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Kunne et al.

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[54] **X-RAY EXAMINING APPARATUS**

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[51] **Int. Cl.**[2] **A61B 6/00**

[58] **Field of Search** ..... 250/444, 445, 446, 447, 250/448, 449, 445 T

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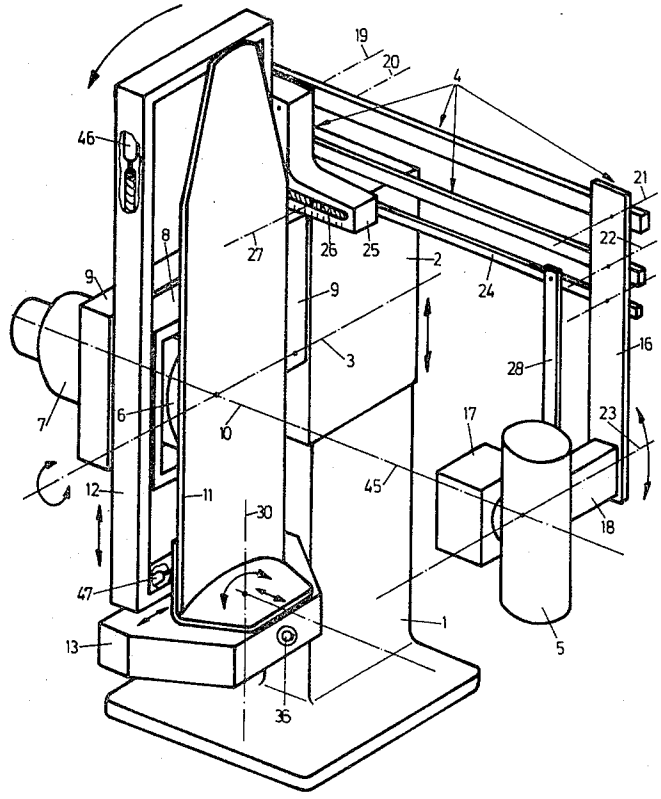
[57] **ABSTRACT**

An X-ray examining apparatus including a support block which is mounted so as to be vertically displaceable along the base of the apparatus; a carrier which is supported on the support block and rotatable about a horizontal pivot axis and which carries an image layer or picture target oriented in parallel to the pivot axis; an X-ray tube which is centered on the picture target; and a removable and interchangeable patient support located between the X-ray tube and the picture target.

12 Claims, 4 Drawing Figures



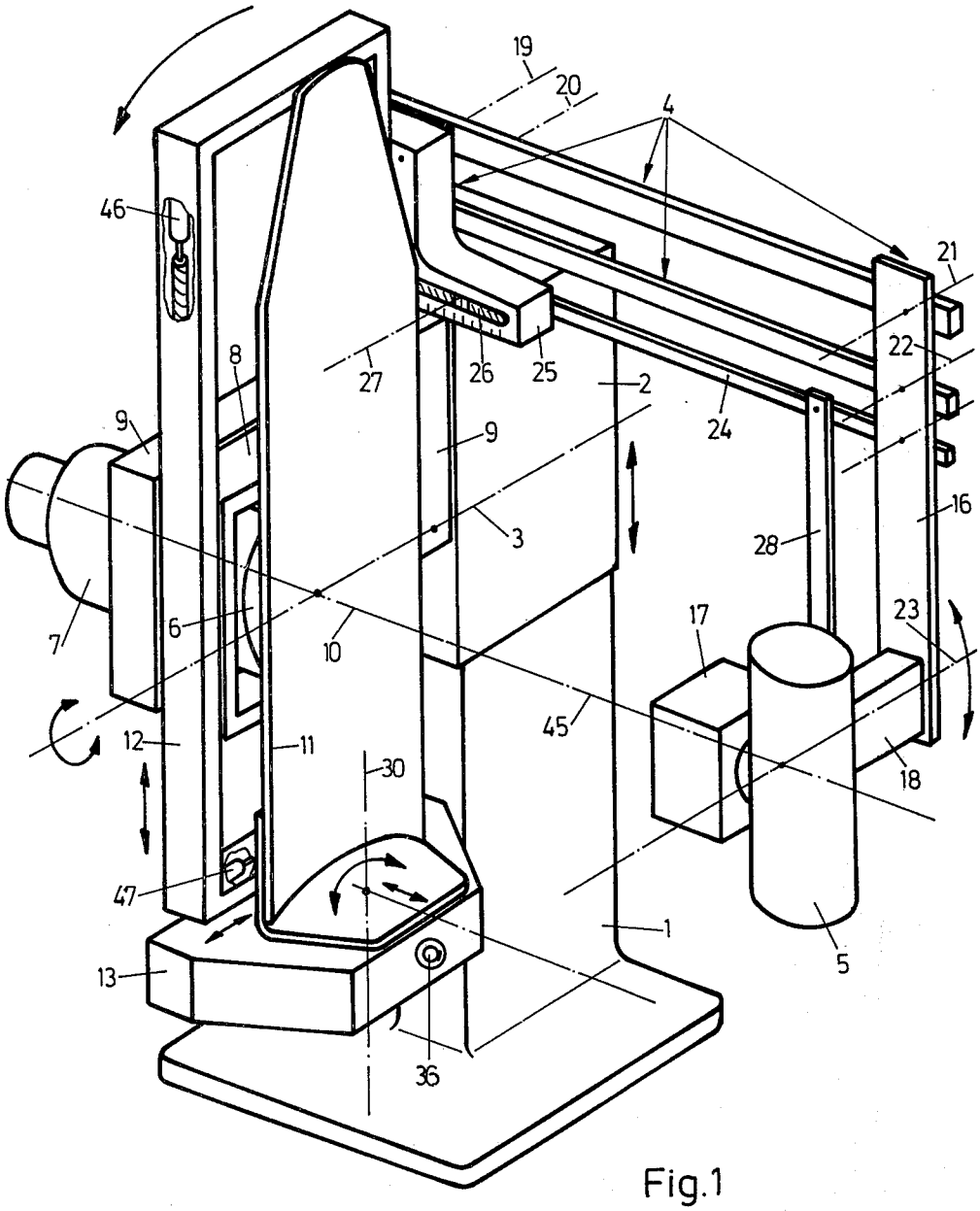

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Fig.1

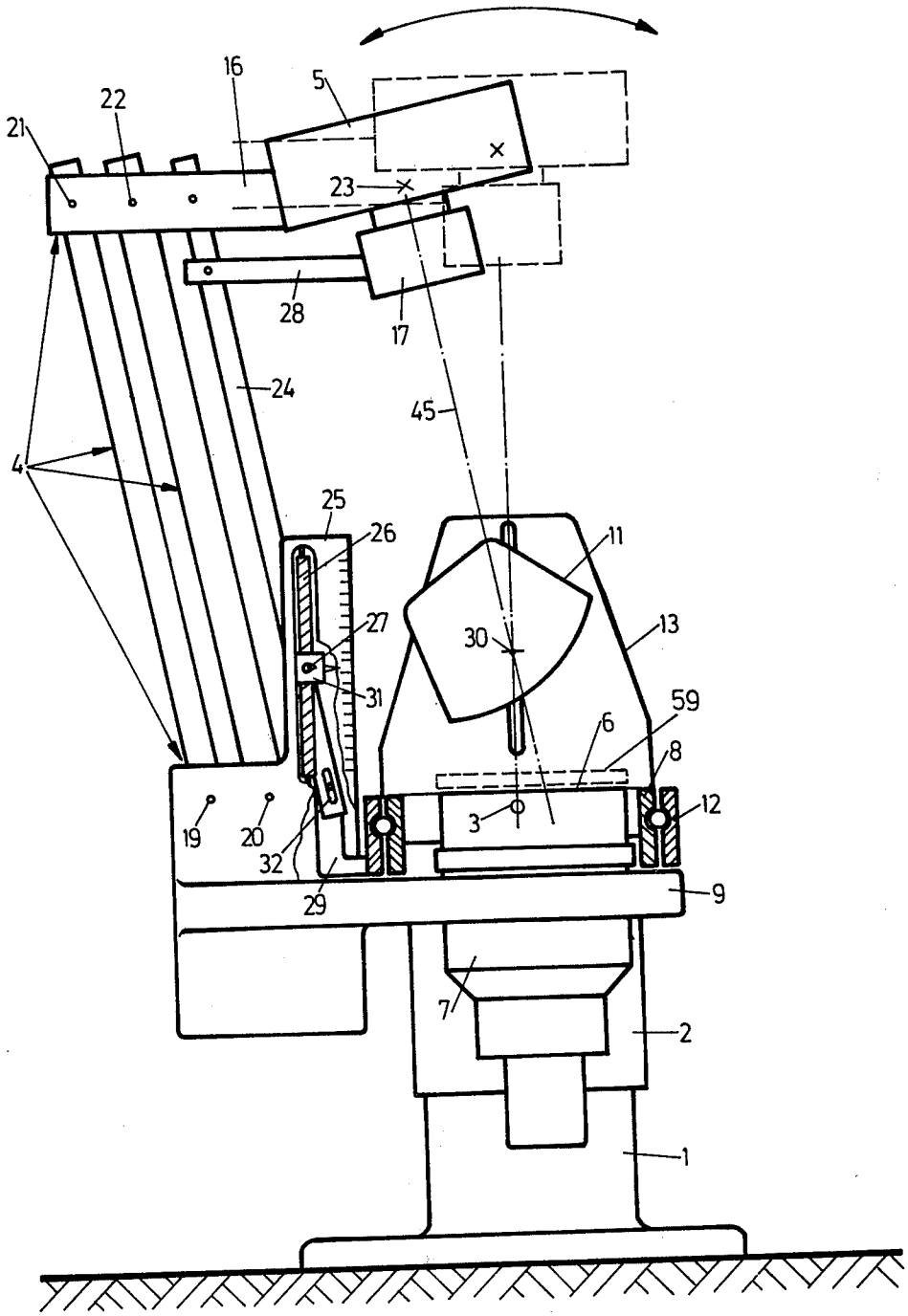
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Fig. 2

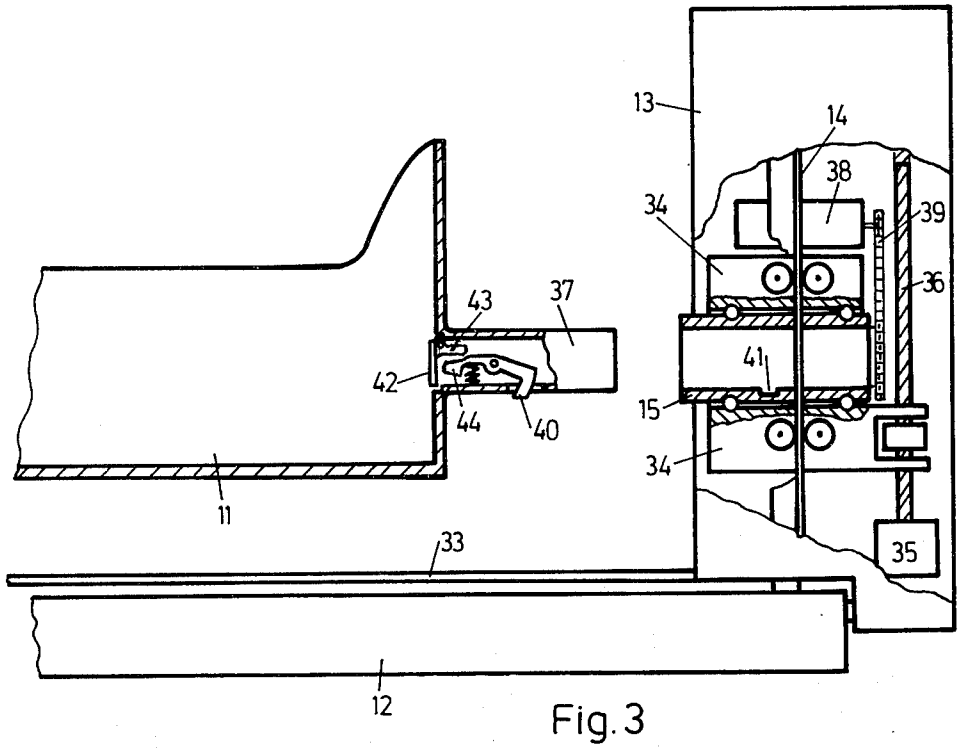
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Fig. 3

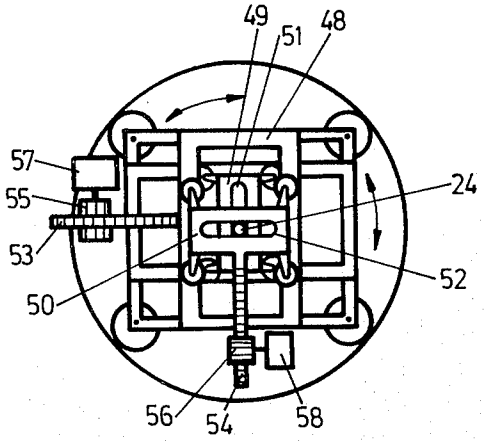
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Fig. 4

X-RAY EXAMINING APPARATUS

FIELD OF THE INVENTION

The present invention relates to an X-ray examining apparatus including a support block which is mounted so as to be vertically displaceable along the base of the apparatus; a carrier which is supported on the support block and rotatable about a horizontal pivot axis and which carries an image layer or picture target oriented in parallel to the pivot axis; an X-ray tube which is centered on the picture target; and a patient support located between the X-ray tube and the picture target.

DISCUSSION OF THE PRIOR ART

At present there is known an X-ray examining apparatus having a support block which is vertically adjustably mounted on the pedestal of the apparatus, on which there is supported a picture target carrier and an X-ray tube operatively associated with the picture target carrier so as to be rotatable about a common horizontal axis. In this X-ray examining apparatus, a patient support pallet which is longitudinally and transversely displaceable, as well as in a direction normal to the surface of the picture target is separately mounted on the support block. The examinations which are adapted to be carried out by means of this known X-ray examining apparatus does not, however, completely provide the fullest possible technical apparatus requirements.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an X-ray examining apparatus which is most universally applicable and adapted to carry out the most varied types of examinations. This object is based on the knowledge that technical apparatus measures which have been created for a particular type of examination may, under circumstances, be utilized for still further types of examinations by means of only relatively minor additional requirements. In that connection, a particularly variably employable X-ray examining apparatus upon careful selection of the range of application, can be manufactured in a relatively economical manner.

In an examining apparatus according to the above-mentioned type, the carrier for the X-ray tube and for the picture target is doubly offset in the form of a U in a plane which is oriented perpendicular to the picture target and rotatably supported about the horizontal pivot axis on the support block through an arm thereof which carries the picture target, the X-ray tube being fastened to the opposite arm of the carrier so that its central beam is centered or focused onto the picture target, and provides a carrying frame for a patient support which is rotatable about a longitudinal axis extending in parallel relative to the surface of the picture target, on which the arm carrying the picture target supported on an intermediate frame rotatable on the picture target, is vertically displaceably mounted along a median vertical. This arrangement facilitates that the patient support together with the patient, at representable requirements, may be rotated about the vertical median of the picture target, independently of the inclined position of the picture target, and to thereby avoid at all examining positions any collisions with the carrier for the X-ray tube and the picture target. In connection with the patient support, which is rotatable about its longitudinal axis, the tube-picture target system can also be rotated about the patients' longitudinal axis, so as to permit the taking of transversely penetrating or radiological exposures in all inclined positions of the patient support. Thus, for example, through the use of this X-ray examining apparatus it also becomes possible to transversely X-ray the patient in any desired inclined position with a horizontal ray beam.

In a particularly advantageous modification of the invention, the patient support on the carrier frame may be supported so as to be displaceable in directions normal to the surface of the picture target. Thereby, it becomes possible, additionally to also vary the exposure relationship. This is of particular advantage in the examination of children, inasmuch as the smaller organs are represented on the basis measurements usual to adults, and may thereby be much better compared in the diagnostic position.

A simplification of the construction of the X-ray apparatus is attained when the patient support, in a suitable embodiment of the invention, is transversely movably supported on the carrier frame. This eliminates the necessity that the picture target and the X-ray tube need be displaced transversely of the longitudinal axis of the patient, without any further measures having to be applied with respect to loss of possible types of examinations.

In a particularly advantageous further embodiment of the invention, there may be utilized a patient support which is fastened to an end plate of the carrier frame facing towards the footside thereof. A patient support which is supported along one side thereof does not only improve accessibility to the patient in the head region, but above all creates particularly advantageous conditions for further constructive measures which will increase the range of application for the X-ray examining apparatus.

Thus, the range of application of the X-ray examining apparatus may be increased when, in a particularly advantageous embodiment of the invention, there are employed varied, mutually interchangeable, for specialized applications adapted, and easily removable patient supports. This will also permit the use of patient supports which are dimensioned in conformance with the body sizes of particular patient groups such as, for example, children of various ages. Such specialized patient support with particular dimensions adapted to the body sizes of the patients facilitate the examination and considerably easier to manipulate when reduced to the body sizes of infants. In this manner, the range of application of the X-ray examining apparatus can be extended to childrens clinics, however, without being restricted thereto. Moreover, for infants or small children, the oft time consuming fastening to a corresponding patient support may be effected remote from the X-ray examining apparatus, for example, in an adjoining chamber, while a previous patient is still being examined on the X-ray apparatus. Thus, the examination sequence becomes more continuous and, above all, the examining capacity and the therewith connected economic value of the X-ray examining apparatus in children's clinics is considerably enhanced. In addition to predetermined patient groups, there may also be utilized patient supports which are adapted to particular examining techniques.

An additional significant increase in the range of applicability of the X-ray examining apparatus can be achieved when the carrier for the X-ray tube and the picture target, in a further embodiment of the invention

for producing tomographic X-ray exposures, is constructed in a type of a parallelogram linkage, wherein a known tomographic rod or linkage is pivotably mounted about a plate axis extending in parallel with the plane of the picture target, and oriented with respect to the linkage axis of the parallelogram and perpendicular to the plane of the picture target, having one end thereof linked to the X-ray tube carrying arm of the carrier, and having the other end connected to the picture target in the plane of the picture target, and the X-ray tube on a boom being rotatably supported with respect to an axis which is oriented in parallel to the target axis, and which is directed in association with the picture target through an auxiliary link connected to linkage of the picture target. Through this further embodiment of the X-ray examining apparatus, the entire range of application of tomographic or layer exposures is encompassed. Thereby is also provided that, in addition to the longitudinal tomographic exposures usual in tomographic exposure apparatus, also tomographic exposures in transverse direction can be carried out. Since it is possible to make these tomographic exposures in all inclined positions of the patient, it is also possible to not only three-dimensionally displace the image plane within the body of the patient by means of a tomographic exposure apparatus, but to additionally rotate this plane about two coordinate axes relative to the body of the patient.

In a further particularly advantageous embodiment of the invention, there may be utilized an X-ray image intensifier which is connected to the tomographic linkage and supported so as to be displaceable in the direction of the target. This has the result that the Bucky diaphragm which is usually required for tomographic exposures may be eliminated, and that in lieu of the presently needed, expensive large-sized film sheets required for tomographic exposures, there may be employed considerably less expensive small-sized film through photographic filming of the outlet luminescent screen of the X-ray image intensifier. This construction leads to a considerable reduction in the cost of the tomographic exposures, in a significant manner increases by a multiple the ability to displace and rotate the sharply imaged plane within the body. This then frees the physician from any holding back due to reasons of costs upon application of the above stated tomographic exposure technology.

BRIEF DESCRIPTION OF THE DRAWINGS

Further details of the invention may now be ascertained from the following description of various embodiments, taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates in perspective, a partly sectional overall view of an X-ray examining apparatus with an upright patient support and horizontal X-ray beam:

FIG. 2 schematically illustrates a partly sectional, overall view of the X-ray examining apparatus in a position for tomographic exposures in transverse direction for a reclining patient,

FIG. 3 is a sectional view through a detachable patient support mounted on an end plate of the carrier frame toward the foot facing side-thereof; and

FIG. 4 is a plan view of a rotatable stage built into the plate block for the electrical remote-controlled relative displacement of the patient support during plate movement.

DETAILED DESCRIPTION

Referring now in detail to FIG. 1 of the drawings, there may be ascertained the base 1 of the X-ray apparatus, on which there is mounted a vertically displaceable support block 2 for a horizontal pivot axis 3. Along the horizontal pivot axis there is supported a U-shaped carrier 4 for an X-ray tube 5 and a picture target 6. The picture target 6, which in the present instance is the inlet luminescent screen of an X-ray image intensifier 7, is encompassed by a rectangular subframe 8, which is supported on the X-ray image intensifier carrying arm 9 of the U-shaped carrier 4 so as to be rotatable with respect to the median vertical 10 on the picture target 6. Along two mutually parallel sides of the subframe 8, supported displaceably in the longitudinal direction, is a carrier frame 12 which is correlated with the dimensions of a patient support 11. On the lower or foot-facing end of the carrier frame there is supported an end plate 13 which is displaceable in a transverse direction relative to the carrier frame. Rails 14 are located at this end plate, which extend perpendicular to the plane of the picture target (FIG. 3), along which a bearing bushing 15 extending in the longitudinal direction of the carrier frame is displaceable perpendicular to the plane of the picture target. Onto this bearing sleeve there is attachedly fastened the rotary-sleeve like patient support 11. Fastened to the arm 16 of the carrier which is opposite to the picture target 6 by means of extension 18, is the X-ray tube 5 with its attached disphragm 17. The U-shaped carrier is constructed to provide the capability of opposite parallel displacement of both its arms with respect to each other in the art of a parallelogram linkage, in which the linkage axis 19, 20, 21, 22 of this parallelogram linkage in the exemplary embodiment are oriented in parallel with the pivot axis 3. The extension 18 of the X-ray tube 5 is supported so as to be rotatable about an axis 23 parallel to the linkage axis of the parallelogram linkage of the U-shaped carrier 4. To the arm 16 of the U-shaped carrier 4 carrying the X-ray tube 5 there is hingedly connected a tomographic rod or link 24 which is connected, so as to be pivotable about a tomographic axis 27 which is vertically adjustable with respect to a plate or target support block 25 along a spindle 26. An auxiliary link 28 is fastened to the tomographic link 24, by means of which the X-ray tube 5 may be pivoted about the axis 23 of the arm 18 and directed towards the picture target 6. At the free end of the link 24 which is opposite to the X-ray tube, there is connected a so-called coupling link 29 in the plane of the picture target through the intermediary of which the picture target, in the present instance this also being the X-ray image intensifier 7, may be displaced interiorly of the subframe 8 in correspondence with the target movement relative to the arm 9 of the carrier which is hinged at the pivot axis 3.

FIG. 2 illustrates the X-ray examining apparatus for the formation of X-ray plates of transverse tomographic movement. This position of the X-ray examining apparatus is achieved, as indicated from the position shown in FIG. 1, through inclination of the X-ray examining apparatus about the pivot axis 3, through the concurrent rotation of the subframe 8 about the median perpendicular 10 on the picture target 6, and the patient support 11 about its longitudinal axis 30 by respectively 90°.

Through an illustrative cut out in the covering of the plate block **25** there may be ascertained the spindle **26,** along which a screw bolt **31** with the horizontal tomographic axis **27,** about which the tomographic link **24** is rotatably supported, is vertically adjustable. At the free end of the plate link there may also be ascertained an elongate aperture **32** into which a coupling link **29** projects for displacement of the X-ray image intensifier **7** in the plane of the picture target.

In the representation of FIG. **3,** the end plate **13** facing towards the foot of carrier frame **12,** which is displaceable transverse to a table frame, is rigidly connected with an additional patient support pallet **33** which is also transversely displaceable on the carrier frame. For purposes of illustrative clarity, the patient support plate is not shown in FIGS. **1** and **2** of the drawings. In the illustrated broken-through section of the housing of the end plate **13** facing towards the foot-side of the carrier frame **12,** there may be ascertained one of two rails **14** which extend in perpendicular to the plane of the carrier frame (only one illustrated), along which a carriage **34** is movable through the intermediary of a spindle **36,** which is driven by a motor **35.** The carriage supports the bearing bushing **15,** the latter of which extends in parallel with the plane of the carrier frame **12** and is rotatable about its own longitudinal axis. Within this bearing bushing there may be provided the various patient supports **11** (only one illustrated) which are associated with the X-ray examining apparatus, the supports having at their foot-facing end, measured in cross-sectional correlation with the smaller width of the bearing bushing, support stub shaft **37** adapted to be slipped into the bushing. In the section of the foot-facing end plate of the carrier frame there may further be ascertained an additionally motor **38** which is fastened onto the carriage **34,** and by means of which the bearing bushing **15** and, consequently, the particular patient support **11** having its stub shaft **37** in the bearing bushing, are rotated about their longitudinal axis by means of a chain drive **39.** In the sectionally shown portion of the foot-facing support stub shaft **37** of the patient support **11** there may be ascertained a pivotally supported, spring-loaded lock **40** which, upon a fully inserted patient support, engages in a recess **41** in the bearing bushing, and to thereby protect the patient support **11** from inadvertent falling out.

In order to remove the patient support, the lock **40** may be withdrawn by the opening of a clamp **42** located on the foot-facing end of the rotational sleeve through manipulation of the mutually interengaging projections **43, 44** of clamp **42** and lock **40.**

During the X-ray examinations of upstanding patients, the patient may stand on the foot-facing face plate of the patient support **11** in the position of the X-ray examining apparatus as shown in the representation of FIG. **1.** For examination of a patient in a horizontal position or in a lowered head position, it is adequate to pivot the U-shaped carrier **4** for the X-ray tube **5** and the picture target **6** about the horizontal pivot axis **3.** By means of the concurrent longitudinal displacement of the carrier frame **12** relative to the subframe **8,** and through displacement of the foot-facing end plate **13** transverse of the carrier frame, all parts of the patient become accessible for X-ray examination. For radiological examination of the patient in a transverse direction, the patient support **11** must be rotated for about 90° about its longitudinal axis on the foot-facing end plate **13** of the carrier frame **12.** Through additional rotation of the subframe **8** about the normal **10** to the picture target **6,** the inclined position of the patient may be varied in accordance with any particular requirements. Changes in the filming proportions may be obtained when the patient support is displaced in perpendicular to the plane of the picture target through the spindle drive **35, 36** within the foot-facing end plate **13** of the carrier frame **12.** With an increasing distance of the patient support from the picture target plane the magnification increases. In all of these positions the patient may be X-rayed from forwardly, from the side or from rearwardly, through rotation of the patient support about its longitudinal axis.

The freely exposed mounting of the patient support **11** on the foot-facing end plate **13** of the carrier frame **12** does not only improve the access to the patient, but also renders easier the exchange of the patient support with another patient support. This is particularly applicable when the patient support which provided at the foot-facing end thereof with the support projection **37,** as shown in FIG. **3,** is merely slid into one of the foot-facing bearing bushings **15** in the end plates **13** of the carrier frame. Due to the easy exchange of the patient supports, in addition to patient supports for adults, also those for infants and, upon occasion, also for special types of examinations, may be mounted on the foot-facing end plate of the carrier frame. Smaller patients supports are of particular advantage during the examination of children, since the children are better supported therein, and the accessibility to the patient, in contrast with the larger patient supports conceived for adults is much more readily resolved. There are also much better provided with support means which are particularly designed for children, as if they had to be concurrently utilized for adults. Above all, children may be already fastened onto one of the patient supports in an adjoining chamber prior to the examination. These patient supports, with the infant thus fastened thereto need, for examination, only be slid onto the foot-facing end plate **13** of the carrier frame of the X-ray examining apparatus. Consequently, the X-ray examining apparatus is not far as long as previously blocked off by such ancillary operations.

In view of the configuration of the U-shaped carrier **4** as a parallelogram linkage, the arm **16** supporting the X-ray tube **5,** and the arm **9** supporting the picture target **6** extend in parallel to each other and are displaceable relative to the picture target. By means of the tomographic link **24** and the auxiliary link **28** hinged thereto, the X-ray tube is constantly supported so as to be directed towards the examining object which is located in the plane of the tomographic axis **27.** As a result of the connection of the picture target carrier with the free end of the tomographic link **24** through coupling link **29,** the picture target is also concurrently directed towards the main or central beam **45** of the X-ray tube **5.** Thereby, in view of the rotation of the subframe **8** about the median perpendicular **10** on the picture plate **6,** it becomes possible to effect tomographic exposures in a patient's longitudinal as well as in the patient's transverse directions, and in all intermediate directions and namely in all inclined positions of the patient around its longitudinal axis and of the central beam **45** of the X-ray tube **5** around the horizontal pivot axis. In that case the target plane within the patient cannot only be displaced three-dimensionally, but may also be rotated about two coordinate axis. In the

embodiment of FIGS. 1 and 2, the patient remains at rest during the X-raying sequence, and the X-ray tubes 5 and the picture layer are oppositely moved. In lieu of a Bucky-diaphragm 59, however, the X-ray image intensifier 7 is moved. This provides the possibility, through a photographing of the outlet luminescent screen of the X-ray image intensifier, that the expensive large-sized tomographic exposures may be replaced by considerably less expensive small-sized films.

Instead of the displacement of the picture target 6 relative to the patient during the X-raying sequence, it is also possible that the picture target 6, in the present instance also the X-ray image intensifier 7, is fixedly fastened to the lower arm 9 of the parallelogram linkage of the U-shaped carrier 4, and to displace the patient the X-raying sequence relative to the picture target 6. Herein, for effecting displacement of the patient, there may be employed the step motors 46, 47 to impart longitudinal and transverse displacement to the patient support 11. Upon rotation of the carrier frame 12 of the patient support 11 about the median perpendicular 10 of the picture target 6, consideration must be given that the movement of the patient support during the X-raying sequence constantly remains parallel to that of the X-ray tube 5. In accordance with the rotational angle in which the patient support is rotated about the median perpendicular 10 of the picture target 6, this signifies that the path of the tomographic link 24 must be resolved as respectively a component in the transverse and longitudinal directions of the patient support 11. For this purpose FIG. 4 illustrates a stage 48 adapted to be built onto the plate or target support block 25 in a plane extending parallel to the picture plate 6, which is rotatably supported in synchronism with the patient support, and supporting two follower plates 49, 50 which are displaceable at right angles relative to each other. Both follower plates 49, 50 are each provided transverse to their direction of displacement with a longitudinal slot 51, 52 in which the tomographic link 24 can slide. Both of the follower plates, futhermore, are provided with a gear rack 53, 54. Each of these gear racks is, respectively, in operative engagement with a pinion 55, 56, which are fastened to an axle of a mechanical-electrical converter 57, 58 located on the stage 48. Through the intermediary of these two converters there is produced one of the positionings of the respective follower plates 49, 50 on the stage 48 in conformance with an electrical reference value.

The stage 48 is connected with the subframe 8 through a gear chain drive (not shown) so that the direction of displacement of one of the follower plates 49 during the rotation of the subframe remains parallel to the longitudinal direction of the patient support 11, and the other follower plate 50 remains oriented in parallel to the transverse direction of the patient support. The converter 58, which is set by the follower plate 50 which displaceable in the transverse direction with respect to the patient support 11 is, together with the step motor 47 and a further similar actual value indicator coupled to the step motor 47, a component of a servo control (not shown). The same also applies to the converter 57, which is adjustable by means of the follower plate 49 which is displaceable in the longitudinal direction of the patient support, the step motor 46 for the longitudinal displacement of the patient support 11 and an actual value indicator connected to this motor.

The rotatable stage 48 facilitates that the stroke of the plate link 24 during the X-raying sequence be divided into a component in the longitudinal direction and a further component in the transverse direction of the patient support 11. The patient support 11 is, during the X-raying sequence, moved by means of converter 57, 58 in accordance with a servo control for the transverse and longitudinal direction converters of the patient support associated converter, and the present motors 46, 47, for the longitudinal and transverse displacement of the patient support. This arrangement has the particular advantage that it facilitates operation with X-ray image intensifiers 7 having large inlet luminescent screens, for which there in particular would be no space in the subframe 8 for sufficient displacement in the target direction. In this embodiment the target axis 27 is rigidly supported on the plate support block in the plane of the picture plate 6, and the stage 48 with the spindle 26 is carried along the tomographic link 24 displaceable in the target height.

When the drive for effecting the rotation of the patient support 11 about its longitudinal axis 30 and for the pivoting of the carrier 4 about the horizontal pivot axis 3 are mutually adjusted in the sense of providing values having equal rotational velocities, it is possible to attain, through opposite rotational motion of the patient support and carrier, that the X-ray tubes and the picture target rotate about the longitudinal axis of the patient without the last-mentioned being rotated with respect to the chamber. In this setting, which may be effected by means of a therefore provided switch, in the X-raying of contrast media-filled organs, the contours of the latter may be controlled in a particularly good manner.

While there has been shown what is considered to be the preferred embodiment of the invention, it will be obvious that modifications may be made which come within the scope of the disclosure of the specification.

What is claimed is:

1. In an X-ray examining apparatus having a pedestal base; a vertically displaceable support block mounted on said base; a carrier supported on said support block for rotation about a horizontal pivot axis; a picture target mounted on said carrier and being oriented in parallel with said pivot axis; an X-ray tube being focused on said picture target; and patient support means interposed between said X-ray tube and said picture target, the improvement comprising: said carrier for said X-ray tube and picture target being dually offset in a U-shape in a plane oriented perpendicular to said picture target, said U-shape forming a first and a second arm, said first arm supporting said picture target and being fastened to said support block for rotation about said horizontal pivot axis, said X-ray tube being fastened to said second arm having the central X-ray beam thereof directed towards said picture target; a carrying frame for a patient support rotatable about an axis parallel to the surface of said picture target; and a subframe rotatable about the median perpendicular of said picture target supporting said first arm, said subframe being longitudinally movably mounted on said carrying frame.

2. An apparatus as claimed in claim 1, said patient support being movably suported on said carrying frame for displacement normal to the surface of said picture target.

3. An apparatus as claimed in claim 1, said patient support being supported on said carrying frame for transverse displacement relative thereto.

4. An apparatus as claimed in claim 1, said carrying frame having an end plate facing the foot of said apparatus, said patient support being mounted on said end plate.

5. An apparatus as claimed in claim 1, said patient support being detachable and interchangeable with patient supports of specialized varied types.

6. An apparatus as claimed in claim 1, said carrier for the X-ray tube and picture target comprising a parallelogram linkage, link means pivotably supported about a target axis, said target axis being parallel to the target plane and the linkage axis of said parallelogram linkage and oriented for adjustability perpendicular relative to the plane of said picture target; said second arm supporting said X-ray tube being hingedly connected to one end of said link means, said link means having the other end thereof connected to said picture target in the plane of said target and a projection supporting said X-ray tube for rotation about an axis oriented in parallel to said target axis, said projection including an auxiliary linkage for maintaining said X-ray tube directed towards said picture target.

7. An apparatus as claimed in claim 6, comprising an X-ray image intensifier connected to said link means and adapted to be moved in the direction of said picture target.

8. An apparatus as claimed in claim 6, comprising Bucky diaphragm means connected to said link means and adapted to be moved in the direction of said picture target.

9. An apparatus as claimed in claim 6, comprising a pair of follower plates a stage rotatable about the median vertical of said picture target, said follower plates being mounted along an axis oriented perpendicular to said target and in synchronism with the rotation of said stage being displaceably supported parallel to said target and to the respective longitudinal and transverse directions of the patient support, said follower plates being connected to said link means for displacement of adjusting means; a reference value indicator fastened to said stage connected to said follower plates, said follower plates including step motors for actuation thereof and being connected to a servo control for the corresponding displacement of said patient support relative to said picture target.

10. An apparatus as claimed in claim 6, said target axis being oriented in parallel to said pivot axis.

11. An apparatus as claimed in claim 6, said target axis being oriented in perpendicular to said pivot axis.

12. An apparatus as claimed in claim 1, the rotational velocity of said patient support about its longitudinal axis and the pivot velocity of said carrier about the pivot axis being correlated with each other.

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