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Amor, Jr. et al.

[11] **3,902,070**

[45] **Aug. 26, 1975**

[54] **SUPPORT SYSTEM FOR X-RAY APPARATUS**

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

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

[21] Appl. No.: **418,051**

[52] **U.S. Cl.** **250/525**; 250/523; 250/445

[51] **Int. Cl.** **G01n 23/00**

[58] **Field of Search** 250/525, 523, 522, 445, 250/490

[56] **References Cited**

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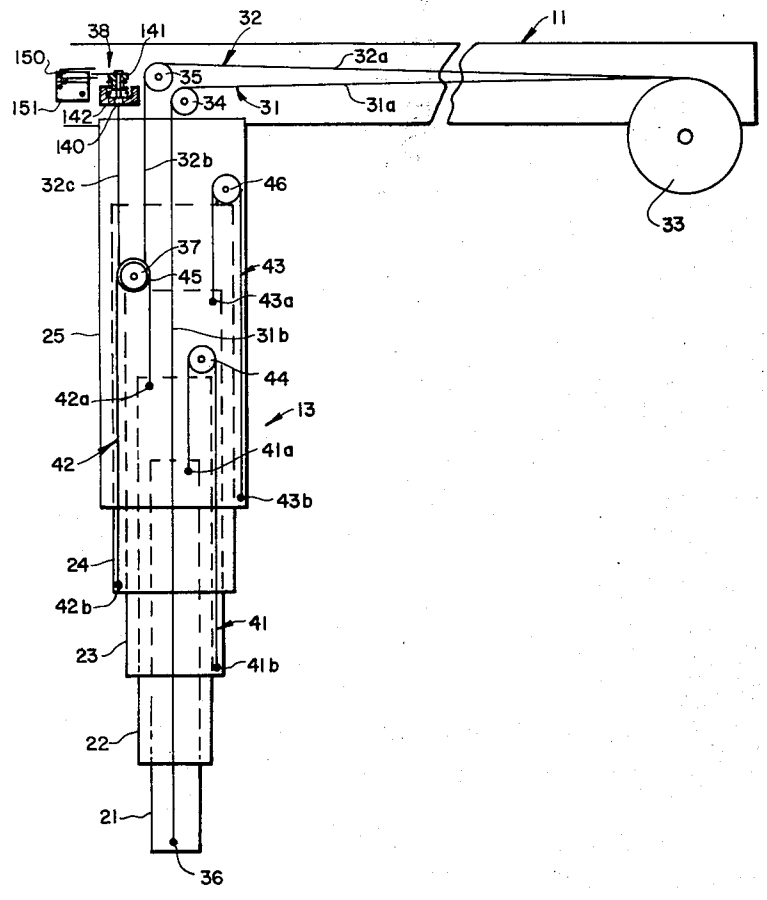
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Primary Examiner—James W. Lawrence
Assistant Examiner—B. C. Anderson
Attorney, Agent, or Firm—Watts, Hoffmann, Fisher & Heinke Co.

[57] **ABSTRACT**

A columnar support includes nested tubular sections which telescope from a retracted storage position adjacent a ceiling-mounted carriage to an extended position. The support carries apparatus such as an X-ray source at selected heights above and about a patient. A counterbalance system is housed in the carriage. A cable and pulley system including two primary support cables interconnects the column sections and the counterbalance. Breakage or stretching of the primary support cables as well as breakage of cables within the counterbalance system is sensed and causes a failsafe system to lock the column against further downward movement.

23 Claims, 9 Drawing Figures



PATENTED AUG 26 1975

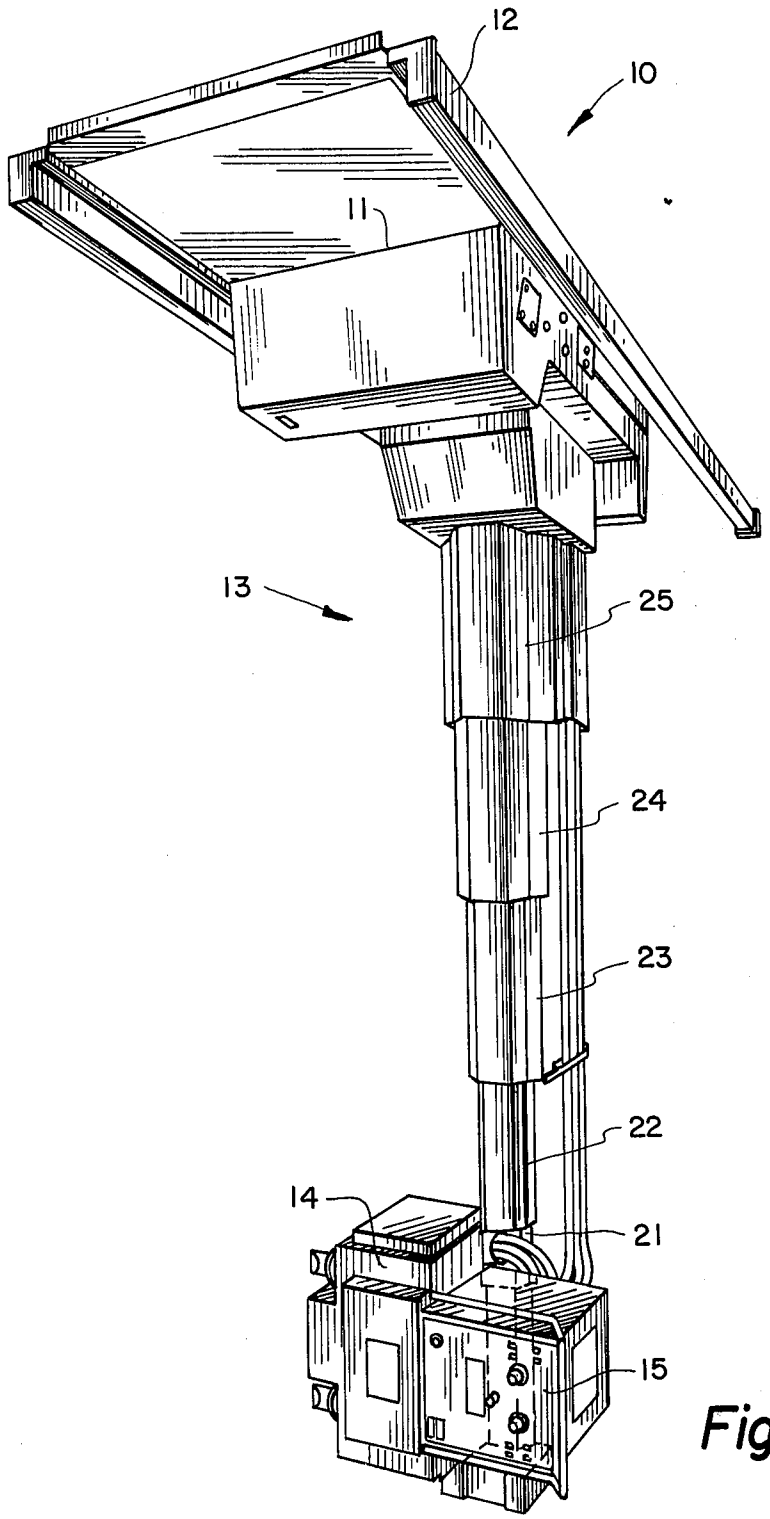


Fig. 1

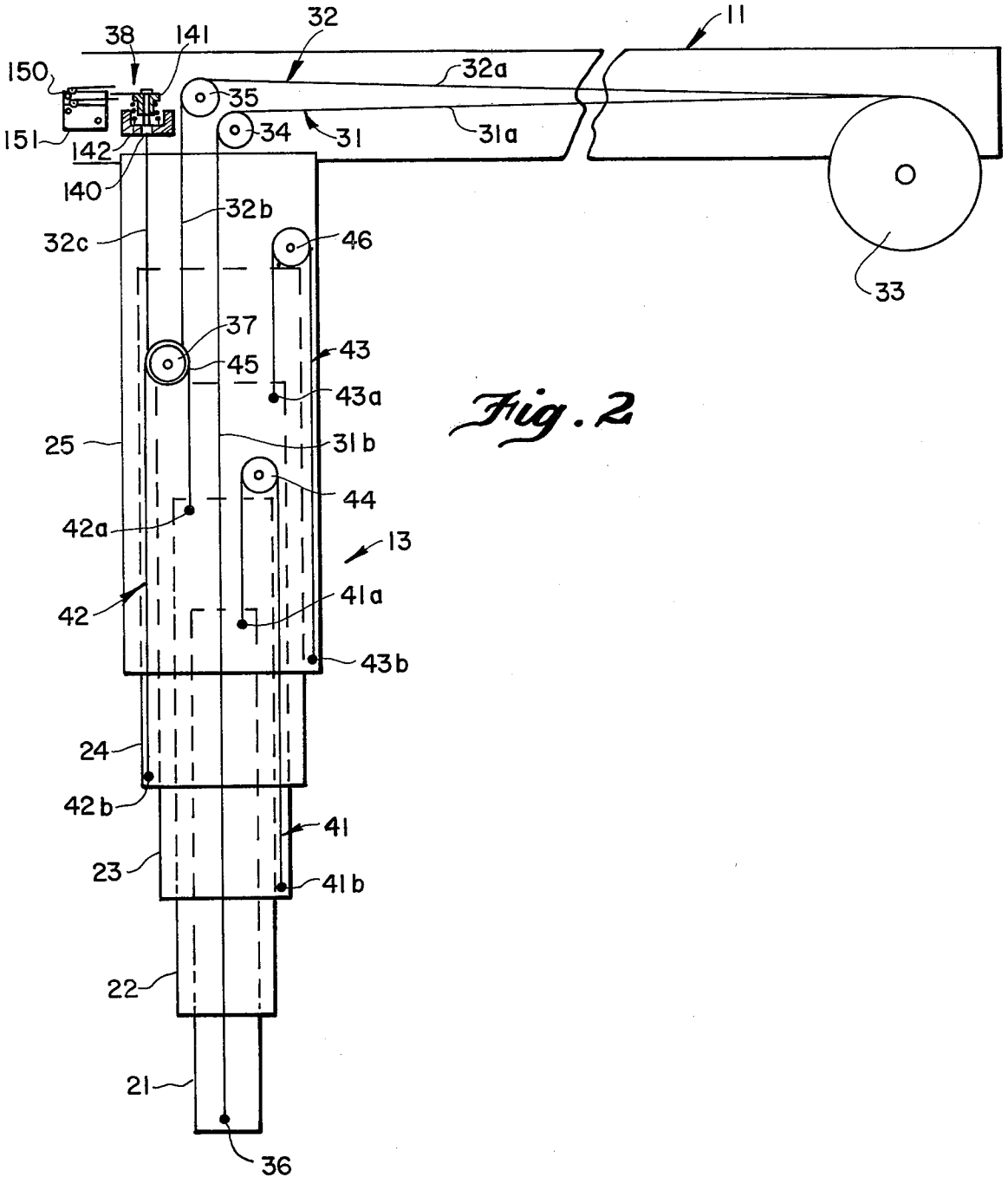

38
141
32
11
150
32a
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151
142
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31
31a
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32b
32c
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43a
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31b
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42a
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42b
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41b
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Fig. 2

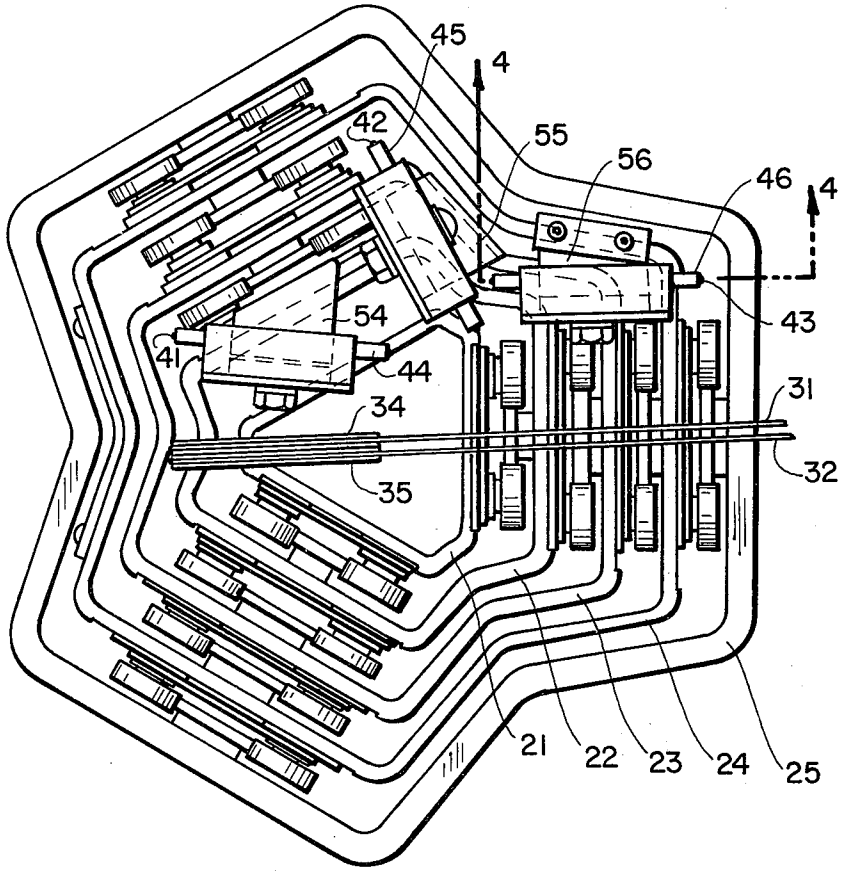


Fig. 3

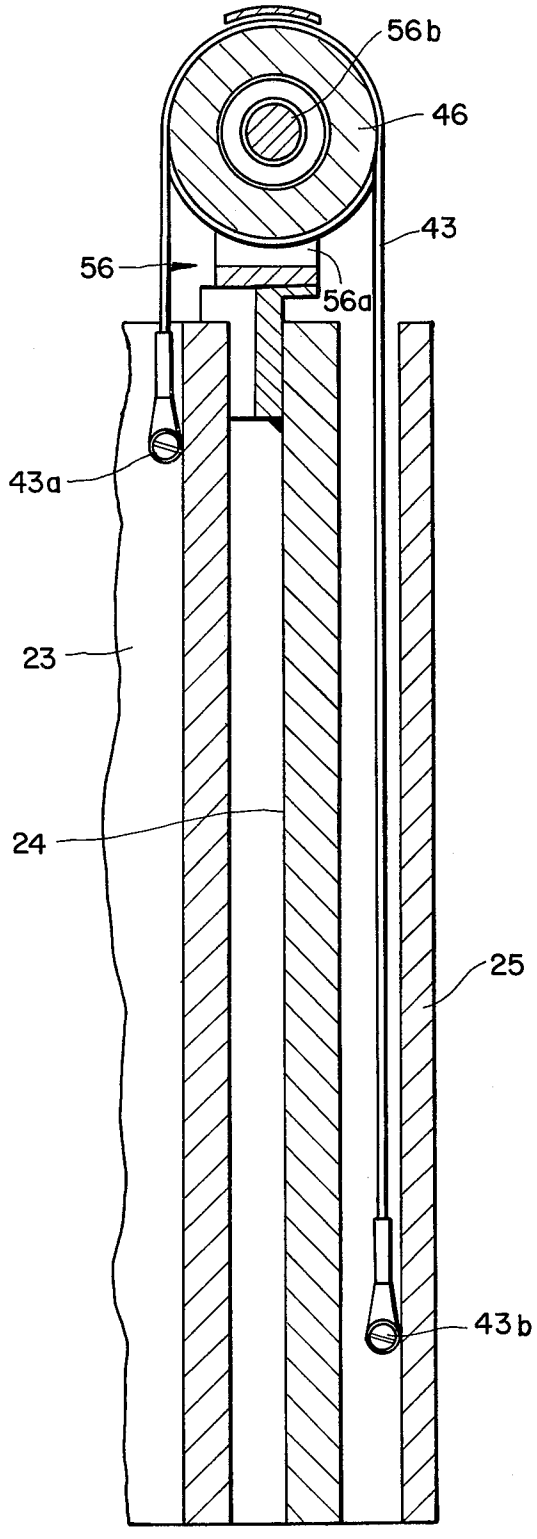


Fig. 4

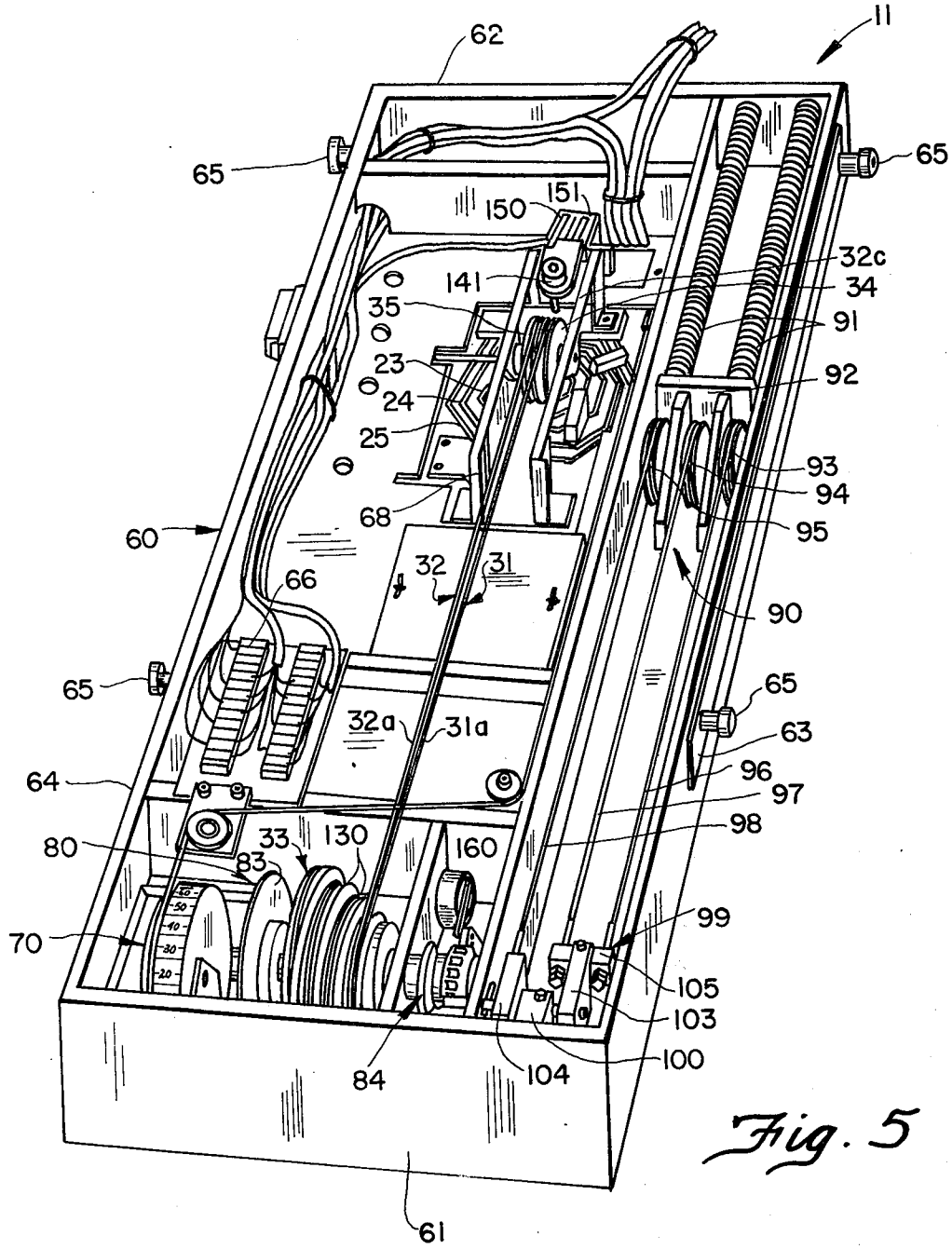

11
62
65
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150
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141
32c
34
35
91
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92
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25
93
94
68
95
60
32
31
66
90
65
65
32a
31a
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80
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130
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104
100
61

Fig. 5

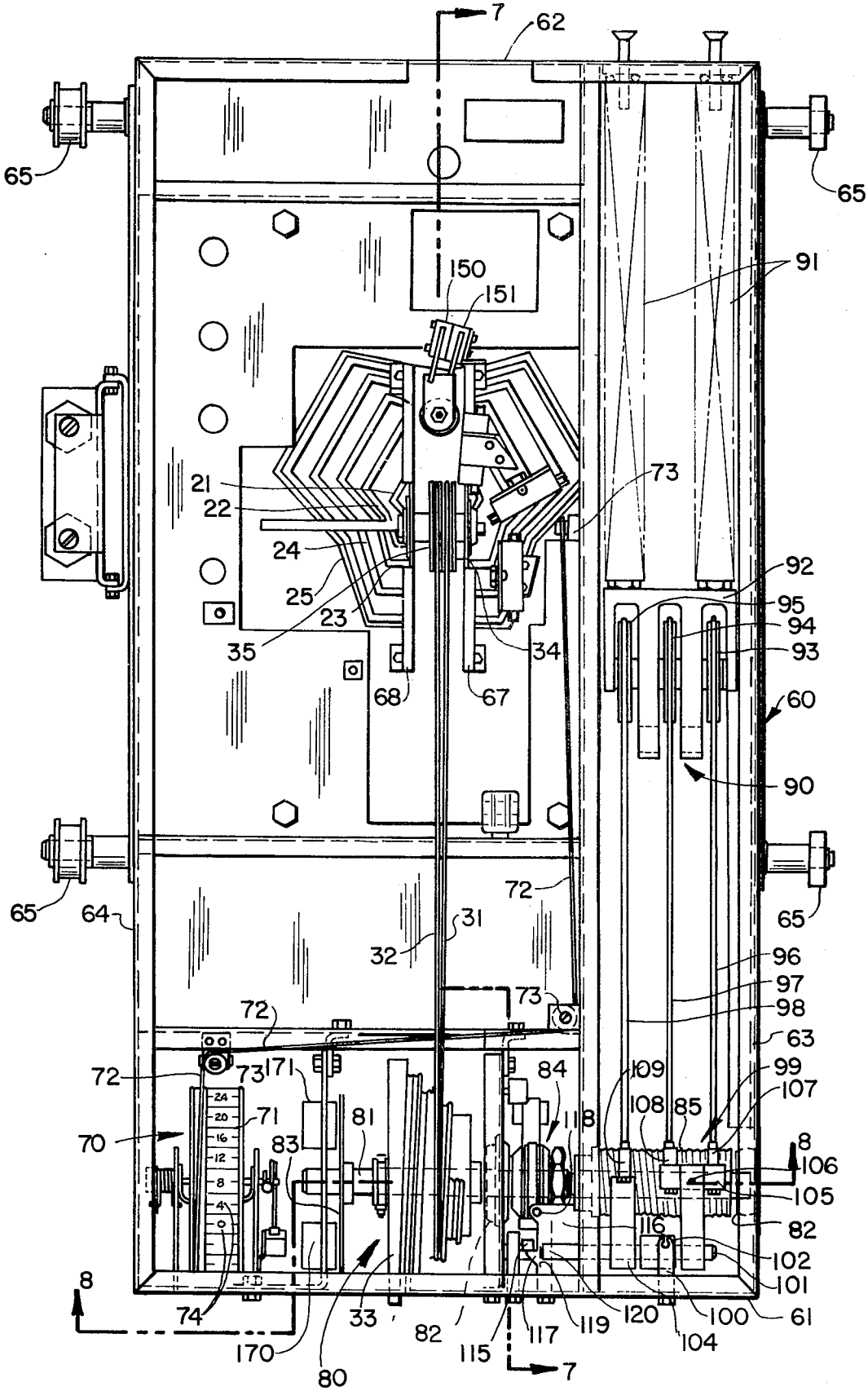

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64
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73
171
84
109
99
107
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81
83
118
108
85
8
106
105
82
116
102
101
61
100
104
120
119
117
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82
33
74
170
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7
70

Fig. 6

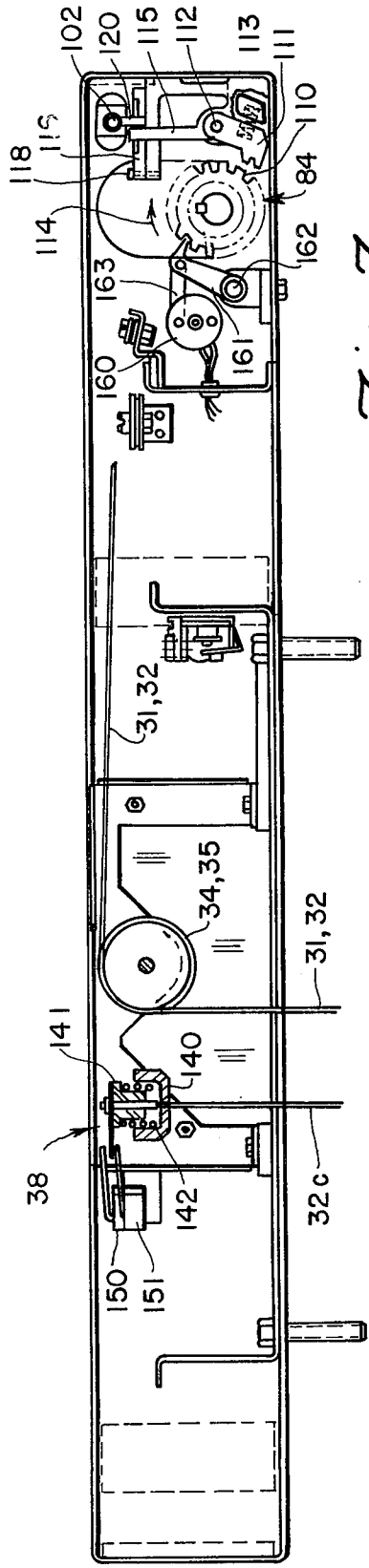

102
120
115
112
113
111
110
118
116
84
114
162
163
161
160
31,32
34,35
31,32
141
140
38
142
32c
150
151

Fig. 7

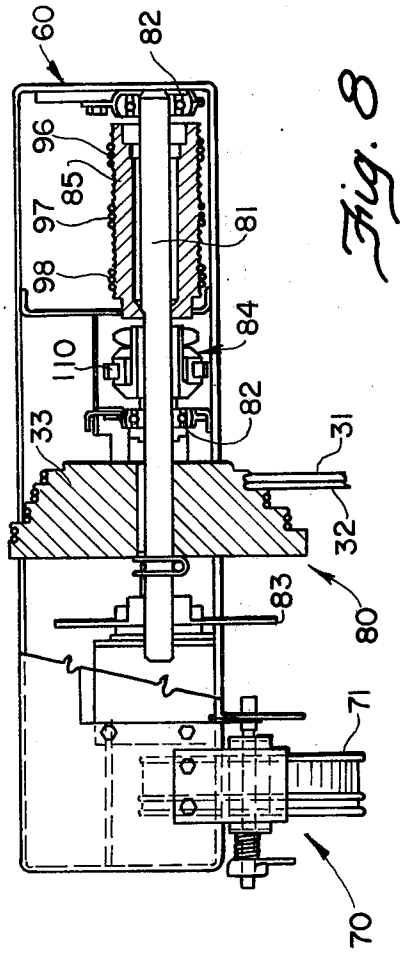

60
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96
85
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110
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31
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83
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71
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Fig. 8

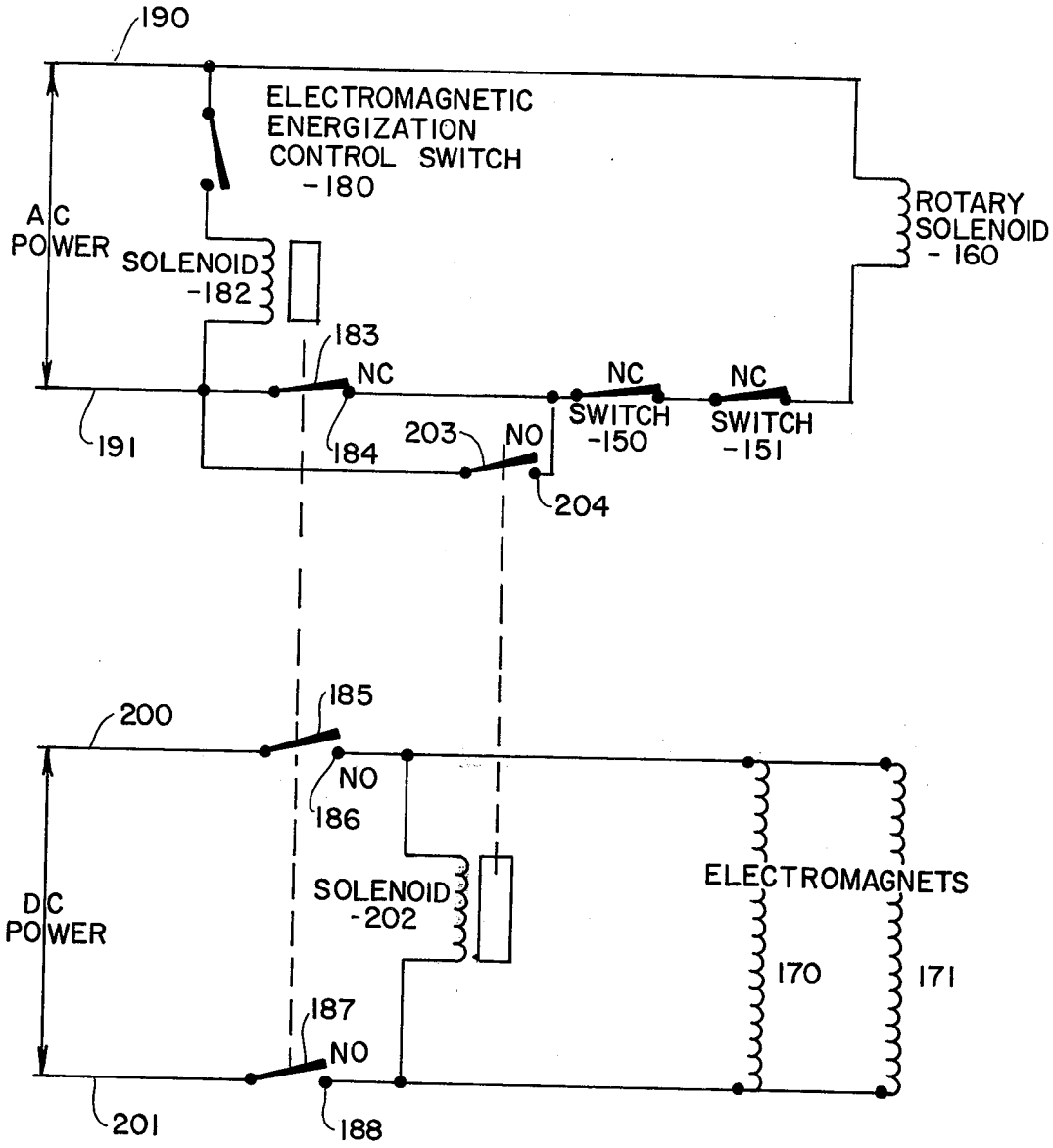

190
ELECTROMAGNETIC
ENERGIZATION
CONTROL SWITCH
-180
AC
POWER
SOLENOID
-182
ROTARY
SOLENOID
- 160
183
NC
NC
NC
SWITCH
-150
SWITCH
-151
191
184
203
NO
204
200
185
NO
186
SOLENOID
-202
ELECTROMAGNETS
DC
POWER
170
171
187
NO
201
188

Fig. 9

SUPPORT SYSTEM FOR X-RAY APPARATUS

CROSS-REFERENCE TO RELATED PATENTS AND APPLICATIONS

Cross-reference is made to the following related patents and applications, the disclosures of which are incorporated by reference:

X-RAY APPARATUS HAVING A TELESCOPIC COLUMNAR SUPPORT, U.S. Pat. No. 3,776,500 issued to Anthony J. Foderaro on an application Ser. No. 163,248 filed July 16, 1971, here the "Columnar Support Patent."

TELESCOPIC COLUMN FOR X-RAY APPARATUS, application Ser. No. 418,128, filed Nov. 21, 1973 by William H. Amor, Jr., et al. William H. Amor and Robert J. Steffeck here the "Extensible Column Patent."

MOUNT FOR CEILING SUPPORTED X-RAY TUBE, application Ser. No. 418,057, filed Nov. 21, 1973 by William H. Amor. Jr., et al. William H. Amor and Robert E. Stancliff, here the "Rotary Mount Patent."

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to X-ray apparatus and more particularly to a ceiling-mounted columnar support having cable-interconnected, counterbalanced, telescopically extensible sections for supporting an X-ray source at selected heights above and about a patient.

2. Prior Art

Ceiling mounted telescopic columnar support systems of various types have long been used in X-ray apparatus. The problems of providing a telescopically extensible column which occupies a minimum of space, which extends and retracts smoothly without binding, and which is capable of providing a play-free stable support when fully extended have posed a challenge to designers.

The referenced Columnar Support Patent and the Extensible Column patent relate to improved bearinged support systems for interconnecting the telescopically extensible sections. As is discussed in these patents, the forces imposed on the column are both large in magnitude due to the weight of the equipment being supported, and variable in direction depending on the orientation of the equipment.

The referenced Rotary Mount Patent relates to an improved mounting system for supporting X-ray equipment from the lowermost column section. As is discussed in this patent, the equipment supported by the column is not always balanced about its axis of support and can cause injury to a patient if the operator fails to have the equipment in firm grasp prior to its being unlocked for movement.

One problem addressed by the present invention relates to the counterbalance support system provided to counteract the weight of the column and the supported equipment. Known counterbalance systems for ceiling mounted supports have included counterbalanced systems coupled by a support cable to the lowermost column section. The support cable is tensioned by the counterbalanced system and the weight of the column. If the support cable should break, the column sections may descend suddenly and without warning and damage can result.

Cable breakage can also occur in other cables of the counterbalance system. Breakage of these cables can go undetected where the cables are hidden from view. The broken cables not only pose a potential hazard but may also cause interference with the operation of other nearby system components.

Known X-ray support systems do not make provision to lock the extensible column against further downward movement in the event of a power failure. Where both A.C. and D.C. power is used in the apparatus, failure of either or both power sources can, under certain circumstances, release the column permitting its movement.

SUMMARY OF THE INVENTION

The present invention overcomes the foregoing and other drawbacks of the prior art and provides a novel and improved fail-safe columnar support system which locks the column against further downward movement immediately upon sensing support cable breakage or stretching in the support cable as typically occurs prior to cable breakage.

In accordance with one feature of the present invention, two separate cables are used to support the column and couple it to a spring-motor counterbalance. Each of the cables is capable of supporting the full columnar load.

A cable tension sensing system senses the tension in one of the two support cables. The tension sensing system employs electrical switches connected to a solenoid operated clutch. In the event that either (1) sensed cable tension increases beyond normal operating limits as occurs if the other cable stretches or breaks and no longer supports its share of the columnar load, or (2) sensed cable tension decreased beyond normal operating limits as occurs if the sensed cable stretches or breaks and no longer supports its share of the load, the solenoid clutch is actuated and locks the column against further downward movement. Since cable stretching is ordinarily a condition precedent to cable failure, this system is operable, in most instances, to lockup the column prior to cable failure.

If a power failure occurs in the A.C. power supply which prevents the cable tension sensing system from performing its safety monitoring functions, the solenoid clutch is automatically actuated to lock the column. Corresponding provision is made to lock the column in the event of power failure in the D.C. power supply system which powers the usual electromagnetic column locking system.

The counterbalance system itself includes three cables. These cables couple a tension coil spring motor to a column drive control shaft to torque-load the drive shaft. A force balance bridge is provided to sense failure of any of the three cables in the counterbalance system. A mechanical linkage coupled to the force balance bridge is operative to lock the column against further movement if one of the counterbalance cables fails.

A slip clutch is provided in the fail-safe system to permit emergency downward columnar movement after the fail-safe system has engaged to lock the column. The slip clutch is typically set such that about 50 pounds of force must be exerted on the column to move it downwardly.

The primary support cables which connect the counterbalance system with the column also cooperate to

facilitate concurrent extension or retraction of the column sections. Concurrent movement of the column sections has been achieved in the prior art by the use of elaborate cable and pulley systems. Five-section columns have typically required six section-interconnecting cables in addition to the column support cable to effect concurrent movement of the sections. The present invention achieves the same result with half that number of section interconnecting cables. This is achieved by connecting one of the primary support cables to the lowermost column section to carry most of the columnar load. The other cable is connected to an intermediate column section to tension the three cables which interconnect the various column sections.

As will be apparent from the foregoing summary, it is a general object of the present invention to provide a novel and improved telescopically extensible columnar support system for X-ray equipment and the like.

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

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the telescopic columnar support system of the present invention with the column sections extended;

FIG. **2** is a schematic illustration of the cable and pulley system which interconnects the various column sections and couples the column to a counterbalance system for support;

FIG. **3** is an enlarged top plan view of the sections of the telescopic column with the section retracted;

FIG. **4** is an enlarged cross-sectional view as seen from the plane indicated by the line **4—4** in FIG. **3**;

FIG. **5** is a perspective view of the carriage assembly which supports the column, the top cover of the carriage assembly having been removed;

FIG. **6** is an enlarged top plan view looking into the carriage assembly with the top cover removed;

FIGS. **7** and **8** are cross-sectional views as seen respectively from the planes indicated by the lines **7—7** and **8—8** in FIG. **6**; and

FIG. **9** is a schematic electrical circuit diagram.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a telescopically extensible support system is shown generally at **10**. The system **10** includes a carriage assembly **11**. A ceiling-mounted track structure **12** movably supports the carriage assembly **11**. A column **13** includes including five telescopically extensible nested sections **21, 22, 23, 24, 25** which depend from the carriage assembly **11**.

An X-ray tube housing assembly **14** and a collimator **15** are carried on the lowermost column section **21**. A rotary and pivotal mount (not shown) described in the referenced Rotary Mount Patent provides the interconnection between the column section **21** and the housing **14**.

In accordance with one feature of the present invention, a novel cable and pulley system is provided which interconnects the column sections **21–23** for concurrent movement and couples the column **13** to a counterbalance system for support. Referring to FIG. **2**, a pair of column support cables **31, 32** are provided. A take-up drum **33** is journaled for rotation in the carriage assembly **11**. Each cable **31, 32** has one end region reeved around and secured to the take-up drum **33**. The cables **31, 32** have reaches **31***a*, **32***a* which extend generally horizontally from the drum **33** to pulleys **34, 35**. The pulleys **34, 35** are rotatably carried in the carriage assembly **11** at a position centrally above the column **13**.

The cables **31, 32** are reeved around the pulleys **34, 35** and depend into the column **13**. The cable **31** has a vertically extending reach **31***b* extending from the pulley **34** to a point of connection **36** with the lowermost column section **21**. The cable **32** has a first vertical reach **32***b* extending from the pulley **35** to a pulley **37**. The pulley **37** is rotatably mounted on the upper end region of the third column section **23**. The cable **32** is reeved around the pulley **37** and has a second vertical reach **32c** extending from the pulley **37** to an end connection assembly **38** in the carriage assembly **11**.

Three additional cables **41, 42, 43** are used to interconnect the column sections **21–25**. The cable **41** connects at one end **41***a* with the upper end region of the first column section **21**, and at the other end **41***b* with the lower end region of the third column section **23**. Intermediate portions of the cable **41** are reeved around a pulley **44** carried on the upper end region of the second column section **22**. In short, the cable **41** interconnects the first three column sections **21, 22, 23**.

In similar fashion, the cable **42** interconnects the second, third and fourth column sections **22, 23, 24** by end connections **42***a*, **42***b* on the second and fourth sections **22, 24**, and by being reeved around a pulley **45** carried on the third column section **23**. Likewise, the cable **43** interconnects the third, fourth and fifth column sections **23, 24, 25** by end connections **43***a*, **43***b* on the third and fifth sections and by being reeved around a pulley **46** carried on the fourth column section **24**.

In operation, the support cable **31** which connects with the lowermost or first column section **21** supports most of the columnar loading. The cable **31** is preferably a one-eighth inch diameter stranded aircraft cable. The support cable **32** serves to tension the section interconnection cables **41, 42, 43**. The cable **32** is preferably a three-thirty-second inch diameter stranded aircraft cable. If the cable **31** should break, the cables **32, 41, 42, 43** operate as a backup system to support the columnar load. If the cable **32** should break, tension will be lost in the cables **41, 42, 43**, but the columnar load will continue to be supported by the cable **31**. As will be explained, a fail-safe system housed in the carriage assembly **11** is operative to lock the column against downward movement in the event either of the cables **31, 32** stretches or breaks.

Referring to FIG. **3**, the column sections **21–25** are shown as viewed from above. The pulleys **44, 45, 46** are rotatably supported on bracket assemblies **54, 55, 56**. These bracket assemblies are respectively secured to the upper ends of the second, third and fourth column sections **22, 23, 24**. Bearinged connections between the various column sections seen in FIG. **3** form the subject matter of the referenced Extensible Column Patent.

Referring to FIG. **4**, the arrangement of cable **43** and pulley **46** arrangement is shown in greater detail together with its interconnections to the third, fourth and fifth column sections **23, 24, 25**. As shown in this FIGURE bracket assembly **56** which supports the pulley **46** comprises a welded structure including an upstanding

arm 56*a*. A stub shaft 56*b* carried on the arm 56*a* journals the pulley 46 for rotation.

Referring to FIGS. 5 and 6, the carriage assembly 11 includes a generally rectangular housing 60 having front and rear walls, 61, 62 and sidewalls 63, 64. Bearinged rollers 65 carried on the sidewalls 63, 64 engage the track structure 12 to permit longitudinal movement of the carriage assembly.

The housing 60 is partitioned into compartments which house the components of the counterbalance and fail-safe cable support system. Frontal regions of the housing 60 carry a column height indicator assembly indicated generally by the numeral 70, and a drive shaft assembly indicated generally by the numeral 80. A spring motor assembly indicated generally by the numeral 90 is housed in a longitudinal compartment along the right sidewall 63. Central regions of the housing 60 carry an electrical connection block 66 and a pair of brackets 67, 68 which rotatably support the pulleys 34, 35.

The height indicator assembly 70 includes a drum 71 having a circumference which is identical in length to the distance traveled by the fourth column section 24 from its fully retracted to its fully extended position. One end region of a cable 72 is reeved around and connected to the drum 71. The cable 72 extends from the drum 71 around several idler pulleys 73 and connects at its other end (not shown) to the fourth column section 24. As the column 13 extends and retracts, indicia 74 inscribed on the drum 71 provide a visual indicator of the amount of columnar extension.

Referring to FIG. 8 in conjunction with FIG. 6, the drive shaft assembly 80 includes a drive shaft 81 journaled for rotation by bearings 82 carried in the housing 60. The cable take-up drum 33 is secured to the drive shaft 81 for rotation therewith. A magnetic locking disc 83, a slip clutch assembly 84, and a spring motor cable drum 85 are also secured to the drive shaft 81 for rotation with it.

The spring motor assembly 90 includes coil springs 91 secured at one end to the rear wall 62 of the housing 60, and at the other end to a movable yoke structure 92. Three cables 96, 97, 98 have intermediate portions reeved around the pulleys 93, 94, 95. One end region of each of the cables 96, 97, 98 is reeved around and connected to the spring motor cable drum 85. The other end regions of the cables 96, 97, 98 connect with a force balance bridge assembly indicated generally by the numeral 99. Tension in the springs 91 establishes corresponding tension forces in the cables 96, 97, 98. This tension applies a counterbalance torque to the drive shaft 81 to counteract the load carried by the cables 31, 32.

The force balance bridge 99 is operative to sense breakage of any of the cables 96, 97, 98. The balance bridge 99 includes a mounting bracket 100 which pivotally supports an actuator lever 101. A pin 102 carried by the bracket 100 establishes a vertical pivot axis about which the lever 101 pivots.

Two cable engaging blocks, 103, 104 are rigidly secured to the lever 101 for movement with it. The block 103 pivotally carries a connector arm 105. A pin 106 carried on the block 103 establishes a vertical pivot axis about which the arm 105 pivots.

The cables 96, 97 connect to the art 105 at locations indicated by the numerals 107, 108. The cable 98 connects to the block 104 at a location indicated by the numeral 109.

In the preferred embodiment of the force balance bridge 99, the relative locations (in directions longitudinally of the actuator lever 101) of the connections 107, 108, 109 and the pivot axes 102, 106 are essential to proper operation. The connections 107, 108 are equally spaced from the pivot axis 106 by a distance which will be called "X." The pivot axis 106 is spaced from the pivot axis 102 (all distances being measured longitudinally of the actuator lever 101) by the distance X. The connection 109 is spaced from the pivot axis 102 by the distance 2X. By this arrangement, equal tension forces in the cables 96, 97, 98 will retain the actuator lever 101 in the equilibrium or balanced position shown in FIG. 6.

A force of "Y" pounds in each of the cables 96, 97 times the distance of application X gives a moment of 2XY about the pivot 102. A force of Y pounds in the cable 98 times the distance of application 2X gives a corresponding moment of 2XY that balances the moment caused by the force in the cables 96, 97. If, however, one of the cables 96, 97, 98 should break, this balanced condition will be disturbed and the actuator lever 101 will be pivoted about the axis of pin 102.

Pivotal movement of the actuator arm 101 from its equilibrium position trips a spring-biased latch which engages the slip clutch 84. Referring to FIG. 7 in conjunction with FIG. 6, the slip clutch 84 has a toothed sprocket 110. A toothed dog 111 is pivotally mounted for movement about a pin 112 into engagement with the sprocket 110. A compression coil spring 113 biases the dog 111 toward engagement with the sprocket 110. The dog 111 is configured such that when it is engaged with the sprocket 110, it will permit the sprocket 110 to rotate in the direction of arrow 114 (FIG. 7), but not in a direction opposite to arrow 114.

A latch arm 115 is secured to the dog 111 for pivotal movement therewith about the pin axis 112. A latch release lever 116 has a projection 117 which engages the upper end region of the latch arm 115 and normally prevents movement of the dog 111 into engagement with the sprocket 110. The latch release lever 116 is pivotally mounted about a pin 118.

A V-shaped notch 119 formed in the latch release lever 116 receives a pin 120 which depends from the actuator arm 101. The notch 119 and the pin 120 cooperate to pivot the latch release lever 116 about the pin axis 118 in response to pivotal movement of the actuator arm 101 from its equilibrium position. As the latch release lever 116 pivots, the projection 117 is drawn out of engagement with the latch arm 115 and the dog 111 is released to move under the influence of the spring 113 into engagement with the sprocket 110.

The support cable take-up drum 33 is provided with a helical groove 130 which receives the support cables 31, 32. The radius of the groove 130 decreases from left to right (as viewed in FIGS. 5 and 6) to accommodate for the variance in spring tension force in the counterbalance springs 91. As is well known, tension coil springs exert greater tension forces the more they are extended. By decreasing the support cable drum take-up radius as the counterbalance springs are extended, a substantially constant counterbalance force is applied to the support cables 31, 32.

In accordance with another feature of the present invention, a fail-safe system is provided to sense elonga-

tion or breakage of either of the primary support cables **31, 32,** and to lock the column **13** against unintended movement when such a condition is sensed. Since stranded aircraft cables ordinarily elongate rather substantially prior to breakage, the fail-safe system of the present invention normally operates to lock the column prior to failure of either of the primary support cables **31, 32.** If one of the cables **31, 32** should fail, the other cable is sufficiently strong to hold the column in locked configuration.

Referring to FIG. **7,** the fail-safe system utilizes the end connection **38** of the cable **32** to sense elongation or breakage of either of the cables **31, 32.** An annular spring support bracket **140** is carried by the housing **60.** A plunger block **141** positioned concentrically within the support bracket **140** connects with the end of the cable reach 32c. A compression coil spring **142** is interposed between the bracket **140** and the plunger **141** and operates to suspend the plunger at a preselected height during normal operation of the apparatus.

A pair of electrical switches **150, 151** are positioned to sense the height of the plunger **141.** The switch **150** is arranged to sense higher than normal positioning of the plunger **141** as occurs if the cable **32** has stretched or broken so it no longer supports its share of the columnar load. The switch **151** is arrayed to sense lower than normal positioning of the plunger as occurs if the cable **31** has stretched or broken thereby transferring a greater than normal share of the columnar load to the cable **32.**

The switches **150, 151** are electrically connected to a rotary solenoid **160** positioned on the opposite side of the slip clutch **84** from the dog **111.** A pawl **161** is pivotally mounted about a pin **162** and arranged to selectively engage the sprocket **110.** A link **163** couples the pawl **161** to the solenoid **160.** When the solenoid **160** is energized, the pawl **161** is retracted out of engagement with the sprocket **110.**

When the solenoid **160** is de-energized, it moves the pawl into engagement with the sprocket **110** to prevent sprocket rotation in the direction opposite arrow **114.** The switches **150, 151** are arranged to effect de-energization of the solenoid **160** when abnormal tension is sensed in the cable **32.**

If a power failure should occur, the solenoid **160** will also be de-energized. This feature assures that when power fails, incapacitating the switches **150, 151** from performing their normal cable tension monitoring function, the pawl **161** will engage the sprocket **110** just as if improper cable tension were sensed.

The slip clutch **84** is preferably pre-set such that it can be overridden by an application of about **50** pounds force to the column **13.** While it is desirable that the slip clutch **84** be operable to securely lock the column against unintended downward movement, it will be necessary on occasion to extend the column downwardly after it has been locked. With the clutch **84** set for a **50** pound override force mast mast operator will be able to move the column if necessary, but the column will not move unless relatively strong forces are applied.

Referring to FIG. **6,** a pair of D.C. electromagnets **170, 171** carried by the housing **60** are positioned adjacent the magnetic locking disc **83.** The electromagnets **170, 171** are operable to lock the drive shaft **81** against rotation in either direction. They are normally energized by actuation of a switch **180** (FIG. **9**) once the operator has positioned the column **13** in a desired position.

Referring to FIG. **9,** the electromagnets **170, 171** are operated from a source of D.C. power represented by the conductors **200, 201.** For D.C. current to be supplied to the electromagnets, two pairs of normally open contacts **185, 186** and **187, 188** must be closed by energizing a solenoid **182.** Once D.C. current flow has been established to the electromagnets **170, 171,** a solenoid **202** connected in parallel with the electromagnets will also be energized to close a pair of normally open contacts **203, 204.**

A.C. power is supplied to the rotary solenoid **160** from a pair of conductors **190, 191.** Under normal operating conditions when normal cable tension is sensed in the primary support cable **32,** the switches **150, 151** will be closed and the solenoid **160** will be energized to release the pawl **161** and permit free extension of the column sections **21–25.** If abnormal tension is sensed in the cable **32,** one of the switches **150, 151** will open and the column will lockup preventing further downward extension. Likewise if power failure should occur in the A.C. power source solenoid **160** will be de-energized and the column will lockup.

If the switch **180** is closed to energize the electromagnets **170, 171,** the rotary solenoid **160** normally remains energized. Energization of the solenoid **182** by the switch **180** causes normally closed contacts **183,** 184 to open. Current flow is maintained to the rotary solenoid **160** by energization of the solenoid **202** which closes normally open contacts **203, 204** shunting the contacts **183, 184.** If a D.C. power failure should occur, the solenoid **202** will de-energize opening the contacts **203, 204** de-energizing the rotary solenoid **160** and locking the column **13.**

As should now be apparent from the foregoing description, the present invention provides a novel and improved fail-safe system which is operative during A.C. or D.C. power failure or in the event of cable failure to lock the extensible column. Other advantages and features of the invention include a simplified cable and pulley system for concurrently moving the column sections.

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 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. In an X-ray apparatus of the type including an X-ray source carried on an extensible column depending from a mount, the improvement of a counterbalance system for supporting the column, comprising:

a. counterbalance means for producing a force which will offset the weight of the column and the X-ray source;

b. a pair of cables each operably connecting said counterbalance means to said column and each being capable of carrying such weight;

c. sensing means for sensing failure of one of said cables; and

d. locking means connected to said sensing means for arresting the movement of the other of said cables when failure of said one cable is sensed.

2. The X-ray apparatus of claim 1 wherein said sensing means is additionally operable to sense stretching of said one cable and said locking means is responsive to said sensed stretching to arrest the movement of said other cable.

3. The X-ray apparatus of claim 1 wherein said locking means is additionally operable to arrest the movement of said cables in the event of a power failure.

4. The X-ray apparatus of claim 1 wherein:

a. said sensing means is arranged to sense failure of either of said cables; and,

b. said locking means is responsive to sensed failure of either of said cables to arrest said column against downward movement.

5. The appartus of claim 4 wherein:

a. said column includes a plurality of telescopically extensible sections;

b. a first one of said cables connects with one of said sections;

c. a second one of said cables is reeved around a pulley carried on another of said sections; and,

d. said tension sensing means is operative to sense abnormal tension forces in a selected one of said cables.

6. The apparatus of claim 5 wherein:

a. said second cable has a reach near one end region thereof which extends from said pulley toward said carriage; and

b. said tension-sensing means operates to sense abnormal tension forces in said reach as an indication of stretching or breakage of either of said cables.

7. The apparatus of claim 6 wherein said tension sensing means includes:

a. bracket means carried by said support structure;

b. plunger means carried by said cable reach;

c. biasing means interposed between said bracket means and said plunger means to bias said plunger means to a normal operating position where said plunger means remains when normal operating tensions are maintained in said second cable; and,

d. electrical switch means carried by said support structure for sensing movement of said plunger means out of said normal operating position.

8. The apparatus of claim 1 wherein said locking means includes a slip clutch which can be overridden by the application of sufficient downward force to said column when said column is arrested against downward movement, whereby said column can be moved downwardly if absolutely necessary when locked.

9. The apparatus of claim 1 wherein said locking means is operative to permit upward column movement when downward movement of said column is arrested.

10. A telescopic columnar support, comprising:

a. a carriage structure;

b. an extensible column carried by said carriage structure and including a plurality of telescopically extensible nested sections;

c. counterbalance means carried by said carriage structure and including first and second cables connected to selected ones of said sections to support said column;

d. each of said cables being capable of supporting said column in the event the other of said cables fails; and

e. fail-safe means for sensing failure of one of said cables and for arresting said column against further movement in at least one direction once cable failure is sensed.

11. The apparatus of claim 10 wherein said fail-safe means includes tension sensing means associated with at least one of said cables for sensing stretching of said cables beyond normal operating limits and for arresting said column against further movement in said direction once cable stretching is sensed.

12. A telescopic columnar support comprising:

a. a support structure;

b. an extensible column coupled to said support structure and including a plurality of extensible sections arranged to extend downwardly from said support structure;

c. counterbalance means including cable means connected to said column to support said column together with such loading as may be applied to said column;

d. sensing means for sensing impending failure of said cable means; and

e. locking means connected to said sensing means and being operable to arrest said column against downward movement when impending failure of said cable means is sensed.

13. The apparatus of claim 12 wherein said sensing means includes means for sensing stretching of said cable means.

14. The apparatus of claim 13 wherein said sensing means is also operative to sense breakage of said cable means.

15. The apparatus of claim 12 wherein said locking means is operable to arrest said column against downward movement in the event of a power failure.

16. A telescopic columnar support for X-ray apparatus comprising:

a. a support structure;

b. an extensible column carried by said support structure in depending relationship thereto and including a plurality of extensible sections;

c. counterbalance means carried by said support structure for supporting the weight of said column and such loading as may be applied thereto;

d. said counterbalance means including first and second cables each interconnecting said column and said counterbalance means, each of said cables being capable of supporting said column and such loading as may be applied thereto in the event the other of said cables fails; and,

e. fail-safe means for sensing failure of one of said cables and for arresting said column against further downward movement once cable failure is sensed.

17. The apparatus of claim 16 wherein:

a. said extensible column includes an upper section, a lower section, and at least one intermediate section;

b. said first cable is connected to said lower section;

c. said second cable is reeved around a pulley carried on said intermediate section; and

d. said fail-safe means includes sensing means for sensing higher and lower than normal tension loading of said second cable.

18. The apparatus of claim 16 wherein:

a. said extensible column includes a lower section, a second section disposed outwardly of said lower section, a third section disposed outwardly of said second section, a fourth section disposed out-

wardly of said third section, and an upper section disposed outwardly of said fourth section;

b. said first cable is connected to said lower section;

c. said second cable is reeved around a pulley carried on said third section and has a reach near one end thereof which extends from said pulley toward said support structure; and

d. said fail-safe means includes sensing means for sensing abnormal tension forces in said reach.

19. The apparatus of claim **18** additionally including first, second and third section interconnecting cables interconnecting said sections for concurrent movement.

20. In an X-ray apparatus of the type including an X-ray source carried on an extensible column, the improvement of a fail-safe counterbalance system for movably supporting the, X-ray apparatus comprising:

a. counterbalance means supported near the column;

b. mounting means movably mounting the X-ray apparatus on the column;

c. first and second cables each interconnecting said counterbalance means and the mounting means for supporting said apparatus, each of said cables being capable of supporting said apparatus in the event the other of said cables fails; and,

d. fail-safe means for sensing impending failure of one of said cables and for arresting the movement of said apparatus once impending cable failure is sensed.

21. The apparatus of claim **20** wherein said fail-safe means includes tension sensing means for detecting stretching of said cables and for arresting movement of said apparatus once cable stretching is sensed.

22. The apparatus of claim **20** wherein said counterbalance means includes:

a. a drive shaft;

b. a support cable drum and a drive cable drum secured to said shaft for rotation therewith;

c. said first and second cables having end portions wrapped around said support cable drum to transfer the columnar load carried by said first and second cables into a torque load imposed on said shaft tending to rotate said shaft in one drive direction;

d. a spring motor including at least one extensible tension coil spring;

e. a plurality of drive cables each having one end region wrapped around said drive cable drum and connected to said spring motor to transfer the tension forces imposed on said drive cables by said spring motor into a torque load imposed on said shaft tending to rotate said shaft in a drive direction opposite said one drive direction thereby counterbalancing the columnar load; and

f. said drive cables being of sufficient strength such that if one of said drive cables should fail, the remaining drive cables will keep said columnar load counterbalanced.

23. The apparatus of claim **22** wherein said counterbalance means additionally includes:

a. force balance bridge means coupled to each of said drive motor cables for effecting movement of an actuator lever if any one of said drive cables should fail; and,

b. clutch means for locking said column against downward movement in response to movement of said actuator lever due to drive cable failure.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,902,070
DATED : August 26, 1975
INVENTOR(S) : William H. Amor, Jr. et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 31, delete "indicator" and substitute - - indication - -

Column 5, line 67, delete "art" and substitute - - arm - -

Column 7, line 59, delete the first occurrence of the word "mast" and substitute - - most - -

Column 7, line 60, delete "tor" and substitute - - tors - -

In the Claims:

Column 9, line 15, delete "appartus" and substitute - - apparatus - -

Signed and Sealed this

second Day of December 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks