United States Patent

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[54] **X-RAY DIAGNOSTIC APPARATUS FOR UROLOGICAL EXAMINATIONS**
4 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **250/58,**
250/65, 250/66, 250/105; 318/266, 318/282

[51] **Int. Cl.** **G03b 41/16**
[50] **Field of Search** 250/53,
57, 58, 65, 66, 105; 318/266, 282, 466, 468

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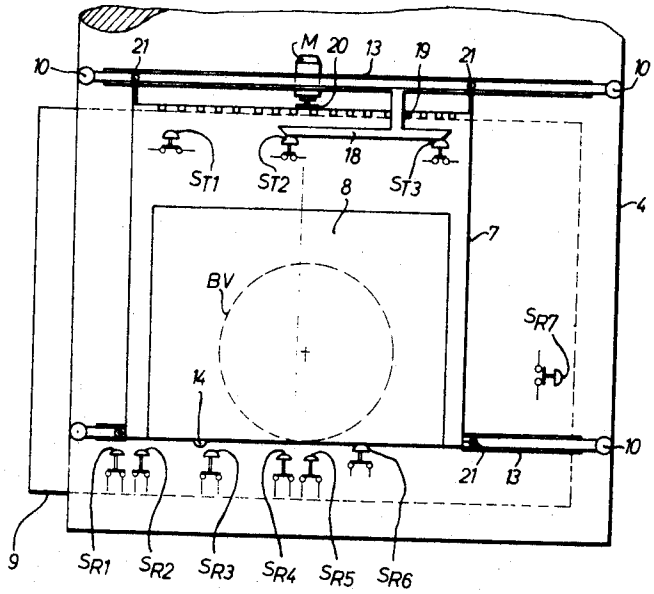
ABSTRACT: An X-ray diagnostic apparatus for urological examinations including a cantilever table plate movable on a frame with a cassette carriage movable within the table plate, and means for automatically moving the carriage and for returning the carriage due to overtravel.



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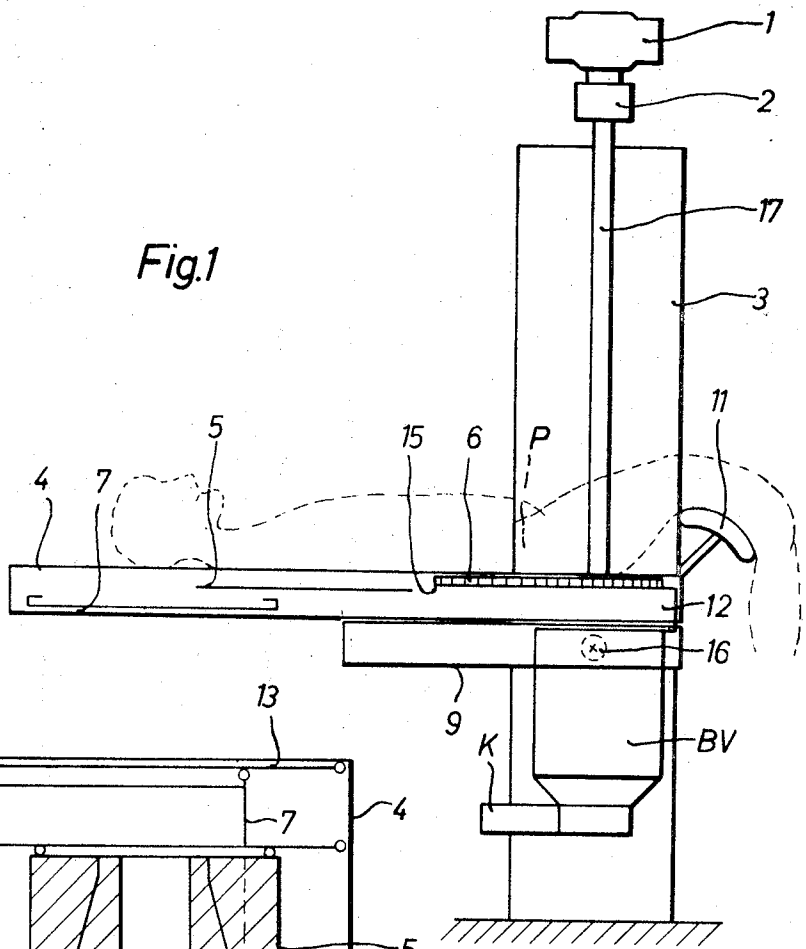
SHEET 1 OF 2

Fig.1



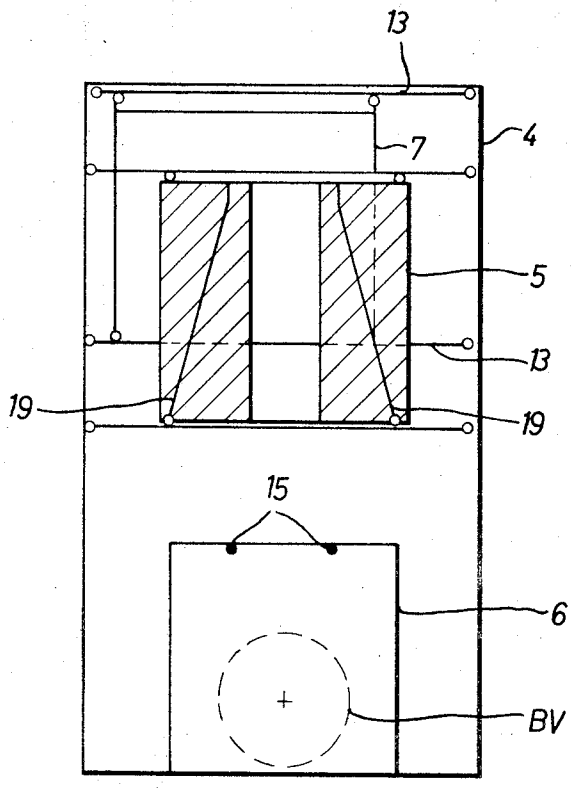


Fig.2

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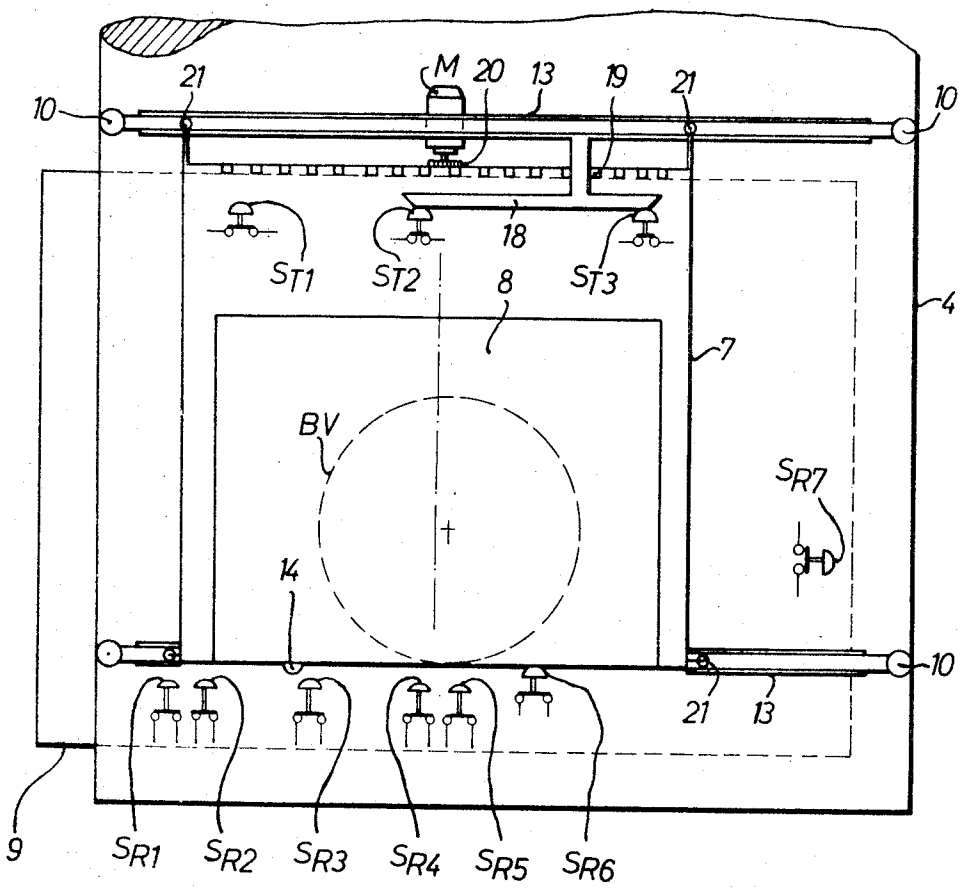

Fig.3

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X-RAY DIAGNOSTIC APPARATUS FOR UROLOGICAL EXAMINATIONS

A urological examination apparatus has to permit the examiner to carry out simultaneously instrumental and X-ray diagnostics of processes in the uretic organs, i.e. kidneys, ureter, bladder and urethra. This involves the requirement for the table supporting the patient to be displaceable laterally and longitudinally ("floating table plate"), to be adapted to be turned about an axis parallel to the narrow table side and finally to be displaceable in a direction of height so that the physician may find an easy position for examination. Experience has shown that urological X-ray photographs, particularly retrograde polygrams cystograms and so on made by directional orientation at the correct instant have a higher information value than those taken on a Bucky table (flat diaphragm table bindly). Consequently, an additional radioscopic device is required. Finally, the subdivision of the photograph in accordance with the physiological conditions may be desirable.

There are known urological examination tables adapted to be shifted and turned and displaced in a direction of height in perfect manner. These tables are equipped with flat diaphragms and gratings. They permit of taking radiograms of slow processes, for example, intravenous polygrams but retrograde polygrams, which require release of the exposure at the correct instant, cannot be made by means of such apparatus.

Urological examination tables have been constructed which permit of taking directional radiograms. In this case a fluorescent screen and an X-ray tube, which are mounted at opposite areas of a pivotal bracket secured to a separate displaceable stand, are shifted sideways over the patient's table so that the tube is located beneath the table plate and the screen is located above it. However, the use of the fluorescent screen requires a dark room, so that operation of the instruments is rendered more difficult.

In a known solution the fluorescent screen is replaced by an image intensifier with a television camera and a television monitor, but the mobility of such an apparatus is limited, since on the one hand the input screen of the image intensifier should be as near the patient as possible, and on the other hand for carrying out an instrumental examination the patient is positioned with lifted thighs, thus the image intensifier can no longer be disposed sufficiently closely to the uretic organs of the patient, which forms the very field of investigation. As stated above, it is necessary to turn the table about an axis parallel to the narrow table side, in which case an image intensifier which is movable independently of the table plate is a source of trouble.

It is therefore advantageous to employ an examination table whose frame, on which also the image intensifier is mounted, is adapted to be displaced in a direction of height and to be turned, and whose "floating table plate" is adapted to be shifted on the frame in a lateral and a longitudinal direction. Above the table plate the X-ray tube is arranged so that in any position the central beam strikes the center of the fluorescent screen of the image intensifier. Such table constructions are commercially available.

In radioscopy the photographic cassette has to be shifted either laterally or longitudinally and to be protected from the rays in order to avoid preliminary exposure. When shifted laterally the cassette with the associated carriage would take up much space at the side of the table, which is, in general, not available, particularly not in the event of simultaneous operation of the uretic organs. When the cassette is shifted longitudinally of the table, difficulties arise in the examination of lateral organs, for example, of a kidney. In order to move the object of the examination into the path of the rays, the table plate has to be shifted laterally for radioscopic observation. Since together with the table plate also the cassette displaceable in a direction of length therein is displaced so that the central beam does no longer coincide with the central line of the cassette, the table plate has to be shifted back for exposure for obtaining coincidence of the central beam and the center line of the cassette. It can not be avoided, however, that the exposed organ, which first appeared at the center of the fluorescent screen, will appear either only at the edge of the film or, if a narrow cassette is used, will lie beyond the film field, so that it does not appear at all on the radiogram.

According to the invention the disadvantages mentioned above are avoided by means of a longitudinally and transversely movable cassette carriage and a control-member, which causes the cassette carriage, when the exposure is started, to travel across the fluorescent screen so that the center line of the screen, extending parallel to the longitudinal side of the table coincides with the corresponding center line of the (divisional) form of the radiogram.

One embodiment is shown in the parts essential to the invention, while structural details are given schematically.

FIG. 1 is a side elevation of an examination apparatus according to the invention.

FIG. 2 is a plan view of the table of the examination apparatus.

FIG. 3 shows the arrangement of the contacts for the control-member for a displaced table plate for a further explanation of the operation.

The examination apparatus shown in FIG. 1 comprises a supporting column 3 supporting a frame 9 by an arm 16 so that the frame can be turned about the arm 16 and be displaced upwardly.

The frame 9 supports a floating table plate 4. The table plate 4 comprises a cassette carriage 7 around a film proximity diaphragm 5, both of which are displaceable longitudinally and transversely of the long side of the table. At the lower end of the table leg supports 11 are provided so that the patient's legs can be hooked for instrumental examination. In the position shown the table plate is displaced completely towards the head end. The frame 9 has mounted on it an X-ray image intensifier 10 with a television camera K. Via a panel 12 having the contacts S_{R1} to S_{R6} of FIG. 3 the image intensifier BV is rigidly connected with a fine grating 6. The fine grating is constructed, for reasons to be explained more fully hereinafter, in the form of a fine mesh grating with fine laminations, the lines of which extend parallel to the long side of the table. The arm 16 has secured to it a bar 17, which supports the X-ray tube 1 with the depth diaphragm 2. It is thus ensured that the central beam always coincides with the center of the input screen of the image intensifier.

FIG. 2 shows the arrangement of the film proximity diaphragm 5 and of the cassette carriage 7 inside the table plate and of the fine grating 6 and of the image intensifier BV. For the sake of clarity the film proximity diaphragm 5 for the subdivision of a given cassette form in the longitudinal direction is shown in a position shifted towards the lower end. The diaphragm 5 is is provided with two control-slides 19. When the diaphragm is displaced further, one of them engages one of the guide pins 15, secured to the grating. In accordance with the control-slide concerned, the diaphragm is pushed either to the right or to the left so that finally the opening lies above the center of the image intensifier. By means of an right—construction of the control-slides it can be ensured that in any possible position of the table and of the diaphragm inside the table the diaphragm is centered to the center of the image intensifier. Since due to the displacement of the table the center line of the cassette does not coincide automatically with the center line of the grating, the cassette carriage is parked beyond the center of the table (viewed in the direction of length) (see FIG. 2), which will be explained hereinafter. For inserting the cassette, the cassette carriage is moved out of the position shown to the right—or to the left in floor apparatus with a supporting column on the opposite side—out of the table. At the head of the table two contacts (not shown) are provided which indicate whether the cassette carriage or the diaphragm is located at the head end or is not located there.

FIG. 3 shows the frame 9 and the arrangement of the contacts for the control member. The contacts designated by R

are located on the frame or on the panel 12, secured to the frame (contacts S_{R1} to S_{R7}), so that their position is not varied; the contacts designated by T (S_{T1} to S_{T3}) are secured to the cassette carriage and their position is therefore modified, when the table frame is displaced.

The cassette carriage is moved downwardly out of the parking position of FIG. 2; it is advantageous to couple the hydraulic or electromotive drive of the carriage in the longitudinal direction of the table with the exposure setting switch; it is guided by rollers 10, which travel along the long sides of the table. At the foot of the frame the cassette carriage actuates a contact S_{R6}, which switches on the motor M for the transverse drive of the cassette carriage. The motor M is secured to the carriage frame 13 and displaces via a pinion 20 and a toothed rack 22 the carriage 7 which is guided by rollers 21 in the carriage frame to the right or to the left in accordance with the direction of rotation.

When the film proximity diaphragm 5 is not located in the path of the rays, the cassette carriage 7 is moved to the right or to the left in accordance with the construction of the fundamental apparatus until the switching cam 14, secured to the carriage, depresses the switch S_{R3} for the central position. The motor drive is thus switched off so that the center of the cassette 8 corresponds with the center of the image intensifier. If the cassette carriage is displaced rapidly, which may be desirable for quick exposure of the process observed on the fluorescent screen, it may occur that the carriage travels across the central position and stands still a given distance beyond the central position due to its weight (inertia) so that the cassette is out of center. In order to avoid this effect, the switch S_{R3} has coupled with it a direction inverter switch, which causes the carriage to return after a travel beyond the switch. Since the switching cam 14 moves again towards the central switch practically immediately after the reversal of the direction of rotation, the switching cam will stand still on the central switch S_{R3} because the carriage will not yet have sufficient kinetic energy to pass again beyond said position; after the termination of the exposure, the carriage returns to the position shown in FIG. 2. The above-mentioned contact at the head is actuated, so that the motor M is again switched on for the transverse displacement. This time the displacement is controlled by the contacts S_{T2} and S_{T3}, always one of which is depressed by the switching bar 18, secured to the cassette frame 13. When the switching bar is located on the contact S_{T2}, for example, the carriage is shifted to the left until also the contact S_{T3} for the right-hand shift is depressed. At this instant, when the contacts S_{T2} and S_{T3} are simultaneously depressed, the drive is interrupted and the carriage stands still. In this way it invariably occupies a defined position with respect to the transversely displaceable table frame.

The contact S_{T1} serves for inserting the cassette carriage after it has been provided with a fresh cassette with unexposed film material. The cassette carriage is moved for this purpose completely to the right out of the table plate and inserted after the exchange of the cassette to an extent such that the switching bar 18 engages the contact S_{T1}. The motor is thus again switched on and the displacement is then continued by motive force until S_{T2} is actuated and holds the cassette in the position described above.

The control of the cassette at the head of the table may, of course, also be carried out by securing the switching bar 18 to the cassette carriage and the control contacts S_{T1} to S_{T3} to the cassette frame.

It can thus be ensured that the switching cam 14 is invariably set between the contacts S_{R1} and S_{R3}, when the cassette carriage is moved downwardly, so that the cassette carriage has always to be displaced to the right only for the coincidence of the center of the cassette and the center of the image intensifier A condition is that the maximum displacement of the table should not exceed the distance between these two contacts; if this condition is not satisfied, a further contact may be provided, which reverses the direction of rotation of the motor, when the switching cam arrives at the right-hand side of the central contact S_{R3}.

By inserting the film proximity diaphragm 5, the form of the film — here three partial forms — can be subdivided. In order of succession the right-hand part, the central part and the left-hand part have to be exposed.

Since as stated above the diaphragm 5 is always positioned centrally to the image intensifier, the cassette or the cassette carriage has to be shifted so that the partial forms arrive one after the other into the path of the rays. For this purpose a program switching network (not shown) is provided, which is actuated by the above-mentioned end position contact at the head of the table plate as soon as it is no longer depressed by the film proximity diaphragm. This programming network, which can be constructed without any difficulty by skilled labour and which is not a subject matter of the present application, includes for the first exposure the contacts S_{R1} and S_{R2}, for the second partial exposure the contacts S_{R3} and for the third partial exposure the contacts S_{R4} and S_{R5} in the current circuit of the motor M. Moreover, the direction of rotation of the motor is reversed for the first exposure, so that the carriage travels to the left. The terminal contact for this first exposure is the switch S_{R1} so that the cassette carriage stands still when the switching cam 14 is directly above this contact. For this purpose the switch S_{R1} can be operative in the motor circuit in the same manner as the switch S_{R3}; however, in order to save the additional space which would be required when the switch S_{R1} is passed by, a switch S_{R2} is provided, which slows down the travel of the carriage by the insertion of a resistor in the motor circuit to an extent such that the contact S_{R1} cannot be passed by.

For the second exposure the contact S_{R3} is inserted into the motor circuit so that the displacement of the cassette carriage is controlled in the manner described above. For the third exposure the contacts S_{R4} and S_{R5} become operative in the current circuit of the motor M, S_{R4} serving again for slowing down the speed. Between the separate exposure the cassette carriage moves always back to the head; this return travel is effectively started by the exposure termination switch, whereas the travel towards the foot end is coupled, as stated above, with the exposure setting means.

Finally, a switch S_{R7} is provided, which is actuated from the side of the table and which inserts a resistor into the current circuit of the motor, when the table is completely displaced to the left. In this position the switching cam 14 would stop between S_{R1} and S_{R2} and at the first partial exposure it would pass beyond S_{R1}, if the speed were not reduced in this case by means of S_{R7}. Like S_{R7} further contacts may be provided, which cooperate with the motor control and are actuated when the displacement of the table exceeds a given dimension. In this manner it can be ensured in any position of the table plate that the cassette displacement is suitably controlled, even when the switching cam stops beyond the contacts S_{R1} and S_{R5}.

The apparatus described above is furthermore characterized in that, for example, with a cassette of the size shown in FIG. 3 the point of impact of the central beam does not coincide with the center of the cassette, but in that it coincides with the center line of the cassette only, so that the beam is diaphragmed out unsymmetrically. It is thus ensured that the lower details, which are of primary importance, are less deformed by the oblique projection than the upper details. A further advantage is that any radiation passing beyond the foot end strikes the floor substantially at right angles so that the examiner sitting at the foot is considerably less exposed than he would be by the radiation passing by obliquely in the case of central projection.

We claim:

1. An X-ray diagnostic apparatus for urological examinations including an upright column, a frame secured to and vertically movable on the column, a table plate secured as a cantilever to the frame and movable transversely and longitudinally thereon, and an X-ray source secured to the column above the table plate and an image intensifier rigidly secured to the frame below the table plate and aligned with said source and further comprising a cassette carriage movable longitu-

dinally and transversely within the table plate, electric motor means for moving said table plate and carriage respectively, first control means for automatically actuating said motor means to move the carriage between preselected positions, and second control means for partially reversing said carriage movement when the carriage overtravels one of said positions, said first and second control means comprising electric switches and cam means for actuating the switches secured to and operable between the frame and the carriage.

2. Apparatus as defined in claim 1, further comprising a film proximity diaphragm movable within said table plate above the cassette carriage, the diaphragm including slide means for variably defining an X-ray aperture, and third control means carried by the frame for engaging and moving said slide means to align the aperture and X-ray source.

3. A program control network for use in an apparatus as claimed in claim 2 characterized in that when the diaphragm is moved into the path of the rays, it acts upon the first and second control means for the frame-dependent disposition of the cassette carriage so that the exposure parts enter consecutively into the path of the rays.

4. An examination apparatus as claimed in claim 1 characterized in that the cassette is moved for exposure over the image intensifier only to an extent such that the lower cassette edge substantially coincides with the lower edge of the image intensifier.