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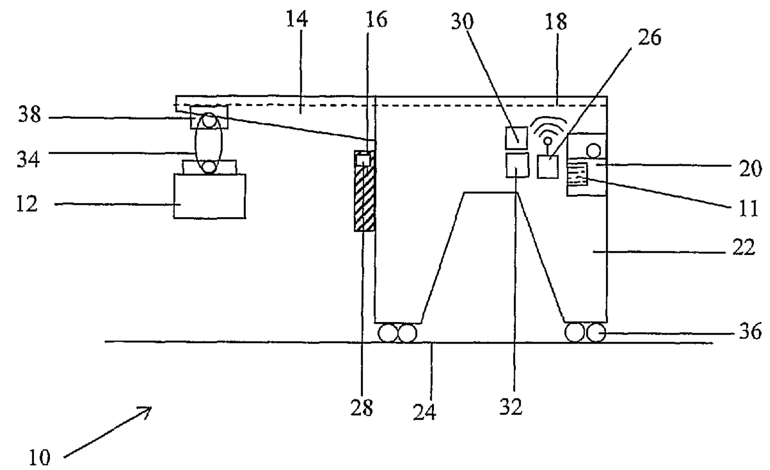
(54) **Title**: SCANNER SYSTEMS

Fig. 1



(57) **Abstract**: A crane comprises support means arranged to support a load and to move the load along a path, and a scanner comprising a radiation source and radiation detection means arranged to scan a scanning volume. The path is arranged to pass through the scanning volume so that the scanner can scan the load as it moves along the path.

WO 2009/141601 A2

SCANNER SYSTEMS

Field of the Invention

The present invention relates to scanning systems, and has particular application in cargo scanning systems.

Background of the invention

There exists a requirement for screening of cargo for detection of illicit materials and devices. Today, the X-ray inspection of containers and other cargo items is becoming more routine. However, the costs of container inspection by this means may be prohibitive in some situations due to the requirement to position the cargo load for inspection separately from its positioning for storage or onwards transport.

As an example, cargo is often taken to a separate scanning area and remains stationary while a moving radiation source and detection system pass along the load. Alternatively, the load is placed onto a moving conveyor and is moved through a stationary imaging system. In either case, the cargo is moved to a separate scanning location to be inspected, resulting in increased cost and time for cargo handling.

Summary of the Invention

The present invention therefore provides a crane comprising support means arranged to support a load and to move the load along a path, and a scanner comprising a radiation source and radiation detection means arranged to scan a scanning volume, wherein the path is arranged to pass through the scanning volume so that the scanner can scan the load as it moves along the path.

The support means may comprise a carrier and suspension means arranged to suspend the load from the carrier. The carrier may be movable in order to move the load along the path.

The detection means may comprise a plurality of detectors mounted on a support structure. The support structure may extend around the scanning volume and define a gap through which a part of the supporting means can pass as the load is moved through the scanning volume, wherein the gap may be in an upper side of the support structure, and a part of the support structure supporting at least one of the detectors may extend upwards adjacent to the gap so as to detect radiation from the source that passes through the gap. The radiation source may be arranged to direct all radiation horizontally or at least partially upwards. The source may be located below the scanning volume.

The crane may further comprise load monitoring means arranged to determine when a load is in the scanning volume and control means arranged to control the scanner in response to signals from the load monitoring means. Optionally, the control means is arranged to determine the position and speed of the load and to control the scanner in response thereto or is arranged to control a pulse frequency of the radiation source dependent on the speed of the load.

The system may further comprise identification means arranged to identify a load and associate scan data from the scanner with a specific load identity. The system may comprise wireless transmission means arranged to transmit scan data from the scanner to a remote station for analysis or transmit scan data from a plurality of cranes to a remote station for analysis.

The present invention further provides a method of scanning a load, comprising moving the load along a path by means of a crane, whilst the load is supported by the crane and the path passes through a scanning volume defined by a scanning system, and scanning the load using the scanning system as it moves along the path.

A system configuration and mode of utilisation may be provided for high throughput screening at large container based facilities with high load throughput. Container ports rely on the use of large cranes for moving containerised cargo from ship to shore and vice versa. An advantage of the present invention is that the cargo can be scanned while in transit, therefore saving time and costs by avoiding the need to take the cargo to a separate scanning location.

Brief Description of the Drawings

Preferred embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of a crane according to an embodiment of the invention.

Figure 2 is a diagram of an imaging system according to an embodiment of the invention.

Figure 3 is a schematic diagram of the imaging system of Figure 2 including a load according to an embodiment of the invention.

Figure 4 is a schematic diagram showing the movement of a load between modes of transport.

Figure 5 is a schematic diagram of a data acquisition system according to an embodiment of the invention.

Description of the Preferred Embodiments

Referring to Figure 1, a crane 10 comprises a main frame 22 supported on wheels 36. A supporting structure 14 projects horizontally from the top of the main frame 22. An operator pod 20 is attached to, or is integral with, the main frame 22 of the crane and includes a control panel 11. A rail 18 extends horizontally along the length of the supporting structure 14 and the frame 22. A carrier 38 is attached to, and moveable along the rail 18. A suspension system 34 is attached to the carrier 38 and may comprise a pulley or winch system. A load 12 can be attached to and suspended by the suspension system 34 by any suitable means as known to a skilled person, such that the load 12 can be moved both vertically and horizontally, along a path which extends along the length of the crane on the rail 18. A scanning system 16 is securely attached to the main frame 22 of the crane 10 and is positioned on the same side of the crane 10 as the supporting structure 14 and below the supporting structure 14. A control system 32, communication system 26 and identification system 30 are mounted on or within the crane 10.

As can be seen from Figures 2 and 3, the scanning system 16 comprises a rectangular support frame 52 which extends around an imaging volume 42, defining an aperture through which the load 12 can pass. A gap 46 is defined in the upper side of the support frame 52 through which the suspension system 34 can pass as the load 12 is moved through the scanning volume 42. A part 54 of the support frame 52 extends vertically upwards from the upper side of the support frame adjacent to the gap 46, on the opposite side of the gap 46 to the X-ray source 44, such that the vertical part 54 is positioned approximately diagonally opposite to the X-ray source in the scanning plane of the scanning system 16.

The scanning system 16 includes an X-ray source in the form of a high energy X-ray linear accelerator 44 (typically 6MV to 9MV beam quality) mounted at a lower corner of the support frame 52. The X-ray linear accelerator 44 includes radiation shielding such that a fan-beam of X-radiation is directed upwards towards an array of individual X-ray detection elements 48 mounted on the support frame 52. The shielding is inherent to the X-ray LINAC package and comprises bulk shielding around the X-ray accelerator plus a fan-shaped lead collimator which projects the X-ray beam into the object. The detection elements 48 are grouped into short linear segments 50, each in the range typically 100mm to 200mm in length. Each of the segments 50 is positioned in a common scanning plane and so that the normal to the centre of each of the linear segments 50 points towards the X-ray source 44. Sufficient sets of segments 50 are positioned within and mounted to the support frame 52 such that X-ray beams that intersect with all parts of the load 12 under inspection will reach a detecting element 48. Detecting segments 50 positioned in the vertical part 54 of the support frame 52 adjacent the gap 46 are arranged to detect radiation from the source 44 that passes through the gap 46.

Because the scanning system 16 is located above ground level and the X-ray beams are directed horizontally or at least partially upwards, little radiation shielding is required to ensure that safe radiation levels are met at ground level. Typically, the crane operator will be a sufficient distance from the X-ray imaging system such that their operating pod 20 need not be shielded.

Referring to Figure 4, the load 12 will be able to move in three dimensions as it migrates from off-loading site 60 to loading site 64 (or vice versa). The crane 10 can move in two dimensions on the ground. When suspended by the crane 10, the load 12 can be moved vertically by operation of the suspension system 34, and horizontally by movement of the carrier 38 along the rail 18, with respect to the crane 10.

The movement of the crane 10 on the ground is controlled by an operator. The control system 32 receives inputs from the control panel 11 and outputs signals to a drive system of the crane 10 to move the crane 10 along the ground in response. The movement of the carrier 38 and the suspension system 34 is also controlled by an operator. The control system 32 receives inputs from the control panel 11 and operates the movement of the carrier 38 and suspension system 34 in response. The scanning system 16 is operated automatically by the control system 32, as described below. The load 12 can therefore be scanned while being moved along the length of the main frame 22 and supporting structure 14 of the crane 10 and while being moved between the off-loading site 60 and the loading site 64. Typically, the load 12 will be scanned through the scanning volume 42 at a speed of around 0.25 m/s. For a standard 40 foot load, this means an X-ray imaging system scan time on the order of 5 seconds. Attenuation data for each load is collected and stored by the control system 32.

The scanning system 16 further comprises a load monitoring system 28, located within the scanning system 16, which detects the presence of a load 12 entering the scanning volume 42. When a load 12 is detected, a signal is output to the control system 32. The control system 32 processes the signal and automatically activates the X-ray source 44 in response. Similarly, the load monitoring system 28 can detect the absence of the load 12 within the scanning volume 42 (i.e. after a scan of the load 12 is complete) and output a signal to the control system 32 to switch off the X-ray source 44 accordingly. The load monitoring system 28 may include an infrared sensor, a video camera, or any other suitable means known to a person skilled in the art. In an alternative embodiment, the scanning system 16 is manually operated and the control system 32 operates the X-ray source 44 in response to user inputs to the control panel 11.

The load monitoring system 28 monitors the position and speed of the load 12 as it passes through, and just before it passes through, the scanning volume 42. This information is output to the control system 32. The control system 32 controls the pulse repetition frequency of the X-ray linear accelerator 44 in response to the information in order to ensure equal distance between samples in the direction the load 12 is moved along the length of the crane 10. In another embodiment, the control system 32 itself directly monitors the position and speed of the load 12 as it controls its movement along the rail 18 and controls the pulse repetition frequency of the X-ray source 44 in response.

Prior to image interpretation, it is necessary to calibrate the X-ray image data. In this particular imaging system, the distance between each detector segment 50 and the X-ray source 44 varies considerably. This is particularly true for segments 50 located in the vertical part 54 of the support frame 52 adjacent to the gap 46. To achieve a satisfactory calibration, it is necessary to collect some X-ray data prior to the start of imaging and further X-ray data immediately after imaging in order that suitable correction factors can be calculated for image calibration.

In a further aspect of this invention, an identification system 30 identifies each load 12 as it moves through the scanning system 16. The identification system 30 may comprise a camera, video camera, infrared barcode scanner or any other suitable means as known to a person skilled in the art. The load number, barcode or other identity information marked on the load 12 is captured by the identification system 30 as the load 12 passes through the scanning system 16. The identification system 30 outputs the identity information for each load 12 to the control system 32 which labels the X-ray attenuation data with the corresponding identity information for each load 12.

Corresponding image and identification data for each load 12 is collected and stored by the control system 32 in a combined data set for each load 12. Referring to Figure 5, the control system 32 feeds the combined data set for each load 12 to a wireless communication system 26 which transmits the combined data set for each load 12, for example by using a wireless Ethernet protocol, to a remote inspection station 68 for analysis. This allows data from a multiple crane imaging systems to be interpreted analysed centrally and remotely. An image generated from scan data associated with a particular load is displayed on a monitor for inspection.

CLAIMS

1. A crane comprising support means arranged to support a load and to move the load along a path, and a scanner comprising a radiation source and radiation detection means arranged to scan a scanning volume, wherein the path is arranged to pass through the scanning volume so that the scanner can scan the load as it moves along the path.

2. A crane according to claim 1 wherein the support means comprises a carrier and suspension means arranged to suspend the load from the carrier.

3. A crane according to claim 2 wherein the carrier is movable to move the load along the path.

4. A crane according to any foregoing claim wherein the detection means comprises a plurality of detectors mounted on a support structure.

5. A crane according to claim 4 wherein the support structure extends around the scanning volume and defines a gap through which a part of the support means can pass as the load is moved through the scanning volume.

6. A crane according to claim 5 wherein the gap is in an upper side of the support structure, and a part of the support structure supporting at least one of the detectors extends upwards adjacent to the gap so as to capture radiation from the source that passes through the gap.

7. A crane according to any foregoing claim further comprising load monitoring means arranged to determine when a load is in the scanning

volume and control means arranged to control the scanner in response to signals from the load monitoring means.

8. A crane according to claim 7 wherein the control means is arranged to determine the position and speed of the load and to control the scanner in response thereto.

9. A crane according to claim 8 wherein the control means is arranged to control a pulse frequency of the radiation source dependent on the speed of the load.

10. A crane according to any foregoing claim wherein the radiation source is arranged to direct all radiation horizontally or at least partially upwards.

11. A crane according to any foregoing claim further comprising identification means arranged to identify a load and associate scan data from the scanner with a specific load identity.

12. A crane according to any foregoing claim further comprising wireless transmission means arranged to transmit scan data from the scanner to a remote station for analysis.

13. A system comprising a plurality of cranes according to any foregoing claim, wherein scan data from each crane is transmitted to a remote station for analysis.

14. A method of scanning a load, comprising moving the load along a path by means of a crane, whilst the load is supported by the crane and the path passes through a scanning volume defined by a scanning system,

and scanning the load using the scanning system as it moves along the path.

Fig. 1

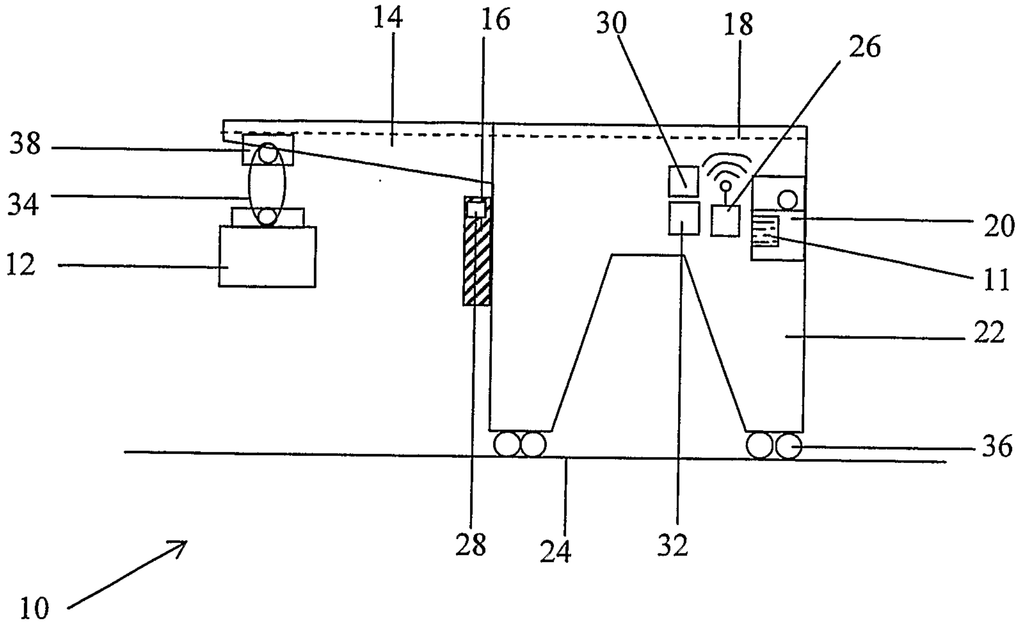


Fig. 2

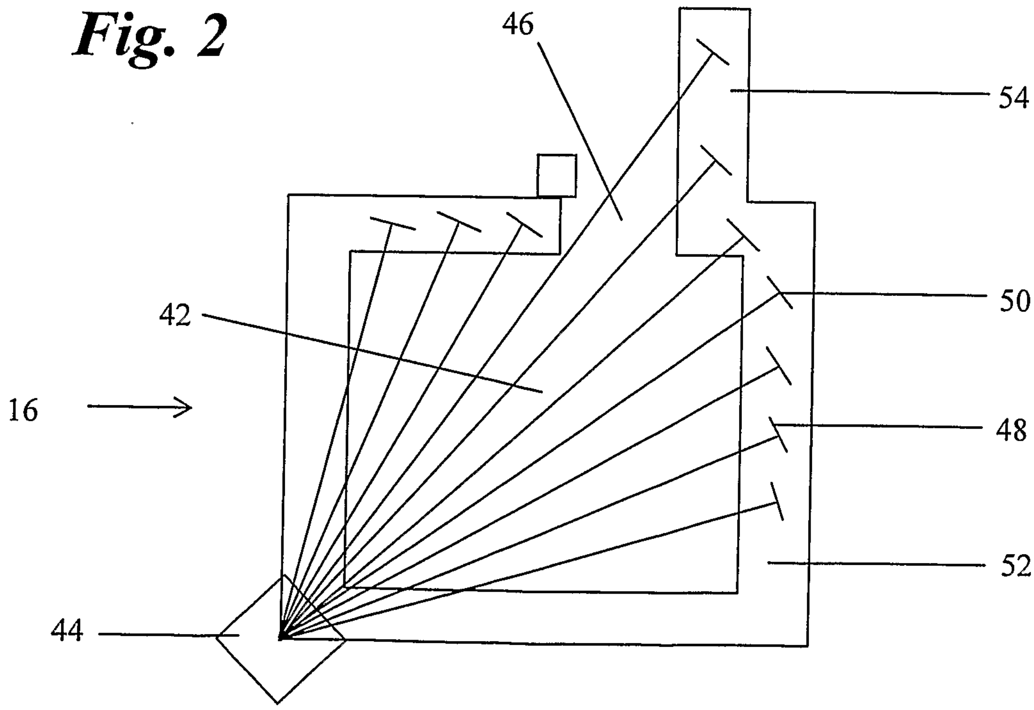


Fig. 3

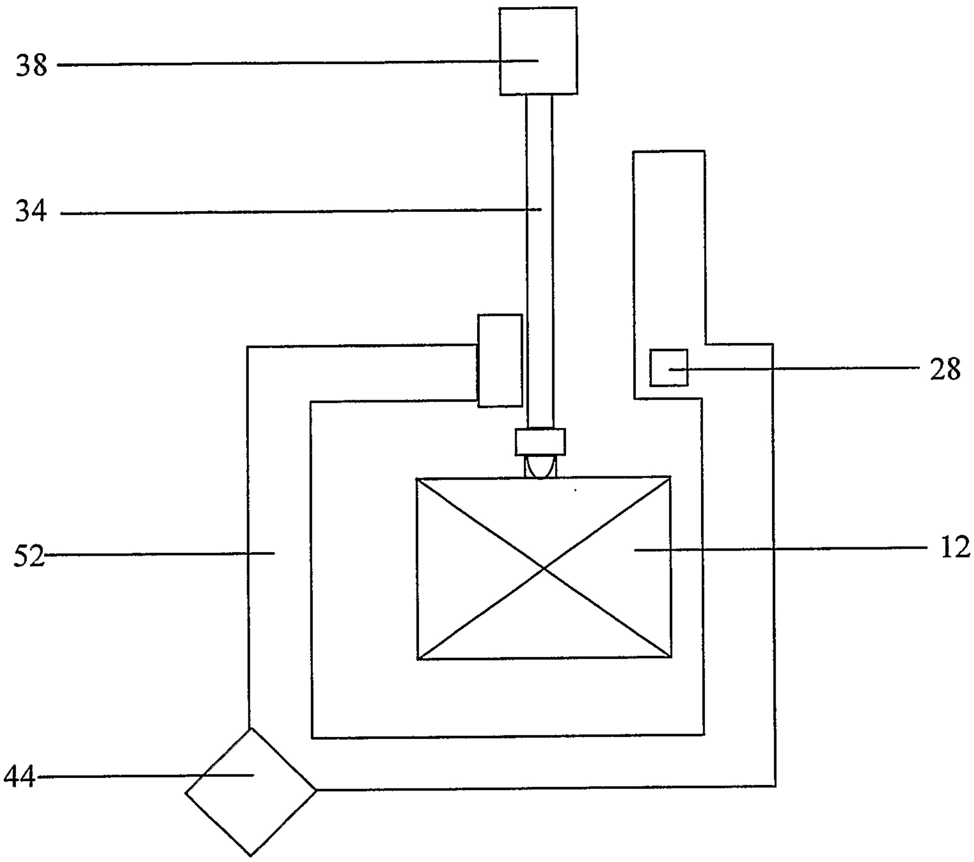


Fig. 4

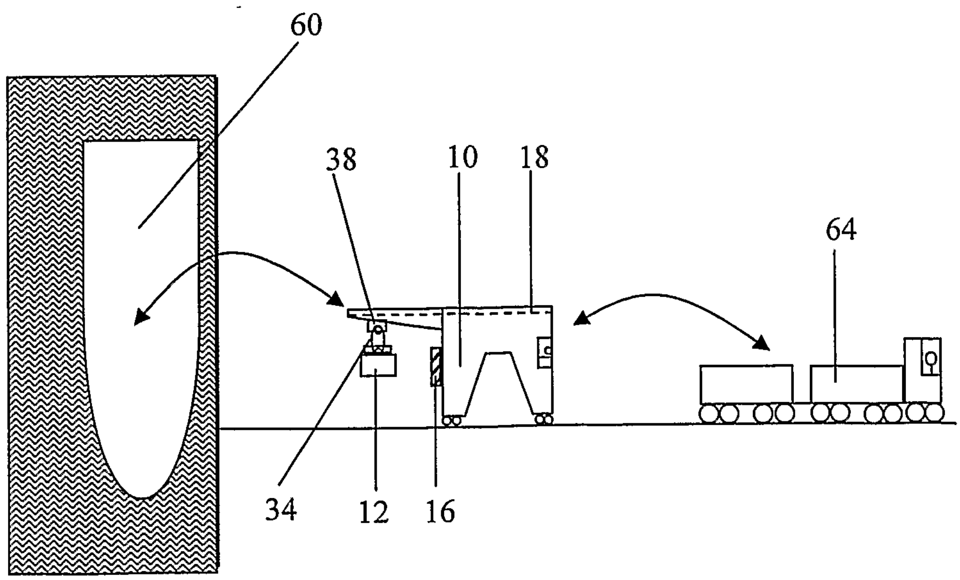


Fig. 5