Abstract: A rock bolt (10) comprising first and second elongate members (11, 12) is disclosed. The first elongate member comprises a first end (13) adapted to penetrate rock, and a second end (14) adapted to provide attachment for actuating means. The first elongate member is disposed at least partially, longitudinally inside the second elongate member. The second elongate member can be adapted for transverse exansion along at least a portion of its length in order to anchor the rock bolt into position. A cavity can be formed between the first and second elongate members extending between the first and second ends of the first elongate member. Methods of drilling with rock bolts according to the invention are also disclosed.
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
ROCK BOLT

Technical Field

The present invention relates to a rock bolt suitable for use in the mining and tunnelling industry.

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Background Art

Roof and wall support is a crucial aspect of mining and tunnelling operations. Mine and tunnel walls and roofs consist of rock strata, which must be reinforced to prevent the possibility of collapse. Rock bolts are widely used for consolidating the rock strata. A rod is anchored and often tensioned in a hole drilled transversely through the rock strata for this purpose. Typically, the bolt is secured using a resin or cement based grouting fluid, which is inserted around the rod and activated.

Self drilling rock bolts combine drilling and insertion of the bolt into the drilled hole. Self drilling rock bolts typically have a drilling tip attached to the end of a tubular steel member so that the hole is drilled and the bolt inserted simultaneously. Self drilling rock bolts are not commonly used in the mining industry due to the high cost of the tubular steel that is used to provide both access to flushing and grouting fluids and the structural strength that is required to consolidate the rock.

The above discussion of background art is included to explain the context of the present invention. It is not to be taken as an admission that any of the documents or other material referred to was published, known or part of the common general knowledge in Australia at the priority date of any one of the claims of this specification.

Description of the Invention

Throughout the description and claims of this specification, the word “comprise” and variations of that word, such as “comprising” and “comprises” are not intended to exclude other additives, steps or integers.

In a first aspect the present invention provides a rock bolt comprising first and second elongate members, the first elongate member comprising a
first end adapted to penetrate rock, and a second end adapted to provide 
attachment for actuating means, wherein the first elongate member is 
disposed at least partially, longitudinally inside the second elongate member. 

Typically the first end of the first elongate member comprises a drill bit 
means.

The first end of the first elongate member may be comprised of a 
hardened material suitable for drilling into a rock wall such as tungsten or 
titanium carbide.

In a second aspect the present invention provides a rock bolt 
comprising first and second elongate members, the first elongate member 
comprising a first end adapted to receive means to penetrate rock, and a 
second end adapted to provide attachment for actuating means, wherein the 
first elongate member is disposed at least partially, longitudinally inside the 
second elongate member.

Means may also be provided for restricting movement of the first 
elongate member relative to the second elongate member.

In an embodiment, the second elongate member is adapted for 
transverse expansion along at least a portion of its length.

In one embodiment the first elongate member comprises a portion of 
greater transverse dimension than the at least portion of the second elongate 
member adapted for transverse expansion.

In another embodiment, the second elongate member comprises at 
least a portion adapted for transverse expansion, and the means for 
penetrating rock comprises a portion of greater transverse dimension than 
the at least portion of the second elongate member adapted for transverse 
expansion.

In an embodiment, an attachment means is provided at the second 
end of the first elongate member to provide attachment for actuating means.

In a further embodiment, on advancement of the attachment means 
towards the first end of the first elongate member, the attachment means is 
arranged to produce, either directly or indirectly, a transverse force in the
portion of the second elongate member adapted for transverse expansion thereby causing transverse expansion thereof.

The first elongate member can be, for example, a hollow rod having a circular cross-section, a solid rod having a circular cross-section, a hollow rod having a non-circular cross-section or a solid rod having a non-circular cross-section. Further, the first elongate member can feature a smooth axially outer surface or alternatively a rough or irregular surface, the rough or irregular surface providing additional bonding between grout and the first elongate member.

The second elongate member can be, for example, a hollow rod having a circular cross-section or a hollow rod having a non-circular cross-section. The inner and outer surfaces of the second elongate member can be smooth or alternatively a rough or irregular surface, the rough or irregular surface providing additional bonding between grout and the second elongate member and between the second elongate member and the rock face. Further, the second elongate member can be corrugated to provide additional bonding between grouting fluid and the second elongate member, the corrugation providing stress transfer between the inner and outer surface of the sleeve. The corrugations may be helical or radial and the depth of the corrugations may be proportional to the radius of the second elongate member.

The first elongate member may be comprised of an elevated tensile strength material, such as steel, suitable for acting as a structural member.

The first elongate member may be comprised of an elevated tensile strength material such as fibreglass, suitable for acting both as a structural member, and which can be cut through once the bolt has been positioned in the rock face by drilling. This allows a rock face that has been bolted to be subsequently excavated.

In an embodiment, the first and second elongate members are arranged to cause expansion of the portion of the second elongate member adapted for transverse expansion by longitudinal advancement of the first end of the first elongate member toward the second elongate member.
Preferably, the second elongate member comprises at least one expansion shell.

The second elongate member may be comprised of a material such as a metal or a composite of multiple elongate metal members and a lower cost plastic tube, having enough longitudinal axial rigidity to allow engagement of the expansion shells. Alternatively, the second elongate member may comprise a plastic tube with a discontinuous steel end collar.

In one embodiment, at least one expansion shell is transversely expanded as the attachment means is advanced towards the first end of the first elongate member.

In another embodiment, the expansion shells are arranged to transversely expand as the first end of the first elongate member is advanced toward the expansion shells.

In another embodiment, the expansion shells are arranged to expand as they are advanced toward the first end of the first elongate member.

In an embodiment, the unexpanded transverse dimension of the expansion shells comprises a portion of lesser transverse dimension than the first elongate member, which is advanced longitudinally into contact with the first elongate member. The transverse force caused by this contact causes expansion of the one or more expansion shells in an embodiment.

A channel may be provided between the first and second elongate members through which flushing fluids for drilling can be passed and grout can be injected, providing extra reinforcement and corrosion protection.

The first end of the first elongate member may include one or more access channels allowing the influx and efflux of materials.

The second end of the first elongate member may include one or more access channels allowing the influx and efflux of materials.

The access channels and first elongate member may be forged.

In one embodiment, the first end of the first elongate member comprises a drill bit means, and the drill bit means may include at least one
access channel to allow the influx and efflux of materials during drilling and grouting.

A cavity may be provided, extending between the first and second elongate members, to allow fluid flow between the first and second ends of the first elongate member. The cavity may extend longitudinally between the first and second elongate members. The cavity may be annular.

The second elongate member may include a material such as a metal or a composite of multiple elongate metal members and a lower cost plastic tube. Alternatively, the second elongate member may include a plastic tube. Preferably, the plastic tube is made from a long life plastic such as polyethylene. The plastic is non-corroding and, should a crack form in the grout, the plastic tube acts as a barrier stopping the crack so that it does not allow water to reach the bolt and corrode it, which would reduce the life of the rock bolt.

In an embodiment, the second end of the first elongate member is further adapted to provide attachment to a first end of a third elongate member, and the second elongate member includes a second end adapted to provide attachment to the first end of a fourth elongate member.

Typically, the first elongate member is arranged to be lockable to the third elongate member to substantially prevent relative rotation between the two in at least one rotational direction when locked together.

The rock bolt may additionally comprise a third elongate member and a fourth elongate member.

The actuating means may comprise rotational driving means removably connected to the attachment means for advancing the drill bit means rotatably through rock in a first rotational direction and for also bringing the first elongate member portion, or the rock penetrating means portion, of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion, into engagement with the portion of the second elongate member adapted for transverse expansion, in the first rotational direction.
Alternatively, the actuating means comprises rotational driving means removably connected to the attachment means for advancing the drill bit means rotatably through rock in a first rotational direction and for bringing the first elongate member portion, or the rock penetrating means portion, of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion, into engagement with the portion of the second elongate member adapted for transverse expansion, in a second rotational direction.

Typically the grout is injected into the cavity between the first and second elongate members after drilling and transverse expansion of the second elongate member.

In a third aspect, the present invention provides rock bolt extension means comprising third and fourth elongate members, the third elongate member comprising a first end adapted to provide attachment to a second end of a first elongate member of a rock bolt according to any one of the previous aspects, and a second end adapted to provide attachment for actuating means and further adapted to provide attachment to a first end of a fifth elongate member, and the fourth elongate member comprising a first end adapted to provide attachment to a second end of a second elongate member of a rock bolt according to any one of the previous aspects, and a second end adapted to provide attachment to a first end of a sixth elongate member, wherein the third elongate member is disposed at least partially, longitudinally inside the fourth elongate member.

A cavity may be provided, extending longitudinally between the third and fourth elongate members, to allow fluid flow between the first and second ends of the third elongate member.

In an embodiment, the third and fifth elongate members are the same, and the fourth and sixth elongate members are the same.

In a fourth aspect the present invention provides a rock bolt kit comprising first and second elongate members and rock penetrating means adapted to be received by the first end of the first elongate member, the first
elongate member comprising a first end adapted to receive the rock penetrating means, and a second end adapted to provide attachment for actuating means, wherein the first elongate member is adapted to be disposed at least partially, longitudinally inside the second elongate member.

In one embodiment, the second elongate member is adapted for transverse expansion along at least a portion of its length.

In one embodiment, the first elongate member comprises a portion of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion.

In another embodiment, the rock penetrating means comprises a portion of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion.

In a further alternative, an attachment means is provided at the second end of the first elongate member to provide attachment for actuating means and wherein on advancement of the attachment means towards the first end of the first elongate member, the attachment means is arranged to produce either directly or indirectly a transverse force in the portion of the second elongate member adapted for transverse expansion thereby causing transverse expansion thereof.

In one preferred embodiment, the attachment means comprises an internally threaded collar mounted on a threaded portion of the first elongate member.

The second elongate member can be, for example, a hollow rod having a circular cross-section or a hollow rod having a non-circular cross-section, the hollow rod having inner and outer surfaces. The inner and outer surfaces of the second elongate member can be smooth or alternatively a rough or irregular surface, the rough or irregular surface providing additional bonding between grout and the second elongate member.

The second elongate member may be corrugated to provide stress transfer between the inner and outer surface of the second elongate member.
The first elongate member may be comprised of an elevated tensile strength material such as steel, suitable for acting as a structural member. The first elongate member and/or second elongate member may be comprised of an elevated tensile strength material such as fibreglass, suitable for acting both as a structural member and which can be cut through once the bolt has been positioned in the rock face by drilling. This allows the rock face that has been bolted to be subsequently excavated.

Preferably the second elongate member comprises at least one expansion shell.

Other preferable features of the rock bolt kit may be provided as for the rock bolt of the previous aspects of the invention.

In a fifth aspect the present invention provides rock penetrating means comprising a cutting element and means for attaching the rock penetrating means to a rock bolt according to the second aspect of the invention. The rock penetrating means may also comprise means for expanding the second elongate member of a rock bolt according to any one of the preceding aspects of the invention wherein the first end of the first member is adapted to receive means to penetrate rock.

In another embodiment, the rock penetrating means comprises a portion of greater transverse dimension than a portion of the second elongate member adapted to restrict longitudinal movement of the second elongate member.

A plate may be provided attached to the first elongate member, the plate being arranged to substantially prevent relative rotation of the attachment means and first elongate member in a first direction of rotation.

In a sixth aspect the present invention provides a method of drilling, the method comprising (a) drilling a drilling member, the drilling member comprising first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to
penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face, while flushing a first fluid between the first elongate member, second elongate member and rock face in the region of the first end of the first elongate member; and (b) removing the drilling member from the rock once a hole of the desired depth has been drilled.

The fluid may be a cooling and/or flushing fluid, which may be a liquid (e.g. water) or a gas (e.g. air).

The fluid may be injected through one or more access channels.

The first elongate member could comprise a first end adapted to receive means to penetrate rock, such as a drill bit. This would allow replacement of the drill bit due to wear or to suit specific conditions.

In a seventh aspect, the present invention provides a method of installing a rock bolt, the method comprising (a) drilling the rock bolt, the rock bolt comprising first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face, while flushing a first fluid through a cavity between the first elongate member and second elongate member and past the rock face in the region of the first end of the first elongate member, (b) injecting a grouting fluid between the first elongate member, second elongate member and rock face, and (c) waiting a preset time period for the grouting fluid to set.

In an eighth aspect, the present invention provides a method of installing a rock bolt, the method comprising (a) drilling the rock bolt, the rock bolt having first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face while flushing a first fluid through a cavity
between the first elongate member and second elongate member and past
the rock face in the region of the first end of the first elongate member, (b)
providing an extension rod comprising third and fourth elongate members,
the third elongate member comprising a first end adapted to lock with the
second end of the first elongate member so as to substantially prevent
relative rotation between the first elongate member and the third elongate
member in at least the rotational direction of drilling, and the fourth elongate
member comprising a first end adapted attach to the second end of the
second elongate member, (c) extending the length of the first elongate
member by locking the first end of the third elongate member into the second
end of the first elongate member, (d) extending the length of the second
elongate member by attaching the first end of the fourth elongate member to
the second end of the second elongate member, (e) repeating (a), (b), (c)
and (d) until a suitable depth has been reached, (f) injecting a grouting fluid
between the first elongate member, second elongate member, extension rod
and rock face, and (g) waiting a preset time period for the grouting fluid to
set.

The method could further include using rock bolt having a first
elongate member also comprising a first end adapted to penetrate rock and a
portion of greater transverse dimension than a portion of the second
elongate member adapted for transverse expansion.

The method could further include tensioning the rock bolt via an
internally threaded collar.

The first fluid may be a cooling and flushing fluid, and the fluids may
be injected through one or more access channels.

The method could further include passing the fluids through a cavity
extending between the third and fourth elongate members to the cavity
between the first and second elongate members and past the rock face in
the region of the first end of the first elongate member.

The second elongate member of the rock bolt used in the method may
additionally include a portion adapted for transverse expansion. In this case,
before (b), the second elongate member may be moved longitudinally
relative to the first end of the first elongate member, to cause the portion adapted for transverse expansion to expand transversely and retain the bolt in the rock face. The longitudinal movement may be caused by relative rotation of the first and second elongate members, causing threads on the first and second elongate members to push the second elongate member toward the first end of the first elongate member.

The longitudinal movement may be caused by relative rotation of the first and second elongate members, pushing the second elongate member toward the first end of the first elongate member, causing expansion of the portion adapted for transverse expansion.

The rock bolt used in the method may be rotationally advanced in a first rotational direction and the portion of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion is then brought into engagement with the portion of the second elongate member adapted for transverse expansion by rotation in the first rotational direction.

Alternatively, the rock bolt used in the method may be rotationally advanced in a first rotational direction and the portion of the first elongate member greater transverse dimension than the portion of the second elongate member adapted for transverse expansion is then brought into engagement with the portion of the second elongate member adapted for transverse expansion by rotation in a second rotational direction opposed to the first rotational direction.

The rock bolt may then be tensioned by further relative rotation of the elongate members.

The fluids may be liquid (e.g. water) or a gas (e.g. air).

The fluids may be injected through one or more access channels in the second end of the first elongate member.

In an embodiment, the fluids are injected through the one or more access channels in the second end of the first elongate member into a cavity between the first and second elongate members and the fluids exit the cavity through one or more further access channels in the region of the first end of
the first elongate member before passing into a second cavity between the second elongate member and the rock face.

The second elongate member of the rock bolt used in the method may be comprised of a low strength material and, in this embodiment, before (b), the second elongate member is brought into engagement with the portion of the first elongate member adapted to penetrate rock by rotation in a first rotational direction, to cause the second elongate member to distort by the lateral force acting on the second elongate member and make at least one portion of the second elongate member come into contact with the rock face.

According to a ninth aspect of the invention, there is provided a method of drilling, the method comprising (a) drilling a rock bolt, the rock bolt having first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face while flushing a fluid between the first elongate member, second elongate member and rock face in the region of the first end of the first elongate member, (b) providing an extension rod comprising third and fourth elongate members, the third elongate member comprising a first end adapted to lock with the second end of the first elongate member so as to substantially prevent relative rotation between the first elongate member and the third elongate member in at least the rotational direction of drilling, and the fourth elongate member comprising a first end adapted attach to the second end of the second elongate member, (c) extending the length of the first elongate member by rotatably locking the first end of the third elongate member into the second end of the first elongate member, (d) extending the length of the second elongate member by attaching the first end of the fourth elongate member to the second end of the second elongate member, (e) repeating (a), (b), (c) and (d) as necessary until a suitable depth has been reached, and (f) removing the at least one extension rod and the rock bolt from the rock.
According to a tenth aspect, there is provided a method of installing a rock bolt, the method comprising: (a) drilling the rock bolt, the rock bolt comprising first and second elongate members, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means and the second elongate member including a portion adapted for transverse expansion, into a rock face, and (b) causing relative movement of the first and second elongate members, to cause the portion adapted for transverse expansion to expand transversely and retain the bolt in the rock face.

According to an eleventh aspect, there is provided a method of installing a rock bolt, the method comprising: (a) drilling the rock bolt, the rock bolt comprising first and second elongate members, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means and the second elongate member including a portion adapted for transverse expansion, into a rock face, (b) providing an extension rod comprising third and fourth elongate members, the third elongate member comprising a first end adapted to lock with the second end of the first elongate member so as to substantially prevent relative rotation between the first elongate member and the third elongate member in at least the rotational direction of drilling, and the fourth elongate member comprising a first end adapted attach to the second end of the second elongate member, (c) extending the length of the first elongate member by rotatably locking a third elongate member into the second end of the first elongate member, (d) extending the length of the second elongate member by attaching the first end of the fourth elongate member to the second end of the second elongate member; (e) repeating (a), (b), (c) and (d) as necessary until a suitable depth has been reached; and (f) causing relative movement of the first and second elongate members, to cause the portion adapted for transverse expansion to expand transversely and retain the bolt in the rock face.
According to a twelfth aspect, the present invention provides a self drilling rock bolt having opposite first and second ends and a shaft extending between the ends, the first end being adapted to penetrate rock and the second end being adapted to be connected to a drilling apparatus to allow rotation of and thrust to the bolt, a sleeve extending along and around the shaft, and a passage formed between the sleeve and the shaft to allow fluid to be passed along the bolt shaft.

With this arrangement, drilling fluid may be passed along the bolt shaft and across the first end to assist in flushing of material from the rock face during drilling. This fluid may be water, or similar liquid, in a wet drilling process, or may be air in a vacuum drilling process. Also, the fluid may forced along the passage to the first end, or alternatively may be drawn from the first end towards the second end.

In one embodiment, the first end incorporates at least one drill tip that extends radially from the bolt axis a distance greater than the sleeve. With this arrangement, in use, an outer passage is formed between the side of the drilled hole and the sleeve. The forming of an outer passage promotes a circulation path in the drilled hole where fluid can be directed towards the first end through one passage and passes from the first end to exit the hole along the other passage. Also, the passages are used introduce grout into the drilled hole and are also able to be filled to promote adequate bonding of the bolt to the rock.

In another embodiment, the self drilling rock bolt further comprises a drill bit which is connected to an end of the shaft and incorporates the drill tip thereon.

The sleeve may be deformable upon the application of an axial force towards the first end of the sleeve and when so deformed, the sleeve extends radially beyond the drill tip.

The rock bolt may further comprise an engaging surface in which the sleeve is deformed on relative movement of the sleeve across the engaging surface.
Alternatively, the engaging surface may be located on the drill bit.

The sleeve may be deformable under axial compression or the sleeve may incorporate at least one weakened area that facilitates deformation of the sleeve.

The at least one weakened area may be in the form of a slit formed in the sleeve.

The self drilling rock bolt may further comprise an anchoring device which is operative to retain the rock bolt when located in a drilled hole.

In one embodiment, the anchoring device is located proximate the first end and is operative in response to axial movement of the shaft relative to the sleeve.

In one embodiment the anchoring device is in the form of at least one expansion shell that is displaceable radially outwardly.

In one form, the rock bolt incorporates an engaging surface and the at least one expansion shell becomes operative on movement of the engaging surface across an inner surface of the at least one expansion shell.

In another embodiment, the self drilling rock bolt further comprises a collar piece that extends about the shaft adjacent its second end and is displaceable axially along the bolt shaft.

The sleeve may be displaceable along the shaft in response to movement of the collar piece along the shaft.

The collar piece may be connected to the shaft by an external thread on the shaft that engages with and a complementary inner thread of the collar piece.

In one embodiment, the rock bolt is adapted to be connected to the drilling apparatus by connection of the drilling apparatus with the collar piece.

To allow fluid to be passed along the bolt shaft, openings are provided to the passage. In one form, these openings are provide at, or adjacent to, the respective ends of the sleeve. Further, a channel may be provided that allows fluid to be introduced into the passage through the collar piece. Another channel may be formed adjacent the first end to facilitate the flow of fluid between the passage and the drill tip.
At least part of the channel that extends to the drill tip may be located within the rock bolt.

In an embodiment, the shaft of the self drilling rock bolt is load bearing on installation of the rock bolt and may be formed from a steel rod.

The sleeve of the self drilling rock bolt may be formed from plastic.

In one embodiment, the self drilling rock bolt further comprises an abutment member located proximate the second end, the abutment member being displaceable along the shaft and having an abutment surface that faces towards the first end and projects radially from the bolt axis a distance greater than the drill tip.

In another embodiment, the drill shaft and sleeve of the self drilling rock bolt are each formed from a plurality of sections that are connected together.

In a thirteenth aspect, the present invention provides a drill bit comprising a bit body having opposite ends and a wall surface extending between the ends, at least one drill tip located at one end and the bit being adapted to be connected to a drill rod at the other end, wherein a least one channel extends from the wall surface to the at least one drill tip.

The drill bit may further include a wall portion from the wall surface that tapers outwardly towards the one end.

According to a fourteenth aspect of the invention, there is provided a method of stabilising rock, comprising drilling a hole into the rock using a self drilling rock bolt having a drilling end and an opposite end connected to a drilling apparatus, providing drilling fluid to the drilling end during drilling of the hole by conveying fluid along the outer surface of the bolt shaft, and fixing the rock bolt within the hole to stabilise the rock.

The drilling fluid may be guided along the shaft in a passage defined by a sleeve disposed around and along the shaft.

In an embodiment, a further passage is formed between the sleeve and the side of the drilled hole and drilling fluid is caused to flow to the drilling end through one passage and to be removed from the hole through the other passage.
The drilling fluid may be pumped to the drilling end from the second end, or the fluid may be drawn towards the second end under a suction arrangement.

Grout may be introduced into the hole to fix the rock bolt to the rock.

The rock bolt may be initially anchored within the hole prior to introducing grout into the hole.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings. It is to be understood that the particularity of the drawings and embodiments does not supersede the generality of the preceding description of the invention.

**Brief Description of the Accompanying Drawings**

Figures 1a and b show a rock bolt of an embodiment of the invention.

Figure 2 shows a rock bolt with expansion shells engaged.

Figures 3a, b and c show an alternative rock bolt of an embodiment of the invention.

Figures 4a, b, c and d show a further alternative rock bolt of an embodiment of the invention.

Figures 5a, b and c show another alternative rock bolt of an embodiment of the invention.

Figures 6a, b, c and d show an alternative rock bolt of an embodiment of the invention.

Figures 7a, b and c show an alternative rock bolt of an embodiment of the invention.

Figures 8a, b and c show an alternative rock bolt of an embodiment of the invention.

Figures 9a and b show a drill of an embodiment of the invention.

Figures 10a, b and c show a further alternative rock bolt of an embodiment of the invention.
Figures 11a, b and c show another alternative rock bolt of an embodiment of the invention.

Best and Other Methods of Carrying Out the Invention

Figure 1a shows a rock bolt 10 of an embodiment of the invention comprising:

a first elongate member, or shaft, 11 and a second elongate member, or sleeve, 12, wherein the first elongate member 11 is disposed at least partially, longitudinally inside the second elongate member 12, the first elongate member 11 comprising a first end 13, at a first end of the bolt 10, in the form of means, in the present embodiment a drill tip, adapted to penetrate rock and a second end 14, at a second end of the bolt which is threaded with an external thread and provided with a collar piece 15 which has an internal, or complementary inner, thread adapted to provide attachment for actuating means by a hexagonal engaging region shown in Figure 1b. The second elongate member 12 is adapted for transverse expansion along at least a portion of its length through provision of an anchoring device in the form of expansion shells 16.

In operation, as shown in Figure 2, the rock bolt 10 of Figure 1 is drilled into the rock wall by attaching a drilling apparatus (not shown) to the internally threaded collar piece 15 and rotating threaded collar piece 15, first elongate member 11 and drill bit means 13. A cavity, or passage, 17 between elongate members 11 and 12 can be provided, and used to transmit water or air while drilling to flush out drilling residue and reduce the temperature of the drill bit means 13. Following drilling and insertion of the rock bolt 10 into the rock internally threaded collar piece 15 is reverse rotated causing the internally threaded collar piece 15 to advance towards the first end 13 of the first elongate member 11 along the complementary external thread provided thereon. Advancement of collar piece 15 by an axial force thereon forces collinear advancement towards the first end of second elongate member 12. Advancement of second elongate member 12 brings the anchoring device, in the present embodiment expansion shells 16, into
engagement with a portion of first elongate member 11 of greater transverse dimension than the unexpanded transverse dimension of the expansion shells 16. The transverse force caused by this engagement causes deformation in the form of transverse expansion of the expansion shells 16 thereby wedging the rock bolt 10 in the hole drilled by drill bit means 13. The anchoring device in the form of expansion shells 16 incorporates at least one weakened area in the form of a slit in the second elongate member 12. The second end 14 of first elongate member 11 may be adapted (by providing a pin such as a cotter or spring pin attached through the end of first elongate member 11 for example) so that threaded collar piece 15 cannot be removed.

Grout can also be injected into the cavity, or passage, 17 between the elongate members for additional reinforcement.

Figures 3a, b and c show a rock bolt 20 of an embodiment of the invention comprising a first elongate member, or shaft, 21 and a second elongate member, or sleeve, 22. The first end of the first elongate member 21 comprises, as rock penetrating means, or drill bit, an integral drill tip 23 in the form of a wedge cutting head, which extends radially from the bolt axis by a distance greater than that of the second elongate member. The second end of first elongate member 21 comprises an externally threaded portion 24 upon which is internally, or complementary inner, threaded nut, or collar piece, 25. Second elongate member 22 is comprised of an elongate hollow tube 26 having a low strength wall and higher strength expansion shells, or anchoring device, 27 located at one end. The first ends of the first and second elongate members 21, 22 correspond to a first end of the bolt 20.

Figure 3a shows the first elongate member 21 separated from the second elongate member 22.

Figure 3b shows the rock bolt 20 drilling into a wall in a first rotational direction by means of drill tip 23 and a drill actuating means, or drilling apparatus, (not shown) acting on nut 25. The end of elongate member 21 is adapted (by providing a plate attached to the end of first elongate member 21 for example) so that nut 25 cannot be removed. First elongate member
21 is disposed partially within second elongate member 22 with drill tip 23 protruding above expansion shells 27. Drill tip 23 is dimensioned to drill a hole large enough to receive both the first elongate member 21 and second elongate member 22. At the desired depth, nut 25 is tightened by turning the nut 25 in a second rotational direction. A washer, or abutment member, 28 extends beyond the hole drilled in the wall so that tightening nut 25 pushes washer 28 into abutment with second elongate member 22 and then urges expansion shells 27 of second elongate member 22 into abutment with drill tip 23. Washer 28 has an abutment surface that faces toward the first end of the bolt and projects radially from the bolt axis a distance greater than the drill tip 23. Drill tip 23 has a splayed portion of larger external (radial) dimension than the internal dimension of expansion shells 27 so that as tightening nut 25 urges expansion shells 27 against drill tip 23, expansion shells 27 expand to accommodate drill tip 23, this expansion forcing expansion shells 27 into contact with the sides of the hole. Figure 3c shows rock bolt 20 at the end of this procedure with elongate hollow tube 26 having a low strength wall distorted, or deformed, by the axial force acting on the tube, and higher strength expansion shells 27 expanded into contact with the drilled hole wall.

Figure 4a shows another rock bolt 30 of an embodiment of the invention. Rock bolt 30 comprises a first elongate member, or shaft, 31 and a second elongate member, or sleeve, 32. First elongate member, or shaft, 31 is disposed partially, longitudinally inside second elongate member 32. First elongate member 31 comprises a first end, which comprises an external thread 33, and a second end 34 comprising a drive element, or attachment means, 35 shown in plan view in Figure 4b in the section taken along line C-C of Figure 4a. As shown in Figure 4b, drive element 35 is surrounded by access holes, or channels, 36. Second elongate member 32 comprises an anchoring device in the form of expansion shells 38 located at its second end 39. Rock penetrating means, or drill bit, in the form of drill tip 40 is internally threaded with a thread 41 that matches external thread 33 and comprises access holes 42 adjacent thread 41 and a central flushing hole 43 as shown
in the cross sections of Figures 4c and 4d taken along lines A-A and B-B respectively. External thread 33 includes a transversely oriented plate member 45 at the first end of first elongate member 31 to prevent counter rotation of the drill tip 40. Drill tip 40 comprises a tapered lower edge 44. Drill tip 40 is attached to the first end, via external thread 33. Drill tip 40 protrudes beyond expansion shells 38 and is dimensioned to drill a hole of sufficient diameter to receive rock bolt 30. Flushing hole, or channel, 43 and access holes 36 and 42 allow influx and efflux of materials during drilling to assist the drilling process. Drilling is actuated by attachment of a driving mechanism, or apparatus, to drive element 35. When a hole of the required depth has been drilled, the drilling mechanism is counter-rotated, screwing external thread of the first end of first elongate member 31 into thread 41 to urge drill tip 40 against expansion shells 38 causing expansion shells 38 to expand. Plate member 45 stops any further relative rotation of the drill tip 40 to prevent first elongate member being rotated out of drill tip 40 during drilling.

Figure 5a shows a further rock bolt 50 of the invention. Rock bolt 50 comprises a first elongate member, or shaft, 51 and a second elongate member, or sleeve, 52. First elongate member 51 is disposed partially, longitudinally inside second elongate member 52. First elongate member 51 comprises a first end 53, and a second end 54, which is adapted to receive a nut, or collar piece, 54a that can receive a drill actuating means, or drilling apparatus, (not shown). Second end 54 comprises transversely oriented plate member 55 installed so that the nut 54a cannot be removed. First elongate member 51 also comprises longitudinal grooves 56. Rock penetrating means in the form of drill bit means 60 is adapted to be butt welded at end 61 to first end 53 of first elongate member 51. Drill bit means 60 comprises a cutting head, or drill tip, 62 and an external thread 64 that matches internal thread 65 inside tapered collar, or engaging surface, 63. The wider part of tapered collar 63 is disposed towards cutting head 62 and the narrower part towards end 61 and comprises access holes, or channels, 66. Further, tapered collar 63 of drill bit means 60, comprises channels 67.
and an internal thread 65 as shown in the cross section of Figure 5a taken along the line A-A. Drill bit means 60 is butt-welded to end 53. Drill bit means 60 protrudes beyond first end 57 of second elongate member 52, which is a portion adapted for transverse expansion, or anchoring device, in the present embodiment. The lower edge of tapered collar 63 allows drill bit means 60 to pass inside second elongate member 52 until the width of tapered collar 63 matches the inner diameter of second elongate member 52. Drill bit means 60 is dimensioned to drill a hole of sufficient diameter to receive rock bolt 50. Grooves, or channels, 56 allow influx and efflux of materials during drilling to assist the drilling process. Drilling is actuated by attachment of the drilling apparatus to nut 54a. When a hole of the required depth has been drilled, the drilling apparatus is counter rotated to urge nut 54a against washer, or abutment member, 58 and washer 58 against the wall. Continued counter rotation of nut 54a urges the tapered collar 63 against first end 57 of second elongate member 52 by pulling the first elongate member 51 back out of the wall while retaining the second elongate member in position, causing anchoring device, or first end, 57 to expand into engagement with the hole wall.

Figure 6a shows a rock bolt 70 of a fifth embodiment of the invention. Where parts of the rock bolt correspond to those of the third aspect, the reference numerals of Figure 5a have been used. The rock bolt 70 comprises a first elongate member, or shaft, 71 and a second elongate member, or sleeve, 72. First elongate member 71 is disposed partially, longitudinally inside second elongate member 72. First elongate member 71 comprises a first end 73A, and a second end 73B, which is adapted to receive nut, or collar piece, 54a that can receive a drill actuating means, or drilling apparatus, (not shown). Second end 73B comprises a substantially 'T' shaped bore 55A to allow influx and efflux of materials during drilling to assist the drilling process. The first and second ends of the first and second elongate members 71, 72 correspond to first and second ends of the rock bolt 70. Nut 54a is welded to the first elongate member 71 so that the nut
54a cannot be removed and so that turning the nut 54a also turns the first elongate member 71. The first end 73A of first elongate member 71 comprises means 74 adapted to penetrate rock in the form of a drill bit. Drill bit means 74 comprises a cutting head or drill tip 75 and channels 76 to provide a return path for the flushing and grouting fluids, shown in the cross section of Figure 6c taken along the line A-A. Drill bit 74 is suitably attached to the first end 73A of first elongate member 71 e.g. by brazing, butt-welding, forging or the like. Drill bit 74 protrudes beyond end 73C of second elongate member 72. Drill bit 74 is dimensioned to drill a hole of sufficient diameter to receive rock bolt 70. Second elongate member 71 is corrugated, the corrugation providing stress transfer between inner and outer surfaces of the second elongate member 71. The corrugations may be helical or radial and the depth of the corrugations is proportional to the radius of the second elongate member. Figure 6d shows the corrugations of second elongate member 72 in detail. The second elongate member has corrugations on its inner and outer surface; the corrugation is defined by its peak 79a and trough 79b. The corrugations have sufficient amplitude so that the notional centre line in Figure 6d enters the regions of both the peak 79a and trough 79b.

Bolts according to any of the embodiments described above and below may also include the corrugated second elongate member.

Second elongate member 72 is suitably held in place e.g. by: a tapered collar, or engaging surface; washer, or abutment member; or the like. Drilling is actuated by attachment of a drilling mechanism, or apparatus, [not shown] to nut 54a and rotating the first elongate member 71 and drill bit 74 in a first rotational direction. Engagement of the drill bit means 74 with the rock requires the application of longitudinal (axial) pressure against the rock face in conjunction with the rotational action of the drilling apparatus. During drilling the drill bit 74 is cooled with a cooling fluid, which is injected in a second cavity 78 between the rock face and second member 72. The cooling fluid flows into and out of the second cavity 78 between the rock face and second member. When a hole of the required depth has been drilled, grouting fluid is injected into a first cavity, or passage, 77, which is annular,
between the first and second member until the first cavity 77 is filled with grouting fluid. Grouting fluid may also be injected into the second cavity 78. The cooling fluid may also be injected into, or flow out of the first cavity. A circulation path between the first and second cavities may occur. The bolt 70 is then left to set in the grouting fluid. In general, such a T type channel in the first elongate member could be used in any embodiment of the invention shown. Such a channel is particularly used where a cotter pin is not used to secure the nut to the first elongate member.

Figure 7a shows a rock bolt 80 of an alternative version of the sixth embodiment of the invention. Where parts of the rock bolt correspond to those of the fifth and sixth aspects, the reference numerals of Figures 5a and 6a have been used. The rock bolt 80 comprises a first elongate member, or shaft, 81 and a second elongate member, or sleeve, 82. First elongate member 81 is disposed partially, longitudinally inside second elongate member 82. Preferably, the expandable end collar 87 is made of an elevated compressive strength material such as steel. First elongate member 81 comprises a first end 83A, and a second end 83B, which is adapted to receive nut, or collar piece, 54a that can receive a drill actuating means, or drilling apparatus (not shown). First end 83A of second elongate member 82 comprises an anchoring device in the form of an expandable end collar 87 to expand into contact with the sides of the drilled hole. Second end 83B comprises transversely oriented pin 55A such as a cotter or spring pin installed below nut 54a and through first elongate member 81 so that the nut 54a in one direction cannot be removed and so that turning the nut 54a also turns the first elongate member 81. First elongate member 81 also comprises access channels in the form of longitudinal grooves 56. The first end 83A of first elongate member 81 comprises drill bit means 84 adapted to penetrate rock.

Drill bit means 84 comprises a cutting head, or drill tip, 85 and tapered collar, or engaging surface, 86. The wider part of tapered collar 86 is disposed towards cutting head 85 and the narrower part towards end collar
87 and comprises access holes, or channels, 87A. Further, tapered collar 86 of drill bit means 84, comprises channels 90 of lesser radial extent that the rest of the tapered collar 86, to provide a return path for the flushing and grouting fluids, shown in the cross section of Figure 7a taken along the line A-A. Drill bit means 84 is suitably attached to tapered collar 86 e.g. by brazing, butt welding forging or the like. Tapered collar 86 protrudes beyond end 83C of second elongate member 82. The lower edge of the taper of collar 86 allows tapered collar 86 to pass inside second elongate member 82 until the width of collar 86 matches the inner diameter of second elongate member 82. Drill bit means 84 is dimensioned to drill a hole of sufficient diameter to receive rock bolt 80. Access channels in the form of grooves 56 allow influx and efflux of materials during drilling to assist the drilling process. Drilling is actuated by attachment of a drilling mechanism, or apparatus, [not shown] to nut, or collar piece, 54a and rotating the first elongate member 81 and drill bit means 84 in a first rotational direction. Engagement of the drill bit means 84 with the rock requires the application of longitudinal (axial) pressure against the rock face in conjunction with the rotational action of the drilling apparatus. During drilling, the drill bit means 84 is cooled with a fluid which is a cooling fluid, and which is injected through access channels 56 at the second end 83B of the first elongate member 81. The cooling fluid flows in a first cavity, or passage, 88 between the first and second member and flows out of the first cavity 88 through access channels 87A and a flushing hole 91 in the drill bit means 84 before being flushed back in a second cavity 89 between the rock face and the second elongate member 82. When a hole of the required depth has been drilled, the drilling mechanism is counter rotated to urge nut 54a against washer 58 and washer 58 against the wall, washer 58 urges second elongate member 82 against tapered collar 86. Alternatively, the drilling mechanism is further rotated to urge nut 54a against washer 58 and washer 58 against the wall, washer 58 urges second elongate member 82 against tapered collar 86. Following drilling and insertion of the rock bolt into the rock, grouting fluid is injected through access channels 56 at the second end 83B of the first elongate member 81.
The grouting fluid flows in a first cavity, or passage, 88 between the first and second member and flows out of the first cavity 88 through access channels 87A and flushing hole 91 in the drill bit means 84 before being flushed back towards washer 58 in a second cavity 89 between the rock face and the second elongate member 82. The grouting fluid is injected until both cavities 88, 89 are filled with grouting fluid and the bolt 80 is then left to set in the grouting fluid. Once the grouting fluid has set, the rock bolt can be optionally tensioned using the internally threaded collar.

Figures 8a, b and c show a rock bolt 20 of a seventh embodiment of the invention. Where parts of the rock bolt correspond to those of the second aspect, the reference numerals of Figure 3 have been used. The rock bolt 20 comprising a first elongate member, or shaft, 21 and a second elongate member, or sleeve, 22. The first end of the first elongate member 21 comprises, as rock penetrating means, an integral drill tip 23 in the form of a wedge cutting head. The second end of first elongate member 21 comprises an externally threaded portion 24 upon which is threaded internally, or complimentary inner, threaded collar piece 25. Second elongate member 22 is comprised of an elongate hollow tube 26 having a low strength wall and higher strength end collar, or anchoring device, 99 located at one end.

Figure 8a shows the first elongate member 21 separated from the second elongate member 22.

Figure 8b shows the rock bolt 20 drilling into a wall in a first rotational direction by means of drill tip 23 and a drill actuating means (not shown) acting on attachment means provided by collar piece 25. The end of elongate member 21 is adapted (by providing a plate attached to the end of elongate member 21 for example) so that nut, or collar piece, 25 cannot be removed. First elongate member 21 is disposed partially within elongate member 22 with drill tip 23 protruding above end collar 99. Drill tip 23 is dimensioned to drill a hole large enough to receive both the first elongate member 21 and second elongate member 22. At the desired depth, collar piece 25 is tightened. Washer, or abutment member, 28 extends beyond the
hole drilled in the wall so that tightening collar piece 25 pushes washer 28 into abutment with second elongate member 22 and then second elongate member 22 into abutment with end collar 99. Drill tip 23 has a splayed portion of larger radial external dimension than the internal dimension of end collar 99 so that as tightening collar piece 25 urges second elongate member 22 against end collar 99, second elongate member 22 buckles, or deforms, because of the axial force applied to it in the direction of the first end of the first elongate member 21, forcing itself into contact with the sides of the drilled hole. Figure 8c shows rock bolt 20 at the end of this procedure with elongate hollow tube 26 having a low strength wall distorted by the force acting on the tube and making contact with the hole wall. Following drilling and insertion of the rock bolt 20 into the rock, grouting fluid is injected through access channels 92 at the second end 96 of the first elongate member 21. The grouting fluid flows in a first cavity, or passage, 97 between the first and second member and flows out of the first cavity 97 through access channels 93 and flushing hole, or channel, 94 in the drill tip 23 before being flushed back towards washer, or abutment member, 28 in a second cavity 98 between the rock face and the second elongate member 22. The grouting fluid is injected until both cavities 97, 98 are filled with grouting fluid and the bolt 20 is then left to set in the grouting fluid.

Figure 9a shows a drill 100 of an eighth embodiment of the invention comprising a first elongate member, or shaft, 101 and a second elongate member, or sleeve, 102. First elongate member 101 is disposed partially, longitudinally inside second elongate member 102, which has first and second ends, 103C, 103D. First elongate member 101 comprises a first end 103A, and a second end 103B comprising as attachment means a drive element 104 that can receive a drill actuating means e.g. a drilling apparatus (not shown). Turning the drive element 104 also turns the first elongate member 101. Second end 103B of first elongate member 101 further comprises external thread 105. The first end 103A of first elongate member 101 comprises drill bit means 106 adapted to penetrate rock. Alternatively, the first end 103A may be adapted to receive a drill bit means to penetrate
rock. Drill bit means 106 comprises a cutting head, or drill tip, 107 and central flushing hole 109. Drill bit means 106 comprises channels 108 to provide a return path for the flushing and grouting fluids, shown in the cross section of Figure 9a taken along the line A-A. Drill bit means 106 is suitably attached to first elongate member 101 e.g. by brazing, butt welding, forging or the like.

Drilling is actuated by attachment of a drilling mechanism [not shown] to drive element 104 and rotating the first elongate member 101 and drill bit means 106 in a first rotational direction. Engagement of the drill bit means 106 with the rock requires the application of longitudinal pressure against the rock face in conjunction with the rotational action of the drilling apparatus. During drilling the drill bit means 106 is cooled with a cooling fluid, which is injected in a first cavity, or passage, 110A between the first and second members 101, 102. The cooling fluid flows into first cavity 110A, through central flushing hole, or channel, 109, past channels 108 and out of second cavity 110B between the rock face and second elongate member 102. Alternatively, the direction of flow can be reversed. When a hole of the required depth has been drilled, the drilling mechanism is removed from the hole and the hole can be used for example to insert explosives or reinforcement cables. The drill 100 can then be used to drill a further hole, the drill bit means 106 can be replaced by a further drill bit means 106 if required, e.g. for replacement of a worn cutting head, or drill tip, 107 or for different drilling conditions.

Figure 10a shows a rock bolt 111 of a further embodiment of the invention comprising a first elongate member, or shaft, 112 and a second elongate member, or sleeve, 113. First elongate member 112 is disposed partially, longitudinally inside second elongate member 113, which has first and second ends, 114C, 114D. First elongate member 112 comprises a first end 114A, and a second end 114B comprising, as attachment means, a drive element 115 that can receive a drill actuating means e.g. a drilling apparatus (not shown). Turning the drive element 115 also turns the first
elongate member 112. Second end 114B of first elongate member 112 further comprises an external thread 116 to rotatably lock internal thread 122 of first end 121A of third elongate member 112B as shown in Figure 10b. The first end 114A of first elongate member 112 comprises drill bit means 117 adapted to penetrate rock. Alternatively, the first end 114A may be adapted to receive a drill bit means to penetrate rock. Drill bit means 117 comprises a cutting head, or drill tip, 118. Drill bit means 117 comprises channels 119 to provide a return path for the flushing and grouting fluids, shown in the cross section of Figure 10a taken along the line A-A. Drill bit means 117 is suitably attached to the first elongate member 112 e.g. by brazing, butt welding forging or the like. Alternatively, the first end 114A may be adapted to receive a drill bit means to penetrate rock. Drill bit means 117 is dimensioned to drill a hole of sufficient diameter to receive rock bolt 111.

Figure 10b shows an extension rod 120 comprising a third elongate member 112B and a fourth elongate member 113B. Third elongate member 112B is disposed partially, longitudinally inside fourth elongate member 113B. First end 121C of fourth elongate member 113B comprises a profiled lip adapted to be locked to the second end 114D of second elongate member 113 in Figure 10a. Further, second end 121D of fourth elongate member 113B comprises a profiled lip adapted to be locked to a first end of sixth elongate member [not shown]. Third elongate member 112B comprises a first end 121A, and a second end 121B, comprising as attachment means a drive element 123 that can receive drill actuating means (not shown). Turning the drive element 123 also turns the third elongate member 112B. First end 121A of third elongate member 112B comprises internal thread 122 to engage and rotatably lock with the external thread 116 of Figure 10a in a first rotational direction. The third elongate member 112B is locked to the first elongate member 112 such that rotation of the third elongate member 112B in the first rotational direction causes the same rotation of the first elongate member 112. In this way, rotation of the third elongate member in the first rotational direction rotates the drill bit and causes drilling to occur. Second end 121B of third elongate member 112B comprises an external
thread 124 to rotatably lock internal thread of the first end of a fifth elongate member [not shown] in the same way as the locking between the first and third elongate members.

Figure 11a shows an alternative rock bolt 130 of the previous embodiment of the invention. Rock bolt 130 comprises a first elongate member, or shaft, 131 and a second elongate member, or sleeve, 132. First elongate member 131 is disposed partially, longitudinally inside second elongate member 132. Second elongate member 132 comprises a first end 133C and a second end 133D. The first ends of the first and second elongate members 131, 132 correspond to the first end of the rock bolt 130. The second elongate member 132 is adapted for deformation in the form of transverse expansion along at least a portion of its length through provision of expansion shells, or anchoring device, 136A. First elongate member 131 comprises a first end 133A, and a second end 133B that is adapted to receive drive element 134 that can receive a drill actuating means (not shown). Second end 133B of first elongate member 131 is further adapted to receive a nut, or collar piece, [not shown]. Turning the drive element 134 also turns the first elongate member 131. Second end 133B of first elongate member 131 as attachment means further comprises an external thread 135 to rotatably lock internal thread 147 of first end 143A of a third elongate member 131B, shown in Figure 11b, when third elongate member 131B is turned in a first direction. The first end 133A of first elongate member 131 comprises drill bit means 137 adapted to penetrate rock. Alternatively, the first end 133A may be adapted to receive a drill bit means to penetrate rock. Drill bit means 137 comprises a cutting head, or drill tip, 138 and a tapered collar, or engaging surface, 136. The wider part of tapered collar 136 is disposed towards cutting head 138 and the narrower part towards first end 133C of second elongate member 132. Further, tapered collar 136 of drill bit means 137 comprises channels 139 to provide a return path for the flushing and grouting fluids, shown in the cross section of Figure 11a taken along the line A-A. Drill bit means 137 is suitably attached first elongate member 131.
e.g. by brazing, butt welding forging or the like. Alternatively, the first end 133A may be adapted to receive a drill bit means to penetrate rock. Drill bit means 137 protrudes beyond end 133C of second elongate member 132. The lower edge of the tapered collar 136 allows drill bit means 137 to pass inside second elongate member 132 until the width of tapered collar 136 matches the inner diameter of second elongate member 132. Drill bit means 137 is dimensioned to drill a hole of sufficient diameter to receive rock bolt 130.

Figure 11b shows an extension rod 140 comprising a third elongate member 131B and a fourth elongate member 132B. Third elongate member 131B is disposed partially, longitudinally inside fourth elongate member 132B. First end 143C of fourth elongate member 132B comprises a profiled lip adapted to be locked to the second end 133D of second elongate member, or sleeve, 132 in Figure 11a. Further, second end 143D of fourth elongate member 132B comprises a profiled lip adapted to be locked to a first end of sixth elongate member [not shown]. Third elongate member 131B comprises a first end 143A, and a second end 143B, comprising as attachment means a drive element 144 that can receive drill actuating means [not shown]. Second end 143B of third elongate member 131B is further adapted to receive the nut, or collar piece, 145. Turning the drive element 144 also turns the third elongate member 131B. First end 143A of third elongate member 131B comprises internal thread 147 to engage and rotatably lock with the external thread 135 of Figure 11a as described above. The third elongate member 131B is locked to the first elongate member 131 such that rotation of the third elongate member 131B in the first direction causes the same rotation of the first elongate member 131. In this way, rotation of the third elongate member in the first direction rotates the drill bit means and causes drilling to occur. Second end 143B of third elongate member 131B comprises an external thread 146 to rotatably lock internal thread of a fifth elongate member [not shown].

It will be appreciated that further extensions can be inserted in the same manner as described above, by connection of further extension rods.
Each extension rod is preferably adapted so that it can receive a further identical extension rod at either, or each end, and function as described above to drill deeper boltholes. Additionally, it is possible to use only a single extension rod, to achieve a shallower bolthole. The rock bolt of an embodiment of the invention comprises the combination of first and second elongate members, together with one or more extensions, as described above.

Bolts according to any of the previous embodiments may be combined with extension rods as described above.

Drilling is actuated by attachment of a drilling mechanism, or apparatus, [not shown] to attachment means, or collar piece, provided by drive element 115 of Figure 10a and rotating the first elongate member 112 and drill bit means 117 in a first rotational direction. Engagement of the drill bit means 117 with the rock requires the application of longitudinal (axial) pressure against the rock face in conjunction with the rotational action of the drilling apparatus. During drilling the drill bit means 117 is cooled with a cooling fluid, which is injected in a second cavity 110B between the rock face and second member 113. The cooling fluid then returns by flowing into and out of a first cavity, or passage, 110A between the first elongate member 112 and second elongate member 113.

Alternatively, the cooling fluid may be injected into the first cavity 110A between the first elongate member 112 and second elongate member 113 and return via the second cavity 110B between the rock face and second elongate member 113.

The length of the bolt is extended using the extension rod 120 of Figure 10b to extend the rock bolt 111. The extension rod 120 is attached to the second end 114B of first elongate member 112 by drilling. Drilling is actuated by attachment of a drilling mechanism, or apparatus, [not shown] to attachment means provided by drive element 123 of the extension rod 120 and rotating the third elongate member 112B in a first rotational direction. The first end 121C of the fourth elongate member 113B is then fitted to the
second end 114D of the second elongate member 113 by attachment means such as a snap fitting.

The depth of the hole is then extended by attachment of the drilling mechanism [not shown] to attachment means provided by drive element 123 which rotates now joined first and third elongate members 112, 112B and drill bit means 119 in a first rotational direction. During drilling the drill bit means 119 is cooled with a cooling fluid, which is injected in the second cavity 110A which now extends between the rock face and the first and third elongate members 112, 112B. The cooling fluid flows into and out of the first and second cavities 110A, 110B between the rock face and the first, and second, and third and fourth members 112, 112B, 113, 113B.

When a hole of the required depth has been drilled, grouting fluid is injected into the first cavity 110A between the joined first and third elongate members 112, 112B and the joined second and fourth elongate members 113, 113B until the cavity 110A is filled with grouting fluid. Grouting fluid may also be injected into the second cavity 78 between the rock face and the joined second and fourth elongate members. The extended bolt 111, 120 is then left to set in the grouting fluid. A circulation path may be formed, with grout being passed into one of the first and second cavities 110A, 78 and passing into the other in the region of the first end of the first elongate member and filling both cavities.

The extendible bolt of Figure 11 is drilled in the same way as described with reference to Figure 10 except that, when a hole of the required depth has been drilled, nut, or collar piece, 145 is rotated on external thread 146 of third elongate member 131B causing the nut 145 to advance towards the first end 143A of the third elongate member 131B and advance fourth elongate member 132B (and therefore second attached elongate member 132). Continued rotation of nut 145 urges the taper of collar 136 against first end 133C of second elongate member, or sleeve, 132 causing expansion shells 136A to expand into engagement with the hole wall.
It will be appreciated that further extensions can be inserted in the same manner as described above, by connection of further extension rods. Each extension rod is preferably adapted so that it can receive a further identical extension rod at either, or each end, and function as described above to drill deeper bolt-holes. Additionally, it is possible to use only a single extension rod, to achieve a shallower bolt-hole.

It will be appreciated that it is possible to use only the single rock bolt 130 of Figure 11a, to achieve a shallower bolt-hole. The nut 145 [not shown in Figure 11a] is attached to the external thread 135 of the first elongate member 131. Nut 145 is rotated on external thread 135 of first elongate member 131 causing the nut 145 to advance towards the first end 133A of the first elongate member 131 and advance second elongate member 132. Continued rotation of nut 145 urges the taper of collar 136 against first end 133C of second elongate member 132 causing expansion shells 136A to expand into engagement with the drilled hole wall.

It will be appreciated that various alterations and/or additions in the particular construction and arrangement of parts previously described may be made without departing from the spirit or ambit of the present invention.
CLAIMS

1. A rock bolt comprising first and second elongate members, the first elongate member comprising a first end adapted to penetrate rock, and a second end adapted to provide attachment for actuating means, wherein the first elongate member is disposed at least partially, longitudinally inside the second elongate member.

2. A rock bolt according to claim 1, wherein the first end of the first elongate member comprises a drill bit means.

3. A rock bolt according to claim 1 or claim 2, wherein the first end of the first elongate member is comprised of tungsten carbide.

4. A rock bolt comprising first and second elongate members, the first elongate member comprising a first end adapted to receive means to penetrate rock, and a second end adapted to provide attachment for actuating means, wherein the first elongate member is disposed at least partially, longitudinally inside the second elongate member.

5. A rock bolt according to any one of the preceding claims, further comprising means for restricting movement of the first elongate member relative to the second elongate member.

6. A rock bolt according to any one of the preceding claims, wherein the second elongate member is adapted for transverse expansion along at least a portion of its length.

7. A rock bolt according to claim 6, wherein the first elongate member comprises a portion of greater transverse dimension than the at least portion of the second elongate member adapted for transverse expansion.
8. A rock bolt according to any one of claims 1 to 3, wherein the second elongate member comprises at least a portion adapted for transverse expansion, and the means for penetrating rock comprises a portion of greater transverse dimension than the at least portion of the second elongate member adapted for transverse expansion.

9. A rock bolt according to any one of the preceding claims, wherein the second end of the first elongate member comprises attachment means.

10. A rock bolt according to claim 9, wherein on advancement of the attachment means towards the first end of the first elongate member, the attachment means is arranged to produce, either directly or indirectly, a transverse force in the region of the second elongate member adapted for transverse expansion, thereby causing transverse expansion thereof.

11. A rock bolt according to any one of the preceding claims, wherein the first elongate member is a hollow rod having a circular cross-section.

12. A rock bolt according to any one of claims 1 to 10, wherein the first elongate member is a solid rod having a circular cross-section.

13. A rock bolt according to any one of claims 1 to 10, wherein the first elongate member is a hollow rod having a non-circular cross-section.

14. A rock bolt according to any one of claims 1 to 10, wherein the first elongate member is a solid rod having a non-circular cross-section.

15. A rock bolt according to any one of the preceding claims, wherein the first elongate member has a smooth axially outer surface.
16. A rock bolt according to any one of claims 1 to 14, wherein the first elongate member has a rough surface for providing additional bonding between grout and the first elongate member.

17. A rock bolt according to any one of the preceding claims, wherein the second elongate member is a hollow rod.

18. A rock bolt according to any one of the preceding claims, wherein the second elongate member has a circular cross-section.

19. A rock bolt according to any one of claims 17 and 18, wherein at least one of the inner and outer surfaces of the second elongate member are smooth.

20. A rock bolt according to any one of the preceding claims, wherein at least one of the inner and outer surfaces of the second elongate member are rough.

21. A rock bolt according to claim 20, wherein the second elongate member is corrugated for providing stress transfer between the inner and outer surface of the sleeve.

22. A rock bolt according to claim 21, wherein the depth of the corrugations is proportional to the radius of the second elongate member.

23. A rock bolt according to any one of the preceding claims, wherein the first elongate member is comprised of an elevated tensile strength material, suitable for acting as a structural member.

24. A rock bolt according to any one of the preceding claims, wherein the second elongate member comprises a composite of multiple elongate metal members and a plastic tube, so as to allow expansion of the portion adapted
for transverse expansion, while resisting deformation of the remainder of the second elongate member.

25. A rock bolt according to any one of claims 1 to 23, wherein the second elongate member comprises a plastic tube with a discontinuous steel end collar.

26. A rock bolt according to any one of the preceding claims, wherein the first and second elongate members are arranged to cause expansion of the at least portion of the second elongate member adapted for transverse expansion by longitudinal advancement of the first end of the first elongate member toward the second elongate member.

27. A rock bolt according to any one of the preceding claims, further comprising at least one expansion shell.

28. A rock bolt according to claim 27 when dependent on claim 10, wherein the at least one expansion shell is adapted to be transversely expanded as the attachment means is advanced towards the first end of the first elongate member.

29. A rock bolt according to claim 27 or claim 28, wherein the expansion shell is arranged to transversely expand as the first end of the first elongate member is moved toward the at least one expansion shell.

30. A rock bolt according to claim 27 or claim 28, wherein the at least one expansion shell is arranged to expand as it is advanced toward the first end of the first elongate member.
31. A rock bolt according to any one of the preceding claims, wherein the first end of the first elongate member includes at least one access channel for allowing the influx and efflux of materials.

32. A rock bolt according to any one of the preceding claims, wherein the second end of the first elongate member includes at least one access channel for allowing the influx and efflux of materials.

33. A rock bolt according to claim 31 or claim 32, wherein the access channels and first elongate member are forged.

34. A rock bolt according to claim 4, or any claim dependent thereon, wherein the first end of the first elongate member comprises a drill bit means.

35. A rock bolt according to claim 2 or claim 34, wherein the drill bit means include at least one access channel for allowing the influx and efflux of materials during drilling and grouting.

36. A rock bolt according to any one of the preceding claims, wherein a cavity is provided, extending between the first and second elongate members, to allow fluid flow between the first and second ends of the first elongate member.

37. A rock bolt according to claim 36, wherein the cavity extends longitudinally between the first and second elongate members.

38. A rock bolt according to any one of claims 36 and 37, wherein the cavity is annular.

39. A rock bolt according to any one of the preceding claims, further comprising a washer mounted on the first elongate member in the region of the second end for abutting the rock wall around a drilled hole.
40. A rock bolt according to any one of the preceding claims, further comprising a third elongate member wherein the second end of the first elongate member is further adapted to provide attachment to a first end of a third elongate member, and the second elongate member includes a second end adapted to provide attachment to the first end of a fourth elongate member.

41. A rock bolt according to claim 40, wherein the first elongate member is arranged to be lockable to the third elongate member to substantially prevent relative rotation between the two in at least one rotational direction when locked together.

42. A rock bolt according to any one of claims 40 and 41, further comprising a third elongate member and a fourth elongate member.

43. A rock bolt extension means comprising third and fourth elongate members, the third elongate member comprising a first end adapted to provide attachment to a second end of a first elongate member of a rock bolt according to any one of the previous claims, and a second end adapted to provide attachment for actuating means and further adapted to provide attachment to a first end of a fifth elongate member, and the fourth elongate member comprising a first end adapted to provide attachment to a second end of a second elongate member of a rock bolt according to any one of the previous claims, and a second end adapted to provide attachment to a first end of a sixth elongate member, wherein the third elongate member is disposed at least partially, longitudinally inside the fourth elongate member.

44. A rock bolt extension means according to claim 43, wherein a cavity is provided, extending longitudinally between the third and fourth elongate members, to allow fluid flow between the first and second ends of the third elongate member.
45. A rock bolt extension means according to claim 43 or claim 44, wherein the third and fifth elongate members are the same, and the fourth and sixth elongate members are the same.

46. A rock bolt kit comprising first and second elongate members, and rock penetrating means adapted to be received by the first end of the first elongate member, the first elongate member comprising a first end adapted to receive the rock penetrating means, and a second end adapted to provide attachment for actuating means, wherein the first elongate member is adapted to be disposed at least partially, longitudinally inside the second elongate member.

47. A rock bolt kit according to claim 46, wherein the second elongate member is adapted for transverse expansion along at least a portion of its length.

48. A rock bolt kit according to claim 47, wherein the first elongate member comprises a portion of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion.

49. A rock bolt kit according to claim 47, wherein the rock penetrating means comprises a portion of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion.

50. A rock bolt kit according to any one of claims 46 to 48, wherein an attachment means is provided at the second end of the first elongate member to provide attachment for actuating means and wherein on advancement of the attachment means towards the first end of the first elongate member, the attachment means is arranged to produce either directly or indirectly a transverse force in the region of the second elongate
member adapted for transverse expansion, thereby causing transverse expansion thereof.

51. A rock bolt kit according to any one of claims 46 to 50, wherein the attachment means comprises an internally threaded collar mounted on a threaded portion of the first elongate member.

52. A rock bolt kit according to any one of claims 46 to 51, wherein the first elongate member is a hollow rod having a non-circular cross-section.

53. A rock bolt kit according to any one of claims 46 to 52, wherein the first elongate member is a solid rod having a non-circular cross-section.

54. A rock bolt kit according to any one of claims 46 to 53, wherein the first elongate member has a smooth axially outer surface.

55. A rock bolt kit according to any one of claims 46 to 53, wherein the first elongate member has a rough surface for providing additional bonding between grout and the first elongate member.

56. A rock bolt kit according to any one of claims 46 to 55, wherein the second elongate member is a hollow rod having inner and outer surfaces.

57. A rock bolt kit according to claim 56, wherein the second elongate member has a circular cross-section.

58. A rock bolt kit according to any one of claims 56 and 57, wherein at least one of the inner and outer surfaces of the second elongate member are smooth.

59. A rock bolt kit according to any one of claims 56 to 58, wherein at least one of the inner and outer surfaces of the second elongate member are
rough for providing additional bonding between grout and the second elongate member.

60. A rock bolt kit according to claim 59, wherein the second elongate member is corrugated for providing stress transfer between the inner and outer surface of the second elongate member.

61. A rock bolt kit according to claim 60, wherein the depth of the corrugations is proportional to the radius of the second elongate member.

62. A rock bolt kit according to any one of claims 46 to 61, wherein the second elongate member comprises at least one expansion shell.

63. Rock penetrating means comprising a cutting element and means for attaching the rock penetrating means to a rock bolt according to claim 4, or any claim dependent thereon.

64. Rock penetrating means according to claim 63, further comprising means for expanding a second elongate member of a rock bolt according to claim 4 or any claim dependent thereon.

65. A method of drilling, the method comprising (a) drilling a drilling member, the drilling member comprising first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face, while flushing a fluid between the first elongate member, second elongate member and rock face in the region of the first end of the first elongate member; and (b) removing the drilling member from the rock once a hole of the desired depth has been drilled.
66. A method of drilling according to claim 65, wherein the fluid is a liquid.

67. A method of installing a rock bolt, the method comprising:
   (a) drilling the rock bolt, the rock bolt comprising first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face, while flushing a first fluid into a cavity between the first elongate member and second elongate member and past the rock face in the region of the first end of the first elongate member;
   (b) injecting a grouting fluid between the first elongate member, second elongate member and rock face; and
   (c) waiting a preset time period for the grouting fluid to set.

68. A method of installing a rock bolt, the method comprising:
   (a) drilling the rock bolt, the rock bolt having first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face while flushing a first fluid through a cavity between the first elongate member and second elongate member, and past the rock face in the region of the first end of the first elongate member;
   (b) providing an extension rod comprising third and fourth elongate members, the third elongate member comprising a first end adapted to lock with the second end of the first elongate member so as to substantially prevent relative rotation between the first elongate member and the third elongate member in at least the rotational direction of drilling, and the fourth elongate member comprising a first end adapted attach to the second end of the second elongate member;
(c) extending the length of the first elongate member by locking the first end of the third elongate member into the second end of the first elongate member;

(d) extending the length of the second elongate member by attaching the first end of the fourth elongate member to the second end of the second elongate member;

(e) repeating (a), (b), (c) and (d) until a suitable depth has been reached;

(f) injecting a grouting fluid between the first elongate member, second elongate member, extension rod and rock face; and

(g) waiting a preset time period for the grouting fluid to set.

69. A method according to claim 68, wherein the first fluid is a flushing and cooling fluid and the first fluid and grouting fluid are passed through a cavity between the third and fourth elongate members, to the cavity between the first and second elongate members and past the rock face in the region of the first end of the first elongate member.

70. A method according to any one of claims 67 to 69, wherein the second elongate member of the rock bolt used in the method additionally includes a portion adapted for transverse expansion and, before (b), the second elongate member is moved longitudinally relative to the first end of the first elongate member, to cause the portion adapted for transverse expansion to expand transversely and retain the bolt in the rock face.

71. A method according to claim 70, wherein the longitudinal movement is caused by relative rotation of the first and second elongate members, relatively pushing the second elongate member toward the first end of the first elongate member, causing expansion of the portion adapted for transverse expansion.
72. A method according to any one of claims 70 and 71, wherein the rock bolt is rotationally advanced in a first rotational direction and the portion of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion is brought into engagement with the portion of the second elongate member adapted for transverse expansion by rotation in the first rotational direction.

73. A method according to any one of claims 70 and 71, wherein the rock bolt is rotationally advanced in a first rotational direction and the portion of the first elongate member of greater transverse dimension than the portion of the second elongate member adapted for transverse expansion is brought into engagement with the portion of the second elongate member adapted for transverse expansion by rotation in a second rotational direction opposed to the first rotational direction.

74. A method according to any one of claims 71 to 73, wherein the rock bolt is then tensioned by further relative rotation of the elongate members.

75. A method according to any one of claims 67 to 74, wherein at least one of the fluids is a liquid.

76. A method according to any one of claims 67 to 75 wherein the fluids are injected through at least one access channel in the second end of the first elongate member into the cavity between the first and second elongate members and the fluids exit the cavity through at least one further access channel in the region of the first end of the first elongate member before passing into a second cavity between the second elongate member and the rock face.

77. A method according to claim 67 wherein the second elongate member of the rock bolt used in the method is comprised of a low strength material and, before (b), the second elongate member is brought into engagement
with the portion of the first elongate member adapted to penetrate rock by rotation in a first rotational direction, to cause the second elongate member to distort by the lateral force acting on the second elongate member and make at least one portion of the second elongate member come into contact with the rock face.

78. A method of drilling, the method comprising:

(a) drilling a rock bolt, the rock bolt having first and second elongate members, the first elongate member being disposed at least partially, longitudinally inside the second elongate member, the first elongate member comprising a first end adapted to penetrate rock and a second end adapted to provide attachment for actuating means, into a rock face while flushing a fluid between the first elongate member, second elongate member and rock face in the region of the first end of the first elongate member;

(b) providing an extension rod comprising third and fourth elongate members, the third elongate member comprising a first end adapted to lock with the second end of the first elongate member so as to substantially prevent relative rotation between the first elongate member and the third elongate member in at least the rotational direction of drilling, and the fourth elongate member comprising a first end adapted attach to the second end of the second elongate member;

(c) extending the length of the first elongate member by rotatably locking the first end of the third elongate member into the second end of the first elongate member;

(d) extending the length of the second elongate member by attaching the first end of the fourth elongate member to the second end of the second elongate member;

(d) repeating (a), (b), (c) and (d) as necessary until a suitable depth has been reached; and

(e) removing the at least one extension rod and the rock bolt from the rock.
79. A method of installing a rock bolt, the method comprising:
   (a) drilling the rock bolt, the rock bolt comprising first and second
   elongate members, the first elongate member being disposed at least
   partially, longitudinally inside the second elongate member, the first elongate
   member comprising a first end adapted to penetrate rock and a second end
   adapted to provide attachment for actuating means and the second elongate
   member including a portion adapted for transverse expansion; into a rock
   face; and
   (b) causing relative movement of the second elongate member
   relative to the first elongate member, to cause the portion adapted for
   transverse expansion to expand transversely and retain the bolt in the rock
   face.

80. A method of installing a rock bolt, the method comprising:
   (a) drilling the rock bolt, the rock bolt comprising first and second
   elongate members, the first elongate member being disposed at least
   partially, longitudinally inside the second elongate member, the first elongate
   member comprising a first end adapted to penetrate rock and a second end
   adapted to provide attachment for actuating means and the second elongate
   member including a portion adapted for transverse expansion;
   (b) providing an extension rod comprising third and fourth elongate
   members, the third elongate member comprising a first end adapted to lock
   with the second end of the first elongate member so as to substantially
   prevent relative rotation between the first elongate member and the third
   elongate member in at least the rotational direction of drilling, and the fourth
   elongate member comprising a first end adapted attach to the second end of
   the second elongate member;
   (c) extending the length of the first elongate member by rotatably
   locking the first end of the third elongate member into the second end of the
   first elongate member;
(d) extending the length of the second elongate member by attaching
the first end of the fourth elongate member to the second end of the second
elongate member;

(e) repeating (a), (b), (c) and (d) as necessary until a suitable depth
has been reached; and

(f) causing relative movement of the first and second elongate
members, to cause the portion adapted for transverse expansion to expand
transversely and retain the bolt in the rock face.

81. A method according to any one of claims 67 to 77, further comprising
cutting through at least one of the first and second elongate members after
the bolt has been drilled.

82. A rock bolt according to any one of claims 1 to 22, 24 to 38 and 40 to
43, wherein the first and second elongate member are comprised of a
material which can be cut after the rock bolt has been drilled into a rock face.

83. A rock bolt according to any one of claims 1 to 43 or 82, wherein the
rock bolt is a self drilling rock bolt.

84. A rock bolt according to any one of claims 4 and 10, or any claim
dependent thereon, further comprising a plate attached to the first elongate
member, the plate being arranged to substantially prevent relative rotation of
the attachment means and first elongate member in a first direction of
rotation.

85. A self drilling rock bolt having opposite first and second ends and a
shaft extending between the ends, the first end being adapted to penetrate
rock and the second end being adapted to be connected to a drilling
apparatus to allow rotation of and thrust to the bolt, a sleeve extending along
and around the shaft, and a passage formed between the sleeve and the
shaft to allow fluid to be passed along the bolt shaft.
86. A self drilling rock bolt according to claim 85, wherein the first end incorporates at least one drill tip that extends radially from the bolt axis a distance greater than the sleeve.

87. A self drilling rock bolt according to claim 86, further comprising a drill bit which is connected to an end of the shaft and incorporates the at least one drill tip thereon.

88. A self drilling rock bolt according to claim 86 or 87, wherein the sleeve is deformable and when so deformed, the sleeve extends radially beyond the drill tip.

89. A self drilling rock bolt according to claim 88, wherein the sleeve is deformable on the application of an axial force to the sleeve.

90. A self drilling rock bolt according to claim 88, wherein the axial force is towards the first end.

91. A self drilling rock bolt according to any one of claims 87 to 89, wherein the rock bolt further comprises at least one engaging surface, and wherein the sleeve is deformed on relative movement of the sleeve across the engaging surface.

92. A self drilling rock bolt according to claim 91, when dependent on claim 87, wherein the engaging surface is located on the drill bit.

93. A self drilling rock bolt according to any one of claims 90 to 92, wherein the sleeve is deformable under axial compression.

94. A self drilling rock bolt according to any one of claims 89 to 93, wherein the sleeve incorporates at least one weakened area that facilitates deformation of the sleeve.
95. A self drilling rock bolt according to claim 94, wherein the at least one weakened area is in the form of a slit formed in the sleeve.

96. A self drilling rock bolt according to any one of claims 85 to 87, further comprising an anchoring device, which is operative to retain the rock bolt when located in a drilled hole.

97. A self drilling bolt according to claim 96, wherein the anchoring device is located proximate to the first end and is operative in response to axial movement of the shaft relative to the sleeve.

98. A self drilling bolt according to either claim 96 or claim 97, wherein the anchoring device is in the form of at least one expansion shell that is displaceable radially outwardly.

99. A self drilling rock bolt according to claim 98, wherein the rock bolt comprises at least one engaging surface, and wherein the at least one expansion shell becomes operative on relative movement of the engaging surface across an inner surface of the at least one expansion shell.

100. A self drilling rock bolt according to anyone of claims 85 to 99, further comprising a collar piece that extends about the shaft adjacent its second end.

101. A self drilling rock bolt according to claim 100, wherein the collar piece is displaceable axially along the bolt shaft.

102. A self drilling rock bolt according to claim 101, wherein the sleeve is displaceable along the shaft in response to movement of the collar piece along the shaft.
103. A self drilling rock bolt according to either claim 101 or 102, wherein the collar piece is connected to the shaft by an external thread on the shaft that engages with and a complementary inner thread of the collar piece.

104. A self drilling rock bolt according to any one of claims 100 to 103, wherein the rock bolt is adapted to be connected to the drilling apparatus by connection of the drilling apparatus with the collar piece.

105. A self drilling rock bolt according to any one of claims 85 to 104, wherein openings are provided to the passage at or adjacent each of the opposite ends of the sleeve.

106. A self drilling rock bolt according to any one of claims 100 to 105, further comprising at least one channel that allows fluid to flow into or out of the passage through the collar piece.

107. A self drilling rock bolt according to claim 106, wherein the at least one channel is formed between the shaft and the collar piece.

108. A self drilling rock bolt according to any one of claims 85 to 107, further comprising at least one channel formed at the first end to facilitate flow of fluid between the passage and the drill tip.

109. A self drilling rock bolt according to claim 108, wherein at least part of the channel that extends to the drill tip is located within the rock bolt.

110. A self drilling rock bolt according to any one of claims 85 to 109, wherein the shaft is load bearing on installation and is formed from steel rod.

111. A self drilling rock bolt according to any one of claims 85 to 110, wherein the sleeve is formed from plastic.
112. A self drilling rock bolt according to any one of claims 85 to 111, further comprising an abutment member located proximate the second end, the abutment member being displaceable along the shaft and having an abutment surface that faces towards the first end and projects radially from the bolt axis a distance greater than the drill tip.

113. A self drilling rock bolt according to any one of claims 85 to 112, wherein the drill shaft and sleeve are each formed from a plurality of sections that are connected together.

114. A drill bit comprising a bit body having opposite ends and a wall surface extending between the ends, at least one drill tip located at one end and the bit being adapted to be connected to a drill rod at the other end, wherein a least one channel extends from the wall surface to the at least one drill tip.

115. A drill bit according to claim 114, wherein wall surface includes a wall portion that tapers outwardly towards the one end.

116. A method of stabilising rock, comprising:
   - drilling a hole into the rock using a self drilling rock bolt having a drilling end and an opposite end connected to a drilling apparatus;
   - providing drilling fluid to the drilling end during drilling of the hole by conveying fluid along the outer surface of the bolt shaft; and
   - fixing the rock bolt within the hole to stabilise the rock.

117. A method according to claim 116, wherein the drilling fluid is guided along the shaft in an inner passage defined by a sleeve disposed around and along the shaft.

118. A method according to claim 117, further comprising forming an outer passage between the sleeve and the side of the hole.
119. A method according to claim 118, wherein fluid is caused to flow to the drilling end through one of either the inner or outer passages, and is removed from the hole through the other of the passages.

120. A method according to any one of claims 116 to 118, wherein grout is introduced into the hole to fix the rock bolt to the rock.

121. A method according to claim 120, wherein the rock bolt is initially anchored within the hole prior to introducing grout into the hole.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl.: E21D 21/00, 20/02

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)

DWPI : E21D 21/00 and Keywords ((rock bolt), drill+, (scf drill+), elongate+, tube, cylinder, hollow, longitudinal+, internal+, inside, expant+, deform+, transverse+, attach+, sleeve) and like terms

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>X</td>
<td>AU 54281/01 A1 (GRAY) 17 January 2002 See whole document</td>
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<td>A</td>
<td>GB 2206172 A (COAL INDUSTRY (PATENTS) LIMITED) 29 December 1988</td>
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<td>A</td>
<td>GB 2352671 A (BOART LONGYEAR LIMITED et al) 7 February 2001</td>
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<td>Derwent Abstract Accession No. B4349 E/06, Class Q49, SU 826004 A (MELNIKOV) 30 April 1981</td>
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Further documents are listed in the continuation of Box C

See patent family annex

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<td>&quot;A&quot;</td>
<td>document defining the general state of the art which is not considered to be of particular relevance</td>
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<td>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)</td>
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<td>&quot;O&quot;</td>
<td>document referring to an oral disclosure, use, exhibition or other means</td>
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<tr>
<td>&quot;P&quot;</td>
<td>document published prior to the international filing date but later than the priority date claimed</td>
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"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** 16 August 2004

**Date of mailing of the international search report** 21 SEP 2004

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Form PCT/ISA/210 (second sheet) (January 2004)
<table>
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INTERNATIONAL SEARCH REPORT

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 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 fee, this Authority did not invite payment of any additional fee.
3. X 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.: 1-66, 79, 82-113
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

X The additional search fees were accompanied by the applicant’s protest.
□ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2004)
Supplemental Box
(To be used when the space in any of Boxes I to VIII is not sufficient)

Continuation of Box No: III

The 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. The International Searching Authority has found that there are different inventions as follows:

1. Claims 1 to 64 and 82 to 84 are directed to a rock bolt (or a rock bolt extension means, a rock bolt kit or a rock penetrating means) comprising, inter alia, first and second elongate members, wherein the first elongate member is disposed at least partially, longitudinally inside the second elongate member. It is considered that the underlined feature comprises a first "special technical feature". Claims 86 to 113 are dependent from claim 85.

2. Claims 65 to 66 and claim 85 are directed to (i) a method of drilling a drilling member and (ii) a self drilling rock bolt, respectively, which method or bolt are characterised by flushing a fluid between a first elongate member, a second elongate member and the rock face. It is considered that the underlined feature comprises a second "special technical feature". Claims 86 to 113 are dependent from claim 85.

3. Claims 67 and 116 to 121 are directed to a method of installing or stabilising a rock bolt which method comprises of providing a flushing or drilling fluid (as in method claim 65) and then fixing the rock bolt by injecting a grouting fluid between the two elongate members and the rock face. It is considered that steps of providing a first fluid and then injecting a grouting fluid comprise a third "special technical feature".

4. Claim 68 is directed to a method of installing a rock bolt (similar to the rock bolt of claim 1) which method comprises, inter alia, of providing an extension rod comprising third and fourth elongate members, wherein the third elongate member is adapted to lock with the first elongate member. It is considered that the underlined feature comprises a fourth "special technical feature". Claims 69 to 77 and 81 are dependent from claims 67 and/or 68.

5. Claim 78 is directed to a method of drilling a rock bolt (similar to the rock bolt of claim 1) which method comprises, inter alia, of providing an extension rod (as in claim 68) and, as the last method step, removing the extension rod and the rock bolt from the rock. It is considered that the combination of the underlined features comprises a fifth "special technical feature".

6. Claim 79 is directed to a method of installing a rock bolt which method comprises of drilling the rock bolt (similar to the rock bolt of claim 1) into a rock face, and causing a portion of the second elongate member to expand transversely and retain the bolt in the rock face. It is considered that the underlined feature comprises a sixth "special technical feature".
7. Claim 80 is directed to a method of installing a rock bolt (similar to the rock bolt of claim 1) which method comprises, inter alia, of providing an extension rod (as in claim 68) and, as the last method step, causing a portion of the second elongate member to expand transversely and retain the bolt in the rock face. It is considered that the underlined features comprise a seventh "special technical feature".

8. Claims 114 and 115 are directed to a drill bit comprising a bit body wherein at least one channel extends from the wall surface of the bit body to the drill tip. It is considered that the drill bit as defined comprises an eighth "special technical feature".

Since the abovementioned groups of claims do not share any of the technical features identified, a “technical relationship” between the inventions, as defined in PCT rule 13.2 does not exist. Accordingly the international application does not relate to one invention or to a single inventive concept, a priori.
This Annex lists the known "A" publication level 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.

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

END OF ANNEX