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(54) Title: ANALYSIS SYSTEM AND ASSOCIATED METHOD OF HANDLING AND ANALYSING DISCRETE MINERAL SAMPLES

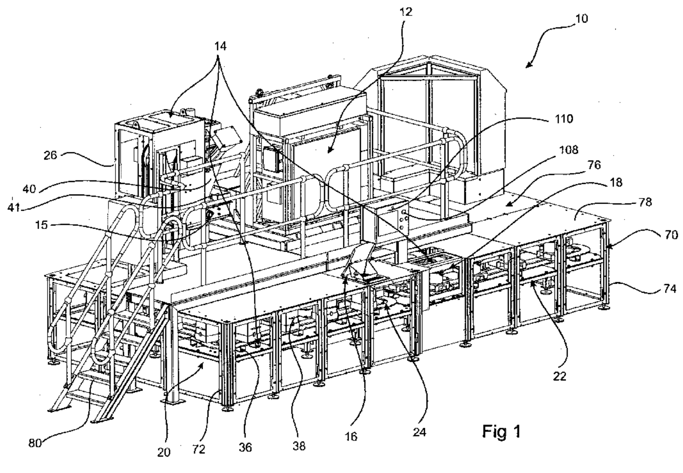

Fig 1

(57) Abstract: A self-contained stand-alone elemental composition analysis system (10) comprises an analyser (12) and a mineral sample and transport handling system (14). The analyser (12) is capable of providing data relating to the elemental composition of a mineral sample. The transport system (14) operates in association with the analyser (12) so as to transport discrete mineral samples from a sample inlet port (16) to the analyser (12) and subsequently transport the analysed mineral samples as discrete samples to a sample outlet port (18). The transport system (14) is constituted by an inlet conveyor system (20) that is arranged to transport discrete mineral samples from the inlet port (16) to an analyser inlet (15); and, a separate outlet conveyor system (22) which is arranged to transport discrete mineral samples after analysis from an analyser output or discharge to the outlet port (18). The system (10) enables discrete samples emptied from a specific container or bag to be returned in that same container or bag thereby minimising the risk of contamination with other samples.

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Analysis System and Associated Method of Handling and Analysing Discrete Mineral Samples

Field of the Invention

The present invention relates to the field of for mineral samples. The invention further relates to a self contained stand alone analysis system; and, to a method of handling and analysing discrete mineral samples.

Background of Invention

Prior to or during the mining of a mineral body it is critical to assay the mineral in the body to maximise the efficiency and profit in subsequent processing of corresponding mined ore. In drill and blast mining operations where a mineral body such as a bench of ore is initially drilled with blast holes, assaying may be performed on samples of cuttings produced by the drilling process prior to blasting.

Assaying is conventionally performed in a laboratory remote from the drilling location. The laboratory contains an apparatus or machine such as an XRF spectrometer for determining the elemental or chemical composition of the sample. A laboratory technician generally prepares and feeds a sample to the spectrometer and operates the spectrometer to determine the elemental composition. Such sample preparation is often laborious and time consuming. The data relating to the composition and/or other characteristics of such a sample is subsequently used by mine planner to determine an appropriate blasting sequence and removal strategy to maximise ore production. There may be substantial lead time between delivering of a sample for analysis and being able to access the results of the analysis.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

It is to be understood that, if any prior art publication is referred to herein; such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

Summary of the Invention

The general idea behind the present invention is to provide a self contained stand alone elemental composition analysis system that enables autonomous handling and analysis of mineral samples. By being stand alone and self contained the system can be easily transported to a location near a mining operation to facilitate quick turn-around time for assaying the mineral samples.

Embodiments of the invention enable discrete mineral samples emptied from respective containers such as sample bags, to be analysed as to their elemental composition and subsequently transferred from the system. This transfer may include but is not limited to:

(a) the samples being returned in their same containers and subsequently removed from the system;

(b) the samples being deposited in new containers and subsequently removed from the system;

(c) dumping at least some of the analysed samples to a waste bunker and at least one of the samples being deposited into their original or new containers (for example to provide a basis for quality control and quality assurance); and

(d) dumping all of the analyses samples to a waste dump or waste location.

In one aspect the invention provides a self-contained stand-alone mineral sample analysis system comprising:

an analyser capable of providing data relating to a characteristic of a mineral sample;

a sample input port;

at least one sample output port; and,

a sample transport and handling system operatively associated with the analyser and arranged to present a plurality of discrete mineral samples provided at the sample port to the analyser, and subsequently transport the analysed mineral sample to a selected one of the at least one sample outlet port.

In one embodiment the sample transport and handling system comprises an inlet transport system arranged to transport the discrete mineral samples to an analyser input; and,

a separate output transport system arranged to transport discrete analysed mineral samples from an analyser output to the selected one of the at least one sample outlet port.

In one embodiment the sample transport and handling system comprises one or more separate buckets demountably carried on or by the inlet transport system.

In one embodiment the sample transport and handling system comprises separate buckets demountably carried on or by the outlet transport system.

In one embodiment the input transport system comprises a sample feed system and an analyser transport system, the sample feed system arranged to convey discrete mineral samples from the sample inlet port to the analyser transport system, the analyser transport system arranged to transfer discrete mineral samples from the sample feed system to the analyser input.

In one embodiment the analyser transport system is arranged to transfer a discrete sample from the sample feed system and deliver the discrete sample to the analyser input.

In one embodiment the analyser transport system is arranged to lift a bucket holding a discrete sample carried on the sample feed system and empty the discrete sample from the bucket into or onto the analyser input.

In one embodiment the analyser transport system is operable to return the emptied bucket to the sample feed system.

In one embodiment the sample feed system is arranged to convey a bucket from the sample inlet port to the analyser transport system and back to the sample inlet port.

In one embodiment the sample feed system transports the discrete samples in a horizontal plane.

In one embodiment the sample feed system transports the samples in a horizontal plane and the analyser transport system transports the samples in a vertical plane.

In one embodiment the outlet transport system is arranged to transport a sample from the analyser output to the selected one of the at least one sample outlet port.

In one embodiment the at least one sample outlet is configured to enable an analysed mineral sample to be removed as a discrete sample in a container from the analysis system.

In one embodiment the at least one sample outlet port comprises: a waste outlet port arranged to direct an analysed sample to a waste location; and, an unload outlet port configured to enable an analysed mineral sample to be removed as a discrete sample in a container from the analysis system.

In one embodiment the sample feed system comprises a conveyor.

In one embodiment the outlet transport system comprises a conveyor.

In one embodiment the outlet transport system comprises a robotic arm or manipulator.

In one embodiment the sample feed system comprises a robotic arm or manipulator.

In one embodiment the analysis system comprises a control system arranged control the sample transport and handling system so that the samples are sequentially progressed from the inlet port through the analyser and to the selected one of the at least one outlet ports.

In one embodiment the analysis system comprises a control system arranged control the sample transport and handling system so that the samples are progressed from the inlet port through the analyser and to the selected one of the at least one outlet ports in a user definable and changeable order.

In one embodiment the control system is arranged enable separate control of the inlet transport system, the outlet transport system and the analyser.

In one embodiment the control system is arranged to associate a container containing a discrete mineral sample with that discrete mineral sample wherein a discrete sample emptied from that container into the sample inlet port is transported in the same container to the unload outlet port.

In one embodiment each bucket on the outlet transport system is configured to demountably engage a sample container in an opened condition.

In one embodiment the unload outlet port is arranged to provide access to the outlet transport system wherein a sample container carrying a discrete sample which is emptied through the sample inlet port is able to be engaged in a bucket of the outlet transport system through the unload outlet port.

In one embodiment the control system is operable to: associate discrete samples with a uniquely identified container; and,

control the sample transport and handling system and the analyser in a manner wherein a sample emptied from a particular container through the sample inlet port is returned in the same container at the unload outlet port.

In one embodiment the control system is operable to: track discrete samples through the analysis system; and control the sample transport and handling system and the analyser in a manner wherein one or more selected samples emptied from a particular container through the sample inlet port can be transported in the same or an alternate container to the unload outlet port and non selected sample can be transported to the dump outlet port.

In one embodiment the analysis system comprises a frame supporting the analyser and the sample transport and handling system.

In one embodiment the frame comprises two or more sub-frames arranged to be assembled together.

In one embodiment a first sub-frame supports the inlet transport system and a second sub-frame supports the outlet transport system.

In one embodiment the analyser is supported by the frame at a level above the inlet transport system.

In one embodiment the analysis system comprises a platform supported by the frame at a level above the inlet transport system and the outlet transport system and wherein the analyser is supported on the platform.

In one embodiment the analysis system comprises stairs to provide an operator with access to walk onto and off of the platform.

In one embodiment the analysis system comprises a crusher arranged to crush the samples to a selectable particle size prior to analysis by the analyser.

In one embodiment the analysis system comprises a dryer arranged to dry the samples to a selectable moisture content prior to analysis by the analyser

In a second aspect the invention provides a method of handling and analysing one or more discrete mineral samples in a self-contained stand-alone mineral analysis system comprising:

autonomously transferring discrete mineral samples emptied from respective containers at an inlet port of the system to an analyser

operating the analyser to generate data relating to one or more characteristics of each discrete sample;

transferring an analysed sample to a selected one of at least one sample outlet port.

In one embodiment the method comprises:

emptying each discrete sample from its container through the inlet port;

transporting the emptied container to a deposit location at which a discrete analysed sample is deposited into the container; and,

subsequently transporting to the outlet port.

In one embodiment the method comprises loading the emptied container onto an outlet transport system operable to transport the emptied container to the deposit location.

Brief Description of the Drawings

An embodiment 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 isometric view from the front of an embodiment of an elemental composition analysis system in accordance with an embodiment of the present invention;

Figure 2 is a top view of the system shown in Figure 1;

Figure 3 is a side view of the system shown in Figure 1;

Figure 4 is a representation of a portion of an inlet conveyor system incorporated in the system shown in Figure 1;

Figure 5 is an enlarged schematic representation of a portion of the system shown in Figure 1 incorporating a part of the inlet conveyor shown in Figure 4;

Figure 6a is schematic isometric view from the rear the system shown in Figure 1;

Figure 6b is a schematic representation of a carriage and bucket used in the conveyor system shown in Figure 6a;

Figure 7a is an isometric view from a first angle of an inlet chute incorporated in the system shown in Figure 1;

Figure 7b is an isometric view from a second angle of the inlet chute shown in Figure 7a;

Figure 8a is a schematic representation of a chute incorporated in the system shown in Figure 1;

Figure 8b is a front view of the chute shown in Figure 8a;

Figure 8c is a side view of the chute shown in Figure 8a;

Figure 8d is a view of detail B shown in Figure 8a;

Figure 9 is a flowchart for operating a method of handling and analysing discrete mineral samples utilising the system shown in Figure 1;

Figure 10 is a flow diagram of an operator loading sequence incorporated in the method;

Figure 11 is a flowchart depicting an analysis sequence incorporated in an embodiment of the method; and,

Figure 12 is a flow diagram depicting an operator unloading sequence incorporated in the method.

Detailed Description of Preferred Embodiments

With reference to the accompanying Figures and in particular Figures 1 -4, a self-contained stand-alone elemental composition analysis system 10 (hereinafter referred to in general as "system 10") comprises an analyser 12 and a mineral sample and transport handling system (hereinafter referred to for convenience as "transport system") 14. The analyser 12 is capable of providing data relating to the elemental composition of a mineral sample. In one embodiment, the analyser 12 may be in the form of a laser induced breakdown spectrometer also known in the art as a "LIBS". However the specific nature of the analyser is not critical and any type of analyser which is able to provide data relating to the elemental composition of a mineral sample may be used. Additionally, the analyser may also measure characteristics or properties of the sample other than elemental composition, such as mineralogy, density and/or moisture content.

The transport system 14 operates in association with the analyser 12 so as to transport discrete mineral samples from a sample inlet port 16 to the analyser 12 and subsequently transport the analysed mineral samples as discrete samples to a sample outlet port 18. In operation, the system 10 is thus able to provide elemental composition data in relation to a number of discrete samples.

The sample outlet port 18 may be the only outlet port in or the outlet port may be one of two or more outlet ports. When there are two or more outlet ports the analysed samples may then be transported to a selected one of sample outlet ports. In embodiments where there are say two outlet ports these ports may be different types of outlet ports namely: a waste outlet port arranged to direct an analysed sample to a waste location or dump; and, an unload outlet port configured to enable an analysed mineral sample to be removed as a discrete sample in a container from the analysis system 10. Delivering the analysed sample to the unload outlet port allows the discrete samples to be kept for later analysis or other use if desired. As will be explained in further detail below, additionally one embodiment of the system 10 enables discrete samples emptied from a specific container or bag to be returned in that same container or bag thereby minimising the risk of contamination with other samples. Although in an alternate embodiment the system 10 can operate to deposit the analysed sample in a new container or bag. For the sake of ease of description the present embodiment the system 10 will be described on the basis that the outlet port 18 is a single unload outlet port.

The transport system 14 is formed from a number of different parts. These parts are an inlet transport system 20 that is arranged to transport discrete mineral samples from the inlet port 16 to an analyser inlet 15; and, a separate outlet transport system 22 which is arranged to transport discrete mineral samples after analysis from an analyser output or discharge to the outlet port 18.

The inlet transport system 20 is itself composed of a sample feed system 24 and an analyser feed system 26. The sample feed system 24 transfers discrete mineral samples to the sample feed system 26. The sample feed system 26 in turn lifts the discrete samples from the sample feed system and delivers them to the analyser inlet 15.

In this embodiment the sample feed system 24 is in the form of a horizontal conveyor in that it conveys the discrete samples in a horizontal plane. However other transport systems can be used in place of a conveyor such for example a robotic arm.

The sample feed system 26 is in the form of an endless vertical conveyor. This conveyor is arranged to lift the samples vertically from the sample feed system 24 to subsequently discharge the samples onto the analyser inlet 15.

In this embodiment the outlet transport system 22 is a horizontal conveyor of similar construction to the sample feed system 24. It is envisaged that in other embodiments the outlet transport system 22 may take forms other than a conveyor such as a robotic arm. The outlet transport system 22 conveys discrete samples after analysis from the analyser outlet to the outlet port 18.

In order to transport the mineral samples, each of the conveyors is arranged to convey individual and demountable buckets. In this particular embodiment the buckets used for the inlet transport system 20 and outlet transport system 22 are different.

Figures 4 and 5 depict aspects of sample feed system 24 which is in the from of a horizontal conveyor. The system 24 includes a roller chain 28 formed in a continuous loop and running in a space between inner and outer horizontal tracks 30 and 32. A plurality of carriages 34 in the form of open top boxes are coupled to the chain 28 at spaced apart locations. Thus when the roller chain 28 is in motion the carriages 34 are driven on and about the tracks 30 and 32. The carriages 34 demountably receive corresponding buckets 36. The buckets 36 are provided on opposite sides with transversely projecting flanges 38 which enable them to be picked up by the analyser feed system 26. The analyser feed system 26 is arranged to lift a bucket 36 and tip or invert it to empty its contents into a chute 40. The chute 40 directs the sample onto the conveyor inlet 15. An optional crusher 41 can be provided to crush the samples to a prescribed particle size prior to entry to the analyser 12. The crusher 41 when provided, may for example be incorporated in the chute 40 or be installed immediately upstream of the chute 40. Once the bucket 36 has been emptied, it is returned to the same carriage 34. The sample feed system 24 is then indexed to move the next bucket 36 to a position where it can be lifted and emptied by the analyser feed system 26. The emptied buckets are returned on the sample feed system 24 so as to sequentially pass under the inlet port 16.

With particular reference to Figures 6a and 6b, the outlet transport system 22 comprises a horizontal conveyor of the same construction as sample feed system24 in that it comprises an endless roller chain which circulates within a space or gap between inner and outer tracks 42 and 44. A plurality of carriages 46 are attached to the roller chain of the outlet transport system 22. The carriages 46 are of a different configuration but perform the same function as carriages 34 in that they demountably carry corresponding buckets 48.

As shown in Figure 6b, the carriages 46 are in the form of rectangular frames having an opening 50 at an upper end in which the buckets 48 sit. The opening 50 is circular in shape and the buckets 48 are likewise circular. An upper end of the bucket 48 is optionally provided with a clamp 52 which is arranged to hold an upper end of a sample bag in opened condition when being carried in the bucket 48. Specifically, when the clamp is provided, a sample bag is placed in the bucket 48, the clamp 52 is opened and the mouth of the bag folded over the top of the bucket 48 and subsequently the clamp 52 is closed to hold the bag open in the bucket 48. In the event that no clamp 52 is provided, an open end of the bag is simply folded over the top of the bucket 48.

The outlet transport system 22 sequentially conveys the buckets 48 with empty sample bags to a position near a discharge or outlet of the analyser 12 so that an analysed sample falls directly into the bucket 48 and attached sample bag. Thereafter the system 22 transfers the bucket 48 to the outlet port 18 which can be opened by an operator to subsequently remove the bagged analysed sample. The sample can then be stored at an appropriate location for further analysis or the like.

With reference to Figures 7a and 7b, the inlet port 16 comprises a lid 54 which is hinged to an inlet funnel 56. When the lid 54 is closed, it completely covers the inlet funnel 56. An inlet chute 58 is formed contiguously with the inlet funnel 56, the inlet chute 58 tapering inwardly as it extends toward the underlying horizontal conveyor of the sample feed system 24. A grate 59 extends across the inlet funnel 56 and notionally separates or demarks the inlet funnel 56 from the inlet chute 58. The grate 59 acts to reject oversized particles in the sample. In one embodiment the inlet port 16 may be provided with a vibrator to assist in flow of the sample through the grate 59 to an underlying bucket 36 and thereby substantially reduce the risk of cross-contamination between sequential samples.

Inlet chute 58 is dimensioned so that when a bucket 36 is directly below the inlet port 16 there is a minimal gap between the bottom edge of the inlet chute and the upper end of the bucket 36. A dust suppression box 60 is fitted to an underside of the inlet port 16 to extract dust that may otherwise be generated when a discrete sample is tipped through the inlet port 16 into an underlying bucket

36. The dust suppression box 60 includes a removable sump 62 which collects dust and can be subsequently emptied. Dust suppression hose connectors 64 are provided on the box 60 for connection to a relative negative pressure to draw dust through an intake 66 formed at the top of the box 60 adjacent the inlet funnel 56.

The system 10 comprises a frame 70 (see in particular Figures 1, 3 and 6) which supports the analyser 12 in the transport system 14. The frame 70 is formed of a plurality of sub-frames which are assembled together. One sub-frame 72 is shown in Figure 4 and supports the sample feed system 24 of the inlet transport system 20. A second sub-frame 74 is shown in Figure 6a which supports the outlet conveyor system 22. The two sub-frames 72 and 74 can be demountably connected together, for example by use of a plurality of bolts to form the frame 70. The analyser feed system 26 is supported by the sub-frame 72 while the analyser 12 is supported by both sub-frames 72 and 74. The frame 70 is arranged to be lifted as a single unit by a fork-lift truck or similar vehicle. This enables the system 10 to be easily transported from location to location. Further in one embodiment the system 10 is dimensioned to fit within a sea-container. Thus the system 10 can be conveniently and safely transported by truck in a sea container.

A platform 76 is supported on the sub-frames 72 and 74. A portion of the platform 76 forms a work bench 78 for a system operator. The inlet port 16 is formed in the work bench 78. As seen most clearly in Figures 1 and 2, system 10 also comprises stairs 80 which allow the; or a different; operator to walk on the platform 76 to obtain access to the analyser 12.

Figures 8a-8c depict an embodiment of the chute 40 incorporated in the system 10. The chute 40 comprises a chute box 82 having an inlet opening 84 at an upper end into which the contents of a bucket 36 is tipped. The chute box 82 is supported on a frame of the analyser feed system 26 by way of four vibration mounts 82, two on each side of the box 82. A back planar wall 88 of the chute box 82 is coupled with a vibrator 90 which vibrates to prevent blockage of the chute 40 and ensure that the entire sample is fed to the analyser input 15. Chute box 82 reduces in cross-sectional area from the inlet 84 to an adjustable outlet 92. The adjustable outlet 92 is provided with a levelling plate 94 which can be adjusted by a pivotally attached stud 96 and nut 98. The analyser input 15 comprises a belt conveyor 100 which is disposed directly beneath the adjustable outlet 92. The levelling plate is spring loaded to optimise the height of sample on the belt 100. By varying the angle of the levelling plate 94 the thickness of the sample on the conveyor 100 which is subsequently fed through the analyser 12 can be adjusted. An optional sample dryer 101 can be provided downstream of the outlet 92 to enable control of sample moisture content prior to analysis by the analyser. This will enable for example samples to be dried to prescribed moisture content prior to analysis. A similar effect can be achieved by replacing the dryer 101 with a moisture content measuring system and arranging the analyser to provide measurements that are compensated for moisture content. In yet a further variation the sample dryer 101 and a moisture content measuring system 103 may be provided downstream of the outlet 92 and before analysis by the analyser 12.

The system 10 is controlled by an electronic controller that facilitates substantially autonomous operation of the analyser 12 and the transport system 14. Once samples have been loaded onto the input transport system 20, the system 10 will operate to automatically analyse the discrete samples and subsequently return the samples in separate containers and ideally in the same container from which they were originally provided to the system 10.

With particular reference to Figure 2, it can be seen that the inlet port 16 and the outlet port 18 are adjacent each other so as to be in easy reach of the same operator. Disposed between the inlet port 16 and outlet port 18 is a control panel 108 and scanner 110. The scanner 110 is part of, or otherwise communicates with, the controller of the system 10. In one method of operation, discrete samples are provided to the system 10 in separate uniquely coded containers such as bags. The coding may be by way of an attached RF tag, or by way of barcode or other readable code. The operator prior to emptying the contents of the container into the inlet port 16 scans the container using the scanner 110. After the container has been emptied, the same operator scans the container again using scanner 110 and then opens the outlet port 18 and loads the emptied container into a corresponding bucket 48. In this way, the controller is able to associate a discrete sample with both a bucket 36 on the inlet transport system 20, and a bucket 48 on the outlet transport system 22. Once the outlet port 18 is shut, the controller is then able to index the inlet system 20 and outlet conveyor system 22 to move the respective buckets toward the analyser inlet 15 and the analyser output. By virtue of the controller, the system 10 can be configured to enable multiple samples to be loaded and then sequentially analysed. For example the analyser may be configured to carry and sequentially analyse, say ten to twenty separate samples each held in respective buckets 36,48. The samples may be from the same blast hole but taken from different depths; or form different blast holes, etc

Figure 9 depicts in a very general form one method of handling and analysing samples which may be performed by the system 10. More specific operational sequences of the system 10 are shown and will be described in greater detail later with reference to Figures 10, 11 and 12. In Figures 10-12 steps that relate to the operation of or an action are performed by: (a) the sample feed system 24 are depicted by boxes having a dotted periphery; (b) the outlet transport system 22 are depicted by boxes having a dashed periphery; (c) the vertical sample feed system 26 are depicted by boxes having a dot-dash periphery, and various optional steps are depicted in boxes having a wave like periphery.

Reverting to Figure 9, a general method 120 of handling and analysing one or more discrete samples can be broken up into four general steps. A first step 122 involves transferring discrete mineral samples emptied from respective containers at the inlet port 16 to the analyser 12. At step 124 the analyser 12 is operated to generate data relating to the elemental composition of the discrete sample. Next at step 126, the discrete sample after being analysed is deposited into the same container from which it was originally emptied at the input port 16. Thereafter, at step 128, the discrete sample is returned to the outlet opening 18 from where it can be removed from the system 10 and stored as required or desired.

The data generated by the analyser 12 can be stored on the system 10 and accessed remotely, or automatically transmitted to a remote location for use by mine planners and other personnel.

Figure 10 depicts an operator loading sequence 130 which may be utilised when operating the system 10. The operator loading sequence 130 commences at a step 132 where sample bags containing discrete mineral samples arrive at the system 10 for analysis. How they arrive or are delivered is inconsequential. However in one embodiment the sample bags may arrive on a trolley. At step 134 an operator using the control panel 108 initiates a loading sequence which is performed by the system controller. In step 136 an operator takes a sample bag from a trolley and scans the bag using the scanner 110. This logs identification data of the bag in the controller. Additionally, the controller at step 138 operates the sample feed system 24 to move the next bucket 36 to a position beneath the inlet port 16. At step 140 an operator now lifts the lid 54 of the inlet port 16 and empties the bag through the inlet funnel 56 so that the discrete sample falls into the underlying bucket 36.

At step 142 the operator again scans the emptied bag via the scanner 110. This causes the controller at step 144 to control the outlet transport system 22 to move an empty bucket 48 to a position adjacent the outlet port 18.

In one variation the controller can be programmed to bypass step 142 and proceed directly from step 140 to step 144 as shown by dashed line 145. In this variation to controller is programmed to: assume that the bag being placed in the next bucket 48 on the outlet conveyor 22 is the same bag from which the previous sample was emptied through the inlet port 16; and automatically move an empty bucket 48 to a position adjacent the outlet port 18.

At step 146 an operator opens the door of the outlet port to access or remove the bucket 48. At step 148 the operator is then able to attach the empty bag to the bucket 48 using the clamp 52. At step 150 with the bucket 48 and attached empty bag loaded back into a corresponding carriage 46, the operator closes the outlet port 18.

The loading sequence 130 is performed for each sample to be analysed by the system 10. The maximum number of discrete samples that can be loaded is equal to the number of buckets 36, 48 that can be held at any one time on the respective feed system 22 and outlet transport system 24.

Once one or more samples have been loaded, an operator can command the controller to commence an autonomous analysis sequence 160 shown in Figure 11. The initial step in the sequence 160 is the operator activation step 162 where the operator via the control panel 108 instructs the controller to perform the analysis sequence. Upon initiating the analysis sequence, the system controller may, as part of step 162, automatically perform a test sequence to ensure the correct operational status of the analyser 12 and other components of the system 10.

At step 164, the controller operates the sample feed system 24 to move the closest or a user selected bucket 36 containing a discrete sample to a loading zone for the analyser feed system 26. With the bucket 36 in the loading zone, at step 166 the vertical conveyor 26 operates to engage or clamp the bucket on or about the flanges 38. At step 168 the analyser feed system 26 now lifts the bucket 36 from its carriage 34 and tips the contents into the chute 40 which subsequently directs and deposits the discrete sample onto the analyser conveyor 100 at the inlet 15. As the sample is passing through the chute 40, at step 170 the controller further operates the vibrator 90 associated with the chute 40 to remove or avoid hang-ups in the chute 40. Concurrently, the controller may operate a compressed air feed to inject compressed air into the chute 40 to further assist in avoiding hang-ups and transferring the entire discrete sample onto the underlying conveyor 100. Also at this time the clamp maybe opened and closed repeatedly to avoid hang-ups. Optionally the sequence 160 may include a step 169 of crushing the sample using the crusher 41 between the steps 168 and 170. Crushing step 169 enables control over the size of particles in the sample prior to analysis.

At step 172 the bucket 36 is returned by the vertical conveyor 26 back into its corresponding carriage 34 on the sample feed system 24. At step 174 the analyser 12 is operated to conduct an elemental composition analysis of the discrete sample and generate corresponding elemental composition data. The sequence 160 may also include the one or both of the optional steps 173a of drying the sample and 173b of measuring moisture content between the steps 172 and 174. The drying step 173a is performed by the dryer 101. The moisture measuring step is performed by the moisture measuring system 103. Information pertaining to the moisture level can be provided to the analyser 12 or the controller to facilitate moisture content compensation moisture of measurements taken by the analyser.

While this analysis is being conducted at step 176, the controller operates the outlet transport system 22 to place the bucket 48 which contains the bag corresponding to the sample currently being analysed to a location beneath the analyser outlet. As the discrete sample passes through the analyser it is subsequently dumped at step 178 into the underlying bag and bucket 48. The steps 164-178 continue for all of the samples previously loaded onto the system 10.

Once one or more of the discrete samples have been analysed, an operator can initiate an operator unloading sequence 200 to unload the analysed samples currently held in respective buckets 48 on the outlet transport system 22. The operator unloading sequence 200 is shown in Figure 12. To commence the sequence 200, an operator at step 210 inputs an appropriate command via the control panel 108 to the controller to initiate the sequence. At step 212 the controller operates the outlet transport system 22 to move the next filled bucket 48 to a location adjacent the outlet port 18. At step 214 the operator is able to open a door at the outlet port to provide access to the bucket 48 and bag contained therein. Now at step 216 the operator releases the clamp 52 and removes the bag containing the sample from the bucket 48. At step 218 the operator closes the door of the outlet port 18. At step 220 the operator places the bag onto a trolley or other vehicle which can carry the sample bag to a storage location. At step 220 the operator pushes a button the control panel providing a command to the controller to cycle back through to step 212 to move the next bucket to a location adjacent the outlet opening 18. The steps 212-220 cycle through until all of the bags contained in the buckets 48 are unloaded from the system 10.

Whilst a specific system and method for handling and analysing discrete samples has been described, it should be appreciated that the system and method may be embodied in many other forms and incorporate additional optional features. For example, the inlet port 16 and/or the outlet port 18 may be provided with sensors which communicate with the controller to prohibit opening thereof during particular stages of operation of the system 10. For example, the controller may prohibit the opening of inlet port 16 while the conveyor 24 is in motion. Similarly, the controller may inhibit the opening of outlet port 18 when the conveyor 22 is in operation. Also, while the frame 70 is described as being composed of two sub-frames, it may be formed as a unitary structure. In addition, carriage 34 and associated bucket 36; and, carriage 46 and associated bucket 48 may be formed of the same construction.

The controller may be pre-programmed with an operational sequence or mode of operation. Alternately or additionally the controller may be provided with instructions by an operator via the control panel 108. In this manner the controller can be arranged to provide various modes of operation of the system 10. Two possible modes of operation include: (a) a sequential mode; and, (b) a user selectable mode.

In the sequential mode of operation the controller controls the transport system 14 and the analyser 12 so that the samples are moved or progressed sequentially one after the other always in a forward direction from the inlet port 16, through the analyser 12 and to the outlet port 18. In this operational state the sample feed system 24, analyser feed system 26 and outlet transport system 22 may be indexed to move together.

In the user selectable mode of operation a user may select the order of progress of a sample through the system 10. For example assume a user loads say samples a-e through the inlet port 16. If the sequential mode was in operation the samples would be progressed and analyser in order a-e. But in the user selectable mode the user can via the control panel 108 instruct the controller to say analyse samples in any order for example b-c-a-d-e. In this mode of operation the controller controls the sample feed system 24, analyser feed system 26 and outlet transport system 22 to move independently of each other rather than in a lock step or indexed manner. Thus in this mode of operation it is not necessary for all of the samples to be loaded through the inlet 16 before commencement of the analysis sequence 160. Moreover in this mode of operation samples can be loaded or unloaded while other samples are being analysed.

As previously described above an embodiment of the system 10 can be provided with a waste outlet port arranged to direct an analysed sample to a waste location or dump; and, an unload outlet port configured to enable an analysed mineral sample to be removed as a discrete sample in a container from the analysis system 10. In such an embodiment the outlet port 18 of the above embodiment acts as the unload outlet port. The waste location can in one example be provided by providing a diverter immediately downstream of the analyser outlet and modifying the outlet transport system 22 to have a second sample transport system 23 (shown in phantom line in Fig 6a), such a belt conveyor say below or adjacent the conveyor the system 22. The second system can further optionally have a folded section 25 and is used to transport samples to a waste or dump location. In such an embodiment the diverter is controlled by the controller to divert a sample between the systems 22 and 23 to enable delivery of a sample to either the waste location or the unload outlet 18. One application of this variation is that it enables for example nine in ten samples to be delivered to a waste dump and a remaining one of the ten sample to be delivered to the unload outlet port for storage and later retesting if desired.

In yet another variation an embodiment of the system 10 can be arranged to physically label a bag or container with information pertaining to the sample. This may be achieved by the controller operating say a labelling machine or a RFID dispenser to tag a container or bag which is later delivered to the outlet port 18. This feature may be for every container or bag delivered to the outlet port 18 or may be used more selectively for example to tag those samples for which the analyser deems there to be some anomaly, for example an unusually small sample size or exceptionally high specific mineral content. Of course such information may also be associated with the container or bag electronically by storing information in an electronic memory together with an identifier of the container or bag.

All such variations and other modifications that would be obvious to persons of ordinary skill in the art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description and the appended claims.

The claims defining the invention are as follows:

1. A self-contained stand-alone mineral sample analysis system comprising:

an analyser capable of providing data relating to a characteristic of a mineral sample;

a sample input port;

at least one sample output port; and,

a sample transport and handling system operatively associated with the analyser and arranged to present a plurality of discrete mineral samples provided at the sample port to the analyser, and subsequently transport the analysed mineral sample to a selected one of the at least one sample outlet port.

2. The analysis system according to claim 1 wherein the sample transport and handling system comprises an inlet transport system arranged to transport the discrete mineral samples to an analyser input; and,

a separate output transport system arranged to transport discrete analysed mineral samples from an analyser output to the selected one of the at least one sample outlet port.

3. The analysis system according to claim 2 wherein the sample transport and handling system comprises one or more separate buckets demountably carried on or by the inlet transport system.

4. The analysis system according to claim 2 or 3 wherein the sample transport and handling system comprises separate buckets demountably carried on or by the outlet transport system.

5. The analysis system according to any one of claims 2 to 4 wherein the input transport system comprises a sample feed system and an analyser transport system, the sample

feed system arranged to convey discrete mineral samples from the sample inlet port to the analyser transport system, the analyser transport system arranged to transfer discrete mineral samples from the sample feed system to the analyser input.

6. The analysis system according to claim 5 wherein the analyser transport system is arranged to transfer a discrete sample from the sample feed system and deliver the discrete sample to the analyser input.

7. The analysis system according to claim 6 wherein the analyser transport system is arranged to lift a bucket holding a discrete sample carried on the sample feed system and empty the discrete sample from the bucket into or onto the analyser input.

8. The analysis system according to claim 7 wherein the analyser transport system is operable to return the emptied bucket to the sample feed system.

9. The analysis system according to any one of claims 5 to 8 wherein the sample feed system is arranged to convey a bucket from the sample inlet port to the analyser transport system and back to the sample inlet port.

10. The analysis system according to any one of claims 5 to 9 wherein the sample feed system transports the discrete samples in a horizontal plane.

11. The analysis system according to any one of claims 5 to 10 wherein the sample feed system transports the samples in a horizontal plane and the analyser transport system transports the samples in a vertical plane.

12. The analysis system according to any one of claims 3 to 11 wherein the outlet transport system is arranged to transport a sample from the analyser output to the

selected one of the at least one sample outlet port.

13. The analysis system according to any one of claims 1 to 12 wherein the at least one sample outlet is configured to enable an analysed mineral sample to be removed as a discrete sample in a container from the analysis system..

14. The analysis system according to any one of claims 1 to 12 wherein the at least one sample outlet port comprises: a waste outlet port arranged to direct an analysed sample to a waste location; and, an unload outlet port configured to enable an analysed mineral sample to be removed as a discrete sample in a container from the analysis system.

15. The analysis system according to any one of claims 1 to 14 wherein the sample feed system comprises a conveyor.

16. The analysis system according to any one of claims 1 to 14 wherein the outlet transport system comprises a conveyor.

17. The analysis system according to any one of claims 1 to 14 wherein the outlet transport system comprises a robotic arm or manipulator.

18. The analysis system according to any one of claims 1 to 14 wherein the sample feed system comprises a robotic arm or manipulator.

19. The analysis system according to any one of claims 1 to 18 comprising a control system arranged control the sample transport and handling system so that the samples are sequentially progressed from the inlet port through the analyser and to the selected one of the at least one outlet ports.

20. The analysis system according to any one of claims 1 to 18 comprising a control system arranged control the sample transport and handling system so that the samples are progressed from the inlet port through the analyser and to the selected one of the at least one outlet ports in a user definable and changeable order.

21. The analysis system according to claim 20 when dependant directly or indirectly on claim 2 wherein the control system is arranged enable separate control of the inlet transport system, the outlet transport system and the analyser.

22. The analysis system according to any one of claims 18 to 21 when dependant directly or indirectly on claim 14 wherein the control system is arranged to associate a container containing a discrete mineral sample with that discrete mineral sample wherein a discrete sample emptied from that container into the sample inlet port is transported in the same container to the unload outlet port.

23. The analysis system according to claim 22 when dependent directly or indirectly on claim 14 wherein each bucket on the outlet transport system is configured to demountably engage a sample container in an opened condition.

24. The analysis system according to claim 22 or 23 wherein the unload outlet port is arranged to provide access to the outlet transport system wherein a sample container carrying a discrete sample which is emptied through the sample inlet port is able to be engaged in a bucket of the outlet transport system through the unload outlet port.

25. The analysis system according to any one of claims 22 to 24 wherein the control system is operable to:

associate discrete samples with a uniquely identified container; and,

control the sample transport and handling system and the analyser in a manner wherein a sample emptied from a particular container through the sample inlet port is returned in the same container at the unload outlet port.

26. The analysis system according to any one of claims 22 to 24 wherein the control system is operable to:

track discrete samples through the analysis system; and control the sample transport and handling system and the analyser in a manner wherein one or more selected samples emptied from a particular container through the sample inlet port can be transported in the same or an alternate container to the unload outlet port and non selected sample can be transported to the dump outlet port.

27. The analysis system according to anyone of claims 1 to 26 comprising a frame supporting the analyser and the sample transport and handling system.

28. The analysis system according to claim 27 wherein the frame comprises two or more sub-frames arranged to be assembled together.

29. The analysis system according to claim 28 wherein a first sub-frame supports the inlet transport system and a second sub-frame supports the outlet transport system.

30. The analysis system according to anyone of claims 27 to 29 wherein the analyser is supported by the frame at a level above the inlet transport system.

31. The analysis system according to any one of claims 27 to 30 comprising a platform supported by the frame at a level above the inlet transport system and the outlet

transport system and wherein the analyser is supported on the platform.

32. The analysis system according to claim 31 comprising stairs to provide an operator with access to walk onto and off of the platform.

33. The analysis system according to any one of claims 1 to 32 comprising a crusher arranged to crush the samples to a selectable particle size prior to analysis by the analyser.

34. The analysis system according to any one of claims 1 to 33 comprising a dryer arranged to dry the samples to a selectable moisture content prior to analysis by the analyser

35. A method of handling and analysing one or more discrete mineral samples in a self-contained stand-alone mineral analysis system comprising:

autonomously transferring discrete mineral samples emptied from respective containers at an inlet port of the system to an analyser

operating the analyser to generate data relating to one or more characteristics of each discrete sample;

transferring an analysed sample to a selected one of at least one sample outlet port.

36. The method according to claim 35 comprising:

emptying each discrete sample from its container through the inlet port;

transporting the emptied container to a deposit location at which a discrete analysed sample is deposited into the container; and,

subsequently transporting to the outlet port.

37. The method according to claim 36 comprising loading the emptied container onto an outlet transport system

operable to transport the emptied container to the deposit location.

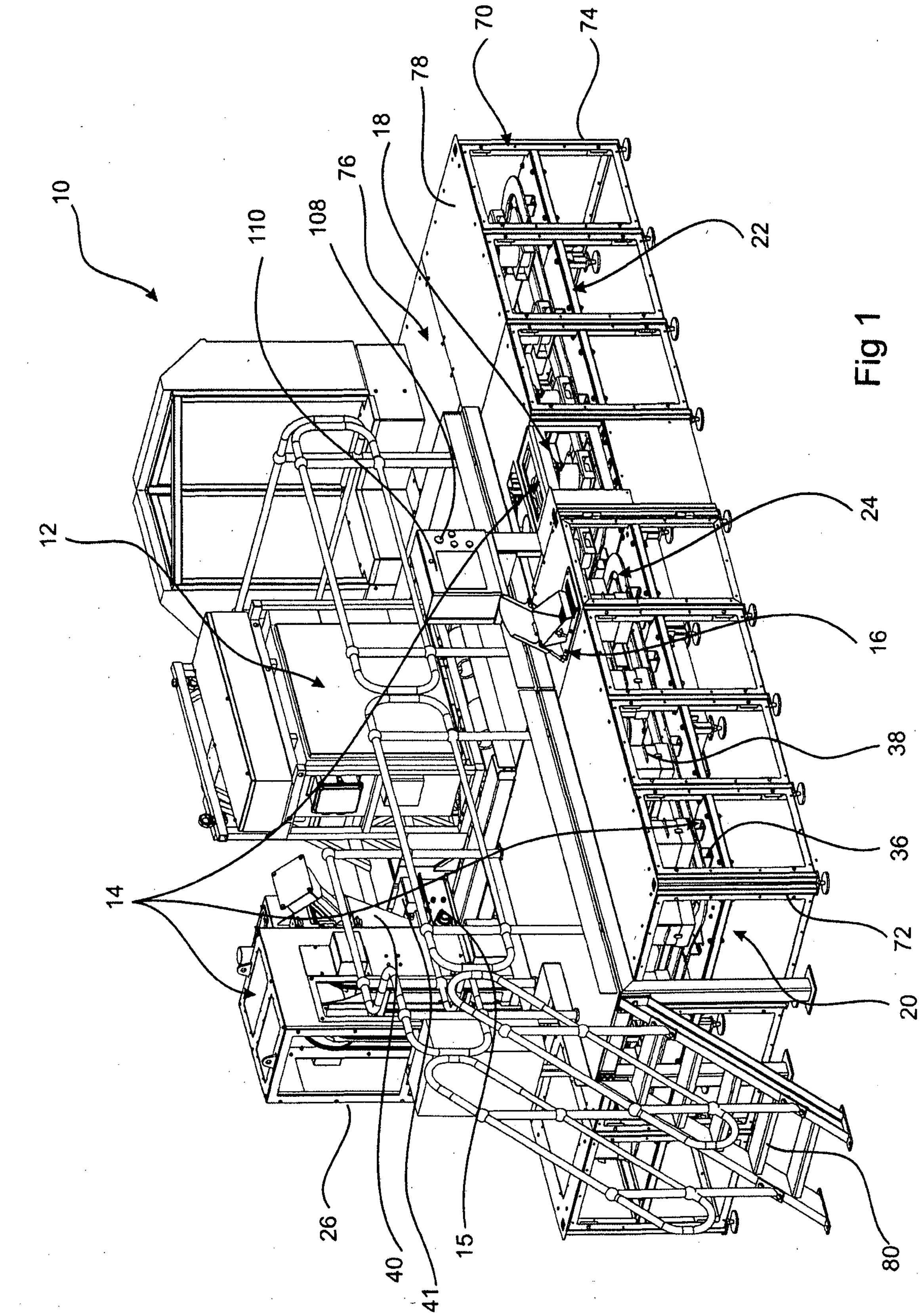

Fig 1

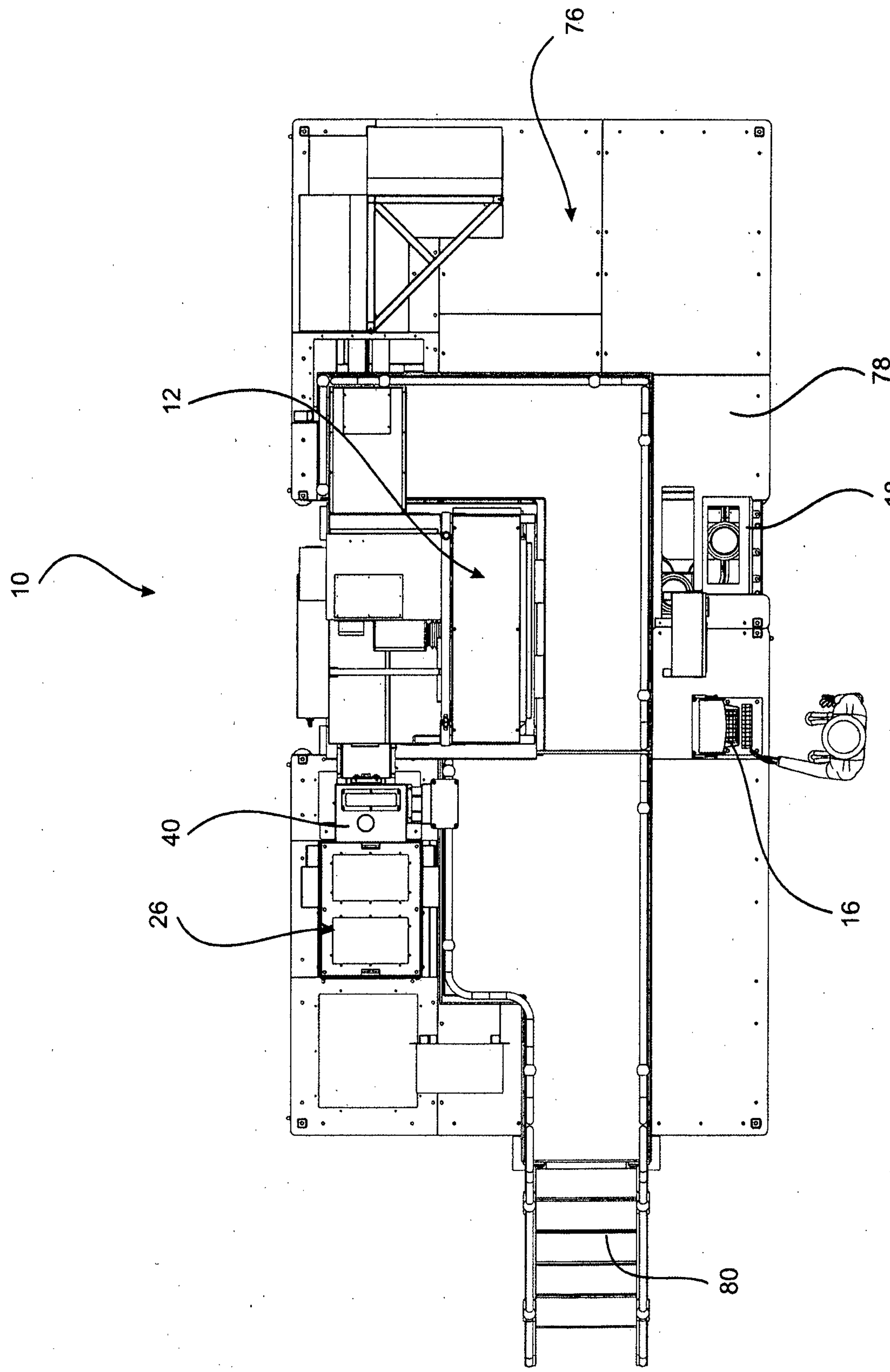

Fig 2

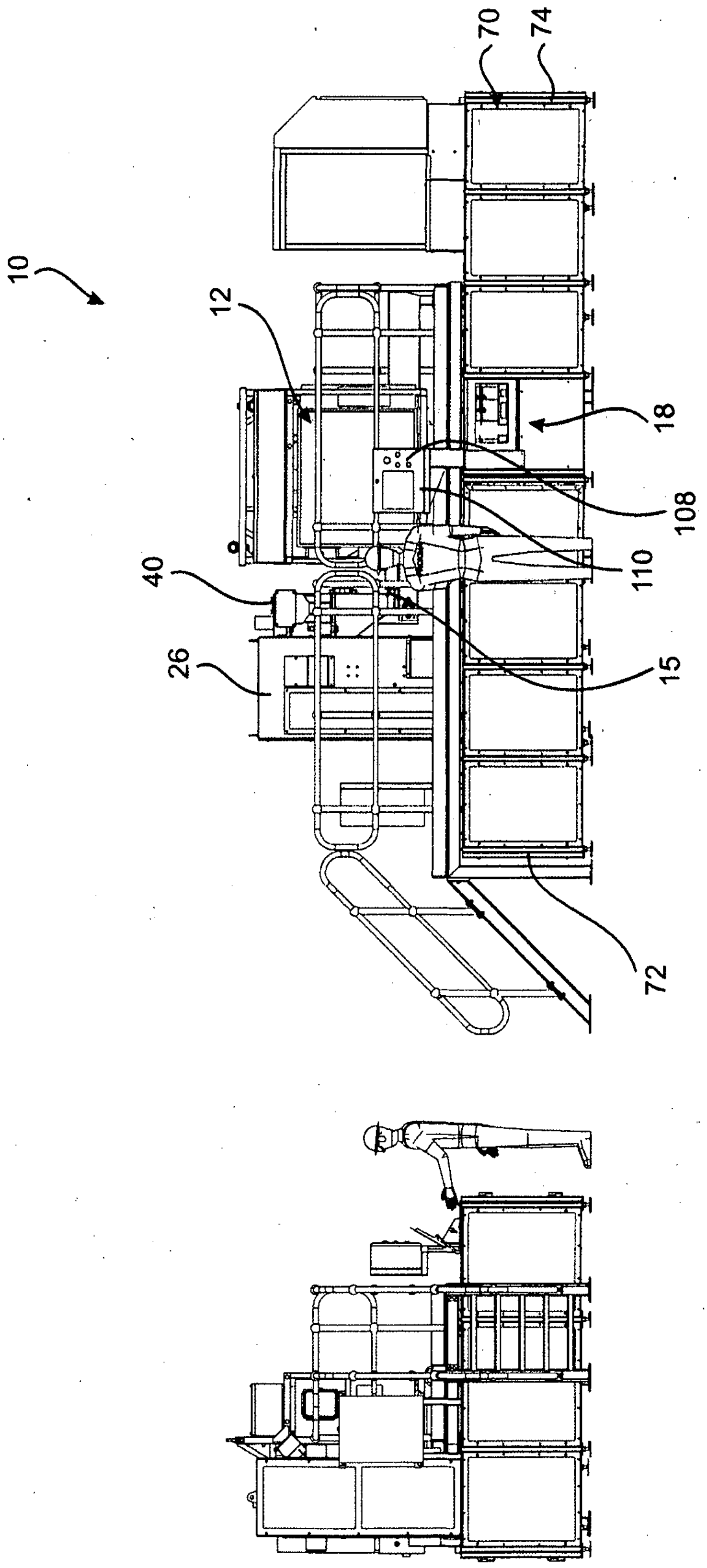

Fig 3

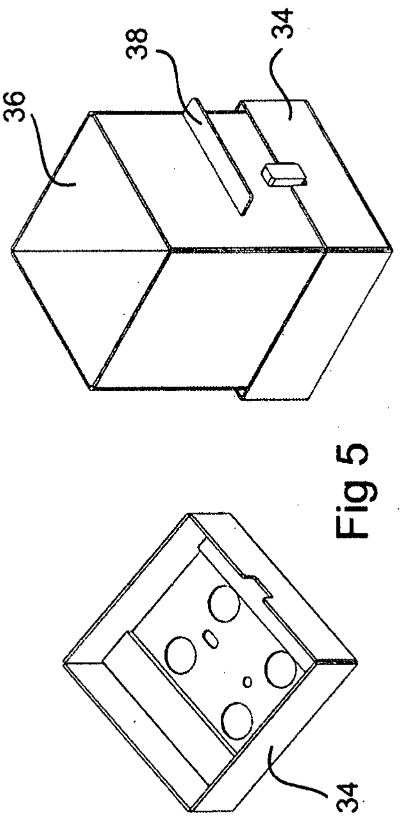

Fig 5

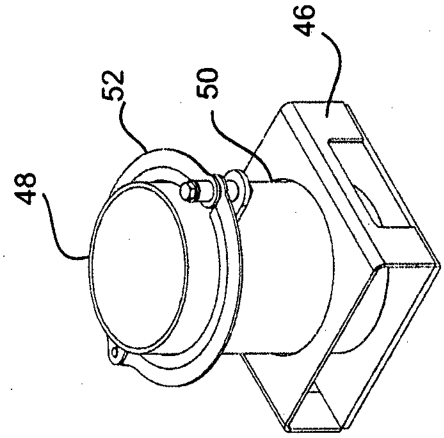

Fig 6b

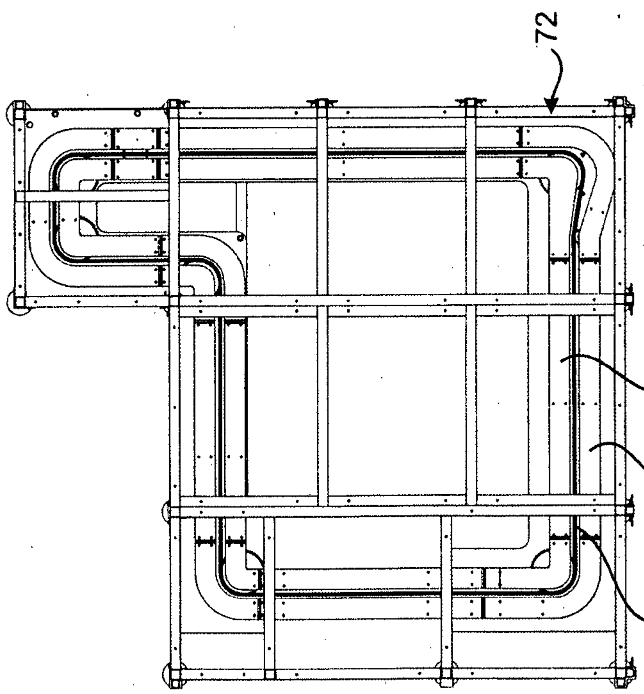

Fig 4

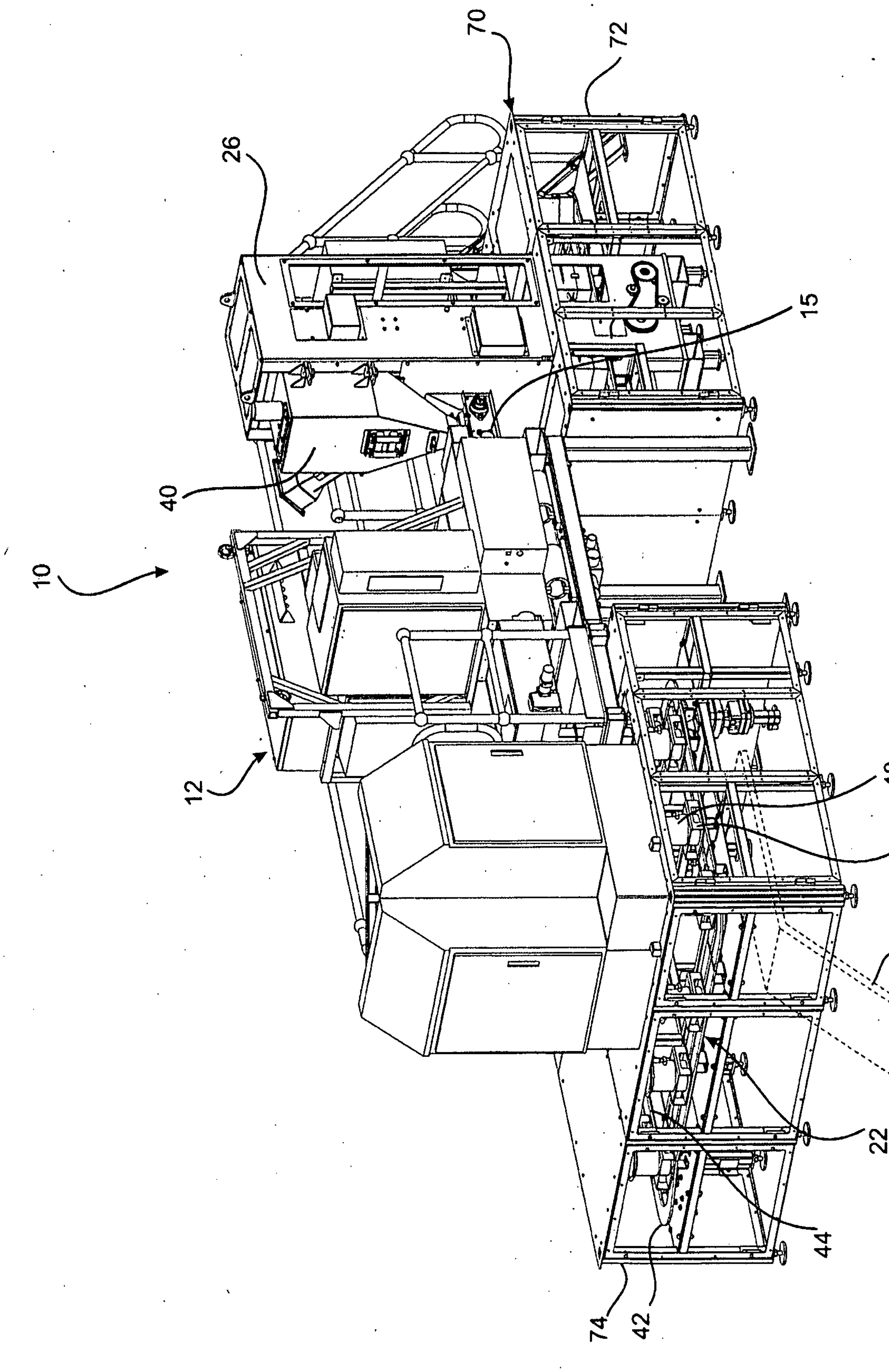

Fig 6a

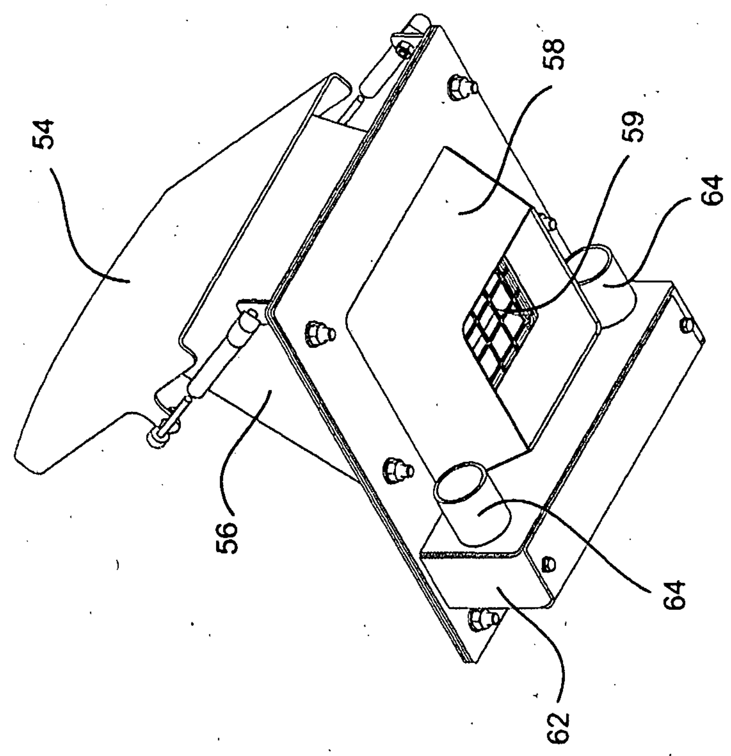

Fig 7b

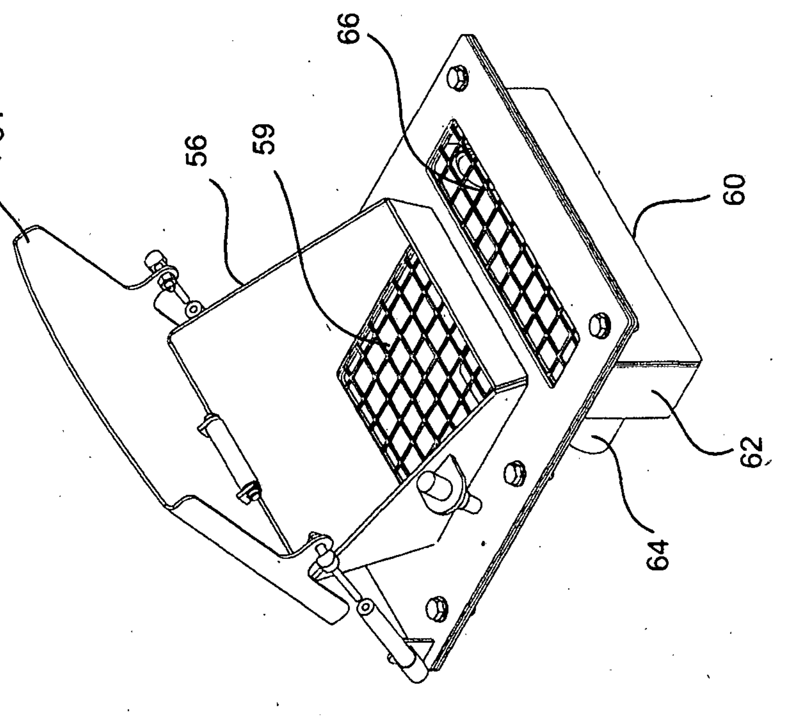

Fig 7a

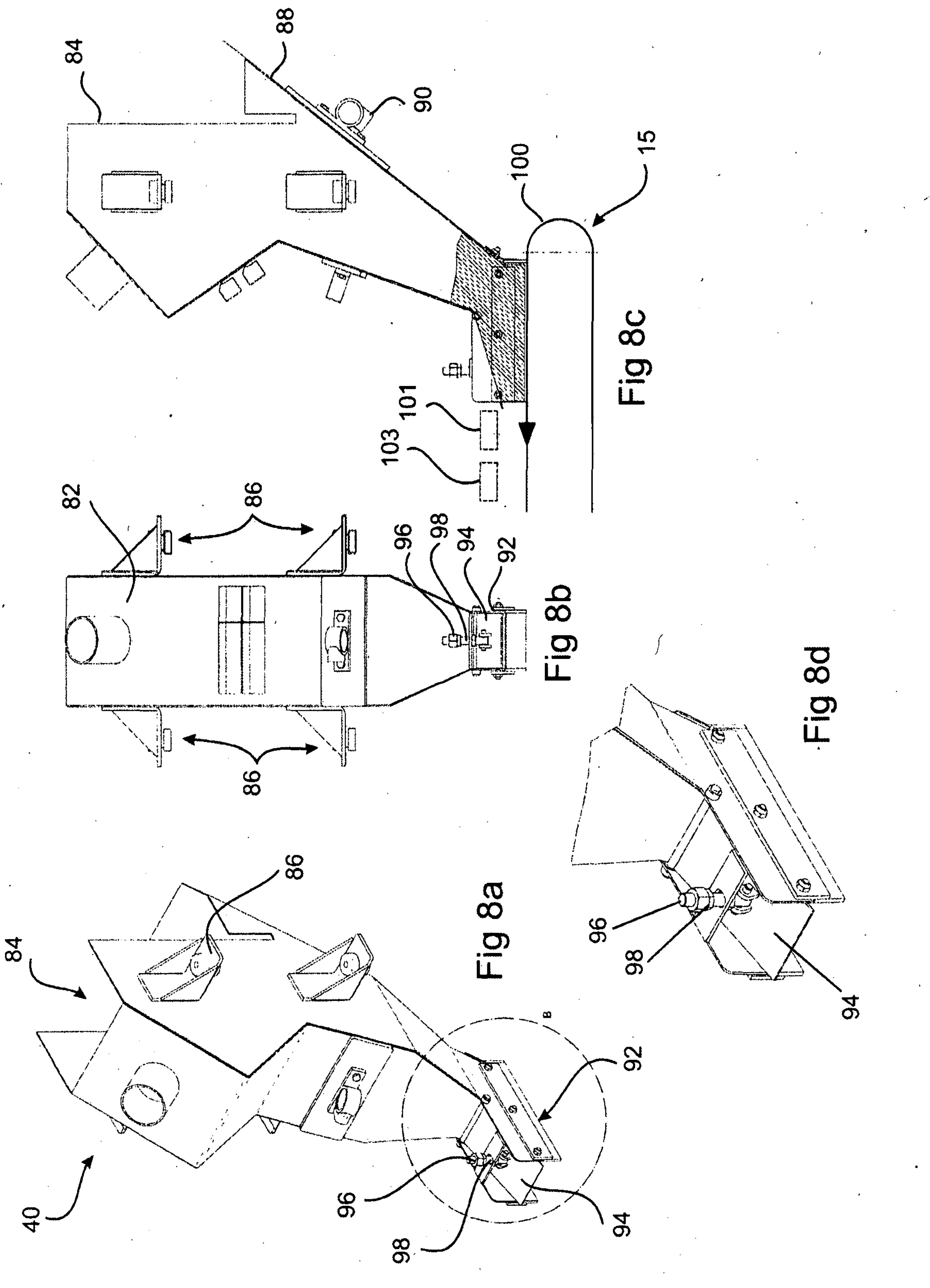

Fig 8a

Fig 8b

Fig 8c

Fig 8d

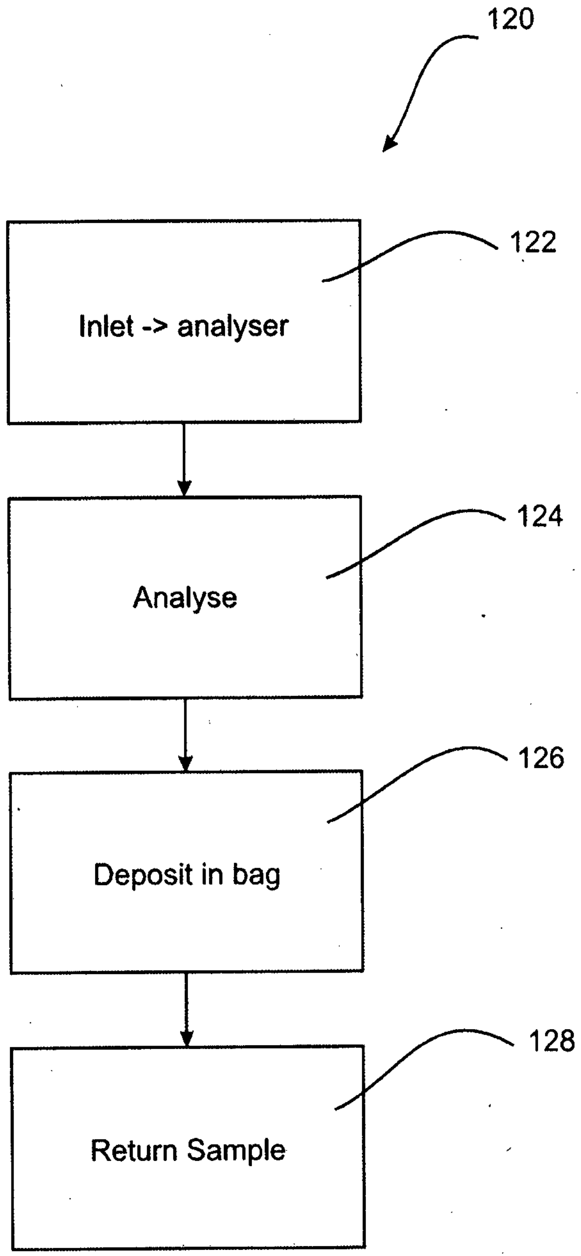
120
122
Inlet -> analyser
124
Analyse
126
Deposit in bag
128
Return Sample

Fig 9

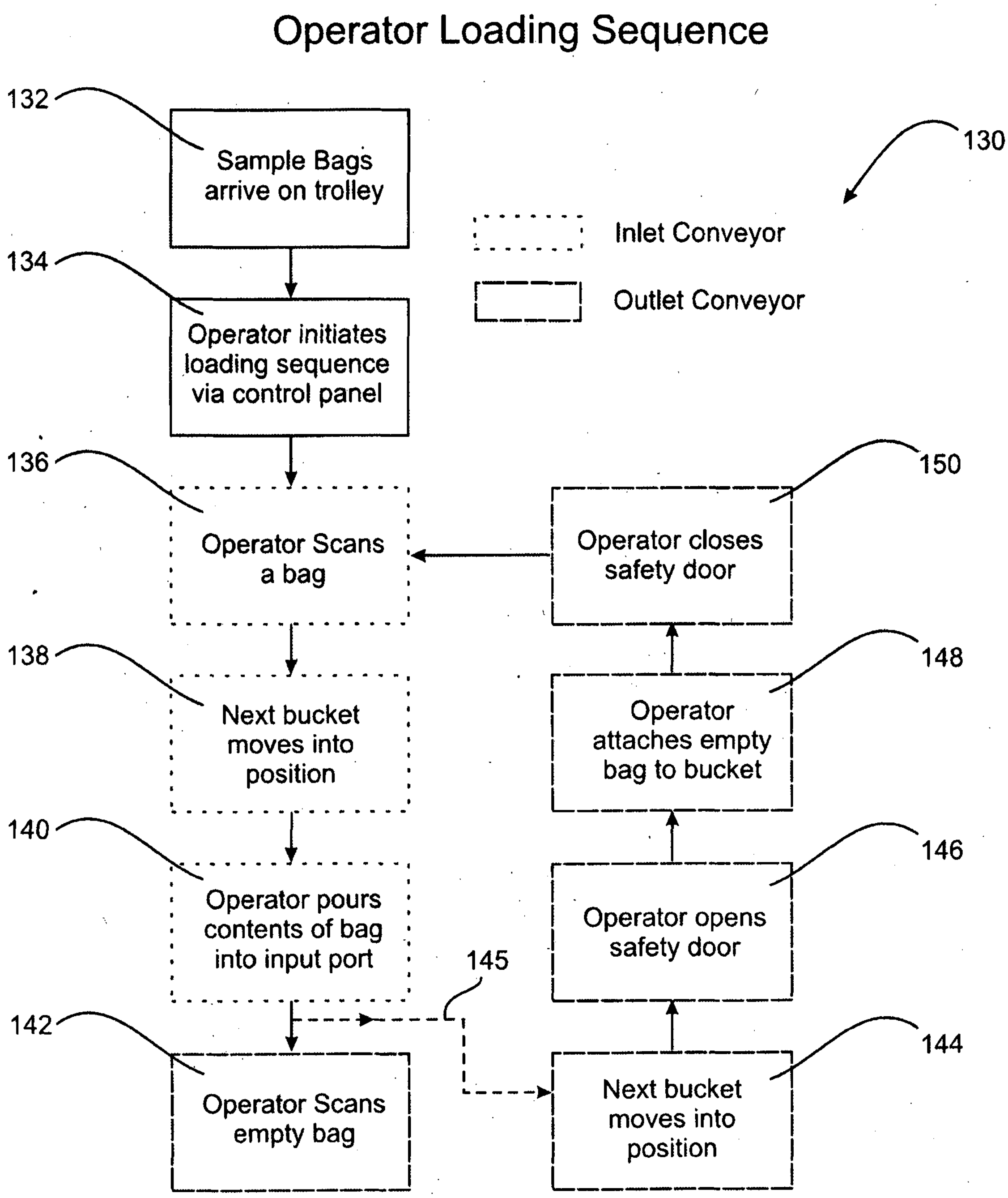
Operator Loading Sequence
132
Sample Bags arrive on trolley
134
Operator initiates loading sequence via control panel
136
Operator Scans a bag
138
Next bucket moves into position
140
Operator pours contents of bag into input port
142
Operator Scans empty bag
145
144
Next bucket moves into position
146
Operator opens safety door
148
Operator attaches empty bag to bucket
150
Operator closes safety door
130
Inlet Conveyor
Outlet Conveyor

Fig 10

Analysis Sequence (autonomous)

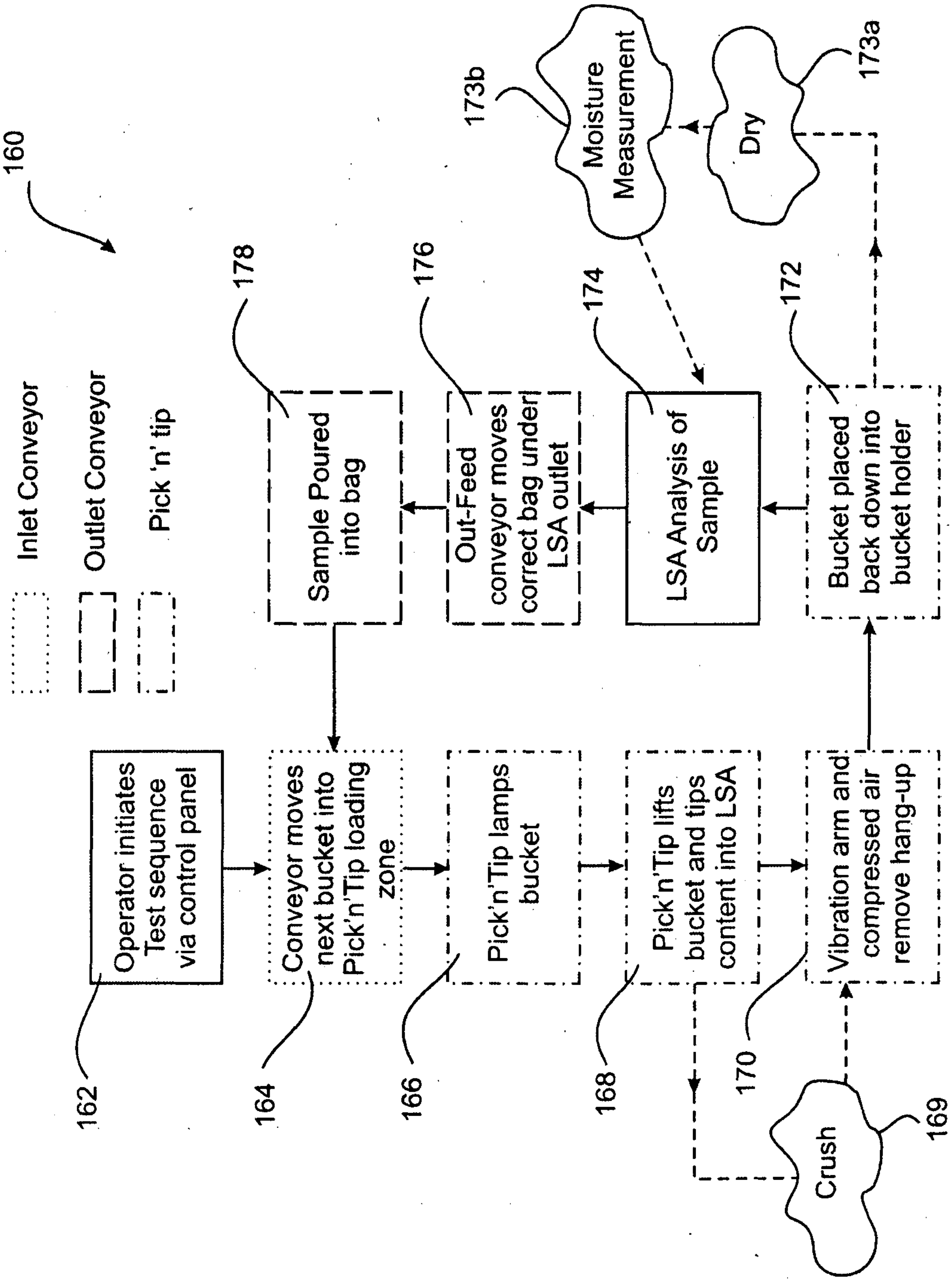

Fig 11

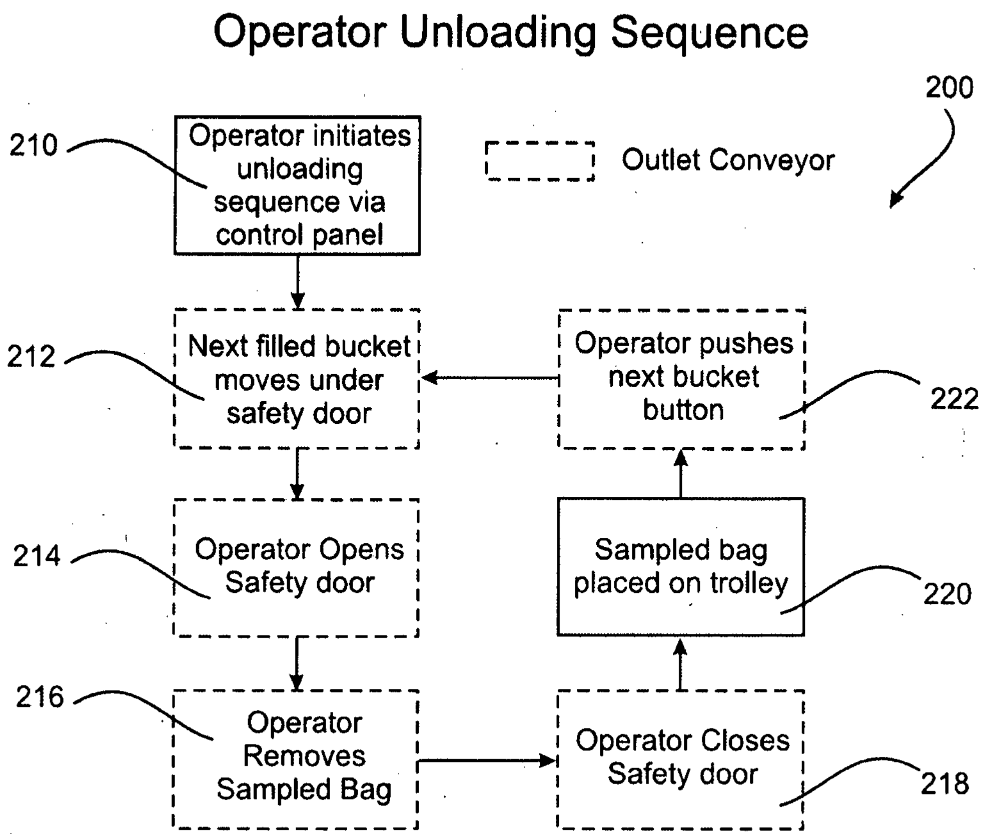
Operator Unloading Sequence
200
210
Operator initiates unloading sequence via control panel
Outlet Conveyor
212
Next filled bucket moves under safety door
Operator pushes next bucket button
222
214
Operator Opens Safety door
Sampled bag placed on trolley
220
216
Operator Removes Sampled Bag
Operator Closes Safety door
218

Fig 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2013/000554

A. CLASSIFICATION OF SUBJECT MATTER

B65G 47/26 (2006.01)

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)

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 practicable, search terms used)

Google: conveyor system for sample analysis ; dual conveyor for transport and similar words.
EPODOC and WPI: conveyor, transport, belt, transfer, input, inlet, entry, intake, output, exit, outlet, return, two, multiple, plural, secondary, additional, another, second, dual, analysis, identification, sort, separate, material, mineral, container, bin, bucket, same, matching, respective and similar related words.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C   [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28 June 2013	28 June 2013
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au Facsimile No.: +61 2 6283 7999	Jyoti Shamdasani AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832836

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	WO 1990/011142 A1 (SELLBERGS ENGINEERING AB) 04 October 1990	
X	Entire document particularly fig. 1 and pages 3-9	1,2, 6-8, 10-21, 27-37
Y	Entire document	3-5, 9
A	Entire document	22-26
	US 3,670,867 A (TRAUBE) 20 June 1972	
Y	Entire document particularly columns 1-2	3-5, 9
A	Entire document	1, 2, 6-8, 10-37

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2013/000554**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
WO 1990/011142 A1	04 Oct 1990	AU 5348290 A	22 Oct 1990
		CA 2049975 A1	24 Sep 1990
		EP 0463087 A1	02 Jan 1992
		JP H06511185 A	15 Dec 1994
		NO 913711 A	31 Oct 1991
		SE 8901046 A	24 Sep 1990
		US 5423431 A	13 Jun 1995
		WO 9011142 A1	04 Oct 1990
US 3670867 A	20 Jun 1972	None	

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.