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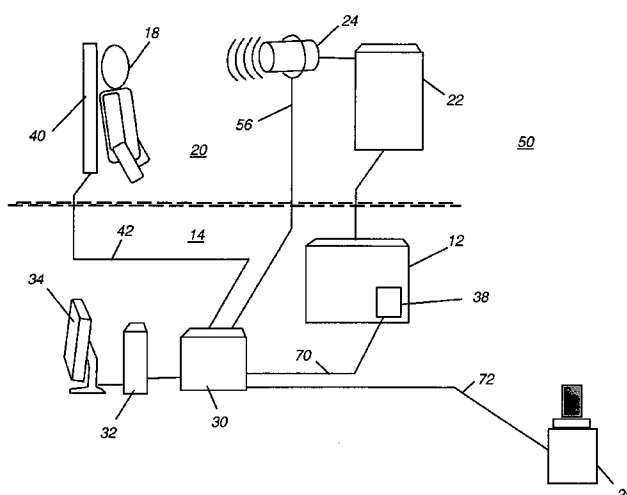


FIG. 3

(57) Abstract: A method and apparatus are disclosed for obtaining an x-ray image from an x-ray imaging apparatus using a digital radiography receiver installs a retrofit connection apparatus that adapts the x-ray imaging apparatus for use with the digital radiography receiver by forming a receiver interface channel for communicating signals to and from the digital radiography receiver, forming an operator interface channel for routing at least an input expose signal from an operator control to the connection apparatus and forming a generator interface channel for transmitting at least an output expose signal from the retrofit connection apparatus to an x-ray generator of the x-ray imaging apparatus. An input expose signal over the operator interface channel initiates a reset of the digital radiography receiver over the receiver interface channel before the output expose signal to the x-ray generator is transmitted over the generator interface channel.

WO 2009/067189 A1

**FIRING DELAY FOR RETROFIT DIGITAL X-RAY DETECTOR****FIELD OF THE INVENTION**

The invention relates generally to digital x-ray imaging and  
5 more particularly relates to an apparatus and a method for adapting the  
timing sequence of a conventional film- based and/or computed  
radiography (CR) x-ray imaging system for using a retrofit digital  
radiography (DR) detector.

**10 BACKGROUND OF THE INVENTION**

DR is an alternative to x-ray imaging technologies that rely on  
photosensitive film layers to capture radiation exposure and thus to produce and  
store an image of a subject's internal physical features. With digital radiography,  
the radiation exposure energy captured on radiation sensitive layers of a digital x-  
15 ray detector is converted, pixel by pixel, to electronic image data which is then  
stored in memory circuitry for subsequent read-out and display on suitable  
electronic image display devices. One of the driving forces in the success of  
digital radiography is the ability to rapidly visualize and communicate stored  
images via data networks to one or more remote locations for analysis and  
20 diagnosis by the radiologist, without the delay that results when film must be  
developed and checked, then packaged and mailed or sent by courier to a remote  
location.

DR is viewed as having some advantages over conventional film-  
based and earlier computed radiography (CR) systems. For example, DR provides  
25 the ability to obtain radiographic image data without the need to move, handle,  
process, or scan any type of imaging medium following exposure. Data  
downloaded directly from the DR receiver panel is then available for viewing and  
diagnosis on-site or at any appropriately networked viewer workstation.

Improvements in performance, miniaturization, and packaging have  
30 enabled the development of a portable DR receiver panel that is battery-powered  
and capable of wireless communication for control signals and image data.

Among other advantages, this provides a DR receiver panel having a low-profile design that can be compatible with receiver dimensions used for earlier film and CR systems.

While DR imaging systems have advantages over earlier film and CR systems, replacing such a earlier x-ray system can be very costly, thereby limiting the availability of DR systems as hospitals attempt to maximize their investment in older equipment and to extend its usable lifetime.

To meet the need for the improved capabilities offered by DR imaging, a number of companies that provide x-ray equipment offer retrofit configurations that allow a DR receiver panel to be used with existing x-ray components, in place of a film or CR cassette. Existing retrofit solutions, however, have one or more limitations, in that they:

(a) do not allow use of both earlier types of receivers and the newer DR panels. A retrofit that completely converts existing hardware to DR use but prevents the use of film or CR receivers is less desirable, since both film and CR media have particular strengths and may still be preferred in some types of imaging situations. There would be advantages to a retrofit solution that retains the ability to use the imaging system with film or CR receivers as well as allowing the use of DR receivers.

(b) do not minimize the impact of the retrofit on system hardware. Regulatory requirements for x-ray equipment make it highly undesirable to tamper with internal circuitry or connections, such as those required for a number of retrofit solutions. Invasive reconfiguration of an x-ray control panel could void existing approvals or certifications of the equipment or could even be in violation of regulatory rules and restrictions in some cases.

(c) do not minimize changes to workflow and impact upon patient care. A suitable retrofit solution should add the new capabilities of DR imaging with as little impact as possible on existing practices for positioning the patient and for obtaining exposures.

Thus, while various retrofit solutions have been proposed, there remains a need for a DR retrofit that has little or no impact on existing hardware,

is minimally invasive with respect to the components of an existing x-ray system, and does not constrain the system's ability to use earlier film and CR imaging media.

5

## SUMMARY OF THE INVENTION

An object of the present invention is to advance the art of diagnostic imaging. The invention provides a method and apparatus for retrofitting an existing film-based or CR x-ray imaging apparatus to capture an x-ray image using a DR receiver. A retrofit connection apparatus is provided that  
10 adapts the x-ray imaging apparatus for use with a DR receiver. The apparatus provides a receiver interface channel for communicating signals to and from the digital radiography receiver, an operator interface channel for routing at least an input expose signal from an operator control to the retrofit connection apparatus, and a generator interface channel for transmitting at least an output expose signal  
15 to an x-ray generator. The apparatus responds to the input expose signal over the operator interface channel by initiating a reset of the digital radiography receiver over the receiver interface channel before transmitting the output expose signal to the x-ray generator over the generator interface channel.

Another object of the present invention is to provide a retrofit  
20 solution that is substantially non-invasive, reducing or eliminating the likelihood that inspection or re-certification of equipment by regulatory authorities would be required.

Another object of the present invention is to provide a retrofit solution that allows an x-ray system user to use one or more earlier imaging media  
25 types in addition to the newer DR receiver panels.

These objects are given only by way of illustrative example, and such objects may be exemplary of one or more embodiments of the invention. Other desirable objectives and advantages inherently achieved by the disclosed invention may occur or become apparent to those skilled in the art. The invention  
30 is defined by the appended claims.

There is provided a method for obtaining an image by using a digital radiography receiver in an x-ray imaging system of a type configured for film or computed radiography. The method comprises: providing a retrofit connection apparatus that adapts the x-ray imaging system for use with the digital radiography receiver by: (a) forming a receiver interface channel for communicating signals to and from the digital radiography receiver; (b) forming an operator interface channel for routing at least an input expose signal from an operator control to the retrofit connection apparatus; and (c) forming a generator interface channel for transmitting at least an output expose signal from the retrofit connection apparatus to an x-ray generator of the x-ray imaging system; in response to the input expose signal routed over the operator interface channel, initiating a reset of the digital radiography receiver over the receiver interface channel; and transmitting the output expose signal to the x-ray generator over the generator interface channel.

There is provided an apparatus for x-ray imaging. The apparatus comprises an interface component installed as a retrofit to an x-ray imaging system. The interface component comprises: a mode selector for selecting at least a first mode setting for image capture using a digital radiography receiver and a second mode setting for image capture using a removable film or computed radiography cassette; a receiver interface channel for communication with such a digital radiography receiver, a generator interface channel for communication with an x-ray generator of such a system; an operator interface channel for communication with an operator control for receiving at least a first, preparation signal and a second, expose signal from an operator; and a programmed control logic processor that, when the first mode setting is selected, responds to such a second, expose signal from the operator interface channel by initiating a reset of such a digital radiography receiver over the receiver interface channel before transmitting an exposure signal to an x-ray generator of such a system over the generator interface channel.

30

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of the embodiments of the invention, as illustrated in the accompanying drawings.

5 The elements of the drawings are not necessarily to scale relative to each other.

FIG. 1A is a schematic diagram showing a conventional x-ray imaging system.

FIG. 1B shows timing states for using a conventional x-ray imaging system with removable film or CR media.

10 FIG. 2 shows timing states for using a digital radiography detector.

FIG. 3 is a schematic diagram showing an x-ray imaging system that has been retrofit according to one embodiment of the present invention.

FIG. 4 is a schematic diagram showing a retrofit imaging system that has been retrofit according to a wireless embodiment of the present invention.

15 FIG. 5A is a schematic block diagram of a conventional operator control console, such as used in the system of FIG. 1.

FIG. 5B is a schematic block diagram of an embodiment of a retrofit connection apparatus that uses panel-mounted or tethered switches of the existing imaging apparatus.

20 FIG. 5C is a schematic block diagram of an embodiment of a retrofit connection apparatus that uses a separate external switch and disables the existing switch for Prep and Expose functions of the apparatus of FIG. 5B.

FIG. 5D is a schematic block diagram of an alternate embodiment for a retrofit connection apparatus that has connection to both existing and retrofit

25 Prep and Expose switches.

FIG. 5E is a schematic block diagram of an embodiment of a retrofit connection apparatus that mounts a separate switch controller on the operator control console.

30 FIG. 5F is a schematic block diagram of an embodiment of a retrofit connection apparatus that mounts a separate switch controller on the operator control console for controlling a single two-position pushbutton.

FIG. 6 is a schematic diagram showing the configuration, components, and signal handling for an interface and control circuit used in one embodiment of the present invention.

FIG. 7A is a perspective view showing the relative position of  
5 Prep/Expose pushbutton on a conventional control console;

FIG. 7B is a perspective view of an operator control console for an x-ray imaging system with a retrofit using a pushbutton control apparatus in one embodiment of the present invention.

FIG. 8 is a perspective view of the inner components of the  
10 pushbutton control apparatus and shows their relation to the surface of the operator control console.

FIG. 9A is a schematic side view showing pushbutton control apparatus component position at rest in an idle state.

FIG. 9B is a schematic side view showing pushbutton control  
15 apparatus component position for actuation of the control panel pushbutton to a first setting.

FIG. 9C is a schematic side view showing pushbutton control apparatus component position for actuation of the control panel pushbutton to a second setting.

FIG. 10 is a perspective view of an alternate embodiment for a  
20 pushbutton control apparatus used with a control panel that has dual pushbuttons.

## DETAILED DESCRIPTION OF THE INVENTION

The following is a detailed description of the preferred  
25 embodiments of the invention, reference being made to the drawings in which the same reference numerals identify the same elements of structure in each of the several figures.

Figure 1A shows a conventional x-ray imaging system 10 that provides images on a removable medium, such as a removable film or CR cassette  
30 16. An operator control console 12 is situated in a control room 14, shown below the dashed line in Figure 1A and subsequent figures. An x-ray generator 22 is

installed in a radiation room 20, shown above the dashed line. Cassette 16 is placed behind a patient 18 for obtaining the image. Exposure energy is provided by an x-ray tube 24 controlled from x-ray generator 22. Not shown, but widely used with conventional equipment are also exposure control apparatus, such as  
5 Automatic Exposure Control (AEC) devices that measure exposure levels and terminate exposure when a target radiation level has been received.

Referring to Figure 1A and to the timing diagram of Figure 1B, an operator control switch 28 that is operatively connected to, and operates as a part of, operator console 12 can be in any of three states, as controlled by the x-ray  
10 technician. Prior to patient set-up and imaging, the system is in an Idle state. Once the patient is properly positioned for imaging, with cassette 16 in place, the operator pushes switch 28 to advance to a Prep state. This instructs the x-ray system to ready itself for an upcoming exposure. In most systems, pressing the Prep switch, or otherwise entering a command to enter the Prep state, brings the  
15 rotor of x-ray tube 24 up to speed as a preparatory step. The operator may set and hold the Prep state, for example, while waiting for the patient to relax or to get into the best position for imaging. The Prep state itself can last from a few seconds to more than a minute in some cases.

When the Prep state is complete, an exposure can be taken as soon  
20 as the operator advances switch 28 to an Expose state or position.

In this sequence, once conditions are suitable for imaging, the operator advances the switch 28 setting to the Expose state. There is a momentary delay period D1, typically not more than about 1 millisecond, for response of the x-ray generator control circuitry. Current then goes to the anode of x-ray tube 24,  
25 which emits the ionizing radiation needed for exposure. At the conclusion of exposure, such as following a preset exposure time or when signalled by an AEC device or other exposure sensing device as described earlier, both rotor and anode current are de-energized and the Idle state resumes.

As is known to x-ray imaging practitioners, a number of additional  
30 conditions must also be satisfied to allow the flow of anode current to the x-ray



tube. This includes, for example, requirements that equipment interlock conditions be satisfied and that rotor conditions be acceptable.

With different x-ray systems, switch 28 is variously embodied in one of a number of ways. In some systems, switch 28 is a two-position  
5 pushbutton mounted on operator console 12. In other systems, switch 28 is embodied as a bank of two pushbuttons or other controls on or near operator console 12, or as a tethered handswitch with a two-position pushbutton switch, connected by a cord that allows freer operator movement.

To provide a retrofit that allows use of a DR receiver panel as the  
10 x-ray detector in place of removable cassette 16 of the conventional system of Figure 1A, the timing of the Prep and Expose states must change accordingly. In order to properly condition its sensing components for obtaining an exposure image, a DR receiver panel requires at least one reset cycle. Reset clears any residual noise, such as so-called "dark noise" from the pixels of the DR receiver  
15 panel so that the next exposure signal that is received is properly read. Only after reset is confirmed should the exposure energy be provided. It is also advantageous to time the exposure integration of the panel so that it follows close upon reset, rather than being further delayed.

The timing diagram of Figure 2 shows the sequence of Prep and  
20 Expose signals and related operations according to one DR retrofit embodiment of the present invention. As was shown for the conventional timing in Figure 1B, pressing the Prep switch initiates x-ray tube rotor spin-up. In addition, this may also change the power mode of the DR receiver panel, particularly for a wireless, battery-powered DR detector. In the embodiment of Figure 2, pressing the Prep  
25 switch sets DR receiver panel power from a low or standby level to a high level. During the period between pressing the Prep switch and pressing the Expose switch, normally from about 2-15 seconds, the operator typically observes the patient to assure that the patient remains still during exposure.

Pressing the Expose switch sends a reset signal to the DR receiver  
30 panel. Reset of DR detector image-sensing circuitry typically takes no more than about 300 milliseconds, shown as time period D2 in Figure 2. An optional

acknowledgement signal is received from the DR receiver panel when reset has been completed. In one embodiment, the reset acknowledgement is required in order for x-rays to be generated and anode current is not provided until a positive acknowledgement of reset has been received back from the DR receiver panel.

- 5 This helps to prevent exposing the patient to the x-ray radiation when the DR panel is not ready to form an image. Anode current that drives x-ray generation is provided for a period D3 that is usually no more than about 500 milliseconds. The integration period of the DR receiver panel is typically about 1 second and begins just before anode current is provided, extending past the time when anode current
- 10 is stopped. In Figure 2, period D1 is again caused by x-ray generator control circuitry and represents the timing interval between the time integration begins at the DR receiver panel and the time x-rays are emitted (anode current ON).

It is noted that the timing diagram of Figure 2 is exemplary and admits a number of modifications within the scope of the present invention. For

15 example, the reset signal could alternately be provided from the moment the Prep switch is depressed, so that exposure and integration can begin more quickly following depressing the exposure switch. Delay time periods D1, D2, and D3 can vary in duration from those described. Timing, rather than positive reset acknowledgement, may be used to delay exposure (that is, with respect to Figure

20 2, to delay anode current ON) for a brief period following selection by the operator in order to allow an interval for DR receiver panel reset before continuing. However, as noted earlier, requiring an actual acknowledgement of reset from the DR receiver panel itself may be more advantageous and may help to prevent wasted exposures where there is an equipment problem or communication

25 difficulty.

As can be appreciated by comparing the timing diagram of Figure 2 with the conventional timing shown in Figure 1B, the retrofit task for using a DR receiver panel with an existing film or CR media system has an added measure of complexity: changing the timing sequence to allow sufficient delay for reset of the

30 DR receiver panel sensing circuitry and timing the integration period of the DR receiver panel circuitry to just overlap the period during which x-rays are

generated. Implementing this change also requires communication with the DR panel, both to initiate reset operation and, optionally, to receive confirmation that reset has been completed. As noted earlier in the background section, modifications to existing equipment are preferably not invasive, such as requiring that an existing x-ray operator control console have parts replaced or be rewired internally. As yet another complication, it would be considered disadvantageous to disable the existing operation scheme so that only the DR receiver panel could be used once the retrofit is installed and film or CR media were thus rendered unusable. It would be much more favorable to allow selectable use of either removable media, that is, either film or CR cassettes, or the DR receiver panel.

The schematic diagram of Figure 3 shows a retrofit imaging system 50 that substitutes a DR receiver panel 40 in place of cassette 16 and makes the necessary changes to x-ray exposure timing according to one embodiment of the present invention using wired connections. An interface and control circuit 30 communicates between DR receiver panel 40 and other components of this system. Image data itself goes to an imaging processor 32, such as a computer or workstation that is in communication with a display 34. A generator interface channel 70 connects interface and control circuit 30 to operator control console 12 by means of a connection apparatus 38 for providing Prep and Expose signals with the appropriate timing. An operator control switch 29 is connected to interface and control circuit 30 by an operator interface channel 72 for operator control, in place of switch 28 used in the conventional system of Figure 1A. Switch 29 may be a tethered switch as in Figure 3 or may be configured to mechanically control existing switches mounted on control console 12. A DR receiver interface channel 42 is provided between DR receiver panel 40 and interface and control circuit 30 by an ethernet cable connection or other type of high-speed data transfer link and may include other control signal lines for sending and receiving reset information and commands.

The schematic diagram of Figure 4 shows retrofit imaging system 50 in an alternate, un-tethered embodiment. Here, a wireless communications link is provided for receiver interface channel 42 between DR receiver panel 40 and

interface and control circuit 30. A transceiver 52 is connected to or provided as part of DR receiver panel 40 and communicates with a transceiver 48 that is connected to or provided as part of interface and control circuit 30. In one embodiment, battery power is also provided within DR receiver panel 40, so that  
5 no external wiring is required to the panel for operation. In another embodiment, only a power cord connection to DR receiver panel 40 is needed; the transmission channel to interface and control circuit 30 is wireless.

Figures 3 and 4 also show an optional sensor 56 for detecting a level of anode current that indicates active x-ray emission from x-ray tube 24.  
10 Anode current sensing by sensor 56 can be used to indicate that signal integration at DR receiver panel 12 should be terminated. It should be observed that the use of this additional sensor can also be done in a non-invasive manner and may therefore be preferable to other methods such as detecting or interrupting a termination signal from an AEC device, as described earlier, for example.

15 The schematic block diagram of Figure 5A shows how switch 28 conventionally has been connected to provide Prep and Expose signals in operator control console 12. A control board 58 within operator control console 12 accepts signals from switch 28 by means of a connector 54 that mates with a connector 53 that is in communication with control board 58. Switch 28 can be provided by a  
20 single two-position switch as already discussed, with one position for the Prep signal, the other for the Expose signal; or by multiple switch elements, one switch element for the Prep signal, the other for the Expose signal, as illustrated in Figure 5A. Switch 28 may be panel-mounted or tethered, as described earlier. The schematic block diagrams of Figures 5B, 5C, 5D, 5E, and 5F then show how the  
25 conventional arrangement of operator control console 12 connections is changed in different embodiments of connector apparatus 38.

Referring to one embodiment of a retrofit apparatus 62 in Figure 5B, switch 28 of the original system is used with the retrofit connection of connector apparatus 38. Connector 54 is removed from connector 53 on control  
30 board 58 and re-connected to interface and control circuit 30 to form operator interface channel 72. Interface and control circuit 30 then uses timing as discussed

with regard to Figure 2 and conditions the signals from switch 28 on operator interface channel 72 to provide the needed delay and provides the conditioned signals over generator interface channel 70 at a connector 55 to control board 58.

Switch 28 in such an embodiment may be panel-mounted or tethered. In one  
5 embodiment, connector 53 is externally mounted as a jack or plug for tethered switch 28 connection, making it particularly straightforward to provide the retrofit arrangement of connection apparatus 38.

Still referring to Figure 5B, an optional mode selector 68 is provided for interface control circuit 30 in one embodiment. Mode selector 68 can  
10 be used to specify operation of control logic in interface and control circuit 30, in order to enable either the signal timing of a first mode shown in Figure 1A when removable media (film or CR cassette) is used or the signal timing of a second mode shown in Figure 2 when a DR receiver panel is used. Other types of mode selector can be provided, including a programmed or operator-entered computer  
15 instruction that specifies either mode, entered from a touchscreen, keyboard, keypad, or mouse or other type of pointer, for example. Using a mode selector switch or other mode selection mechanism, the same x-ray imaging apparatus can provide imaging on either removable media or the DR digital receiver panel, allowing the operator to choose the imaging mode of preference.

Referring to the alternate embodiment of retrofit apparatus 62  
20 shown in Figure 5C, existing switch or switches 28 are not used with the retrofit arrangement of connection apparatus 38. Here, connector 54 is disconnected from control board 58 or otherwise bypassed, and a cover 66 is applied over switches 28, preventing these switches from being seen and used. Tethered switch 29 on  
25 operator interface channel 72 substitutes as the switch for sending Prep and Expose signals to interface and control circuit 30. Connection is provided over generator interface channel 70 from interface and control circuit 30 to inner control board 58.

The schematic block diagram of Figure 5D shows an alternate  
30 embodiment of retrofit apparatus 62 in which mode selector 68 would not be necessary, since both switches 28 and 29 are connected. In this embodiment,

generator interface channel 70 connects to control board 58 at a second connector 53'. Cover 66 is removable or has an access door or panel, allowing the technician to obtain images from removable film or CR media using switch 28 when exposed; for DR receiver panel imaging, the technician uses switch 29.

5 Yet another alternate embodiment of retrofit apparatus 62 is shown in Figure 5E. This embodiment of connector apparatus 38 mounts a switch controller 60 over a pair of switches 28. Switch controller 60 mechanically manipulates each of switches 28 for sending Prep and Expose signals, respectively, to control board 58. The operator uses one or two switches 29 to  
10 send Prep and Expose signals. Switches 29 can be separately mounted or tethered, or can be mounted on switch controller 60. No internal re-wiring is needed with this embodiment; switch controller 60 includes an appropriate type of actuator, such as one or more solenoids, for example, selectively energized in order to operate existing switches 28 under control of interface and control circuit 30 with  
15 this embodiment. Generator interface channel 70 is thus used to manipulate existing pushbutton switches in this embodiment. In one embodiment, cover 66 can be removed for use when it is desirable to obtain an image on a removable film or CR cassette, using switches 28 rather than using the DR receiver panel using one or two switches 29.

20 The block diagram of Figure 5F shows components in an embodiment of retrofit apparatus 62 using switch controller 60, mounted onto operator control console 12 and controlling the operation of pushbutton switch 28. Generator interface channel 70 connects to switch controller 60 and, based on the position of switch 29 as set by the operator, provides signals to actuators on switch  
25 controller 60 that urge pushbutton switch 28 into Prep or Expose positions, as described earlier. Switch 29 can be separately mounted or tethered, or can be mounted on switch controller 60, so that both operator interface channel 72 and generator interface channel 70 can follow the same basic path between switch controller 60 and interface and control circuit 30. No internal re-wiring is needed  
30 with this embodiment. Further details on configuration and operation of this device are given subsequently.

The schematic block diagram of Figure 6 shows the functional components and signal connections of a retrofit apparatus 62 with interface and control circuit 30 in additional detail, with particular emphasis on its components as they relate to retrofit timing control. Components of retrofit apparatus 62 are generally outlined within the dashed-line boundaries. A control logic processor 46, which may be a microprocessor or other logic processing device having stored programmed instructions or may be implemented in hardware, runs the timing sequence for Prep and Exposure stages, as was described earlier with respect to Figure 2. Prep and Expose signals from switch 29 are directed to control logic processor 46 for delay of the Expose signal timing, as described previously. In embodiments where the Prep signal only has the function of energizing the x-ray rotor, as shown in Figure 2, the Prep signal may alternately bypass control logic processor 46, as indicated in a dotted line connection in Figure 6.

Continuing with Figure 6, a communication interface circuit 44 provides the needed interface for control and command data over receiver interface channel 42 with DR receiver panel 40. Communication interface circuit 44 is used to send the reset command, to receive confirmation of reset completion, and to terminate integration where sensor 56 or other device is used. Additional circuitry, not shown in Figure 6, would be used for obtaining image data from DR receiver panel 40 through interface and control circuit 30 and for passing this image data on to imaging processor 32 and display 34, as shown earlier in Figures 3 and 4.

As shown in Figure 6, connection apparatus 38, using an arrangement of components such as those shown in Figures 5B, 5C, 5D, 5E, and 5F provides the Prep and Expose signals from control logic on interface and control circuit 30 to operator control console 12 over generator interface channel 70. As described earlier, connection between connection apparatus 38 and operator control console 12 can be in any of a number of forms.

The perspective view of Figure 7A shows a conventional control console 12 having a single Prep/Exposure pushbutton control 28. The perspective view of Figure 7B then shows an embodiment with switch controller 60 as a type

of pushbutton control apparatus mounted onto operator control console 12.

Switch controller 60 has a cover 66 and an optional access panel 74, in a retracted position in Figure 7B, allowing selection of an alternate timing mode in one embodiment. A bypass switch 78 is accessible by sliding back access panel 74.

- 5 Pressing bypass switch 78 enables the operator to bypass operation using the pushbutton control apparatus of switch controller 60, one option for specifying the mode when CR or film receivers are alternately used for imaging with the x-ray system.

- 10 Switch controller 60 mounts onto operator control console 12 in an appropriate manner. Mechanical fasteners can be used. In one embodiment, switch controller 60 is mounted onto operator control console 12 using adhesive material, such as a pressure-sensitive adhesive (PSA), for example.

- Figure 8 is a perspective view of some of the inner components that are mounted within protective outer cover 66 of the pushbutton control apparatus, switch controller 60 of Figure 7B in this embodiment, and shows their relation to the surface of operator control console 12. Based on operator use of switch 29 (as shown, for example, in Figures 5F and 6), the inner mechanism of switch controller 60 operates to urge pushbutton 28 to one of its operating positions by moving one end of a rocker arm 84, supported at a pivot 86. Actuators 80 and 82 cooperate to provide the needed force against pushbutton switch 28. In one embodiment, actuators 80 and 82 are solenoids. Alternate types of actuators 80 and 82 include motor driven shafts, lead screws, or cams, or other actuation devices driven magnetically, pneumatically, or using air pressure, for example.

- 25 The sequence of Figures 9A, 9B, and 9C shows the mechanical interaction of switch controller 60 components in the embodiment of Figure 8, again with cover 66 removed. To give an idea of the relative amount of switch movement that is needed for pushbutton switch 28, exemplary values for the position of switch 28 are as follows in one typical embodiment:



<b>Selected State</b>	<b>Range of Switch 28 Movement</b>
Idle	0 – 1.3 mm
Prep	1.5 – 2.6 mm
Expose	5.5 – 6.7mm

Figure 9A shows the pushbutton control apparatus at rest in an idle state. Pivot 86 is shown within an outlined rectangle to indicate that this point is held stationary by cover 66, which is removed for Figures 9A-C.

Figure 9B is a schematic side view showing switch controller 60 component position for actuation of the control panel pushbutton to a first setting, the Prep setting for most x-ray systems. As shown by the dashed-outline arrow, actuator 82 is energized, pulling upward on the corresponding section of rocker arm 84. Actuator 80 is de-energized. A shaft 88 provides the upward support for moving rocker arm 84, using leverage from pivot 86. A wheel 90 at the end of rocker arm 84 provides a mechanical interface with reduced friction against pushbutton 28.

The schematic of Figure 9C shows switch controller 60 component position for actuation of the control panel pushbutton to a second setting, the Expose setting. Here, actuator 80 is energized, pulling upward on the end of rocker arm 84. Actuator 82 remains energized, but is already at the end of its travel path. Rocker arm 84 lifts off of shaft 88 in this embodiment, as it is pivoted into this next position.

In one embodiment using solenoids, the use of two solenoids is advantaged over the use of a single actuator. It can be difficult to obtain a single solenoid capable of the full travel path for each signal position. Moreover, each solenoid has simple operation in the embodiment described with respect to Figures 9A-9C, having only fully energized or de-energized states.

The alternate switch controller 60 embodiment of Figure 10 shows an arrangement of internal components in which the pushbutton control apparatus of switch controller 60 mounts to a panel having separate Prep and Expose

switches 28 as described earlier with reference to Figure 5E, rather than the single-pushbutton embodiment for the devices shown in Figures 7B-9C. Switch controller 60 again has two actuators 80 and 82, one for controlling each of the two switches 28. Pressing the Prep switch 29, on the left side in the embodiment of Figure 10, energizes actuator 80 for pressing Prep switch 28 on control console 12. Pressing the Expose switch 29 on the right side in this embodiment sends a signal to control logic processor 46 in interface and control circuit 30 (Figure 5E). Drive current that energizes actuator 82 for pressing the Expose switch is transmitted through control logic processor 46. The Expose signal then goes to control board 58.

The invention has been described in detail with particular reference to a presently preferred embodiment, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention. For example, various types of cable connections can be used for forming each interface channel, in this case, providing Prep and Expose signals from interface and control circuit 30 over generator interface channel 70. Wired or wireless communication could be used from interface and control circuit 30 over any individual interface channel 42, 70, and 72.

**PARTS LIST**

- 10. x-ray imaging system
- 12. Operator control console
- 14. Control room
- 16. Film-based or computed radiography cassette
- 18. Patient
- 20. Radiation room
- 22. x-ray generator
- 24. x-ray tube
- 28. Operator control switch
- 29. Operator control switch
- 30. Interface and control circuit
- 32. Imaging processor
- 34. Display
- 38. Connection apparatus
- 40. DR receiver panel
- 42. DR receiver interface channel
- 44. Communication interface circuit
- 46. Control logic processor
- 48. Transceiver connected to interface and control circuit 30
- 50. Retrofitted imaging system
- 52. Transceiver connected to DR receiver panel 40
- 53, 53', 54, 55. Connector
- 56. Sensor of anode current in 24
- 58. Control board
- 60. Switch controller
- 62. Retrofit apparatus
- 66. Cover
- 68. Mode selector
- 70. Generator interface channel
- 72. Operator interface channel

- 74. Access panel
- 78. Bypass switch
- 80, 82. Actuator
- 84. Rocker arm
- 86. Pivot
- 88. Shaft
- 90. Wheel

- D1 Delay period after Expose state of 28
- D2 Reset period of DR receiver panel 40
- D3 Period of anode current for x-ray generator 22

**CLAIMS:**

1. A method for obtaining an image by using a digital radiography receiver in an x-ray imaging system of a type configured for film or  
5 computed radiography, the method comprising:  
    providing a retrofit connection apparatus that adapts the x-ray imaging system for use with the digital radiography receiver by:  
        forming a receiver interface channel for communicating signals to and from the digital radiography receiver;  
10          forming an operator interface channel for routing at least an input expose signal from an operator control to the retrofit connection apparatus;  
        and  
        forming a generator interface channel for transmitting at least an output expose signal from the retrofit connection apparatus to an x-ray  
15 generator of the x-ray imaging system;  
        in response to the input expose signal routed over the operator interface channel, initiating a reset of the digital radiography receiver over the receiver interface channel; and  
        transmitting the output expose signal to the x-ray generator over the  
20 generator interface channel.
2. The method of claim 1 wherein forming an operator interface channel comprises providing a hand-held switch.
- 25 3. The method of claim 1 further comprising, in response to the input expose signal, initiating image signal integration at the digital radiography receiver before transmitting the output expose signal.
- 30 4. The method of claim 1 further comprising providing a mode selector that selects an alternate timing sequence wherein the input expose signal is directly provided as the output expose signal.

5. The method of claim 1 further comprising sensing an x-ray anode current level at least during image exposure.

6. The method of claim 5 further comprising terminating  
5 signal integration on the digital radiography receiver according to the sensed x-ray anode current level.

7. The method of claim 1 wherein forming a receiver interface channel further comprises providing a wireless communication link between the  
10 retrofit connection apparatus and the digital radiography receiver.

8. The method of claim 1 wherein forming an operator interface channel comprises disconnecting at least one control switch from a first connector comprised in the x-ray imaging system and connecting the at least one  
15 control switch to a second connector comprised in the retrofit connection apparatus.

9. The method of claim 1 wherein forming an operator interface channel comprises mounting a device that covers at least one front panel  
20 switch of the x-ray imaging system.

10. The method of claim 1 further comprising receiving an acknowledgement of reset from the digital radiography receiver before transmitting the output expose signal.  
25

11. An apparatus for x-ray imaging comprising:  
an interface component installed as a retrofit to an x-ray imaging system, the interface component comprising:  
a mode selector for selecting at least a first mode setting for  
30 image capture using a digital radiography receiver and a second mode setting for image capture using a removable film or computed radiography cassette;

a receiver interface channel for communication with such a digital radiography receiver,

a generator interface channel for communication with an x-ray generator of such a system;

5 an operator interface channel for communication with an operator control for receiving at least a first, preparation signal and a second, expose signal from an operator; and

a programmed control logic processor that, when the first mode setting is selected, responds to such a second, expose signal from the operator interface channel by initiating a reset of such a digital radiography receiver over the receiver interface channel before transmitting an exposure signal to an x-ray generator of such a system over the generator interface channel.

12. The apparatus of claim 11 wherein the receiver interface channel comprises a wireless communication link for use between the interface component and such a digital radiography receiver.

13. The apparatus of claim 11 wherein the interface component further comprises a sensor for x-ray anode current level of such a system.

20

14. The apparatus of claim 11 wherein the interface component further comprises a sensor for providing a signal indicative of x-ray emission according to a sensed electrical current level.

25 15. The apparatus of claim 11 wherein the mode selector provides an instruction to the control logic processor.

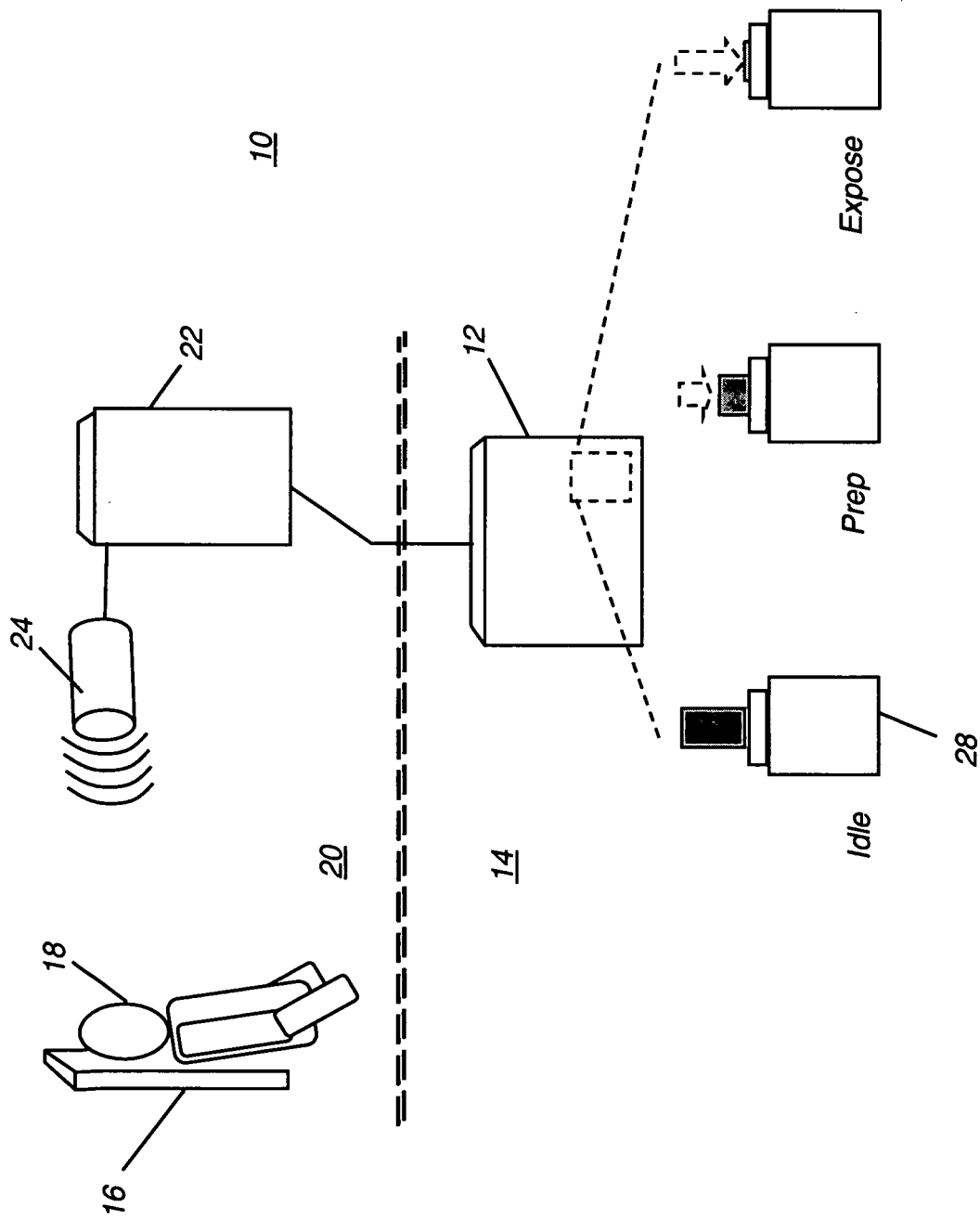
16. The apparatus of claim 11 wherein the generator interface channel further comprises a switch controller for covering at least a first switch on a control panel of such a system and for controlling the setting of at least the first switch according to a setting of a second switch by an operator.

30

17. The apparatus of claim 16 wherein the second switch is mounted on the switch controller.

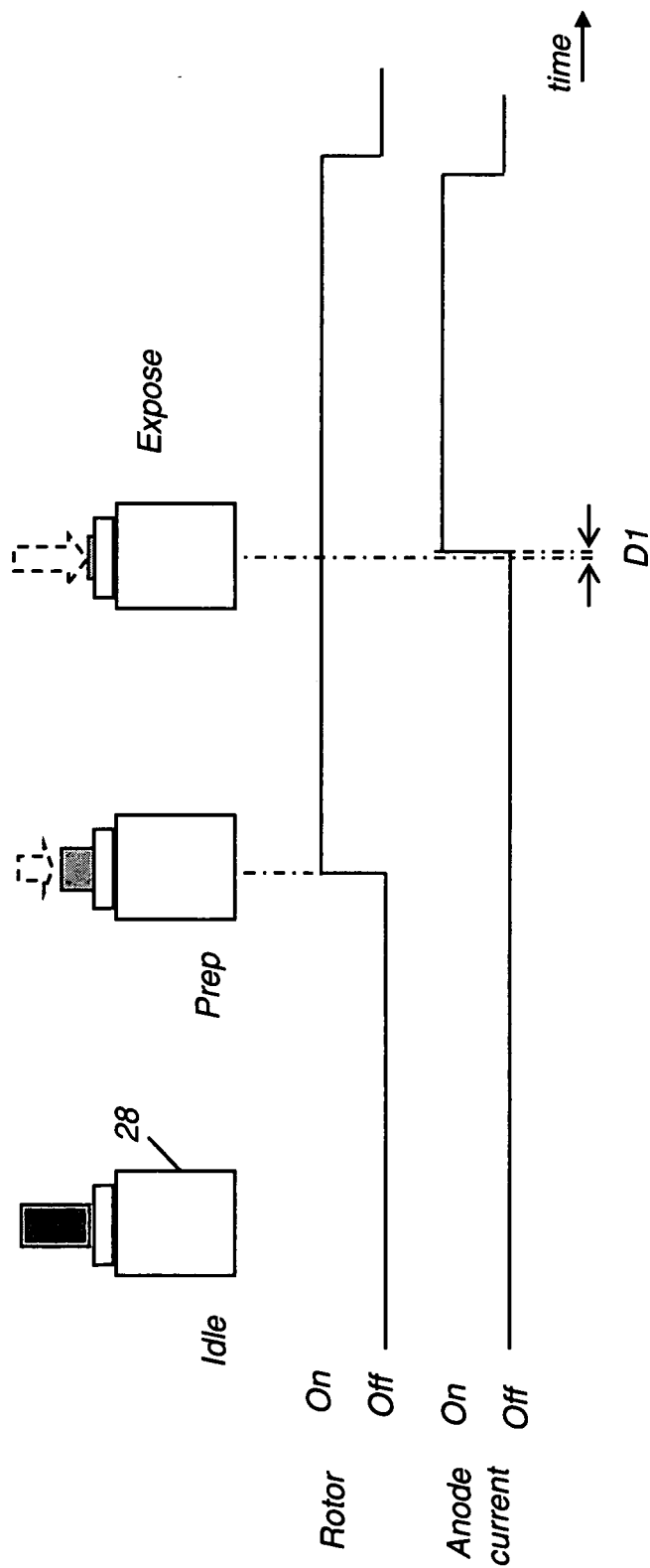
5                   18. The apparatus of claim 16 wherein the switch controller further comprises at least one actuator that is controlled by a signal from the interface component on the generator interface channel.





**FIG. 1A**

(Prior Art)



**FIG. 1B**

(Prior Art)

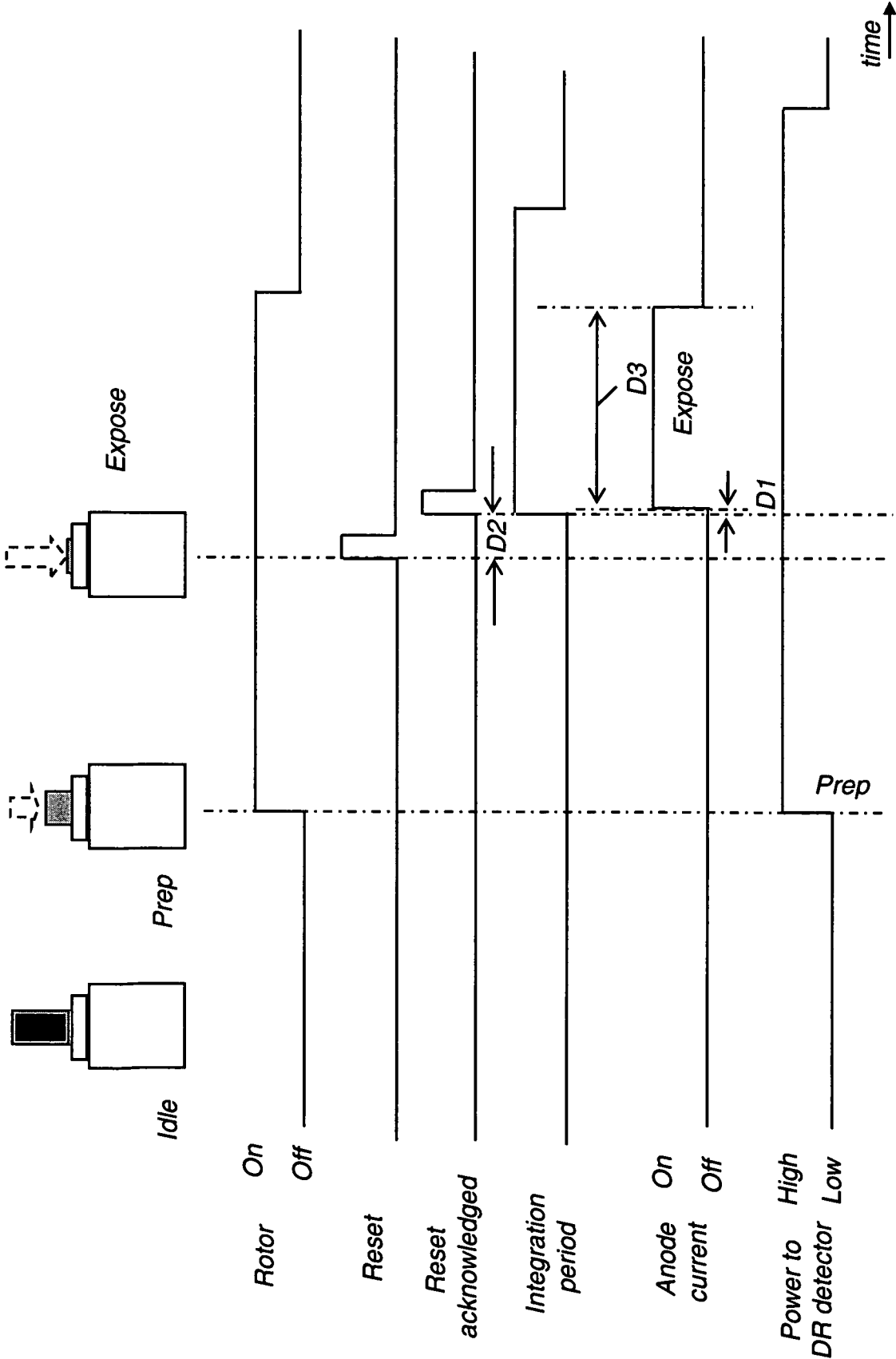
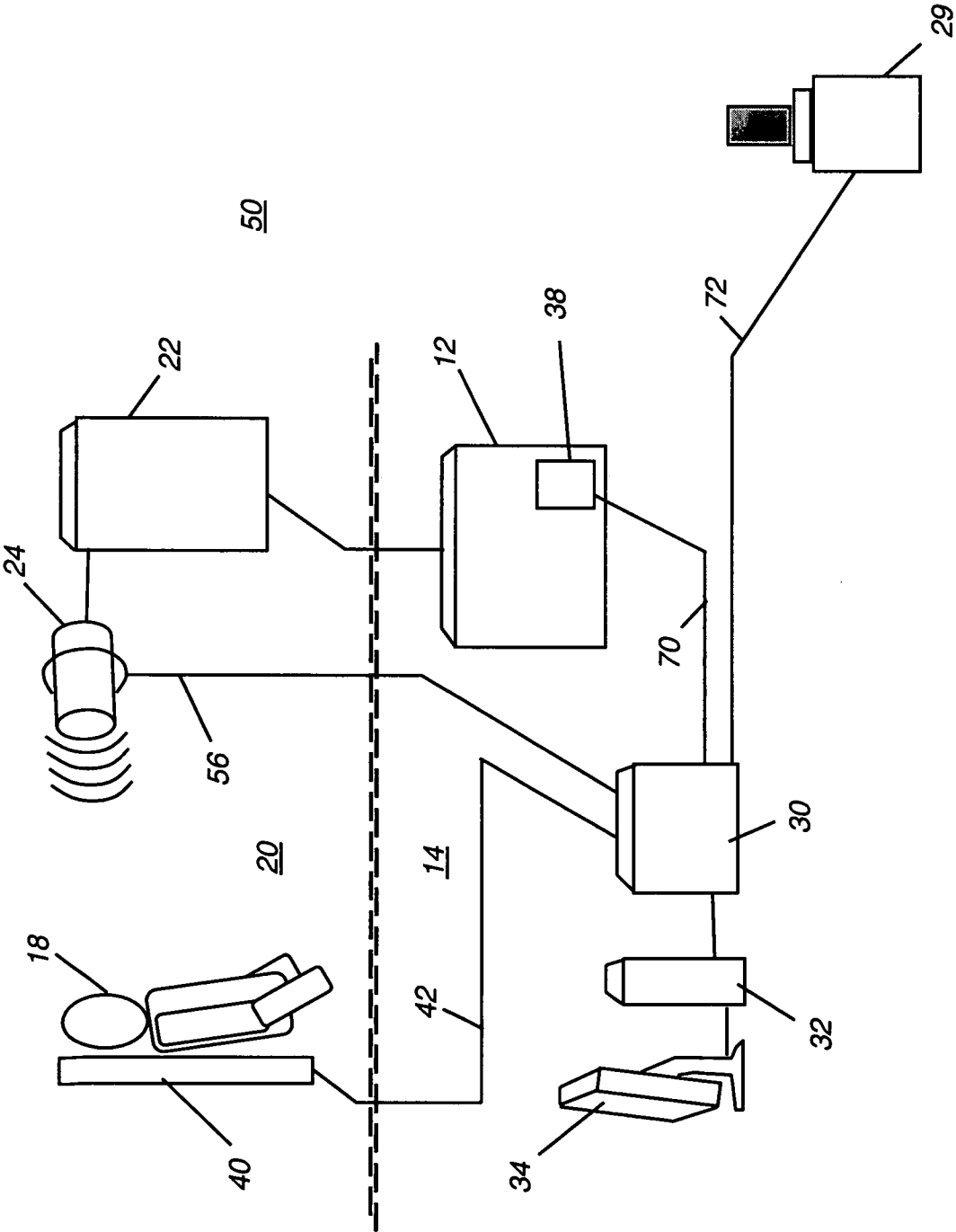


FIG. 2



**FIG. 3**

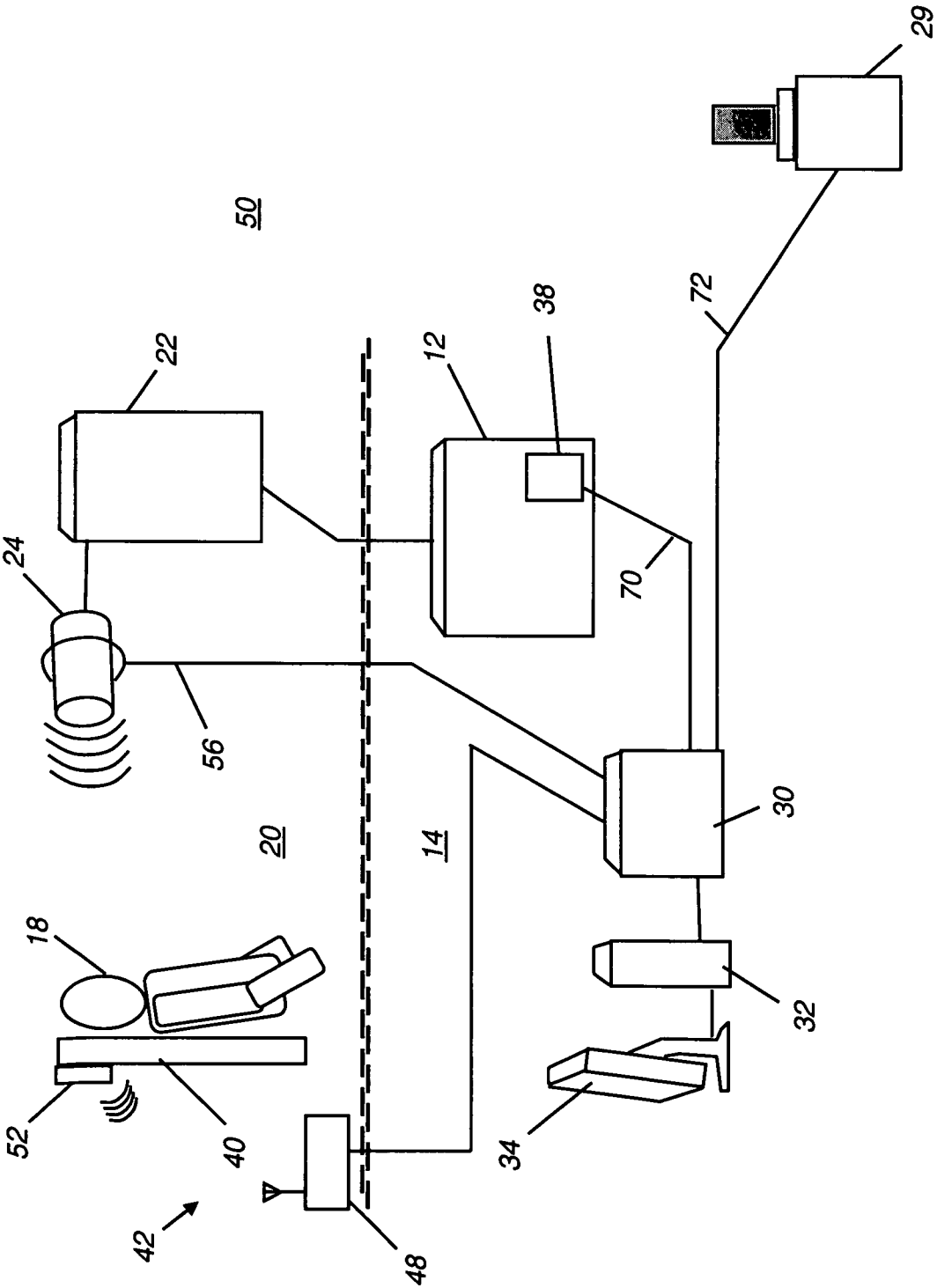
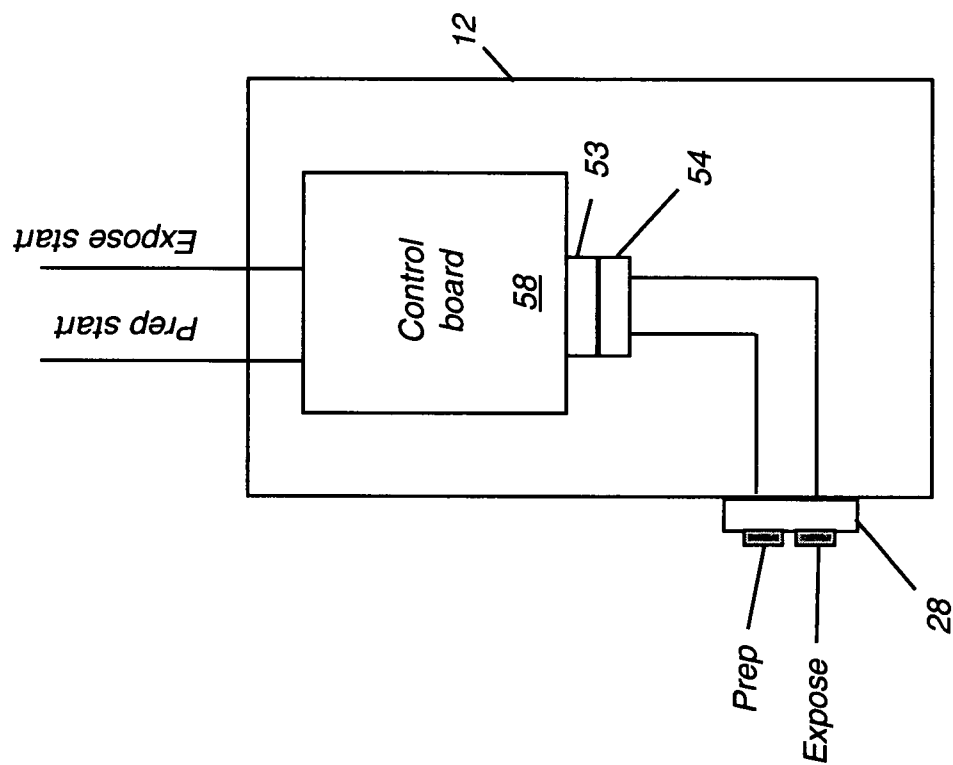
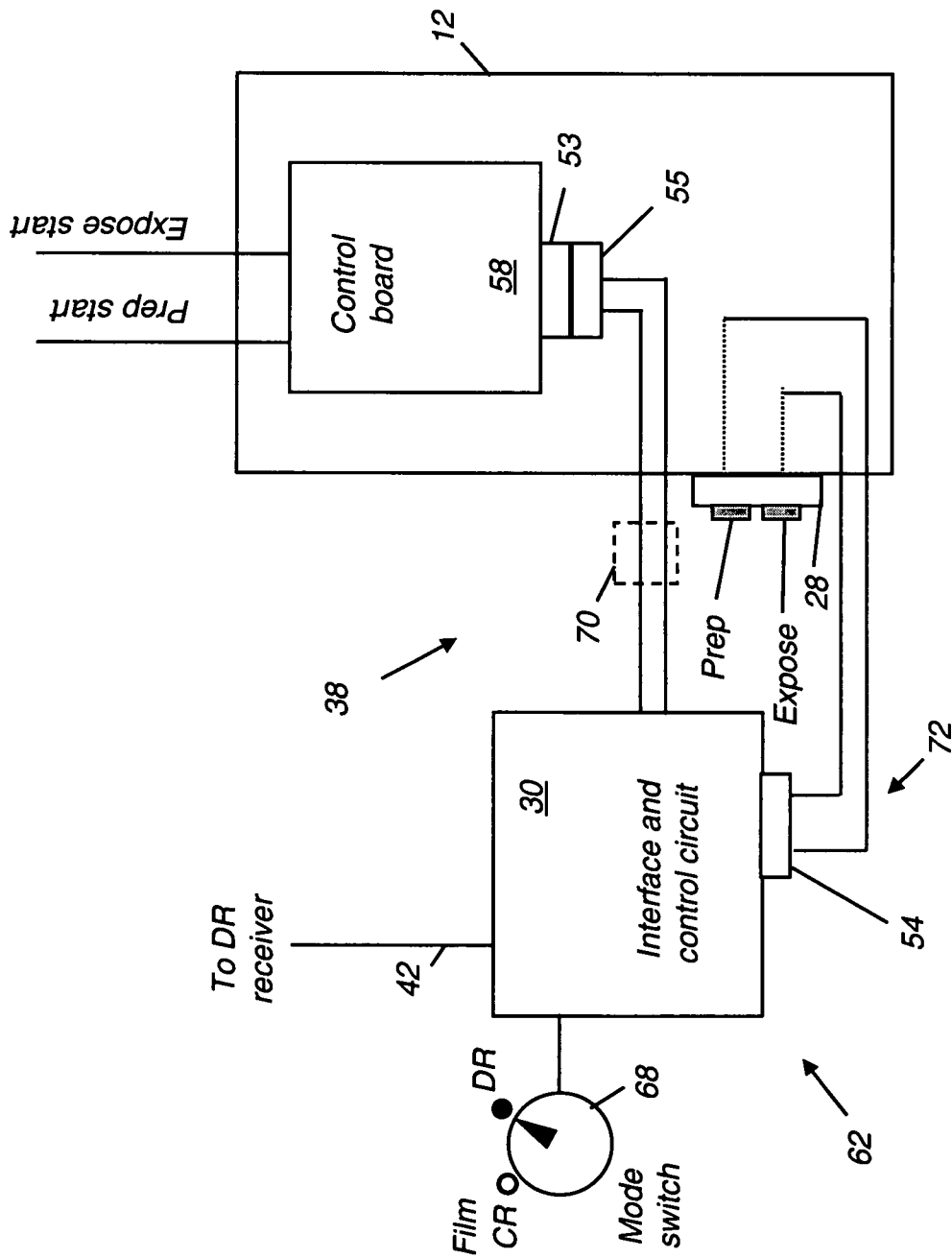


FIG. 4



**FIG. 5A**  
*(Prior Art)*

7/18



**FIG. 5B**

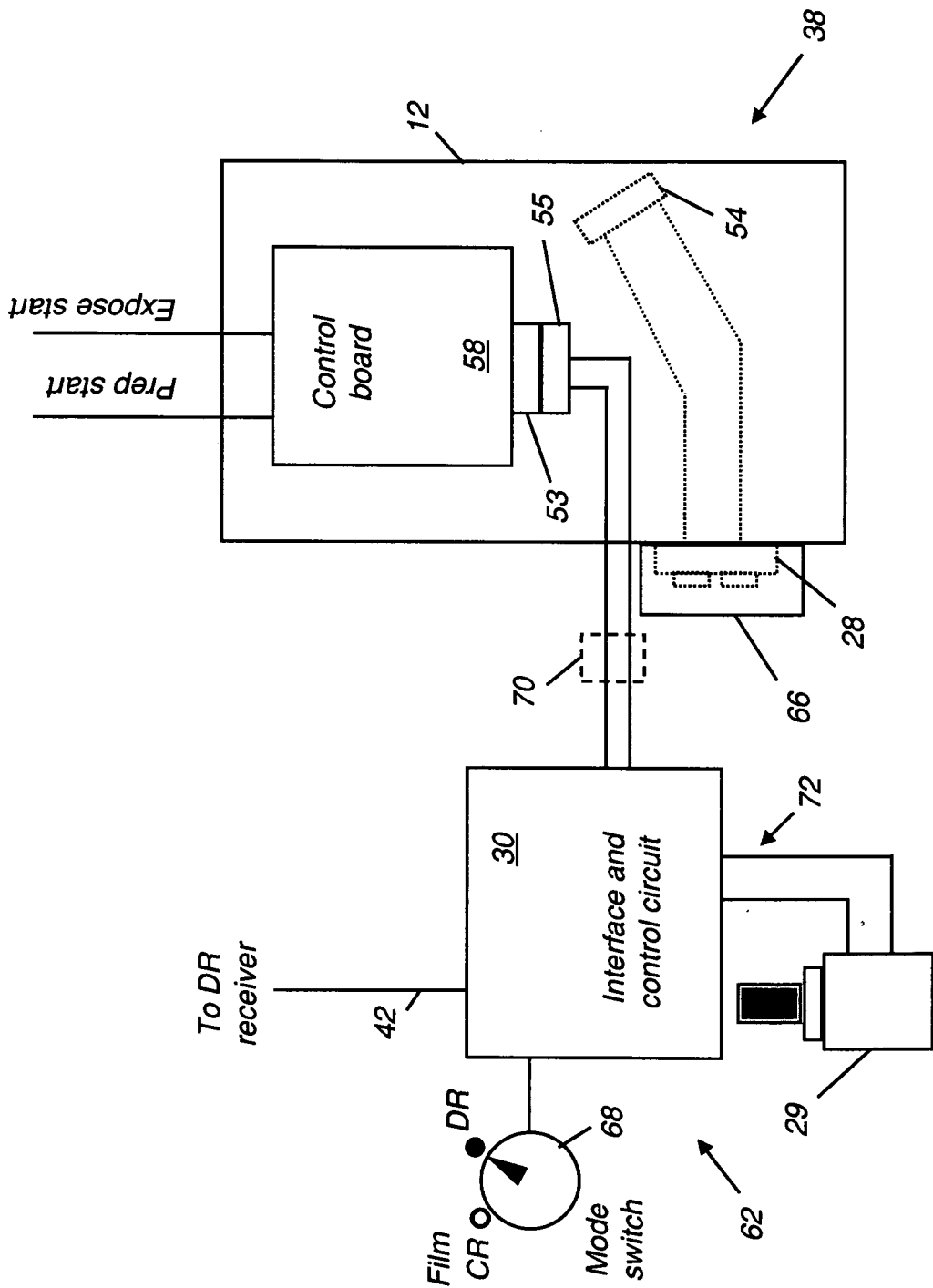


FIG. 5C



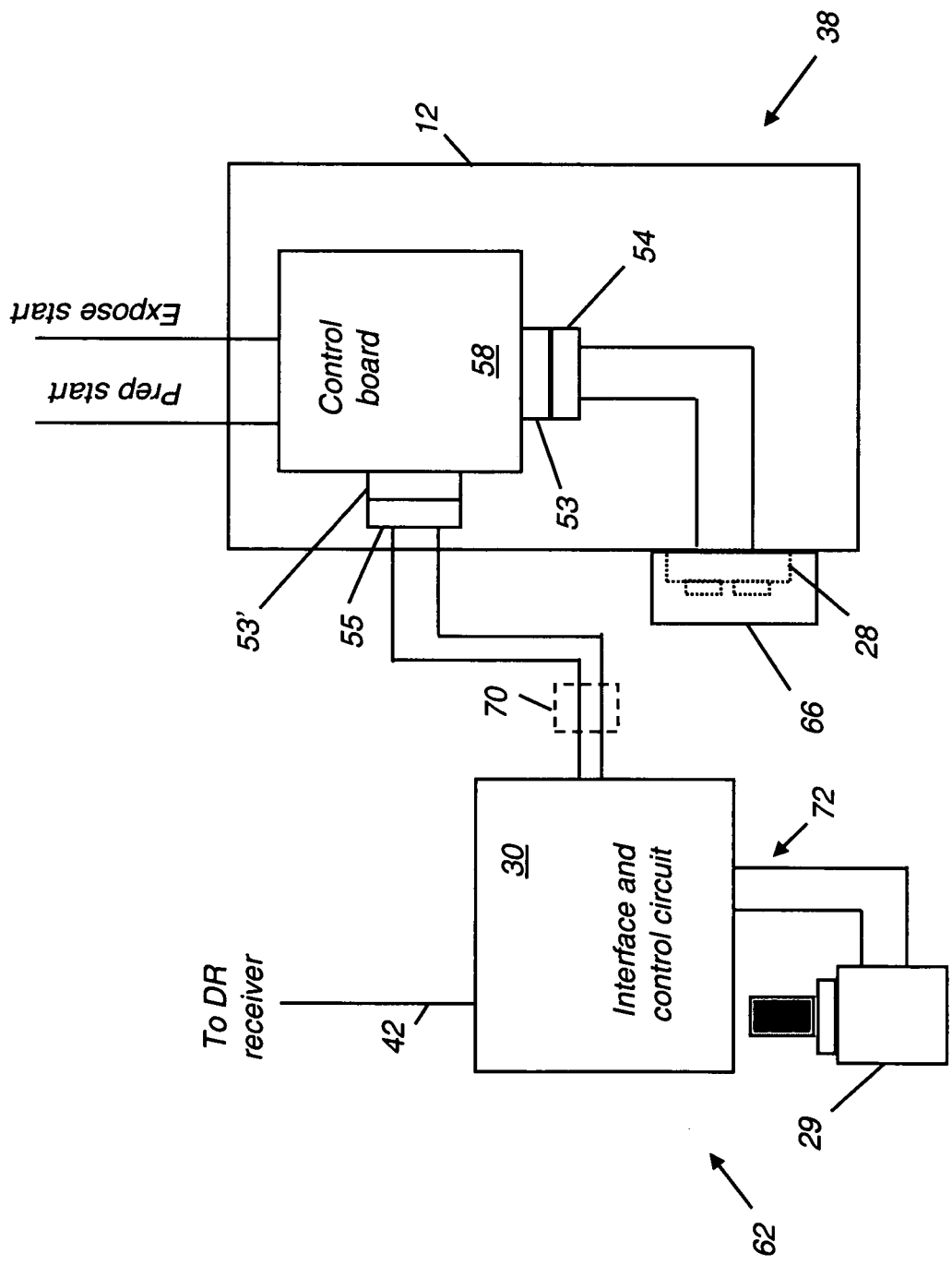


FIG. 5D

10/18

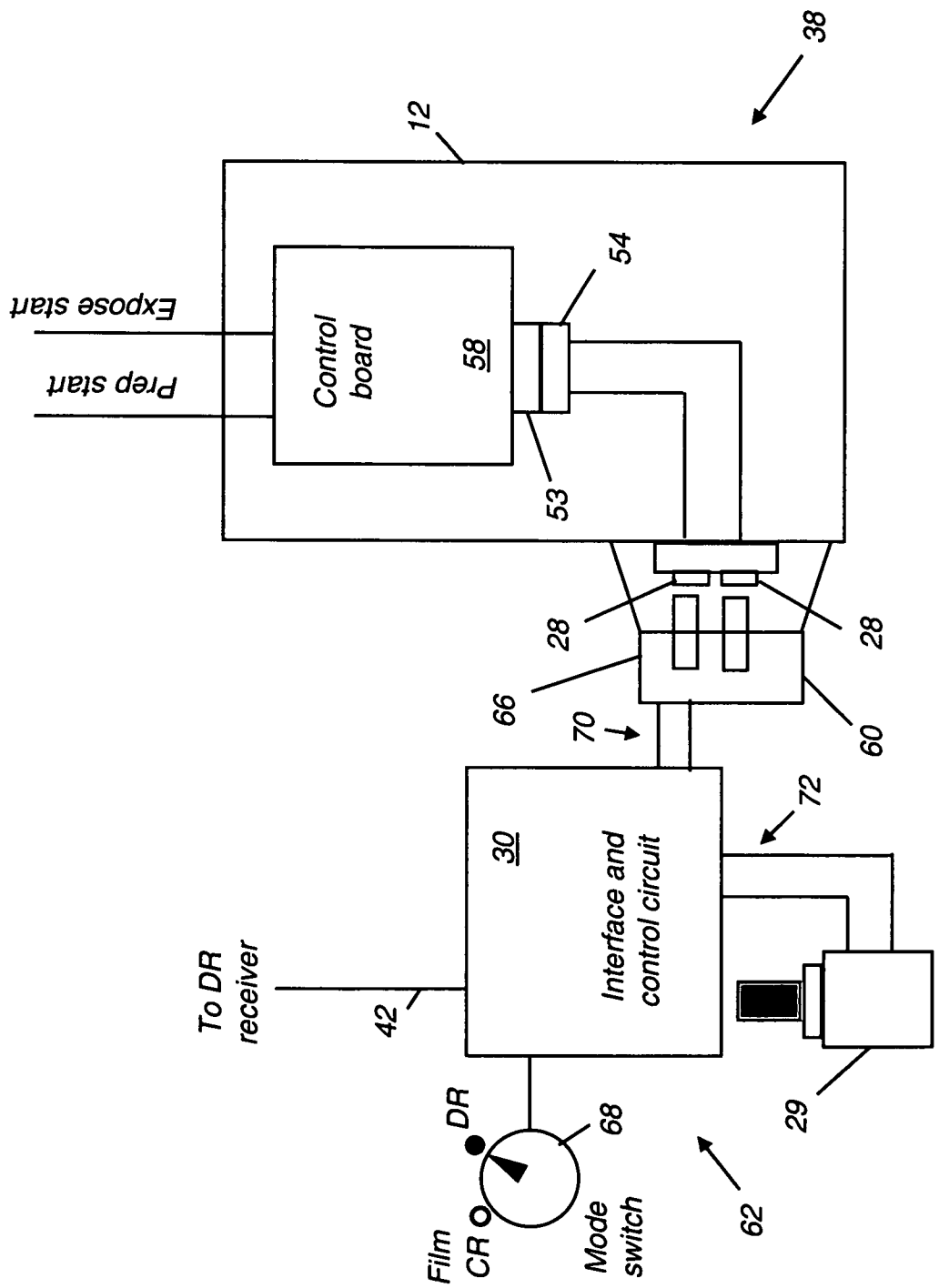


FIG. 5E

11/18

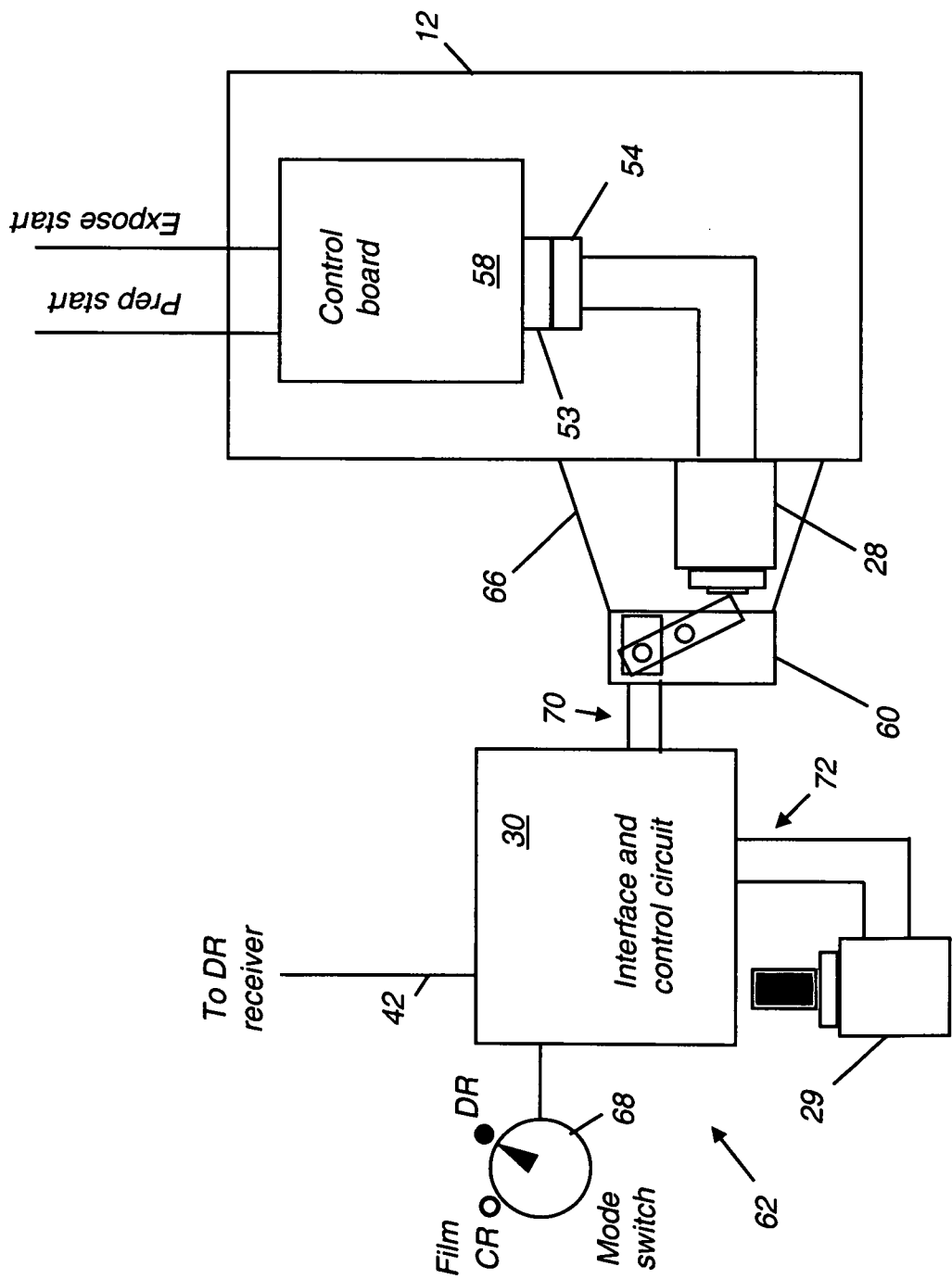
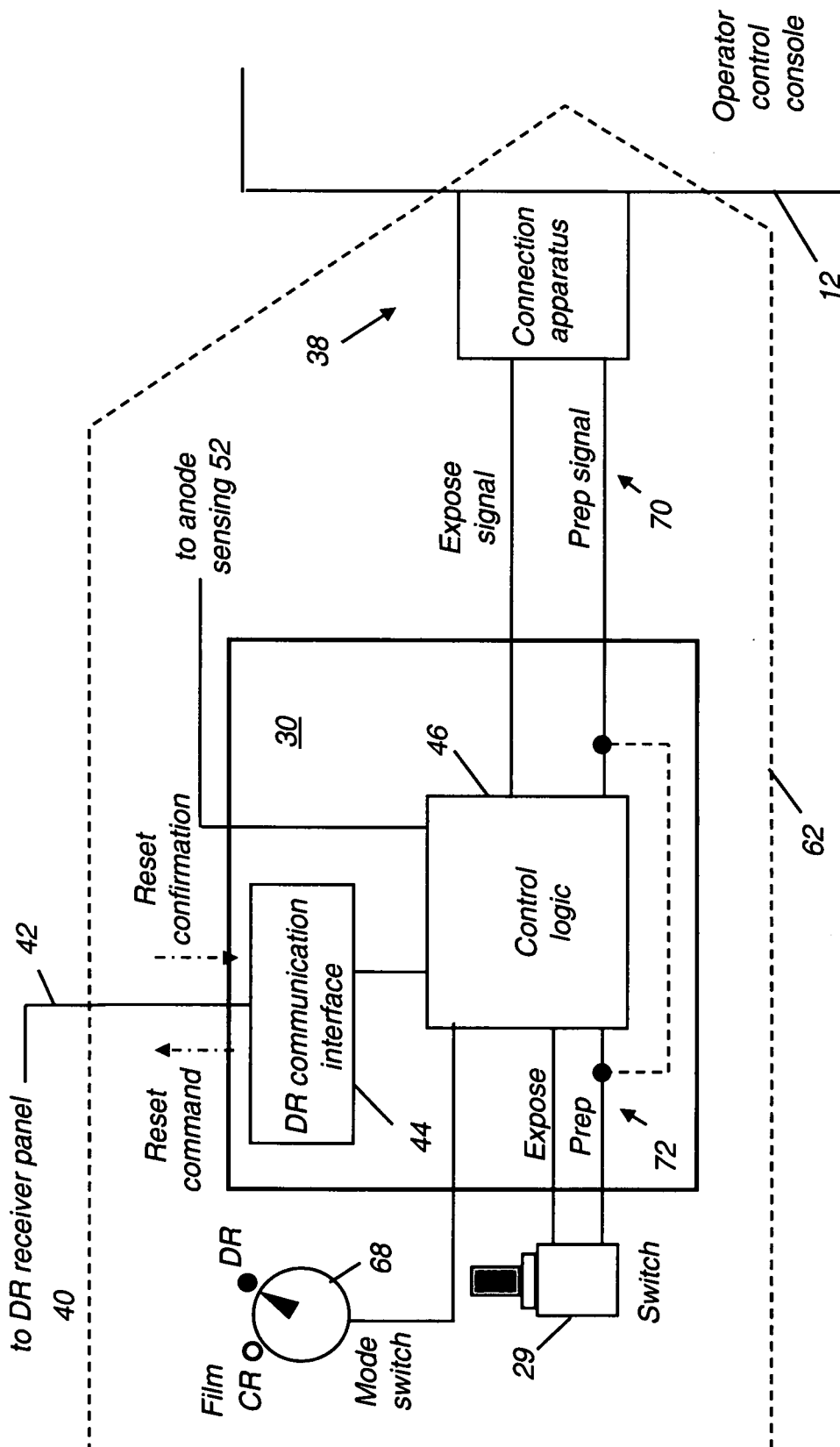
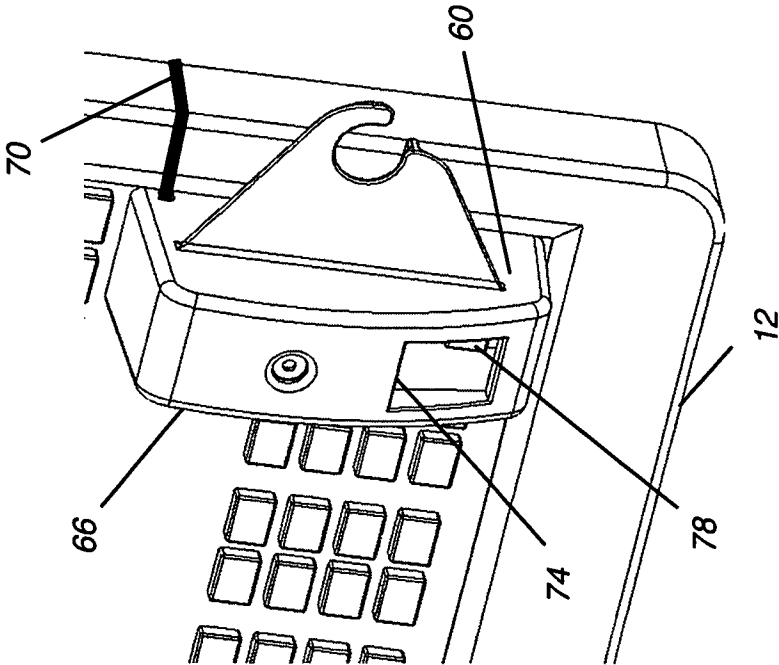


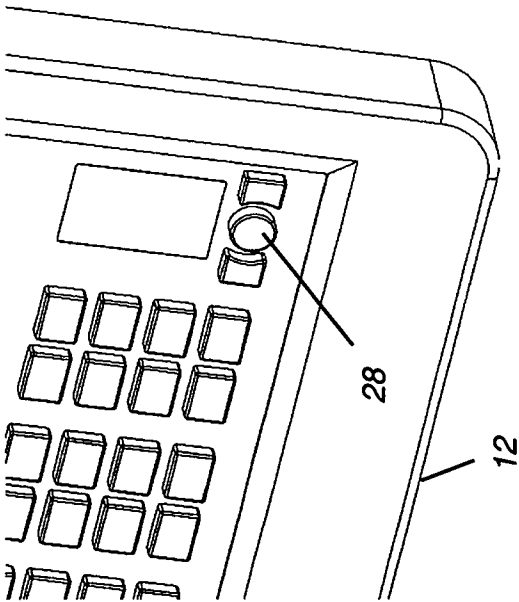
FIG. 5F



**FIG. 6**



**FIG. 7B**



**FIG. 7A**

(Prior Art)

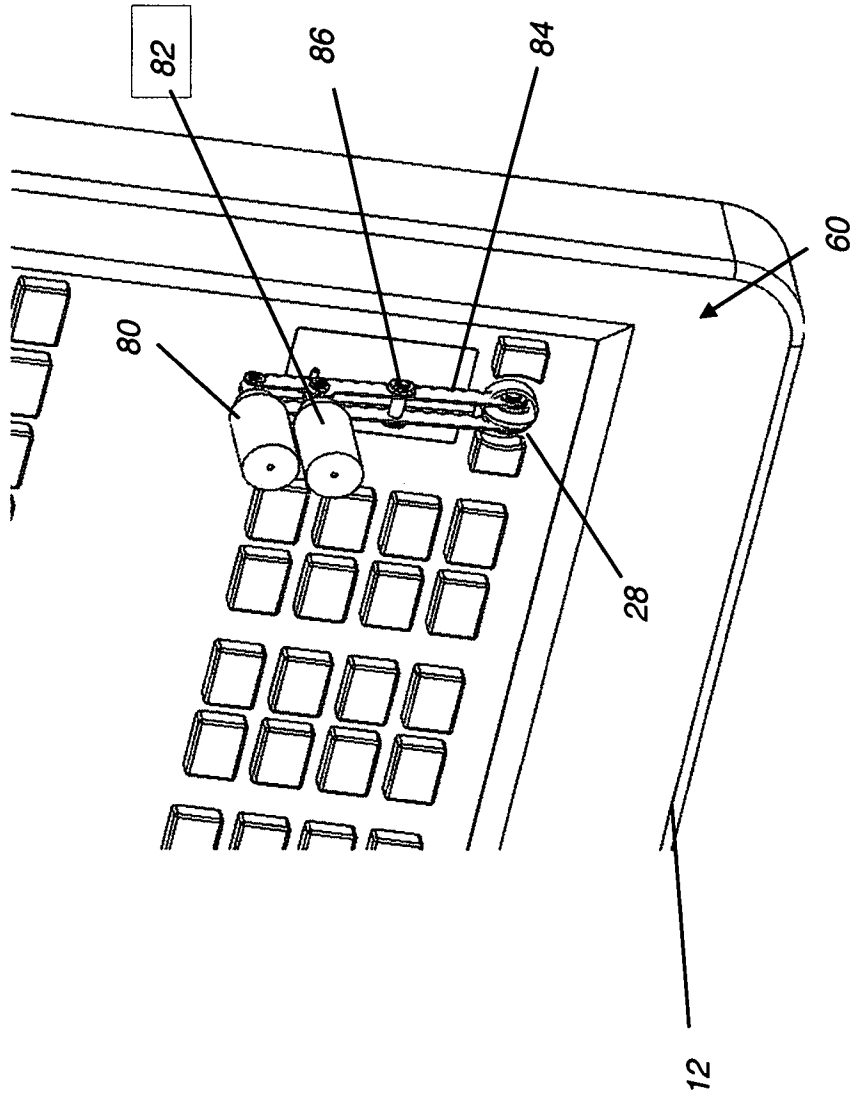
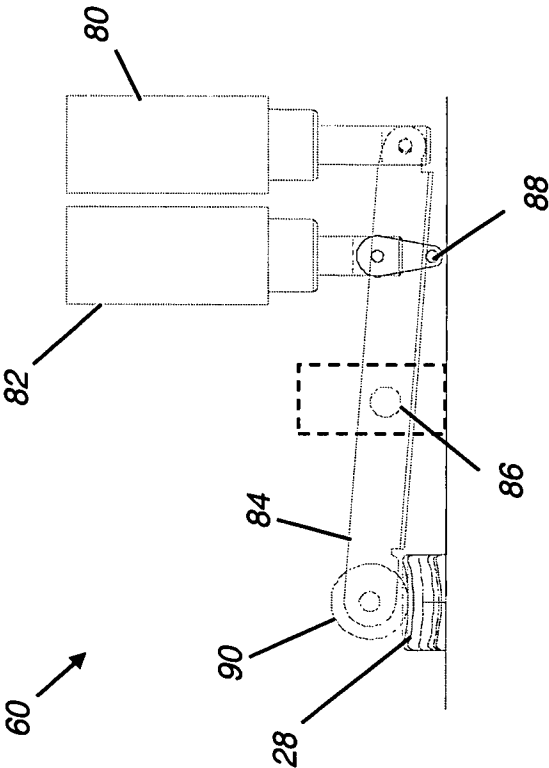
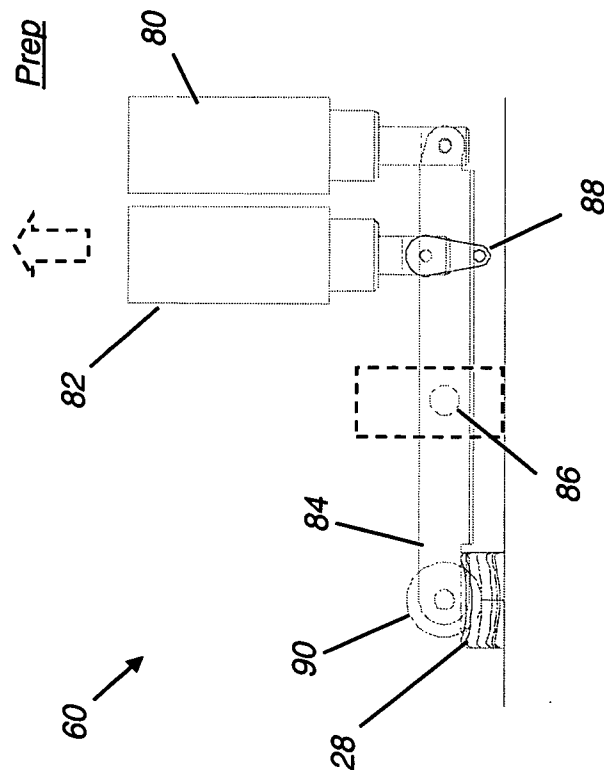


FIG. 8



**FIG. 9A**



**FIG. 9B**



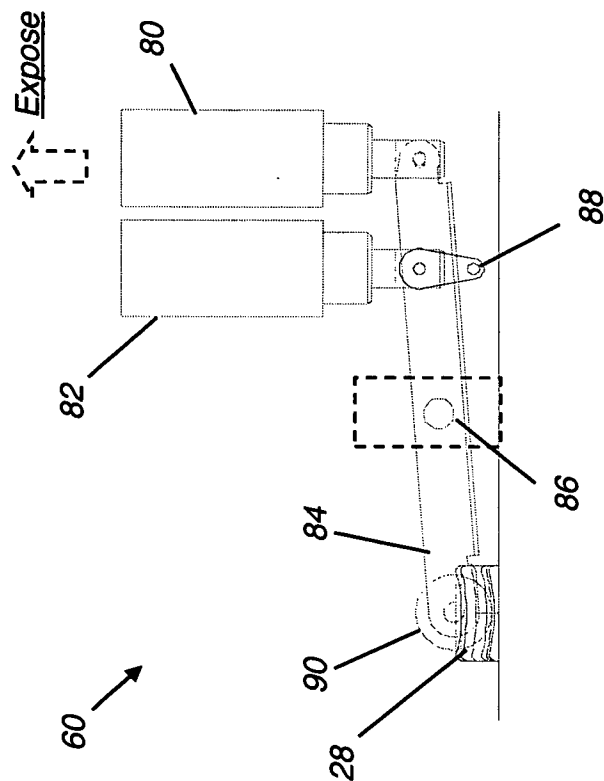
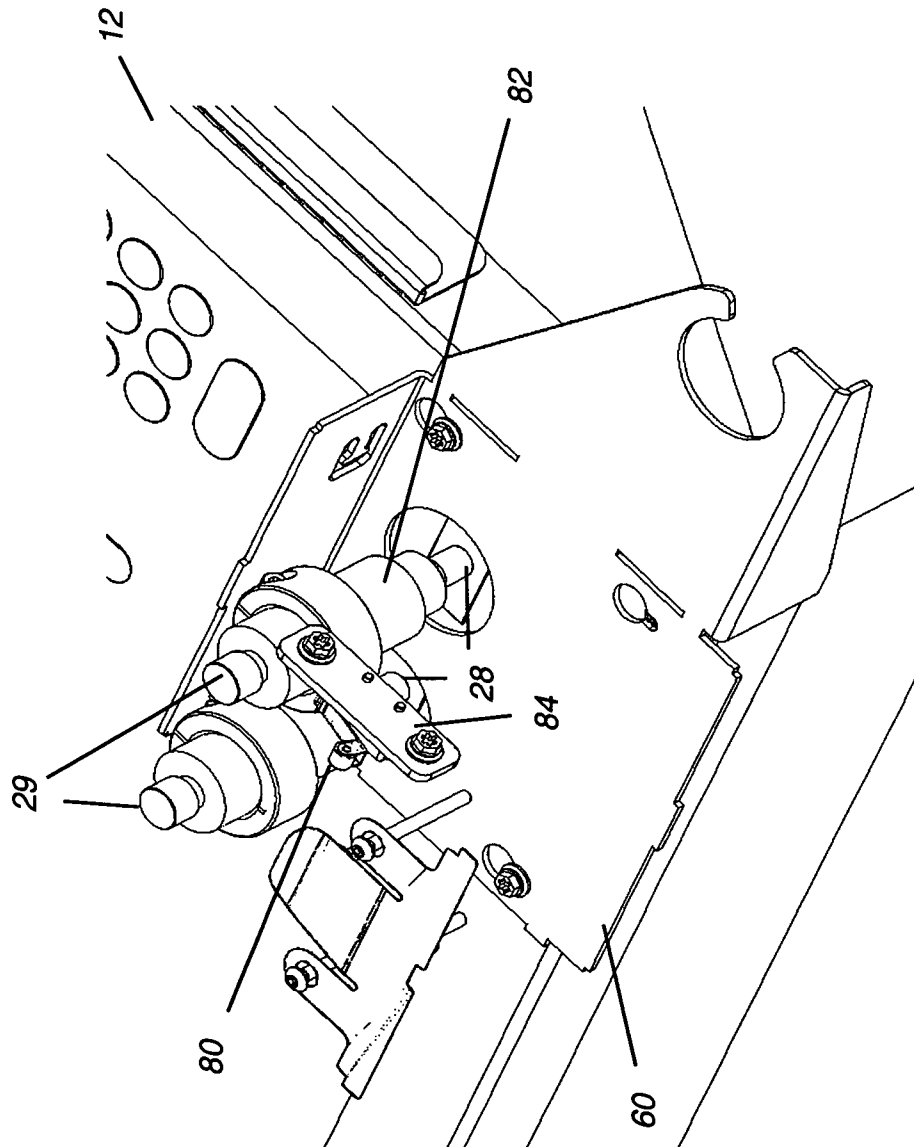


FIG. 9C

18/18



**FIG. 10**

# INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2008/012872

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. A61B6/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/098920 A2 (RAPP INFORMATIK SYSTEME GMBH [DE]; RAPP WOLFGANG [DE]) 7 September 2007 (2007-09-07) abstract; figures 1-4 page 1, line 3 - page 3, line 21 page 6, line 27 - page 10, line 4; claim 1	1-18
X	ANONYMOUS: "CDRPan FOR PANORAMIC SYSTEMS Installation - Instructions for Panoramic Corporation PC-1000" CDRPAN INSTALLATION GUIDE, [Online] October 2000 (2000-10), XP002516607 Retrieved from the Internet: URL: <a href="http://www.schicktech.com/uploads/downloads/B1051101Rev-.pdf">http://www.schicktech.com/uploads/downloads/B1051101Rev-.pdf</a> [retrieved on 2009-02-24]	1,3,5-10
A	the whole document ----- -/--	11-18

☒ Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search

24 February 2009

Date of mailing of the international search report

19/03/2009

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# INTERNATIONAL SEARCH REPORT

International application No

PCT/US2008/012872

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01/33921 A1 (STERLING DIAGNOSTICS IMAGING I [US]; CROWELL JOHN ARNOLD [US]; KENYON) 10 May 2001 (2001-05-10) abstract; figures 1-7 page 3, line 9 - page 4, line 29 page 6, line 25 - page 8, line 27 -----	1-18
A	US 2007/145280 A1 (CAMPBELL WILLIAM E [US]) 28 June 2007 (2007-06-28) abstract; figures 1A-B,4 paragraphs [0004] - [0009], [0034] - [0041] -----	1-18

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Information on patent family members

International application No

PCT/US2008/012872

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		EP 1285559 A1	26-02-2003
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