United States Patent [19]

Amor, Jr. et al.

[11] **3,891,856**

[45] **June 24, 1975**

[54] **MOUNT FOR CEILING SUPPORTED X-RAY TUBE**

[75] Inventors: **William H. Amor, Jr.**, Auburn Township; **Robert E. Stancliff**, Mentor, both of Ohio

[73] Assignee: **Picker Corporation**, Cleveland, Ohio

[22] Filed: **Nov. 21, 1973**

[21] Appl. No.: **418,057**

[52] **U.S. Cl.** **250/523**; 250/439; 250/525

[51] **Int. Cl.** **H05g 1/02**

[58] **Field of Search** 250/523, 525, 323, 439, 250/444–450, 490, 521, 522

[56] **References Cited**

UNITED STATES PATENTS

2,968,732	1/1961	Foderaro	250/523 X
3,359,423	12/1967	Koerner et al.	250/523 X

Primary Examiner—Paul L. Gensler

Attorney, Agent, or Firm—Watts, Hoffmann, Fisher & Heinke

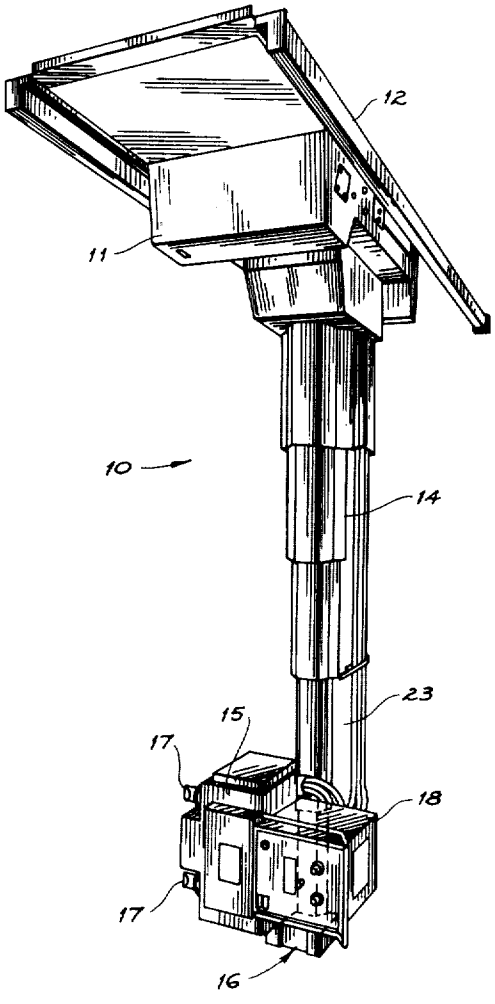
[57] **ABSTRACT**

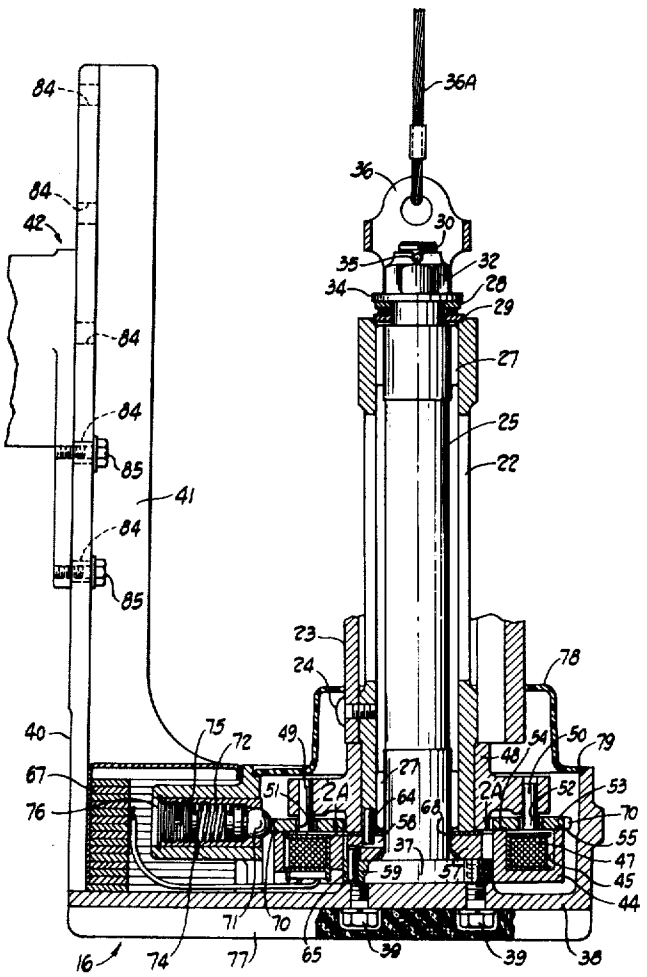
An X-ray apparatus in which an X-ray tube is mounted on a column. The tube mounting includes provision for rotating the X-ray tube about an axis which is longitudinal of the column and about a second axis which is normal to the column axis. Novel rotation limiting structure is provided to limit the rotation about the column axis to a predetermined amount.

A fail-safe mechanism is provided to limit rotation about the second axis. The fail-safe mechanism automatically senses abnormal conditions such as power failure and is rendered inoperative until such abnormal conditions are detected.

A fail-safe override is provided. The fail-safe override can be actuated when, but only when, the X-ray tube and associated structure are controlled by the operator.

21 Claims, 9 Drawing Figures





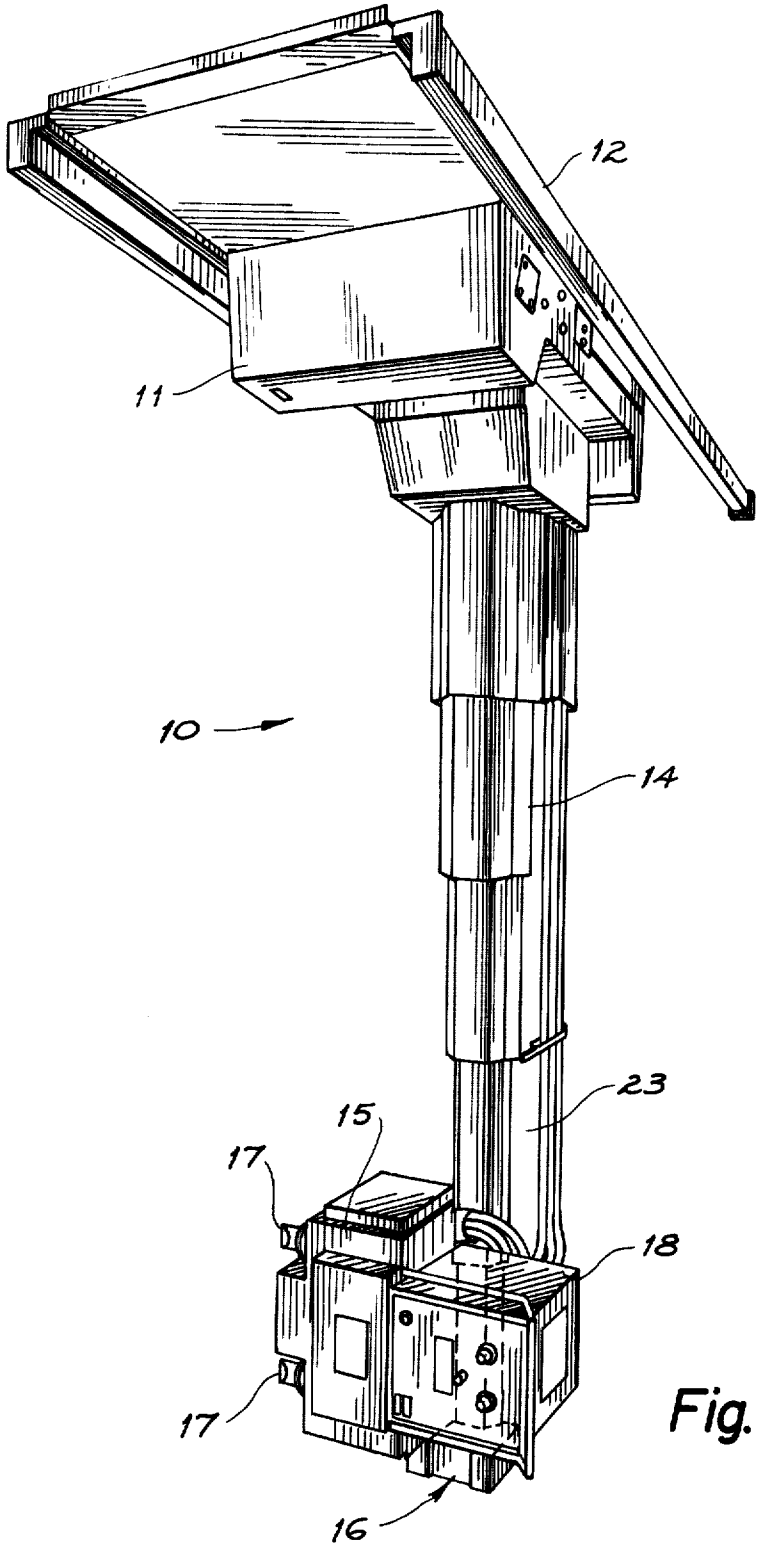


Fig. 1

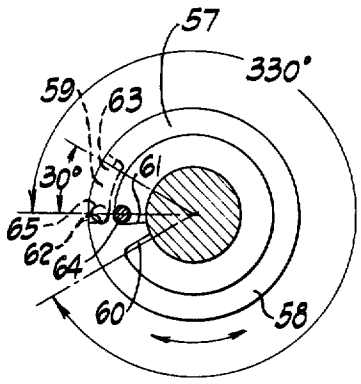

57
330°
59
63
61
30°
65
62
64
60
58

Fig. 2A

84
84
42
84
84
85
41
84
85
36A
36
30
35
32
34
28
29
27
25
22
23
24
78
40
75
72
49
54
50
79
67
27
48
76
51
2A
64
2A
52
53
68
58
70
37
55
59
57
47
45
44
71
70
65
39
39
38
16
74
77

Fig. 2

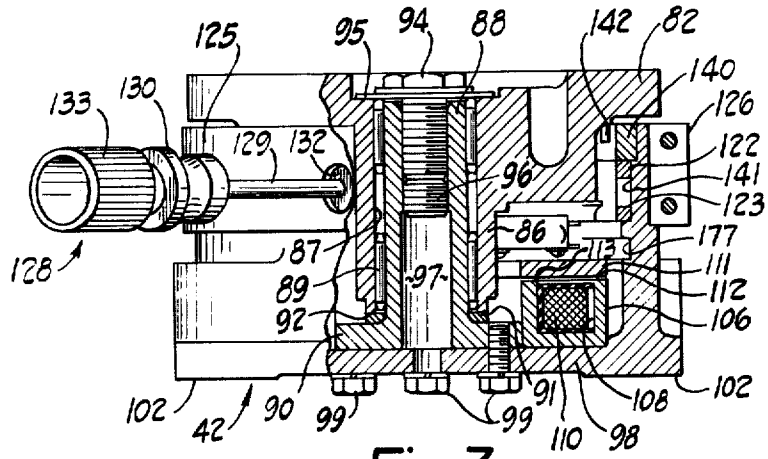


Fig. 3

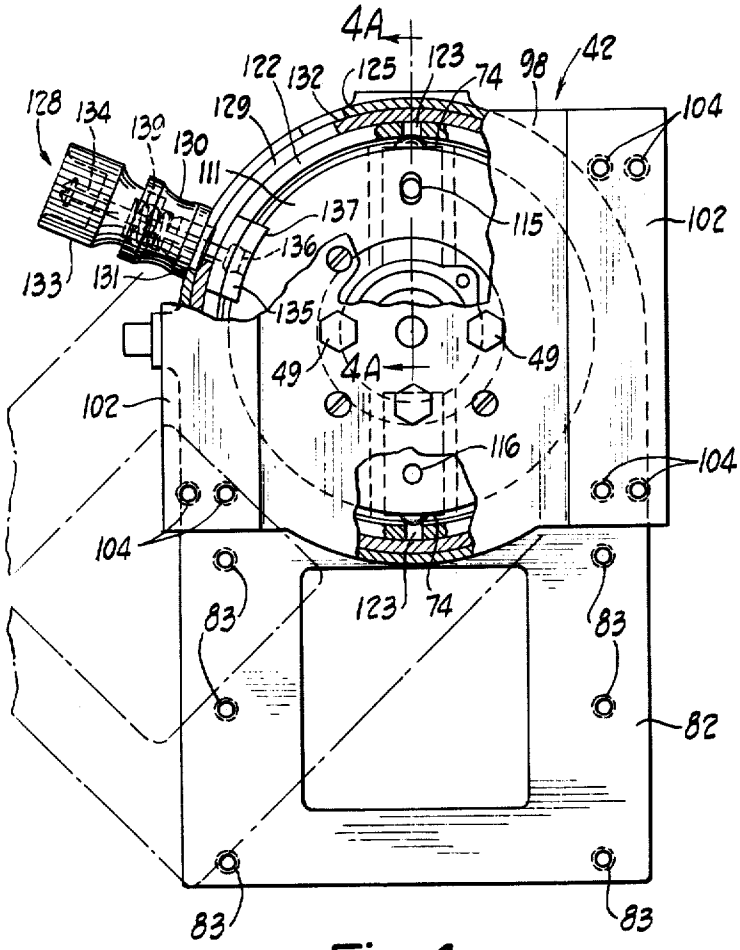


Fig. 4

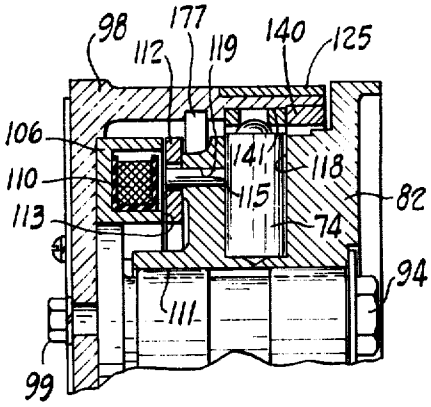


Fig. 4A

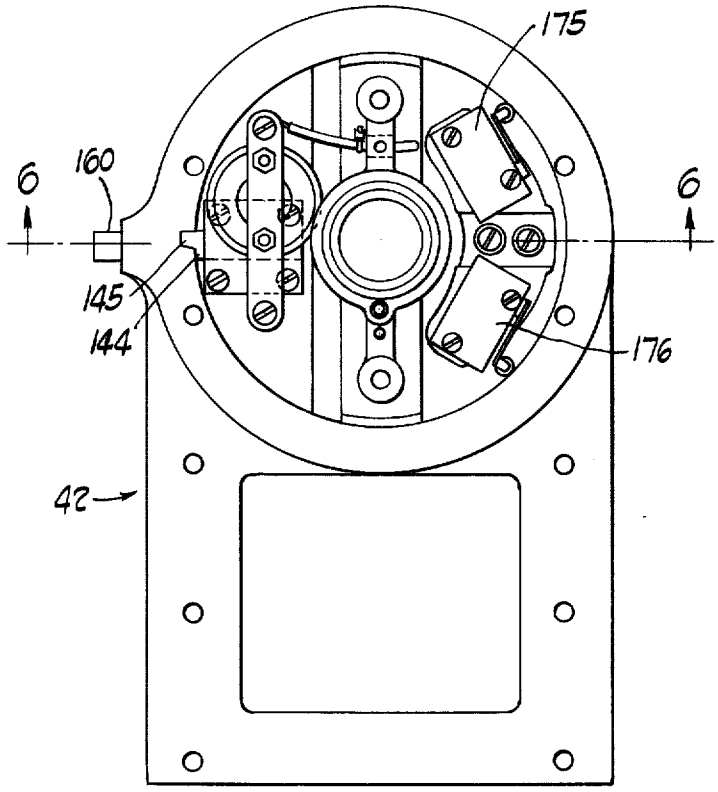


Fig. 5

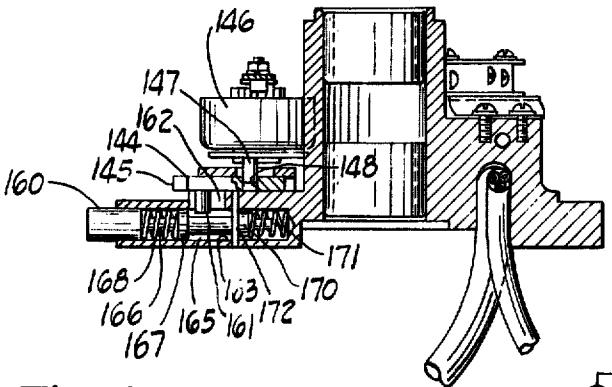


Fig. 6

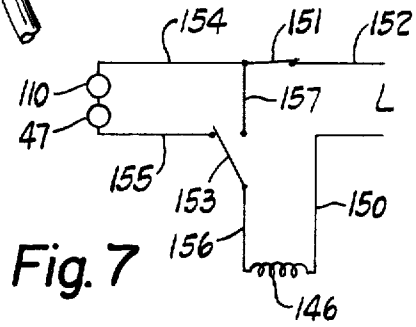


Fig. 7

MOUNT FOR CEILING SUPPORTED X-RAY TUBE

CROSS REFERENCES TO RELATED PATENTS AND APPLICATIONS

1. U.S. Pat. No. 2,997,585 issued Aug. 22, 1961 to R. C. Schiring, under the title "Combined Image Amplifier and Fluoroscopic Screen above X-ray Examination Table," here the SYSTEM PATENT.

2. U.S. Pat. No. 2,968,732, issued Jan. 17, 1961 to A. J. Foderaro under the title "Tube Stand Head Counterbalance," here the TUBE MOUNT PATENT.

3. U.S. Pat. No. 3,643,095, issued Feb. 15, 1972 to R. F. Shuster, under the title "Automatic Collimator Control for X-Ray Apparatus," here the AUTOMATIC COLLIMATOR PATENT.

4. Concurrently filed application Ser. No. 418,051 filed by William H. Amor, Jr., and A. Thomas DiFranco under the title "Fail-Safe Telescopic Support System for X-Ray Apparatus," here the COUNTERBALANCE APPLICATION.

5. Concurrently filed application Ser. No. 418,128 filed by William H. Amor, Jr., and Robert J. Steffek, under the title "Telescopic Column for X-Ray Apparatus," here the COLUMN APPLICATION.

The disclosures of the referenced applications are incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to ceiling mounted X-ray tubes and more particularly to the mechanism interconnecting a ceiling supported telescopic column and an X-ray tube carried by the column.

2. Description of the Prior Art

In a typical modern X-ray room an X-ray tube is supported from the ceiling. A carriage is mounted on tracks suspended from the ceiling to provide longitudinal and transverse movement of the carriage. An extensible telescopic column depends from the carriage. This column supports an X-ray tube which may be moved from a storage position to a selected operative position and returned.

Usually the ceiling mounted apparatus is positionable over an X-ray table. In operation, the operator grasps the X-ray tube, or the associated equipment such as the tube mounting or the collimator, and shifts the carriage and supported column horizontally to a desired position over the table. The column is extended or retracted to adjust the X-ray tube into an appropriate position over a patient on the table. When an exposure is made by directing the X-ray beam vertically downwardly, usually a film positioned beneath the patient in what is known as a Bucky tray is exposed.

The system thus far described is described and explained in greater detail in the referenced SYSTEM PATENT. As is described in some detail in the reference TUBE MOUNT and AUTOMATIC COLLIMATOR PATENTS, the X-ray tube support is rotatable about a horizontal axis. This permits the ceiling supported X-ray tube to be used for such purposes as laminography or to expose a film in the Bucky when the table is vertical.

The ceiling supported tube may be used for other purposes. For example, the tube may be used to conduct chest X-ray studies. When a chest is to be X-rayed, the subject typically stands against a chest machine. Where a ceiling mounted tube is used, it is oriented to direct its beam about a horizontal axis toward the chest machine. These alternate orientations of the X-ray tube are shown and described in some detail in the referenced AUTOMATIC COLLIMATOR PATENT.

When the X-ray tube mount is rotated about either its horizontal or vertical axes of rotative adjustment, the rotation should be free and easily accomplished. Once rotated to a desired position, there is need for mechanism to restrain the X-ray tube in its adjusted position.

The mechanisms which have been used in the past to maintain an X-ray tube mount in an adjusted position are typically manual. Electromagnets have been used on one or the other, but not both of the rotative adjustments in the mount. Use of electromagnets to maintain the adjusted position can have certain inherent drawbacks. One drawback is that in the past systems which employed magnetic locks on the tube mount have not permitted movement of the overhead carriage or retraction of the column while the X-ray tube mount is maintained in its adjusted position.

Another drawback of prior magnetic locks is that on power failure, the X-ray tube and collimator, if in an orientation to emit a horizontal beam of X-radiation could rotate and can cause damage to equipment or injury to a patient.

In prior mechanisms detents have been provided to index an X-ray tube into selected adjusted positions. A disadvantage which has been present if detents were provided for locating adjustment positions as the tube mount is rotated about its horizontal axis is the detents interfere with the use of the tube with such techniques as laminography.

A problem which has existed with at least some prior art structures and proposals is in controlling the amount of rotation of the X-ray tube mount about its vertical axis of rotation. If the tube is rotated excessively, power cables which supply energy to the X-ray tube can become entangled or damaged. In addition, a support cable which is within the tube can be excessively twisted.

The present invention provides an improved X-ray tube mount which overcomes the foregoing and other drawbacks of the prior art.

SUMMARY OF THE INVENTION

One feature of the invention resides in the magnetic locks. The magnetic locks for both horizontal and vertical movement are in fact restraining mechanisms, not positive locks. Thus, the frictional drag of the magnetic restrainers is adequate to hold the X-ray tube in an adjusted position in normal circumstances. At the same time, the drag is low enough to permit relative movement if, for example, there is a collision.

One advantage of these restrainers is the X-ray tube can be shifted from an adjusted position when the magnets are energized. At the same time, the magnetic lock arrangement permits the tube mount normally to be maintained in adjusted position.

Another advantage is that the mount restraining mechanism is independent of conventional magnetic locks in the column and the carriage. Accordingly, the ceiling mounted carriage may be moved horizontally or the telescopic column extended or retracted without altering the adjusted rotative position of the X-ray tube

with respect to the supporting telescopic column. This is desirable, for example, to permit a patient to get on or off the table, and then return.

With the present invention, the X-ray tube mount is freely rotatable 180° in either direction from a central position. A novel and improved positive stop mechanism is provided to prevent excessive rotation. To achieve this, a rotation control disc is provided. Arcuate slots are formed in the opposite faces of the disc. A fixed pin extends into one slot and a pin which moves with the rotating mechanism extends into the other. The two slots total 360° of arcuate extent so that when the mechanism is rotated 180° in either position from its center position it strikes a positive stop achieved by the two pins engaging ends of the slots in the rotation control disc.

Detents are provided at 90° intervals for indexing the rotation of the X-ray tube mount about its horizontal axis. Detent interference in such situations as when a laminographic study is performed is avoided with a novel detent control arrangement.

When it is desired to use the ceiling mounted X-ray tube of this invention is laminography, a detent control ring is moved 45° from its normal orientation. This permits the X-ray tube to be rotated 45° in either direction from its vertical beam orientation before detents are engaged. Accordingly, an ample range of rotation without detent interference is provided for any laminographic study.

A novel and improved fail-safe mechanism is provided to permit normal free adjustment and operation of the equipment but to provide automatic locking of a mechanism at or near its adjusted position on power failure. With this mechanism, a radially reciprocal dog is mounted in and forms a part of the horizontal pivot assembly. A solenoid holds the dog in a retracted position against the biasing action of a spring. The solenoid is serially coupled to the magnetic restrainer whenever the restrainer is energized. Accordingly, whenever the magnet is de-energized due to a broken wire, power failure, or the like, the solenoid is also de-energized. The spring-biased dog then shifts radially outwardly into engagement with one of a plurality of notches.

A manual override release is provided for the fail-safe dog. The manual override release can be operated only when the X-ray tube and collimator have been manually grasped to take weight off the dog. The override release includes a spring which transmits pressure from a manual release button to the dog. The resilience of the spring is such that one cannot apply adequate force to move the dog unless the weight of the supported mechanism is taken off the dog. Accordingly, the fail-safe mechanism release is operative only when the X-ray tube and its collimator are manually in control. One cannot accidentally disable the fail-safe mechanism by depressing the fail-safe release button at any time other than when the assembly is in control.

When the horizontal rotation magnetic restrainer is de-energized and its switch is in the off position, the fail-safe dog solenoid will be energized so long as the main power is on. Thus, the fail-safe dog will not interfere with the free rotation and adjustment of the mechanism when the magnet is off, but will on power failure, whether the magnet is operative or inoperative, release the dog to prevent accidental, uncontrolled rotation and thereby prevent patient injury or potential damage to the equipment.

Accordingly, a principle object of this invention is to provide a novel and improved mount for coupling an X-ray tube to a support and a method of operating such a mount.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a ceiling mounted carriage, a depending extensible mast and an X-ray tube and collimator carried by the mast;

FIG. 2 is a vertical sectional view of the X-ray tube mount showing the details of construction of the mounting and particularly the details of construction which permit controlled rotation about a vertical axis;

FIG. 2A is a sectional view as seen from the plane indicated by the line 2A—2A of FIG. 2;

FIG. 3 is a top plan view with parts broken away to show internal construction of the mechanism for rotation about a horizontal axis;

FIG. 4 is an elevational view of the horizontal rotation assembly and its carriage with parts broken away to show the detent assembly and the mechanism for adjusting the detent assembly for laminography;

FIG. 4A is a fragmentary sectional view of the horizontal rotation control assembly as seen from the plane indicated by the line 4A—4A of FIG. 4;

FIG. 5 is an elevational view of a portion of the horizontal rotation assembly mechanism with the detent rotation control mechanism eliminated for clarity of illustration;

FIG. 6 is a fragmentary sectional view showing the fail-safe mechanism for control of horizontal rotation on power failure; and,

FIG. 7 is a schematic wiring diagram of the fail-safe circuit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings and to FIG. 1 in particular, a ceiling mounted X-ray tube assembly is shown generally at **10.** The X-ray assembly includes a carriage **11** which is movably supported on a ceiling mounted track assembly **12.** The carriage is movable horizontally over a predetermined area. The carriage and the supporting track assembly are described in greater detail in the COUNTERBALANCE APPLICATION.

An extensible column **14** depends from the carriage **11.** The column **14** is described in greater detail in the COLUMN APPLICATION. An X-ray tube, not shown, is mounted within an X-ray tube housing **15.** The X-ray tube housing **15** is secured to a tube mounting assembly **16,** only a portion of which is visible in FIG. 1. High tension cables are connected to the X-ray tube. Fragmentary portions of the cables are shown at **17.** These high tension cables provide power for operation of the X-ray tube.

A collimator is shown at **18.** The collimator **18** is secured to the X-ray tube housing **15.** The collimator is of known construction and is a device which is used to delineate the perimeter of an X-ray beam emitted by the tube.

FIG. 2 is a sectional view, on an enlarged scale with respect to FIG. 1, a major portion of the X-ray tube mounting assembly **16.** The mounting assembly **16** in-

cludes a support sleeve 22 which is fixed to a lower tube 23 of the depending column 14. The sleeve 22 is contoured to telescope snugly into the lower tube 23. The sleeve and tube 22, 23 are suitably fixed together as by three fasteners, one of which is shown at 24 in FIG. 2. Thus, the lower tube 23 serves as a support member for the sleeve 22 and mechanism carried by the sleeve.

A tube support shaft 25 is journaled in the sleeve 22 by a pair of needle bearings 27. The shaft 25 is vertically supported by a thrust bearing 28. The thrust bearing 28 rests in an annular recess 29 in the upper end of the sleeve 22.

The shaft 25 has a reduced diameter threaded portion 30 adjacent its upper end. A nut 32 is threaded on the reduced diameter portion 30. The nut 32 acts against a washer 34 which in turn engages the thrust bearing 28. A pin 35 extends through the nut 32 and the reduced diameter portion 30 to maintain the nut in position.

A counterbalance cable bracket 36 is suitably fixed to the upper end of the sleeve 22. The bracket 36 connects to a counterbalancing cable, 36A, which depends from a counterbalancing system within the carriage 11.

The shaft 25 includes a lower mounting flange 37 of a diameter larger than the remainder of the shaft. A frame element 38 is fixed to the shaft flange 37 by suitable fasteners such as bolts 39. The frame 38 includes an upwardly extending mounting plate 40 and a web reinforcement 41 which reinforces the mounting plate. A horizontal rotation assembly 42 is secured to the mounting plate 40 in a manner which will be described in greater detail presently. The horizontal rotation assembly 42 is shown in greater detail in FIGS. 3 through 6.

An annular magnet housing 44 surrounds and is fixed to the flange 37. The magnet housing 44 defines an annular magnet recess 45 which is open at its top. An annular magnet coil 47 is in the recess 45.

An annular motion restraining collar 48 surrounds and is fixed to a lower portion of the support sleeve 22. The collar 48 carries a pair of fixed pins 49, 50. The pins 49, 50 respectively extend into circular and elongated recesses 51, 52 in a combination striker and detent plate 53.

When the magnetic coil 47 is energized, the striker plate 53 is drawn against upper bearing surfaces 54, 55 on the magnet housing 44. The limited surface area of these bearing surfaces and the striker plate are adequate to restrain the X-ray tube mount against rotation about the axis of the shaft 25, but permit limited rotation, even when the magnet is energized. This limited rotation inhibits, for example, injury to the equipment if there is an accidental collision. It also permits emergency manual override of the magnetic restraining forces.

When the magnet 47 is de-energized, the frame 38 and the shaft 25 are freely rotatable about the shaft axis in the sleeve 22. Rotation is limited to 180° in either direction from a central position to a total of 360°. This rotation limitation is achieved with a novel rotation control assembly.

A rotation control ring 57 is around the shaft 25 and rests on the shaft flange 37. The rotation control ring 57 has upper and lower rotation limiting recesses 58, 59 formed in it. The upper rotation control recess 58 is an arcuately formed recess extending 330° from a stop surface 60 to a stop surface 61, FIG. 2A. The lower rotation control recess 59 extends for 30° in the lower face of the rotation control element 57 from a stop surface 62 to a stop surface 63.

A rotation limiting pin 64 is carried by the sleeve 22. This pin 64 forms a sleeve projection which extends into the recess 58. A second rotation limiting pin 65 is carried by the shaft flange 37. The rotation limiting pin 65 forms a shaft projection extending into the recess 59.

When the pins 64, 65 are respectively in engagement with the stop surfaces 60, 62, one limit of travel of rotation has been reached. This limit is reached by rotating the shaft in a clockwise direction relative to the sleeve as viewed in FIG. 2A. Counterclockwise rotation is limited by the pins 64, 65 respectively engaging the surfaces 61, 63.

Another feature of the rotation control assembly is that the rotation control ring 57 will under certain conditions serve as a thrust bearing. Normally the weight of the X-ray tube and the tube mounting assembly, including trimming weights 67, is great enough to bring the shaft downwardly until the X-ray tube and its mounting assembly are supported vertically by the thrust washer 28. In shipment the collar 48 is left loose on the sleeve 22. Relative vertical movement is then limited by coaction of the rotation control element 57 and a thrust washer 68 which is around the shaft 25 and interposed between the rotation control element 57 and the lower end of the collar 48. This prevents the pins 49, 50 from damaging the magnet 47.

One of the advantages of the invention is achieved through utilizing the striker plate 53 in a dual function. The dual or second function is that the striker plate serves as a detent plate. To achieve the indexing detent function, the plate 53 has spaced detent recesses 70 at four locations around its perimeter. The recesses are spaced 90° apart so that the tube mount may be indexed into four determined locations.

A ball detent element 71 is biased by a spring 72 into an aligned detent recess 70. The detent ball 71 and its spring 72 form part of a detent assembly 74 maintained in a detent bore 75 by a snap ring 76. As shown, and preferably, the detent bore 75 is formed as an integral part of the frame 38.

For appearance and protection, the rotation pivot mount portion of the X-ray tube mounting assembly shown in FIG. 2 includes a soft plastic element 77 secured to the bottom of the frame 38 and a plastic covering 78 which rests in a recess 79 formed near the top of the frame 38.

FIGS. 3 and 4 are partially sectioned views of the horizontal rotation assembly 42. Referring to those Figures, the horizontal assembly 42 includes a mounting bracket 82. The mounting bracket 82 includes a plurality of mounting holes 83 aligned in spaced rows, FIG. 4.

Referring again to FIG. 2, the mounting plate 40 has a spaced pair of rows of holes 84. The holes of only one of the rows are shown in dotted lines in FIG. 2 with the second row of holes being aligned with them and spaced center to center a distance equal to the spacing of rows of holes 83. Vertically speaking, as seen in FIG. 2, the holes 84 are spaced center to center distances equal to the spacing of the holes 83.

For mounting the bracket 82 on the mounting plate 40 all that is needed is two pairs of bolts 85 extending

through four of the holes **84** and threading into the tapped holes **83.** The purpose of extra holes **83** and **84** is to provide selectivity in the vertical positioning of the X-ray tube and its collimator. This permits, for example, the utilization of a standard column assembly with a predetermined range of travel in X-ray rooms of varying ceiling heights while permitting substantially identical tube positioning relative to an X-ray table from room to room.

The tube support bracket **82** has a forwardly extending hub portion **86.** A cylindrically contoured bore **87** is formed in a hub portion **86.** An X-ray tube support shaft **88** is provided. The X-ray tube support shaft **88** is journaled in the hub bore **87** by a pair of bearings **89.**

The X-ray tube support shaft **88** has a mounting flange **90** at its forward end. A thrust bearing **91** is between the shaft mounting flange **90** and a forward end **92** of the hub portion **86.** The tube support shaft **88** is axially fixed relative to the hub portion **86** by a positioning nut **94** which acts against thrust washers **95.**

A socketed setscrew **96** secures the positioning nut **94** in place with appropriate compressive forces on the thrust bearing **92** and the thrust washers, **95.** The setscrew **96** is locked in place by inserting an Allen wrench from the forward end through a bore **97** in the tube shaft **88.**

An X-ray tube support **98** is fixed to the shaft mounting flange **90** by suitable fasteners such as bolts **99.** The X-ray tube support **98** has a pair of flat mounting surfaces **102.** The X-ray tube housing **15** is secured against mounting surfaces **102** by threading nuts into selected ones of tapped holes **104.**

A motion arresting magnet assembly similar to the motion arresting magnet assembly of FIG. **2** is provided to limit relative rotation of the X-ray tube support **98** and the bracket **82.** An annular magnetic housing **106** is positioned around and fixed to the shaft mounting flange **90.** The magnet housing **106** defines a magnet recess **108** which is annular and which is open toward the rear, or the left as viewed in FIG. **3.** An annular magnet **110** is positioned in the recess **108.**

An annular magnetic striker plate **111** is provided. The annular magnetic striker plate is designed to engage bearing surfaces **112, 113** on the magnet housing **106** whenever the magnet **110** is energized. A pair of pins **115, 116** coact with holes in the striker plate **111** to prevent rotation of the striker plate relative to the bracket **82,** FIG. **4.** These pins, like the pins **49, 50** of FIG. **2,** permit relative axial movement of the striker plate while preventing relative rotative movement.

The mounting of the pin **115** in the bracket **82** is shown in FIG. **4A.** A detent assembly **74,** identical to the detent assembly of FIG. **2,** is mounted in a bottomed detent bore **118.** The detent bore **118** is formed in the bracket **82.** The pin **115** is mounted in a pin bore **119** which is perpendicular to and intersects the detent bore **118.**

As shown in FIG. **4,** the angular adjustment assembly includes a pair of detent assemblies **74.** Thus, a second detent assembly **74** is positioned in a second bottomed detent bore **120** which is diametrically opposite the detent bore **118.** The pin **116** projects into a bore comparable to the pin bore **119.** The bore for the pin **116** intersects the bore **120** but is not shown.

An annular detent ring **122** is carried by the X-ray tube support **98.** The detent ring has four spaced detent recesses **123,** two of which are visible in FIG. **4** and a third of which is visible in FIG. **3.** Accordingly, it can be seen that the X-ray tube support housing **98** can be rotated relative to the bracket **82** and detents **73** will index the support and the bracket into predetermined positions **90°** apart.

When the X-ray tube support **98** is in the position shown in FIG. **4,** the X-ray tube will emit a beam along a vertical axis paralleling the axis of the vertical shaft **25** and the supporting column **14.** For laminography it is desirable to rotate the X-ray tube support back and forth about the axis of the tube support shaft **88.** Accordingly, when a laminographic study is being conducted, the detents, if in the position of FIG. **4,** will interfere with a study.

One of the outstanding advantages of this invention is the provision of a mechanism which permits detent repositioning. Accordingly, laminographic studies can be conducted without the detents interfering.

To achieve detent repositioning, a clamp ring **125** surrounds the tube support **98.** End flanges **126** of the clamp ring **125** are bolted together to fix the clamp ring relative to the tube support **98.** A detent ring positioning assembly is shown generally at **128.** This ring positioning assembly extends through an arcuate slot **129** formed in the clamp ring **125,** FIG. **4.**

A position control collar **130** forms a part of the detent positioning assembly **128.** The collar **130** is selectively positionable in either of two circular recesses **131, 132** which are formed in the clamp ring 45° apart center to center and around the ends of the slot **129.** A positioning knob **133** is connected to the detent ring **122** by a shaft **134.** A detent locating bracket **135** is secured to the detent ring **122.** The shaft **134** has a head **136** which is positioned in a recess **137** formed in the detent bracket and detent ring **135, 122.**

When the positioning knob **133** is rotated, a threaded connection between the knob and the shaft **134** is loosened. One may then grasp the positioning collar **130** and pull it outwardly against the biasing action of a spring **139** which is around the shaft **134** and interposed between the collar and the knob **130, 133.** The detent ring can then be rotated 45° from, for example, engagement of the collar with the recess **131** to collar engagement with the recess **132.** The knob **133** is then tightened to securely fix the detent in its newly adjusted position. This 45° rotation moves the detent recesses **123** to positions where nearly 45° of X-ray tube rotation in either direction from its vertical orientation can be had without detent interference.

Another of the features of the invention is a novel fail-safe arrangement. When the X-ray tube and collimator are in the position of FIG. **1** to direct an X-ray beam along the horizontal axis, that position is normally maintained by energizing the magnet **110.** If the magnet is de-energized due to a power failure, in the absence of any fail-safe mechanism the tube and collimator will automatically rotate to a position where the X-ray tube has its beam axis vertical. Such movement could cause patient injury or equipment damage on collision. Accordingly, a fail-safe mechanism is provided.

A fail-safe ring **140** is fixed to and forms a part of the X-ray tube support **98.** The fail-safe ring performs the dual function of securing the detent ring **122** in a groove **141** in the tube support **98** and providing a portion of the fail-safe mechanism. The fail-safe ring has a plurality of notches **142** formed in it. These notches

are about 10° apart. Referring to FIGS. **5** and **6**, a fail-safe dog **144** is provided. The dog **144** has a tapered head **145** which is designed to engage aligned ones of the notches **142**.

A rotary solenoid **146** is provided. The rotary solenoid **146** has a pin **147** which extends into a bore **148** in the dog **144**, FIG. **6**. When the rotary solenoid **146** is energized, its rotary action causes the pin to shift to the right as viewed in FIG. **6** and retract the dog against the action of a spring within the solenoid. Accordingly, whenever the rotary solenoid is energized, the dog will be maintained out of engagement with the notches **142** but, upon de-energization, the solenoid spring will shift the dog into engagement with the notches.

Referring to FIG. **7**, a suitable circuit is shown schematically. This circuit is independent of other system locking devices so that the magnets **47** and **110** may be energized to maintain the tube mount adjustment while other movements can be freely made.

The solenoid **146** is connected to one side of a line L, by conductor **150**. A main power switch **151** is connected to the other side of the line by a conductor **152**. A magnet control switch **153** is provided. When the magnet control switch **153** is in the position shown in FIG. **7**, and the main power switch **151** is closed as shown, the magnet **110** and the solenoid **146** are series connected to the line by a conductor **152**, the switch **151**, conductors **154**, **155**, the switch **153**, the conductor **156** and the conductor **150**. Accordingly, whenever there is a power failure which would de-energize the magnet, the solenoid is simultaneously de-energized and the fail-safe system will operate.

To prevent the fail-safe system from interfering with adjustments of the X-ray tube position, the switch **153** is shown as a single-throw, double-pole switch. Thus, when the switch **153** is moved to de-energize the magnet, it will, so long as the main switch **151** is closed, maintain the solenoid **146** in an energized condition. In these circumstances, the solenoid is connected to the line L through the switch **151**, the conductor **152**, a conductor **157**, the switch **153** and the conductors **156**, 150.

One of the outstanding advantages of the present invention is the provision of a fail-safe mechanism which, once engaged, cannot be accidentally disengaged by depression of a fail-safe release button **160**, FIGS. **5** and **6**. The dog **144** is equipped with a release pin **161** which extends rearwardly, downwardly as viewed in FIG. **6**. The release pin **161** projects through a recess **162** formed in the tube support bracket **82** and into a release mechanism bore **163**.

A dog-release actuator tube **165** is positioned in the release bore **163**. A dog release shaft **166** is connected to the release button **160** and extends through the tube **165**. The tube **165** is equipped with an end flange **167**, at the left as viewed in FIG. **6**. A dog release spring **168** is interposed between the button **160** and the flange **167**. A positioning collar **170** is fixed to the right-hand end, as seen in FIG. **6**, of the tube **165**. A spring **171** is between the collar **170** and the bottom of the release bore **163**. The spring **171** biases the collar **170** against a stop **172**.

When the dog release button **160** is depressed, the spring **168** is compressed, forcing the release tube **165** to the right, as viewed in FIG. **6**, until the flange **167** engages the release pin **161**. Simultaneously, the positioning collar **170** is acting against the positioning spring **171**.

The weight of the X-ray tube and collimator resting on the fail-safe mechanism causes considerable frictional force between the dog head **145** and an engaged one of the notches **142**. The force transmitted to the release tube **165** is, due to the action of the springs **168**, 171, insufficient to overcome this frictional force. Accordingly, the depression of the fail-safe button **160** will not disengage the fail-safe mechanism unless an operator has grasped the X-ray tube and collimator to lift it some and relieve the force maintaining engagement between the dog and the notch. When the tube is lifted, adequate force can be transmitted through the spring **168** to overcome the weaker spring and disengage the dog.

A pair of microswitches **175**, **176** are provided, FIG. **5**. The microswitches are actuatable by a pair of cams, not shown, positioned in a cam groove **177**, FIGS. **3** and **4A**. The microswitches actuate disabling circuits which prevent radiographic exposures in certain kinds of studies unless the X-ray tube is appropriately and accurately positioned in its intended position.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. X-ray apparatus comprising:

a. supporting and supported members;

b. bearing mechanism interposed between the members to permit relative rotation of the members;

c. an X-ray tube carried by one of the members;

d. tube supporting structure connected to the other of the members for supporting the members and the tube;

e. a rotation control element rotatably positioned between the members and coactable with the members to provide relative rotation of a predetermined maximum amount;

f. a selected one of the element and the supporting member having a first recess formed therein and defined in part by a pair of arcuately spaced stop surfaces, said surfaces being coactable with a projection extending from the other of the element and the supporting member;

g. a selected one of the element and the supported member having a second recess formed therein and defined in part by another pair of arcuately spaced stop surfaces, said other surfaces being coactable with another projection extending from the other of the element and the support member; and,

h. the members being at one limit of relative rotation when said projections are respectively in engagement with a first one of each pair of stop surfaces and being at the other limit of relative rotation when the projections respectively engage the second stop surfaces of each pair.

2. The apparatus of claim **1** wherein each of said recesses is an arcuate slot disposed circumferentially about the axis of relative rotation of the members.

3. The apparatus of claim **2** wherein the arcuate spacing of the first pair of stops plus the arcuate spacing of

the second pair of stops equals said predetermined maximum amount of relative rotation.

4. The apparatus of claim **3** wherein said predetermined maximum amount is approximately 360°.

5. The apparatus of claim **1** wherein said recesses are formed in the control element and the projections comprise pins each carried by one of the members.

6. X-ray apparatus comprising:

a. supporting and supported members;

b. bearing mechanism interposed between the members to permit relative rotation of the members;

c. an X-ray tube carried by one of the members;

d. tube supporting structure connected to the other of the members for supporting the members and the tube;

e. a rotation arresting assembly comprising an annular striker plate element connected to one of the members and an electromagnet connected to the other of the members, whereby the striker plate element and the magnet rotate relatively with the members;

f. said striker plate element being a component of detent assembly, another component of said detent assembly being connected to said other member;

g. one of said components having detent recesses formed therein; and,

h. a biased detent projection carried by the other of said components for selective engagement with said detent recesses one at a time whereby to index said members into selective relative positions.

7. The apparatus of claim **6** wherein the striker plate is the one component.

8. In an X-ray apparatus the improvement comprising

a. X-ray tube support and bracket members;

b. bearing means journaling the members for relative rotation about an axis;

c. a rotation arresting electromagnetic assembly interposed between the members for arresting relative rotation of the members when the assembly is energized;

d. a fail-safe mechanism interposed between the members and comprising:

i. a movable dog carried by one of the members;

ii. dog-engageable surfaces on the other of the members for selective engagement by the dog; and,

iii. dog control means operatively connected to the dog for maintaining the dog out of engagement under normal conditions and for shifting the dog into engagement with such surfaces upon a power failure to said magnet.

9. The apparatus of claim **8** wherein the dog control means comprises a solenoid serially connected with said electromagnetic assembly when the assembly is energized.

10. The apparatus of claim **9** wherein said solenoid is energized whenever a main power switch is closed and power is supplied to the system whether said magnet is energized or de-energized.

11. The apparatus of claim **8** wherein the movable dog is mounted on the bracket member and wherein an annular notched ring is secured to the support member to provide such dog engagement surfaces.

12. In an X-ray apparatus the improvement comprising:

a. X-ray tube support and bracket members;

b. bearing means journaling the members for relative rotation about an axis;

c. a fail-safe mechanism interposed between the members and including a movable element carried by one of the members which is selectively engageable with surfaces formed on the other of the members;

d. a fail-safe release mechanism for disengaging the fail-safe mechanism after it has operated including:

i. a component for engaging said movable element;

ii. a push button;

iii. a pressure-sensing and limitation means operatively connected to the push button and the release component for transmitting force of a predetermined maximum quantity to the release component, such force being insufficient to move the fail-safe element until a rotational force is applied to the members to reduce the engagement force of the movable element and an engaged surface.

13. The device of claim **12** wherein the pressure-sensing and limitation means is a spring.

14. In an X-ray apparatus the improvement comprising:

a. X-ray tube support and bracket members;

b. bearing means journaling the members for relative rotation about an axis;

c. a fail-safe mechanism interposed between the members and including a movable element carried by one of the members which is selectively engageable with fail-safe surfaces formed on the other of the members;

d. a fail-safe release mechanism for disengaging the fail-safe mechanism after it has operated including:

i. structure defining a fail-safe release assembly recess;

ii. a tubular, movable, release component disposed in said recess;

iii. a push button, a shaft connected to the button extending through said tubular component;

iv. a spring around the shaft and interposed between the push button and the tubular component;

v. a second spring between the tubular component; and the recess for acting against the first spring;

vi. said tubular component and said movable element having coactable surfaces; and,

vii. the strength of said springs being such that the force which is transmitted from the push button to the tubular component in an effort to move the movable element is inadequate to overcome friction between engaged fail-safe surfaces until rotational force is applied to said members to reduce the pressure applied to the fail-safe surfaces.

15. X-ray apparatus comprising:

a. supporting and supported devices;

b. bearing mechanism interposed between the devices to permit relative rotation of the devices;

c. an X-ray tube carried by one of the devices;

d. tube supporting structure connected to the other of the devices for supporting the devices and the tube;

e. each of said devices including a detent element, one of the detent elements providing detent recesses and the other element being a coacting element, selectively engageable with said recesses one

at a time to index the devices into an adjusted position; and,

f. detent element positioning means interposed between one of the elements and its associated device whereby the one element may be moved from one predetermined position to another relative to its supporting device and to the other element thereby moving said index positions from one determined orientation to another.

16. The apparatus of claim **15** wherein the one detent element is a detent ring with a plurality of spaced detent recesses and wherein the ring is rotatable relative to the remainder of its associated device upon actuation of the detent element positioning means.

17. X-ray apparatus comprising:

a. supporting and supported devices;

b. bearing mechanism interposed between the devices to permit relative rotation of the devices;

c. an X-ray tube carried by one of the devices;

d. tube supporting structure connected to the other of the devices for supporting the device and the tube;

e. a spring biased detent element carried by one of the devices;

f. a detent ring carried by the other of the devices and including a plurality of spaced recesses selectively engageable one at a time by the detent element upon relative rotation of the devices;

g. said other device having a longitudinal slot formed therein;

h. a shaft projecting through the slot and secured to said detent ring;

i. said one device having locating surfaces at spaced locations along and communicating with said slot;

j. a detent ring locating element around said shaft and positionable selectively one at a time in engagement with a selected one of said locating surfaces whereby the detent ring may be rotated relative to said other device and maintained in a selected position by coaction of said locating element and a selected locating surface.

18. The apparatus of claim **17** wherein said locating element is biased into engagement with said selected locating surface.

19. The device of claim **18** wherein a locking knob is threaded on said shaft and engageable with said locating element to lock the locating element in an adjusted position and wherein said bias is provided by a spring interposed between the locking knob and said locating element.

20. In combination:

a. an extensible tubular column;

b. a ceiling mounted carriage supporting said column and movable over a predetermined area;

c. an X-ray tube mount carried by the column;

d. an X-ray tube and collimator assembly on the mount;

e. said mount comprising:

i. first means permitting relative rotation about an axis longitudinal of said column;

ii. other means providing relative rotation of the X-ray tube and the first means about an axis generally transverse to said column;

iii. magnetic restraining means for securing each of said relative rotation means in a respective adjusted position; and,

iv. a circuit independent of other structure in the combination for energizing said magnetic means whereby the tube mount may be restrained in adjusted position independent of other adjustments in the combination.

21. The combination of claim **20** wherein said restraining means is manually overridable to move said tube assembly and modify said mount positioning even when said magnetic means is energized.

* * * * *