June 11, 1957 J. DE L. S. MORRIS 2,795,702

CASSETTE CONVEYING APPARATUS

Filed Aug. 11, 1953

FIG. 1.

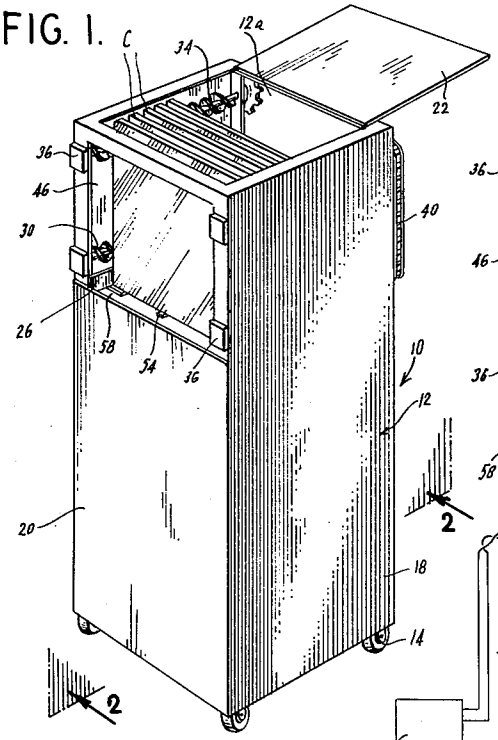


FIG. 2.

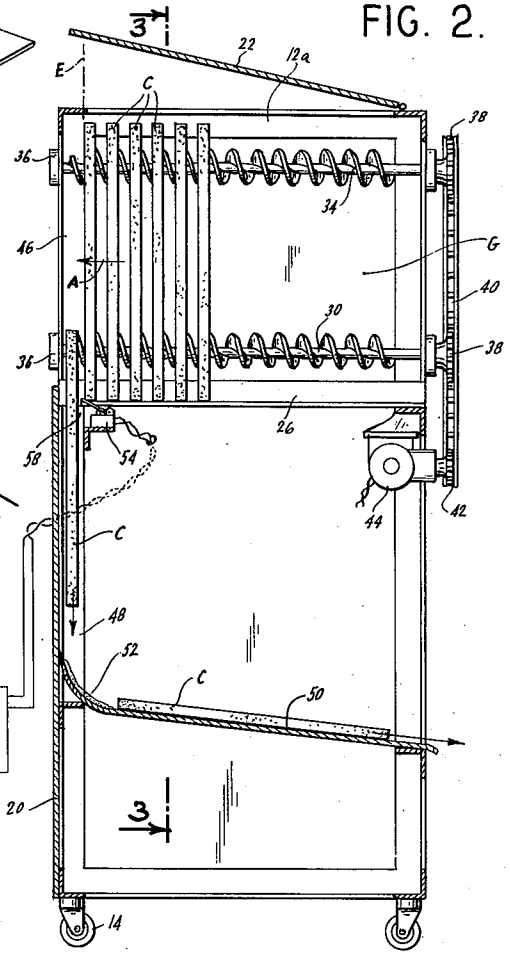
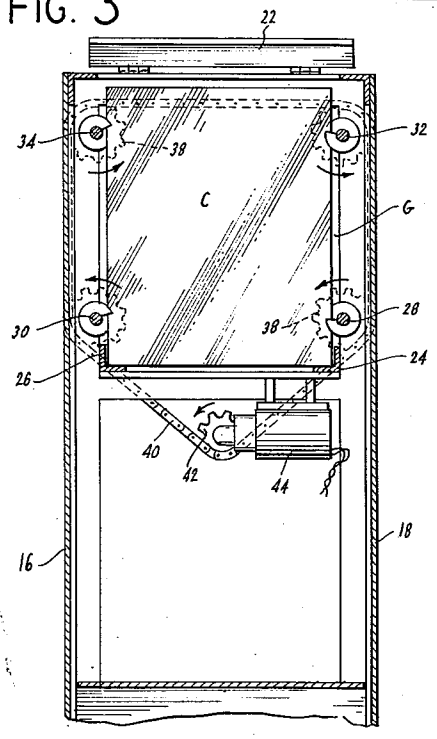


FIG. 3



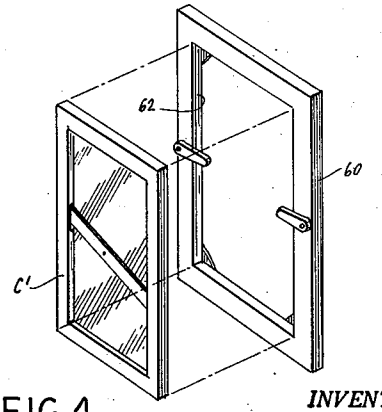


FIG. 4.

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CASSETTE CONVEYING APPARATUS

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11 Claims. (Cl. 250—66)

The present invention relates to conveying mechanisms, and in particular to a cassette changer for use with radiological apparatus. The invention is especially advantageous for relatively high speed angiocardiography of patients in an erect position.

For sequence radiological studies, it is necessary to successively expose plural sensitized films to radiation from an X-ray source. Usually exposure of a large number of films occurs at critical times during a relatively short study interval. Although the study period is short, the preliminary preparation of the patient is time consuming, often involving careful observation for a given period followed by the introduction of special contrasting substances into the circulatory system immediately before actually conducting the test.

The inherent nature of the outlined procedure imposes a number of requirements on the changing equipment which delivers successive sensitized films to the exposure region, namely; simplicity in the mechanisms, of prime consideration when it is recalled that failure might be fatal to a patient who may not be able to tolerate a repeat of the treatment necessary for further study without an appreciable lapse in time; ability to handle large size films, preferably in standard cassettes; and adaptability with respect to the study interval, the number of films handled, and the delivery rate of successive films. Broader objectives are more apparent, such as, the ability to withstand wear, accessibility from the standpoint of servicing and replacing parts, and ease of operation.

It is an object of the present invention to provide novel cassette-changing apparatus embodying one or more of the aforesaid features. It is within the contemplation of the present invention to provide a radiological plate changer which feeds plate holders or the like to an exposure position at predetermined and easily controlled time intervals.

It is among the objects of the present invention to provide conveying mechanism designed to handle standard and relatively large size cassettes, the film of which may in turn be processed by conventional and well understood techniques.

A still further object of the present invention is the provision of a cassette changer facilitating radiological studies with a patient in the post-anterior erect position. Among the advantages of conducting studies with the patient seated in front of the cassette changer are the ease of comparing any one of the multiple study exposures with single-study exposures, and the enhanced circulatory hemodynamics in this position, which may be due in part to the ability of an upright patient to make a better sudden inspiratory effort.

It is a further object of the present invention to provide a cassette changer which may be readily adapted to a variety of studies, and in each instant is reliable and assures film delivery at prescribed rates. Among the studies for which the cassette changer has been found to be exceptionally useful are those related to congenital and acquired heart disease; lung cancer and other tumors of

the chest; aortography, which is visualization of the largest artery in the body and is exceptionally important in the study of abdominal cancer; and peripheral angiography which is visualization of the largest arteries and veins of the extremities and is important in diagnosing war injuries of blood vessels and diseases, such as Berger's disease and arteriosclerosis.

In accordance with one aspect of the invention, a cassette conveyer or changer is provided which may be used with an X-ray source and includes plural feed screws defining a guideway for receiving cassettes in stacked and spaced formation. A drive is provided for rotating the feed screws at a prescribed rate to advance the cassettes along the guideway, removal of the cassettes after being exposed in a predetermined plane intersecting the guideway being accomplished preferably by a gravity drop.

As a feature of the invention, the feed screws or members have spiral cassette-propelling surfaces having a pitch selected to obtain a prescribed spacing between successive cassettes, the feed rate being varied by the spacing of the cassettes or the speed of rotation of the feed screws.

As a still further feature of the invention, the cassette changer is coordinated with a conventional X-ray apparatus of the type having an electrically-operable exposure control by the provision of a quick-acting switch along the guideway which preferably is operated by direct contact with successive cassettes and energizes the exposure control of the X-ray apparatus.

The above and still further objects, features and advantages of the invention will become apparent upon reference to a detailed description of a presently preferred embodiment, when taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a perspective view showing a cassette changer or conveyer embodying features of the present invention;

Fig. 2 is an elevational view on an enlarged scale, taken along the line 2—2 of Fig. 1 and looking in the direction of the arrows;

Fig. 3 is a sectional view, with parts broken away, taken substantially along the line 3—3 of Fig. 1, and looking in the direction of the arrows; and

Fig. 4 is an exploded perspective view of an adapter to be used in conjunction with the cassette changer of Figs. 1 to 3.

Referring now specifically to the drawings, there is shown in Figs. 1 to 3 a cassette changer or conveyer **10** having a cabinet or housing **12** supported on casters **14** or the like. The housing **12** which has an open top **12***a* is substantially rectangular in cross-section and includes opposed side walls or panels **16**, **18**, a front panel **20** extending between the side panels **16**, **18** and terminating short of the open top of the cabinet, and a swingable cover or lid **22**, movable into and out of a closing position with respect to the open top **12***a*. Extending at right angles to the front panel **20** and substantially at the level of the upper edge of the front panel **20** are a pair of track-forming elements **24**, **26**, which are arranged in spaced and parallel relation and extend front to the rear of the cabinet **12**. In the illustrative embodiment, the track-forming elements **24**, **26** are angle irons having horizontal legs arranged in coplanar relation and providing an abutment or supporting ledge along which objects may be moved, and upstanding lateral-confining legs which preclude side-to-side displacement of the articles.

As a prominent feature of the present invention, spiral feed screws **28**, **30**, **32** and **34** are mounted on the cabinet for axial rotation and cooperate with the track-forming elements **24**, **26** to maintain a plurality of cassettes, generally designated by the letter C in spaced and parallel planes. Although the illustrative embodiment shows

four marginally-arranged spiral feed screws or cassette-propelling members engaging opposite side edges of the cassettes C, it is to be expressly understood that different feed screw arrangements are within the contemplation of the present invention. It has been found in actual practice that the illustrated mechanism provides the requisite constant thrust necessary for displacing the cassettes along the guideway G defined by the cooperating tracks and feed screws. At their respective forward ends, each of the feed screws or cassette propelling members is mounted for axial rotation by an appropriate bearing or the like, designated by the numeral **36**. Connected at the ends of the feed screws remote from the forward extremities are coupling sprockets, generally designated by the numeral **38**. The sprockets **38** are arranged in coplanar relation and are driven by a common chain **40** from a main drive gear **42** which is connected to an appropriate variable speed motor **44**. The respective spiral feed screw members, of the same uniform pitch and operated in tandem, define a laterally accessible magazine having individual seats for maintaining the respective cassettes in a predetermined spaced relationship normal to the path of advance, designated by the arrow A in Fig. 2. This path of advance, coaxial with the guideway G, intersects an exposure plane E where the respective cassettes are subjected to radiation from appropriate X-ray apparatus in accordance with techniques understood per se.

At a prescribed location along the guideway G there is provided a gravity drop-off station, designated by the numeral **58**, which is effective to sequentially remove the cassettes C from the path of advance toward the front window **46** at the terminal or leading end of the guideway G. In the illustrative embodiment, drop-off is accomplished by terminating the respective track-forming elements or members **24, 26** short of and at a predetermined spaced location from the front window **46** of the cabinet **12**. As seen in Fig. 2, the width of the drop-off station is somewhat in excess of the width of the cassettes. Therefore, as the cassettes are advanced toward the terminal ends of the track-forming elements **24, 26**, the successive cassettes drop from the guideway G and follow along a prescribed take-off path.

This take-off path is seen to include an upstanding run **48** merging into a rearwardly directed and downwardly inclined run **50** which directs the cassettes toward the back of the cabinet and into an appropriate bin or receptacle, not shown. At the curved part of the removal guideway between the upstanding run **48** and the rearwardly directed and downwardly inclined run **50**, a cushioning member **52** may be placed to eliminate distracting noises and the like incident to cassettes coming into contact with the run-off track.

Substantially at the exposure plane there is a quick-acting switch means **54** arranged in controlling relation to the well-known exposure actuating circuit **56** of the X-ray apparatus, the circuit **56** initiating operation of the X-ray apparatus for a predetermined interval. Specifically, the quick-acting switch means **54** is a microswitch, of well known construction per se, which is depressible by successive cassettes coming into the exposure plane E.

In an actual construction, particularly suited for conventional 14" x 17" cassettes, four spiral feed screws or cassette-propelling members each 21" in length were arranged in pairs to engage opposite side edges of the cassettes C, the spacing between successive convolutions, referred to as the pitch, being slightly larger than the thickness of the conventional cassette. Twenty-four seats, uniformly spaced and transverse to the line of advance of the cassettes were provided, it being found that this number was sufficient for most radiological studies. Cassettes were exposed at varying rates ranging from one a second to six a second, the rate being controlled by several parameters including the speed of the motor **44** and/or the pitch of the respective spiral feed screw members, and/or the initial disposition of the cassettes.

The present apparatus does not require material modification of the cassettes. However, it has been found preferable to employ a backing layer of X-ray impervious material, such as a $\frac{1}{32}$" thickness of lead, to effectively isolate the trailing cassettes with respect to the single cassette being exposed at plane E. Although forward motion is continuously imparted to the leading cassette during exposure, there has been no observed adverse effects on the quality of the picture, such as blurring of images. This may be attributed to the short interval of exposure and to the fact that the axis of the X-ray beam and of the motion coincide.

In lieu of cassette advancing surfaces or lands of uniform pitch as disclosed and described, it is to be expressly understood that a variable pitch may be employed for the respective cassette advancing members. For example, the pitch rate may be varied to deliver successive cassettes at equally spaced intervals for a predetermined portion of the study interval and at a different or varying rate during the remaining portion. The same result may be obtained to a limited extent by utilizing successive spaces for one portion of the magazine, and alternate spaces for the remaining portion of the magazine. For example, if it is desired to visualize right heart opacification at the rate of two per second and the left heart at one per second, and it is assumed that the apparatus is originally designed to have an exposure rate of two films per second, the cassettes may be placed in each available space for one portion of the magazine and in alternate spaces in the remaining portion. It can be appreciated that the radiation hazard is appreciably reduced and the X-ray tube life and films are conserved by employing such techniques.

With the present gravity-drop automatic changer, it has been found exceptionally easy to make studies with the patient seated in the post-anterior erect position. In this position, it appears that circulatory hemodynamics operate more favorably, perhaps since the bolus of contrast substance remains well concentrated. This may be due in part to the ability of the patient to make a better sudden inspiratory effort in the erect position, practical experience pointing out that 90% of adult patients referred for this study can easily tolerate injections of contrasting substances while in the sitting position.

Aside from the preferred use of the post anterior erect position, the unit may be used in the recumbent position which makes it suitable for aortography and for those patients who are not able to tolerate the procedure in the upright position, providing there is no objection to using the lateral ducutubus position for study. In this event, the unit is brought to the side of the radiological table, and the tube directed horizontally. Lateral films may thus be easily exposed with the patient in the supine position.

Reference will now be made to Fig. 4 wherein there is shown an adapter **60** which facilitates use of the cassette changer with somewhat smaller cassettes, designated generally by the letter C'. The adapter **60** is formed with a complementary seat **62** conformably receiving the smaller cassette C', the outer dimensions of the adapter **60** being substantially equal to the standard sized cassette. By the use of plural adapters in conjunction with the smaller cassettes, usually 11" x 14", it is possible to conduct studies with the smaller cassettes even though a specific changer may be designed for the fixed and larger cassette size.

From the foregoing, it can be appreciated that the cassette changer of the present invention is simple in construction and operation and virtually eliminates mechanical failure. The possibilities of electrical or mechanical failure are fairly well isolated to the drive and care may be taken to provide a high quality electric motor for reliably imparting the desired driving motion to the cassette-advancing members. The use of large size film assures quick and accurate positioning, a more complete angiographic study and easy film processing. Variations in the rate of exposure are readily accomplished and are

comparable to the range of existing commercial equipment. Further, the rate of exposure may be varied during study resulting in X-ray tube and film conservation, and decreased risk of radiation to the patient and operating personnel.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

What I claim is:

1. A cassette changer for use with an X-ray source having an exposure-actuating means comprising a track for receiving a plurality of upright cassettes, plural spiral feed screws each mounted for rotation and cooperating with said track to maintain said cassettes in spaced and parallel planes, a drive operatively connected to said spiral feed screws for rotating same to displace said cassettes along a path substantially normal to said space and parallel planes, a drop-off station at a predetermined location along said path for sequentially removing casettes from said path, and means along said path in advance of said drop-off station operated by successive cassettes and controlling said exposure-actuating means of said X-ray source to expose the leading cassette to said X-ray source prior to removal from said path.

2. A cassette conveyer for use with an X-ray source having operating means comprising means including spiral feed screws defining a magazine for receiving cassettes in stacked and spaced formation, means for rotating said feed screws to advance said cassettes along said magazine, a drop-off station at a selected location along said magazine for removing cassettes in sequence from said stacked formation, and switch means controlling the operating means for said X-ray source and operable by successive cassettes to expose the leading cassette to said X-ray source prior to removal from said stacked formation.

3. In combination with an X-ray machine having an electrically-operable exposure control, a cassette changer arranged to feed cassettes at selected intervals to an exposure plane, said cassette changer including spiral feed means mounted for rotation and maintaining said cassettes in spaced and parallel planes, means operatively connected to said spiral feed means for rotating same to displace said cassettes along a path substantially normal to said spaced and parallel planes and toward said exposure plane, a drop-off station along said path after said exposure plane for sequentially removing cassettes from said path, and quick-acting switch means at said exposure plane and operated by successive cassettes to intermittently energize said exposure control.

4. For use with X-ray apparatus having an electrically-operable exposure control, a cassette changer for bringing successive cassettes into an exposure position relative to said X-ray apparatus, said cassette changer including means defining a guideway terminating in an exposure window alignable with said X-ray apparatus, cassette-feeding means arranged marginally of said guideway and defining a magazine having individual seats extending transversely of said guideway and each receiving a cassette, a switch along said guideway for intermittently energizing said exposure control and operated by contact with successive cassettes, and means for driving said cassette-feeding means to advance successive cassettes into contact with said switch and toward said exposure window.

5. In combination with X-way apparatus having an exposure-operating circuit, a cassette changer for bringing successive cassettes into an exposure position relative to said X-ray apparatus, said cassette changer including forward-feeding means defining a magazine having individual cassette-receiving seats, a drop-off station adjacent one end of said magazine, means driving said forward feed means for advancing successive cassettes to said drop-off station, and a trip mechanism in advance of said drop-off station and controlling said exposure-operating circuit, said trip mechanism being arranged for operation by successive cassettes arriving at said exposure position.

6. A cassette changer for serial angiocardiography in the erect position with X-ray apparatus comprising means defining a horizontally extending guideway terminating in an upright exposure window, a plurality of spiral feed members coextensive with said guideway and cooperating to define laterally accessible vertically-extending seats each adapted to accommodate a cassette, means operating said spiral feed members in unison to advance successive cassettes toward said exposure window at a uniform and controlled rate, a drop-off station along said guideway and following said exposure window for removing successive cassettes from said guideway, and means operable under control of successive cassettes arriving at said exposure window for energizing said X-ray apparatus.

7. A cassette changer for serial angiocardiography in the erect position with X-ray apparatus comprising means defining a horizontally extending guideway intersecting an exposure plane, a plurality of spiral feed members coextensive with said guideway and cooperating to define laterally accessible vertically-extending seats each adapted to accommodate a cassette, the pitch of said spiral feed members being selected to provide a predetermined separation between successive cassettes, means operating said spiral feed members in unison to advance successive cassettes toward said exposure plane at a uniform and controlled rate, a drop-off station along said guideway and following said exposure plane for removing successive cassettes from said guideway, said drop-off station being spaced from said exposure plane a distance less than the spacing between successive cassettes, and means operable under control of successive cassettes arriving at said exposure plane for energizing said X-ray apparatus.

8. A cassette changer for serial angiocardiography with X-ray apparatus comprising means defining a guideway lead toward and intersecting an exposure plane, rotatable spiral feed members coextensive with said guideway, said spiral feed members having cassette-advancing lands defining laterally accessible vertically-extending seats each adapted to accommodate a cassette, means rotating said spiral feed members in unison to advance successive cassettes toward said exposure plane at a uniform and controlled rate, a drop-off station along said guideway and following said exposure plane for removing successive cassettes from said guideway, and means operable under control of successive cassettes arriving at said exposure plane for energizing said X-ray apparatus.

9. The combination with X-ray apparatus directed at an exposure plane of a cassette changer for bringing successive cassettes into said exposure plane, said cassette changer including rotatable feed screws defining a magazine having multiple compartments, each of said compartments being arranged to receive and support a cassette in a plane parallel to said exposure plane, means for rotating said feed screws for advancing successive cassettes into said exposure plane, said feed screws being arranged to advance successive cassettes beyond said exposure plane to a drop-off location whereby successive cassettes may be removed from the field of said X-ray apparatus after passing through said exposure plane.

10. The combination with X-ray apparatus directed at a vertical exposure plane of a cassette changer for bringing successive cassettes into said exposure plane, said cassette changer including horizontally-extending upper and lower rotatable feed screws defining a magazine having multiple compartments, each of said compartments extending vertically and being arranged to receive and support a cassette in a plane parallel to said exposure

plane, means for rotating said feed screws for advancing successive cassettes into said exposure plane, said feed screws extending beyond said exposure plane and being arranged to advance successive cassettes to a drop-off location at which successive cassettes are removed from the field of said X-ray apparatus.

11. The combination with X-ray apparatus directed at an exposure plane and having an electrically operated exposure control of a cassette changer for bringing successive cassettes into said exposure plane, said cassette changer including rotatable feed screws defining a magazine having multiple compartments, each of said compartments being arranged to receive and support a cassette in a plane parallel to said exposure plane, means for rotating said feed screws for advancing successive cassettes into said exposure plane, said feed screws being

arranged to advance successive cassettes beyond said exposure plane to a drop-off location whereby successive cassettes may be removed from the field of said X-ray apparatus after passing through said exposure plane, and switch means adjacent said exposure plane and in controlling relation to said exposure control, said switch means being arranged to be contacted and closed by successive cassettes being delivered to said exposure plane.

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