May 29, 1956 J. L. WORDEN 2,748,292

SIMPLIFIED X-RAY APPARATUS

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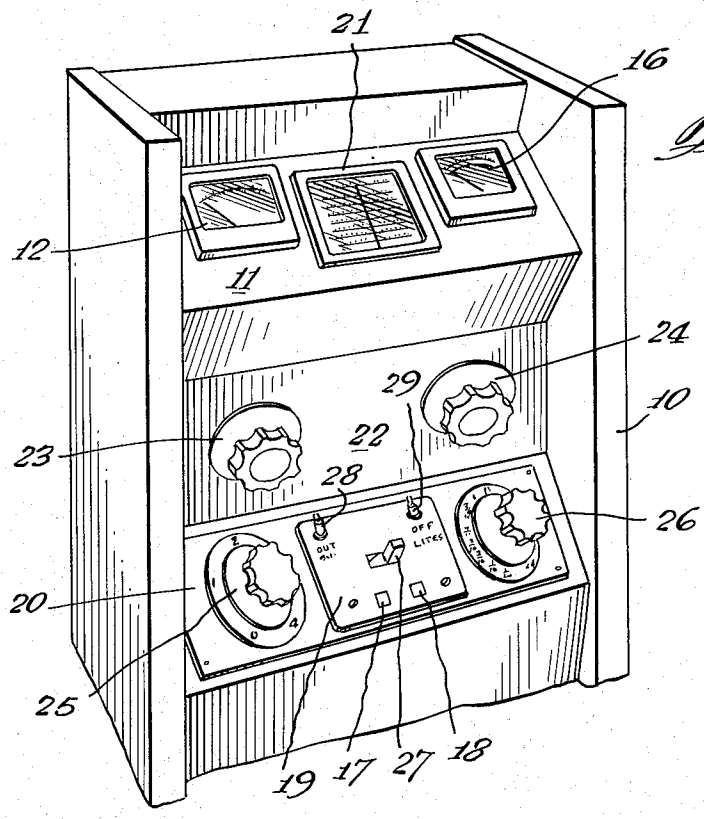


Fig. 1.

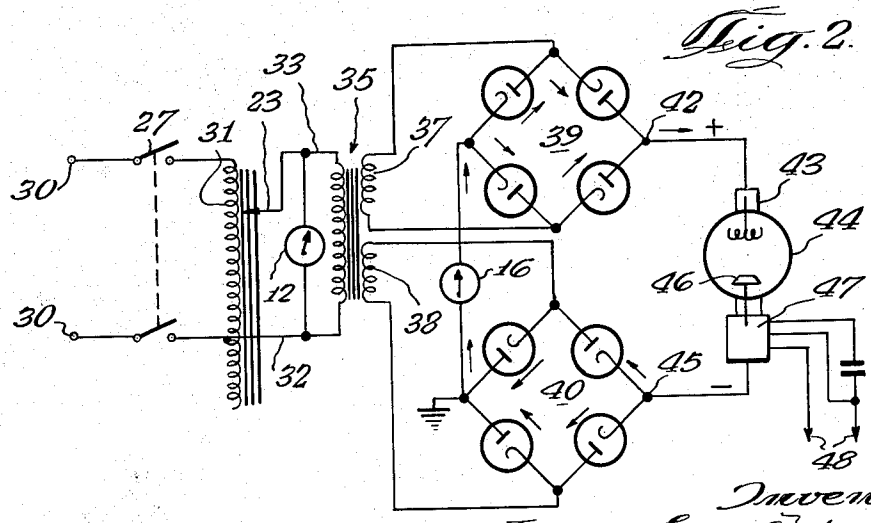


Fig. 2.

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Fig. 4.

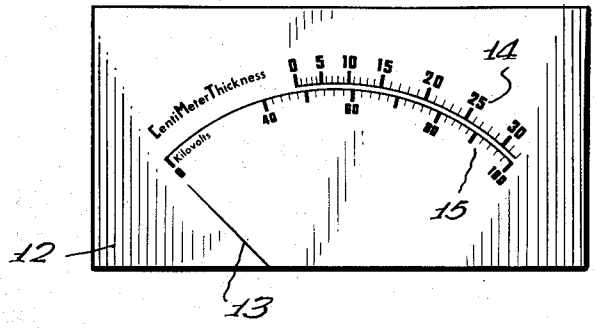


Fig. 3.

SIMPLIFIED 100 Ma TECHNIQUE

PART		DIST.	BUCKY	TIME
Chest & Heart	PA	72"	No	1/20
Chest & Heart	OBL	72"	No	1/10
Chest & Heart	LAT	72"	No	1/10
Stomach	PA	30"	Yes	3/10
Colon	PA	30"	Yes	3/10
Esophagus	OBL	30"	No	1/10
Esophagus	OBL	30"	Yes	3/10
Kidney	AP	30"	Yes	4/10
Urinary Tract	AP	30"	Yes	4/10
Urinary Bladder	AP	30"	Yes	4/10
Gall Bladder	PA	30"	Yes	3/10
Ribs	AD	30"	Yes	1/10
Ribs	BD	30"	Yes	3/10
Pelvis	AP	30"	Yes	3/4
Foetus	AP-PA	30"	Yes	1/2
Foetus	LAT	30"	Yes	3/4
Hip Joints	AP	30"	Yes	1/2
Hip Joints	OBL	30"	Yes	1/2
Thigh	AP	36"	Yes	1/2
Thigh	LAT	36"	Yes	1/2
Shoulder	AP	36"	Yes	4/10
Sinus	ALL	30"	No	2/10
Sinus	ALL	30"	Yes	1/2

PART		DIST.	BUCKY	TIME
Skull	AP	30"	Yes	3/4
Skull	LAT	30"	Yes	3/4
Cervical	AP	30"	Yes	1/2
Cervical	LAT	30"	Yes	1/2
Cervical	LAT	72"	No	1/2
Dorsal	AP	30"	Yes	3/4
Dorsal	OBL	30"	Yes	1/2
Dorsal	LAT	30"	Yes	1/2
Lumbar	AP	30"	Yes	3/4
Lumbar	LAT	30"	Yes	1
Extremities 2 to 5 cm.	Exposure Holder	36"	No	3/10
Extremities 6 to 10 cm.	Exposure Holder	36"	No	4/10
Extremities 2 to 5 cm.	Screens & Cassette	36"	No	1/20
Extremities 6 to 9 cm.	Screens & Cassette	36"	No	1/10
Extremities 10 to 15 cm.	Screens & Cassette	36".	Yes	3/10

Cast Work...Add 5 cm. to thickness measurement

Based on Par-Speed Screens

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2,748,292

SIMPLIFIED X-RAY APPARATUS

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Application May 14, 1953, Serial No. 355,145

6 Claims. (Cl. 250—100)

This invention relates generally to an X-ray system or apparatus and more particularly is concerned with an X-ray apparatus which is fool-proof and extremely simple to operate properly without danger either to the technician or to the patient.

The apparatus of the invention is a departure from the conventional X-ray apparatus in that a great many disadvantages of prior equipments have been overcome in a relatively small and inexpensive device. It comprises a combination of features the association of which give rise to the advantages.

The apparatus of the invention is advantageous especially in the fact that as a result of the construction, the output of the X-ray tube is always fixed at a predetermined value of current. The practical embodiment of the invention is constructed for an output of 100 milliamperes. The focal spot of the X-ray tube is constant; there is no need to calculate anything about kilovoltage or milliamperes; there is no need to calibrate the equipment; in fact there is nothing that need be done which cannot be accomplished by anyone of just ordinary intelligence. The result is that training for operating this equipment is a minimum. All that the operator does is to adjust the kilovolt output by a simple control to the proper value for the thickness of the part of the body to be X-rayed. The meter is calibrated directly in centimeters of thickness. The operator then chooses the proper time for the particular part of the body from a simple chart, sets that time in the timer, and throws a switch which will expose the said part. This is in great contrast to the complicated procedure which must be followed in using ordinary X-ray equipment.

It is therefore the principal object of the invention to provide an X-ray apparatus which eliminates a great many complications prevalent in ordinary apparatus; which provides fixed current output of the X-ray tube; which may be operated simply and effectively with a minimum of adjustments.

An important object of the invention is to provide a device which is extremely economical, not only to produce but also to operate. In connection with this object, the component parts of the apparatus are more economical, the time required to set up the apparatus for use is very much less than on previous machines, the power line requirements are less than on other apparatus of the same type, the X-ray radiographs are of high detail and contrast.

Many other objects will be come apparent as a description of the invention proceeds, from an inspection of which advantages and features not described will be apparent. I have illustrated a preferred embodiment of the invention in the drawings in which:

Fig. 1 is a perspective view of the control cabinet of the apparatus embodying the invention.

Fig. 2 is a circuit diagram of the basic parts of the apparatus.

Fig. 3 is a plan view of the technique chart used with the apparatus.

Fig. 4 is a plan view of the simple meter used in connection with the chart.

The invention herein comprises a combination of features which makes possible the extremely simplified technique of the apparatus. These features are a result of the use of certain hereinafter described structural parts, each of which contributes to the whole to produce the desired results.

In Fig. 1, there is shown the console or cabinet **10** of apparatus embodying the invention, the X-ray tube, the table, connecting cables, and the like not being illustrated in this figure. In order to explain the use of the various meters and controls, the technique practiced will be described prior to continuing with the explanation of the features of construction making the same possible.

In the top panel **11** of the console **10** there are shown two meters and a technique chart. On the left there is provided the meter **12**, same being a voltmeter. This voltmeter has been pre-calibrated so that it measures the primary voltage of the principal transformer of the equipment in terms of the peak kilovoltage applied to the X-ray tube. Since penetration of the X-rays is a function of the peak kilovoltage applied to the X-ray tube, the meter may be calibrated also in centimeter thickness of the part of the body to be X-rayed, taking into account the output of the tube. Since the output of the tube is constant, the only variable to consider in the exposure is the thickness of the part of the body. The face of the meter **12** is illustrated in Fig. 4. It will be noted that the needle **13** plays over a scale the upper part **14** of which is marked off from zero to 30, signifying centimeter thickness of the part of the body being radiographed, and the bottom part **15** of which is marked off from 40 to 100, reading peak kilovolts applied to the X-ray tube.

The right hand meter **16** is a simple milliameter which has two ranges in the embodiment illustrated. One range is zero to 100 milliamperes, which is used when the X-ray equipment is being operated for making radiographs, and the other range is for use in practising other techniques with the apparatus. The latter range is not of concern to this invention, and in fact, the 100 milliampere range is used only to assure that the apparatus is working properly, since the needle will be on 100 milliamperes during the entire time that the apparatus is being used, the relations for calibrating the meter **12** being based upon this presupposition. The push-buttons **17** and **18** on the switch plate **19** of the lower panel **20** control meter range.

In the center of the upper panel **11** is a technique chart **21**, preferably illuminated from its rear. This chart is shown enlarged in Fig. 3 and will be explained shortly.

On the central panel **22** there are provided two knobs **23** and **24**, the left hand knob **23** being for adjusting the kilovoltage of the apparatus to correspond to the proper thickness of part of the body being radiographed, and the right hand knob adjusts the milliamperage output of the X-ray tube, but only when the meter **16** is being used on its 30 milliampere scale. For the 100 milliampere scale the needle will remain at 100 milliamperes during use.

The bottom panel **20** has an integrating or cumulative timer control **25** for use in connection with fluoriscopy, a central switch panel **19**, and an electronic timer control **26** for use in connection with radiography. The main switch is indicated at **27**, a bucky diaphragm switch at **28**, and a light switch at **29**. Not illustrated is a plug-in receptacle for a hand-held switch connected by a cable to close the circuit when it is desired to expose film. This is a simple arrangement in common use in practically all X-ray equipment.

The apparatus is used in the following manner; presuming that the equipment is properly adjusted and properly warmed up, and the patient is placed upon the table with the particular part of the body over the radio

graphic plate, first the proper height of the tube over the film is adjusted. Since the table and tube adjusting means form no part of the invention but may be of any type, these are not illustrated. Furthermore, since the equipment is admirably suited for use in industrial applications, the tube may not be used with a table, but may be secured with brackets, etc. to a metal member or the like. Continuing with the explanation of the manner of use in obtaining a radiograph of a patient, suppose that a lateral X-ray of the skull is to be taken. The adjustment of thirty inches as shown in the technique chart is made to raise the tube the proper height above the film. The technique chart requires the use of the bucky diaphragm, and hence the switch **28** is thrown to "on" position. Let us say that the thickness of the skull being X-rayed is measured as 18 centimeters. The knob **23** is turned until the needle **13** reaches 18 on scale **14**. This signifies a kilovoltage of 72 will be applied to the tube. According to the technique chart, the time of exposure is three quarters second. This value is set into the electronic timer by the knob **24**. Now, the operator merely closes his hand held switch, and the film is exposed at 100 milliamperes output of the X-ray tube.

Slight variations of technique are required under varying circumstances, but obviously the basic steps are the same. The thickness of the part of the body is set into the meter **12**, the time is set into the electronic timer, and the film exposed.

The circuit of the apparatus is shown in Fig. 1. The line **30** is connected across an auto-transformer **31** through ganged switches. These switches are operated by the toggle **27** appearing on the plate **19**. The output of the auto-transformer appears from the lead **32** to the lead **33** and is applied to the primary **34** of the high voltage transformer **35**. The voltage across leads **32** and **33** is varied by means of a brush which wipes exposed turns of the auto-transformer. The movement is controlled by the knob **23** and hence the brush connection is designated by this character. The meter **12** is also connected across the output of the autotransformer. The high voltage transformer **35** has two secondaries **37** and **38** each of which is connected across a four diode bridge rectifier **39** and **40** respectively. The right hand juncture **42** of the bridge **39** is connected to the cathode or electron gun **43** of the X-ray tube **44**, while the right hand terminal **45** of the bridge **40** is connected to the target or anode **46** of the tube **44**. The tube **44** is of the rotating anode type, as indicated by the motor **47** connected to a source of electrical power **48** for rotating the anode. The left hand terminals **49** and **50** of the bridges are connected together through an ammeter, the same ammeter **16** is illustrated in Fig. 1, and also to ground. Thus the ammeter **16** is at very low potential, need not be insulated, and is not a dangerous portion of the apparatus.

This is full wave rectification which enables the meter **16** to be at ground potential. In addition, considerable savings are effected because the kind of vacuum tube diodes required for an eight tube arrangement are of considerable lesser voltage rating than in the event a four tube arrangement were utilized. This latter system is in known use but is inferior to the circuit shown.

The use of a full wave rectifier prevents high inverse voltages and currents from being produced and hence effects great savings in power requirements. It also enables higher powers to be used without danger to equipment or to the operator. It has been found that none of the so-called 100 milliampere 100 peak kilovolt equipments heretofore known operate at their full rated capacity because of the likelihood of damage to equipment, tubes and cables. With the apparatus of the invention, it will be noted that when operating with parts of the body through thicknesses of around thirty centimeters, which is most usual, the apparatus is operating at full capacity.

The use of a rotating anode tube also contributes to the ease of technique. In the first place, all of the advantages of the rotating anode tube are achieved, and in the second place, the use in the invention, enables the simplified procedure to be attained. There is no need to adjust focal spot, and in the case of the rotating anode the spot is exceedingly small giving great detail and sharp contrast. The tube used in the commercial embodiment has a focal spot of 1.5 mm. The tube lasts longer and can be exposed longer without damage thus increasing the usefulness of the tube and enabling the apparatus to be used at high powers.

In all small X-ray equipments heretofore used the voltage applied to the tube was a higher voltage A. C. potential, it being left to the X-ray tube itself to do the rectifying. In the present apparatus, the full wave rectifier eliminates the strain on the tube, the dangerous inverse voltages, and still does not increase the cost thereof to any substantial extent because of the elimination of other controls and apparatus required in said prior devices.

Since the equipment is constructed to enable the use of maximum rated peak kilovoltage without danger because of the rotating anode tube and the full wave rectification—the time in which an exposure can be made is reduced from that required in other equipments of the same rating and even of greater power. For example, an exposure of 100 milliamperes at 100 kvp. is equal in value to 200 ma. at 90 kvp. The tube limitations at the latter conditions however, allow exposure of only one and one-half seconds, while the former conditions readily attainable with my apparatus permit an exposure of over 14 seconds without damage to the tube. In both cases it is presumed that other conditions are equal—that the focal spot is the same.

Because of this the time of exposure may be decreased, using higher kvp. on the tube.

It is believed that the invention should be fully understood and appreciated without further explanation and it is desired to point out that variations are possible without departing from the spirit or scope of the invention as defined in the appended claims.

I claim:

1. A simple-operating X-ray equipment which is adapted to operate from a single-phase A. C. line of relatively low voltage and at relatively low load conditions, which comprises an X-ray tube of the type providing a constant focal spot for all conditions of radiographic use, a full wave rectifier directly connected across the tube and providing constant current to the tube under all conditions of radiographic use, a high voltage transformer connected to the line and having its output connected to the rectifier, means for varying the primary voltage of the transformer, a voltmeter connected for reading the said primary voltage and said meter being calibrated to read directly thickness of the part being X-rayed as a function of peak kilovoltage applied to the tube at the said constant current for proper exposure of said part, and a timing device connected to close the circuit of the X-ray tube for a predetermined time.

2. An equipment as described in claim 1 in which the rectifier comprises a pair of four tube bridge-connected diode arrangements, the high voltage transformer has a pair of secondaries, each secondary being connected across the respective bridge arrangements, each arrangement having one juncture of each at common potential and the tube being connected across another juncture of each arrangement.

3. A simple-operating X-ray apparatus comprising a single-phase A. C. source of relatively low voltage, said apparatus adapted to operate at relatively low load conditions, an X-ray tube of the rotating anode type, a full-wave rectifier unit directly connected across the tube and providing constant current to said tube under all load conditions, a high voltage transformer connected across the line and having its output connected to the rectifier,

means for varying the primary voltage of the transformer, a meter connected for reading the said primary voltage and said meter being calibrated to read thickness of the part being X-rayed as a function of peak kilovoltage applied to the tube at the said constant current for proper exposure of said part, a timing device connected to close the circuit of the X-ray tube for a predetermined time, said rectifier comprising a pair of four tube bridge-connected diode arrangements, the high voltage transformer having a pair of secondary windings each connected across one of the four tube bridge arrangements, each arrangement having one juncture of each at substantially the same potential and the tube being connected across another juncture of each arrangement, there being an ammeter connected between said junctures having substantially the same potential, one of said last mentioned junctures being grounded.

4. An X-ray equipment comprising, a single phase relatively low voltage source of A. C., high voltage transformer means having primary winding means connected across the source, a pair of secondaries insulated one from the other and from ground, a pair of four branch rectifying bridges with a rectifier device in each branch, each secondary being connected across one of said bridges, an X-ray tube having anode and cathode, each bridge having a positive and a negative terminal, a current indicating device, the positive terminal of the first of said bridges connected to the anode of said X-ray tube, the negative terminal of said first bridge being connected to said current indicating device and being substantially at ground potential, the negative terminal of the second of the said bridges being connected to the cathode of the X-ray tube and having its positive terminal connected to said current indicating device.

5. An X-ray equipment as described in claim 4 in which means are provided for varying the voltage of the primary winding means, a voltmeter connected to read the variable primary voltage and calibrated in part thickness, said X-ray tube having a constant current output so related to the calibration of said voltmeter as to permit the use of a highly simplified chart which indicates the time for any given part thickness, and a timer for presetting energization time of said equipment.

6. The combination in an X-ray apparatus, of an X-ray tube having a fixed focal spot, means providing a fixed predetermined current flow in said tube under all conditions of radiographic use, a rectifier providing direct current for said tube, a source of A. C. voltage connected to said rectifier, means for varying the voltage of said A. C. source, and a voltmeter connected across said source and calibrated to read directly the thickness of a part being radiographed as a function of the source voltage for said particular value of current flow.

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