: No. (Measure plane through 6th thoracic vertebra, obliquely.)																			
Cms. thickness:	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Variable Kv.P.:	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88
With medium speed screens	28 Ma.S.					22 Ma.S.					18 Ma.S.					16 Ma.S.				
Using grid (5–1 ratio)	84 Ma.S.					66 Ma.S. (Basic Ma.S. 400)					54 Ma.S.					48 Ma.S.				

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[A. G. 062.11 (3–5–41).]

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