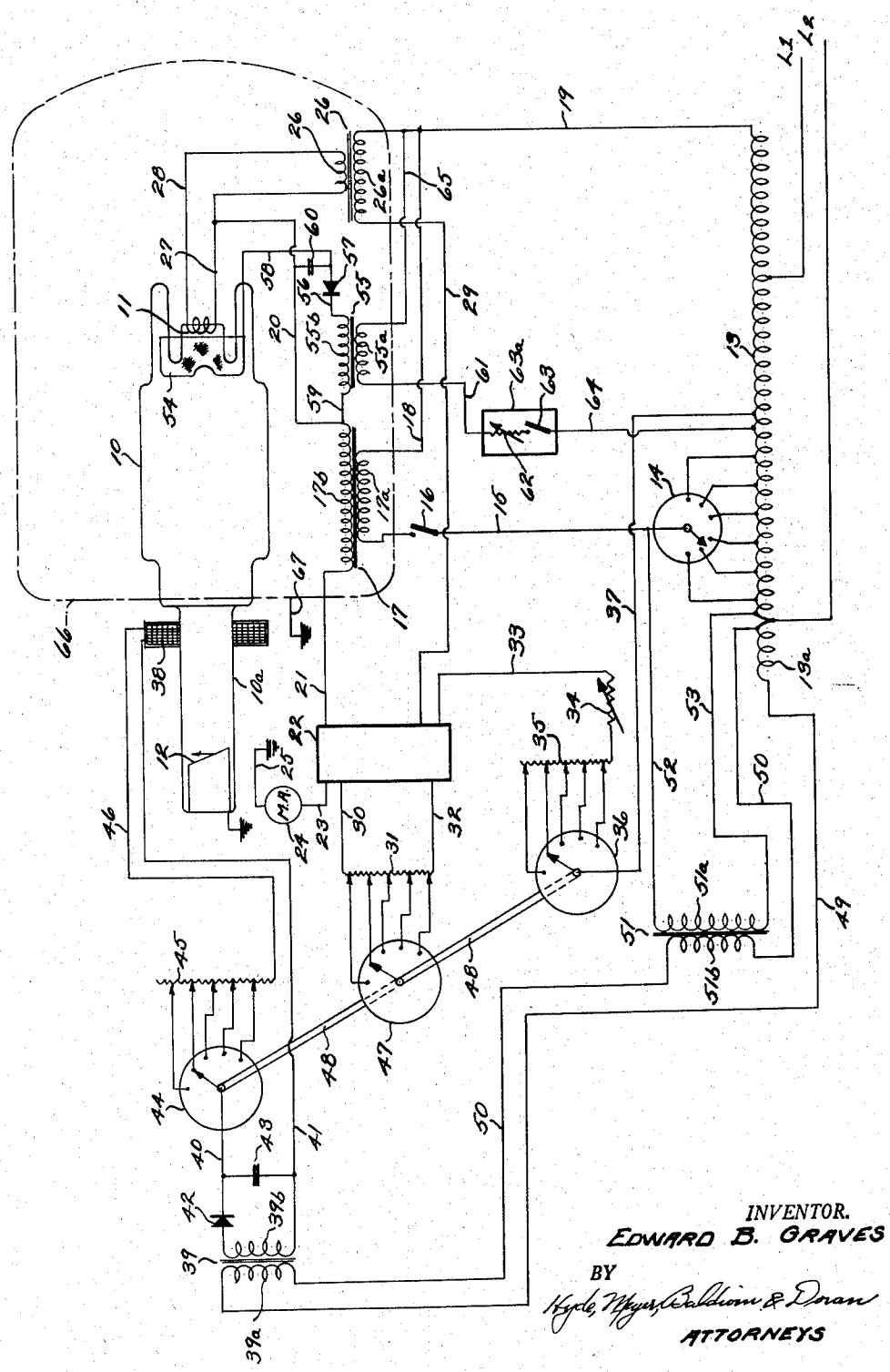
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X-RAY TUBE WITH VARIABLE FOCAL SPOT AND CONTROL MEANS THEREFOR

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INVENTOR.
EDWARD B. GRAVES
BY
Hyde, Myers, Baldwin & Doran
ATTORNEYS

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X-RAY TUBE WITH VARIABLE FOCAL SPOT AND CONTROL MEANS THEREFOR

Edward B. Graves, University Heights, Ohio, assignor to Picker X-Ray Corporation, Waite Manufacturing Division, Inc., Cleveland, Ohio, a corporation of Ohio

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This invention relates to improvements in an X-ray tube with a variable focal spot and control means for the same.

One of the objects of the present invention is an improvement in an X-ray tube having a filament adapted to emit a stream of electrons striking the focal spot on an anode and having electrical means for energizing the tube including means controlling an energizing electrical supply to the tube filament to increase and decrease the milliamperage flowing in the tube, the improvement comprising means for controlling the size of the focal spot and a single control means for varying this focal spot size in step with the milliamperage flowing in the tube.

Another object of the present invention is the provision of an electromagnetic focusing coil embracing the stream of electrodes passing from the filament to the anode of the X-ray tube with means for supplying electrical current to the coil, the arrangement being such that the current in said focusing coil is increased or decreased in step with the adjustment of the increase and decrease respectively of the milliamperage flowing in the tube.

A further object of the present invention includes means for varying the kilovoltage supplied to the X-ray tube and means responsive to the variation of the kilovoltage for changing the size of the focal spot.

Still a further object of the present invention is the provision in combination with an X-ray tube as described in the preceding paragraphs, of a control grid adjacent the filament of the X-ray tube and positioned to control the emission of electrons from the filament, together with control means for supplying to the control grid a potential negative with respect to the filament and completely blocking electron flow from the filament, this block being removed when it is desired to initiate an exposure, whereby the selected conditions for operation of the X-ray tube may be pre-selected with reference to milliamperage flow, kilovoltage and focal spot size, after which the exposure may be initiated simply by removing the negative bias from the control grid.

Other objects and advantages of the present invention will be apparent from the accompanying drawing and description and the essential features thereof will be set forth in the appended claims.

In the drawing, an X-ray tube is shown somewhat diagrammatically as having the usual glass wall **10** in one end of which is embedded the filament **11**, and in the other end of which there is fixed the anode **12**. In the present embodiment of the invention, the anode end of the tube is grounded so that the anode **12** may be water cooled if desired but this forms no part of the present invention.

Electrical means is provided for energizing the X-ray tube and this is shown as comprising an auto-transformer **13** supplied from the line source L1, L2 and having suitable taps connected to a kilovoltage selector **14** which in turn is connected to line **15** and switch **16** to the primary **17***a* of the high voltage transformer **17**. The other

end of the transformer primary is connected through lines **18** and **19** back to the auto-transformer. The secondary **17***b* of the high voltage transformer is connected by line **20** to the filament end of the X-ray tube, and is connected by line **21** through the milliamperage stabilizer **22**, line **23**, milliammeter **24** and line **25** to ground.

The energizing electrical supply for the filament **11** comprises the secondary **26***b* of transformer **26** which is connected by lines **27** and **28** to the filament **11**. The primary **26***a* of this transformer is connected by line **19** to one tap on the auto-transformer **13**. The other end of the primary winding **26***a* is connected by line **29** through milliamperage stabilizer **22**, line **30**, resistance **31**, line **32**, milliamperage stabilizer **22**, line **33**, variable resistance **34**, resistance **35** with its various taps, the filament current selector **36** and line **37** back to another tap on the auto-transformer. As mentioned above, one of the objects of the present invention is to vary the focal spot size as the milliamperage is changed on the X-ray tube. To this end, an electromagnetic focusing coil **38** is provided around the anode stem **10***a* of the X-ray tube so as to provide the known focusing effect on the stream of electrons passing from the filament **11** to the anode **12**. A suitable source of energizing electricity is provided for the focusing coil and this might be a battery or any other suitable source. In the present embodiment, we show a transformer **39** utilized for this purpose and having its secondary **39***b* connected across lines **40** and **41** utilizing the rectifier **42** and condenser **43** to supply rectified current to the focusing coil. The line **40** is connected through the focal spot control deck of a control monitor **44** which has various taps connected to points on resistance **45** which in turn is connected through line **46** to the focusing coil.

The device shown at **47** is a milliamperage calibration deck on the monitor control which has a plurality of taps connected at spaced points on the resistance **31** previously described.

It results from the above described construction, that the X-ray tube **10** may be operated as follows: The various decks of the monitor control are shown diagrammatically connected by the means **48** so that they may all be adjusted simultaneously. The operator adjusts the monitor control means **48** to move the filament input selector **36** and the milliamperage calibration device **47** to the desired point to provide the desired milliamperage flow through the tube. At the same time, the monitor deck **44** moves the focal spot control device so that as the milliamperage flow through the X-ray tube is changed, the current in the focusing coil **38** is changed by a proportionate change in resistance **45**. This gives the X-ray tube greater flexibility because at higher milliamperage flow through the X-ray tube **10**, the coil **38** focuses the electron stream to a larger focal spot on the anode **12**.

A modification of the above described apparatus is provided by adding means for increasing or decreasing the potential on the focusing coil **38** in proportion to the kilovoltage applied to the transformer **17** so as to maintain the relatively uniform focusing as selected by the initial monitor setting. To understand this modification, it should be noted that the supply to the primary **39***a* of the transformer **39** is by way of the isolated winding **13***a* on the auto-transformer which is connected by lines **49** and **50** with the transformer winding **39***a*. To provide the above mentioned kilovoltage correction, the secondary winding **51***b* of transformer **51** is included in series in line **50**. The primary **51***a* of this transformer is connected by lines **52** and **53** to pass through the kilovoltage selector **14** so that the kilovoltage selected is automatically imposed on the winding **51***a*. It results from this arrangement, that after the preliminary setting of the devices shown at **36, 44** and **47**, to control the mil-

liamperage flowing in the tube and to control the focal spot size, thereafter an increase or decrease in the kilovoltage selected at **14** will cause an increase or decrease respectively in the potential applied through lines **40** and **41** to the focusing coil **38** so that the higher kilovoltage selected will tend to decrease the size of the focal spot on the anode **12**. This will tend to maintain relatively uniform focusing as selected by the initial monitor setting by the device **48**.

One of the objects of the present invention is to provide a tube wherein all of the necessary factors for an exposure may be pre-set so that very short exposures under predetermined conditions may be provided. Under conditions presently common, wherein 60 cycle current is used, exposures down to $\frac{1}{60}$ second are possible. By the use of higher frequencies, the exposure time might be reduced to $\frac{1}{400}$ or even to $\frac{1}{1200}$ of a second. During such short exposures, no time is available to adjust the desired tube conditions as to milliamperage flow and focal spot size or to adjust for changes in kilovoltage. In order to obtain this instantaneous control of exposures, we have combined with the previously described devices a trigger grid or control grid **54** which is positioned adjacent the filament **11** in such a manner that when it is properly biased, it will completely block the flow of electrons from the filament **11**. In the embodiment shown, a means is shown for providing a negative bias on the grid **54** with respect to the filament **11** through the secondary winding **55***b* of the transformer **55**. This winding is connected through line **56**, rectifier **57**, and line **58** to the grid **54**. The other end of winding **55***b* has its connection through line **59** and lines **20** and **27** to the filament **11**. A condenser **60** is connected across the rectifier in the usual manner. The primary **55***a* of transformer **55** is connected through line **61**, variable resistance **62**, exposure switch **63** and line **64** to a suitable tap on the transformer **13**. The other end of the winding **55***a* is connected through lines **65** and **19** to the auto-transformer.

It results from the above connection of the control grid **54**, that, with switch **63** closed, the monitor may be pre-set to make the desired selection of milliamperage flow through the X-ray tube and size of focal spot while device **14** may also be pre-set for the desired kilovoltage. Meanwhile, the negative bias on grid **54** stops all electron flow from filament **11** toward the anode **12**. When it is desired to initiate an exposure, switch **63** is opened for the desired exposure and closed again, preferably by use of an automatic timer, many of which are well known and in common use today and the showing of switch **63** and the device **63***a* is only a diagrammatic showing to illustrate the use of the present invention.

If desired, but not necessary to the use of this invention, the tube and transformers **17**, **26** and **55**, may be submerged in a dielectric liquid or gas in a tank **66** indicated in dot-dash line and grounded at **67**.

What is claimed is:

1. In an X-ray tube having a filament adapted to emit a stream of electrons striking the focal spot on an anode and having electrical means for energizing said tube including means controlling an energizing electrical supply

to said filament to increase and decrease the milliamperage flowing in said tube, the combination therewith of means controlling said focal spot size including an electromagnetic focusing coil embracing said stream of electrodes intermediate said filament and anode, means for supplying electrical potential to said coil, means for varying the kilovoltage in said tube energizing means, and means for increasing and decreasing said potential in step with increase and decrease respectively in said kilovoltage.

2. In an X-ray tube having a filament adapted to emit a stream of electrons striking the focal spot on an anode and having electrical means for energizing said tube including means controlling an energizing electrical supply to said filament to increase and decrease the milliamperage flowing in said tube, the combination therewith of means controlling said focal spot size independent of said filament electrical supply control means and providing a focal spot of varying area, and a single control means for varying said focal spot size control means in step with said filament electrical supply control means, said single control means being constructed and arranged to decrease and increase said focal spot size in step with adjustment of said filament electrical supply control means to increase and decrease respectively said milliamperage flowing in said tube.

3. The combination of claim 2 including an electromagnetic focusing coil embracing said stream of electrodes intermediate said filament and said anode, means for supplying electrical current to said coil, said control means having operative connections for increasing and decreasing said current in step with said adjustment of said filament electrical supply control means to increase and decrease respectively said milliamperage flowing in said tube, means for varying the kilovoltage in said means for energizing said tube, and means responsive to variation of said kilovoltage for increasing and decreasing the potential of said current supply to said coil in step with increase and decrease respectively in said kilovoltage in said tube energizing means.

4. The combination of claim 2 including a control grid adjacent said filament and positioned to control emission of electrons from said filament and control means for supplying to and removing from said grid potential negative with respect to the filament and respectively completely blocking and permitting electron flow therefrom, whereby the desired milliamperage flow in said tube and focal spot size may be selected and thereafter an exposure may be initiated simply by removing said bias from said grid.

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