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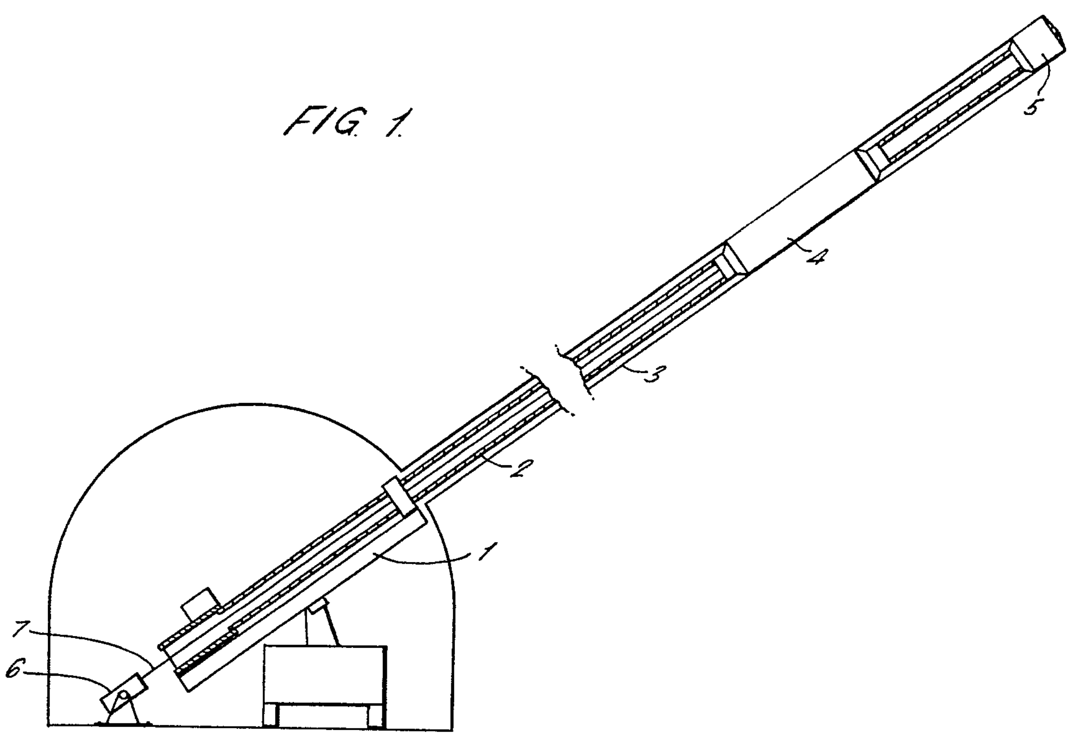
(54) Rock drilling

(57) The invention concerns drilling of long and straight holes (3) in rock. The method is based on the use of a drill rig (1) that may be aligned by means of a laser beam (7), and which comprises a hollow drill stem (2) with a pressure device for guiding the drill stem (2) in a correct direction on applying pressure against the wall of the drilled hole (3). The laser beam (7) is sent into the hollow drill stem (2) towards an optical detecting unit placed inside a hollow control means (4) joined into a drill stem (2) behind its drill bit (5), the control means being operated by means of signals from the detecting unit. The means (4) constitutes a connecting piece of the drill stem (2) and comprises the pressure device which is in contact with the wall of the hole. The optical detecting device is arranged with unobstructed sight to the source of the laser beam (7) as long as the drill stem (2) is sufficiently straight.

FIG. 1



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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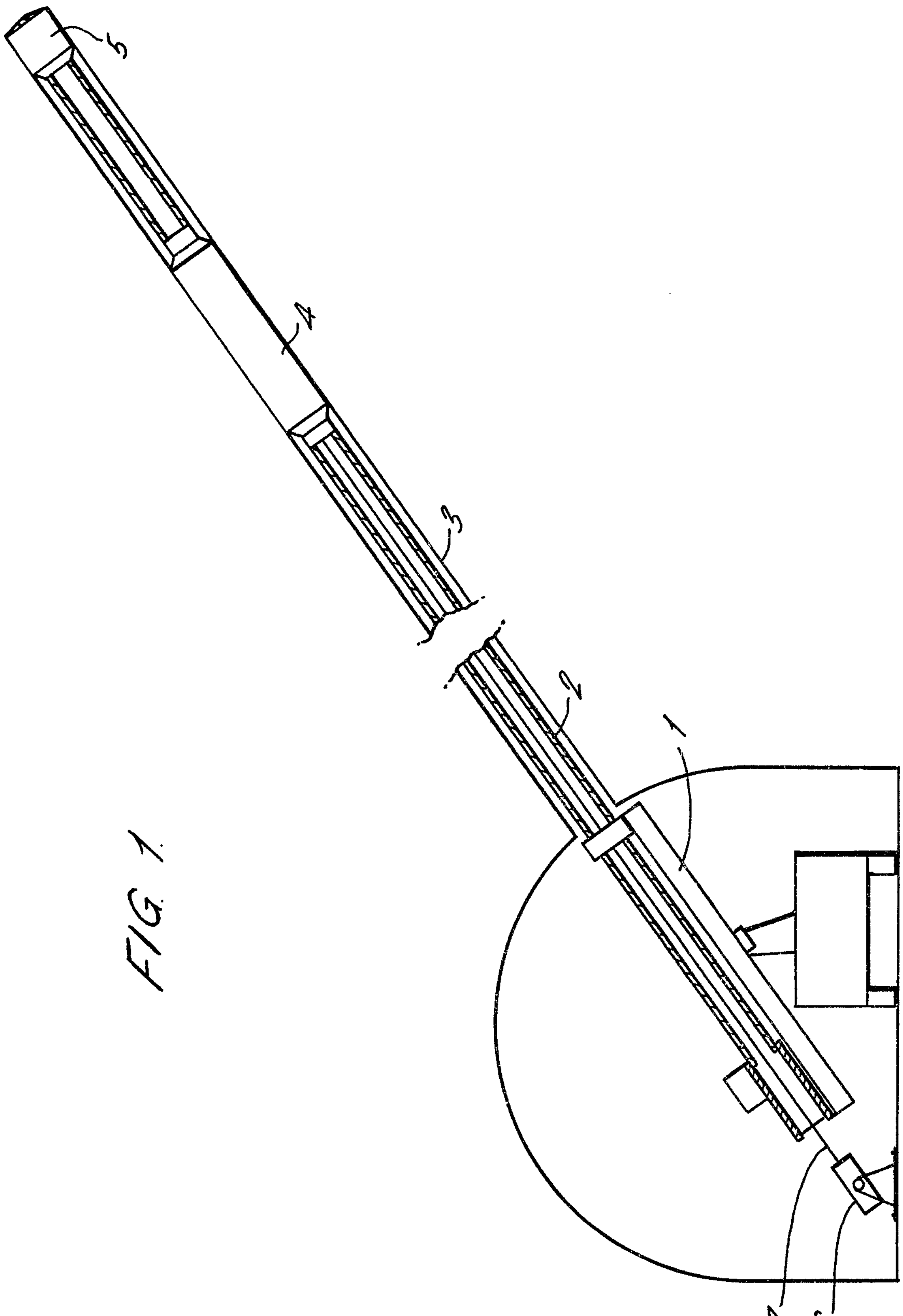


FIG. 1

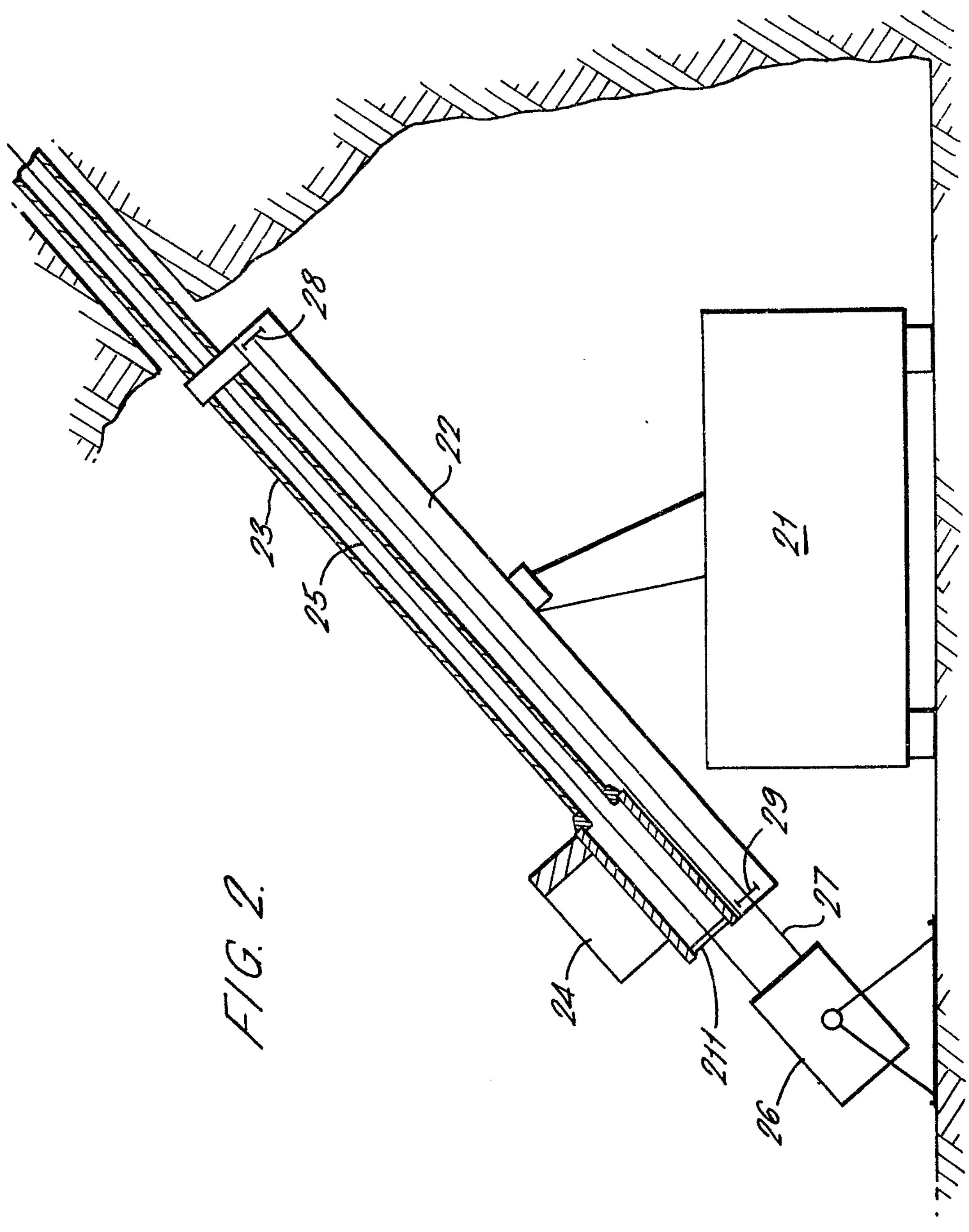


FIG. 2.

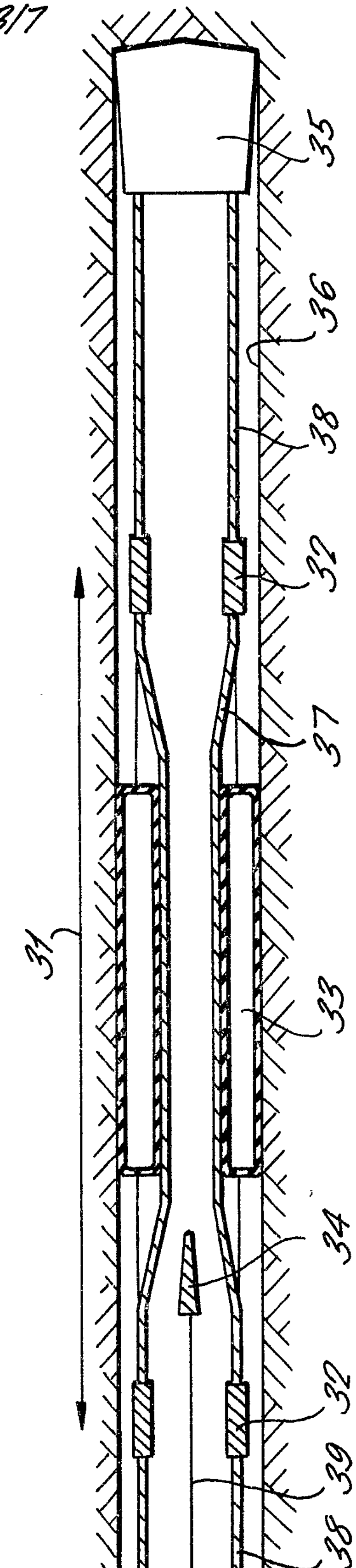


FIG. 3.

FIG. 4.

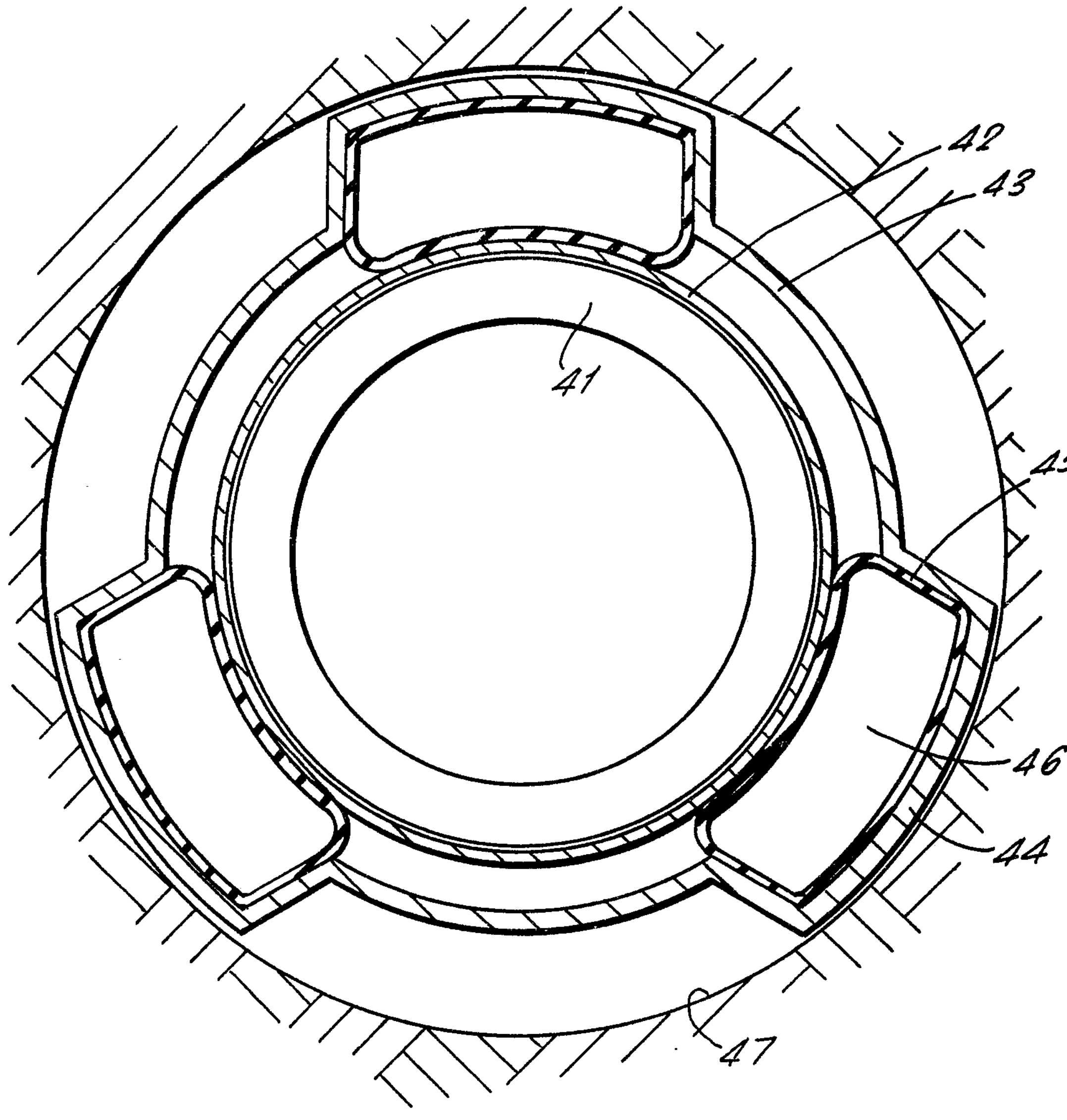
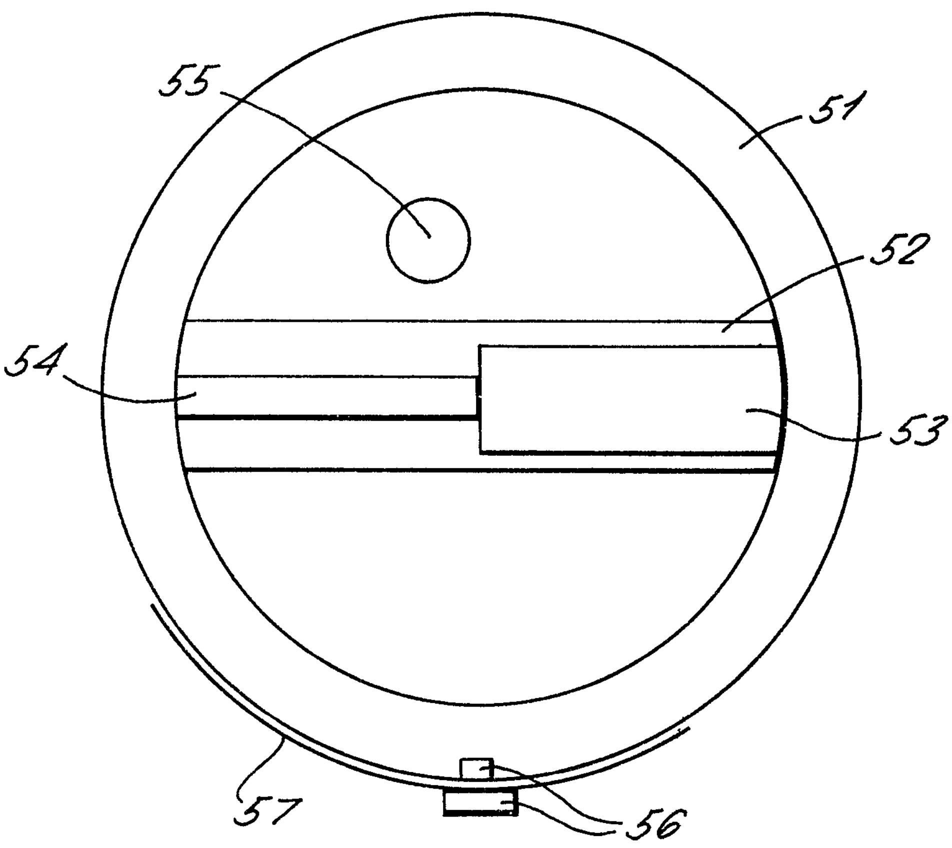


FIG. 5.



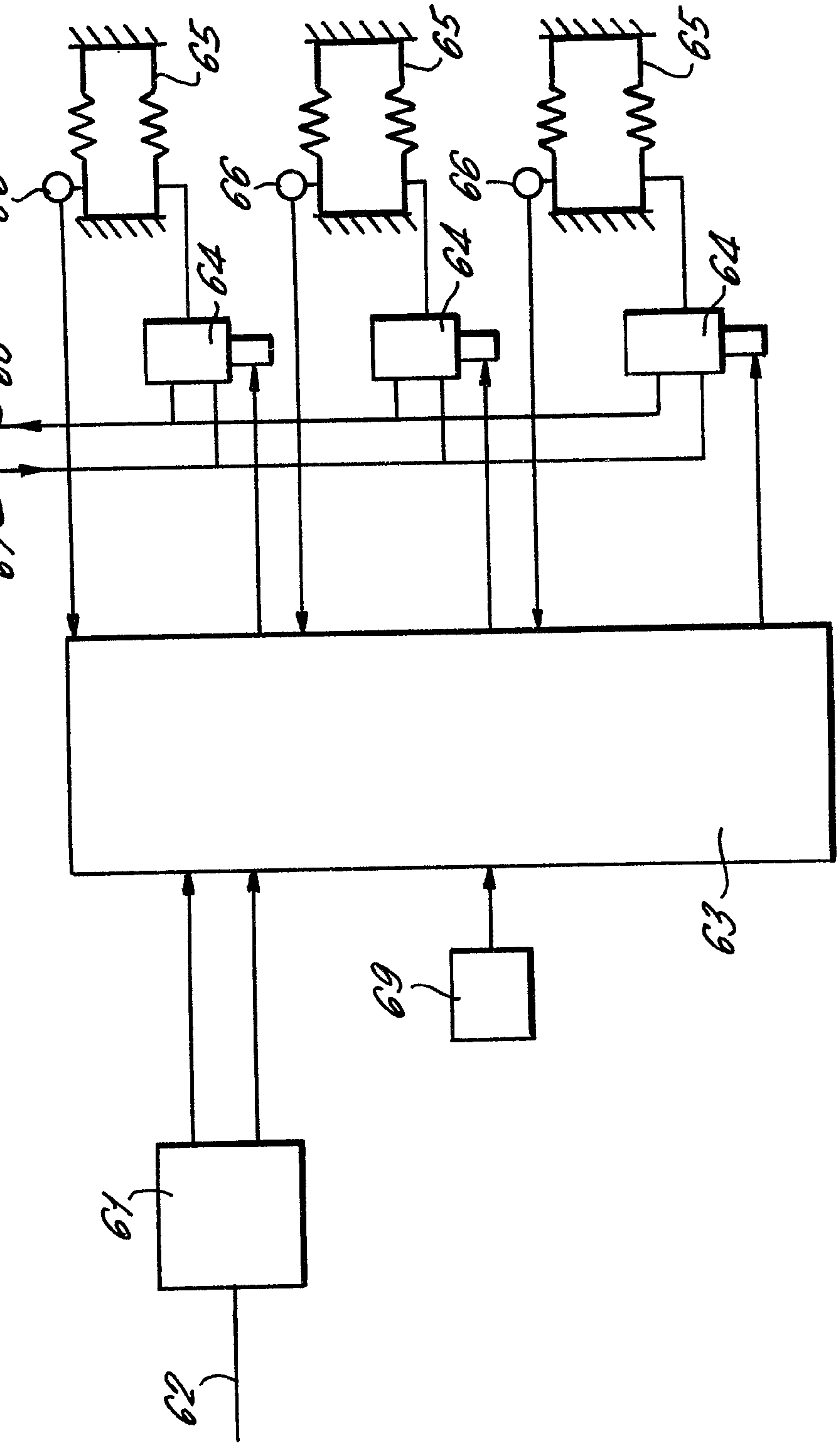


FIG. 6.

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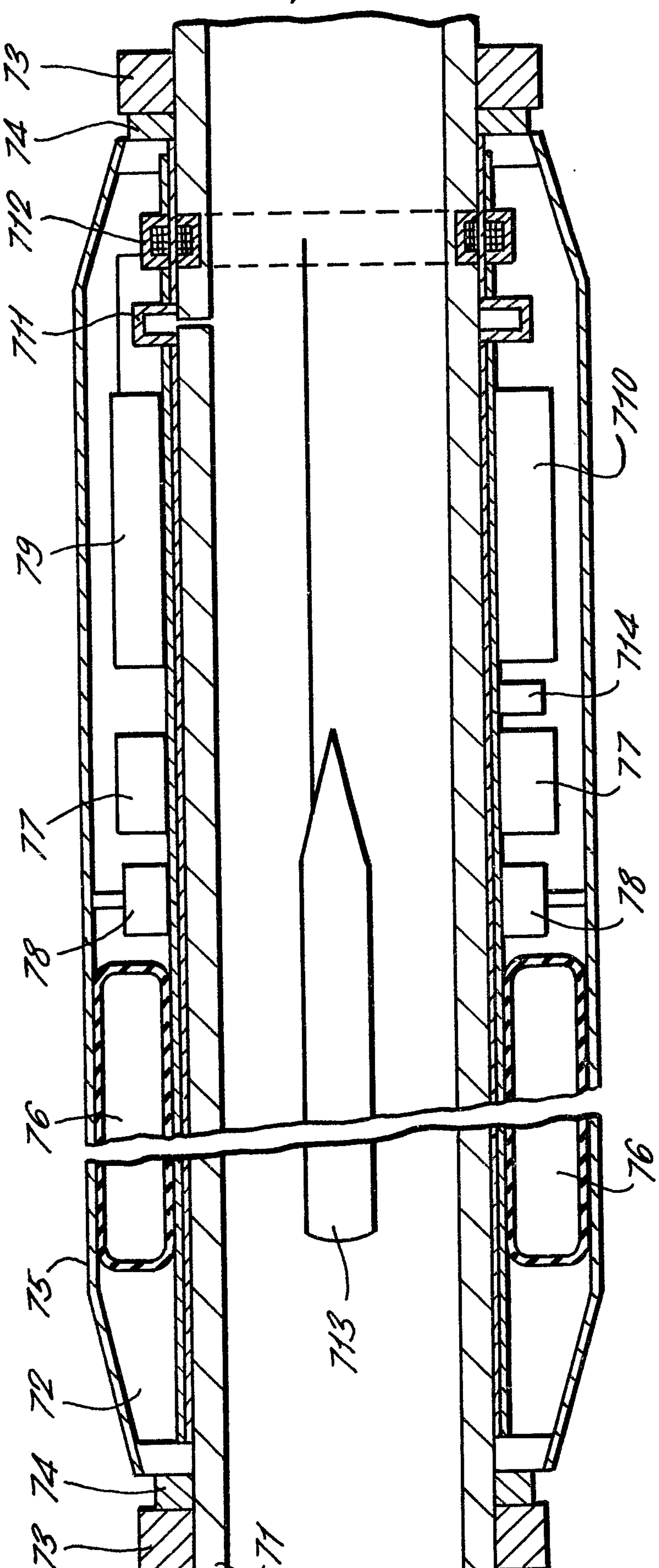

FIG. 7.

SPECIFICATION
Rock drilling

The present invention relates to a method for drilling long and straight holes in rocks by means of a drill rig that may be aligned by means of a laser beam, which drill rig comprises a hollow drill stem with a pressure device for guiding the drill stem in a correct direction on applying pressure against the wall of the drilled hole. Further, the invention relates to apparatus for performing the method.

Cutting or rocks and ores in mines, both above and under ground, is mainly done by drilling and blasting.

Investigations have shown that the costs of cutting can be reduced substantially if the technology concerning the drilling of long holes at a high precision be mastered. In mine-cutting today the lengths of the holes are limited by the large hole deviations, which means that it can hardly be foreseen where a hole ends.

Thus, a requirement on using longer drill holes and also on increasing the distance between holes is that a new drilling technology be made available, thus making it possible to drill holes with an essentially higher precision than is obtainable today.

At present the drilling precision is limited by the stability and accuracy of the drill rigs being used, and by how accurately the rigs can be adjusted in relation to a reference coordinate system.

The present development in this respect is directed to developing drill rigs with better rigidity and stability so that the drill stem can get a start direction which is as correct as possible. Such drill rigs may improve the drilling accuracy to some extent, but fundamental limitations are implied in how far this technology can be run.

Firstly, an uncertainty will remain with respect to the start direction of the drill. Besides, the drill stem may change direction on its way due to different reasons, such as:

— inhomogeneities, slips etcetera in the rock
— distortions in the drill stem
— influence of gravity, and so on.

Increase of rigidity and stability requires more costly drill rigs. Additionally, the accuracy depends on wearing of the equipment, and on the operator as well.

The present invention aims at drilling holes with great accuracy independent of the length of the hole, and without necessitating improvement on the rigidity of the drill rig.

The method according to the invention is directed to sending the laser beam through the hollow drill stem towards an optical detecting unit placed inside a hollow control unit that constitutes a portion of the drill stem, which control means comprises the pressure device, and to deriving laser generated signals from the detecting unit for control of the pressure device, whereby long and straight holes can be drilled with high accuracy. In this way deviations may be reduced to essentially less than the diameter of the drill hole.

The laser beam may be led through a window at the rear of the drilling aggregate whence it enters the hollow drill stem which may be filled with filtered air. Since the drill stem is guided automatically all the time, the hole will be so straight that the laser beam can pass unhindered the whole length of the drill stem as the drilling is going on.

Apparatus according to the invention is characterized in that it has been joined into the hollow drill stem behind its drill bit and constitutes a connecting piece of the drill stem, and that it comprises the pressure device and an optical detecting unit having free sight to the source of the laser beam as long as the drill stem remains sufficiently straight. Thus, the end of the drill stem is aligned along the extension of the laser beam.

The apparatus can be an autonomic and automatic unit which can be joined into the drill stem without additional physical connections out from the drill hole.

The apparatus controls the drilling direction either by introducing a bend on the drill stem or by pushing the drill stem in a correct direction sideways in relation to the wall of the hole.

Energy for this control can be obtained in various ways. In the most simple way energy can be obtained by utilizing compressed air being supplied through the hollow drill stem, or by utilizing energy from the rotation of the drill stem in relation to the wall of the drill hole.

The apparatus may comprise a photo detector to detect relative position and direction of the drill in relation to the laser beam. The detector can be designed to measure both sense and magnitude of the deviation or alternatively only its sense, so that a control unit having been built into the apparatus can determine in which direction the course is to be corrected.

The photo detector should determine the position of the laser beam without regard to where the beam hits within the cross section of the hollow drill stem. On the other hand, the photo detector must not hinder the passage of compressed air forward to the drill bit and a possible hammer. In one way this can be achieved by shaping the photo detector as a narrow arm across a guide tube, such that the compressed air can pass on both sides of the detector, and let the laser beam sweep across the entire cross section of the hollow drill stem as the drill stem rotates.

By way of example, a method and apparatus according to the invention will be described below with reference to the drawings, wherein:

Fig. 1 shows a set up of equipment for performance of the method,

Fig. 2 shows further details of the drill rig for performance of the method,

Fig. 3 shows a longitudinal section of the means for automatic control of the drill stem,

Fig. 4 shows a cross section of the means for controlling the drill stem,

Fig. 5 shows another cross section of the means,

Fig. 6 shows a block diagram of a preferred example of a system included in the means, and

Fig. 7 shows a longitudinal section of the means with one possible arrangement of components.

In figure 1 a drill rig 1 pushes and rotates a hollow drill stem 2 in a drill hole 3. The drill stem 2 comprises a drill bit 5, possibly with an air operated drilling hammer. Behind these components is joined into the drill stem 2 apparatus 4 that automatically bends the drill stem such that the drill bit 5 follows the direction of a laser beam 7 from a source 6 which is mounted steadily and apart from the drill rig 1, so that the laser beam is conducted inside the hollow drill stem 2.

In figure 2 the drill rig 21 carries a feed support 22 for a drill stem 23 and a rotary motor 24. A laser beam 25 from a source 26 is conducted into the hollow drill stem 23 through a window 211 which shuts for the compressed air in the drill stem. The source 26 can send out one or more laser beams 27 parallel to the main beam 25. The purpose of these beams is to simplify the adjustment of the feed support 22, this support being equipped with sighting aids 28 and 29 to control in a simple manner that the feed support is in a tolerable correct position at the start of the drilling.

In figure 3 a hollow control means 31 comprises a tube 37 having been joined into a drill stem 38 for instance by means of usual threaded joints 32. The tube 37 rotates with the drill stem 38 when the stem 38 is rotating. Inside the tube 31 is arranged an optical sensor 34 for sensing the position and direction of the tube 37 in relation to a laser beam 39. The sensor 34 is arranged such that compressed air can pass approximately unhindered forward to the drill bit 35 and a possible drilling hammer. Outside the tube 37 is a sleeve 33 that is prevented from rotating with the tube 37 because of friction against the wall in the drill hole 36. The tube 37 is arranged to rotate freely in relation to the sleeve 33 for instance by means of rollers or sleeve slidings. The sleeve 33 comprises actuators (see figure 4) that can push the tube sideways inside the drill hole, such that the drill bit 35 thereby changes direction. The actuators are controlled by a control unit (not shown) in such a way that the drill bit 35 follows the direction of the laser beam 39 as accurate as possible all the time. The control unit may be mounted either in the sleeve on the outside of the tube 37, or inside the tube 37.

In figure 4 a tubular control means 41 rotates with a drill stem while the sleeve shown in figure 3 is prevented from rotating by friction against the wall of the drill hole 47. The sleeve comprises an inner bearing surface 42, an outer sliding surface 43 with wearing/friction surfaces 44 and actuators 46 with rubber bellows 45. A control unit (not shown) controls by means of valves (not shown) supply of compressed air to the individual actuator-bellows 45 in such a way that the position of the tubular means 41 in relation to a drill hole 47 is changed as intended.

In figure 5 is shown an optical sensor for sensing the position and direction of a tubular control means 51 in relation to a laser beam 55. A sensor unit 52 shaped as a narrow object is mounted diametrically in the control means 51, such that compressed air to the drill bit and a possible drilling hammer can pass substantially unhindered. The dimension of the sensor unit in the longitudinal direction of the control means 51 is less important.

The sensor unit 52 may comprise a member 53 for sensing the direction of the laser beam 55 in relation to the longitudinal axis of the control means 51, and a component 54 for sensing the position of the beam 55 in relation to the cross section of the control means 51. Since the control means 51 rotates about its axis, both sensors 53 and 54 will be hit by the laser beam 55 at each revolution, such that suitable laser generated signals can be derived from the sensors 53 and 54 and transferred to a control unit (not shown) notwithstanding where the beam 55 strikes within the cross section of the tubular control means 51. The signals from the sensor unit 52 give the relative position and direction between the sensor unit 52 and the laser beam 55.

An angle sensor 56 measures the angle of rotation between the sensor unit 52 in the control means 51 and a reference direction in a guide sleeve 57. This measurement gives the necessary information to the control unit such that the control unit can correct the course of the drill stem on operating the proper actuators.

Figure 6 shows a control unit 63 which receives information on the position and direction of a sensor 61 in a relation to a laser beam 62 as well as information from an angle sensor 69 on the angle of rotation of the sensor 61 in relation to such a guide sleeve as has been mentioned above.

The control unit 63 controls the air supply to actuators 65 by means of valves 64 that either admit compressed air 67 to the actuators 65 from the tubular control means described above or allow air 68 to escape from the actuators 65 to the outside of the control means where the air pressure is low.

The control system may comprise sensors 66 for sensing the position of the actuators 65 and for reporting on this information to the control unit 63. These sensors 66 are not strictly necessary, but will improve the accuracy and stability of the system.

Figure 7 shows a hollow control means or guide tube 71 which is joined into the drill stem. The guide tube 71 is surrounded by a guide sleeve 72. The sleeve 72 is prevented from sliding axially along the tube by clamping rings 73 which are fixed to the tube 71, and bearing rings 74 which also can act as dust tightenings, and as vibration dampers when axial vibrations in the drill stem are transferred to the sleeve 72.

The outer sliding surface 75 of the sleeve 72 is preformed such that the surface 75 can allow radial movements of the inner tube 71 in relation to the sliding surface 75.

Actuator bellows 76, control valves 77, sensors 78 for sensing actuator positions and a control unit 79 with batteries 710 are arranged inside the sleeve 72.

Compressed air to the actuators 76 is supplied from the guide tube 71 through a hole in the tube wall to a tight-sitting assembly ring 711.

Measured signals from an optical sensor unit 713 may be transferred to the control unit 79 via a rotating transformer coupling 712. Energy to the optical sensor unit 713 can either be supplied by a battery on the tube 71 or be transferred from a battery on the sleeve 72 via for instance a rotating transformer.

The batteries 710 may be exchangeable, provided that their capacity is sufficiently high for drilling one or more drill holes, or a charging unit may be connected thereto, which unit may be driven for instance by the compressed air.

The angle of rotation of the guide tube 71 in relation to the guide sleeve 72 is measured by means of an angle sensor 714. Since the tube 71 in practice rotates with an approximately constant speed, the angle sensor 714 can be realized by means of for example a pulse supplier that yields a pulse to the control unit 79 each time a particular spot on the circumference of the tube 71 passes the pulse supplier.

The above described performance is an example with a preferred embodiment of the invention. It will be apparent that the individual components can be shaped and arranged in different ways. As an example, the actuators can be designed as purely mechanically, electrically or hydraulically operated actuators, or designed to be operated in such manners in combination.

The actuators can be supplied with energy from the compressed air as described above, or from the rotating drill stem tube which rotates in relation to the sleeve. If a percussion drilling machine is used, energy may also be taken from its vibrations.

The described sliding surfaces of the sleeve can be mere sliding/friction surfaces, for instance as described. They may, however, be shaped in different ways, for instance in the form of rollers that can roll alongside the drill hole but not across it.

It is no requirement that the guide sleeve does not rotate in relation to the wall of the drill hole, provided that a rotation of the guide sleeve is so slow that the control system manages to adjust the actuators in accordance with the rotation. The energy consumption of the actuators will be less the slower the sleeve rotates.

Neither need the actuators push the rod in relation to the wall of the drill hole. Instead, the actuators may be shaped to control an angle articulation in the rod.

Preferably the control means is realized by means of modern technology such as micro processors, electro-optical arrays and so on. However, such technology is not essential for the realization of apparatus according to the invention.

The method and apparatus can also be used if the drilling hammer is driven by hydraulic or electrical energy instead of compressed air.

CLAIMS

1. A method for drilling long and straight holes in rocks by using a drill rig that may be aligned by means of a laser beam, which drill rig comprises a hollow drill stem with a pressure device for guiding the drill stem in a correct direction on applying pressure against the wall of the drilled hole, which method comprises the steps of sending the laser beam into the hollow drill stem towards an optical detecting unit placed inside a hollow control means that constitutes a portion of the drill stem, which control means comprises the pressure device, and deriving laser generated signals from the detecting unit for control of the pressure device.

2. Apparatus for performing the method as claimed in claim 1, wherein the laser beam may be directed towards the rear of the feed support of the drill rig, which feed support carries a hollow drill stem equipped with a pressure device for contact with the wall of the drilled hole, said means being joined into the hollow drill stem behind its drill bit and constitutes a connecting piece of the drill stem, and comprises the pressure device, said means further comprising an optical detecting unit having free sight to the source of the laser beam as long as the drill stem remains sufficiently straight.

3. Apparatus as claimed in claim 2, the means being joined into the drill stem a distance behind its drill bit where bending of the drill stem easily results in a changed drilling direction.

4. Apparatus as claimed in claim 2 or 3, wherein the means is arranged to receive energy for change of the drilling direction from compressed air which is supplied through the hollow drill stem.

5. Apparatus as claimed in claim 2 or 3, wherein the means is arranged to receive energy for change of the drilling direction, from rotation of the drill stem in relation to the drill hole.

6. Apparatus as claimed in claim 4 or 5, the means comprising a guide tube joined into the drill stem with which said tube rotates, and comprising a guide sleeve having been arranged outside the guide tube such that the guide sleeve wholly or partly may be prevented from rotating by friction against the wall of the drill hole although the drill stem rotates, which guide tube comprises an optical sensor unit arranged to detect the position and direction of the guide tube in relation to the laser beam, and which guide sleeve comprises a control unit arranged to receive signals from the sensor unit, and comprising an angle sensor arranged to supply signals to the control unit concerning the angle of rotation of the guide tube in relation to the guide sleeve, and further comprising actuators connected to the control unit and arranged to press an outer sliding surface of the guide sleeve against the wall of the drilled hole for adjusting the guide tube in relation to the laser beam.

7. Apparatus as claimed in claim 6, wherein the sensor unit is shaped as a narrow object mounted diametrically in the guide tube such that compressed air to the drill bit of the drill stem may pass substantially unhindered, the sensor unit being mounted such that its sensors are struck by the laser beam when the drill stem is rotating, independent of where the laser beam strikes within the hollow cross section of the drill stem.

8. Apparatus as claimed in claim 6, wherein the guide sleeve comprises sensors arranged to measure the position of the guide tube in relation to the guide sleeve, said sensors being arranged to supply measured information to the control unit.

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