

[54] **TOMOGRAPHIC X-RAY SYSTEM WITH A MOVABLE TABLE**

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[52] U.S. Cl. 250/320, 250/444, 250/490

[51] Int. Cl. **G01n 21/00**

[58] Field of Search 250/61.5, 53

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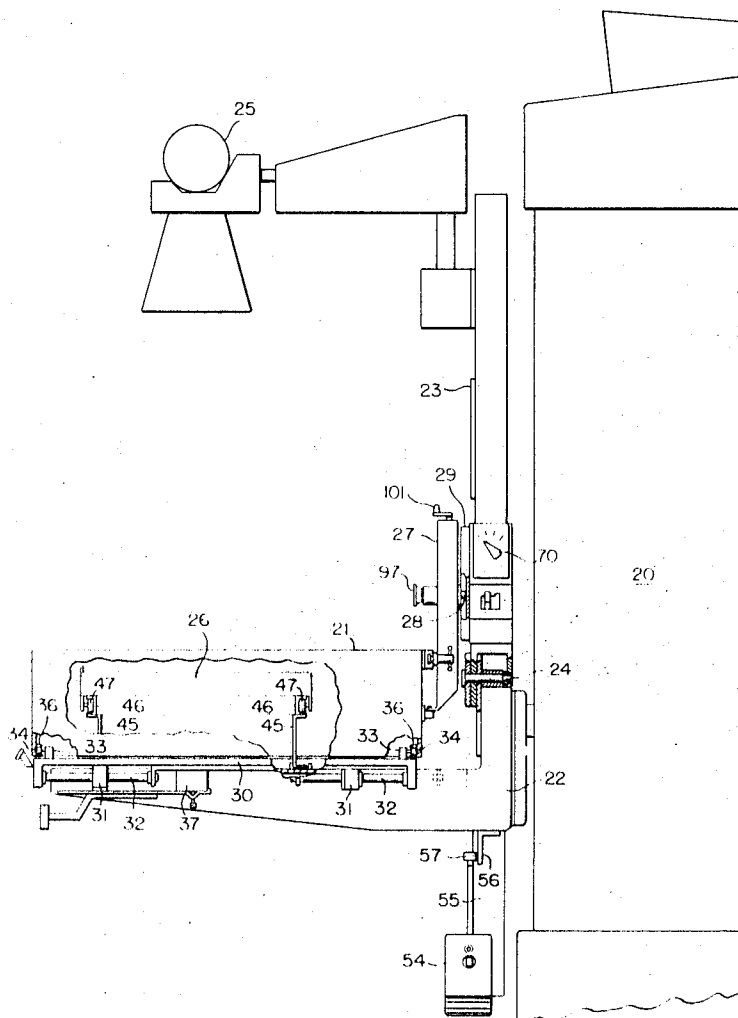
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ABSTRACT

An x-ray table having a table support, a stationary film cabinet mounted on the support, and a table mounted on the support for longitudinal movement with respect to the film cabinet is provided with means for obtaining plane section radiographs. A tube column is pivotally mounted to the table support and the x-ray tube is mounted on the other end of this column. A plane selector mechanism is mounted on the table. A vertically adjustable pin on the plane selector is coupled to the tube column in an area between the pivot and the x-ray tube. Thus, as the table is moved longitudinally, the tube column is pivoted through an arc. Switches on the tube column initiate and terminate the exposure as the x-ray moves through its arc.

In the preferred embodiment the coupling pin on the plane selector mechanism may be disengaged from the tube column and the tube column may be locked in one position so that the apparatus may also be used for conventional radiographic procedures. The plane selector mechanism is releasably mounted on the table so that it does not interfere with lateral movement of the table.

12 Claims, 12 Drawing Figures



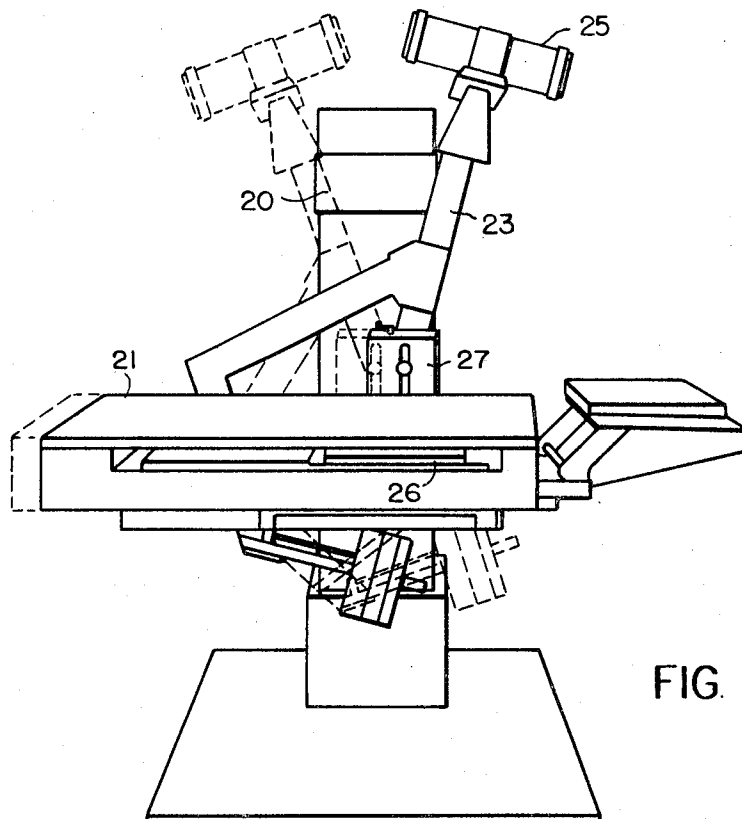


FIG. 1

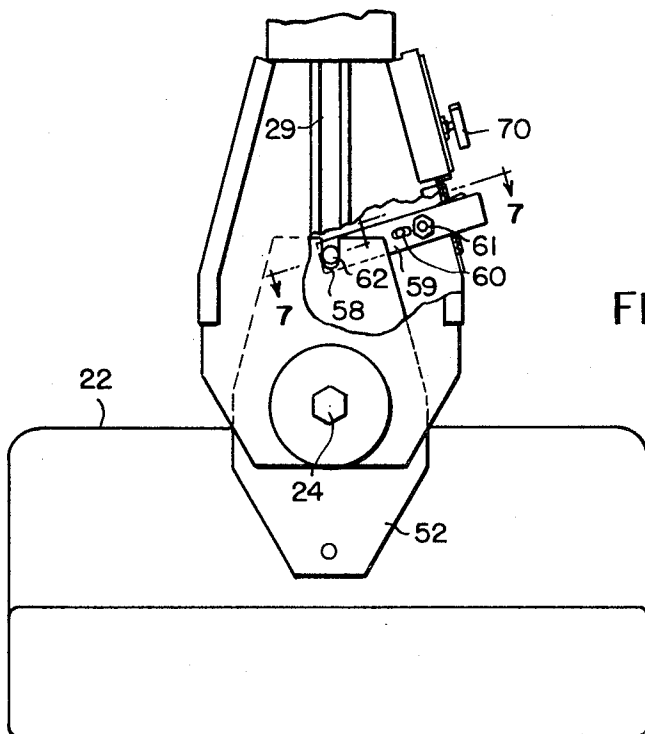
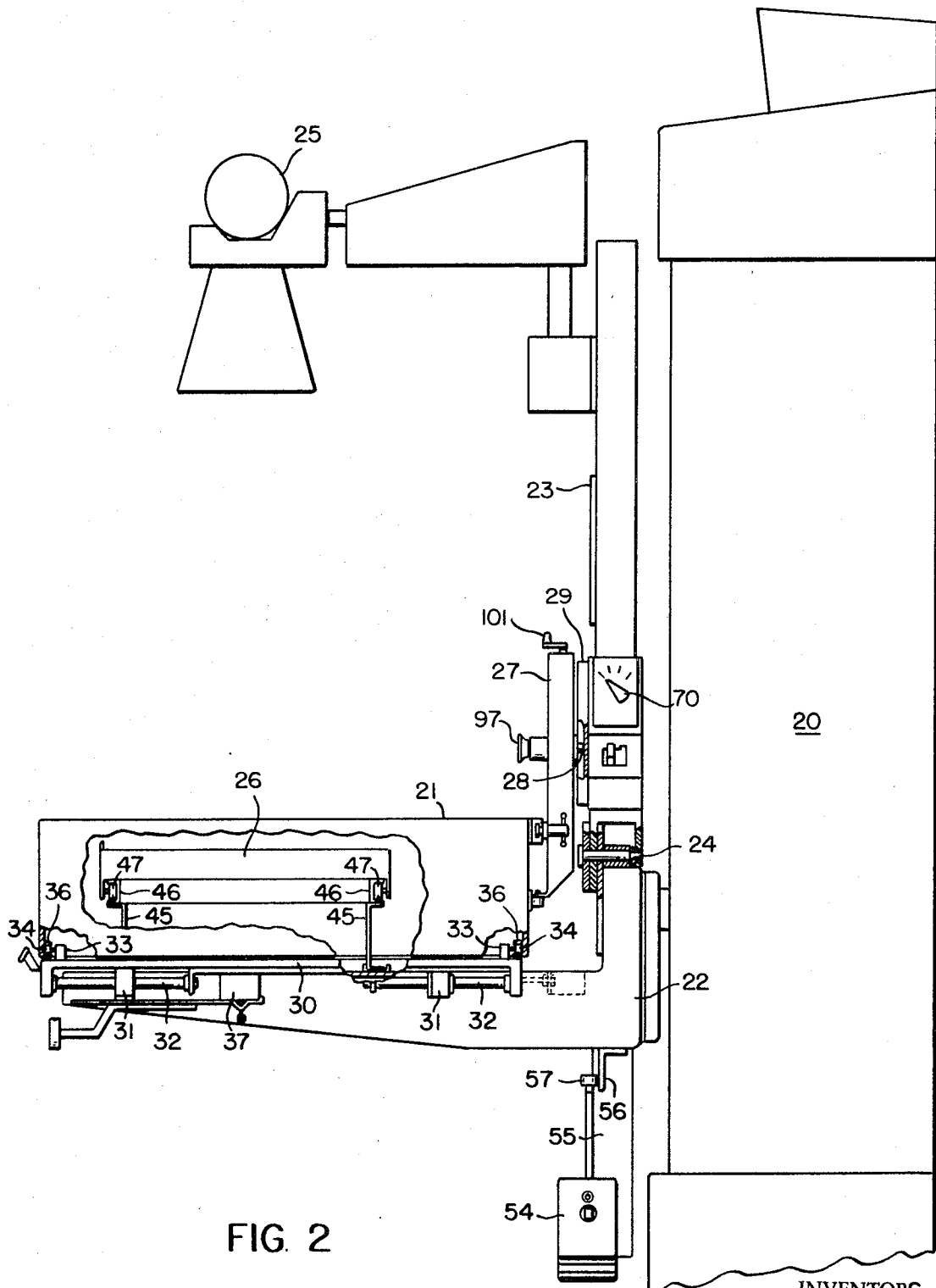


FIG. 5

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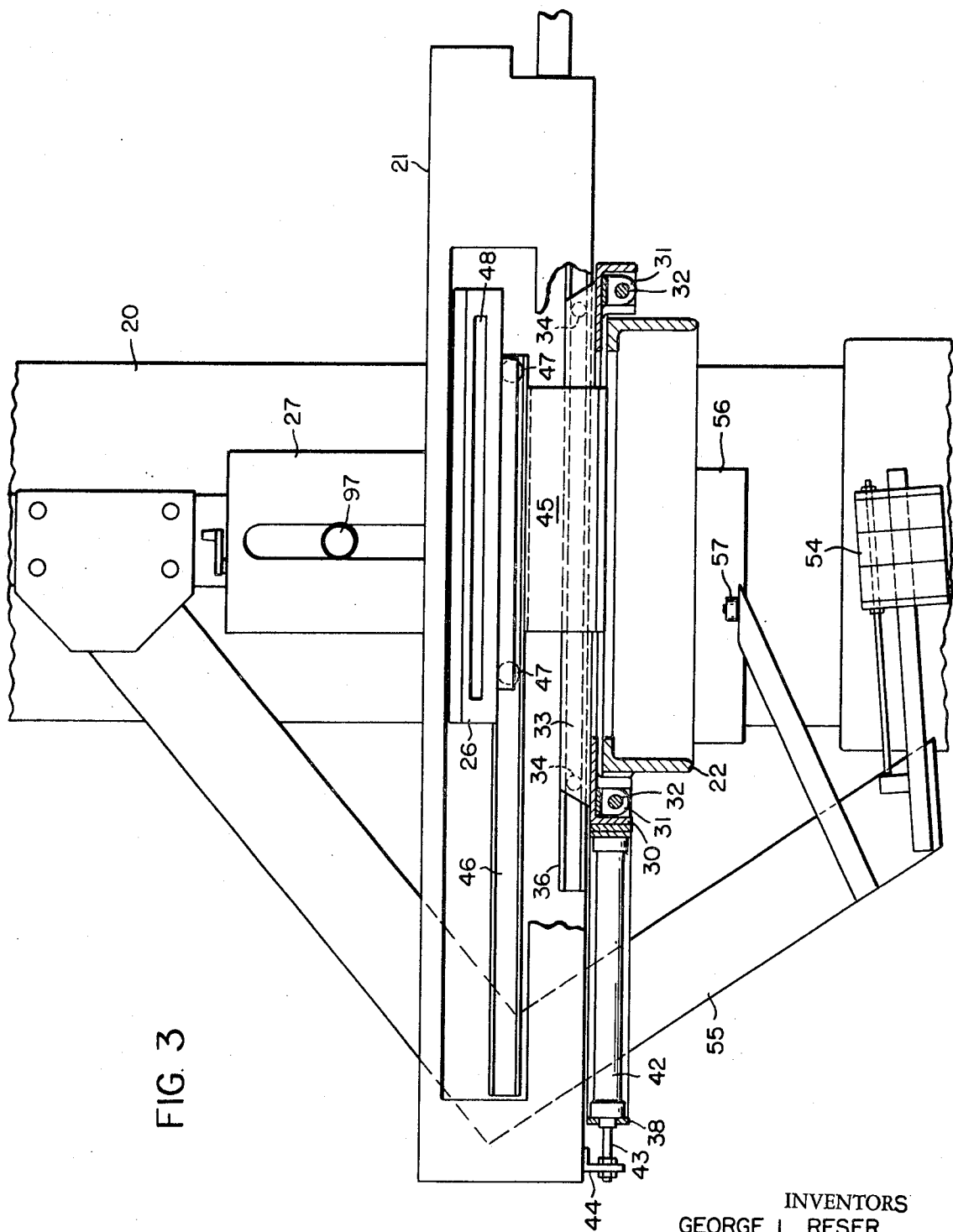


FIG. 3

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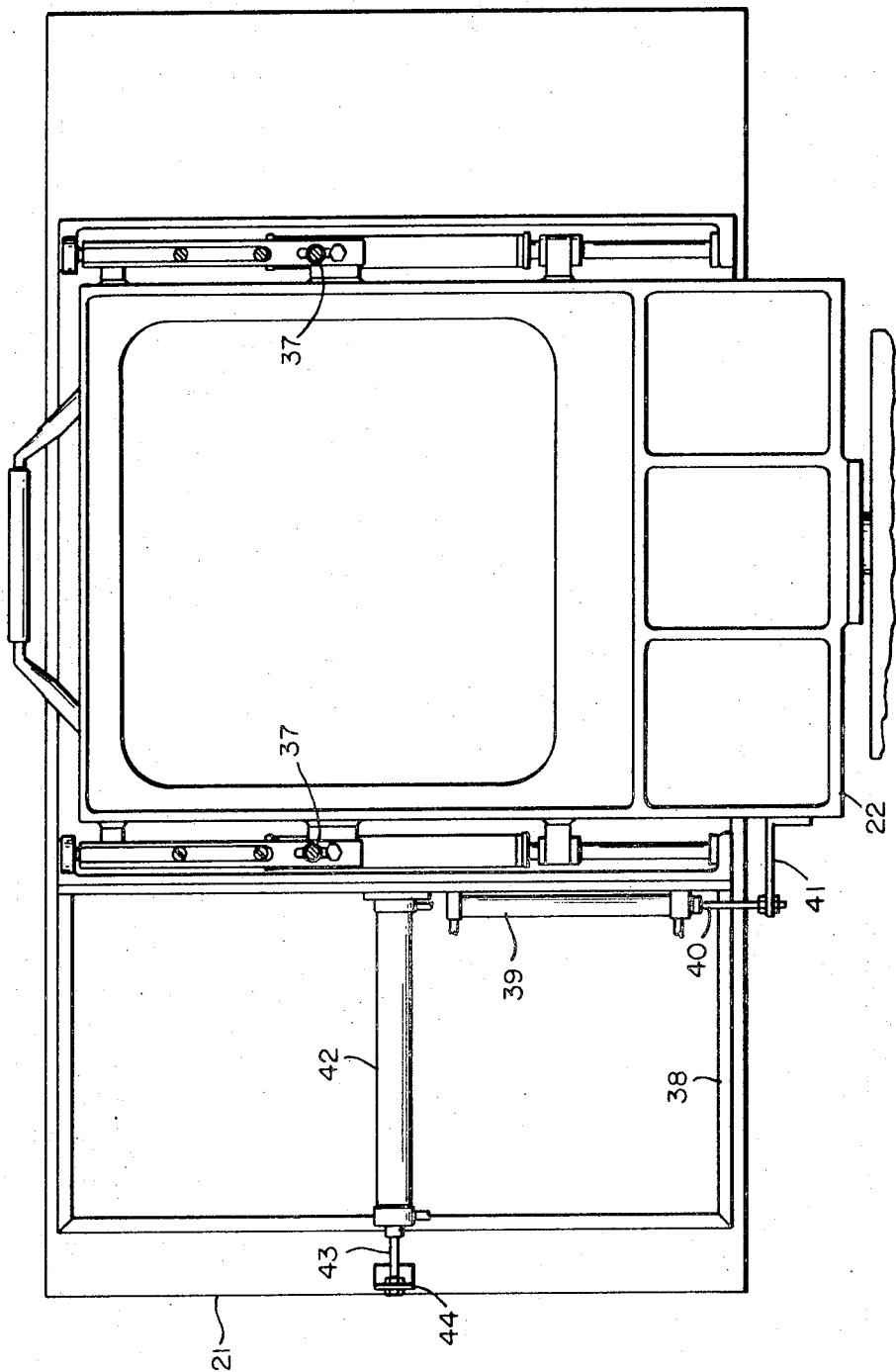
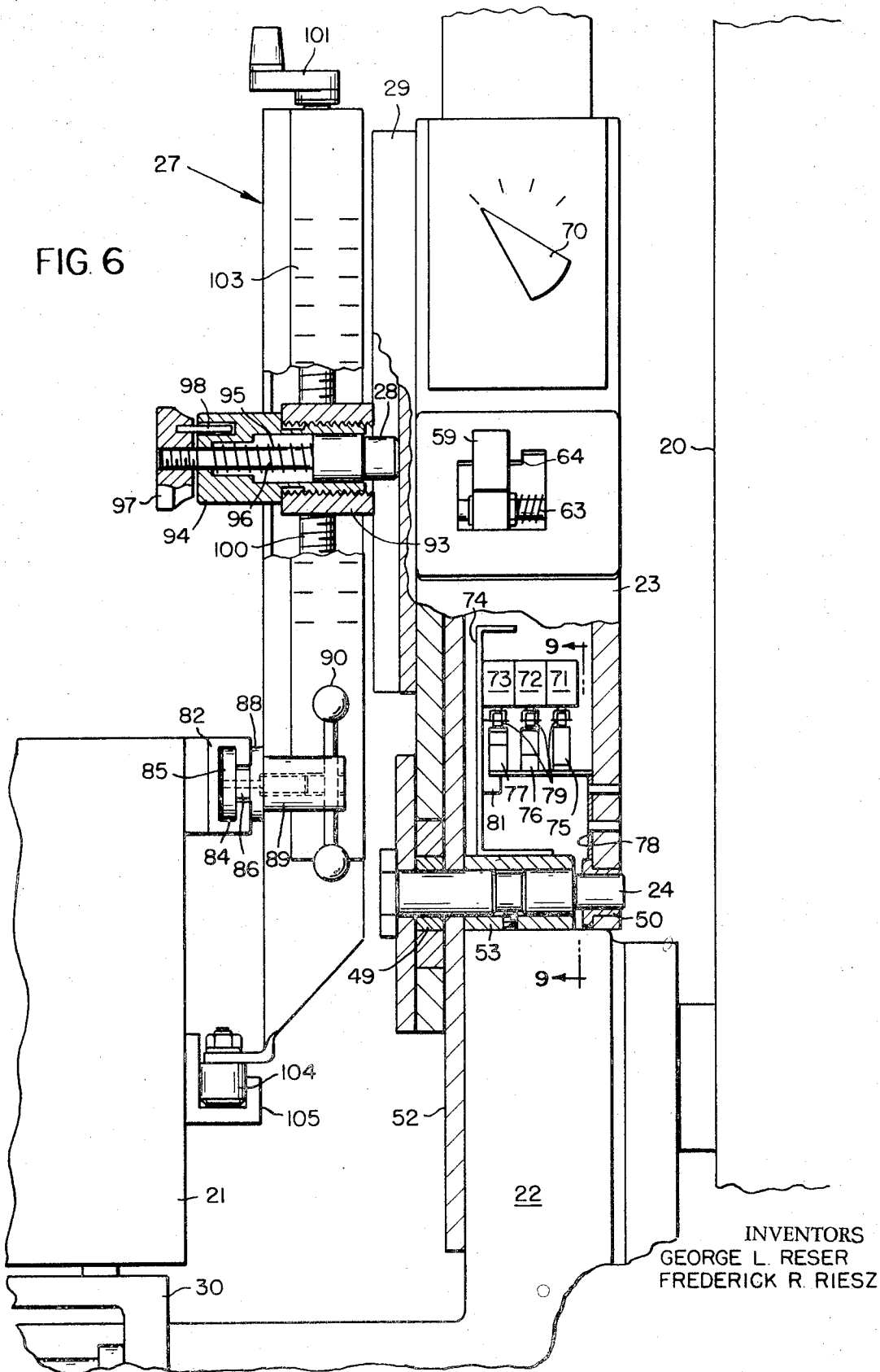


FIG. 4

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FIG. 6



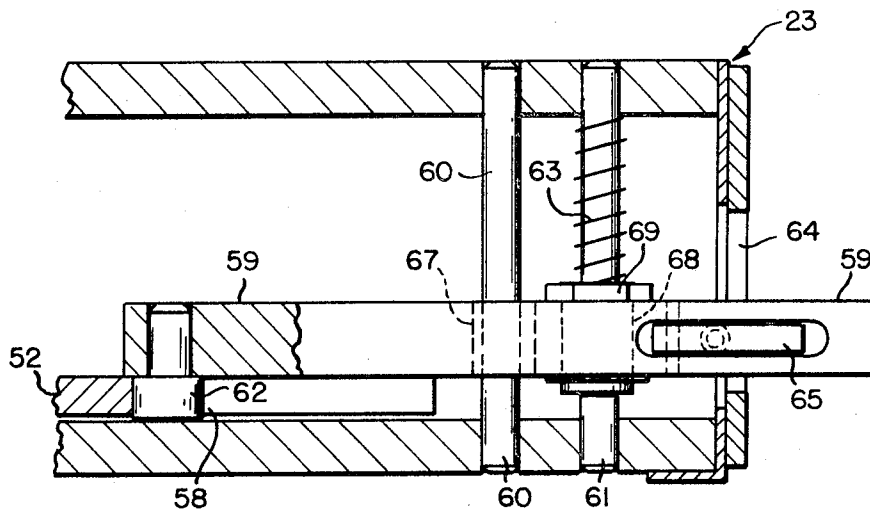


FIG. 7

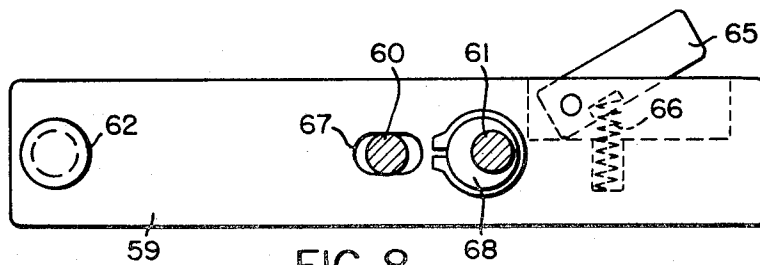


FIG. 8

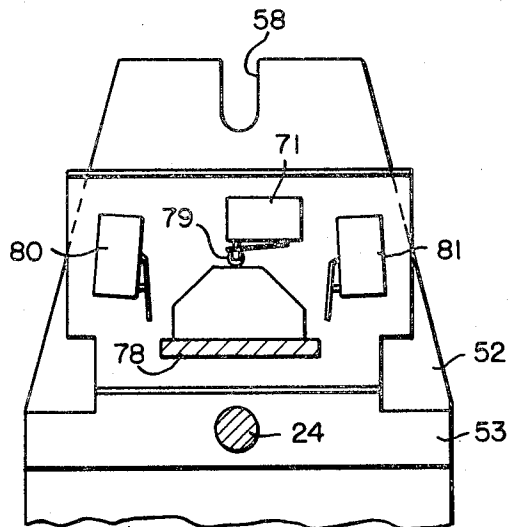
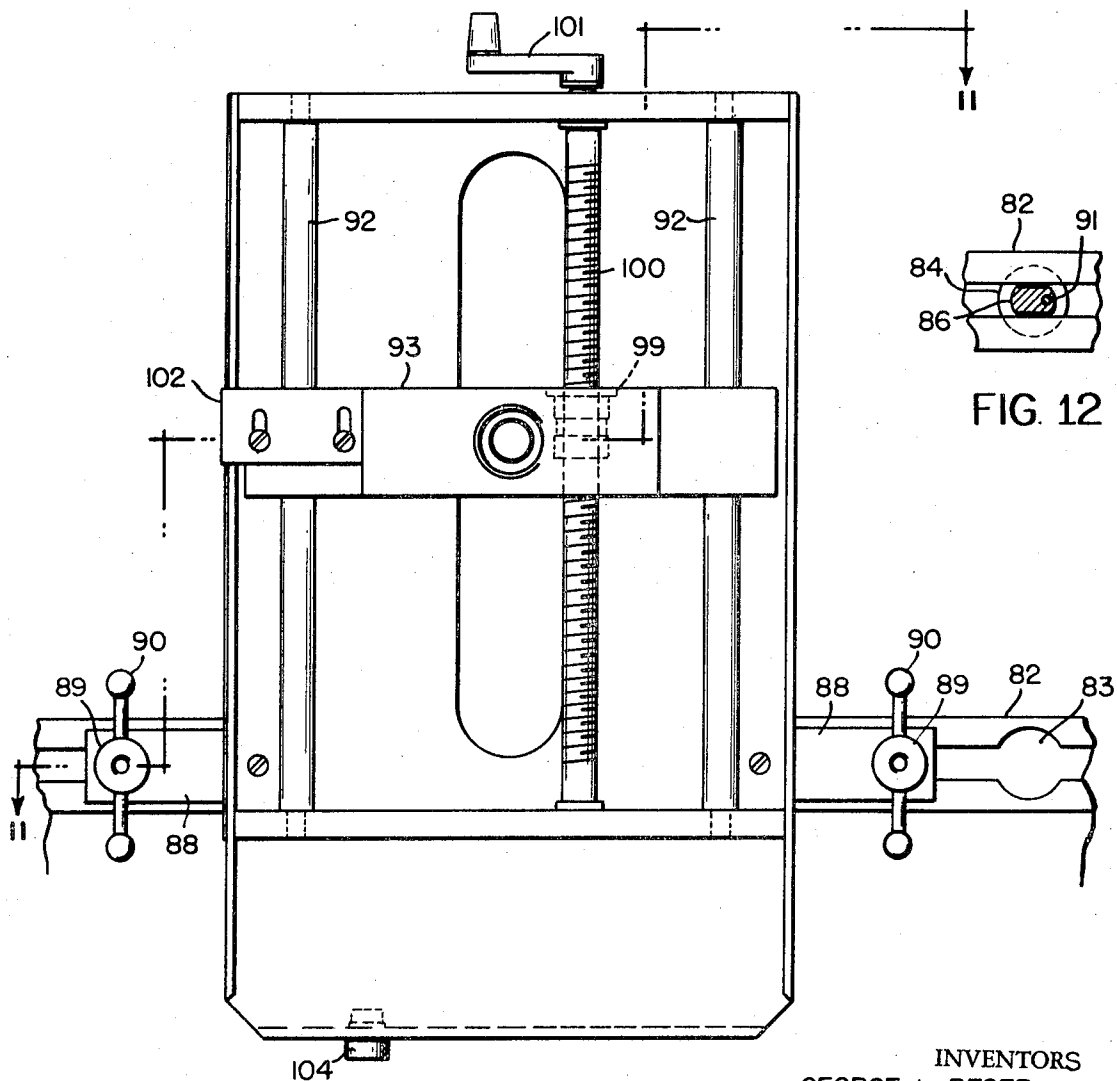
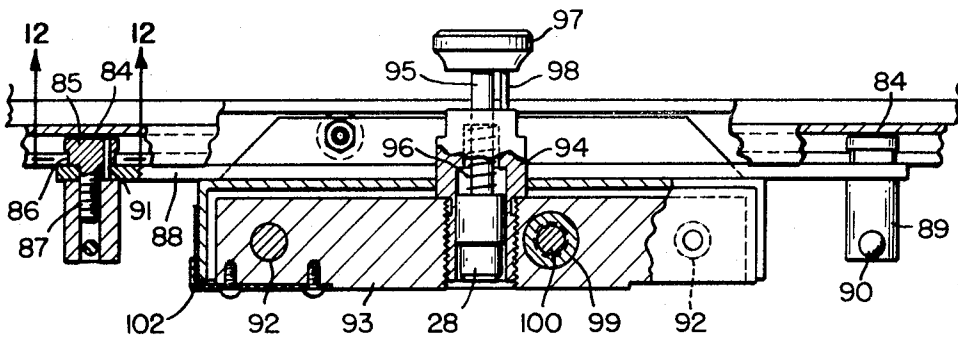


FIG. 9

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FIG. 11



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TOMOGRAPHIC X-RAY SYSTEM WITH A MOVABLE TABLE

BACKGROUND OF THE INVENTION

There are a number of conventional x-ray systems that provide means for obtaining plane section radiographs of a body. These systems, which are variously known as tomographic, laminagraphic, planigraphic and stratigraphic system, provide relative motion between the x-ray tube, the body being examined and the film in order to blur out objects above or below a thin slice in the body. In some of these systems the x-ray tube and film are mounted on opposite ends of an arm which is pivoted about a point in the plane to be examined. In others, the x-ray tube moves longitudinally above the body while the film moves longitudinally in the opposite direction below the body. In still others, the body being examined and the film are rotated simultaneously while the x-rays pass through the body at an acute angle to the axis of rotation.

These systems are extremely useful in certain types of examination because they enable the radiologist to examine a particular organ or section of the body without interference from objects above or below the desired section. However, conventional tomographic systems are quite expensive. Most individual radiologists and many smaller hospitals who have an occasional need for obtaining radiographs of this type cannot justify the expenditure required for a conventional system. It is an object of this invention to provide an inexpensive means for converting existing x-ray tables so they may be used for obtaining plane section radiographs.

Another drawback of conventional tomographic systems is that they cannot be used for a number of conventional radiographic techniques. Thus, even large hospitals which can afford tomographic systems find themselves in a situation where they could use additional tomographic capacity but are unable to justify it because the demand does not justify the required expenditure. Another object of this invention is provide apparatus which may be readily converted from tomographic procedures to other radiographic procedures.

SUMMARY OF THE INVENTION

This invention utilizes a conventional x-ray table having a support, a stationary film cabinet mounted on this support, and a table mounted on the support for longitudinal movement past the film cabinet. Tomographic capability is obtained by mounting a tube column to the support for pivotal movement about an axis perpendicular to the direction of longitudinal movement of the table. The x-ray tube is attached to the tube column at a point displaced from this pivot. A plane selector is mounted on the table and a vertically adjustable pin on the plane selector is coupled to the tube column in an area between the pivot and the x-ray tube. Thus, when the table is moved longitudinally the tube column is pivoted through an arc.

In the preferred embodiment of this invention, the means for coupling the column to the table comprises a vertically adjustable bushing on the plane selector and a pin mounted in the bushing which reciprocates into and out of a channel on the tube column. Thus, the table may be readily disengaged from the column when the apparatus is to be used for some purpose other than obtaining tomographs. Means are provided for locking the tube column in a fixed position when the table is

disengaged. In addition the plane selector is releasably mounted on the table so that it may be removed to extend the range of lateral movement of the table.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front perspective view of one embodiment of this invention showing the movement of the table, plane selector and tube column during tomography.

FIG. 2 is an elevation view of the right or foot end of this table, partially cut away to show the film cabinet, mounting of the table, mounting of the tube column, and coupling of the table to the tube column.

FIG. 3 is a front elevation view partially cut away to show the table mounting.

FIG. 4 is a bottom view of the table.

FIG. 5 is an enlarged front elevation view of the tube column and table support partially broken away to show the mounting of the tube column and the means for locking the tube column in a fixed position when it is not being used for tomography.

FIG. 6 is an enlarged right hand elevation of the tube column, table and plane selector, partially broken away to show the coupling between the plane selector and the tube column, the mounting of the column to the support and the control switches associated with the tube column.

FIG. 7 is a cross sectional view taken along lines 7—7 of FIG. 5 showing the means for locking the tube column in place.

FIG. 8 is a detail view of the locking bar used in the locking means shown in FIGS. 5 & 7.

FIG. 9 is a detail view taken along lines 9—9 of FIG. 6.

FIG. 10 is an enlarged rear view of the plane selector.

FIG. 11 is a sectional view taken along lines 11—11 of FIG. 10.

FIG. 12 is a cross sectional detail view taken along lines 12—12 of FIG. 11.

DETAILED DESCRIPTION

The preferred embodiment of this invention utilizes most of the components of the cantilever supported urological x-ray table disclosed in U.S. Pat. No. 3,302,022 to O. R. Brenner and G. L. Reser, which is assigned to the assignee of the present invention.

Referring to FIGS. 1 & 2, this apparatus includes a tower or column 20 which supports a movable table 21. As shown in FIG. 2 the table is supported by a yoke 22 which extends from the column. The yoke may be moved vertically and/or rotated in order to adjust the position of the table. The means for effecting vertical movement and rotation, which form no part of the present invention, are disclosed in detail in U.S. Pat. No. 3,302,022.

Tomographic capability is provided on this table by mounting a tube column 23, pivoted about a rod 24, to yoke 22 by means which are disclosed in more detail below. The x-ray tube 25 is mounted at the upper end of column 23. Yoke 22 also supports a stationary film cabinet 26. The pivot rod 24 is preferably located in or near the plane at which the x-ray film is located in cabinet 26.

A plane selector 27 is mounted on table 21. The selector carries a vertically adjustable roller 28 which can be reciprocated into and out of a channel 29 on the face of tube column 23. With the roller inserted in the channel as shown in FIG. 2, longitudinal movement of

the table pivots the tube column about pivot rod 24. As shown in FIG. 1, during tomography the table and plane selector move longitudinally from right to left or vice versa and this causes the tube column to pivot through an arc from right to left or vice versa.

As the tube column pivots, switches, which are described in more detail below, energize and de-energize x-ray tube 25. Assuming that the pivot rod 24 is located in the plane of the film in cabinet 26, objects on a line which passes through the coupling roller and is parallel to the pivot rod will be projected on the film as stationary points. Objects above the below this line are projected on the film as moving points. Consequently, objects more than a slight amount above or below this line are blurred out and do not appear on the resulting tomograph.

Objects which are at the same height as the coupling roller but longitudinally displaced from it are also projected on the film as moving points. These objects will be blurred somewhat, depending on the amount of longitudinal displacement, the height of the object above the film, the length of the pivoting tube column and the amplitude of the exposure arc. In the preferred embodiment of this invention; wherein the tube column is 40 inches long and the height of cut, i.e. the distance between the film and the plane being examined, can be up to 22 centimeters (8.7 inches); exposure arcs of at least 30° can be used without causing any noticeable blurring of longitudinally displaced objects at the edge of a 17 inch wide tomograph.

TABLE ASSEMBLY

Table 21 is mounted on the yoke 22 for both longitudinal and lateral movement. As shown in FIGS. 2 & 3, a carriage 30 is mounted to the yoke by four bearing blocks 31 attached to the yoke through which extend guide rods 32 depending from the carriage. A pair of upwardly extending ribs 33 are located along the front and rear edges of carriage 30. Each rib supports a pair of laterally extending rollers 34 that extend into a pair of laterally spaced U-shaped channels or tracks 36 attached to the bottom of the table. The tracks and rollers allow the table to move longitudinally while the guide rods on the carriage and bearing blocks on the yoke allow the table to move laterally.

As shown in FIGS. 2 & 4, the table is provided with a pair of lateral center locks 37, which are described in greater detail in U.S. Pat. No. 3,302,022. These center locks prevent movement of the carriage with respect to yoke 22. The basic cantilever urological table disclosed in U.S. Pat. No. 3,302,022 only has one of these center locks, however, when this table is used with tomographic equipment of the present invention, we prefer to use two center locks, as shown in FIG. 4, in order to provide increased rigidity and to prevent any torque applied to the table by the tube column arm from being transmitted to guide rods 32 and bearing blocks 31.

The table is moved longitudinally and laterally by hydraulic cylinders which are also shown in FIGS. 3 and 4. The cylinders are held in place by a frame 38 which is attached to carriage 30.

Lateral movement is provided by a hydraulic cylinder 39 mounted along the inner end of frame 38. Piston rod 40 extends from cylinder 39 and is attached to a bracket 41 which is mounted on the yoke 22. This cylinder is not needed for tomography and may be omitted. However, in many conventional radiographic tech-

niques it is desirable to have an easy and rapid method for positioning the patient laterally beneath the x-ray tube.

Longitudinal movement of the table is effected by a second hydraulic cylinder 42 extending along the longitudinal center line of the table. Piston rod 43 extending from this cylinder is attached to a bracket 44 which depends from the head end of table 21. Since the cylinder is connected to the carriage 30, which is mounted on the yoke, movement of the rod within the cylinder moves the table longitudinally with respect to the yoke.

Hydraulic fluid is supplied to these cylinders by two pumps mounted at the top of the tower 20. Electrically actuated multi-way valves (not shown) provide means for reversing the direction of fluid flow to and from the cylinders. Speed control valves are provided in the hydraulic fluid supply system to control the speed at which the table moves. With this system the table top can be moved either longitudinally or laterally at a controllable constant speed.

Other means of moving the table may be used, but the means for providing longitudinal movement should preferably move the table at a controlled speed. In this embodiment, the amplitude of the arc during which the x-ray tube is energized and therefore the length of exposure are controlled by switches which close and then open as the tube column moves through its arc. A controlled longitudinal movement is desirable in order to insure that, with a given exposure arc and plane elevation, the duration of exposure is constant.

FILM CABINET

As was mentioned above, yoke 22 also supports a film cabinet 26. As shown in FIGS. 2 & 3, two channels 45 are attached to the yoke and tracks 46 are mounted on top of the channels. Rollers 47 on the cabinet ride in the tracks. The cabinet may be moved along the track to get it out from under the x-ray tube so that the table can be used with an image intensification unit as described in U.S. Pat. No. 3,302,022. However, in tomography the cabinet remains stationary in the position shown in the drawings.

As seen in FIG. 3, the cabinet has an opening 48 into which an x-ray film cassette may be inserted. Either a single film cassette or a cassette with a plurality of vertically spaced films may be used. When a multifilm cassette is used, a plurality of tomographs of vertically spaced sections are produced in a single exposure.

Other x-ray film cabinets such as the Bucky shown in U.S. Pat. No. 3,302,022 may be used. However, if an installation such as the one in that patent, which is mounted on the movable table, is used means must be provided to secure the cabinet to the yoke so that it will remain stationary during tomography.

TUBE COLUMN

The mounting of the tube column 23 to the yoke is best seen in FIGS. 5 & 6. Pivot rod 24 extends through bearings 49, 50 in the tube column and through a mounting assembly secured to the yoke. The mounting assembly consists of a vertically extending plate 52 which is bolted to the front face of the yoke and a flat bar 53, best seen in FIG. 9, that extends across and is fastened to the rear of the vertically extending plate. The flat bar 53 rests on top of the yoke and carries the weight of the tube column.

As shown in FIGS. 2 & 3 the weight of the tube column and x-ray tube is counterbalanced by weights 54 mounted on an arm 55 extending around the yoke. An angle 56 is bolted to the bottom of the yoke and a roller 57 mounted on arm 55 bears on the angle. The roller helps maintain vertical alignment of the tube column and also helps resist the moment created by the cantilevered x-ray tube. This permits the tube column to pivot easily on rod 24.

The features for locking the tube column in place when the apparatus is not being used for tomography are shown in FIGS. 5, 6, 7 & 8. The vertical plate 52 on the tube column mounting assembly has a notch 58 in its upper edge. A locking bar 59 is mounted for reciprocating movement along a pair of rods 60, 61 which are mounted on the tube column at an angle, preferably a right angle, to plate 52. As bar 59 reciprocates, a pin 62 mounted on the bar moves into and out of notch 58. When the pin is in the notch, the column is locked in place. As best seen in FIG. 7, a spring 63 biases the locking bar towards the notch and insures that the pin does not slip out accidentally.

As shown in FIGS. 6 & 7, the locking bar extends through a stepped opening 64 in a plate on the tube column. A pivoted catch 65, best shown in FIG. 8, is biased by a spring 66 into the larger portion of opening 64 when the bar is moved backwards to unlock the tube column. Catch 65 and the step in opening 64 hold the bar in the unlocked position during tomography.

Rod 60 passes through an elongated slot 67 in the locking bar while rod 61 passes through an eccentric 68, best seen in FIG. 11, held in locking bar 59 by a set screw. As seen in FIG. 7, there is a hexagonal head 69 on one end of the eccentric extending from the locking bar which can be used to rotate the eccentric within the bar. The position in which the tube column is locked may be adjusted by rotating the eccentric within the locking bar, which causes the locking bar to move with respect to rods 60 and 61.

Switches for selecting the amplitude of the exposure arc, activating the x-ray tube and limiting movement of the table during tomography are associated with the tube column and mounting assembly. These switches are best seen in FIGS. 6 and 9. The amplitude selector switch 70 is a four position rotary switch with an off position in which the x-ray tube is not activated and positions for selecting exposure arcs of 10, 20, and 30°. In the latter positions, selector switch 70 completes a circuit through one of three roller lever actuated switches 71, 72, 73 mounted on a plate 74 that in turn is secured to the stationary tube column mounting assembly. These switches are activated by cams 75, 76, 77 mounted on a plate 78 fastened to the tube column. The profile for the 10 degree cam is shown in FIG. 9. The cams for the 20 and 30 degree switches are similar. Each cam has a relatively steep ramp on each side and a curved center section. As the tube column pivots, rollers 79 on the switch actuators move up the ramps on one side of the cams, thereby closing the switches. The switches remain closed until the rollers go back down the ramps on the other side of the cams. The switch connected in series with amplitude selector switch 70 completes the circuit that energizes and de-energizes the x-ray tube as the tube column pivots, thereby initiating and terminating the exposure.

Two lever actuated switches 80, 81 are also mounted on plate 74. These switches limit the longitudinal travel

of the table and may also be used to deactivate certain other features of the table which are not utilized during tomography. These switches are operated by the edges of the 30 degree cam 77.

PLANE SELECTOR

The plane selector 27 is shown in FIGS. 6, 10, 11 & 12. A generally C shaped channel 82 with a relatively large center section and a relatively narrow opening in one side is mounted on table 21. Enlarged access holes 83 are provided along the channel to facilitate installation of the plane selector. The selector is mounted to the channel by studs 84 with enlarged ends 85, flattened central portions 86, best seen in FIG. 12, that extend through the narrow opening in the channel, and threaded ends 87 that extend through a bar 88 on the back of the plane selector and into nuts 89 that tighten the studs within the channel. The nuts are provided with T handles 90 that facilitate installation and removal of the selector. As can be seen in FIG. 11, the flattened portion of each stud is maintained in the desired orientation with respect to the channel by a pin 91 that extends through the enlarged end 85, the flattened center portion 86 and through a hole in the bar 88. This also facilitates installation of the plane selector.

As best seen in FIG. 6, the plane selector is held in a vertical position by a roller 104 that rides in a channel 105 attached to the table.

The plane selector has two rods 92, best seen in FIG. 10, that support a vertically adjustable bar 93. A bushing 94 is mounted in the bar and a spring loaded pin 95, best seen in FIG. 11, which carries the coupling roller 28, is mounted for reciprocation in the bushing. Spring 96 biases the pin and roller into the position shown in FIG. 6, wherein the coupling roller is in the channel 29 mounted on the tube column. When the roller is in the channel, the tube column is pivoted when the table moves longitudinally. The pin and roller may be retracted into the bushing as shown in FIG. 11 so that the table may be moved without pivoting the tube column when the table is not being used for tomography. There is a knob 97 on the end of coupling pin 95 and a retaining pin 98 mounted in the knob which holds the coupling pin and roller in the retracted position. The knob and coupling pin are rotated into the position shown in FIG. 6 to allow retaining pin 98 to mate with a hole in bushing 94 and permit the coupling pin 95 and rollers 28 to move into the channel 29 on the tube column.

As best seen in FIG. 10, there is a nut 99 in bar 93 and a rotatable screw 100 that extends through the nut. The screw may be rotated by crank 101 to raise the bar and coupling roller to the height of the section in the body that is to be examined.

There is an indicator 102, shown in FIGS. 10 and 11, mounted on bar 93 and a scale 103, shown in FIG. 6, on the body of the plane selector so that the operator can readily determine the height of cut, i. e. of the slice that will appear in the tomograph.

CONVERSION OF CONVENTIONAL TABLES FOR TOMOGRAPHY

The basic features which must be added to the table shown in U. S. Pat. No. 3,302,022 in order to provide it with the capability of producing tomographs are the pivoting tube column, its associated controls, and the plane selector. Models which utilize a Bucky mounted

to the table itself, such as the one shown in U.S. Pat. No. 3,302,022, must also be provided with some means to hold the Bucky in a fixed position over the yoke. However, this is usually a relatively simple conversion to make. Thus, it can be seen that the apparatus of this invention provides an inexpensive means for converting existing x-ray tables to provide tomographic capability. In addition, due to the flexibility of the equipment described above, this invention provides x-ray apparatus which may be used equally well for tomography and for other radiographic techniques.

Of course, the features of this invention may be used with a number of conventional x-ray tables other than the one shown in U.S. Pat. No. 3,302,022. The description of that table and the rest of the foregoing description are illustrative and are not meant to limit the scope of this invention, which is defined by the appended claims.

We claim:

1. A tomographic attachment for an x-ray table assembly having a support, a film cabinet carried by the support, and a table carried by the support and adapted for longitudinal movement past the film cabinet, said attachment comprising:

- a. a column, means for pivotally mounting the column to said support at a fixed point, means for attaching an x-ray tube to said column at a point displaced from said pivotal mounting means, a channel on the column between said pivotal mounting means and said x-ray tube; and
- b. a plane selector adapted for attachment to said table, said plane selector having a vertically adjustable pin adapted to ride in said channel in an area of the column between said pivotal mounting means and said x-ray tube and at a predetermined elevation with respect to the table, whereby longitudinal movement of the table pivots the column and the x-ray tube through an arc.

2. An attachment according to claim 1 wherein said pivotal mounting means locates said column so that it pivots about a point in or near the plane at which x-ray film is located in said film cabinet and said plane selector engages the tube column at or near the height of the desired plane section radiograph.

3. An attachment according to claim 1 wherein a channel is attached to the column and said plane selector comprises a vertically adjustable bushing and a pin mounted within said bushing for reciprocation into and out of said channel, whereby the pin may be withdrawn from the channel so that the table and column may be moved independently.

4. An attachment according to claim 1

- a. wherein the said pivotal mounting means comprises a plate adapted to be rigidly attached to said support, said plate having an opening therein; and
- b. a locking member is mounted on said column and adapted for movement into and out of said opening, whereby said column is locked in one position when said locking member is in said opening.

5. Apparatus for obtaining plane section radiographs comprising:

- a. a support;
- b. a film carried by said support;
- c. a table carried by said support and adapted for longitudinal movement past said film;

d. a column, means for pivotally mounting said column to said support, and an x-ray tube attached to the column at a point displaced from the pivot; and

e. means for coupling said table to said column in an area of the column between the pivot and the x-ray tube and at a predetermined elevation with respect to the table, comprising:

- i. a channel mounted on the column;
- ii. a vertically adjustable bushing attached to the table; and
- iii. a pin mounted within the bushing for reciprocation into and out of said channel, whereby longitudinal movement of the table moves the x-ray tube through an arc when the pin is in the channel and the table may be moved without pivoting the column and x-ray tube when the pin is withdrawn from the channel.

6. Apparatus for obtaining plane section radiographs comprising:

- a. a support;
- b. a film carried by said support;
- c. a table carried by said support and adapted for longitudinal movement past said film;
- d. a column, means for pivotally mounting said column to said support, and an x-ray tube attached to the column at a point displaced from the pivot;
- e. means for coupling said table to said column in an area of the column between the pivot and the x-ray tube and at a predetermined elevation with respect to the table, whereby longitudinal movement of the table moves the x-ray tube through an arc; and
- f. means for locking the column in one position, said locking means comprising:
 - i. a plate rigidly attached to said support, said plate having an opening therein; and
 - ii. a locking member mounted on said column and adapted for movement into and out of said opening, whereby the column is locked in one position when said locking member is in said opening.

7. Apparatus according to claim 6 wherein the locking member comprises a bar mounted for reciprocating movement along a plurality of rods mounted on the column at an angle to said plate.

8. Apparatus according to claim 7 wherein at least one of said rods passes through an elongated slot in said bar and another one of said rods passes through an eccentric mounted in said bar and adapted for rotation therein, whereby the position in which the column is locked may be adjusted by rotating the eccentric in the bar.

9. A tomographic attachment for an x-ray table assembly having a support, a film cabinet carried by the support, and a table carried by the support and adapted for longitudinal movement past the film cabinet, said attachment comprising:

- a. a column, a channel attached to the column, means for pivotally mounting the column to said support, and means for attaching an x-ray tube to said column at a point displaced from said pivotal mounting means; and
- b. a plane selector adapted for attachment to said table, said plane selector having vertically adjustable means for engaging the column in an area of the column between said pivotal mounting means and said x-ray tube comprising a vertically adjustable bushing and a pin mounted within said bushing for reciprocation into and out of said channel,

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whereby longitudinal movement of the table moves the x-ray tube through an arc when the pin is in the channel and the table and column may be moved independently when the pin is withdrawn from the channel.

10. A tomographic attachment for an x-ray table assembly having a support, a film cabinet carried by the support, and a table carried by the support and adapted for longitudinal movement past the film cabinet, said attachment comprising:

- a. a column;
- b. means for pivotally mounting the column to said support comprising:
 - i. a plate adapted to be rigidly attached to said support, said plate having an opening therein; and
 - ii. a locking member mounted said column and adapted for movement into and out of said opening, whereby said column is locked in one position when said locking member is in said opening;
- c. means for attaching an x-ray tube to said column

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at a point displaced from said pivotal mounting means; and

- d. a plane selector adapted for attachment to said table, said plane selector having vertically adjustable means for engaging the column in an area of the column between said pivotal mounting means and said x-ray tube, whereby longitudinal movement of the table moves the x-ray tube through an arc.

11. An attachment according to claim 10 wherein the locking member comprises a bar mounted for reciprocating movement along a plurality of rods mounted on the column at an angle to said plate.

12. An attachment according to claim 11 wherein at least one of said rods passes through an elongated slot in said bar and another one of said rods passes through an eccentric mounted in said bar and adapted for rotation therein, whereby the position in which the column is locked may be adjusted by rotating the eccentric in the bar.

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