An apparatus for use by an operator in forming boreholes in an underground mine passage including ribs and a roof. The apparatus includes a base and first and second booms pivotally mounted to the base for swinging toward and away from the adjacent rib. A drill is mounted to the base independent of the first and second booms. An actuator including first and second independently movable rods may be used to move the drill relative to the boom.
MINING MACHINE WITH BOOMS PROVIDING ENHANCED RIB ACCESS

[0001] This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/286,587, filed Dec. 15, 2009, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to the mining arts and, more particularly, to a mining machine and methods for installing support in a mine passage.

BACKGROUND OF THE INVENTION

[0003] During underground mining, it is a requirement for purposes of safety as well as federal law to install support to the roof of a passage at various intervals. This is often done using a mining machine known in the vernacular as a “roof” bolter. Typically, such a roof bolter is capable of both forming (drilling) boreholes and then installing roof anchors or “bolts” in the boreholes.

[0004] Bolters sometimes include an elongated boom for raising and lowering an attached bolting module, which incorporates a drill for forming the borehole for receiving the bolt or anchor. Sometimes, these booms are unmanned. However, in some cases they include an onboard station designed to support the operator of the bolting module.

[0005] In such cases where an operator station is provided, it has in the past been the case that the elongated boom is positioned between the operator and the corresponding rib of the mine passage to protect the operator from lateral hazards, such as rib rolls. From this position the boom serves as an obstacle that prevents the operator from easily and efficiently accessing the rib, such as to install the resin or bolt in the borehole once formed. As a result, it has in the past been proposed to use mechanical systems for installing the resin and bolts in the rib, but this increases the complexity and cost of the resulting bolting module.

[0006] A boom arrangement carrying an operator station adapted for installing support in the rib of a mine passage addresses the above-identified need (see, e.g., U.S. patent application Ser. No. 12/559,933, the disclosure of which is incorporated herein by reference). This boom arrangement affords an operator positioned at the station easy access to the rib for drilling a borehole, inserting resin in the borehole, and installing an anchor, such as a bolt. Despite the enhanced access provided by this boom arrangement, the area of coverage may be further increased to maximize efficiency of the bolting operation.

[0007] Accordingly, a need is identified for a bolting apparatus having a boom arrangement utilizing multiple heads adapted for drilling boreholes and installing bolts or anchors therein to increase the efficiency of the bolting operation. Further, a need is identified for a cylinder assembly for use in moving the boom arrangement, which prevents the operator from moving the boom to an undesirable position.

SUMMARY OF THE INVENTION

[0008] One aspect of the present disclosure relates to an apparatus for use by an operator in forming boreholes in an underground mine passage including ribs and a roof. The apparatus has a base and first and second booms pivotally mounted to the base for swinging toward and away from an adjacent rib. A drill is mounted to the base independent of the first and second booms. The drill may be positioned between the first and second booms. Furthermore, the first and second booms may each carry another drill.

[0009] In one embodiment, one of the first and second booms has a proximal end mounted to the base, a distal end opposite the proximal end, a first lateral side adjacent the rib and a second lateral side opposite the first lateral side. A first support is supported by the boom near the distal end and is adapted for drilling into the rib of the mine passage. A first operator’s station carried by the boom adjacent the first drill is adapted to allow the operator to access the rib when positioned on the operator’s station without interference from the boom. Further, a cylinder assembly including first and second independently movable rods may be used to move the drill relative to the boom.

[0010] Another aspect of this disclosure relates to an apparatus for use by an operator in forming boreholes in a mine passage including a rib and a roof includes a base and a boom mounted to the base. The apparatus also includes a cylinder assembly with a first rod having a first end mounted to the base and a second rod having a second end mounted to the boom. The apparatus may include a first and second pair of ports for directing fluid for extending or retracting the first rod and the second rod, respectively. Preferably, the first rod is shorter than the second rod and the first and second rods are independently actuated.

[0011] In accordance with another aspect of the disclosure, a method for forming boreholes in a mine passage including an adjacent rib and a roof is disclosed. The method includes: (1) providing a vehicle including two pivotally mounted booms, each carrying a drill and including a station adapted for receiving an operator; and (2) providing the vehicle with a drill independent of the booms.

[0012] A further aspect of the disclosure relates to a method of operating an apparatus for forming boreholes in a mine passage. The method includes: (1) providing a base having a boom; (2) moving the boom from a stowed to a home position by moving a first rod of a cylinder assembly in a first direction; and (3) moving the boom to an operative position by moving a second rod of the cylinder assembly in the first direction.

[0013] Preferably, the step of moving the boom to the home position comprises extending the first and second rods, while the step of moving the boom to the operative position comprises retracting the first and second rods. In addition, the step of moving the boom to the operative position comprises retracting the first rod before retracting the second rod. Finally, the step of moving the boom to the home position comprises moving the first rod using a first control on a base of the apparatus and the step of moving the boom to the operative position comprises moving the second rod using a second control on a boom mounted to the base.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1a is a top plan view of a boom specially adapted for installing support in the rib of a mine passage.

[0015] FIG. 1b is a side view of the boom of FIG. 1a.

[0016] FIG. 2a is a side view of the boom of FIGS. 1a and 1b, showing the drill oriented toward the rib.

[0017] FIG. 2b is a front perspective view of the boom of FIG. 2a.

[0018] FIG. 2c is a top plan view of the boom of FIG. 2b;
With continued reference to FIG. 1a, as well as to FIG. 1b, it can be best understood that a station 12 for supporting the operator O is provided. Preferably, the operator station 12 is near the distal end D of the boom 10, adjacent to a drill 14. Most preferably, the operator’s station 12 includes at least one platform 12a providing a place on which the operator O may stand during a drilling or bolting event. This platform 12a is preferably mounted directly to the distal end D of the boom 10, and thus moves along with it in all possible directions.

The drill 14 (commonly referred to as a rig) is adapted for forming boreholes in a corresponding face of the mine passage, including at least the rib R. Consequently, this drill 14 is mounted for movement in multiple directions along with the boom 10 so as to facilitate the drilling of boreholes. This is preferably achieved by pivotally mounting the drill 14 to the distal end of the boom 12, such as by connecting it to a turret 16 having an axis of rotation that is generally orthogonal to a drilling axis X formed by the linear path of travel of a drill head 14a (preferably, a rotary one incorporating a hydraulic motor, not shown) along a guide frame 14b both forming part of the drill 14 (see FIG. 1a). Thus, as shown in FIGS. 2a, 2b, and 2c, the drill 14 may roll over and also may be knuckled inward such that this drilling axis X intersects a vertical plane Y aligned generally parallel to the rib R (compare FIGS. 1b and 2b).

Means may also be provided for moving the drill 14 relative to the operator’s platform 12, such as a motive device in the form of cylinder H4. This may be used to rotate or swing the drill 14 within a plane generally parallel to the ground G (see action arrow J in FIG. 2c). As should be appreciated, this swinging may alter the relative positioning of the drilling axis X and, thus, the direction(s) in which the borehole is formed or any bolt or anchor installed. The orientation of this axis X may also be altered based on the relative swinging of the boom 10 about the pivot point established by the mounting at the proximal end P to base B, which may be effected by a motive device such as cylinder H4 (see FIG. 4b) or similar actuator.

Controls for manually or automatically controlling the drill 14 and the associated moving means may also be provided in a convenient place for being accessed by the operator O when positioned at or adjacent to the operator’s station 12. Most preferably, the platform 12a may also be raised or lowered relative to any controls associated with the operator’s station 12.

In accordance with one aspect of the disclosure, the operator’s station 12 associated with the boom 10 may be arranged in use so as to occupy a space at least partially between a generally vertical plane aligned with the lateral side L2 and the vertical plane X generally parallel to a vertical face of the adjacent rib R. In the particular embodiment illustrated, the station 12 is thus positioned so as to intersect with the longitudinal axis A of the boom 10, adjacent the distal end D of the boom 10 (see FIG. 1a). Preferably, an upper surface U of the boom 10 is also arranged to as to be lower that a top of the shoulder S of the operator O when standing at the station 12, and most preferably lies below the upper torus T of the operator O.

Consequently, it can be seen that the operator O when positioned at the station 12 is able to fully and freely access the rib R, such as for inserting resin cartridges or bolts into boreholes formed, for example, using the drill 14 (see, e.g., U.S. Pat. Nos. 5,951,208 and 7,428,936, the disclosures thereof).
of which are incorporated herein by reference). This includes standing on the station 12 in line with a longitudinal axis A of the boom 10, and possibly in the space between the lateral side L₁ and the adjacent rib R at least partially occupied by platform 12a. Such enhanced access allows for a remarkable reduction in the time and expense associated with installing the resin and bolt, since the necessary operations can be at least partially performed in a manual fashion without requiring the operator O to leave the station 12. The improved reachability afforded thus not only eases the burdens on the operator, but also may eliminate the need for associated machinery for performing one or more of these functions characteristic of past approaches.

[0045] In the illustrated embodiment, at least the platform 12a of the operator’s station 12 is arranged to be positioned between the distal end D of the boom 10 and the drill 14 (or in other words, is in tandem with the boom 10). However, it is possible to provide the drill 14 between the operator’s station 12 and the distal end D of the boom 10 while retaining the benefits of the inventive approach. Also, the operator’s station 12 may include an auxiliary platform 12b that extends adjacent the corresponding end of drill 14 on the lateral side L₂ of the boom 10, opposite the side L₁ facing the rib R (which platform 12b may be made accessible from a central walkway W through an associated vehicle V; see FIGS. 4a and 4b).

[0046] Turning now to FIGS. 3a and 3b, it may also be desirable to provide a guard, such as shield 18, on the side of the operator’s station 12 adjacent the rib R. This shield 18 should be of a height sufficient to prevent the operator from exiting the platform 12a of the station 12 in the direction of the rib R, and preferably of a height sufficient to protect the operator from the rib R (including rib rolls) without hampering access. In addition, as shown in FIGS. 2b and 3a, the upper section 18a of this shield 18 may be angled outwardly in the direction of the rib R to facilitate access thereto.

[0047] A further shield in the form of a canopy (not shown) may also be provided adjacent the station 12 for shielding the operator from the roof T, as well as for possibly engaging it and providing temporary support thereto before the anchors are installed. Preferably, any corresponding support is also positioned so as to avoid interfering with the operator’s access to the rib R.

[0048] Referring to FIGS. 3a and 3b, an optional but desirable feature is to strategically associate a disable switch with the boom 10. For example, a lever 20 may be capable of cutting off the power required for moving the boom 10 when pushed towards the rib R. Preferably, the lever 20 is located so it will be activated if the operator O standing adjacent shield 18 on platform 12a leans towards the rib R, and thus upon being activated prevent further advance of the boom 10 in this condition. Most preferably, the upper section 18a of the shield 18 supports the lever 20, such as by carrying a pivot mount 22 (which may be biased toward the operator O to prevent inadvertent actuation). A linkage 24 may also mechanically connect the lever 20 to a disable mechanism 26, which may comprise a valve positioned in the path of the fluid flow from the control for controlling the boom to the associated motive device(s).

[0049] FIGS. 4a and 4b show a bolting machine in the form of a mobile vehicle V (note crawler tracks K) serving as the base and incorporating a boom 10 with the improved rib reach feature. This vehicle V includes an interior walkway W defined at least partially by an elevated platform 32 to allow the operator to access the operator station 12 from inside the vehicle V, thereby avoiding the need for the operator to walk in the space between the lateral side L₁ and the rib R. With specific reference to FIG. 4b, it can be seen that the operator O simply steps from this walkway onto the associated auxiliary platform 12b when the boom 10 is in the home or retracted position. An optional gate 28 may also be pivotally mounted to block access to the walkway W once the operator is onboard and the boom 10 is deployed. The vehicle V shown also includes an automated temporary roof support device 30 for engaging the roof F adjacent the leading end.

[0050] Turning now to FIGS. 5-8a, a bolting apparatus 100 having at least three drills 102, 104, 106 adapted for drilling boreholes and installing bolts or anchors therein is illustrated. Two of these drills 102, 104 are mounted on swinging booms 110, which may be the same or similar as the boom 10 outlined in the foregoing discussion. These booms 110 are mounted laterally alongside the base, which in the preferred embodiment comprises a vehicle V adapted for tranaming around the mine passage. The other drill 106 is positioned between the booms 110, preferably adjacent the front end of the vehicle V, and most preferably mounted for movement relative to the front end of the vehicle (e.g., sliding from side-to-side or in the travel direction). Preferably, this drill 106 mounts to or adjacent to a device 130 for providing temporary roof support that is associated with the vehicle V. As shown in FIG. 7, the booms 110 may also be mounted for being raised in the vertical direction, as may drill 106 via a corresponding pivot (vehicle V) and suitable lifting devices (e.g., hydraulic cylinders).

[0051] Use of this arrangement advantageously allows for the booms 110 carrying drills 102, 104 to swing out and install bolts alongside the vehicle V, including in the rib of the mine passage, while the intermediate drill 106 may be independently used to form borehole and install bolts directly in the roof above the path of travel of the vehicle (and most preferably, the vehicle chassis itself). The area of coverage is thus increased, and efficiency is thus maximized.

[0052] Turning to FIGS. 9a-9d and 10, a related aspect of the disclosure is a novel actuator for use in moving at least one and preferably both of the booms 110. In the illustrated embodiment of FIGS. 9a-9e, the actuator comprises a cylinder 200 mounted to the vehicle V adjacent the boom 110, and includes first and second rods 202, 204. The first rod 202 extends in a first direction and is connected to the vehicle V, while the second rod 204 extends in a second, generally opposite direction and connects to the pivotally mounted end of the boom 110, preferably via a connector 206 having a longitudinal axis generally perpendicular to the longitudinal axis of the boom.

[0053] The cylinder assembly 200 includes a first pair of ports 208 for use in supplying the fluid that causes the first rod 202 to extend or retract, and a second pair of ports 210 providing a similar function for the second rod 204. As a consequence of this arrangement, fluid may be used to extend or retract the first or second rods 202, 204 independently, and thus move the associated boom 110 accordingly.

[0054] Using this type of arrangement, and with reference to FIGS. 9a, 9b, and 9c, it can be observed that both rods 202, 204 may be fully extended to move the associated boom 110 to a stowed position, such as for tranaming the vehicle from one location to another. Specifically, the movement is such that the free end of the boom 110 is caused to pivot about pivot point Q. As can be seen in FIG. 9a, the boom 110 in this retracted position is arranged such that its longitudinal axis is
generally parallel with a longitudinal axis of the first rod 202. The free end is within the perimeter of the base or chassis of the vehicle V, and the side-to-side profile is thus minimized for tramming about the mine passage.

[0055]  When use of the boom 110 is desired, the first rod 202 may be fully retracted, such as by controlling the flow of fluid to the associated ports 208 of the cylinder assembly 200. This retraction is most preferably done using controls 220 located on the vehicle V, as opposed to on the boom 110. This arrangement thus precludes the operator on the boom 110 from moving it inwardly to a position that is too close to the central portion of the vehicle or its operator (such as at an operator’s station for using drill 106).

[0056]  Retraction of the rod 202 causes the boom 110 to pivot to a retracted or home position alongside the vehicle V and generally with its axis of elongation parallel to the direction of travel (but with the free end remaining at least partially within the perimeter; see FIG. 9b). The length of the first rod 202 helps to define the maximum swing distance for the boom 110 in this first operation, and is thus intentionally made short enough such that the associated boom cannot be swung outwardly to a point beyond an initial position.

[0057]  From this initial or home position, and with the first rod 202 remaining retracted, the operator may assume the working position at the station 212, and use the associated controls 222 or 224 to extend and retract the second rod 204 for purposes of swinging the boom 110 toward and away from the rib. As should be appreciated, and as shown in FIG. 9e, the maximum extended position of the boom 110’ is defined by the second rod 204 being completely retracted. Preferably, the second rod 204 is substantially longer than the first rod 202, and thus can pivot the associated boom 110 through a much wider range of angles, which is of course advantageous for purposes of installing support in the adjacent roof and rib of the mine passage. However, the boom 110 cannot be moved to the stowed position by the operator thereon using controls 222, 224, since the appropriate controls are located elsewhere. Bolting intermediate of the home position of boom 110’ may be accomplished using the movable drill 106 carried by the base (vehicle V) independent of the boom(s) 110.

[0058]  The foregoing descriptions of various embodiments of the invention are provided for purposes of illustration, and are not intended to be exhaustive or limiting. Modifications or variations are also possible in light of the above teachings. The embodiments described above were chosen to provide the best application to thereby enable one of ordinary skill in the art to utilize the disclosed inventions in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the invention.

1. An apparatus for use by an operator in forming boreholes in an underground mine passage including ribs and a roof, comprising:
   a base;
   first and second booms pivotally mounted to the base for swinging toward and away from the adjacent rib; and a drill mounted to the base independent of the first and second booms.

2. The apparatus of claim 1, wherein the first and second booms each carry another drill.

3. The apparatus of claim 1, wherein the drill lies between the first and second booms.

4. The apparatus of any of claim 1, wherein one of the first and second booms comprises a first operator’s station adjacent the first drill, said operator’s station adapted to allow the operator to access the rib when positioned on the operator’s station without interference from the boom.

5. The apparatus of claim 4, wherein the operator’s station is at least partially positioned between a first plane extending generally parallel to the rib and a second plane aligned with an adjacent face of the boom.

6. The apparatus of claim 4, wherein the operator’s station includes a platform for supporting the operator arranged at least partially between a generally vertical plane aligned with the second lateral side and the rib.

7. The apparatus of claim 4, wherein the operator’s station extends across a central longitudinal axis of the boom to the second lateral side of the boom.

8. The apparatus of claim 4, wherein the operator’s station includes a platform for supporting the operator in a standing position, and an upper surface of the boom is lower than a top of the operator’s shoulder.

9. The apparatus of claim 4, further including a vehicle having a walingway with an exit end adjacent to the platform of the operator’s station.

10. The apparatus of any of claim 4, wherein the operator’s station further includes a shield for at least partially shielding the operator from a face of the mine passage.

11. The apparatus of claim 10, wherein the shield is adapted to prevent the operator from exiting the platform in a direction of the rib.

12. The apparatus of claim 10, wherein a disable switch is associated with the shield.

13. The apparatus of claim 10, wherein the disable switch is connected to a lever pivotally mounted to an upper portion of the shield.

14. The apparatus of claim 1, further including means for raising or lowering the boom.

15. The apparatus of claim 1, further including means for moving the drill relative to the boom.

16. The apparatus of claim 15, wherein the means for moving comprises an actuator including first and second independently movable rods.

17. The apparatus of claim 1, wherein the second boom includes a second operator’s station accessible from the walkway.

18. The apparatus of claim 1, further including a turret for mounting a drill to the distal end of at least one of the first or second booms.

19. The apparatus of claim 1, wherein one of said first or second booms includes a first end pivotally mounted to the base and a second end adapted for swinging outwardly from the base from a first home position to a second extended position closer to an adjacent rib than at the home position, and returning to the third stowed position farther from the adjacent rib than at the home position.

20. An apparatus for use by an operator in forming boreholes in a mine passage including a rib and a roof, comprising:
   a base;
   a boom mounted to the base;
   an actuator for moving the boom relative to the base, said actuator including a first extensible rod having a first end mounted to the base and a second extensible rod having a second end mounted to the boom.
21. The apparatus of claim 20, further including a first pair of ports for directing fluid for extending or retracting the first rod.

22. The apparatus of claim 20, further including a second pair of ports for directing fluid for extending or retracting the second rod.

23. The apparatus of claim 20, wherein the first rod is shorter than the second rod.

24. The apparatus of claim 20, wherein the first rod is arranged to extend a first maximum distance from a housing of the actuator that is less than a second maximum distance that the second rod may extend from the housing.

25. The apparatus of claim 20, wherein the first and second rods are independently actuated.

26. The apparatus of claim 20, wherein a first control for controlling the first rod is mounted on the base, and a second control for controlling the second rod is mounted on a boom associated with the base.

27. A mine roof bolter including the apparatus of claim 20.

28. A method for forming boreholes in a mine passage including an adjacent rib and a roof, comprising:
   providing a vehicle including a first pivotally mounted boom carrying a first drill and a second pivotally mounted boom carrying a second drill, each boom including a station adapted for receiving an operator, and providing the vehicle with a third drill independent of the first and second drills of the first and second booms.

29. The method of claim 28, further including simultaneously drilling the rib or roof using the first, second, and third drills.

30. A method of operating an apparatus for forming boreholes in a mine passage, comprising:
   providing a base having a boom;
   moving the boom from a stowed to a home position by moving a first rod of an actuator in a first direction; and
   moving the boom to an operative position by moving a second rod of an actuator in the first direction.

31. The method of claim 30, wherein the step of moving the boom to the home position comprises extending the first and second rods.

32. The method of claim 30, wherein the step of moving the boom to the operative position comprises retracting the first and second rods.

33. The method of claim 30, wherein the step of moving the boom to the operative position comprises retracting the first rod before retracting the second rod.

34. The method of claim 30, where the step of moving the boom to the home position comprises moving the first rod using a first control on a base of the apparatus and the step of moving the boom to the operative position comprises moving the second rod using a second control on a boom mounted to the base.

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