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(54) **Title**: APPARATUS AND METHOD FOR PRODUCTION OF HOLES FOR MOUNTING OF EQUIPMENT ELEMENTS ON TUNNEL WALLS

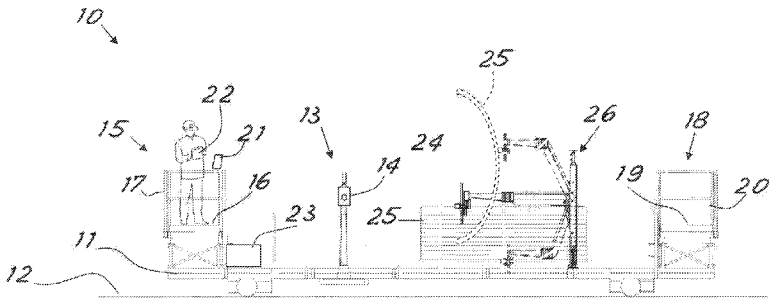

Fig. 1

(57) **Abstract**: An apparatus for the production of holes in walls of a tunnel comprises a carriage (11) designed to travel along rails inside the tunnel, a mechanical drilling arm (13) mounted on the carriage and provided with a drilling head (14), a camera (44) associated with the drilling head for recording a drilling area of the drilling head, a control console (21, 22) associated with the drilling arm and the drilling head and equipped with manual controls for controlling the positioning in space of the drilling head (14) and operation of the drilling head (14). The console (21, 22) is also provided with a monitor (50) connected to the said camera (44) for displaying the image of the drilling area recorded by the camera so that the operator may position the drilling head at the point to be drilled. A method for the production of holes and for mounting elements in the holes is also described.

WO 2017/115240 A1

Title

"Apparatus and method for production of holes for mounting of equipment elements on tunnel walls"

Description

The present invention relates to an innovative apparatus suitable for the production of holes for mounting equipment elements on the walls of a tunnel, in particular a tunnel for light trains. A method is also described and claimed.

In the sector relating to the construction of railway lines in tunnels, for example underground metropolitan lines, it is known that problems exist with regard to mounting the fixed equipment required for these lines along the walls of the tunnel. The equipment may comprise for example lighting systems, electric cables, walkways, pipes, etc.

In order to mount this equipment it is usually required to make a very large number of holes in the walls in precise positions so as to be able to fix the structural elements of the equipment by means of expansion plugs. In general, these holes are produced using portable impact drills, this being a physically very demanding task for the personnel responsible for the drilling operation, in particular when one considers that the walls of the tunnel are made of high-quality reinforced concrete which is therefore extremely hard. The portable drills used therefore usually have large dimensions and are very heavy and a considerable amount of force is needed n order to handle them correctly. In particular, the holes are made at different heights in the wall and also in the zone close to the arch of the tunnel, this making the drilling operation even more difficult.

In addition, the handling of the equipment elements to be fixed is difficult for the personnel carrying out the mounting operation.

For example, often the fixed equipment requires the mounting on the tunnel wall of special, metal, vertical arches which are uniformly spaced every few meters or so along the length of the tunnel and on which the equipment and the associated supports are then mounted, these usually extending along the axis of the tunnel.

These elements, in addition to be being relatively heavy, generally have a length (even of a few meters) which makes them to difficult to position vertically along the wall and fix them to the previously drilled holes. Often several operators are required and they must work together even only to lift one of the elements, rotate it vertically and fix it in position.

The mounting procedure therefore usually requires that, while one or more operators work along the tunnel making the holes, other operators follow them and together remove manually

from a transportation means the elements to be fixed and position and fix them in the holes which have already been made.

It can be easily imagined how all of this means that the operations for preparing and mounting the equipment inside the tunnel are costly, time-consuming and difficult.

The general object of the present invention is to provide an apparatus and a method which allow the necessary holes to be produced with the desired precision, without excessive effort on the part of the personnel involved.

A further object is to provide an apparatus and a method which allow in addition also the easy positioning and mounting of the accessory elements which form at least part of the equipment structure and which are to be fixed by means of the holes produced.

A further object is to allow all of this to be achieved using a smaller number of operators and without excessive effort required on the part of said operators.

In view of this object, the idea which has occurred is to provide, according to the invention, an apparatus for the production of holes in walls of a tunnel, comprising a carriage designed to travel along rails inside the tunnel, a drilling arm mounted on the carriage and provided with a drilling head, a camera associated with the drilling head for recording a drilling area of the drilling head, a control console associated with the drilling arm and the drilling head and equipped with manual controls for controlling the positioning in space of the drilling head and operation of the drilling head, the console also being provided with a monitor connected to the said camera for displaying the image of the drilling area recorded by the camera.

Still according to the invention the idea which has occurred is to provide a method for production of holes in a tunnel by means of the apparatus, comprising the steps of positioning the carriage along the tunnel so that the drilling arm is situated in a zone of the tunnel in which holes must be made, controlling the position of the drilling arm by means of the console and the image on the monitor so that the drilling head with the drilling bit is aligned with a point to be drilled, advancing the drilling head towards the wall and drilling the hole, if necessary drilling other holes in the same area by repositioning the drilling head so as to produce a series of holes, moving the carriage to a following drilling zone in order to drill other holes or series of holes. Between a drilling step in one zone and the next one it is also possible to move the elements to be fixed and fix them to the holes produced. This may be performed without moving the carriage or by moving the carriage stepwise between one drilling zone and the next one, as will be clear below.

In order to illustrate more clearly the innovative principles of the present invention and its advantages compared to the prior art, an example of embodiment applying these principles

will be described below with the aid of the accompanying drawings. In the drawings:

- Figure 1 shows a schematic side elevation view of an embodiment of an apparatus according to the invention;
- Figure 2 shows a schematic plan view of a tunnel section with the apparatus according to Figure 1 in an operative position;
- Figure 3 shows a schematic view cross-sectioned along the line III-III of Figure 2;
- Figures 4, 5 and 6 show schematic views, i.e. a side view, front view and top view, of an embodiment of a drilling head of an apparatus according to the invention;
- Figures 7 and 8 shows schematic side views of two operating conditions of the head shown in Figures 4, 5 and 6;
- Figure 9 shows a schematic view of a possible control console of the apparatus according to the invention;
- Figure 10 shows a schematic view cross-sectioned along the line X-X of Figure 2;
- Figure 11 shows a schematic side elevation view of a device for handling mounting accessories of an apparatus according to the invention;
- Figure 12 shows a schematic view of a mobile head of the device shown in Figure 11.

With reference to the figures, Figure 1 shows a possible embodiment of an apparatus, denoted generally by 10, for mounting equipment in a tunnel, realized in accordance with the invention.

The apparatus 10 comprises a railway carriage 11 which travels along rails 12 by means of an associated drive unit or pulled by a suitable motor unit (known per se in the art and therefore not shown). The carriage is advantageously of the type with a low bed on which the various devices are mounted.

As can be clearly seen also in Figure 2, the carriage 11 comprises a mechanical drilling arm 13 which is provided with a drilling head 14 and which can be controlled by an operator by means of a dedicated console connected to the control system 23 (known per se) of the arm 14 (for example of the electrohydraulic type).

The head 14 comprises, or may have mounted thereon, a suitable drilling bit which is suitably motor-driven (for example rotatably and, where necessary, with an impact action) so as to be able to form the desired holes in the material of the tunnel wall.

The console may be of the fixed type in a control station 15 (as indicated schematically by 21) or may be advantageously portable so as to be gripped by the operator (as schematically indicated by 22). In the case of a portable console, the operator, if it is considered to be useful, may also leave or not use the control station 15 and control the arm 13 from another

location, even only temporarily.

In the case of a portable console, the connection with the control system may be performed advantageously by means of a wireless transmission system (for example by means of radio waves).

The control station 15 may be advantageously arranged at one end of the carriage 11 and may be realized with a platform 16 having handrails 17.

A second station 18, which may also be realized with a platform 19 having handrails 20, may also be provided for the personnel responsible for mounting the accessories, as will be clarified below.

Both the platforms 16 and 19 may also be elevated and be used by the personnel responsible for carrying out mounting, if necessary, as will be clarified below.

As can be seen in Figure 2, the platform or platforms 16, 19 may be advantageously movable laterally, transversely with respect to the carriage, so as to be able to move towards the wall of the tunnel (indicated generally by 27) from one side or the other, depending on the desired working side, so as to facilitate the mounting operations.

Advantageously, the carriage 11 comprises an area or a store 21 for storing the elements or accessories 25 which are to be mounted, for example known arch elements to be fitted vertically along the wall of the tunnel.

The storage area 24 is advantageously served by one (or preferably two) handling devices 26 which allow a single operator to raise, rotate and position an accessory to be fixed to the tunnel wall, removing it from the storage area 24, as will be clarified below.

As can be clearly seen in Figure 2, there may be advantageously only one drilling arm arranged in a central position on the surface of the carriage, namely equidistant from the side edges of the carriage, so as to be able to reach both the right-hand wall and the left-hand wall of the tunnel (if the tunnel has a single track).

The handling device 26 is instead advantageously arranged close to the side edge of the carriage on the side where the tunnel wall to be worked on is situated. In this case, if it is wished to be able to operate on both sides, there may be two devices 26, each one close to a respective side edge of the carriage.

The arm 13 is motor-driven so as to be controlled by the console 21 or 22 so that the operator may suitably position the drilling head at a desired point on the tunnel wall, in the position along the tunnel which is at least approximately reached by means of the movement of the carriage on the rails, as will be clarified below.

Figure 3 shows in greater detail a possible preferred form of the drilling arm 13. In this

embodiment, the drilling arm 13 has a directable part 30 which supports at its free end the head 14 and which is motor-driven so as to be movable in a vertical plane (as shown in broken lines in Figure 3), rotating about a horizontal axis 31, so as to direct the head 14 at various heights on the tunnel wall. The axis 31 is generally parallel to the carriage, namely to its direction of movement along the tunnel.

The directable part 30 is advantageously telescopic (with a structure which is known per se and may be easily imagined by the person skilled in the art) so as to move controllably the head 14 towards the tunnel wall.

Preferably, the rotation axis 31 is arranged so as to be close to the axis of the tunnel (or in any case to the centre of curvature of the tunnel wall which is to be worked on) so that, upon movement thereof in the vertical plane (arranged transverse to the tunnel), the head 14 moves close to the tunnel wall, following at least approximately its curvature.

Advantageously, the directable part 30 protrudes from a vertical upright 32, the base 33 of which is mounted on the bed of the carriage 11. The base may be rotatable about a vertical axis 34 so as to direct the directable arm towards the desired side of the tunnel. If necessary, the base may also be displaceable at least laterally (namely transversely relative to the axis of the tunnel) for example so as to position the rotation axis 31 close to or coinciding with the centre of curvature of the tunnel wall which is to be worked on. A longitudinal movement may also be envisaged for positioning the drilling head.

The movements both about the axis 31 and about the axis 33 as well as the telescopic movement of the part 30 may be advantageously controllable by means of the console 21, 22 for positioning the drilling head on the wall to be drilled.

Figure 4 shows a schematic side view of a possible advantageous embodiment of the drilling head 14.

In this embodiment the head 14 comprises a box-like frame 35 which is mounted on the end of the arm 13 by means of a support bracket 36 (advantageously fork-shaped) so as to be able to rotate about a horizontal axis 37. Inside the frame 35 there is a drill unit 38 with a motor-driven mandrel 39 holding the drilling bit 40 which projects forwards from the frame. The bit will be of a known type suitable for the wall to be drilled and may also comprise or be associated with a known suction system (not shown) for sucking up the dust producing during drilling.

The drill unit 38 is advantageously displaceable inside the frame in an axial direction relative to the drilling bit 40 by means of suitable guides 45 (more clearly visible in Figure 5) and by means of an actuator 42 which is controlled by the operator console, such that it can be moved

from a first retracted rest position (as shown in Figure 2) into a more advanced operating or drilling position (as shown for example in broken lines in Figure 6).

Advantageously, support tips 43 which are generally parallel to the drilling bit 40 protrude forwards from the head 14. Preferably, the tips are four in number and arranged at the corners of a rectangle, with the drilling bit in the centre, as can be clearly seen in Figure 5.

As can be clearly seen in Figures 4 and 6, the support tips 43 have a length such that they protrude beyond the end of the drilling bit 40 when the drill unit 38 is in its retracted or rest position. When the drill unit is in its more advanced position, the drilling bit protrudes instead beyond the support tips 43 by an amount suitable for the maximum depth of drilling required.

The head 14 also advantageously comprises a camera 44 which records the drilling zone and shows this image on a monitor of the control console.

Advantageously, the head has a directional movement about the axis 37 so as to be able to displaced between at least a first position, in which the drilling bit 40 is substantially parallel to the arm 13, and a second position, directed downwards so that the drilling bit is located in a vertical position directed downwards when the arm 13 is moved fully downwards in order to be able to drill the floor of the tunnel (as for example shown in Figure 8).

Advantageously this directional movement of the head about the axis 37 is controlled by means of displacement of the barycenter of the head relative to the axis 37.

This may be achieved by ensuring that, when the drill unit is in its retracted position, the overall barycenter is on the side where the axis 37 is situated towards the rear of the head (on the left in Figure 4), whereas, when the drill unit is in its advanced position, the overall barycenter is on the side where the axis 37 is situated towards the front of the head (on the right in Figure 4). With this movement the head is inclined, as shown for example in Figure 7, by an amount such that, by repositioning the drill unit in its retracted position, the barycenter returns into the position behind the axis 37 and the head returns into the position shown in Figure 4.

In this way, during use, by initially keeping the head with the drill unit retracted, the operator may control the arm 13 so as to position the head until the drilling bit is aligned with the point to be drilled on the side wall of the tunnel. After this the head is advanced, for example by causing the arm to extend telescopically, so that the support tips 43 rest against the wall. Owing to the play around the horizontal axis 37 (and optionally a suitable small amount of play along a vertical axis, if desired), the supporting action of the four tips 43 against the wall ensures suitable perpendicularity of the drilling bit on the wall at the drilling point. Moreover, as a result of the supporting action, it is possible to prevent the displacement of the barycenter

due to the advancing movement of the drill unit from causing the head to tip over downwards. Once the support tips rest against the wall, the drill unit may be moved forwards by means of the actuator 42 so to drill the hole to the desired depth. The support tips ensure also a suitable stability of the head during drilling, preventing for example any sideways slipping.

Once drilling has been finished, the drill unit may be retracted and the head may be then moved away from the wall.

If it is required to mount for example elements extending vertically, several holes are usually required, these being aligned along the diameter of the tunnel. In this case, once the head has been positioned for the first hole and the hole drilled, in order to achieve positioning for drilling of the remaining holes in the wall for the same element to be fixed, it is sufficient to rotate the arm 13 about the horizontal axis 31.

If instead it is required to make a hole in the floor of the tunnel close to the side wall, the operator first causes the drill unit to advance so as to cause tipping of the head downwards (Figure 7) and then moves the arm 13 downwards until the point to be drilled on the floor is reached.

For example, a vertical element may require a fixing hole at the top end, a middle fixing hole and a fixing hole on the ground.

After drilling the holes for an element to be fixed, the carriage may be displaced along the tunnel by the amount needed to make the following series of holes in the wall for the next element to be fixed and so on. This movement may also be controlled by the operator who is drilling the holes.

If it is necessary to make corresponding holes also in the opposite wall of the tunnel, the arm may also be rotated through 180 degrees about the vertical axis so as to position it for working on the other side of the carriage in order to drill the series of corresponding holes.

All the operations may be easily controlled via the control console.

Figure 9 shows an example of a console (advantageously the portable console 22, but the console 21 may have a similar structure).

The console is provided with a monitor 50 where the operator sees the drilling zone recorded by the camera 44, with the drill but 40 and, advantageously, a mark 51 provided beforehand on the wall in order to indicate the point to be drilled. Joysticks 52 and 53 may be operated with both hands (advantageously with the thumbs of the hands holding the portable console) in order to control the movement along the two - vertical and horizontal - axes (joystick 52) and advance and retract the head (joystick 53) for example by means of elongation of the telescopic arm. Another control 54 may control instead retraction and advancing of the drill

unit inside the frame of the head in order to perform drilling or to tip over the head. Further controls, for easier illustration not shown, may be now easily imagined by the person skilled in the art and may be provided on the console in order to perform other functions of the apparatus 10, for example movement of the carriage, starting and stopping of the drill unit, etc.

In order to facilitate alignment and prevent any errors due to the parallax of the camera, a laser locating mark may also be used, said mark being projected onto the wall by means of suitable laser projectors (not shown) arranged on the head, as is known per se to the person skilled in the art, so as to indicate with precision on the wall the point aligned with the drilling bit.

Figure 10 shows the zone of the carriage with the handling devices and an example of their possible radius of action (greater than the distance from the wall of the tunnel) towards the outside of the carriage. Figure 11 shows in greater detail one (or the sole) handling device.

Advantageously this device may be of the type known per se which helps an operator to move heavy and/or bulky loads by following passively - but with systems for reducing the weight of the load (for example counterweights, springs and/or hydraulic systems) - the movements which the operator imparts, with minimum effort, to the front end of the device on which the element to be moved is fixed.

The device 26 comprises an articulated arm 62, 63 which has at a free end thereof a handling head 65 for an element 25.

Figure 12 shows an advantageous embodiment of the handling head 65, rotated through 90 degrees with respect to Figure 11.

Advantageously, the device 26 comprises a vertical upright 60 from which there projects the articulated arm which may rotate freely with minimum friction about a vertical axis 61. The articulated arm may comprises a parallelogram structure 62 and an end arm 63 which supports the head 65. Owing to the parallelogram structure, the end arm 63 may be raised or lowered by the operator, keeping it always horizontal and parallel with itself.

The end arm 63 is pivotably mounted on one side on the parallelogram structure so as to be able to rotate about a second vertical axis 64 and supports at its free end the handling head 65 which may rotate on the arm 63 about a third vertical axis 66 and about a horizontal axis 65.

The handling head 65 comprises a gripper 68 which can be controlled so as to suitably grip an element 25 to be positioned, and two handlebars 69 for gripping by the operator using both hands in order to move and rotate the head.

The parallelogram structure may comprise a suitable balancing spring or piston 70 in order to

reduce the force needed by the operator when raising the head also when there is the load consisting of the element 25 to be positioned and held inside the gripper 68.

After the holes for an element have been provided, it is thus possible to grip with the gripper 68 an element in the store area 24, position it with minimum effort on the wall opposite the fixing holes and suitably rotate it and fix it inside the holes, for example using expansion plugs.

Once the element to be fixed has been positioned, the elevated platform (16 or 19) may assist an operator to perform final fixing also at the top end of the element 25.

It is now clear that the drilling and fixing operations may be performed in sequence and with a high frequency.

Moreover, advantageously, the length of the carriage and the relative position of the drilling arm and the handling devices may be established so that, while the drilling arm performs a series of holes for the next element to be mounted, the handling devices are in position such as to allow the simultaneous positioning and fixing of an element to be mounted in the series of holes drilled beforehand.

The relative position of the arm 13 and the handling devices 26 may also be variable (for example by providing the possibility of mounting the devices 26 in different positions along the side edges of the carriage) so as to be able to adapt rapidly the distance along the axis of the tunnel between the arm 13 and the handling devices 26 depending on the interval to be maintained between the elements 24 along the length of the tunnel.

At this point it is clear how the predefined objects have been achieved, providing an apparatus which allows a plurality of holes to be made rapidly and without effort in a tunnel wall and, if required, also the easy positioning and fixing of elements which are engaged with these holes. Moreover, the number of persons required to carry out the operations is reduced.

Obviously the description above of an embodiment applying the innovative principles of the present invention is provided by way of example of these innovative principles and must therefore not be regarded as limiting the scope of the rights claimed herein.

The carriage may have other devices and controls and may have, for example, an electric power supply which is autonomous (for example of the battery type) or supplied externally, for powering of the various devices and circuits. In the case where hydraulic or pneumatic systems are used to move the various mechanisms of the apparatus, one or more suitable hydraulic control units may also be provided (for example inside, or associated together with, the control system 23), as may be now easily imagined by the person skilled in the art. The drilling arm and/or any handling devices may also be designed differently from that shown, as

may be now be easily imagined by the person skilled in the art based on the description provided here.

Claims

1. Apparatus for production of holes in the walls of a tunnel, comprising a carriage (11) designed to travel along rails inside the tunnel, a mechanical drilling arm (13) mounted on the carriage and provided with a drilling head (14), a camera (44) associated with the drilling head for recording a drilling area of the drilling head, a control console (21, 22) associated with the drilling arm and the drilling head and equipped with manual controls for controlling the positioning in space of the drilling head (14) and operation of the drilling head (14), the console (21, 22) also being provided with a monitor (50) connected to said camera (44) for displaying the image of the drilling area recorded by the camera.

2. Apparatus according to claim 1, characterized in that it comprises a storage area (24) for receiving elements to be fixed to the holes produced, and at least one handling device (26) associated with the storage area (24) for allowing an operator to move an element from the storage area to the tunnel wall.

3. Apparatus according to claim 1, characterized in that the carriage comprises stations (15, 18) with an elevated platform and, preferably, the elevated platform is mobile transversely relative to the carriage.

4. Apparatus according to claim 1, characterized in that the drilling arm (13) has a horizontal rotation axis (31) which is parallel to the carriage so as to move in a vertical plane transverse to the carriage.

5. Apparatus according to claim 1, characterized in that the drilling arm (13) has a vertical rotation axis (34).

6. Apparatus according to claim 1, characterized in that the drilling arm (13) has a telescopic end part (30) that supports the drilling head.

7. Apparatus according to claim 1, characterized in that the drilling head (14) has a frame (35) in which there is present a drill unit (38) with a drilling bit (40), the drill unit being displaceable controllably in the frame (35) in a direction which is parallel to the drilling bit (40) between a retracted position and an advanced position.

8. Apparatus according to claim 7, characterized in that the drilling head (14) includes support tips (43) directed in the same manner as the drilling bit (40) and intended to rest against the wall to be drilled, the support tips protruding from the drilling head (14) more than the drilling bit when the drill unit is in the retracted position and less than the drilling bit when the drill unit is in the advanced position.

9. Apparatus according to claim 7, characterized in that the drilling head (14) is connected to the drilling arm (13) by means of a rotation axis (37) of the head which is horizontal and

transverse to the head.

10. Apparatus according to claim 7, characterized in that, for movement of the head about the rotation axis (37) of the head, this rotation axis of the head is positioned on the head so that the barycenter of the head is behind this rotation axis (37) when the drill unit is in the retracted position and is in front of this rotation axis (37) when the drill unit is in the advanced position.

11. Apparatus according to claim 2, characterized in that the at least one handling device (26) comprises an articulated arm (62,63) provided at a free end with a handling head (65) provided with a gripper (68) intended to grasp an element (25) to be moved.

12. Apparatus according to claim 11, characterized in that the at least one handling device (26) comprises a vertical upright (60) from which the articulated arm (62,63) protrudes, the articulated arm being fixed to the upright so as to be rotatable on the upright about a first vertical axis (61).

13. Apparatus according to claim 11, characterized in that the articulated arm comprises a first part in the form an articulated parallelogram (62) which supports a second end part (63) which ends in the handling head (65).

14. Apparatus according to claim 11, characterized in that the handling head is mounted on the articulated arm so as to be manually rotatable about a vertical axis (66) and about a horizontal axis (67).

15. A method for production of holes in a tunnel by means of the apparatus according to any one of the preceding claims, comprising the steps of positioning the carriage (11) along the tunnel so that the drilling arm (13) is situated opposite a zone of tunnel in which holes have to be made; controlling the position of the drilling arm by means of the console and the image on the monitor so that the drilling head (14) with the drilling bit is aligned with a point to be drilled; advancing the drilling head (14) towards the wall and drilling the hole; if necessary drilling other holes in the same area by repositioning the drilling head so as to provide a series of holes; moving the carriage to a following drilling zone in order to drill another hole or another series of holes; preferably between a hole or a series of holes in two successive zones, moving elements present in a storage area on the carriage and securing them to the wall of the tunnel by means of the holes produced.

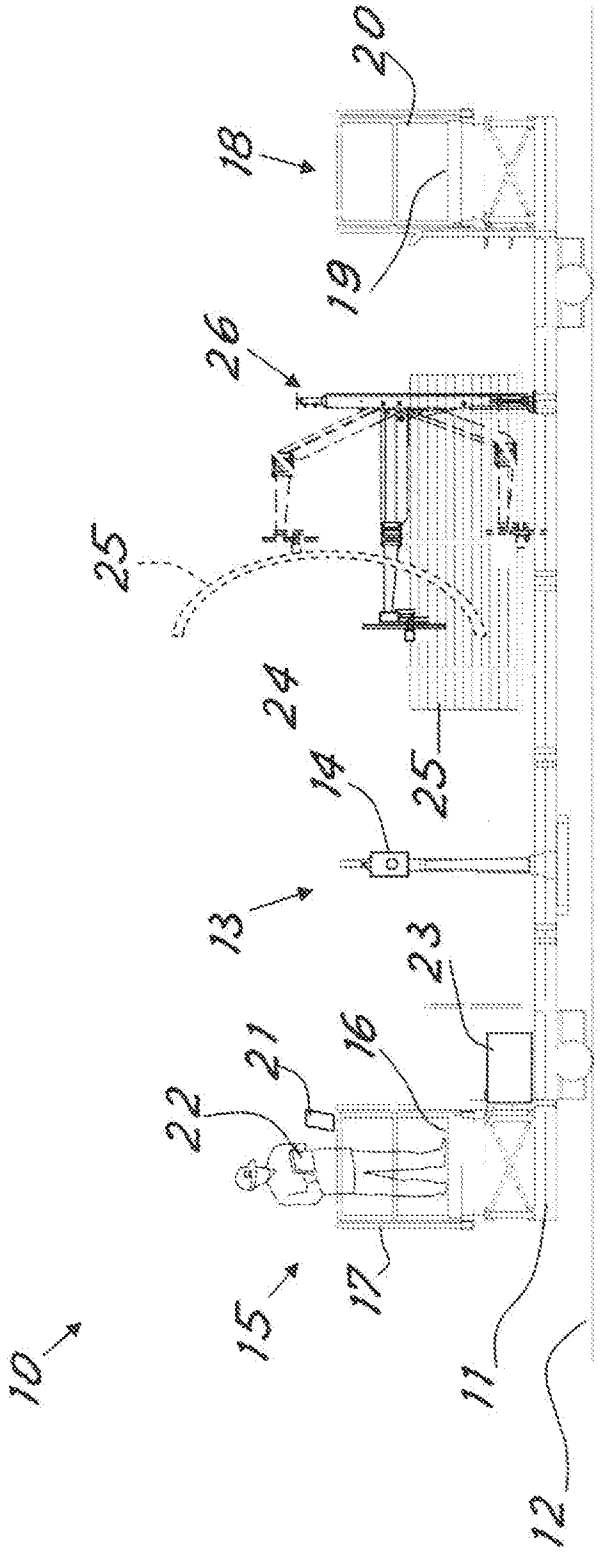

Fig. 1

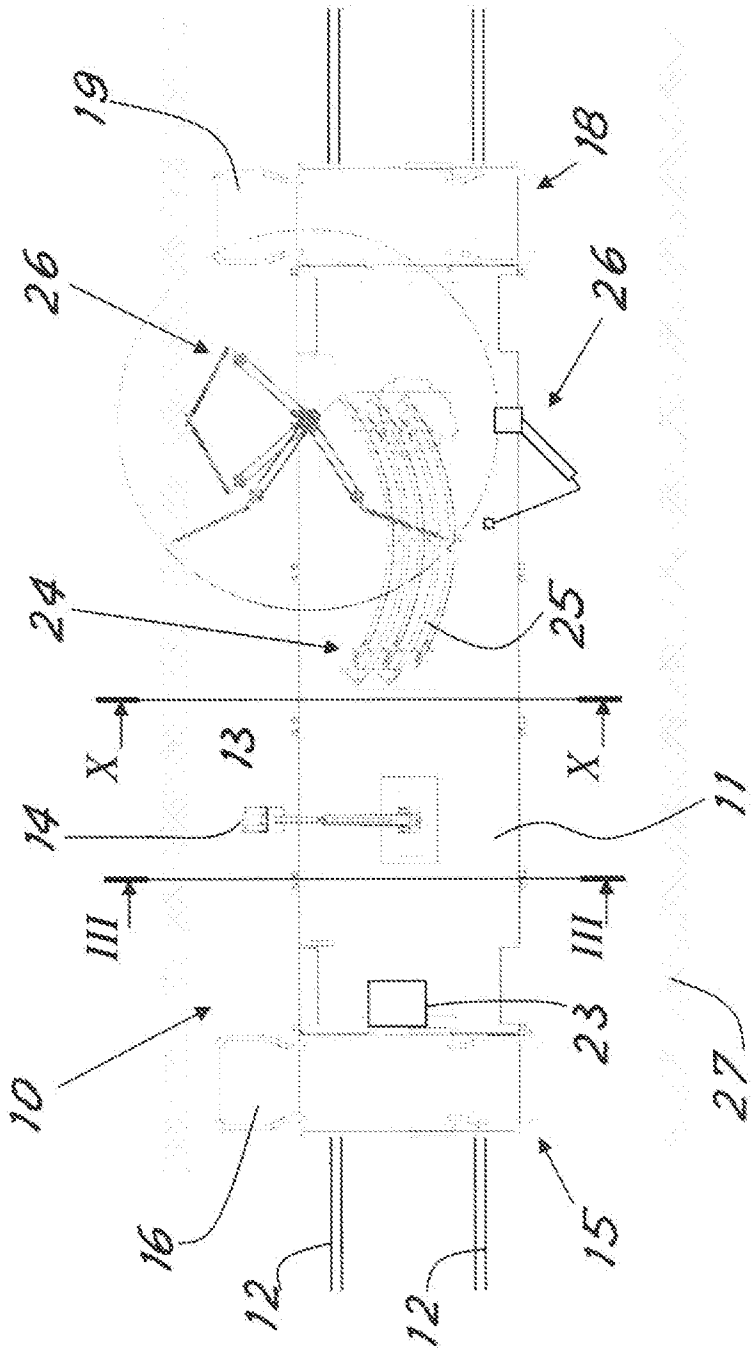

Fig.2

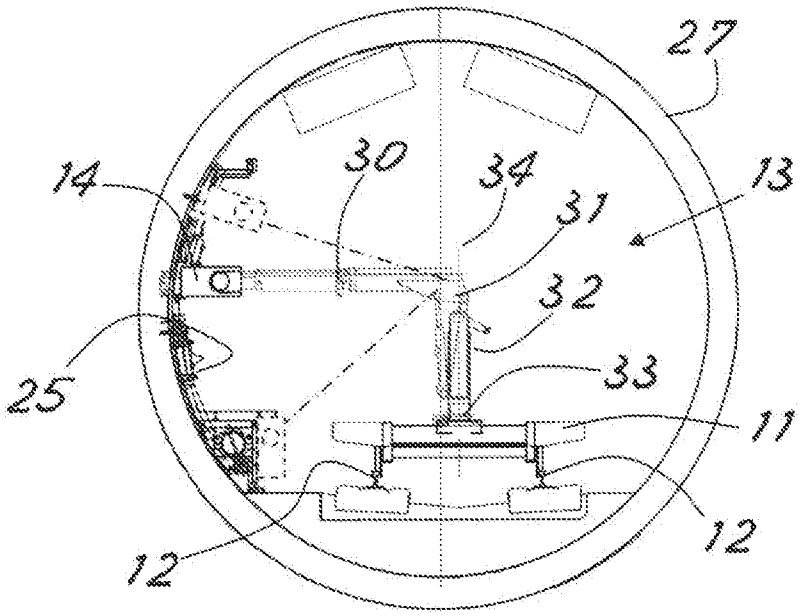
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Fig.3

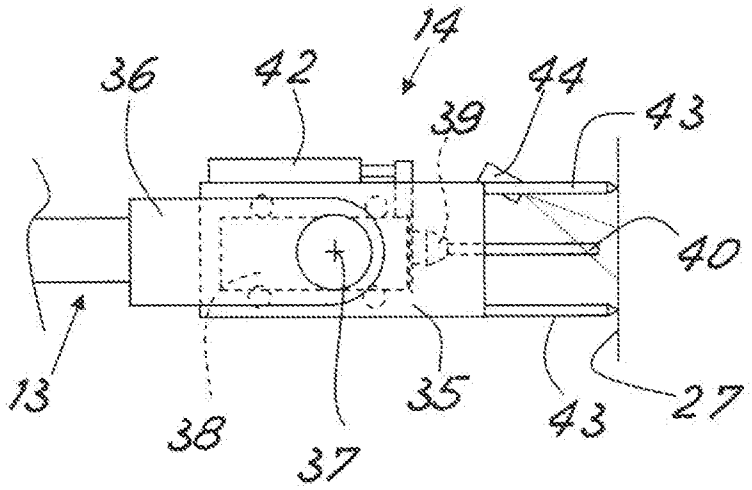
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Fig.4

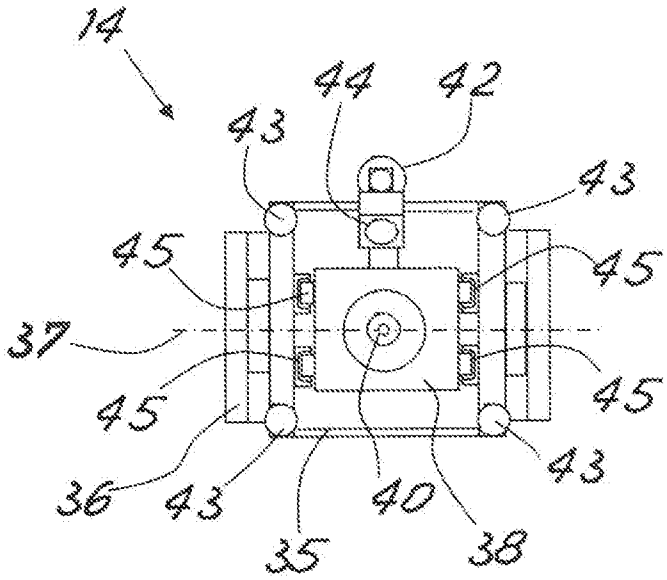
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Fig.5

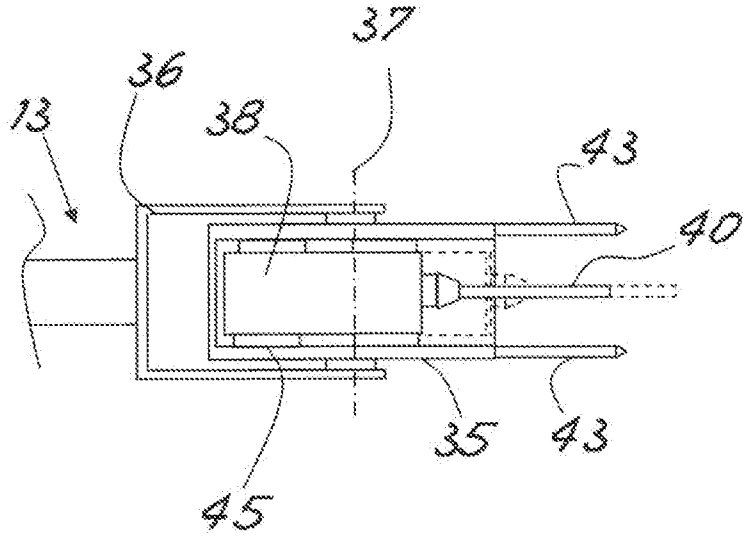
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Fig.6

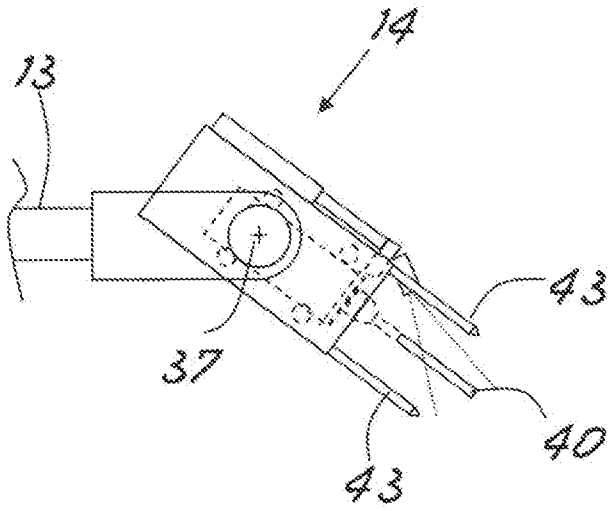

Fig.7

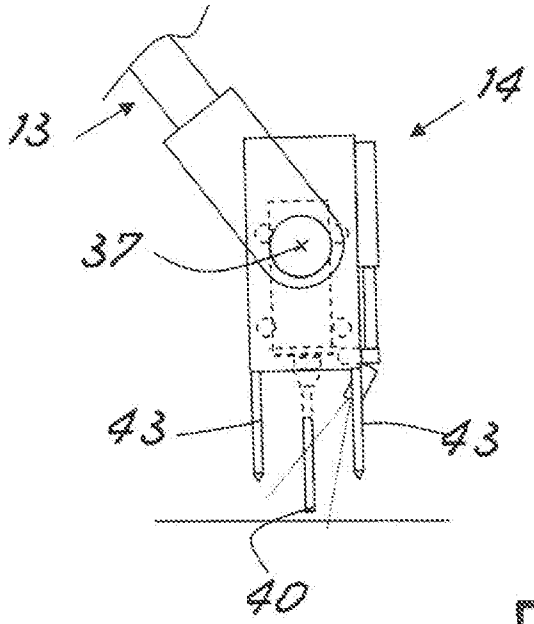

Fig.8

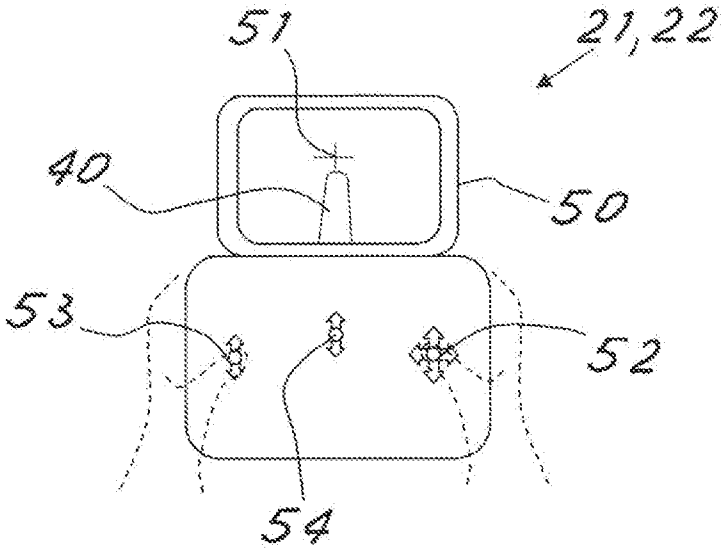

Fig.9

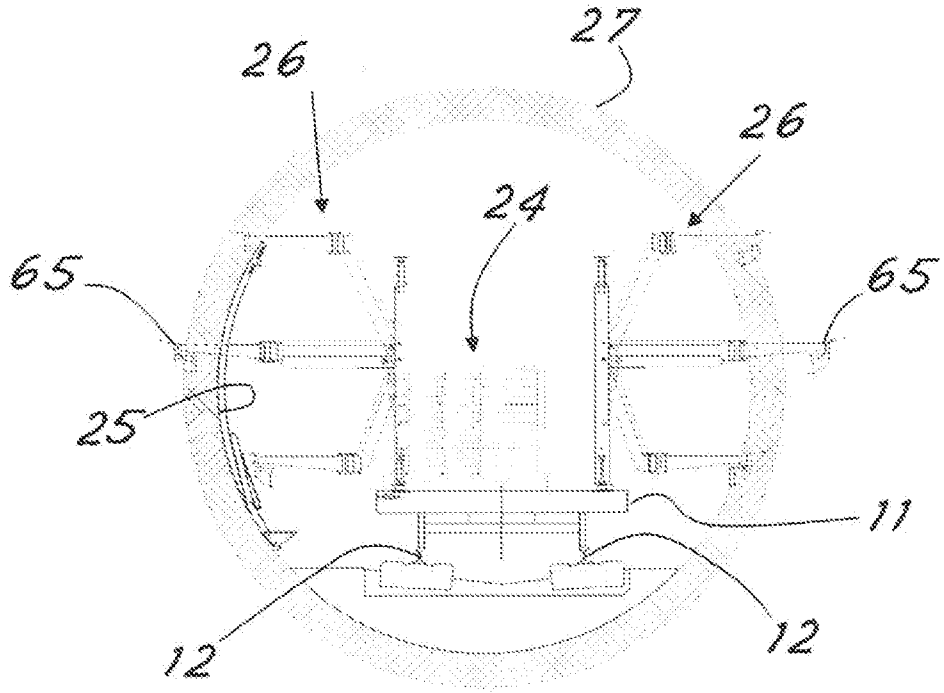

Fig.10

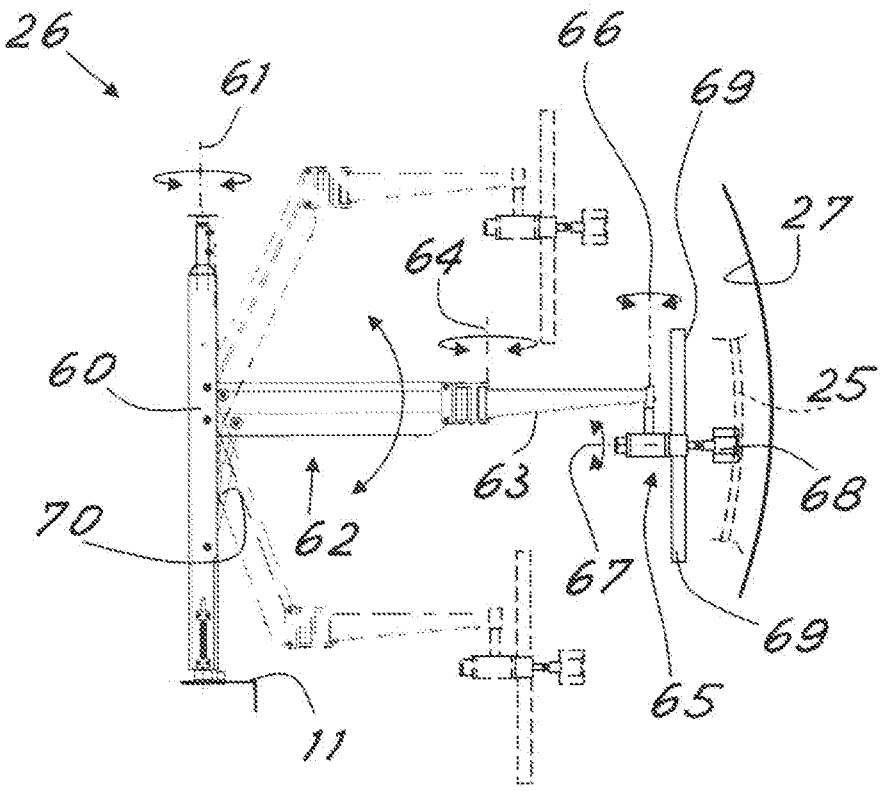

Fig.11

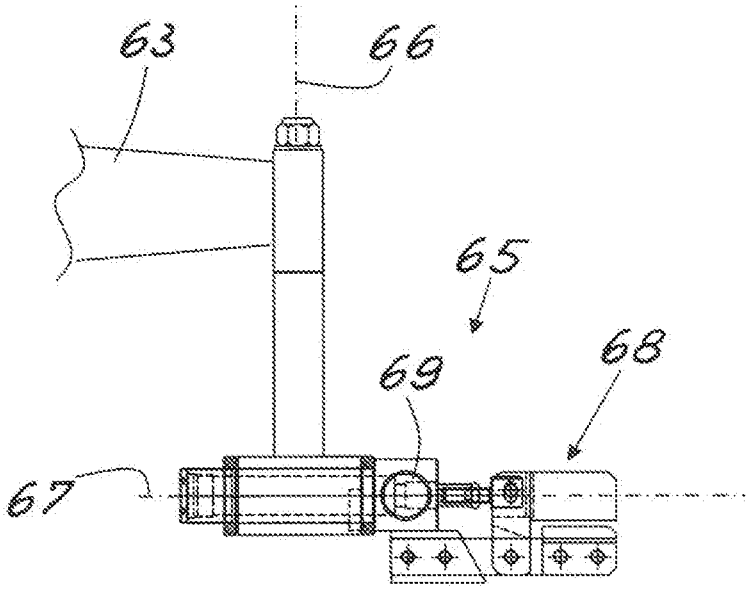

Fig.12

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/057927

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B7/02 E21D9/08 E21B19/087 E21B19/16 E21D11/40
ADD.

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)
E21B E21D

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2014/187473 A1 (SANDVIK MINING & CONSTR OY [FI]) 27 November 2014 (2014-11-27)	1-7,11, 15
Y	page 12, lines 16-19	8-10,12, 14
	the whole document	
	leaning on ground;	
	figure 1	
	page 15, lines 23-25	
	page 15, lines 7-26; figure 3	

Y	CN 103 306 690 B (SHANGHAI TUNNEL ENG CO LTD) 2 December 2015 (2015-12-02)	12,14
A	figure 2	11
	the whole document	
	figures 1,3-5	

X	WO 2015/106799 A1 (SANDVIK MINING & CONSTR OY [FI]) 23 July 2015 (2015-07-23)	1,15
	the whole document	

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 May 2017	30/05/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	van Berlo, André

3

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NL 288 166 A (HUGO HERZBRUCH) 10 March 1965 (1965-03-10) figures 1,2 the whole document	12,14
A	CN 204 716 131 U (CHENGDU SWJTU DRIVE TECHNOLOGY CO LTD) 21 October 2015 (2015-10-21) claim 5; figure 3	1
A	WO 88/09426 A1 (ANDERSON STRATHCLYDE PLC [GB]) 1 December 1988 (1988-12-01) the whole document	1
A	WO 01/75269 A2 (LINK PIPE INC [CA]; MAIMETS LEMBIT [CA]) 11 October 2001 (2001-10-11) figures 6-11	13
A	US 3 902 561 A (FRIBERG KARL HERBERT ET AL) 2 September 1975 (1975-09-02) roofbolt could be element to be fixed to drilled hole; figure 1 the whole document	2,12-14
A	Simone Vazzaz: "TBM Minerva - Copenhagen Cityringen Metro Project", , 7 September 2014 (2014-09-07), page 1, XP054976724, Retrieved from the Internet: URL:https://www.youtube.com/watch?v=UjGWhYm2Edw [retrieved on 2016-08-16] the whole document	1
Y	WO 89/02513 A1 (BOGDANY BELA [HU]) 23 March 1989 (1989-03-23) pages 40,41; figures 2,13,14,16,26 figure 14 hanging; page 3; figure 3 the whole document page 44, line 33 - page 46, line 23	8-10
A	WO 2014/191013 A1 (SANDVIK MINING & CONSTR OY [FI]) 4 December 2014 (2014-12-04) page 10, lines 14-25 the whole document support beam 11; figures 1,2,7	8

-/--

3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/057927

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/098460 A1 (SANDVIK MINING & CONSTR OY [FI]; SCOLARI FEDERICO [IT]) 4 July 2013 (2013-07-04) the whole document -----	8
A	WO 00/60211 A1 (CHRISTOS BYRON PERCY [ZA]) 12 October 2000 (2000-10-12) the whole document -----	9,10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2016/057927

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014187473 A1	27-11-2014	AU 2013390350 A1	10-12-2015
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		WO 2013098460 A1	04-07-2013

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2016/057927

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 0060211 A1	12-10-2000

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2016/057927

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 additional sheet

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 an 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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7, 11-15

   Apparatus for the production of holes in the walls of a tunnel

   ---

2. claims: 8-10

   Drilling head including support tips / rotation axis of head / barycenter position

   ---