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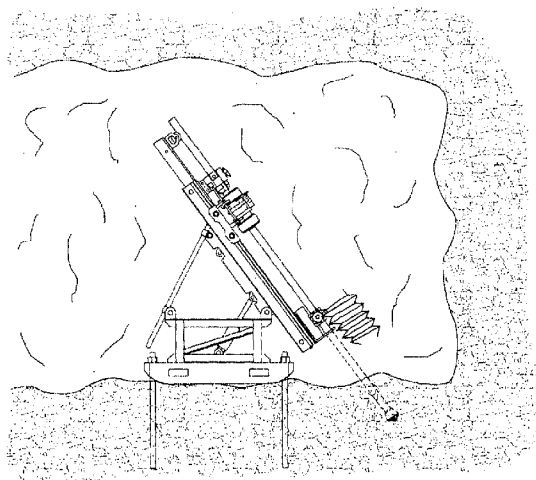
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(54) Title: LASER ALIGNMENT DEVICE FOR USE WITH A DRILL RIG

Fig-3



(57) Abstract: A laser alignment device for use with a drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting device to indicate the drill rod orientation and an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and an attachment arrangement to attach the head unit to a drill rig wherein the alignment device is used to align at least the azimuth of the drill rod relative to one or more survey points. The attachment arrangement includes a head chuck, tail chuck and connecting rod which allows the laser emitting device to be located and orientated in a direction which simulates the drill rod.



LASER ALIGNMENT DEVICE FOR USE WITH A DRILL RIG

TECHNICAL FIELD

[0001] The present invention relates to alignment devices and particularly to those which can be used to align drilling rigs to ensure correct drilling azimuth and/or dip angle.

BACKGROUND ART

[0002] In mining, whether underground or surface mining (e.g. diamond mining, goldmining etc), once the mine has been formed, exploratory drill holes are typically then formed to try to locate ore bodies. These drill holes can have a length of up to 1 km but are usually much shorter.

[0003] Initially, geologists will determine the likely location of an ore body or seam. The mine geologist will design the mine and the location of the exploratory holes and the surveyors will place survey markers in appropriate locations marking the intended hole positions. The survey markers will comprise a first mark on one wall of the mine and a second mark on an opposed wall of the mine. The markers are usually small reflective squares pinned to the mine wall. A "string line" between the two markers will show exactly the direction that the drilling apparatus will need to drill. This is known technology. For surface mines, a pair of pegs or markers inserted into the ground are typically used.

[0004] The direction typically includes the two components "elevation" and the "azimuth". The elevation is the angle to the horizontal at which the drill rod is oriented and the azimuth is the degree or direction about a vertical axis that the drill rod is oriented.

[0005] Ensuring the correct "elevation" is usually not a great problem as the drill rig can quite easily be angled upwardly or downwardly to the correct elevation. However, ensuring the correct "azimuth" has been a problem to date and even a small error in the azimuth can cause rejection of the bore hole.

[0006] Once the survey markers have been completed, a drill rig is positioned to drill the required core samples. The drill rig is usually a very large self-propelled apparatus. A typical apparatus comprises a wheeled or tractor vehicle which has a forwardly extending boom arm and attached to the boom arm is a drill rig. The drill rig is attached to the boom arm such that it can adopt any required angle (in Figures 1 and 2 the drill rig is pointing downwardly)

[0007] This type of apparatus is well-known and there are many different sizes and types of

such apparatus, such as that illustrated in Figure 3 for example which is an example of a skid-steered self-propelled rig.

[0008] Once the drill rig is roughly in position (determined by the survey markers), it needs to be very accurately adjusted to the survey markers. Once the adjustment is complete, the drill rig is secured in position and this is usually done by bolting the drill rig to the mine floor using a known type of feed frame positioner. For larger rigs, the weight of the rig can be sufficient to maintain the position.

[0009] The drill rig is then turned on to drill the required hole.

[0010] The present invention is directed to a laser unit device that can be used to very accurately correctly adjust the azimuth of the rig prior to bolting (securing) the rig into position. Preferably, the laser unit device is a gyroscopically aligned laser unit device.

[0011] Conventionally, string lines are used to align the rig prior to securement of the rig into position. That is, a string line is stretched between the survey markers on the opposed walls of the mine shaft. The apparatus is then positioned as close as possible to the string line and is aligned with the string line (that is the drill rig is aligned to be parallel with the string line to get the correct azimuth). Because of the size and shape of the apparatus, it is not possible to place the apparatus against the string line and usually the apparatus will be some distance away from the string line. For a "normal" sized apparatus, the apparatus will still be about 1 m away from the string line but for a larger apparatus, this can be between 3 to 4 m from the string line. A measuring tape is then used to accurately measure the distance between the front and the rear of the apparatus and the string line to ensure that the apparatus is exactly parallel with the string line such that when a hole is drilled, the hole will be at the correct azimuth.

[0012] In practice, it is difficult to obtain the level of accuracy that is demanded by the geologists using this known technique of string lines and measuring tapes. Once a pilot hole is collared, and it reaches its first survey mark (normally at approximately 5 to 15 meters) a survey tool is then inserted into the drilled hole. This survey tool normally provides a reading of both the elevation and the azimuth of the pilot hole. The driller then checks this against the hole plans and if not exactly correct, the hole will need to be redone.

[0013] The cost of drilling each hole can be many thousands of dollars and it is not unknown for the cost to be about \$100,000 per hole. A drilling contractor is not paid for a "rejected" hole.

[0014] In the present specification, the term "drill rig" is not intended to be limiting and

includes any type of drill or surface rig adapted to drill a hole in any type of mine including a surface or underground mine.

[0015] It will be clearly understood that, if a prior art publication is referred to herein, this reference does not constitute an admission that the publication forms part of the common general knowledge in the art in Australia or in any other country.

SUMMARY OF INVENTION

[0016] The present invention is directed to a laser alignment device, which may at least partially overcome at least one of the abovementioned disadvantages or provide the consumer with a useful or commercial choice.

[0017] With the foregoing in view, the present invention in one broad form, resides broadly in a laser alignment device for use with a drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting device, the laser devices movable in one plane only, an attachment means to attach the head unit to a drill rig and an adjustable assembly to adjust the positioning of the head unit relative to the drill rod, wherein the alignment device is used to align at least the azimuth of the drill rod relative to a desired orientation.

[0018] In an alternative, the invention resides in a laser alignment device for use with a drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting devices, the laser devices movable in one plane only, an attachment means to attach the head unit to a drill rig and an adjustable assembly to adjust the positioning of the head unit relative to the drill rod, wherein the alignment device is used to align at least the yaw of the drill rod relative to a desired orientation.

[0019] The least one laser emitting device may be a rotating or static laser capable of projecting a laser beam. The desired orientation can be indicated in any way including through the use of survey points or simply as an angle with appropriate descriptive information.

[0020] In a preferred embodiment, the laser alignment device will align the pitch and the yaw of the drill rod, or put another way, the inclination and azimuth of the drill rod. Normally, a laser device will be used to align the azimuth or yaw of a drill rod relative to survey marks to ensure that the drill rod is on the correct heading. In addition or in the alternative, bearing devices may be used once a laser beam device has established the alignment.

[0021] An inclinometer, clinometer, gyroscope, sensors laser detectors repeaters or any type of device may be used to ensure that the drill rod has the correct inclination or tilt angle.

[0022] The device of the present invention can be used in underground situations or above ground, surface situations.

[0023] With the foregoing in view, the present invention in a second form, resides broadly in a laser alignment device for use with a drill rig having an elongate drill rod, the laser alignment device including a head unit having at least a pair of laser emitting devices mounted independently to one another thereon, each of the laser devices movable in one plane only and oriented in substantially opposite directions to one another, an attachment means to attach the head unit to a drill rig and a length adjustable assembly to adjust the separation distance between the head unit and the drill rod, wherein the alignment device is used to align at least the azimuth of the drill rod relative to survey marks.

[0024] Typically, the lasers will be used to align or adjust the drill rod to the correct elevation or angle as well as azimuth.

[0025] As discussed above, it is typically difficult to obtain the level of accuracy of alignment of the drill that is demanded by the geologists and surveyors using the known technique of string lines and measuring tapes. The present invention obviates the need for string lines and droppers and measuring tapes and increases the accuracy of the alignment of the drill rig and thereby the precision of the holes which is drilled.

[0026] Preferably the alignment of the drill rig takes place prior to securing the drilling rig in position to drill the hole.

[0027] The drill rig in relation to which the device of the present invention is used normally includes a pair of parallel steel feed rails. A carriage is provided which normally slides relative to the rails.

[0028] The device of the present invention will normally be attached to the feed rails although it may be attached to any portion of the drill rig. Any mechanism of attachment may be used but the preferred form of attachment is a secure attachment but one which is also easily removable as the device will normally be removed prior to commencement of the drilling.

[0029] Preferred methods of attachment include pin and slot or clamping arrangements but most preferred is a magnetic attachment. A magnetic attachment increase utility of the device as

the device can be attached to any metal portion of the drill rig according to the preference the user.

[0030] The device will typically be temporarily attached to the drill rig during the alignment phase of the operation of preparing the drill rig for use and will be removed prior to operation of the drill rig. The device will normally remain in place until after the drill rig has been secured in position to limit the chance that the drill rig moves accidentally during the fixing process and to check the alignment of the drill rig.

[0031] The device of the present invention includes a head unit. The head unit typically mounts the pair of opposed laser pointing devices in a removable manner. Alternatively, the head unit may mount a single rotating laser device.

[0032] Any laser pointing devices may be used. Each of the laser pointing devices are typically held by a laser holding means. The laser holding means are typically attached relative to one another. Each laser pointing device can be moved relative to one another via a hinge or pivot or the like extending through both

[0033] Each laser holding means will typically clamp or receive the laser pointing devices in a threaded engagement.

[0034] Each laser holding means is preferably provided with a finger tab extending at an angle to the holding means. These finger tabs typically allow each laser to be moved so to point to the survey marks during the alignment process.

[0035] The laser holding means may be "sandwiched" between a backing plate and a front plate. Each of the plates and typically the laser holding means itself will be provided with at least one magnetic strip. The respective magnetic strips will preferably function to magnetically clamp the laser holding means to hold the laser holding means in position once aligned with the survey marks or pegs. A pair of arcuate openings may be provided through the front plate through which the finger tabs extend.

[0036] Although the abovementioned magnetic means is preferred, any releasable attachment means can be used.

[0037] Importantly, each of the laser devices move only in a plane which is substantially vertical, such that the laser pointing devices can move up and down only and not side to side. The head unit will therefore also be parallel to the foot portion.

[0038] The attachment means of the head unit is preferably associated with attachment means to attach the head unit relative to the drill rig.

[0039] Preferably an actuable electromagnet attachment will be used. The attachment means will also typically be length adjustable to adjust the distance between the drill rig in general and the drill rod in particular and the head unit.

[0040] The length adjustment means will typically include a rod or arm assembly which is length adjustable. Located at one end of the arm assembly will normally be the head unit and at the opposite end will be a foot to attach the arm assembly to the drill rig. The arm assembly may be length adjustable in any manner including telescopically or through the provision of a number of arm portions which are attachable relative to one another.

[0041] There is also typically an ability to move the head unit upwardly and downwardly relative to the rig.

[0042] There may also be a "remote control" variation. To explain, sometimes, the drilling rigs are operated by a single person. Larger rigs are medium-sized having a control cabin to operate the boom arm and various other components. As the laser unit is attached to the drill rig, it may become difficult for a sole operator to (a) operate the entire drill rig from the cabin while at the same time (b) needing to leave the cabin constantly keep check on the laser unit.

Therefore, a remote-control laser unit where the lasers might be attached to some form of motor or other type of driving mechanism to adjust the lasers and where the telescopic arm can be extended and retracted by remote-control may be provided. The laser unit could then be operated from the cabin.

[0043] A further option is to have an alarm (which could be a light) which lights up when the lasers are correctly aligned. To do so, a reflective strip may be placed on the survey marker and if the laser beam is correctly aligned, the laser beam will bounce off the reflective strip and back to a sensor provided on the laser unit which would then activate the alarm when the laser is correctly aligned. An audio alarm may be provided although a mine is a very noisy environment and a visual alarm is probably of most benefit.

[0044] A further option is to have a digital inclinometer attached to the laser unit (typically to the telescopic rod). This can then allow the correct elevation or inclination of the drill rig to be quickly determined, and together with the two lasers (to determine the azimuth), the drill rig can be correctly orientated. By having the inclinometer attached to the laser unit, it can also be

removed prior to operation of the drill rig.

[0045] In another form, the invention resides in a laser alignment device for use with a drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting device to indicate the drill rod orientation and an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and an attachment arrangement to attach the head unit to a drill rig wherein the alignment device is used to align at least the azimuth of the drill rod relative to one or more survey points.

[0046] Typically, the laser alignment device will be used to align the drill rig whilst the drill rod is not mounted to the drill rig. The laser alignment device will typically be mounted to the drill rig in place of the drill rod and the at least one laser emitting device is used to indicate the orientation of the drill rod once the drill rod is attached or mounted to the drill rig. The laser alignment device is removed from the drill rig once the drill rig has been aligned and replaced with a drill rod which is then used to drill the hole.

[0047] However, the alignment device can be used to align the drill rig whilst the drill rod is mounted to the drill rig.

[0048] Typically, the laser alignment device will provide an indication of the drill rod dip as well as the azimuth. Still further, it is preferred that the laser alignment device be provided with a mechanism to locate the drill rig as well as provide the azimuth and dip angle of the drill rod.

[0049] The head unit of the laser alignment device of a preferred embodiment includes at least one laser emitting device located at least parallel to the drill rod, but preferably mounted relative to the drill rig in the position which the drill rod normally occupies during operation. As mentioned above, the head unit is therefore preferably mounted in place of the drill rod with the drill rod temporarily removed from the rig during alignment. In this way, the laser emitting device can be used to ensure that the drill rod (once fitted) will be oriented as required.

[0050] Typically, the least one laser emitting device points forwardly, that is in the direction of the drilling but the at least one laser emitting device or another laser emitting device can point rearwardly or in both directions. For example a rotating laser device can be used.

[0051] Typically, the at least one laser emitting device is fixed relative to the head unit such that any emission from the device is in a fixed direction. Typically, the least one laser emitting device is mounted substantially in line with the drive of the drill rod. The method of accomplishing end this may differ according to the drill rig.

[0052] For example, surface drilling typically uses a survey peg or similar to indicate the drilling location. The at least one laser emitting device of the present invention is preferably used to point to that location while the required azimuth and dip angle of the drill rod are established. Typically, the laser emitting device is maintained pointing at the desired point whilst the position and/or orientation of the drill rig is adjusted for the required azimuth and dip angle to ensure the correct positioning. In this embodiment, the at least one laser emitting device takes the place of the drill rod or in other words, indicates that position and/or orientation of a virtual drill rod which indicates the position and/or orientation that the actual drill rod will assume when attached to the drill rig.

[0053] The head unit of this embodiment of the present invention preferably includes an inertial measurement device or unit to indicate at least the azimuth of the at least one laser emitting device on the basis that orienting the beam from the laser emitting device will have the effect of orienting the drill rig so that the drill rod is properly aligned once the drill rod is attached to the drill rig.

[0054] The type of inertial measurement device used is not essential but a gyrocompass or similar is preferred and a particularly preferred type is a fiber optic gyrocompass. The inertial measurement device or unit may use a combination of accelerometers and gyroscopes, sometimes also magnetometers. Recent developments allow for the production of inertial measurement device or unit-enabled GPS devices. An inertial measurement device (navigation system) provides position relative to a given reference (often GPS) but will continue to provide a position reference when GPS is not available. GPS is an aiding sensor to an inertial navigation system. This is particularly useful in tunnels, inside buildings, or when electronic interference is present. In some cases an inertial measurement device may be aligned with a GPS system in order to provide latitude and/or longitude or other location data.

[0055] The inertial measurement device may indicate a measure of the azimuth or simply indicate when the beam of the at least one laser emitting device is aligned with a particular azimuth. An azimuth is normally measured in degrees, typically from the North direction but any units may be used.

[0056] The head unit may also include a device to measure the dip angle or ensure the dip angle of the at least one laser emitting device (or beam) is correct. Typically, a suitable device is an inclinometer although other devices such as accelerometers may be used instead of or in addition thereto. If a single device can provide both functions (azimuth and dip angle), then a

single device may be used or separate devices may be provided in a single head unit.

[0057] Typically, the devices are integrated into a single head unit such that all three parameters (location, azimuth and dip angle) can be used to correctly position and orient the at least one laser emitting device (or beam) which is subsequently replaced by the drill rod.

[0058] The laser and gyroscope/azimuth alignment device may be either co-located or be located separately on the drill rig and the alignment between the two devices calculated and used as an offset such that the two devices can function together as if co-located in the tool body.

[0059] According to alternatives of the present invention, the head unit can be positioned parallel to the drill rod rather than replacing the drill rod and the same methodology used albeit allowing for the separation distance between the head unit and a drill rod.

[0060] A display device can be used to display the parameters measured or indicated by the head unit. Typically, a tablet PC or other computing device can be used for this purpose. Typically these devices include a display screen as well as at least one, and typically a variety of communication possibilities and pathways including WIFI, Bluetooth®, WLAN, LAN, USB and serial communications, and/or other communications pathways such as those used by mobile telephony and the like. The display device will typically also be capable of operating software to assist with the location and orientation of the drill rig and rod, both prior to drilling and preferable also during the drilling operation to ensure that the drilling not only begins at the correct location and orientation but also that it remains on target.

[0061] A particularly appropriate series of devices is the Leica iCON tablet devices. These devices are wireless and can function remotely from the head unit. Typically, the head unit and/or the device will include a GPS locator in order to assist with positioning of the drill rig and drill rod. Other appropriate devices are computer tablets which may be connect by wireless or hard wired communications to other components.

[0062] Each of the devices integrated into the head unit (or if attached separately) may be independently actuatable and/or powered so that any device is not required to be powered down or off. Preferably, the devices also report information and communicate data to/from one or more display devices and/or storage servers.

[0063] Typically, the at least one laser emitting device is located in line with the position of the drill rod and the remaining devices can be offset from the position of the drill rod and either attached to the housing or integrated into the housing containing the at least one laser emitting

device.

[0064] The device of the present invention also includes an attachment arrangement to attach the head unit to drill rig. Normally, the attachment arrangement is adapted to attach the head unit to the drill rig in place of the drill rod. Typically, drill rigs are one of two main types, namely either an end drive or a collar drive.

[0065] When applied in an end drive configuration, namely where a drive is provided at one end of a drill rod, an adapter is preferably provided to attach the device to the drive. Typically, the adapter will attach directly to the drive and to the housing of the head unit.

[0066] Typically, the adapter will mount the device to the drill rig such that the at least one laser emitting device is coaxial with the drive.

[0067] A spindle may be provided in or as part of the adapter or separately. Typically, the spindle will attach between the head unit and the drive. The spindle will typically include a bearing race in order to allow the inertial measurement device of the head unit to self-position and/or level. Preferably, the order of mounting to the drive of the drill rig will be the adapter then the spindle then the housing of the head unit.

[0068] When applied in a collar drive configuration, namely where the drill rod is typically received through a generally cylindrical opening and driven by a drive provided in the cylindrical opening, the spindle as provided above may still be provided. Typically, the attachment arrangement will include a mounting system which will allow the at least one laser emitting device to be located and oriented in a direction which simulates the drill rod which has typically been removed from the drill rig and replaced with the device of the present invention.

[0069] It is particularly preferred that a centering attachment arrangement is provided. In a particularly preferred embodiment, the attachment arrangement will include a head chuck, a tail chuck and a connecting rod located between the two chucks. Typically, the head chuck is attached to the connecting rod and the tail chuck is removably attached to the connecting rod at an opposite end to the head chuck and is movable along at least a portion of the length of the connecting rod.

[0070] Typically, the head chuck is generally conical in shape as this allows the chuck to centre within the collar drive opening. Normally, the preferred shape will have a larger end surface which is typically circular and a smaller end surface, also typically circular joined by a generally conical sidewall. In preferred configurations, the head chuck will be frustoconical.

[0071] The conical shape of the head chuck may be defined by a solid member or alternatively and more preferred, by framework of ribs provided to define the conical shape, but reduce the amount of material used and/or the weight of the head chuck.

[0072] The head chuck of the preferred attachment arrangement will normally have an attachment portion for the attachment of the spindle or directly to the head unit of the device. The attachment portion will normally be in the larger end surface. Typically, the attachment portion will include a threaded opening which will allow engagement with a preferred rigid threaded portion provided on the spindle.

[0073] Normally, the connecting rod is mounted centrally, extending from the smaller end surface of the head chuck. Preferably, the connecting rod is permanently attached to the head chuck.

[0074] The connecting rod will typically be elongate and normally substantially circular in cross-section although any cross-sectional shape can be used. The connecting rod is typically mounted permanently to the head chuck but is received through the tail chuck in order that the tail chuck can be removed from the rod and also moved along the length of the rod.

[0075] Appropriate features will be provided on the rod and/or the tail chuck to allow the fixing of the position of the tail chuck on the connecting rod at a variety of positions along the length of the connecting rod in order to control the separation distance between the head chuck and the tail chuck.

[0076] One simple mechanism for achieving this is to provide a threaded portion at least partially along the length of the connecting rod. Normally, the threaded portion will be of sufficient length in order to fit the head chuck and tail chuck on either side of a variety of collar drives from different drill rig manufacturers. In a particularly preferred embodiment, the threaded portion will extend from the end of the connecting rod furthest from the head chuck to approximately half to 3/4 of the length of the connecting rod. In some embodiments, the entire rod can be threaded.

[0077] The tail chuck is similar in many respects to the head chuck it is typically oriented in the reverse direction with the small end surface facing the small end surface of the head chuck. This results in the converging conical surfaces of both the head and tail chuck facing one another.

[0078] Typically, the tail chuck will include a bore extending through the tail chuck, from the smaller end surface to the larger end surface. According to a preferred embodiment, the bore

will be internally threaded in order to engage with the preferably threaded connecting rod although the fixing mechanism used to fix the position of the tail chuck relative to the rod will largely determine the configuration of the fixing mechanism provided on the tail chuck, if any.

[0079] In order to ensure that the hole drilled remains on line, an alignment detector attachment and system can be provided. The alignment tool discussed above can be used with a laser alignment detector attachment as a part of a system to ensure that the hole remains online as it is drilled as well as at setup.

[0080] Therefore, as an alternative aspect, the present invention may reside in a drill rod alignment detector system including a laser device mounted relative to a drill rig for indicating a drill rod orientation and an alignment detector device adapted to be placed at least partially in a partially drilled hole and having a laser point detection portion that detects where a laser light point of the laser device strikes the face of the detector enabling calculation of the position of the drill rod in relation to the centre of the partially drilled hole.

[0081] Normally, the alignment tool discussed above is used during the original rig setup and the alignment tool is then removed from the drill rig. According to this aspect of the present invention, normally, after the hole is drilled to a sufficient indicated depth, the alignment tool can be reattached to the drill rig. Normally, no changes are made to the rig setup during this process, that is the alignment is not adjusted. The alignment detector attachment is then typically placed into the hole which has been partially drilled and the alignment tool or laser is directed at the alignment detector attachment.

[0082] The alignment detector attachment will preferably provide data to a display device outside the whole of the orientation of the laser and thereby of the drill rod in order to allow adjustment of the alignment tool and thereby adjustment of the drill rod to ensure correct drilling.

[0083] This alignment detector attachment preferably includes a laser point detection plate (typically an optical detection array) that detects where the laser light point strikes the face of the detector and will calculate this position in relation to the centre of the drilled hole, normally in two axes.

[0084] The orientation of the laser point detection plate in relation to the orientation of the alignment tool is preferably measured by rotational alignment detectors, which may be inclinometers measuring one or two axes or other similar inclination measuring device.

[0085] The alignment detector attachment is typically centred in the drilled hole by a

mechanical centring mechanism. This will usually be a length of machined rod – similar to a drill rod and either of the same diameter as the drill rod used to drill the hole, or extended to this diameter using collars, extensions, bushes or similar devices.

[0086] This information or sufficient data to allow a visual representation of the orientation of the laser is preferably transmitted to a display device outside the hole. Transmission of this information may be by wireless communication means or by way of a hard wired connection. The information is then processed in software running on the display device to compensate for any rotation of the alignment tool within the hole. An image is preferably generated and displayed on the display in an easy to read information display depicting the angular offset of the hole from the centre line of the drill in two axes.

[0087] The alignment detector attachment will preferably be self centering in the hole and also be capable of self centering in a hole of any larger size. The alignment detector attachment will preferably have a detector allowing for positional and/or rotational alignment relative to the alignment tool or to determine alignment relative to the alignment tool.

[0088] For surface drilling applications the gyrocompass preferred for underground use may be replaced by an inertial navigation system (INS). This INS will preferably receive an input from available GPS/DGPS/RTK GPS navigation systems.

[0089] Display software provided on a display device will preferably utilise the navigation data output by the INS to plot the position of the drill rig - with offsets preferably included to navigate the centre of the drill on a generated map/or grid display of the drill site and surrounds.

[0090] The navigation position provided by the INS can normally be plotted within a few centimetres dependent upon the accuracy of the available GPS signal. The display will preferably allow zooming in to allow correct positioning of the rig.

[0091] The software will access a database of desired or required hole locations to provide coordinates for each hole to the display allowing an operator to correctly position the drill rig. Each hole will be able to be selected as a navigation waypoint and displayed on the map/grid display.

[0092] Further, the software is preferably able to log all data and display onto the display device. The software will also preferably communicate with a server or similar device to maintain back up data in relation to hole set ups as well as real time recording of movements between holes and hole set ups. This will preferably allow an operator to access and preferably

view data in relation to the past, present or future drilling activities for planning or review purposes.

[0093] A variety of information will preferably be accessible via the system software including shift reports, pre starts, drill hole run recording, and/or survey results. In addition, it is preferred that photos also can be taken of drilled ground, equipment or anything and used in daily shift reporting such as safety issues, damage to equipment, hazards and the like.

[0094] Information can be used or recorded as required by clients or drill companies. This information can typically be downloaded or sent directly via the display device or any type of recording or display device each day or when need to a server that processes and stores information for later use.

[0095] Preferably, software is provided that can also be used when a laser device and a gyrocompass type device are mounted separately on rig to transmit information to a display device which is either separate from the drill rig (such as a tablet computer or similar device) or mounted relative thereto. Any of the components can be mounted separately on the drill rig and communicate (via wireless or wired connections) to a remote computing device, on eth rig or not.

[0096] A fully automated option may also be provided with a mobile drill rig integrated with drill rig hydraulics and software such that the location of the rig and each drill hole is programmed into software allowing the rig to self-navigate to each location and then align itself using the components described herein making set up fully automated. In this case, an operator would simply upload or enter required information and the drill rig in conjunction with gyrocompass/navigational devices/software will automatically move to required location, align itself and begin the drilling operation.

[0097] Laser beam can go from a single dot and using internal lenses can adjust to any diameter required. This laser can then be used to identify where hole is going to be drilled, collared, bored. Once set up, use of the laser beam can show circular reference to hole diameter that is going to be drilled. Also, use of a laser can assist with reinterring drill holes simply adjust laser beam to hole diameter or slightly bigger this helps operator see a circular beam around drill hole.

[0098] Any of the features described herein can be combined in any combination with any one or more of the other features described herein within the scope of the invention.

[0099] The reference to any prior art in this specification is not, and should not be taken as

an acknowledgement or any form of suggestion that the prior art forms part of the common general knowledge.

BRIEF DESCRIPTION OF DRAWINGS

[00100] Various embodiments of the invention will be described with reference to the following drawings, in which:

[0100] Figure 1 is a perspective photograph of a conventional boom operated drill rig in operation.

[0101] Figure 2 is a perspective photograph of the drill rig illustrated in Figure 1 from an alternative angle.

[0102] Figure 3 is a side elevation view of a conventional skid-based drill rig in the installed configuration and anchored to the floor.

[0103] Figure 4 is a schematic isometric view of a device of the present invention according to a preferred embodiment.

[0104] Figure 5 is a perspective view of a drill rig with a laser alignment device according to a first embodiment temporarily attached to the drill rig.

[0105] Figure 6 is a perspective view of a drill rig with a laser alignment device according to a second embodiment temporarily attached to the drill rig.

[0106] Figure 7 is a group of views illustrating a device and components thereof according to a preferred embodiment.

[0107] Figure 8 is an exploded perspective view of an alternative attachment mechanism for the device of the present invention.

[0108] Figure 9 is a side view of the attachment mechanism illustrated in Figure 8 in the assembled condition.

[0109] Figure 10 is a schematic top view showing the alignment of a drilling rig using the present invention.

[0110] Figure 11 is a schematic side view of the arrangement illustrated in Figure 12.

[0111] Figure 12 is a schematic perspective view of a drilling rig with the device according

to a preferred embodiment attached and aligned.

[0112] Figure 13 is a further schematic perspective view of a drilling rig with the device according to a preferred embodiment attached and aligned.

[0113] Figure 14a is a view from above of a drill rig with alignment device of a preferred embodiment prior to alignment.

[0114] Figure 14b is a view from above of a drill rig with alignment device of a preferred embodiment after alignment.

[0115] Figure 15 is an isometric view of another variation of the present invention that allows the alignment of the drilling rig to the marker points without having to implicitly align the laser beams to the marker tags.

[0116] Figure 16a is a view from above of a preferred embodiment of device of the present invention mounted to a tripod to reference bearings for aligning a drill rig.

[0117] Figure 16b is a view from above of the device illustrated in Figure 16a transferred to a cradle mounted on a drilling rig.

[0118] Figure 16c is a detailed view of a compass dial on the device illustrated in Figure 16a showing orientation.

[0119] Figure 16d is a detailed view of a compass dial on the device illustrated in Figure 16c with the outer dial zeroed.

[0120] Figure 16e is a detailed view of a compass dial on the device illustrated in Figure 16b with the outer dial indicating zero and therefore aligned.

[0121] Figure 17 is an axonometric view of a preferred embodiment of an alternative aspect of the present invention.

[0122] Figure 18 is a view from the rear of the device illustrated in Figure 17 in a partially exploded configuration.

[0123] Figure 19 is an exploded axonometric view of the device illustrated in Figure 17.

[0124] Figure 20 is an axonometric view of the device illustrated in Figure 17 attached to an Atlas Copco® Diamec MCRU6 drill rig.

[0125] Figure 21 is an axonometric view of the device illustrated in Figure 17 attached to an Atlas Copco® Diamec U8 drill rig.

[0126] Figure 22 is an axonometric view of the device illustrated in Figure 17 attached to an Atlas Copco® top drive drill rig.

[0127] Figure 22A is a detailed view of the drill drive portion of the rig illustrated in Figure 22 showing the attachment of the device thereto.

[0128] Figure 23 is an axonometric view of the device illustrated in Figure 17 attached to a DE 130 drill rig.

[0129] Figure 24 is an axonometric view of the device illustrated in Figure 17 attached to a Sandvik top drive drill rig.

[0130] Figure 25 is a schematic illustration of generated and displayed image of a drill hole pattern and the indicative movement of a drill rig relative thereto to a drilling position according to a preferred embodiment of the present invention.

[0131] Figure 26 is a schematic illustration of one possible system configuration showing communications pathways between elements of the system according to a preferred embodiment of the present invention.

[0132] Figure 27 is a schematic illustration of an alignment/orientation detector according to a preferred embodiment of the present invention.

[0133] Figure 27A is a detailed view of the detector plate illustrated in Figure 27 showing the laser point.

[0134] Figure 27B is a detailed view of the detector plate illustrated in Figure 27 showing the output display according to a preferred embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0135] According to a preferred embodiment, a laser device for use with a drilling rig and a drill rig with the device attached, are provided.

[0136] A conventional drill rig is illustrated in Figure 3. The drilling rig itself is of a commercial type and basically comprises a pair of parallel steel feed rails 10 which will typically have a length of between 1.5 m up to 6 m. A carriage 11 slides over the top of each feed rail, and

can reciprocate between the retracted position illustrated above and an extended position where the carriage has been moved to the front of the feed rails 10. A hydraulic ram 12 powers the carriage between its positions. On top of the carriage is a high speed hydraulic rotating apparatus 13. The rotating apparatus will typically rotate at speeds of between 1000-10,000 rpm. A drill rod (not illustrated) passes into the front opening of the rotating apparatus and is rotated by the rotating apparatus. In a front part of the drill rig is a "centraliser" 14 through which the rods pass and the function of the centraliser is to keep the rods aligned and to minimise "wobble". A hydraulic piston 15 is associated with the centraliser. The piston extends to lock the drill rod when the drill rod has stopped rotating.

[0137] In figure 5 and figure 6, the drill rig is exactly the same but the laser unit is slightly different in how the laser unit is attached to the drill rig.

[0138] Turning now to the laser unit, the various parts are illustrated in figure 7.

[0139] Basically, the laser unit is temporarily attached to the drill rig during the alignment process and is then removed prior to operation of the drill. Usually, the laser unit will also remain in place as the drill rig is secured in position just in case there is any inadvertent movement during the securing process. Once the rig is secured, the laser unit is removed and the drilling begins.

[0140] It is envisaged that the laser unit will be a separate device that can be attached to any commercial type of drilling rig. Therefore, the inventor believes that a magnetic attachment of the laser unit to the rig will be most versatile as this means that the laser unit can simply be magnetically clamped to any commercial rig. It also allows the laser unit to be clamped at any suitable position on the rig.

[0141] In practice, it is envisaged that in most circumstances, the laser unit will be attached to one of the feed frames of the drilling rig this being illustrated in figure 5 and figure 6. The feed frames are made of steel.

[0142] Figure 5 best illustrates the attachment of the laser unit. According to an embodiment illustrated generally by 20A, the laser unit has a base member 20 in which is positioned a strong magnet. A switch is positioned on the base unit and turning the switch causes the strong magnet to turn inside the base member between a magnetic clamping position and a free position where the entire laser unit can be removed. The invention advises that this type of device is known.

[0143] Figure 6 illustrates an alternative attachment 20B of the laser unit which does not use the magnet. Instead, a more conventional fastener arrangement is used. A disadvantage with this alternative attachment is that it does require fasteners or something equivalent to be welded or otherwise attached to the feed frames which can result in projections that can form "snagging points" which is somewhat undesirable.

[0144] While a magnetic attachment is desirable, other forms of attachments may also be used such as temporary clamps, a pin and slot arrangement, fasteners, possibly the use of straps and the like. The inventor also does not see any reason to limit exactly where the laser unit is attached to the drill rig. In practice, the attachment will most probably be on the feed frame but this need not be so.

[0145] A rod 21 extends outwardly from the mounting plate or mounting block. The rod in the particular embodiment is length adjustable and this can be done by making the rod telescopic. The length of the rod should be sufficient to allow the lasers to align with the survey marks on the mine shaft wall.

[0146] As a typical drill rig can be placed no closer than about 1 m to the "string lines" which are presently in use, it is considered that the rod should at least be extendable to about 1 m. For the smaller drilling rigs, the rod should be extendable from at least 20 cm up to 1.5 m and for the larger drilling rigs the rod may need to be longer such as between 1.5 m up to 4 m.

[0147] Usually two rod designs will be used, one being telescopic for the smaller units and therefore being extendable between 20 cm up to 1.5 m and a second rod design which can extend between 1.5 m up to 4 m and which can be used for the larger units.

[0148] Attached to the end of the rod are two oppositely pointing lasers. An advantage of the present invention is that two lasers 22, 23 (see figure 7) are used which point in the opposite direction. Each laser can be commercially available laser can be screwed into a laser holder. Therefore, there will be two laser holders as well.

[0149] The laser holders are attached to each other by a fastener 24 and importantly each holder (and therefore each laser) can hinge or pivot relative to each other.

[0150] Each laser holder is provided with a finger tab 25, 26. This enables each laser to be gripped and moved depending on the survey markers. Each laser holder is also provided with a magnetic strip.

[0151] The laser holders are "sandwiched" between a backing plate 27 (see for instance, figure 6 and which can be made of thin metal or plastic) and a front plate 28. The backing plate also contains magnetic strips (see figure 7). These magnetic strips will magnetically clamp to the magnetic strip on each laser holder. In this manner, once a particular laser holder has been aligned with a survey mark, it will be held in place by the magnetic strip 30 on the backing plate attaching to the magnetic strip on the laser holder. The front plate 28 is provided with a pair of arcuate openings 29 through which the finger tabs 25, 26 extend and allowing rotation of the lasers 22, 23.

[0152] The advantage of the "twin" lasers may be better illustrated with reference to figures 10 and 11 which are rough schematic views. Figure 10 is a top view looking down on the apparatus and what can be seen is the self-propelled wheeled or tractor vehicle 30, the boom arm 31 and the drilling rig 32. Also shown in figure 10 and in figure 11 are the two markers 33 and 34. In the side view (figure 11), it can be seen that one of the markers (e.g. 33) is in an upper part of the mine wall while the other marker (34) is at the bottom of the mine wall. This is not unusual, but if using string lines, it becomes very difficult to try to perfectly align the drill rig with the string line.

[0153] When using the twin lasers, (see particularly figure 11), the front laser can be pivoted upwardly to target the upper marker 33 while the rear laser can be pivoted downwardly to target the lower marker 34. When looking at this in plan (figure 10) it looks like a straight line but when looking at this in side view (figure 11) it can be seen that the two lasers are at an angle relative to each other. Importantly however the lasers still project a "straight" line when viewed in plan (figure 10) and this allows the drill rig 34 to be aligned with the lasers to be perfectly parallel thereto. That is, the front of the drill rig 35 and the rear of the drill rig 36 must be exactly the same distance away from the imaginary line formed by the lasers (see figure 10). Any deviation may result in the formed hole being rejected. This deviation can be seen as the "azimuth" and therefore the main function of the laser unit is to ensure that there is no deviation in the azimuth that is required.

[0154] The "elevation" can be seen as the angle of the drill rig from the horizontal (e.g. the mine floor) this can be easily adjusted by the apparatus. Thus, when looking at figure 6, it can be seen that the drilling rig has not yet been correctly "elevated" such that the drilling rig will ultimately drill a hole next to the upper marker 33. Once the all important "azimuth" of the drill rig has been aligned, the drill rig is secured (e.g. bolted to the floor) and then the elevation of the drill rig can be adjusted using the hydraulics of the apparatus.

[0155] For this reason, it is quite important that the lasers can only move up and down but cannot move from side to side. Any side to side movement can compromise the correct azimuth which is undesirable. It is also quite important that the lasers are exactly parallel to the drilling rig when the laser unit is attached thereto. The inventor advises that the drilling rigs are very precise and that the feed frames on the drilling rig are exactly parallel to the drilling rods. Thus, attachment of the laser unit to a feed frame will result in the lasers projecting a laser beam which is exactly parallel to the drilling rods. It also seems important in the manufacture of the laser units that the laser holders are exactly parallel to the magnetic mounting block wall mounting frame.

[0156] Figure 4 is an isometric view of the head unit 50 of a laser device according to a further preferred embodiment including lights 37 which are activated once the correct azimuth is reached. Also illustrated is an alternative method of connecting the head unit to the rod for simple and easy attachment and removal.

[0157] The head unit 50 is provided with a bore therethrough. A collar 38 is located in the bore. The rod 21 of the device is provided with an internally threaded end portion into which a threaded fastener 39 is received. The threaded fastener 39 extends through the collar 38 located in the head unit 50 and attaches the head unit 50 to the rod 21 quickly and easily. An o-ring 40 or similar is provided to minimise unwanted rotation of the head unit 50 relative to the rod 21.

[0158] A further embodiment of the present invention is illustrated in Figure 13 showing a drilling rig 80 fitted with a cradle 82 at the rear of the boom 81. The cradle 82 in turn holds a removable laser unit 83 comprising a rotating or static laser 85 capable of projecting a laser beam 84 to the extremities of the front and rear walls of the tunnel. The unit 83 will also contain a clinometer to take pitch readings and a device that will capture the yaw of the rig. The laser unit is set up so that the beam emitted runs parallel to the drill shaft. This means that when the drill rig 80 is moved to a position where the laser beam is aligned to the front marker tag 86 and rear marker tag 87 on the front and rear walls, as illustrated in Figure 14A, the drill rig is in the correct alignment for drilling, illustrated in Figure 14B.

[0159] The cradle 82 is fitted with a removable extender section 88, which can be stored safely when not in use. It also has a geared rack 89 incorporated to allow the head unit 83 to be moved in and out remotely. This function is to allow the fine-tuning which may be required to compensate for the movement of the rig 80 relative to the marker points.

[0160] If on the rare occasion the drill rig 80 isn't able to be positioned close enough to the

marker points for the laser beams to reach the markers then alignment can be approximated by eye and the fine-tuning can be done by measuring the distances between the laser beam 84 and the tag at the front 86 and back 87 markers.

[0161] The clamp on cradle 82 has adjustable fixing points so it can be adapted to the majority of drill rigs used in this application.

[0162] The preferred embodiment illustrated in Figure 15 is another variation of the present invention that allows the alignment of the drilling rig to the marker points without having to implicitly align the laser beams to the marker tags.

[0163] This embodiment has all of the functionality of the embodiment illustrated in Figure 13 but adds a bearing device such as a compass or gyrocompass that allows the operator to align the rig 80 according to a bearing taken from the site plans or by repeating a bearing from a remote reading obtained by aligning the compass to the front 86 and back 87 markers. A laser/compass unit 90 including both a laser unit and a compass or bearing unit is provided.

[0164] This embodiment does not require an extended support system or the ability to move the laser/compass unit 90 relative to the rig 80 (as used in the previous embodiment) as there is no need to align the laser to the marker points when the unit is fixed to the rig.

[0165] In use a remote reading is translated to or taken from the compass from the alignment of the compass to the marker points on the front and back walls, using a laser beam 84. This reading can be translated to the rig 80 by taking the laser/compass unit 90 with the reading on it and fixing it to the drilling rig 80. The actual reading can be translated to the rig or a marker can be used to capture the zero point on the compass when aligned to the marker tags and then the rig can be aligned to the zero point defined by that marker.

[0166] For example, as illustrated in Figure 16A, a laser/compass unit 90 is mounted on a tripod and using the laser being aligned with the front and rear markers, a true bearing from the tripod mounted laser/compass unit 90 reads 45°. An outer dial of the compass of the preferred embodiment can then be rotated to read 0°.

[0167] As illustrated in Figure 16B, the laser/compass unit 90 can then be transferred to the cradle 82 mounted on the drilling rig 80 entity drill rig is then rotated until the compass again shows the zero reading. The drill rig 80 will be parallel to the market points when the compass read zero as illustrated in Figure 16E.

[0168] If the readings are to be taken from site plans then the compass should be calibrated to the site plans before any readings can be translated to the drilling rig. This would need to compensate for specific site grids that may be a fixed number of degrees off true north. In these situations the bearing may be a simple translation of the bearing dictated on the plans to the rig. Alternatively a true north reading can be translated directly to the rig with any site anomalies being accounted for in the bearing.

[0169] In order for the operator of the drilling rig to align the drilling shaft with the marker points he/she estimates the correct proximity to the front marker and then rotates the rig until the required bearing is met. The bearing devices used will need to be impervious to any external influences that may affect its accuracy, such as magnetic effects which are typically present in underground mines.

[0170] The compass, gyrocompass or any type of bearing reader/repeater and inclination reader (clinometer) can also be used to align any type of surface drill rig or any type of drilling equipment that needs aligning. Alternatively a true north bearing gyrocompass can be used to align the drill rig or equipment to the required azimuth and a clinometer can be used to determine the depth, or the gyrocompass can be set to a particular mine grid depending on the user's requirements that can be fixed to the mast of the rig or side or any part of the rig or equipment.

[0171] It is intended that the mobile units are stored safely and transported to the rig when required.

[0172] In an alternative embodiment illustrated in Figures 17 to 24, the laser alignment device 150 includes a head unit 101 having a laser emitting device 107 to indicate the drill rod orientation and a gyrocompass 102 to indicate at least the azimuth of the laser emitting device. An attachment arrangement 105 is provided to attach the head unit 101 to a drill rig 103.

[0173] In this form, the laser alignment device is used to align the drill rig whilst the drill rod is removed from the drill rig. The laser alignment device is mounted to the drill rig in place of the drill rod and the laser emitting device is used to indicate the orientation of the drill rod once the drill rod is attached or mounted to the drill rig. The laser alignment device is removed from the drill rig once the drill rig has been aligned and replaced with a drill rod which is being used to drill the hole.

[0174] The laser alignment device of this embodiment provides an indication of the drill rod dip as well as the azimuth.

[0175] The head unit 101 of the laser alignment device of this embodiment includes one laser emitting device mounted relative to the drill rig in the position which the drill rod normally occupies during operation. As mentioned above, the head unit is therefore preferably mounted in place of the drill rod with the drill rod temporarily removed from the rig during alignment. In this way, the laser emitting device can be used to ensure that the drill rod (once fitted) will be oriented as required. The position of the unit on a number of different drill rigs is illustrated in Figures 20 to 24.

[0176] The laser emitting device points forwardly, that is in the direction of the drilling and emits a beam in that direction 104. As illustrated in Figures 20 to 24, the laser emitting device is mounted substantially in line with the drive of the drill rod. The methods of accomplishing this differ according to the drill rig and more precisely, the type of drive the drill rig uses.

[0177] The head unit of this embodiment includes a gyrocompass 102 to indicate at least the azimuth of the laser emitting device on the basis that orienting the laser emitting device will have the effect of orienting the drill rod once the drill rod is attached to the drill rig. The gyrocompass will normally be battery powered and wirelessly transmit information to a tablet computer for display to an operator. A cover 108 is normally provided to cover connectors and wireless transmitter.

[0178] Typically, the devices are integrated into a single head unit as illustrated in Figures 17 to 19 such that all three parameters (location, azimuth and dip angle) can be used to correctly position and orient the laser emitting device which is subsequently replaced by the drill rod.

[0179] Each of the laser emitting device 107 and the gyrocompass 102 integrated into the head unit is independently actuatable and powered so that any device is not required can be powered down or off. As illustrated in Figure 19, two power switches 106, one for each device are provided.

[0180] The attachment arrangement 105 is adapted to attach the head unit 101 to the drill rig 103 instead of the drill rod. Typically, drill rigs are one of two main types, namely either an end drive as illustrated in Figures 22 and 24 or a collar drive as illustrated in Figures 20, 21 and 23.

[0181] When applied in an end drive configuration, namely where a drive is provided at one end of a drill rod, an adapter 110 is provided to attach the drive and to the housing of the head unit 101 such that the laser emitting device 107 is coaxial with the drive.

[0182] In the embodiments illustrated in Figures 22 and 24, the adapter 110 is attached to a

spindle 109 including a bearing race 111 in order to allow the gyrocompass 102 of the head unit 101 to self level.

[0183] When applied in a collar drive configuration as illustrated in Figures 20, 21 and 23, where the drill rod is typically received through a generally cylindrical opening and driven by a drive provided in the cylindrical opening, the spindle 109 as described above is still provided. In this form, a preferred embodiment of the attachment arrangement allows the laser emitting device to be located and oriented in a direction which simulates the drill rod which has typically been removed from the drill rig and replaced with the device of the present invention.

[0184] In the preferred embodiment illustrated in Figures 17 to 19, the attachment arrangement includes a head chuck 112, a tail chuck 113 and a connecting rod 114 located between the two chucks 112, 113. The head chuck 112 is attached to the connecting rod 114 and the tail chuck 113 is removably attached to the connecting rod 114 at an opposite end to the head chuck 112 and is movable along at least a portion of the length of the connecting rod 114.

[0185] Typically, the head chuck 112 is generally conical or frustoconical in shape as this allows the chuck to centre within the collar drive opening. The illustrated head chuck 112 has a larger end surface which is typically circular and a smaller end surface, also typically circular joined by a generally conical sidewall.

[0186] The conical shape of the head chuck is defined by a framework of ribs provided to define the conical shape, but reduce the amount of material used and/or the weight of the head chuck.

[0187] The head chuck 112 illustrated has an attachment portion 115 for the attachment of the spindle 109 or directly to the head unit of the device. The attachment portion 115 is normally be in the larger end surface and in the illustrated embodiment includes a threaded opening which allows engagement with a correspondingly threaded portion 116 provided on the spindle 109.

[0188] The connecting rod 114 is permanently attached centrally extending from the smaller end surface of the head chuck 112.

[0189] The connecting rod 114 is elongate is received through the tail chuck 113 in order that the tail chuck 113 can be removed from rod 114 and also moved along the length of the rod 114.

[0190] A threaded portion is provided at least partially along the length of the connecting

rod 114. Normally, the threaded portion will be of sufficient length in order to fit the head chuck 112 and tail chuck 113 on either side of a variety of collar drives from different drill rig manufacturers.

[0191] The tail chuck 113 is similar in many respects to the head chuck 112 it is typically oriented in the reverse direction with the small end surface facing the small end surface of the head chuck 112. This results in the converging conical surfaces of both the head and tail chuck facing one another.

[0192] The tail chuck 113 includes a bore extending through the tail chuck 113, from the smaller end surface to the larger end surface. The bore is internally threaded in order to engage with the threaded connecting rod 114.

[0193] In use, regardless of whether the drill rig is used in a surface application or underground, an indicator such as a peg 117 or survey mark or similar to is used to indicate the drilling location. The laser emitting device 107 of the device is used to point to that location while the position of the drill rig is adjusted to achieve the required azimuth and dip angle of the drill rod. Typically, the laser emitting device 107 is maintained pointing at the desired point whilst the position or orientation of the drill rig is adjusted for the required azimuth and dip angle to ensure the correct positioning. In this embodiment, the laser emitting device 107 takes the place of the drill rod or in other words, indicates that position and/or orientation of a virtual drill rod which indicates the position and/or orientation that the actual drill rod will assume when attached to the drill rig.

[0194] Illustrated in Figure 25 is a schematic example of a generated and displayed image of a drill hole pattern 30 showing the movement of a drill rig 103 relative thereto into a final position.

[0195] For surface drilling applications the gyrocompass preferred for underground use is replaced by an inertial navigation system (INS). This INS will preferably receive an input from available GPS/DGPS/RTK GPS navigation systems. A general system configuration is illustrated in Figure 26.

[0196] The system as illustrated includes a drill rig 103 with alignment tool as previously explained and with an INS rather than a gyrocompass which accordingly creates an alignment and positioning tool 31. The INS can receive data from a satellite based location system including one or more satellites 32 such as GPS, GLONASS or other system. The alignment and

positioning tool 31 also communicates with some form of display, usually on a computing device 33 which can be either mounted to the drill rig 103 or separate therefrom to allow an operator the freedom of movement. This computing device 33 will normally be adapted for two way communication and/or data transfer with a remote server 34.

[0197] Display software provided on the computing device 33 such as a tablet or similar will utilise the navigation data output by the INS to plot the position of the drill rig 103 relative to the required holes and preferably down to the level of navigating to the centre of the drill on a generated map/or grid display of the drill site and surrounds such as that illustrated in Figure 25.

[0198] The navigation position provided by the INS can normally be plotted within a few centimetres dependent upon the accuracy of the available (GPS) signal. The display will preferably allow zooming in to allow correct positioning of the rig 103 and the drill rod to form the holes as required.

[0199] The software will access a database of desired or required hole locations located on the server 34 to provide coordinates for each hole to the display, allowing an operator to correctly position the drill rig 103. Each hole (illustrated by "o" on Figure 25) will be able to be selected as a navigation waypoint and displayed on the map/grid display allowing a rig 103 to be moved relative to drilling pattern to a final drilling position 35 as illustrated in Figure 25.

[0200] Further, the software is preferably able to log all data and display onto the display device. The software will also preferably communicate with a server 34 or similar device to maintain back up data in relation to hole set ups as well as real time recording of movements between holes and hole set ups. This will preferably allow an operator to access and preferably view data in relation to the past, present or future drilling activities for planning or review purposes.

[0201] To allow the operator to ensure that the hole drilled remains on line, an alignment detector attachment and system can be provided such as is illustrated in Figure 27. The alignment tool head unit 101 with laser device discussed above can be used with a laser alignment detector attachment as a part of a system to ensure that the hole 37 in the surface 38 remains online as it is drilled as well as at setup.

[0202] Normally, the alignment tool head unit 101 discussed above is used during the original rig setup and the alignment tool head unit 101 is then removed from the drill rig. According to the preferred embodiment illustrated in Figure 27, normally, after the hole 37 is

drilled to a sufficient depth (generally at least 300mm and normally at any depth or depths following that), the alignment tool head unit 101 can be reattached to the drill rig. Normally, no changes are made to the rig setup during this process, that is the alignment is not adjusted. The alignment detector attachment 36 is then typically placed into the hole 37 which has been partially drilled and the laser is directed at the alignment detector attachment 36.

[0203] The alignment detector attachment 36 provides data to a display 50 outside the hole 37 of the orientation of the laser and thereby of the drill rod in order to allow adjustment of the alignment tool and thereby adjustment of the drill rod to ensure correct drilling angle and/or direction is maintained. The display 50 may be on the rig or on a portable computer device such as a tablet or similar.

[0204] This alignment detector attachment 36 of the preferred embodiment includes a laser point detection plate (typically an optical detection array) that detects where the laser light point strikes the face of the detector as illustrated in Figure 27B and will calculate this position in relation to the centre of the drilled hole, normally in two axes and provide for this to be illustrated for an operator as seen in Figure 27A. A quantitative measure of the precision of alignment may also be represented on the display.

[0205] The orientation of the laser point detection plate in relation to the orientation of the alignment tool is preferably measured by rotational alignment detectors, which may be inclinometers measuring one or two axes or other similar inclination measuring device.

[0206] The alignment detector attachment 36 is centred in the drilled hole 37 by a mechanical centring mechanism. This will usually be a length of machined rod – similar to a drill rod and either of the same diameter as the drill rod used to drill the hole, or extended to this diameter using collars, extensions, bushes or similar devices.

[0207] This information or sufficient data to allow a visual representation of the orientation of the laser is preferably transmitted to a display device outside the hole. Transmission of this information may be by wireless communication means or by way of a hard wired connection. The information is then processed in software running on the display device to compensate for any rotation of the alignment tool within the hole. An image such as that illustrated in Figure 27A can be generated and displayed on the display in an easy to read information display depicting the angular offset of the hole 37 from the centre line of the drill in two axes.

[0208] The alignment detector attachment 36 is typically self centering in the hole and also

be capable of self centering in a hole of any larger size. The alignment detector attachment 36 will preferably have a detector allowing for positional and/or rotational alignment relative to the alignment tool or to determine alignment relative to the alignment tool.

[0209] In the present specification and claims (if any), the word "comprising" and its derivatives including "comprises" and "comprise" include each of the stated integers but does not exclude the inclusion of one or more further integers.

[0210] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more combinations.

CLAIMS

1. A laser alignment device for use with drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting device to indicate the drill rod orientation and an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and attachment arrangement to attach the head unit to a drill rig wherein the alignment device is used to align at least the azimuth of the drill rod relative to a desired orientation.
2. A laser alignment device as claimed in claim 1 wherein the device is also used to align the drill rod to a required drill rod dip angle.
3. A laser alignment device as claimed in claim 1 or claim 2 wherein the laser alignment device is provided with a mechanism to locate the drill rig.
4. A laser alignment device as claimed in any one of the preceding claims wherein the least one laser emitting device points forwardly, that is in the direction of the drilling.
5. A laser alignment device as claimed in any one of the preceding claims wherein an inclinometer is provided to align the drill rod to a required drill rod dip angle.
6. A laser alignment device as claimed in any one of the preceding claims further including a display device to display any parameters measured or indicated by the head unit.
7. A laser alignment device as claimed in any one of the preceding claims wherein a spindle including a bearing race is provided as a part of the attachment arrangement in order to allow the gyrocompass of the head unit to self-position.
8. A laser alignment device as claimed in any one of the preceding claims wherein the attachment arrangement includes a head chuck, a tail chuck and a connecting rod located between the head chuck and tail chuck.
9. A laser alignment device as claimed in claim 8 wherein the head chuck is attached to the connecting rod and the tail chuck is removably attached to the connecting rod at an opposite end to the head chuck and is movable along at least a portion of the length of the connecting rod.
10. A laser alignment device as claimed in claim 8 or claim 9 wherein the head chuck is substantially conical in shape.

11. A laser alignment device as claimed in claim 8 or claim 9 wherein the head chuck is substantially frustoconical.
12. A laser alignment device as claimed in any one of claims 8 to 11 wherein the connecting rod is mounted permanently to the head chuck and is received through the tail chuck in order that the tail chuck can be removed from the connecting rod and also moved along the length of the connecting rod.
13. A laser alignment device as claimed in any one of claims 8 to 12 wherein a threaded portion is provided at least partially along the length of the connecting rod of sufficient length in order to fit the head chuck and tail chuck on either side of a collar drives.
14. A laser alignment device as claimed in any one of claims 8 to 13 wherein the tail chuck is substantially conical in shape.
15. A laser alignment device as claimed in any one of claims 8 to 13 wherein the tail chuck is substantially frustoconical.
16. A laser alignment device as claimed in claim 14 or claim 15 wherein the tail chuck is oriented in a reverse direction to the head chuck.
17. A laser alignment device as claimed in any one of claims 8 to 16 wherein the tail chuck includes a bore extending through the tail chuck.
18. A method of aligning a laser emitting device for use with drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting device to indicate the drill rod orientation and an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and attachment arrangement to attach the head unit to a drill rig the method including the steps of pointing the at least one laser emitting device at a desired drill point and adjusting the position or orientation of the drill rig for the required azimuth and dip angle to ensure the correct positioning.
19. A drill rod alignment detector system including a laser device mounted relative to a drill rig for indicating a drill rod orientation and an alignment detector device adapted to be placed at least partially in a partially drilled hole and having a laser point detection portion that detects where a laser light point of the laser device strikes the face of the detector enabling calculation of the position of the drill rod in relation to the centre of the partially drilled hole.

AMENDED CLAIMS

received by the International Bureau on 17 december 2013 (16.12.2013)

CLAIMS

1. A laser alignment device for use with drill rig having an elongate drill rod, the laser alignment device including a head unit having at least one laser emitting device to indicate the drill rod orientation and an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and attachment arrangement to attach the head unit to a drill rig wherein the alignment device is used to align at least the azimuth of the drill rod relative to a desired orientation by adjusting the position of the drill rig and the at least one laser emitting device is maintained in a fixed orientation pointing indicating the orientation of the drill rod.
2. A laser alignment device as claimed in claim 1 wherein the device is also used to align the drill rod to a required drill rod dip angle.
3. A laser alignment device as claimed in claim 1 or claim 2 wherein the laser alignment device is provided with a mechanism to locate the drill rig.
4. A laser alignment device as claimed in any one of the preceding claims wherein the least one laser emitting device points forwardly, that is in the direction of the drilling.
5. A laser alignment device as claimed in any one of the preceding claims wherein an inclinometer is provided to align the drill rod to a required drill rod dip angle.
6. A laser alignment device as claimed in any one of the preceding claims further including a display device to display any parameters measured or indicated by the head unit.
7. A laser alignment device as claimed in any one of the preceding claims wherein a spindle including a bearing race is provided as a part of the attachment arrangement in order to allow the gyrocompass of the head unit to self-position.
8. A laser alignment device as claimed in any one of the preceding claims wherein the attachment arrangement includes a head chuck, a tail chuck and a connecting rod located between the head chuck and tail chuck.
9. A laser alignment device as claimed in claim 8 wherein the head chuck is attached to the connecting rod and the tail chuck is removably attached to the connecting rod at an opposite end to the head chuck and is movable along at least a portion of the length of the connecting rod.

10. A laser alignment device as claimed in claim 8 or claim 9 wherein the head chuck is substantially conical in shape.
11. A laser alignment device as claimed in claim 8 or claim 9 wherein the head chuck is substantially frustoconical.
12. A laser alignment device as claimed in any one of claims 8 to 11 wherein the connecting rod is mounted permanently to the head chuck and is received through the tail chuck in order that the tail chuck can be removed from the connecting rod and also moved along the length of the connecting rod.
13. A laser alignment device as claimed in any one of claims 8 to 12 wherein a threaded portion is provided at least partially along the length of the connecting rod of sufficient length in order to fit the head chuck and tail chuck on either side of a collar drives.
14. A laser alignment device as claimed in any one of claims 8 to 13 wherein the tail chuck is substantially conical in shape.
15. A laser alignment device as claimed in any one of claims 8 to 13 wherein the tail chuck is substantially frustoconical.
16. A laser alignment device as claimed in claim 14 or claim 15 wherein the tail chuck is oriented in a reverse direction to the head chuck.
17. A laser alignment device as claimed in any one of claims 8 to 16 wherein the tail chuck includes a bore extending through the tail chuck.
18. A laser alignment device for use with drill rig having an elongate drill rod, the laser alignment device including
 - a. a head unit having at least one laser emitting device to indicate the drill rod orientation;
 - b. an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and
 - c. an attachment arrangement to attach the head unit to a drill rig wherein the alignment device is used to align at least the azimuth of the drill rod relative to one or more survey points

wherein the position of the drill rig is adjusted to align at least the azimuth of the drill rod

relative to one or more survey points and the laser emitting device is maintained in a fixed orientation pointing indicating the orientation of the drill rod.

19. A laser alignment device as claimed in claim 18 wherein the head unit is permanently attached to a drill rig.
20. A laser alignment device as claimed in claim 18 or claim 19 wherein the inertial device is permanently attached to a drill rig.
21. A laser alignment device as claimed in any one of the preceding claims wherein at least one of the head unit and the inertial device transmit alignment information to an electronic graphic display remote from the head unit and the inertial device.
22. A drill rig including a laser alignment device of any one of the preceding claims linked to drive apparatus such that drilling parameters can be entered into a control panel or other computing device to enable the drill rig to automatically move to a location corresponding to the entered parameters.
23. A drill rig as claimed in claim 22 wherein display and control software is provided on a display device capable of transmission of control information to the drive apparatus such that a visual display of a drill site can be produced on the display device and control instructions can be issued from the display device to the drive apparatus to navigate the drill rig to a whole location allowing both navigation and alignment of the drill rig.
24. A method of aligning a drill rig having an elongate drill rod using a laser alignment device including a head unit having at least one laser emitting device to indicate the drill rod orientation and an inertial measurement device to indicate at least the azimuth of the at least one laser emitting device, and an attachment arrangement to attach the head unit to a drill rig the method including the steps of adjusting the position or orientation of the drill rig for the required azimuth and dip angle to ensure the correct positioning and using the at least one laser emitting device maintained in a fixed orientation pointing to indicate the orientation of the drill rod.
25. A drill rod alignment detector system including a laser device mounted relative to a drill rig for indicating a drill rod orientation and an alignment detector device adapted to be placed at least partially in a partially drilled hole and having a laser point detection portion that detects where a laser light point of the laser device strikes the face of the detector enabling calculation of the position of the drill rod in relation to the centre of the partially drilled hole.

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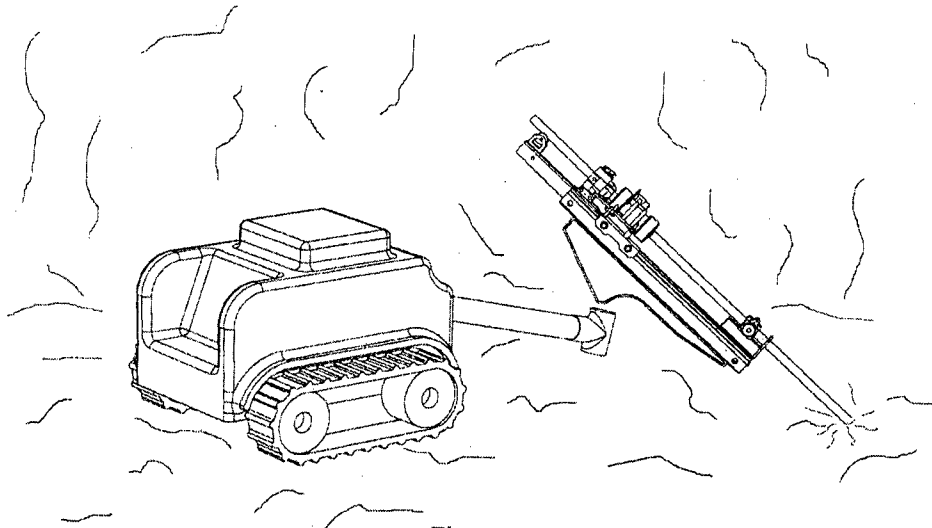


Fig-1
(Prior Art)

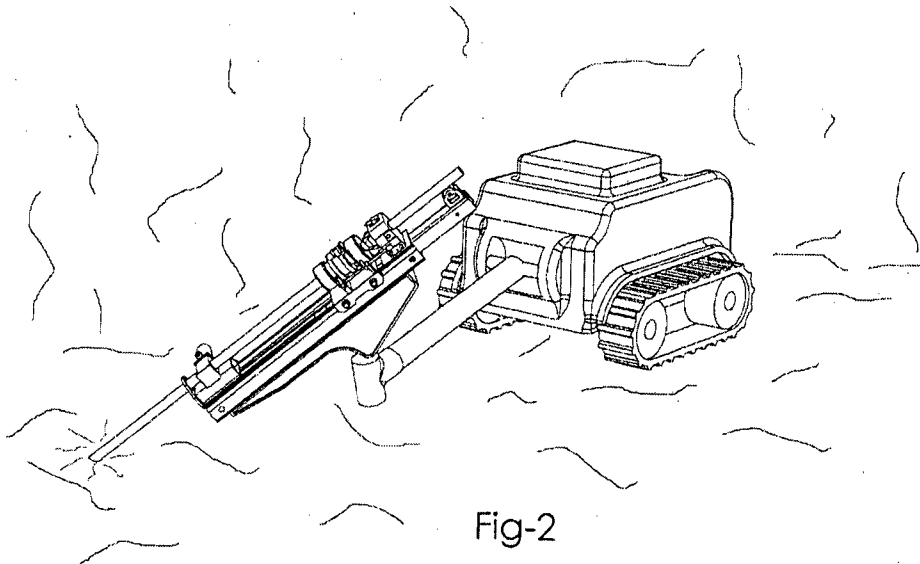


Fig-2
(Prior Art)

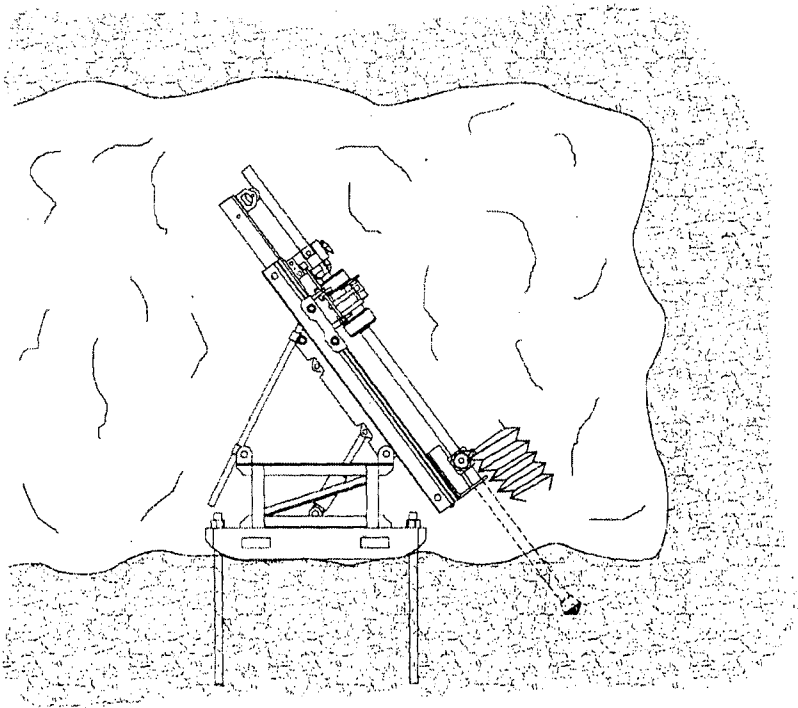


Fig-3

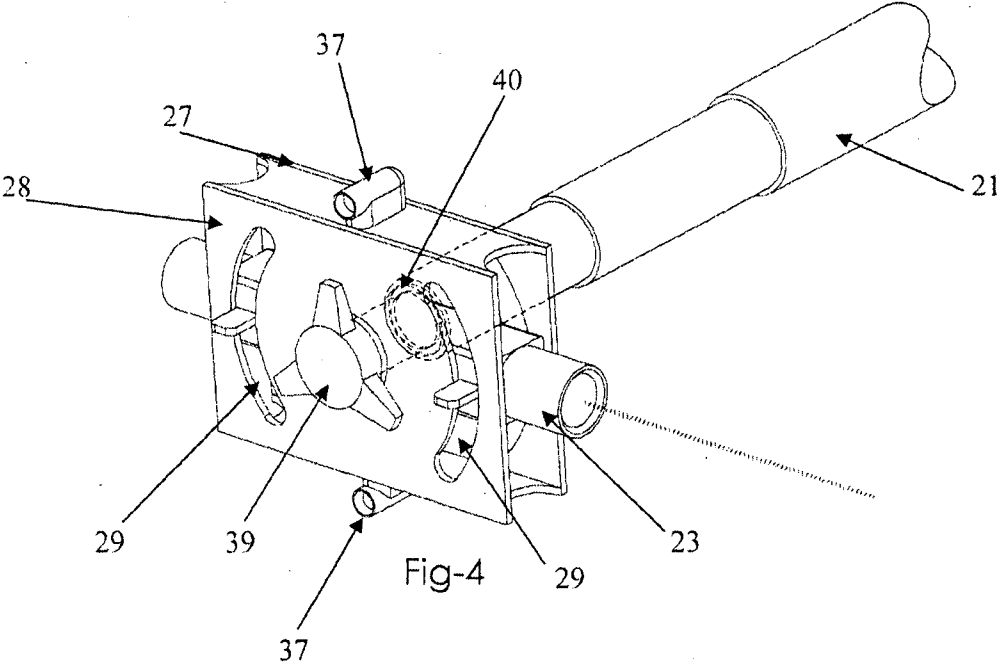


Fig-4

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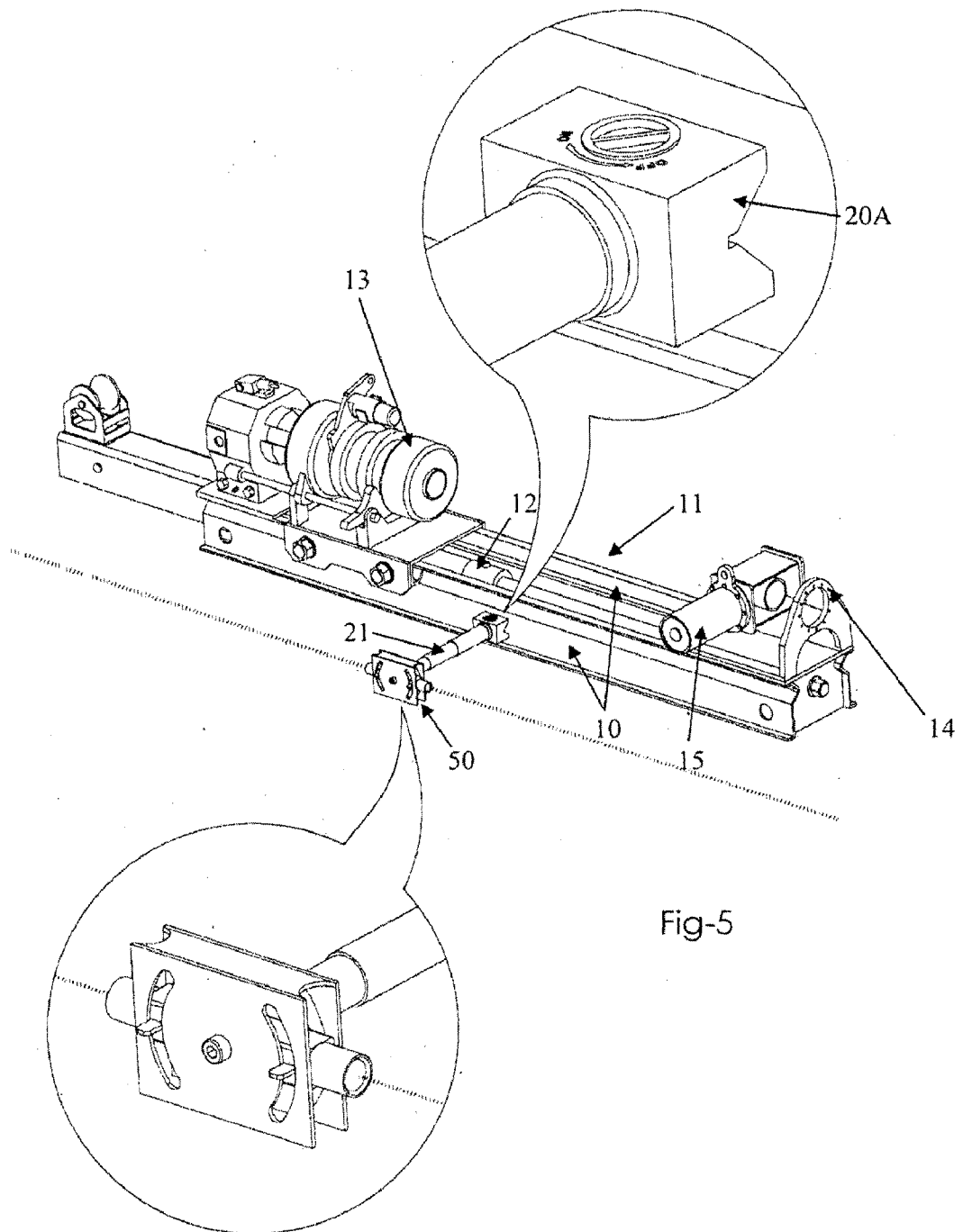


Fig-5

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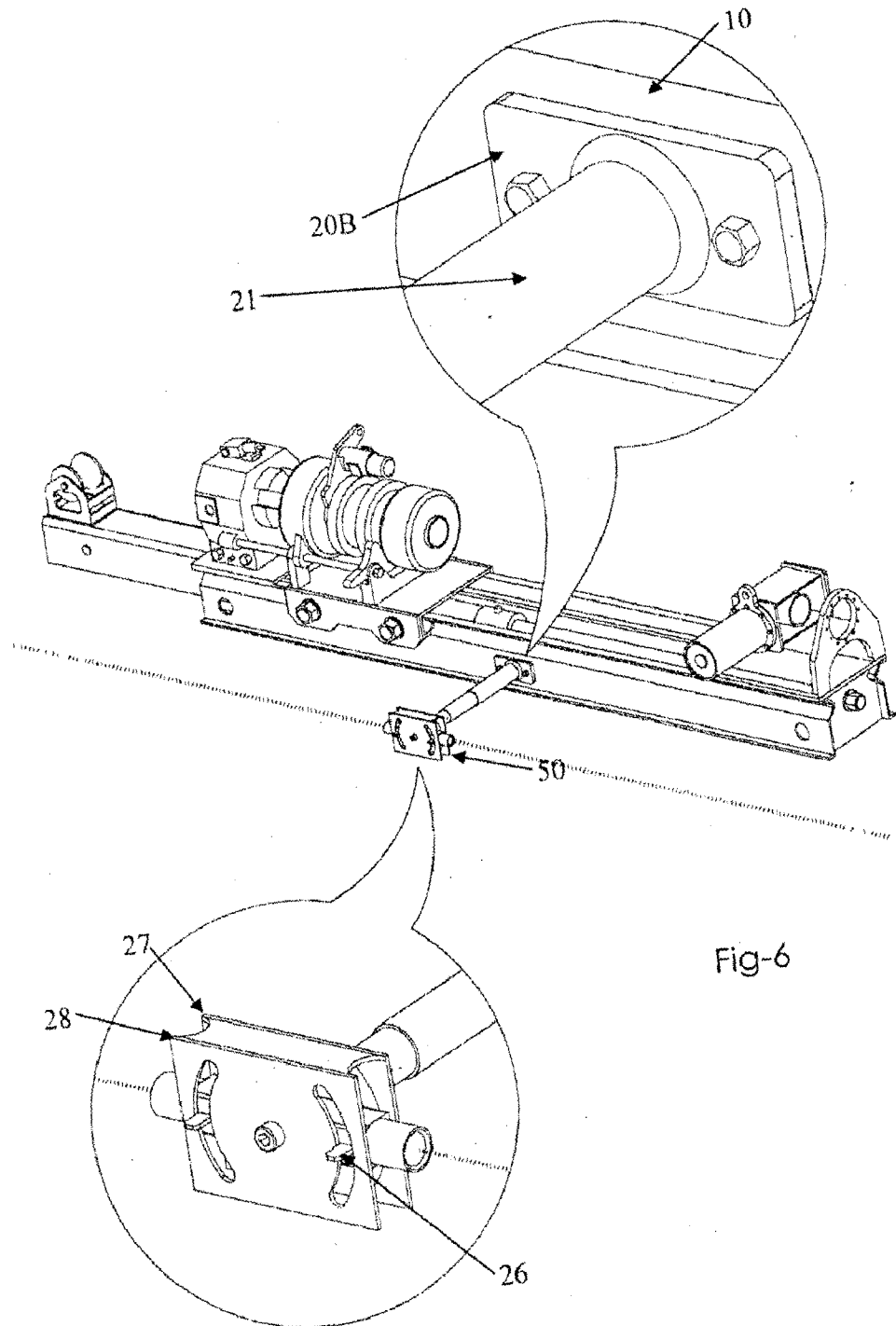


Fig-6

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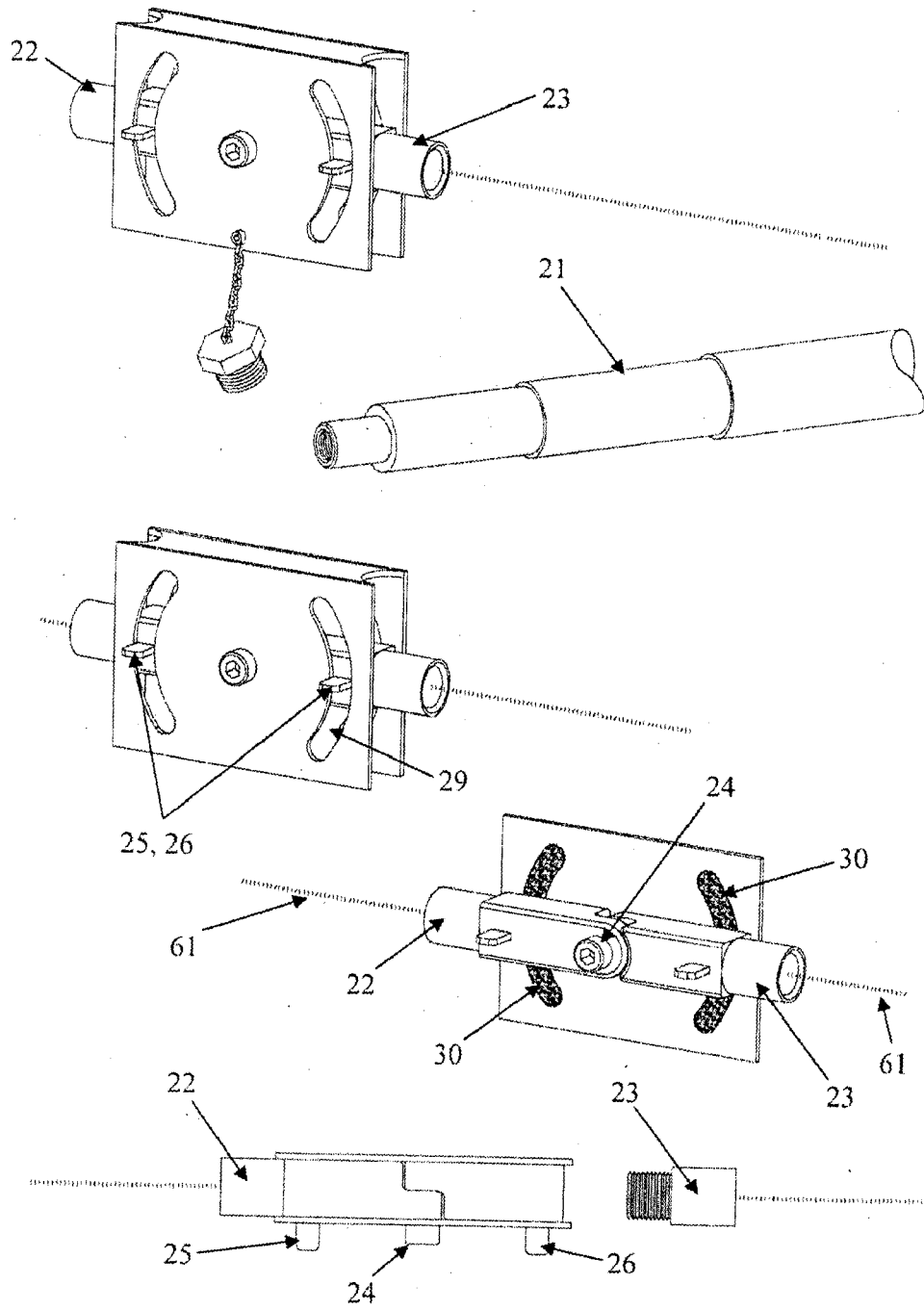


Fig-7

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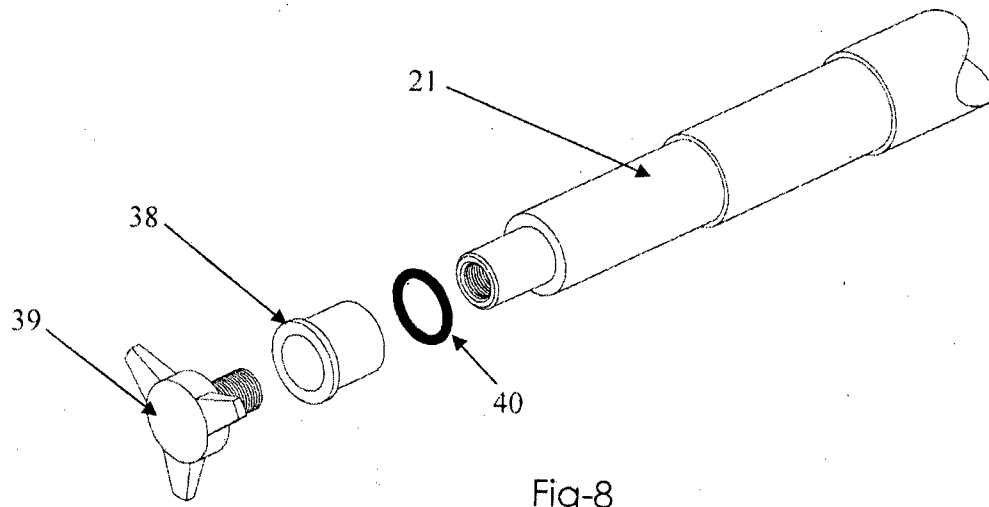


Fig-8

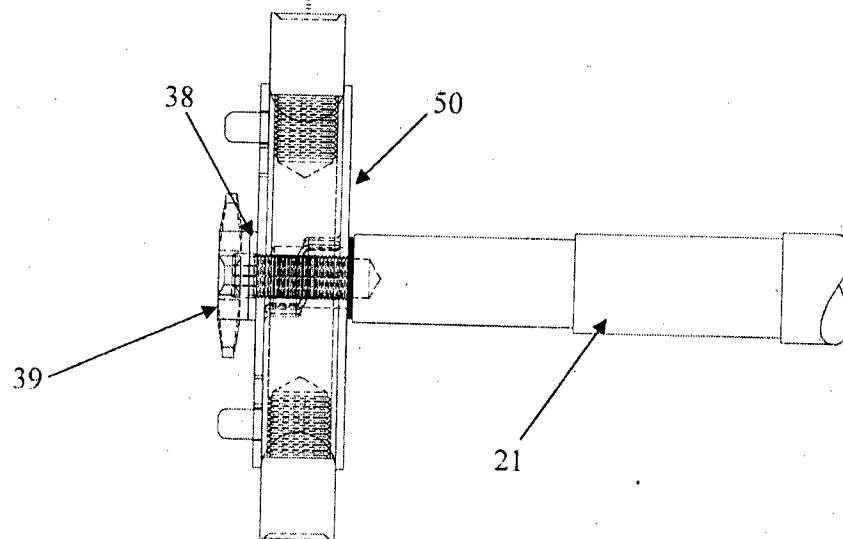


Fig-9

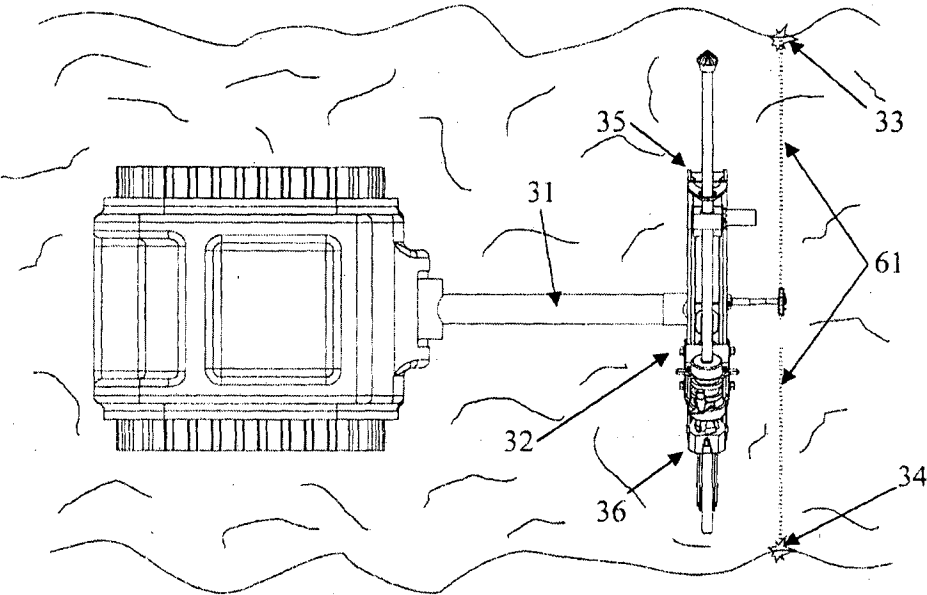


Fig-10

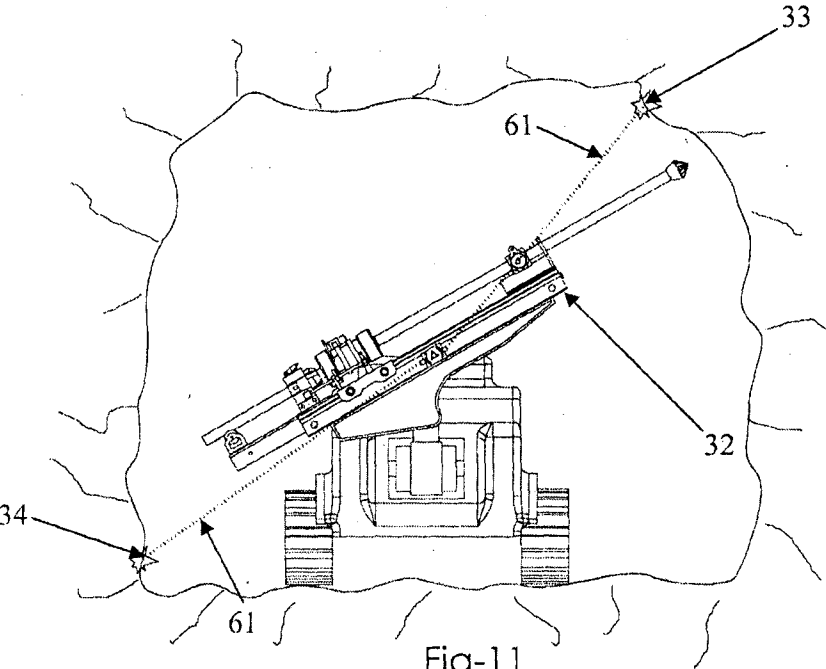


Fig-11

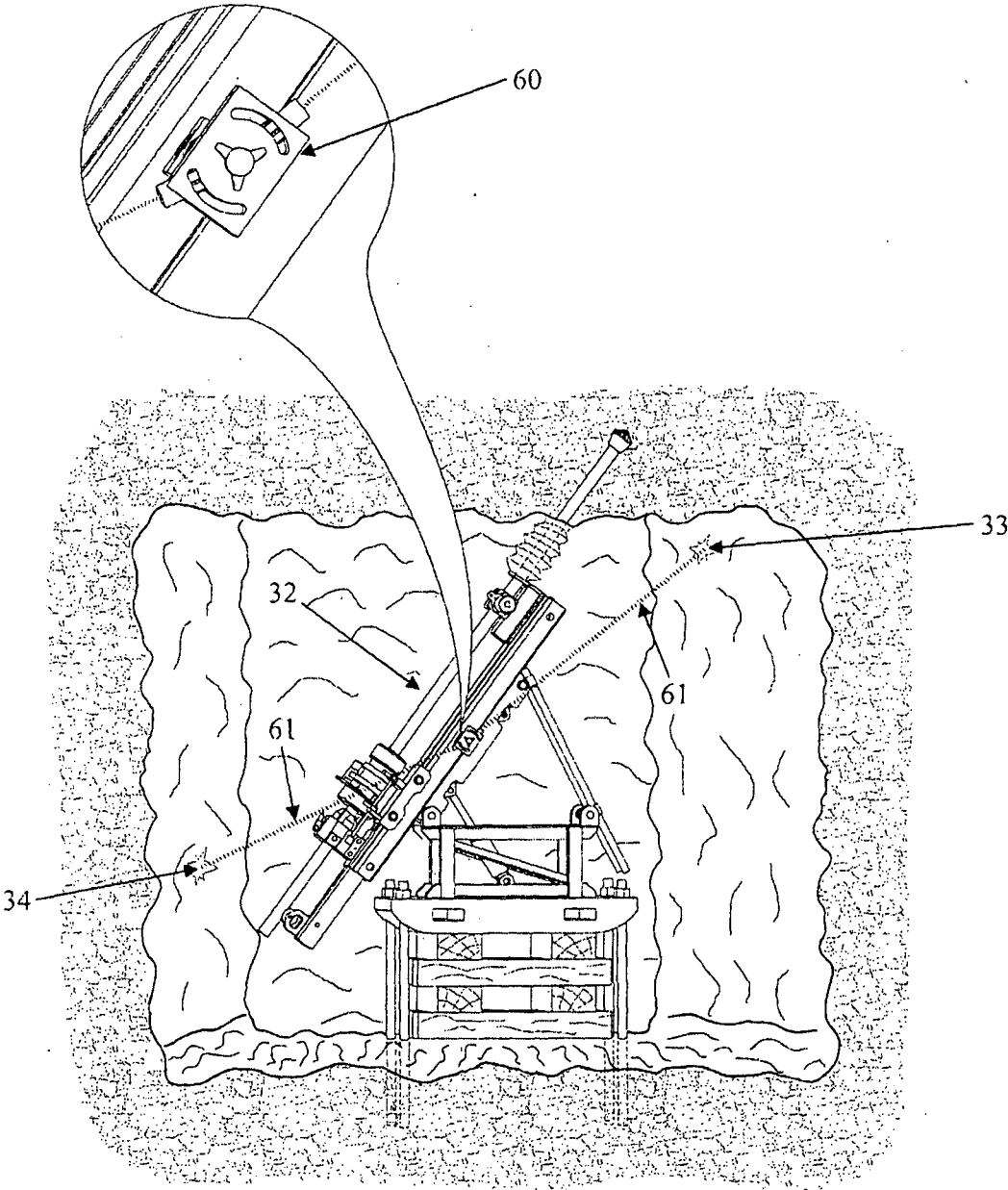


Fig-12

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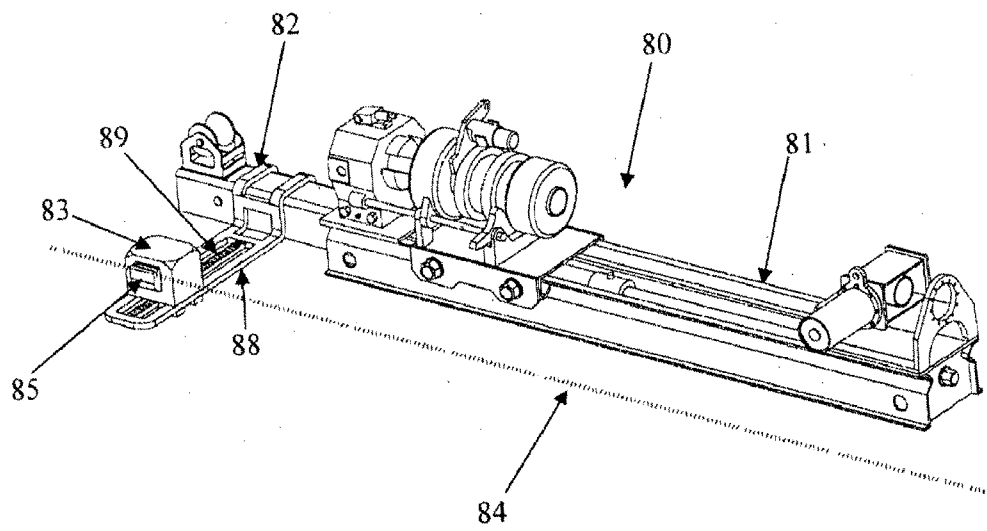


Fig-13

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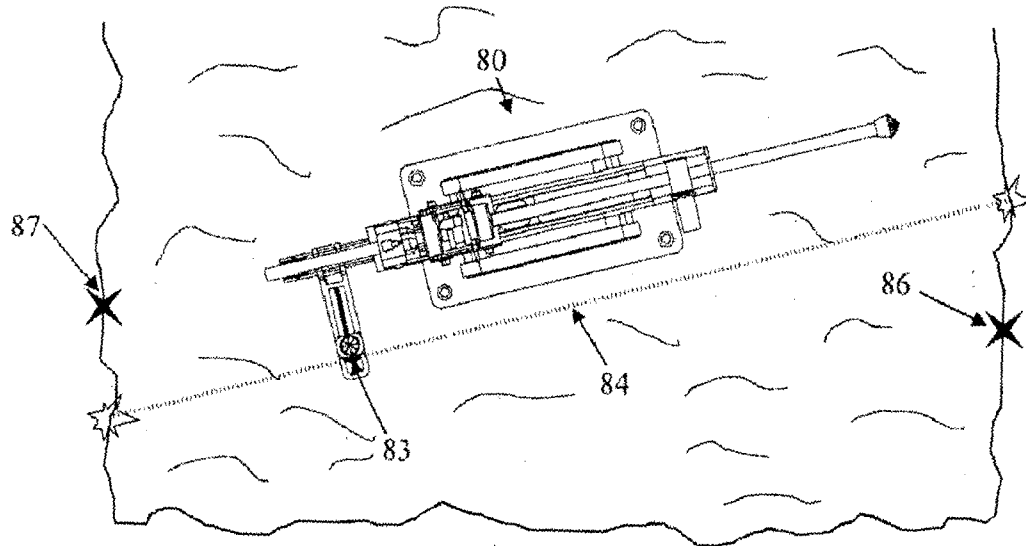


Fig-14a

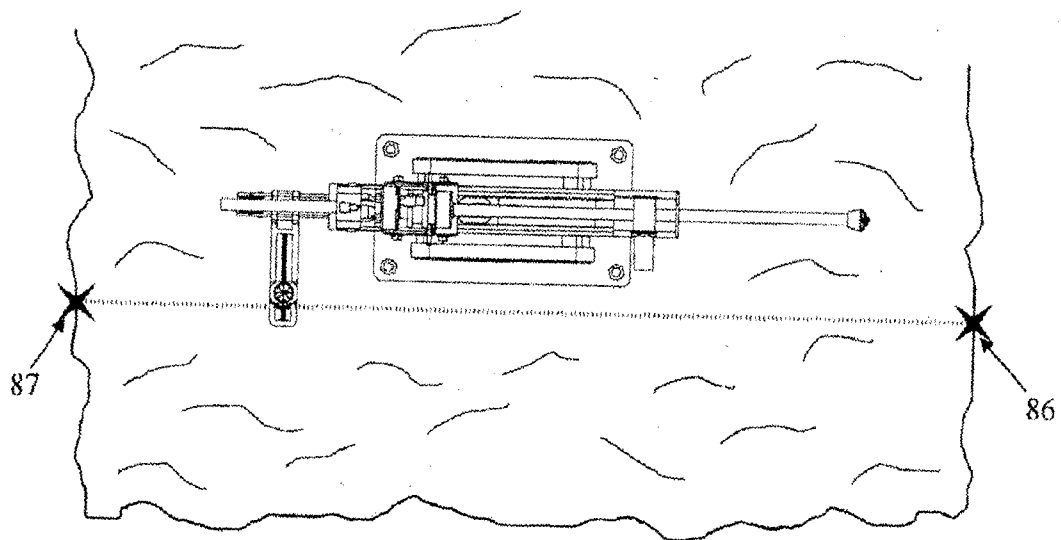


Fig-14b

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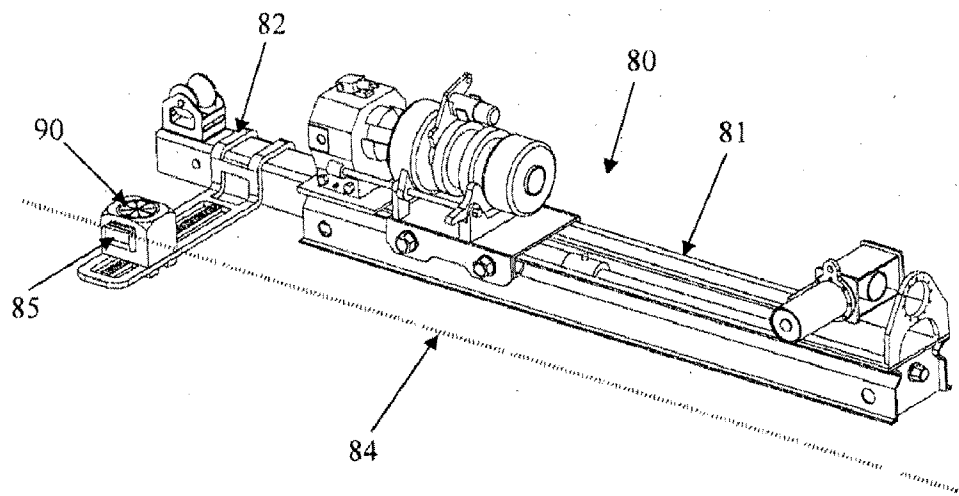
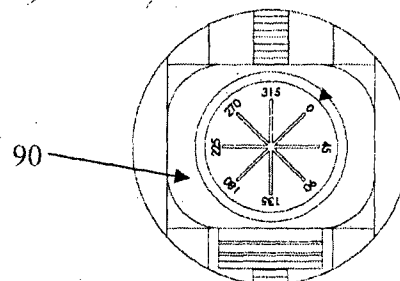
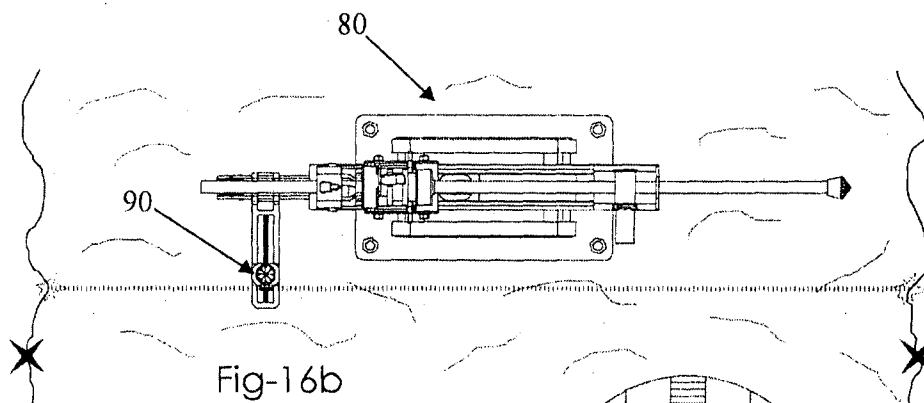
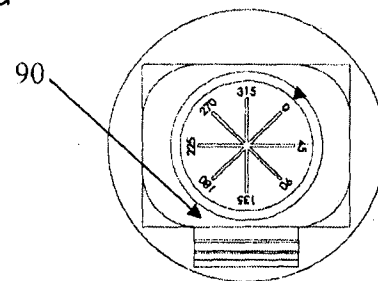
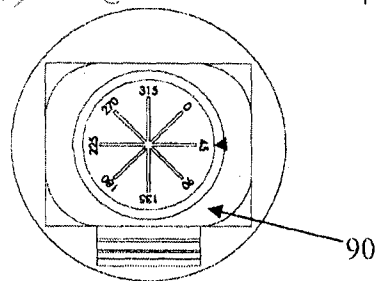
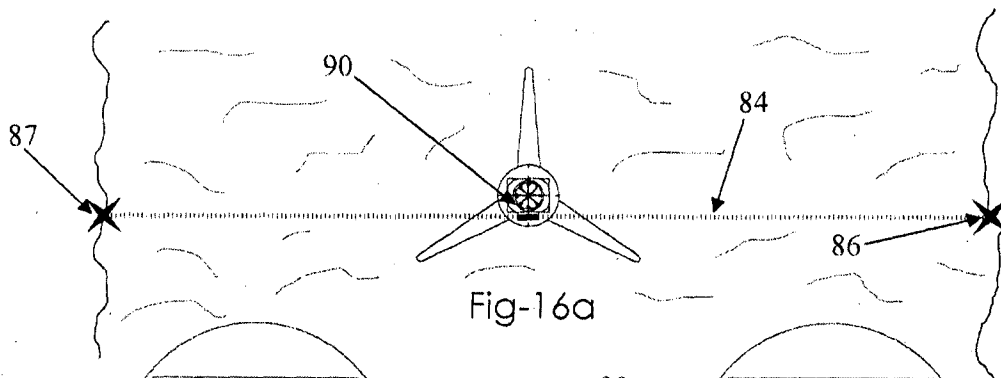


Fig-15

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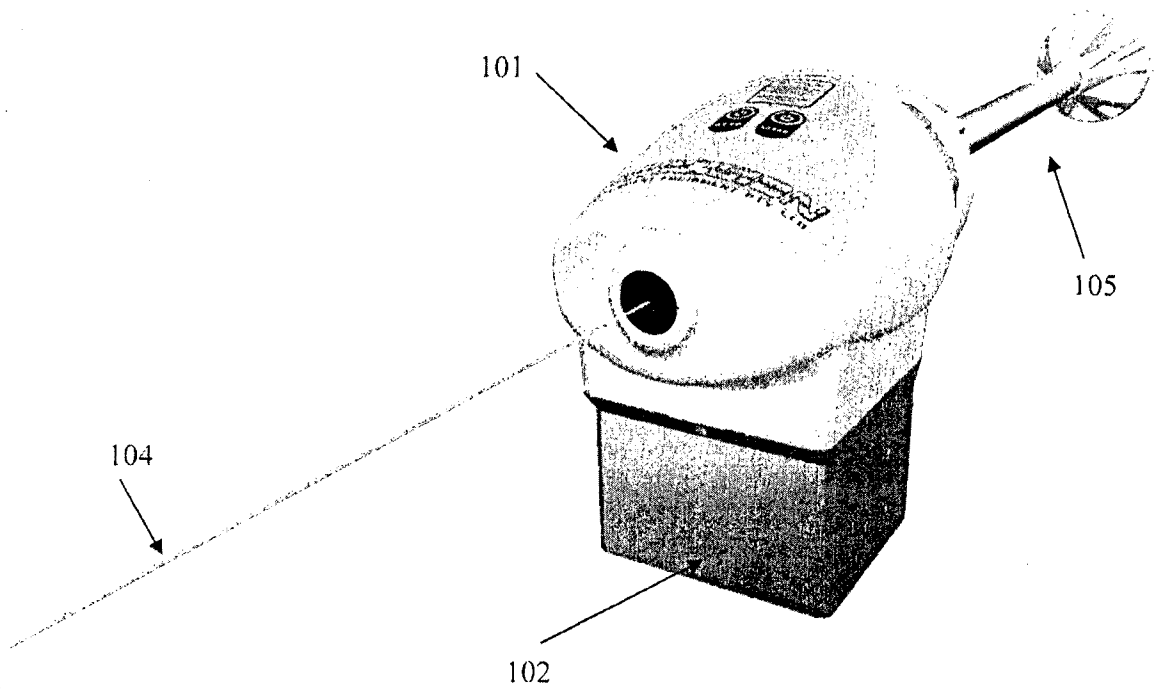


Figure 17

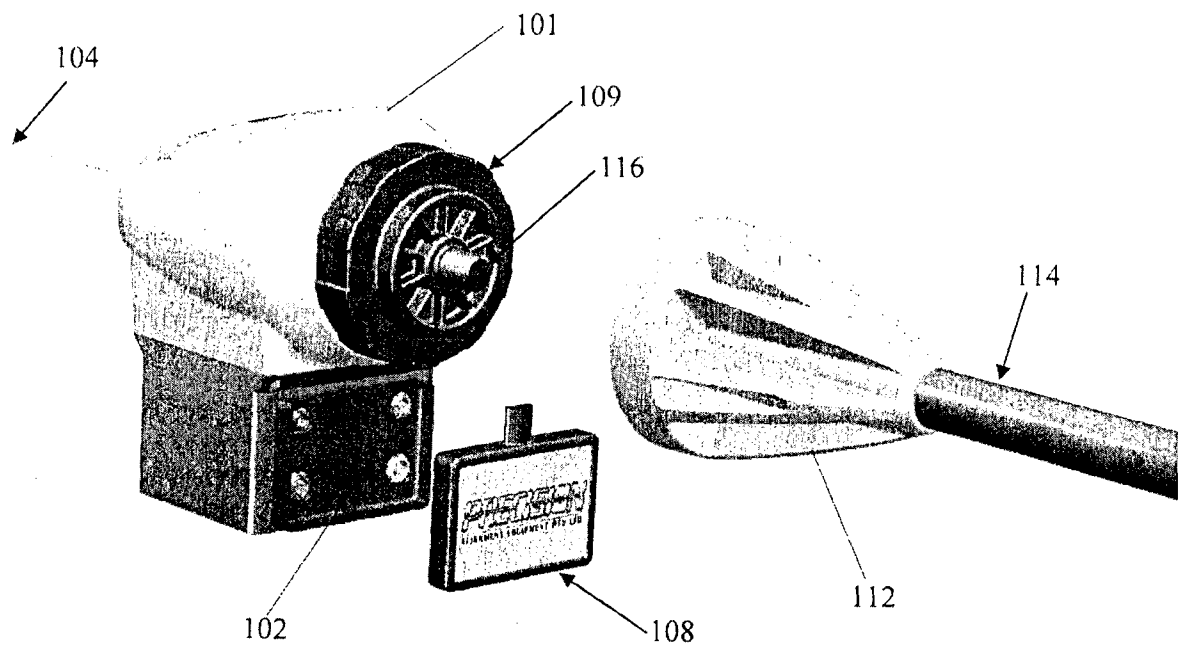


Figure 18

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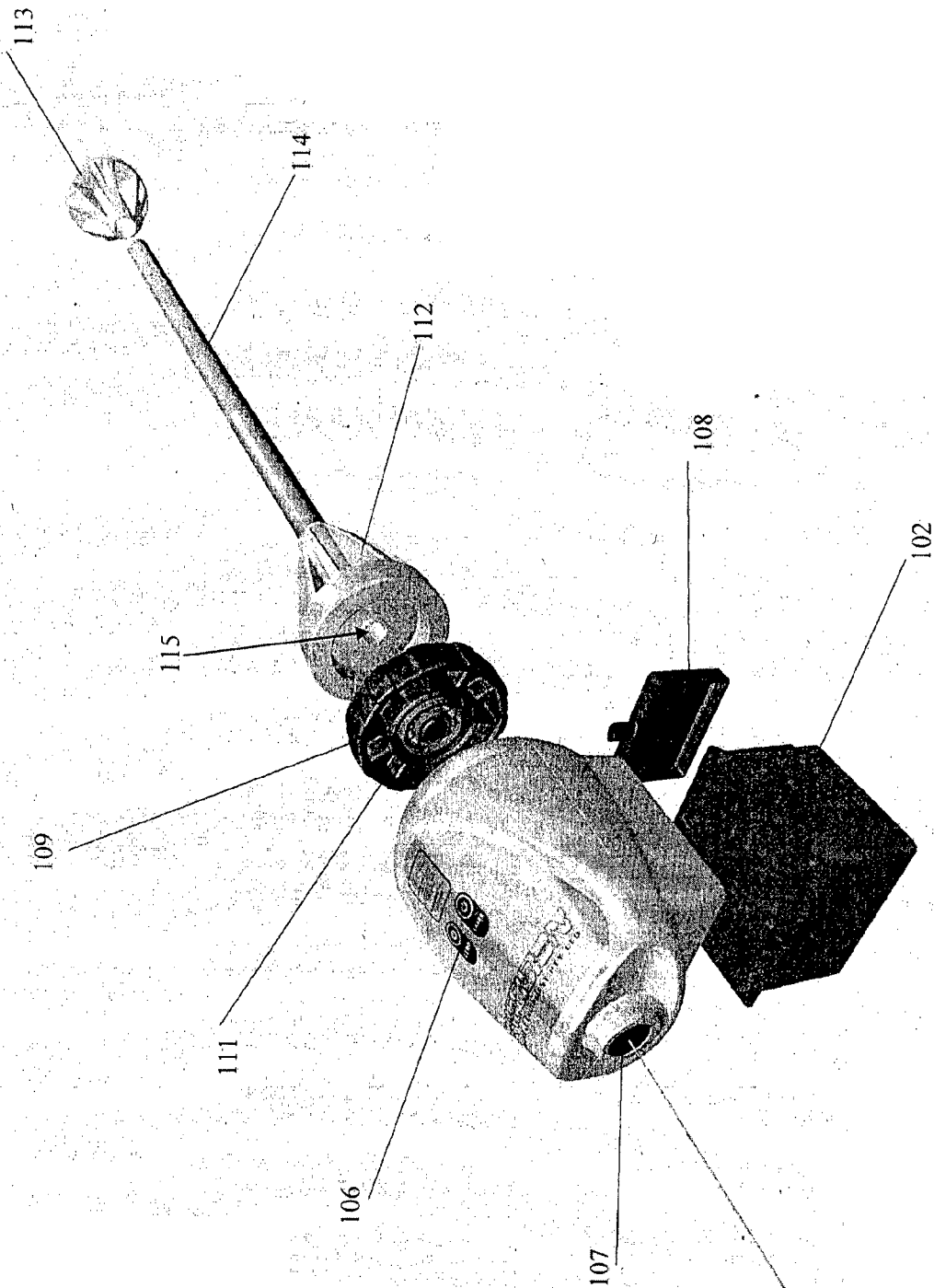


Figure 19

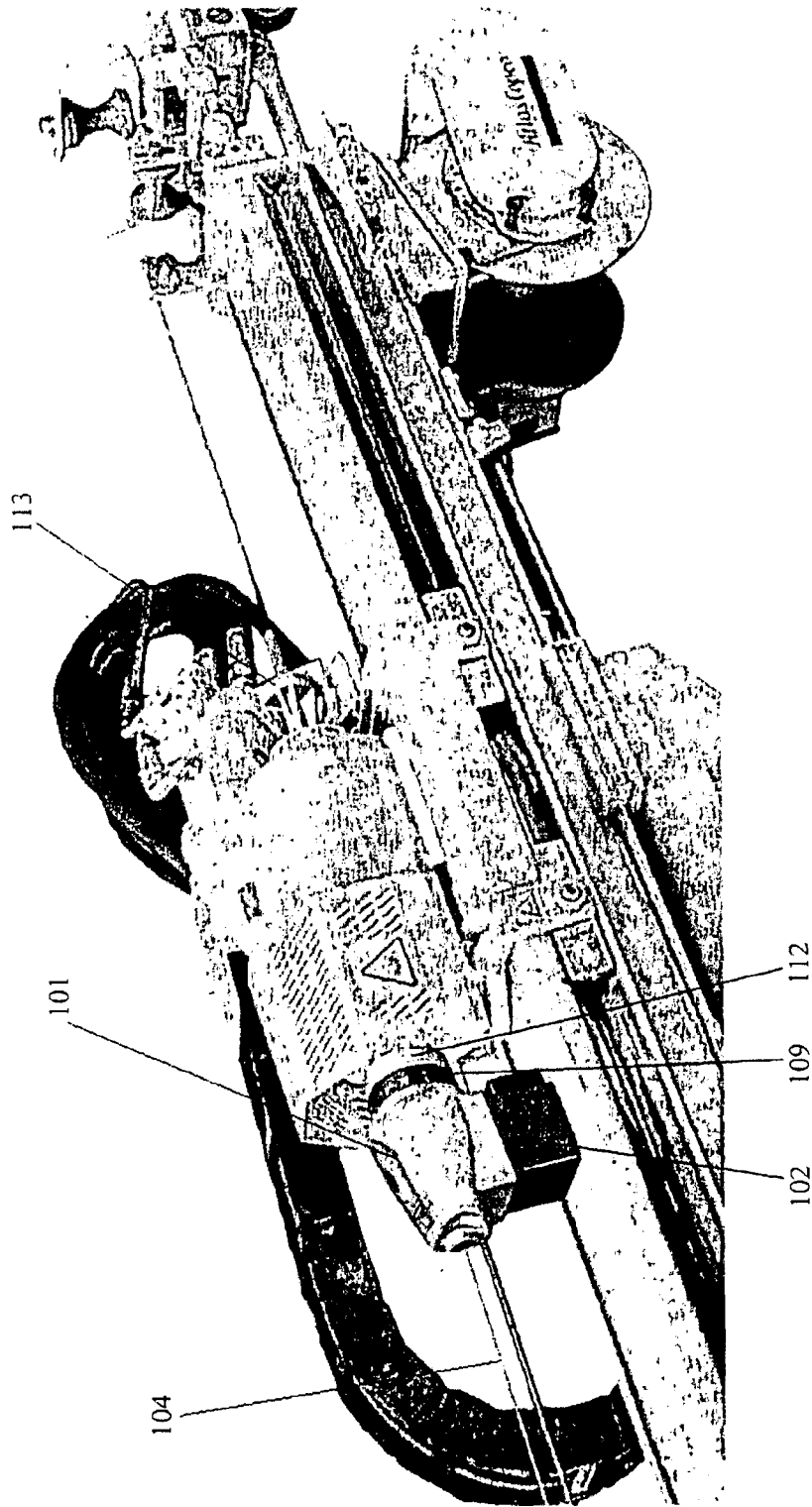


Figure 20

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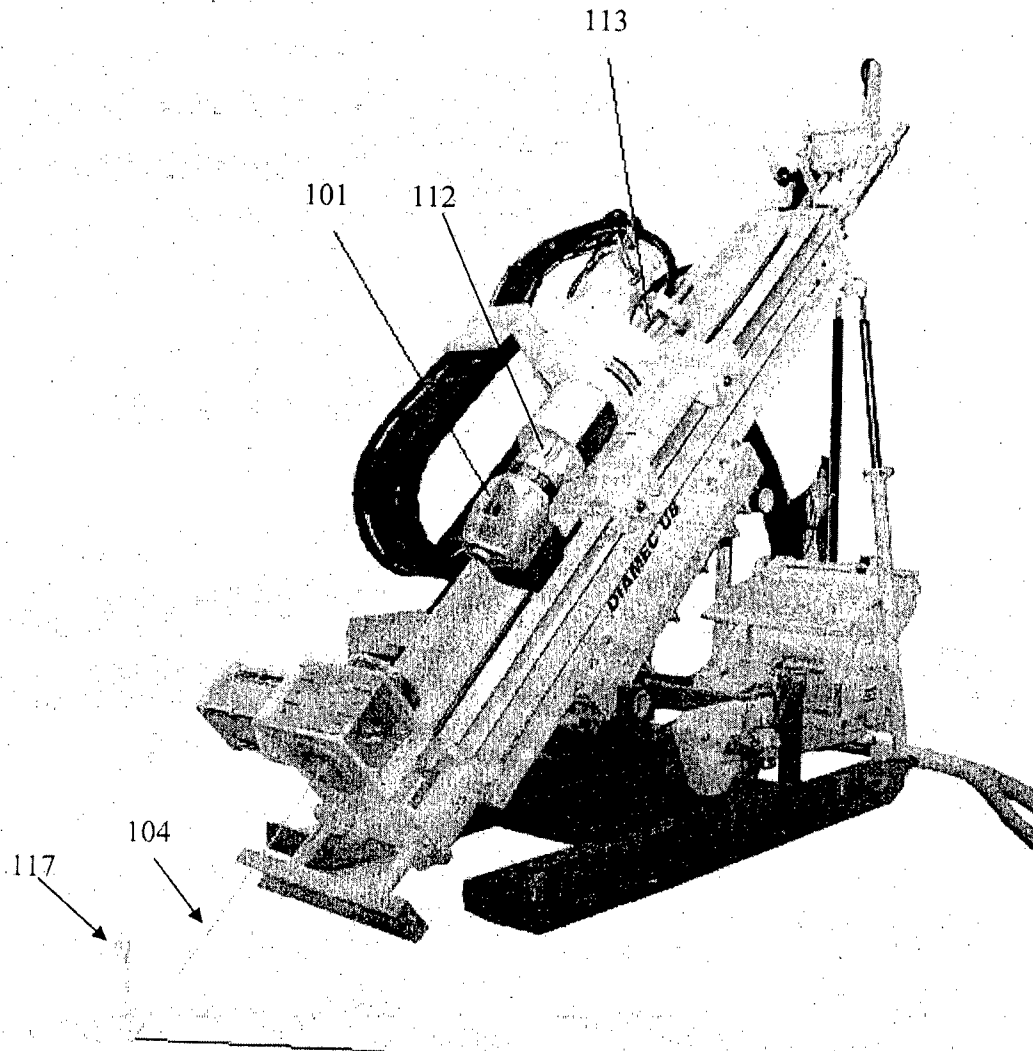


Figure 21

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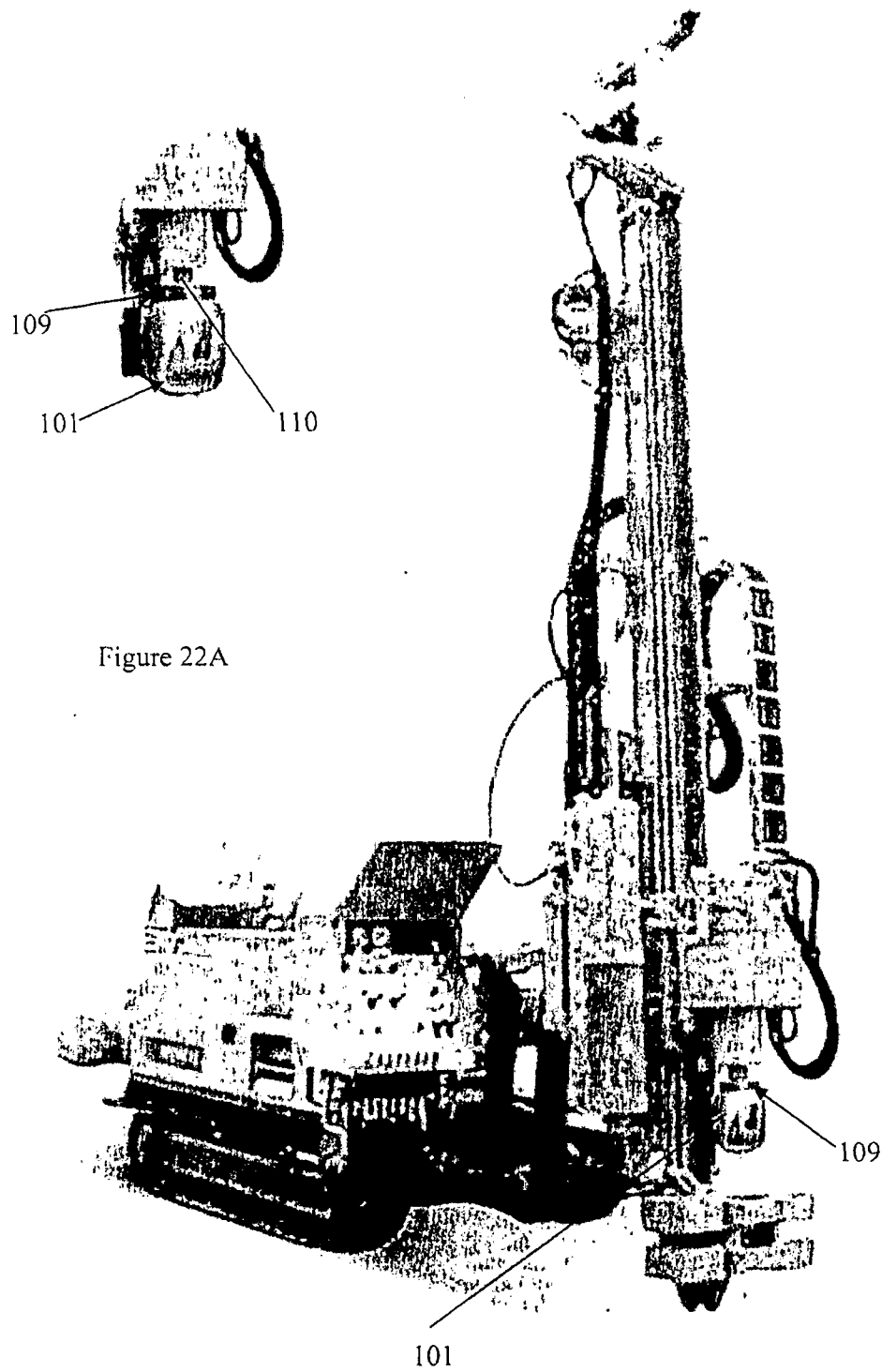


Figure 22A

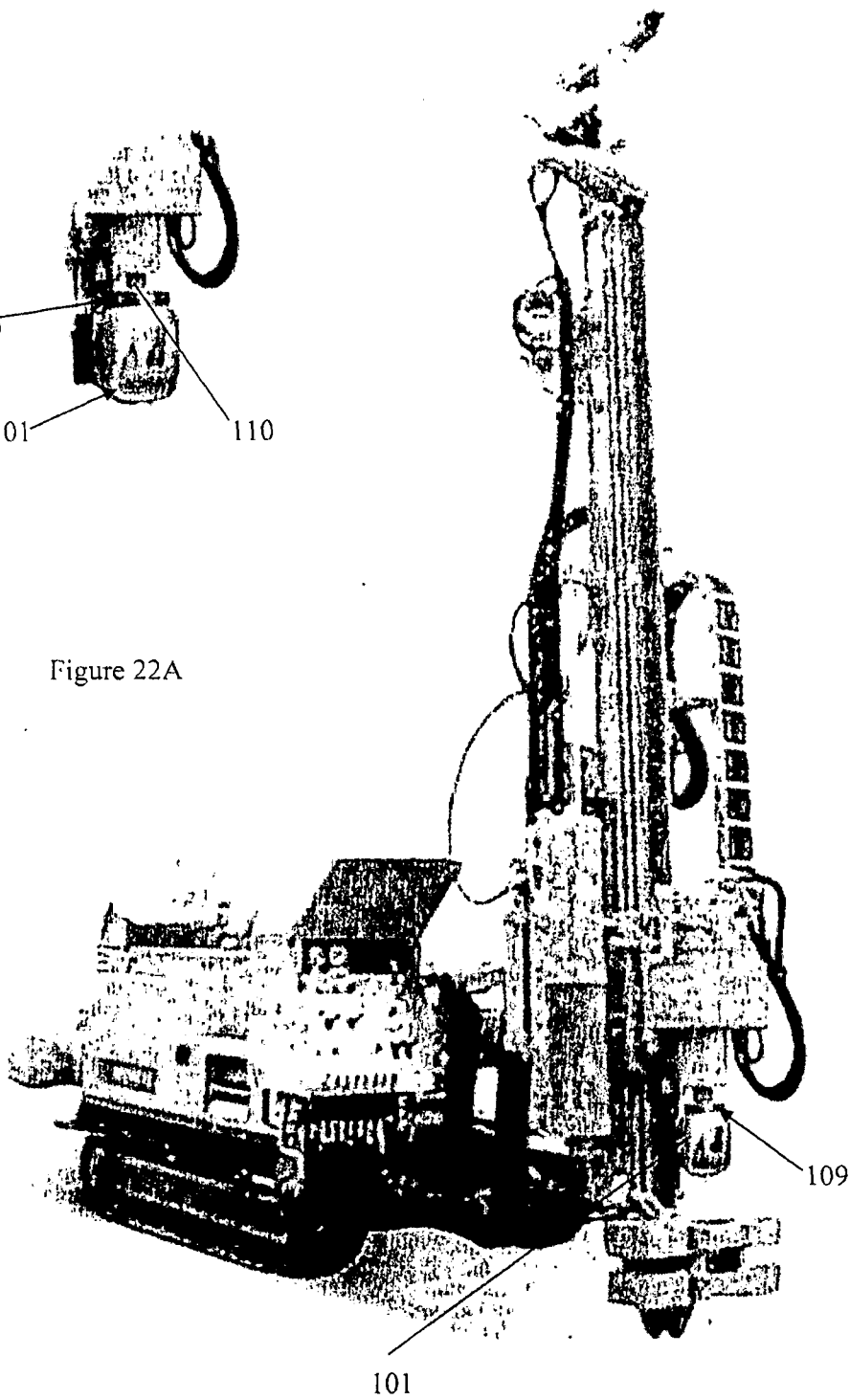


Figure 22

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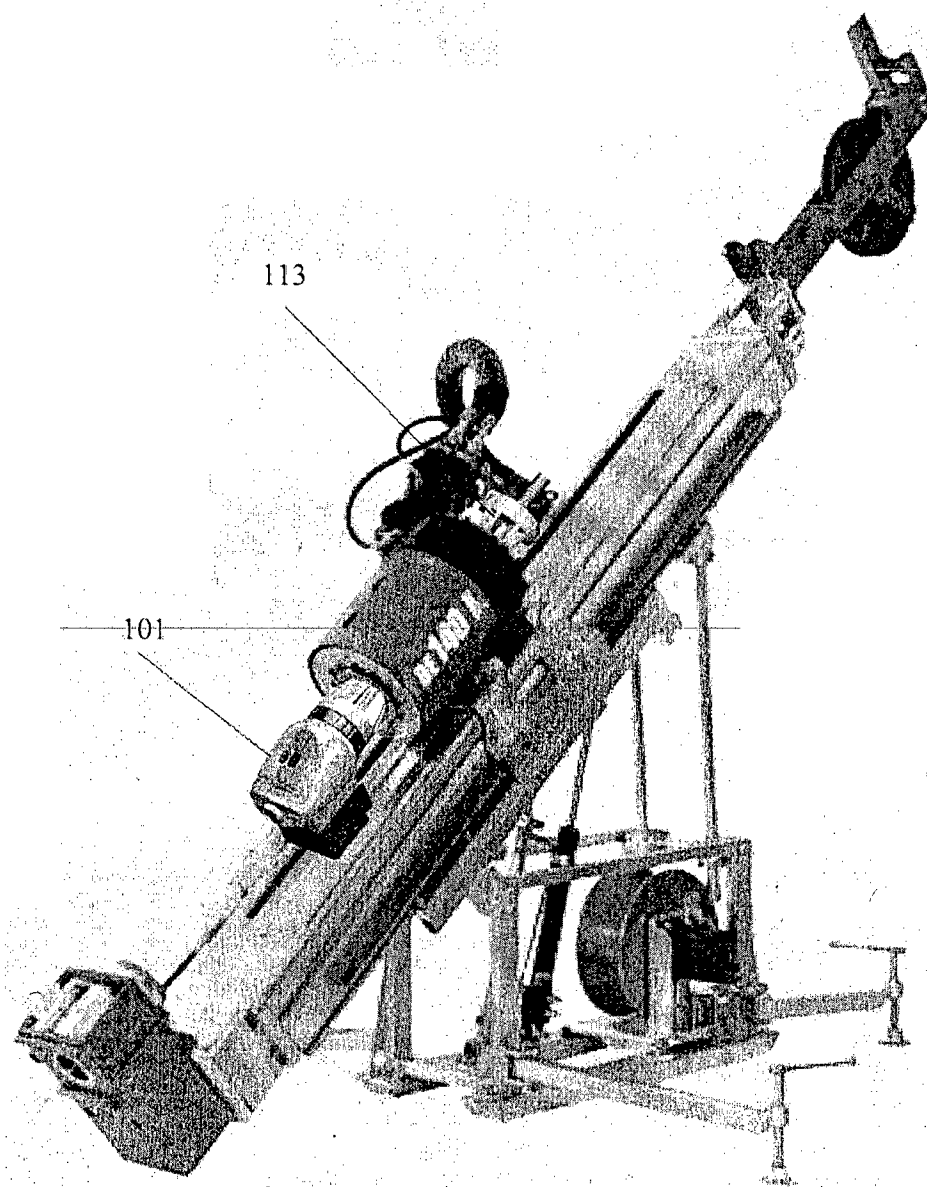


Figure 23

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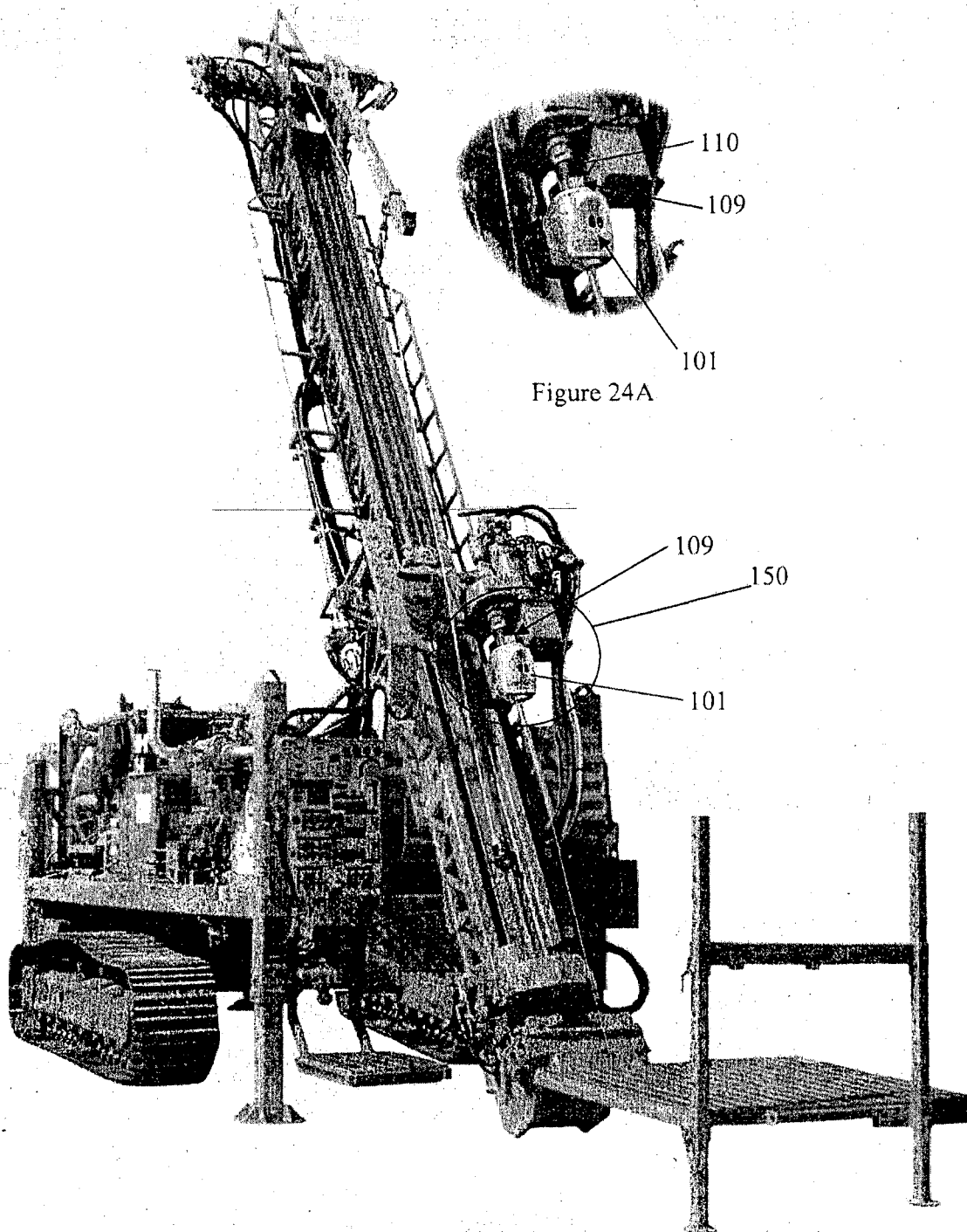


Figure 24

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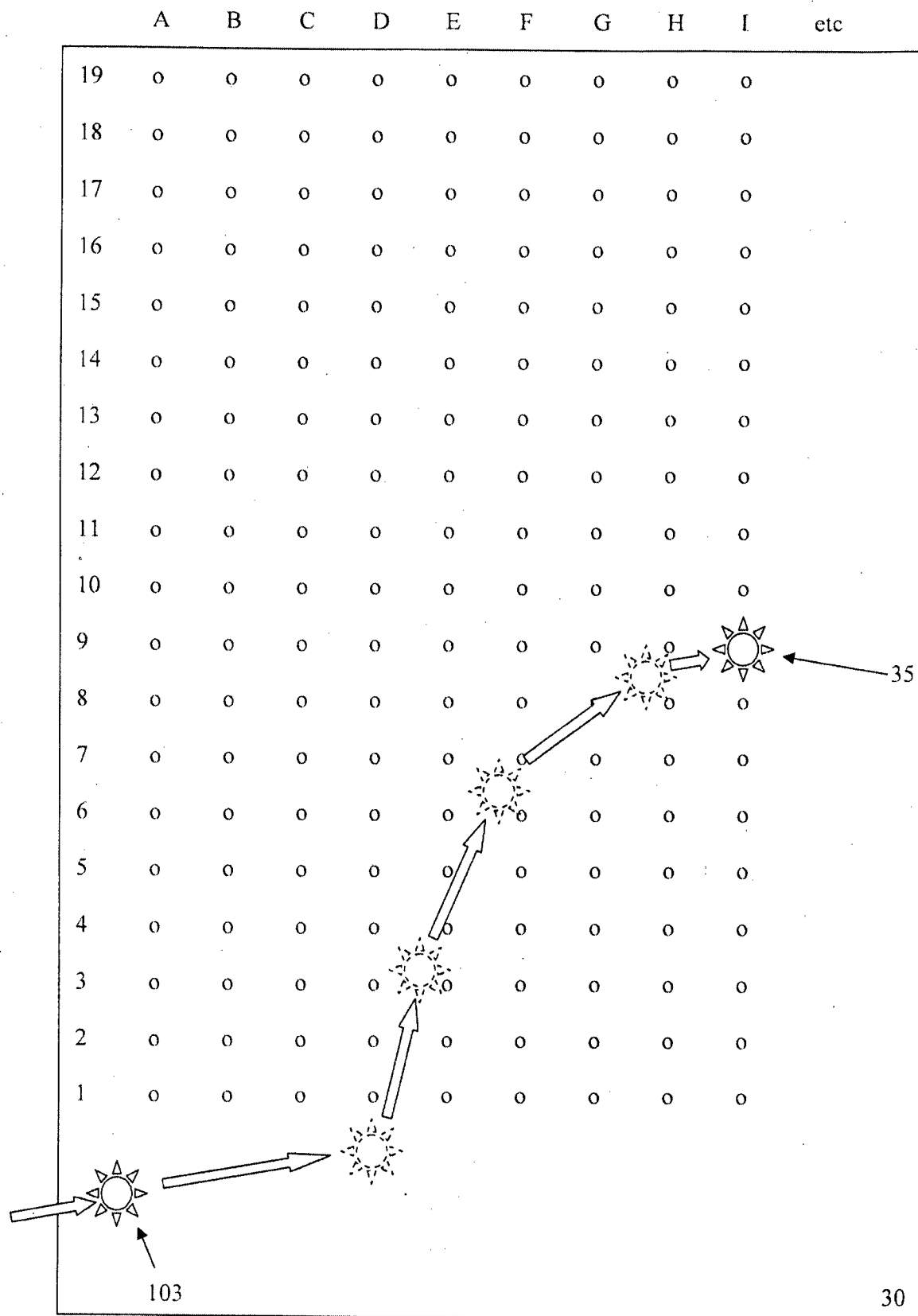


Figure 25

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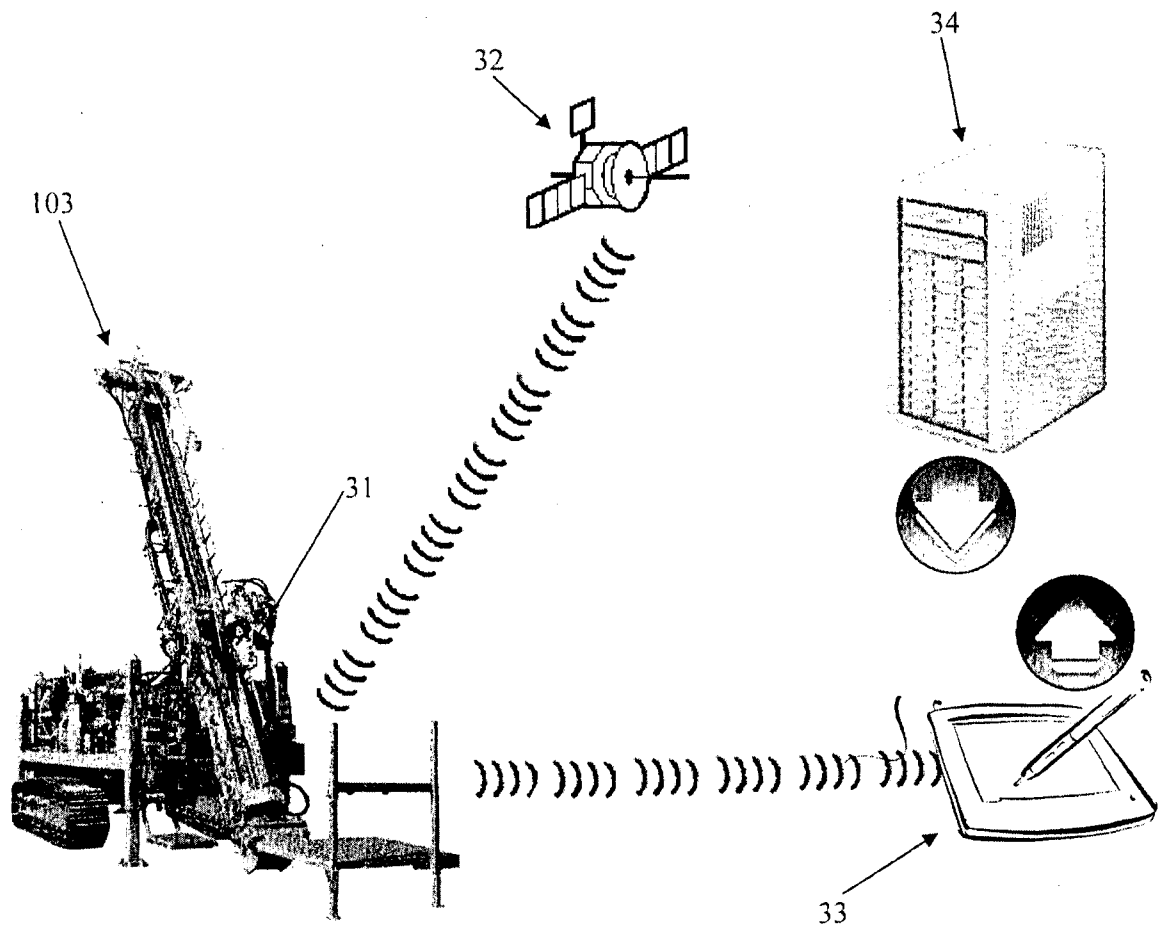
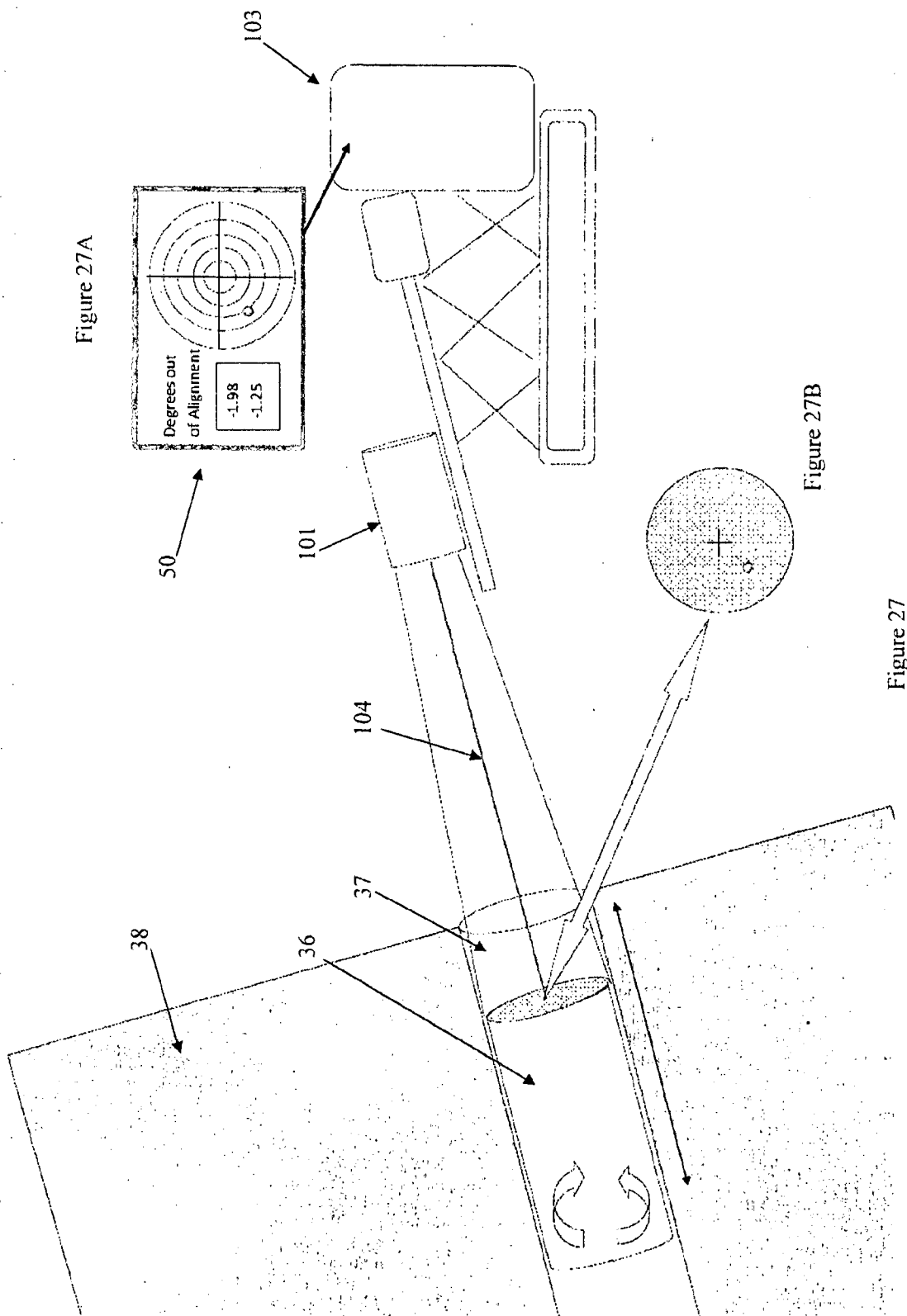


Figure 26



INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2013/000733

A. CLASSIFICATION OF SUBJECT MATTER

E21B 47/02 (2006.01) E21B 19/24 (2006.01) E21B 7/04 (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)

EPODOC & WPI: IPC & CPC E21B7/00 or E21B7/02 or E21B7/04 or E21B47/00 or E21B47/01 or E21B47/02/LOW or G01B7/004/LOW & keywords: laser, beam, ray, infra, align, orient, in-line, coincident, bearing, azimuth, direction, co-ordinate, polar, drill, rig, head, co-axial, chuck, transceiver, receiver, detector, sensing, sensor, pick-up, dish, parabolic and similar terms.

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	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"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
"E"	earlier application or patent but published on or after the international filing date	"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
"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)	"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
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
17 October 2013

Date of mailing of the international search report
17 October 2013

Name and mailing address of the ISA/AU

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Authorised officer

Shane Kilcullen
AUSTRALIAN PATENT OFFICE
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Telephone No. 0262832168

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2013/000733
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2011/057319 A1 (O'REILLY) 19 May 2011 Page 3, line 12-18; page 3, line 32 - page 4, line 4; page 12, line 20-25	1-7, 18
X	US 4506745 A (BJOR) 26 March 1985 col. 1, line 54-68; col. 2, line 29-36	19

Form PCT/ISA/210 (fifth sheet) (July 2009)

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Supplemental Box**Continuation of: Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- Claims 1-18 are directed to a laser alignment device for use with a drill rig. The feature of attaching the device to the drill rig via an attachment arrangement is specific to this group of claims.
- Claims 19 is directed to a drill rod alignment system. The feature of having an alignment detector device adapted to be placed at least partially in a partially drilled hole is specific to this group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is a laser alignment device for use with a drill rig.

However this feature does not make a contribution over the prior art because it is disclosed in:
D1- WO2011/057319 , fig 3; D2- US4506745, fig 1

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

INTERNATIONAL SEARCH REPORT Information on patent family members		International application No. PCT/AU2013/000733	
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 2011/057319 A1	19 May 2011	US 2012279782 A1	08 Nov 2012
		WO 2011057319 A1	19 May 2011
US 4506745 A	26 Mar 1985	AU 8967582 A	28 Apr 1983
		CA 1186677 A1	07 May 1985
		GB 2110274 A	15 Jun 1983
		GB 2110274 B	31 Jul 1985
		NO 813562 A	25 Apr 1983
		NO 152762 B	05 Aug 1985
		SE 450145 B	09 Jun 1987
		SE 8205978 A	21 Oct 1982
		US 4506745 A	26 Mar 1985
		ZA 8207612 A	31 Aug 1983
End of Annex			
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001. Form PCT/ISA/210 (Family Annex)(July 2009)			