PATENT SPECIFICATION (11) 1603546

1603546

(21) Application No. 20113/78 (22) Filed 17 May 1978 (19)
(31) Convention Application No. 799089 (32) Filed 20 May 1977 in
(33) United States of America (US)
(44) Complete Specification published 25 Nov. 1981
(51) INT. CL.³ B65H 57/00
(52) Index at acceptance
B8B R12

(54) ARRANGEMENT FOR GUIDING TRANSPORT CABLES

(71) We, U.S. PHILIPS CORPORATION, residing at 345 Scarborough Road, Briarcliff Manor, New York 10510, United States of America, a Corporation organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an arrangement having a first plate-shaped member which is rotatable in a frame about a horizontal axis and in a vertical plane and which is provided with a guide for a second plate-shaped member which is movable relative to the first plate-shaped member in a vertical plane and on which there is located an energy-consuming device, the energy-consuming device being connected to a source of energy by means of at least one flexible transmission cable which is connected near one of its ends to the energy-consuming device and near its other end to the frame, and the two plate-shaped members being provided with an opening for positioning an object to be examined.

The arrangement mentioned in the preamble is in particular intended for guiding and supporting a plurality of transport cables in X-ray equipment, such as, for example, an axial tomographic scanner. Such scanners are widely used for making absorption images of patients to be examined. These absorption images are composed with the aid of a computing device which processes the absorption values measured by means of a radiation detector which is disposed opposite an X-ray source. The images generally relate to the tissue structure of planar body sections which are disposed transversely to the body axis of a patient. For this purpose a planar fan-shaped radiation beam is used. Both the radiation source and the radiation detector should be capable of performing a rotary and a translational movement so as to enable the patient to be irradiated from a large number of directions. For the application of, *inter alia*, electrical energy to the radiation source and the radiation detector, flexible transport cables are employed, which are connected near one end to a stationarily arranged energy source and near their other end to the radiation source and the radiation detector respectively (energy consuming devices). The transport cable may also be used for supplying cooling water to the radiation source. Hence, the term "transport cable" should be interpreted in its widest sense and understood to include hose.

Owing to the successive translational and rotational movements of the radiation source and the radiation detector respectively, the transport cables are subject to continually varying degrees of bending, and they must therefore be supported and guided in such a way as to avoid being damaged.

It is an object of the invention to provide an arrangement of the type mentioned in the preamble which supports and guides the transport cables in a reliable manner.

According to the invention there is provided an arrangement having a first plate-shaped member which is rotatable in a frame about a horizontal axis and in a vertical plane and which is provided with a guide for a second plate-shaped member which is movable relative to the first plate-shaped member in a vertical plane and on which there is located an energy-consuming device, the energy-consuming device being connected to a source of energy by means of at least one flexible transport cable which is connected near one of its ends to the energy-consuming device and near its other end to the frame, and the two plate-shaped members being provided with an opening for positioning an object to be examined, wherein between its two ends the transport cable is secured to the first plate-shaped member so as to obtain a first length of cable disposed in a first plane and a second length of cable disposed in a second plane which is transverse to the first plane, which first length of cable can be unrolled from a circular guide which is supported by the frame, whilst between its two fixing points the second length of cable passes around a roller which is rotatable on a carriage which is movable

over the first plate-shaped member, which carriage is driven by a drive means which is secured to the first plate-shaped member and which also drives the second plate-shaped member at a speed which is in a fixed ratio to the speed of the carriage.

An embodiment of the invention will now be described in more detail with reference to the accompanying drawings, in which:

Figure 1 is an exploded perspective front view of a preferred embodiment of an arrangement in accordance with the invention,

Figure 2 is an enlarged perspective front view of a part of the arrangement shown in Figure 1,

Figure 3 is an enlarged perspective rear view of a part of the arrangement shown in Fig. 1,

Figure 4 is an enlarged perspective view of a chain-and-cable combination used in the arrangement shown in the preceding Figures,

Figure 5 shows a detail of the anchoring of the chain-and-cable combination shown in Figure 4,

Figures 6A, 6B and 6C are schematic front view of the arrangement of Figure 1, showing the first plate-shaped member in different angular positions.

The apparatus 1 shown in Figure 1 is an axial tomographic scanner, whose processing unit (computing device, monitor, printer etc.) is not shown for the sake of clarity. The apparatus 1 comprises a frame 12 which is pivotable about a horizontal spindle 20 which is supported in a vertical column 18. To the right of the frame 12 (as viewed in Figure 1) and not shown, there are located a second spindle 20 and a second vertical column 18. The apparatus 1 is frequently used with the frame 12 in the vertical position shown in Figure 1. The frame 12 has two parallel side walls 22 and 23 which are journalled on the spindles 20. In the centre of the frame 12 there is located a supporting ring 28 which is connected to the side walls 22 and 23 by means of cross-connections 25 and 26 respectively. A gear ring 32 is rotatably journalled on the supporting ring. The gear ring 32 is secured to a plate 14 (first plate-shaped member). In the frame 12 there is located a pinion 34 which is in engagement with the gear ring 32. The pinion 34 is driven *via* a gear transmission 36, which is stationarily arranged in the frame 12, and a motor 56 (see Fig. 3), which for the sake of simplicity is not shown in Figure 1. The gear transmission 36 and the motor 56 are secured to the cross-connection 26 in a manner not shown.

At the front of the plate 14 there are located two parallel rails 38 and 39 along which a plate 16 (second plate-shaped member), which is parallel to the plate 14, can be moved. The translational movement of the plate 16 is obtained by means of a driven pinion 46 which meshes with a toothed rack 48, which is secured to the front of the plate 16 and which is parallel to the rails 38 and 39. The pinion 46 is driven by a motor 41 which is coupled to the pinion 46 by means of a gear transmission 42. The motor 41 and the gear transmission 42 are mounted on the plate 14. The pinion 46 is mounted on a spindle 44, which is vertical in the illustrated position of the frame and on which there is also mounted a second pinion 106 for a purpose to be described hereinafter.

The plates 14 and 16 are provided with central openings 50 and 51 for positioning a patient to be examined. This examination is effected with the aid of a radiation source 53, for example an X-ray source, which is mounted on the plate 16. An X-ray detector 54 is mounted on the plate 16 opposite the X-ray source 53 for measuring the X-rays which have passed through a patient. Measuring is effected for a number of different orientations of the X-ray source 53 relative to the patient. These orientations can be obtained by rotation of the plate 14 and by translation of the plate 16 relative to the plate 14, the patient being in a fixed position. The rotational and translational movements of the plates 14 and 16 respectively are performed consecutively. For this purpose the motors 41 and 56 are connected to a timer 58 (see Fig. 3), which is not described in further detail.

For the electrical power supply to the X-ray source 53 and the detector 54, and, if desired, for the supply of coolant to the X-ray source 53, there is provided a series of flexible transport cables 59, which from a specific point in the apparatus are bundled in a manner to be described hereinafter. At the location of the reference numeral 60 in Fig. 1 the comparatively slack bundle of transport cables 59 is led upwards into the apparatus 1 onto a bracket 73 which is stationarily arranged in the frame 12. From the first bracket 73 the transport cables 59 are bundled so that their centre lines are disposed in the same plane. Such a bundle is obtained with the aid of two chains 66 and 67 which each extend along one side of the transport cables 59, and which are kept parallel to each other by a plurality of regularly spaced profiled cross-connections 69 (see Figs. 3 and 4). The transport cables are attached to the cross-connections 69 in a manner to be described hereinafter. From the bracket 73 the chains 66 and 67 pass round a rotatable double sprocket 63 and a rotatable double sprocket 64 in succession. Subsequently the chains 66 and 67 pass round a number of rotatable toothed rollers 93 which are arranged in pairs in a circular pattern and which mesh with the chains. The toothed rollers 93 are mounted on the stationarily arranged supporting ring 28 (Fig. 1). On the plate 14 a second bracket 75 is mounted from

which the fixed bundle of transport cables 59, between the brackets 73 and 75, further extends as a slacker bundle which is not retained by chains with cross-connections. The chains 66 and 67 have their ends near the brackets 73 and 75. The transport cables 59 constitute a first length 61 of transport cable between the brackets 73 and 75, which length of cable is always situated in a vertical plane. In order to distinguish between the comparatively slack bundle of transport cables and the more rigidly bundled transport cables the relevant lengths are referred to by different reference numerals (59, 61, 70). At the location of the brackets 73 and 75 the chains 66 and 67 are secured to the frame 12 and the plate 14 respectively. Moreover, the chains 66 and 67 are kept taut at the location of the brackets 73 and 75 (see Figure 5). The bracket 73 is provided with an aperture 77 for each of the chains (only one aperture is visible). Through the aperture 77 passes a pull rod 78 which is provided with a collar 79. Between the collar 79 and the bracket 73 a coil spring 80 is held in compression, which spring surrounds the pull rod 78. Such a construction is also used for the bracket 75.

The rotatable double sprocket 64 is secured to the frame 12 with the aid of a flanged plate 82 (see Figure 3). In the frame 12 there is provided a stationarily arranged guide which comprises two parallel horizontal guide rods 85 along which a movable carriage 84 is guided. The sprocket 63 is rotatably mounted on the carriage 84. The carriage 84 is coupled to a horizontal timing belt 89 by means of a clamp 91, which belt is driven by the motor 56 *via* a gear transmission 87 and a chain 90. It will be evident that the transmission ratio between the pinion 34 and the gear ring 32 (see Figure 1) and the transmission ratio between the gear transmission 87, the chain 90 and the clamp 91 are selected to that upon rotation of the gear ring 32 and the plate 14 the unrolled length of cable is compensated for by the displacement of the carriage 84 with the sprocket 63 along the guide rods 85.

From bracket 75 the comparatively slack bundle of transport cables 59 without chains is guided to a bracket 95 which is secured to the plate 14. Bracket 95 is of a similar type as the brackets 73 and 75. Between bracket 95 and a similar bracket 96 mounted on the plate 16 two chains 71 and 72 are tensioned, which chains each extend along one side of the transport cables and to which chains the transport cables are attached in the manner shown in Figure 4. Between the brackets 95 and 96 the transport cables together with the chains 71 and 72 pass in a rigid bundle around a double sprocket 98 which meshes with the two chains 71 and 72. Thus a second length 70 of transport cable is obtained. The plane of the loop formed by the second transport-cable length 70 is transverse to the plane of the loop formed by the first transport-cable length 61. This relationship is maintained during all movements of the plates 14 and 16.

The rotatable sprocket 98 is mounted on a carriage 100 which is movable along a guide 102 which is secured to the plate 14 and is parallel to the rails 38 and 39. The carriage 100 is provided with a toothed rack 104 which meshes with a pinion 106 which is driven by the motor 41 *via* the gear transmission 42. The motor 41 and the gear transmission 42 are mounted on the plate 14. As previously stated, the motor 41 also drives the pinion 46 *via* the gear transmission 42, which pinion meshes with the toothed rack 48 at the front of the plate 16 (Figure 1). As Figure 1 is an exploded view the letters A and B are used to indicate corresponding points in the various parts. When the plate 16 moves over the plate 14 the plate 16 moves relative to the plate 14 at a speed which is twice the speed of the carriage 100 relative to the plate 14. The pitch circles of the pinions 46 and 106 are in conformity with this. For an equal angular speed of the two pinions this means that the pitch circle of the pinion 46 should have a diameter which is twice that of the pitch circle of pinion 106.

From the bracket 96 the transport cables 59 (Figure 2) are guided further as a comparatively slack bundle. Subsequently the bundle divides and some of the cables lead to the X-ray source 53 and some other cables to the detector 54. The arrangement described in the foregoing ensures a reliable and compact guidance of the transport cables both in the stationary condition of the plates 14 and 16 and in the various different positions which the plates 14 and 16 may assume relative to each other and relative to the frame 12. The transport-cable lengths 61 and 70 may also be attached to a toothed or non-toothed belt which passes round rollers, instead of to the chains described in the foregoing. The guide of the transport-cable length 61 may also be a rotary guide which is secured to the gear ring 32 or the plate 14. If said rotary guide is channel-shaped no chain or belt is needed for guidance. The individual cables which are retained by the cross-connections then simply roll down the channel-shaped guide.

The cross-connections 69 for the individual transport cables are preferably constructed as shown in Figure 4. The cross-connections 69 which are secured to the chains 66, 67 and 71, 72 consist of profiled strips having such a shape that the centre lines of the cables are situated in the same plane. The customary collection of transport cables 59 shown in Figure 4 comprises a high-voltage power supply cable 110 for the X-ray source 53, a cooling water supply cable

111 in the form of a hose, and a cooling water discharge cable 112 in the form of a hose, for the X-ray source 53, an earthing cable 113 and a power supply cable 114 for the detector 54. The cables are attached to the cross-connections 69 with the aid of flexible tie straps 108.

As previously stated, Figures 6A, 6B and 6C schematically represent the various angular positions of the plate 14. The position of the first-transport-cable length 61 corresponding to these angular positions is clearly visible.

Although the invention has been described with reference to an axial tomographic scanner for patients it may also be employed for the examination of non-organic objects. An example of this is the examination of castings. Instead of a detector an X-ray film may be arranged opposite the source. It is alternatively conceivable that there is no external radiation source but only a detector for the detection of, for example, isotopes in an organic object. In fact the arrangement may be used in all cases where an energy-consuming device intended for examination of an object is located on a second plate-shaped member which is movable relative to a first rotatable plate-shaped member. In this respect the expression "plate-shaped" is to be taken in its widest sense. All metal members whose thickness dimension is comparatively small relative to the length and width or other dimensions (for example, a circular plate) and which can be used in an arrangement as described hereinbefore, should be regarded as plate-shaped members.

WHAT WE CLAIM IS:—

1. An arrangement having a first plate-shaped member which is rotatable in a frame about a horizontal axis and in a vertical plane and which is provided with a guide for a second plate-shaped member which is movable relative to the first plate-shaped member in a vertical plane and on which there is located an energy-consuming device, the energy-consuming device being connected to a source of energy by means of at least one flexible transport cable which is connected near one of its ends to the energy-consuming device and near its other end to the frame, and the two plate-shaped members being provided with an opening for positioning an object to be examined, wherein between its two ends the transport cable is secured to the first plate-shaped member so as to obtain a first length of cable disposed in a first plane and a second length of cable disposed in a second plane which is transverse to the first plane, which first length of cable can be unrolled from a circular guide which is supported by the frame, whilst between its two fixing points the second length of cable passes around a roller which is rotatable on a carriage which is movable over the first plate-shaped member, which carriage is driven by a drive means which is secured to the first plate-shaped member and which also drives the second plate-shaped member at a speed which is in a fixed ratio to the speed of the carriage.

2. An arrangement as claimed in Claim 1, wherein the energy-consuming device comprises an X-ray source with an X-ray detector disposed opposite said source.

3. An arrangement as claimed in Claim 1, wherein the transport cable is secured to a chain which extends along the two lengths of cable, the part of the chain that is secured to the first length of cable meshing with toothed rollers which are rotatably arranged in the frame in a circular pattern, whilst the part of the chain that is secured to the second length of cable meshes with a pinion which is connected to the rotatable roller on the carriage.

4. An arrangement as claimed in Claim 3, wherein the transport cable is secured to chains which extend one along each side of the cable, the cable being secured to the chain, by means of profiled cross-connections which are transverse to the cable and are connected to the chains.

5. An arrangement as claimed in Claim 4, wherein the transport cable is secured to a cross-connection with the aid of a tie strap.

6. An arrangement as claimed in Claim 1, wherein the first length of cable passes around first and second rotatable rollers which are disposed in the frame, the first roller being rotatable about a fixed spindle, whilst the second roller is movable along a horizontal guide in the frame with the aid of a carriage.

7. An axial tomographic scanner substantially as herein described with reference to the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon) Ltd.—1981. Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1603546 COMPLETE SPECIFICATION

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Sheet 1

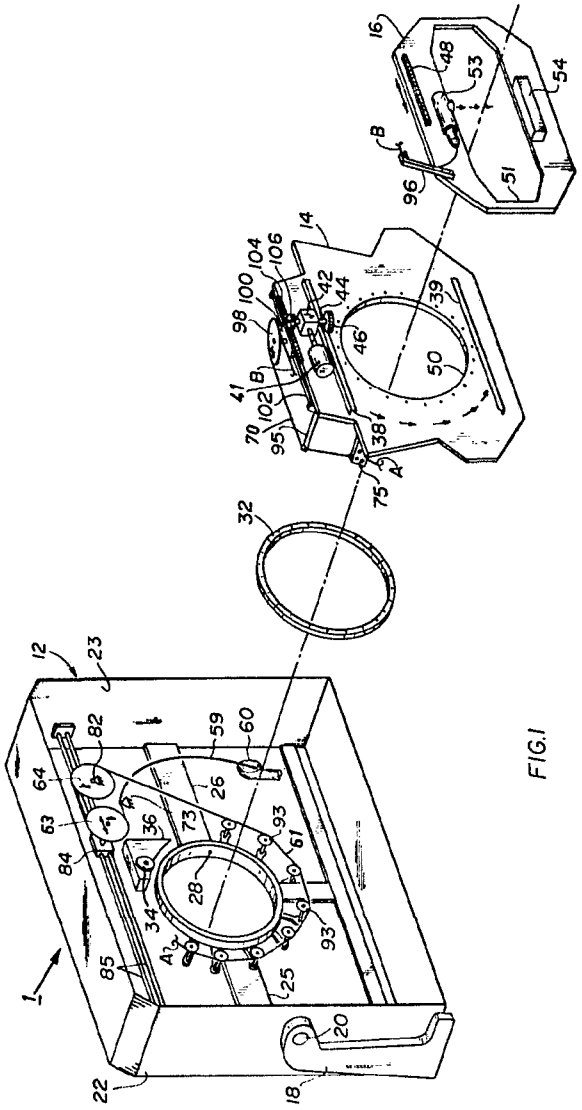

FIG.1

1603546 COMPLETE SPECIFICATION

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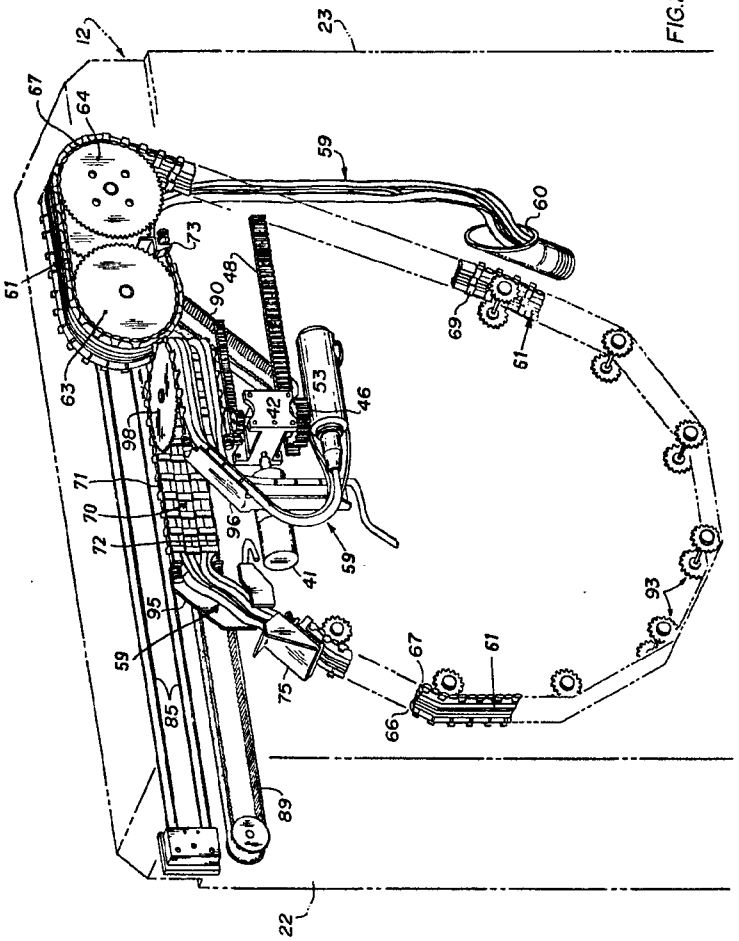
Sheet 2

FIG.2



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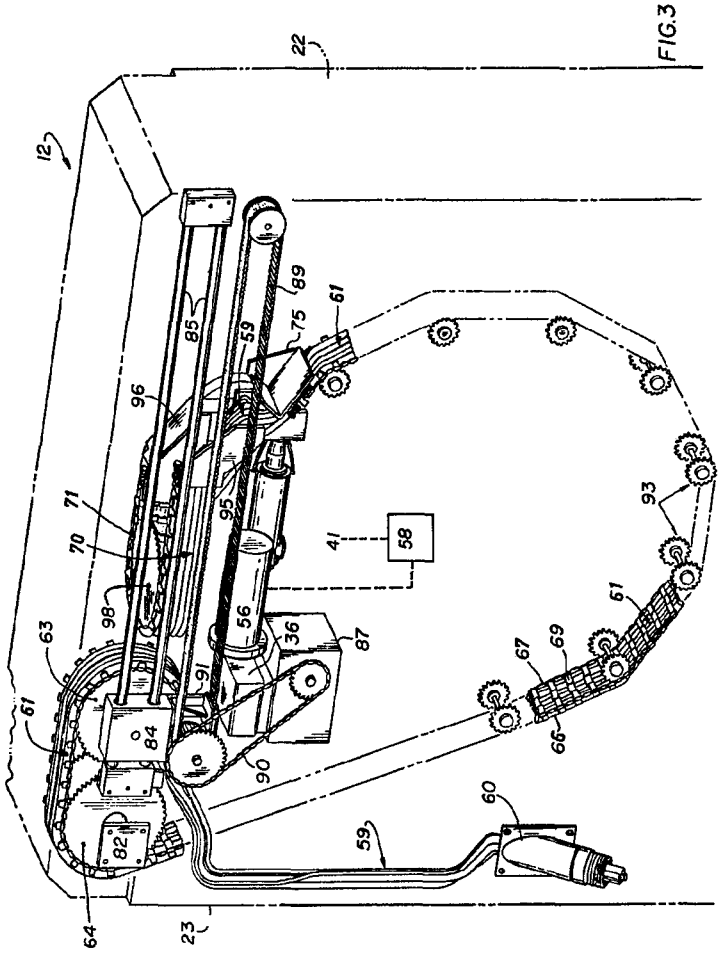
Sheet 3

FIG.3



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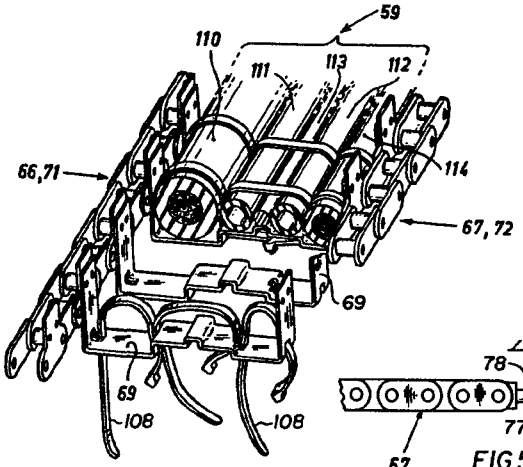

FIG.4

FIG.5

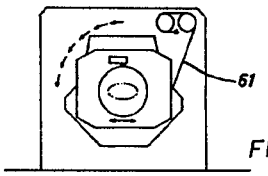

FIG.6A

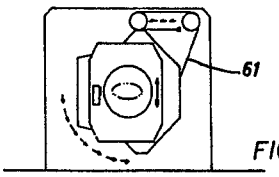

FIG.6B

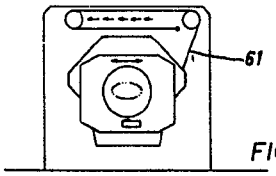

FIG.6C