Nov. 2, 1965 R. J. MUELLER 3,215,835

SELECTIVELY ENGAGEABLE POWER-ASSIST FOR X-RAY TABLE COMPONENTS

Filed June 4, 1963

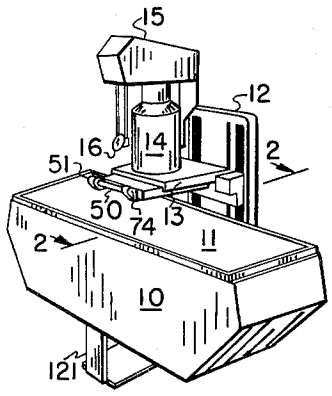

FIG. 1

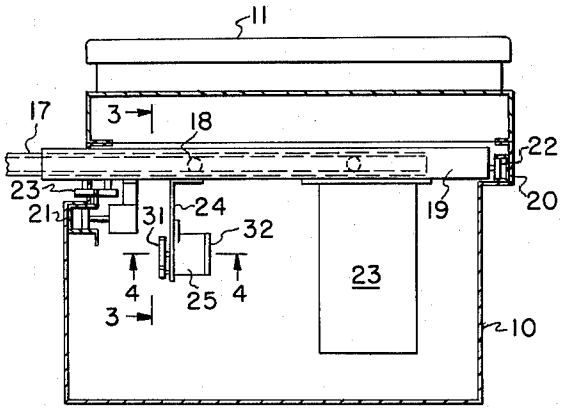

FIG. 2

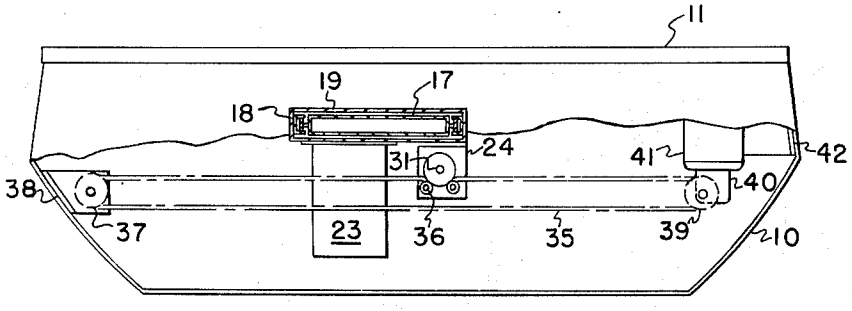

FIG. 3

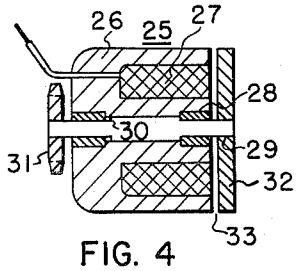

FIG. 4

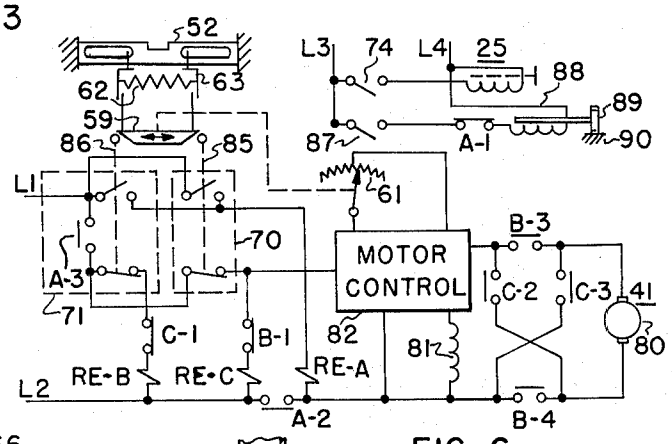

FIG. 6

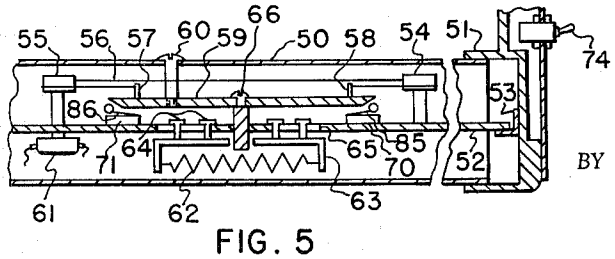

FIG. 5

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SELECTIVELY ENGAGEABLE POWER-ASSIST FOR X-RAY TABLE COMPONENTS

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This invention relates to diagnostic X-ray tables and is specifically concerned with a power-assist device for positioning the fluoroscopic carriage or other components of such tables.

Diagnostic X-ray tables customarily have an X-ray tube inside the table body which directs rays through a patient who is supported on its top. The radiologist views the intervening anatomy of interest on a fluoroscopic screen which is over the patient and jointly movable with the tube laterally and longitudinally of the table. The carriage and tower which supports the X-ray tube and screen have relatively low inertia so that they may be manually positioned with small effort.

X-ray image intensifier systems are now being more commonly substituted for fluoroscopic screens. Such systems include an electronic image intensifier tube, a housing, and optical system for direct viewing, and a cine camera and a television camera for according and transmitting the X-ray image. Consequently, the systems are more massive and require considerable effort to overcome their inertia during the positioning process.

A widely adopted expedient is to apply a motor drive to the fluoroscopic carriage so that the radiologist may move it by operating a switch. This is not without its disadvantages, however, because the radiologist loses the sense of feel that enables him to position the intensifier efficiently over the area of interest without over-travel or falling short as he could do readily with manual movement. It also requires the radiologist to be conscious of the switching choice that he is making in contrast with his natural inclination to merely push in the direction that he wants the fluoroscopic carriage to move. The purpose of the present invention is to overcome these and other disadvantages.

An object of the present invention is to provide the fluoroscopic device with a handle that the radiologist may urge in the desired direction of travel and which causes the fluoroscope carriage to move under a power-assist at a velocity that is proportional to the applied force as is the case with direct manual positioning.

A further object is to provide a fluoroscope carriage with accessories that allow convenient selection of either power-assisted movement or direct manual movement and that impose no burden on the manual movements when the power-assist is inactivated. An adjunct of this object is the provision of a system wherein the fluoroscope carriage is completely free for easy movement if the power-assist cannot be energized for any reason.

A more specific object is to provide a power-assist system that serves to both variably drive the fluoroscope carriage and to automatically lock the same at the position in which it is finally desired by using a minimum number of components and simplified construction.

Another object is to provide a fluoroscope power-assist system that is readily adaptable to existing X-ray tables without major modification.

A general object is to provide a diagnostic X-ray table that is more convenient to operate than those heretofore known.

Achievement of the aforegoing and other objects will appear from time to time throughout the course of the specification.

A preferred embodiment of the invention is characterized by a tubular handle to which the operator has convenient access because of it being mounted on the front of the fluoroscope tower. The handle is carried in recessed brackets which allow it to yield axially in the selected direction of movement in opposition to a spring which yields in proportion to the force applied. Within the handle are electric controls that energize the power-assist mechanism when the handle is urged from its neutral position. The electric controls are adapted to vary the speed of the power-assist device in accordance with the force applied to the handle.

The power-assist drive comprises a stationary motor having a speed reducer that drives a sprocket. Remote from the drive sprocket within the table body is an idler sprocket which is mounted for rotation on a fixed support. A closed loop chain belt passes over both sprockets. The fluoroscope tower is engaged or disengaged from the chain belt by a rotating magnetic lock or coupling device that has a sprocket on its shaft. When the coupling is energized and the chain belt is moving, the fluoroscope carriage is caused to translate longitudinally of the table. When the coupling is de-energized, the carriage may be moved manually.

A preferred embodiment of the invention will now be described in conjunction with the drawing in which:

FIG. 1 depicts a typical X-ray table with which the invention may be utilized;

FIG. 2 is a cross-section of the table body, with parts removed, taken on a line corresponding with 2—2 in FIG. 1;

FIG. 3 is an elevation view, omitting some parts of the interior of the table body, taken on a line corresponding with 3—3 in FIG. 2;

FIG. 4 is a cross-section of a magnetic lock, which is especially suitable for use with the invention, taken on a line corresponding with 4—4 in FIG. 2;

FIG. 5 is a cross-section of the fluoroscope carriage positioning handle, this view being partially schematic and partially structural; and,

FIG. 6 is a schematic representation of part of the power-assist device along with its wiring diagram.

A typical diagnostic X-ray table is seen in FIG. 1 and comprises a table body **10** and top **11**. The body is supported on a base **121** on which the body is adapted to tilt from horizontal to opposite vertical positions by conventional mechanism which need not be described nor is it shown. Adjacent the body is fluoroscope tower **12** which will be seen later to have its lower portion mounted on rollers for movement laterally and longitudinally of the table body. Extending laterally from tower **12** is a vertically movable support **13** on which there is mounted an X-ray image intensifier tube casing **14**. The image created by intensifier tube in casing **14** is projected through an optical system, not shown, in housing **15**. The housing may also contain a cine camera and a television camera. For direct viewing the image is directed outward to where it can be seen by the radiologist on a mirror **16** that is suspended from housing **15** and is universally adjustable. When an X-ray tube within table body **10** is energized, the anatomy of a patient intervening between table top **12** and the image intensifier **14** is imaged in mirror **16** for viewing by the radiologist, as is well known.

In some installations, the weight of the image intensifier and its housing is removed from the support **13** by a cable that connects with the top of housing **15** and which is suspended from a bilaterally movable overhead crane, not shown. It can be perceived, however, that any effort to move the fluoroscope tower **12** lengthwise of the table entails the burden of overcoming the inertia of the crane also.

In FIG. 2 it may be seen that the fluoroscope tower is adapted for lateral and longitudinal movement with re-

spect to the table 10 in a typical fashion. The bottom of the tower 12 connects with a laterally movable carriage 17 which has rollers 18 that allow it to move freely with respect to a longitudinal carriage 19. Carriage 19 is supported at its opposite ends on rails 20 and 21 by means of rollers 22 and 23, for example, so that carriage 19 may be translated over nearly the length of the table body while it carries the transversely movable carriage 17 with it.

Suspended from lateral carriage 17 within the table body is an X-ray tube and shutter box housing 23. The center of the X-ray tube housing 23 and the axis of the image intensifier tube in casing 14 are always aligned by virtue of their common support from tower 12.

Fastened to the bottom of longitudinal carriage 19 is a bracket 24 that supports a magnetic coupling or lock 25 whose details may be seen in FIG. 4. It can be seen in FIG. 2 that when carriage 19 is moved lengthwise of the table 10, that is, on a line normal to the plane of the drawing, the magnetic lock 25 will translate with the carriage 19.

As may be seen best in FIG. 4, lock 25 includes a ferromagnetic stator frame 26 in whose recess there is magnet coil 27. In the center of stator 26 there is journaled on bearings 28 a shaft 29 which has a shoulder in the vicinity of 30 that allows it to move with small axial free-play to the left in FIG. 4. Carried on one end of shaft 29 is a sprocket 31 and on the other end it has a magnetizable brake disk 32. There is an air gap 33 between brake disk 32 and the faced ends of stator 26. In reality, the free-play, and hence the air gap may be one-thousandth of an inch although the gap is exaggerated in the drawing for clarity. When coil 27 is energized, brake disk 32 is attracted and this imposes a frictional force that inhibits rotation of sprocket 31. When coil 27 is de-energized, sprocket 31 may rotate freely with shaft 29 and brake disk 32. The magnetic coupling type of lock described in this paragraph is not new by itself.

In reference to FIG. 3, sprocket 31 of the lock is engaged with a chain belt 35. The sprocket is maintained in engagement with the chain belt by a pair of rollers 36 that are journaled on bracket 24. It will be seen that if the top portion of chain belt 35 translates lengthwise of the table body 10, that X-ray tube 23 and its supporting carriage 19 will remain stationary if the clutch lock 25 is de-energized. Under this condition, pinion 31 will merely rotate freely with its shaft 29 and the brake disk 32. On the other hand, if the top portion of belt 35 translates while the magnetic coupling lock 25 is energized, it will lock carriage 19 to the chain for joint translation.

Chain belt 35 passes over an idler sprocket 37 which is journaled on a stationary bracket 38 that is mounted inside the table body. In the commercial embodiment, bracket 38 is provided with adjustment means in order to obtain proper tension on the chain belt 35.

The chain belt 35 is operated by suitable wheel means which in this example is a drive sprocket 39 which is driven by the shaft of a speed reducer 40 whose prime mover is a variable speed motor 41. The motor 41 is mounted on a bracket 42 which is fixed to the interior of table body 10 by any suitable means. Thus, if variable speed motor 41 is run in either of its directions of rotation, drive sprocket 39 will move the chain belt 35 and the carriage 19 along with it if the magnetic coupling 25 is locked. Otherwise, if the coupling 25 is not locked and the chain belt is stationary, the carriage is free to roll longitudinally of the table body while the locking sprocket 31 turns freely with shaft 29.

The handle which the operator uses to control motor 41 for obtaining power-assist drive of the fluoroscope carriage, comprises a tubular member 50 which is supported in recessed hangers 51 as may be seen in FIGS. 1 and 5. If the power-assist device is not engaged, and the operator urges the handle 50 in FIG. 1 to the right he will have to apply such force as is necessary to overcome the inertia of the fluoroscope device in order to make it move to the right. The same is true if he moves the handle 50 from its neutral position axially to the left. On the other hand, if the power-assist device is engaged, the handle 50 will yield axially as before and because of mechanism which is about to be described, the fluoroscope carriage will move at a speed that is proportional to the applied force and to the axial displacement of the handle.

One way of achieving this result may be seen in FIG. 5 which shows the handle assembly partially schematically and partially as actually constructed. Tubular handle 50 is seen to enter one of the brackets 51 with sufficient space at the end of the tubular handle 50 to allow it to be slid axially for a short distance in the bracket. Near the center of tube 50 there is an axially extending bar 52 which constitutes a chassis on which other mechanism inside the handle is carried. The bar 52 is fastened to angle brackets 53 which are anchored inside the main end brackets 51 as shown. The fastening means are omitted for clarity. On suitable bearing posts extending from bar 52 are a pair of pulleys 54 and 55 which are spaced from each other on equal distances opposite the center of the tubular handle's length. A string or belt 56 loops around the pulleys 54 and 55 and the ends thereof terminate at anchor points 57 and 58 which are carried on an actuator 59. The actuator 59 is connected with tubular handle 50 by a stud 60. When one moves tubular handle 50 to the right, for instance, actuator 59 moves with it, causing string 56 to rotate pulleys 54 and 55. Pulley 55 is carried on a common shaft with an adjustable resistor 61 whose resistivity varies in accordance with the axial position of the handle 50. Adjustable resistor 61, as will be explained in more detail later, is in the motor speed control circuit and is capable of controlling the power-assist speed for either direction of rotation of motor 41.

In order to obtain the feeling that the fluoroscope carriage is moving at a speed that is related to the force applied to handle 50, the latter works against a spring 62. The spring 62 has its opposite ends fastened on guides which are in the form of right angular members 63. The guides are adapted to slide axially with respect to bar 52 by virtue of their being carried on spaced pins 64 which are headed so that they cannot come out of an elongated slot 65 in bar 52. There is a rod 66 which is carried by actuator 59 and extends into the space between the spring urged brackets 63. Rod 66 extends through a suitable aperture in bar 52. It may be seen that when the handle 50, and consequently actuator 59, is moved to the right or left in FIG. 5, post 66 will move one of the spring brackets 63 and extend the spring 62 while the other bracket remains stationary due to its manner of mounting for sliding in one direction only. The more actuator 59 is shifted, the more load will be placed on the spring 62 and the faster the carriage will travel as a result of the changing adjustment of resistor 61.

Also shown in the FIG. 5 handle assembly is a pair of microswitches 70 and 71 which have to do with selection of the rotational direction of motor 41. For reasons which will be explained in connection with describing the electrical circuitry, microswitches 70 and 71 both have a set of normally open and normally closed contacts. When actuator 59 is in its neutral position, the microswitches are in their normal positions. When the handle 50 and actuator 59 are shifted to the right, for example, the beveled end of the actuator moves the roller terminated arm of microswitch 70 to perform a switching function. Moving tubular handle 50 axially is opposed by a spring force. Concurrently the direction of power-assist is automatically selected and the translational speed of the fluoroscope carriage is governed by the amount of handle movement through the agency of a motor speed control resistor 61.

Mounted on the handle bracket is a switch 74 whose position determines whether the power-assist mechanism

is energized or whether movement of the fluoroscope carriage is wholly under manual control.

Discussion of the electric circuitry and operating mode of the new power-assist mechanism will now continue primarily in reference to FIG. 6. In this instance the power-assist drive motor 41 includes an armature 80 and a field winding 81 that are energized from a D.-C. motor control 82. A desirable type of control 82 is one that is available from the General Electric Company under the tradename "Statatrol." It is designed for maintaining essentially a constant motor torque regardless of its speed. Those versed in the electrical arts will readily understand that other reversing, variable speed motor controls may be substituted. In this case, as is usual with D.-C. motors, rotational direction may be changed by reversal of the armature leads. Thus, when contacts C–2 and C–3 are closed, current from the motor control will pass through the armature circuit in one direction. When these contacts are open and B–3 and B–4 are closed, armature current and rotation will be in the opposite direction.

For convenience in following the diagram, all relay coils are designated with a capital letter and all contacts operated by the same relay coil are designated with the same capital letter and a number. For example, a relay may be designated RE–A and its contacts are designated A–1, A–2, etc.

Essential mechanical parts of the operating handle are schematized in FIG. 6 and bear corresponding reference numerals. The element of first interest is actuator 59 which is shown in its neutral position with its beveled ends nearly contacting the roller arm extensions 85 and 86 from microswitches 70 and 71, respectively. D.-C. control power is obtained from lines L–1, L–2. When actuator 59 is moved to the left in FIG. 6, the normally open contact of microswitch 71 closes and its normally closed contact opens. Closure of the top microswitch contact energizes RE–A which in turn closes contact A–3. This completes a path from L–1 through relay coil RE–C by way of the normally closed contact of the other microswitch 70. When RE–C is energized, its contact C–1 opens and contacts C–2 and C–3 close to pass current to armature 80 in one direction. When the actuator 59 is shifted further, motor speed control resistor 61 is adjusted in proportion to the amount of actuator movement since the actuator and arm of the resistor 61 are coupled. This effects increased motor speed. Closure of RE–C, opens C–1 contact for the purpose of preventing opposing electric signals to the motor control 82.

When actuator 59 is shifted to the right, the reverse sequence of events takes place. That is, microswitch 71 is unaffected but the normally open contact of microswitch 70 is closed and its normally closed contact is open. This again energizes RE–A and closes A–3. Since the normally closed contact of microswitch 70 is now open, relay RE–B is energized through the normally closed contact of microswitch 71 and normally closed contact C–1. This closes contacts B–3 and B–4 in the motor armature circuit and brings about a different direction of rotation. Actuator 59 is restored to neutral by spring 52 when tubular handle 50 is released. Then no power is applied to the motor 41.

It will be recalled that any time motor 41 is energized, chain 35 is driven but no power-assist is applied to the fluoroscope carriage unless magnetic coupling lock 25 is also energized. Thus, to effectuate the power-assist, a switch 74 must be closed. This supplies D.-C. power to lock 25 from lines L–3 and L–4 and locks the fluoroscope carriage to the chain. With lock 25 de-energized with the intention of moving the fluoroscope carriage wholly under manual influence by pushing on tubular handle 50, it is still advantageous to run the motor as is done in this case in order to overcome the friction which is imparted to the system by the engagement of the coupling sprocket 31 with chain 35. When power-assist switch 74 is closed and lock 25 is locked, the carriage is driven essentially under the influence of motor 41.

Although it has not been mentioned before, the transverse movement of the fluoroscope tower with respect to the table is also governed by a magnetic lock which may be active or inactive depending upon circumstances. It is desirable that when power-assist is applied to the longitudinal movement of the tower that the transverse movement of the fluoroscope carriage be free in order to permit its manual positioning laterally while it is being positioned longitudinally under power. For this reason there is provided a switch 87 adjacent power-assist control switch 74. Switch 87 is in circuit with a contact A–1 and the coil of a lateral movement lock 88. Lock 88 may be constructed similarly to the one shown in FIG. 4 and it may be provided with a pinion 89 that engages with a gear rack 90 that is affixed as is the case in FIG. 5. When power-assist switch 74 is selected to be closed, switch 87 may also close so that lateral lock 88 is energized. As explained before, however, when the operating handle is moved, relay RE–A is energized. This opens contact A–1 and de-energizes the lateral lock 88, so that the fluoroscope tower 12 may be moved laterally with respect to the table while the longitudinal movement of the carriage is under power-assist. With this setting, when power-assist handle 50 is released for restoration to neutral position, the transverse and longitudinal locks 88 and 25 set automatically so that a radiograph or inspection with the image intensifier may be made immediately when the desired position of the carriage is obtained. If the power-assist is driven until the longitudinal movement of the carriage reaches its limits, brake disk 32 of lock 25 will merely slip without overloading the motor. If it is desired to move the fluoroscope tower 12 wholly by manual means, switches 74 and 87 remain open so that the locks that they control remain de-energized.

Those who want to employ the principles of the invention will realize that they are not confined to the specific structure described above. For example, in place of the tubular handle 50, one may want to substitute a bi-directionally movable lever type handle which acts in opposition to a spring and affects longitudinal carriage speed variations in proportion to the amount of force applied to the handle. One may also substitute another type of belt means in place of the chain belt 35 without departing from the spirit of the invention for it is then only necessary to substitute a different form of magnetic lock for the rotary type described above. For instance, one may mount a street-car type of magnetic brake on the fluoroscope carriage and have it engage with a closely adjacent metal band belt instead of the chain. Various modes for sequencing the different mangetic locks may also be adopted as a matter of preference with particular X-ray tables.

Although a preferred form of the invention has been shown, it is to be understood that this has been done to demonstrate its principles and that those skilled in the art may want to make various changes in its construction without departing from the spirit of the invention as defined in the appended claims.

It is claimed:

1. A power-assist device for a movable fluoroscope tower of an X-ray table comprising:

(a) a belt means having its ends connected directly to each other to form an uninterrupted closed loop,

(b) wheel means mounted on the X-ray table, said belt means mounted so as to run over said wheel means,

(c) reversible motor means mounted in a driving relationship with said wheel means,

(d) an adjustable motor speed control switch for said motor means mounted on the fluoroscope tower, and

(e) a selectively energizable electromagnetic coupling means connected with the movable fluoroscope tower and adapted for being energized to effect a coupling

between said belt means and the movable fluoroscope tower,

(f) whereby said movable fluoroscope tower may be positioned under the influence of said motor means when a coupling between the movable fluoroscope tower and said belt means is effected or alternately positioned by manually urging the movable fluoroscope tower in the desired direction when coupling is not effected.

2. A power-assist device for a movable fluoroscope tower of an X-ray table comprising:

(a) a belt means having its ends connected directly to each other to form an uninterrupted closed loop,

(b) wheel means mounted on the X-ray table, said belt means mounted so as to run over said wheel means,

(c) reversible motor means that are fixedly mounted with respect to the X-ray table and adapted to drive said wheel means,

(d) a manually and bi-directionally operable control handle means, for said motor means, that is jointly translatable with the movable fluoroscope tower,

(e) resilient means that resist movement of said control handle means in relation to the manual force applied to the latter,

(f) an adjustable motor speed element that is coupled with said control handle means for increasing the motor speed in relation to the displacement of said handle means, and

(g) a selectively energizable magnetic coupling means connected with the movable fluoroscope tower and adapted for being energized to effect a coupling between said belt means and the movable fluoroscope tower,

(h) whereby the movable fluoroscope tower may be positioned under the influence of said motor means when a coupling between the movable fluoroscope tower and said belt means is effected or alternately positioned by manually urging the movable fluoroscope tower in the desired direction when a coupling is not effected.

3. A power-assist device for a movable component of an X-ray table comprising:

(a) a chain means that has its ends connected directly to each other to form an uninterrupted closed loop,

(b) a reversible motor means that is fixedly mounted with respect to the X-ray table and that has a shaft,

(c) a driven sprocket on said shaft,

(d) an idler sprocket that is journaled for rotation in a stationary position with respect to the table and spaced from said driven sprocket,

(e) said chain means being run on said sprockets,

(f) a magnetic coupling means including a stator that has an exciting winding, said stator being fixedly connected with the movable component of the X-ray table,

(g) a rotatable disk means that is magnetically attractable to said stator when said winding is energized,

(h) a shaft and another sprocket carried thereon along with said disk means, said other sprocket being engaged with said chain means,

(i) whereby said other sprocket will rotate freely to enable manual movement of the movable component when said winding is de-energized and said other sprocket will be locked with said chain means when said winding is energized so that the movable component will translate with said chain means when said motor drives the latter.

4. A power-assist device for moving the fluoroscope support of an X-ray table comprising:

(a) a table body having a patient supporting top,

(b) fluoroscope means and means supporting the same from the body for movement in planes parallel with the top,

(c) motor means fixedly mounted relative to the body,

(d) a drive sprocket that is rotatable by the motor means,

(e) an idler sprocket and a fixed journal support for the same,

(f) a closed loop of chain belt engaged with both sprockets,

(g) a magnetic lock means including a stator and a rotatable brake disk that is selectively attractable to the stator, said stator being connected with the fluoroscope means,

(h) a locking sprocket that is connected and rotatable with the disk and engaged with the chain,

(i) a slidable tubular handle means mounted on the fluoroscope means and against which a manual force may be applied to urge the fluoroscope means in a desired direction,

(j) spring means inside the handle means and connected between the handle means and fluoroscope means for being stressed in proportion to the travel of the handle,

(k) a bi-directionally adjustable resistor means in circuit with the motor means for controlling its speed,

(l) said resistor means being coupled with the handle means, and

(m) means for selectively energizing the lock means and the motor means,

(n) whereby said locking sprocket may be engaged with the chain belt means for translating the fluoroscope means under the influence of the motor.

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