

Feb. 18, 1969

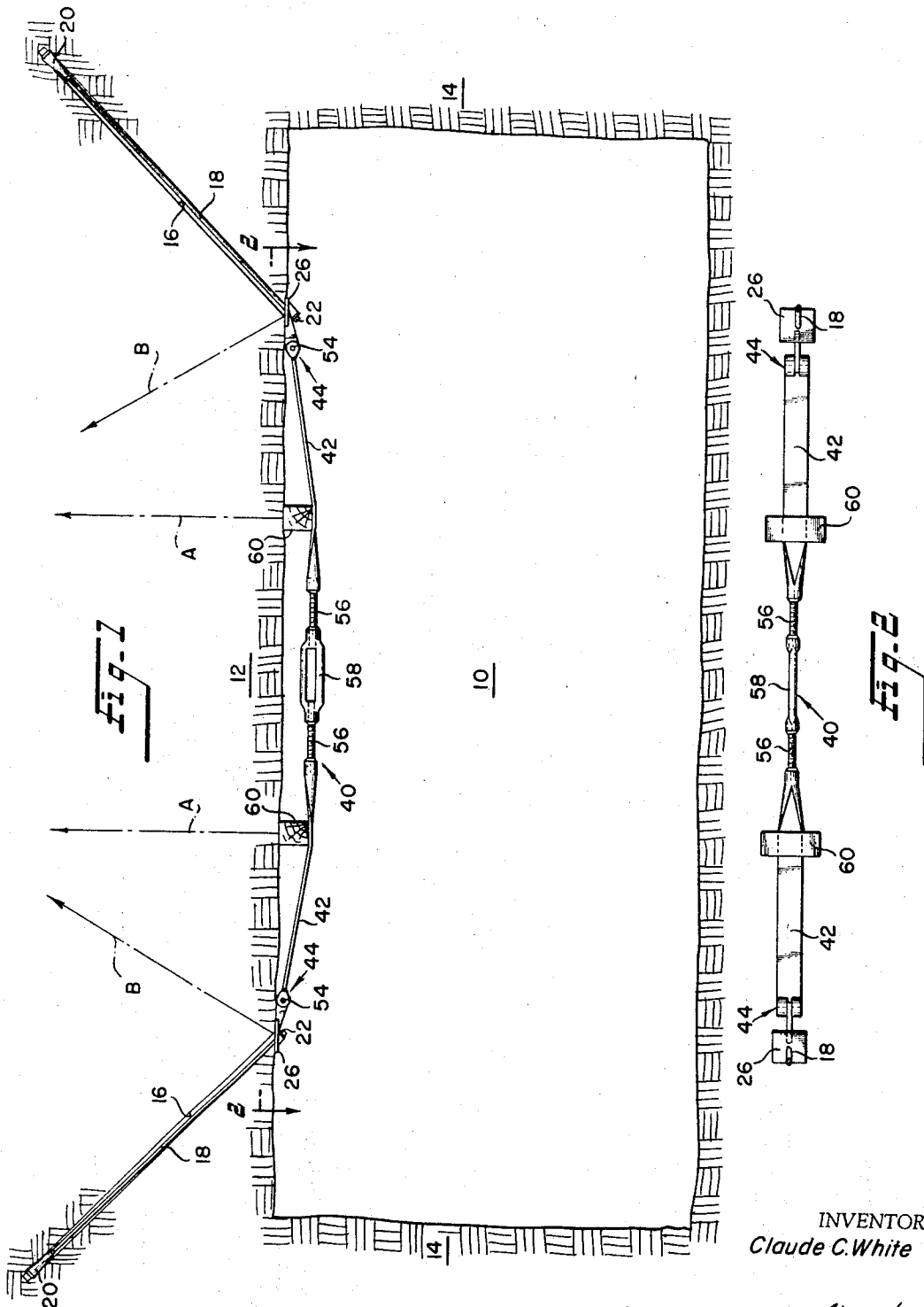
C. C. WHITE

3,427,811

MINE ROOF SUPPORT SYSTEM

Filed March 22, 1967

Sheet 1 of 3



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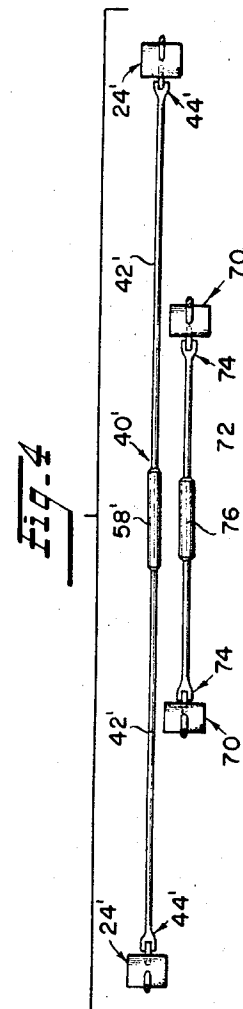
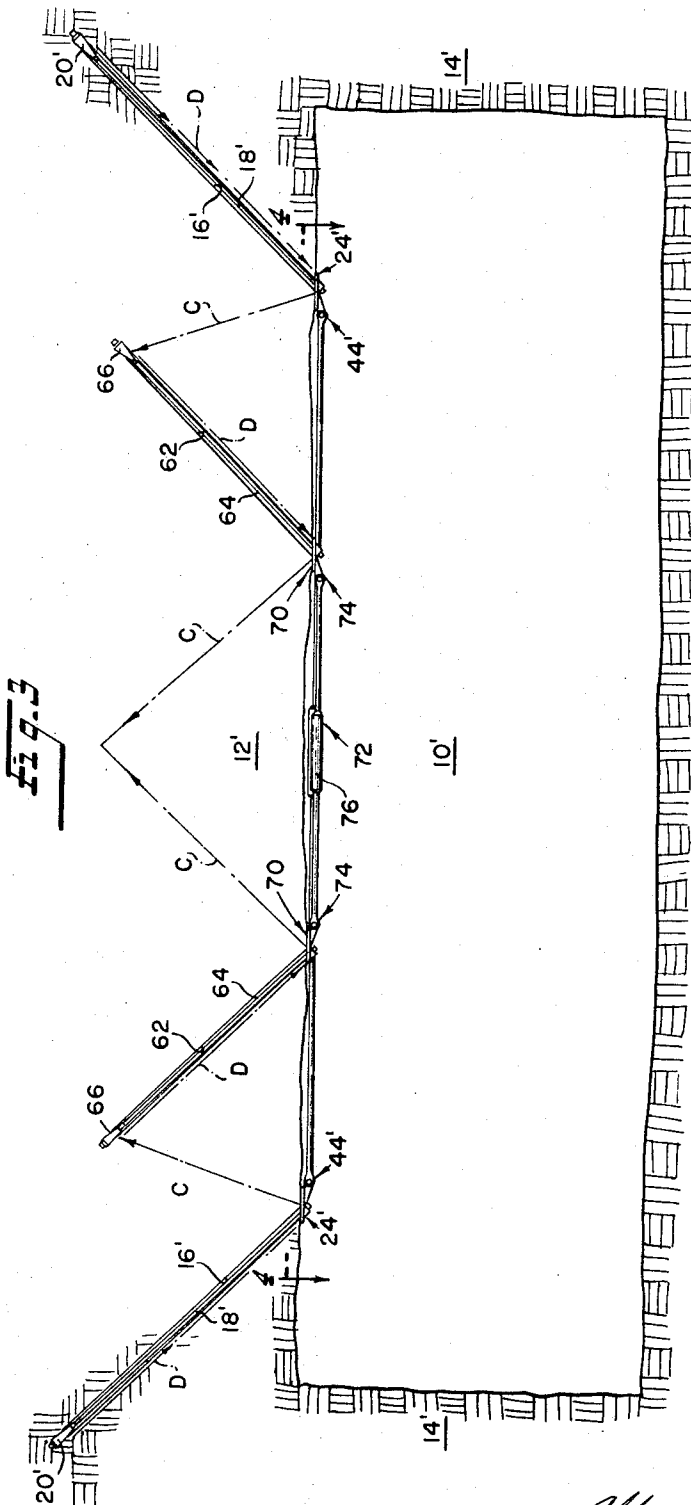
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Fig. 5

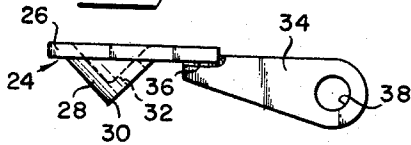


Fig. 7

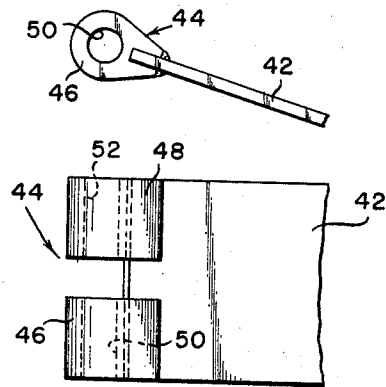


Fig. 6

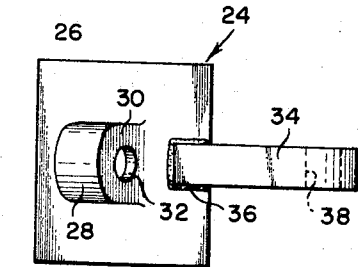


Fig. 8

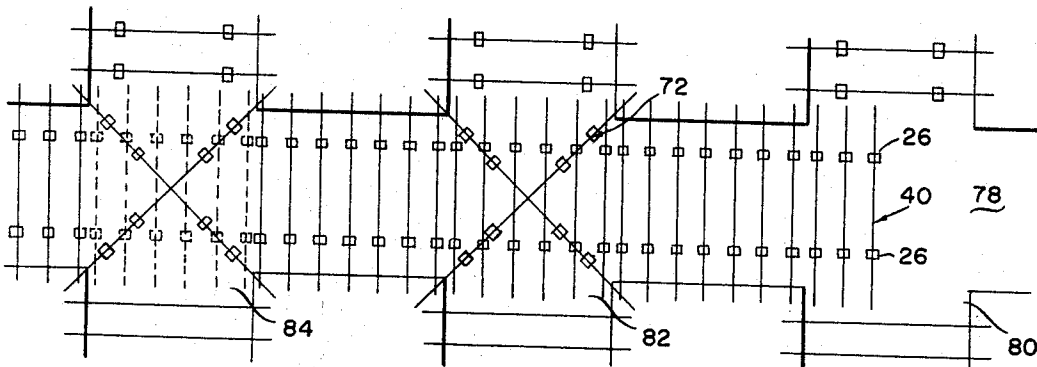
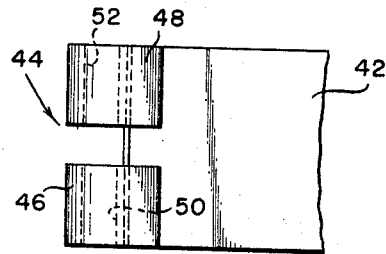


Fig. 9

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MINE ROOF SUPPORT SYSTEM

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13 Claims

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ABSTRACT OF THE DISCLOSURE

A roof support for underground mines and openings embodying angular roof bolts installed in the mine roof and extending above the pillars of the mine in opposed relationship, prestressed reinforcing members extending between the roof bolts subjacent the roof, utilizing the inherent compressive strength of the roof masonry to form a reinforced prestressed masonry beam or a combination reinforcing member masonry roof truss in the existing roof which spans the opening, a plurality of the support members being positioned in spaced parallel relationship transversely of the mine passage and diagonally at the intersection of mine openings, a second roof support member being installed inwardly of the first roof support in openings where a large area of roof is to be supported.

This invention relates to the roof support of underground mines and openings.

Prior art systems and objects

Existing systems for roof bolting mines act to support the roof in two ways; first, the roof strata immediately above the openings are suspended from beds higher up which are stronger or are above the compression arch; secondly, roof bolts act to squeeze many rock beds of varying strengths together to form a deep monolithic beam, thereby reducing horizontal tensile and compressive stresses and increasing horizontal shear strength in beams so formed. Nevertheless, in many areas, these roof bolting systems have proven ineffective due to the fact that roof bolting alone does not provide additional shear strength near the pillars, nor does it produce the monolithic beam effect in fractured strata or conglomerates. It has further been determined that the tendency for a mine roof to break and fall is not only due to its own weight but also to expansion of higher strata, plastic flow of beds over pillars, compression of pillars and mountain building stresses over huge areas of the earth's crust.

It is an object of this invention to provide a roof support for underground mines and openings embodying anchor members installed in the roof above the pillars of the opening in a manner which utilizes the inherent compressive strength of the roof masonry, the anchor members being connected by a reinforcing member to form a vertical reinforced prestressed masonry beam or a combination reinforcing member masonry roof truss in the existing mine roof.

Another object is to provide a roof support including mine roof bolts having expansion shells installed in the mine roof under tension over the pillars of an opening and in opposed relationship, a reinforcing member under tension extending between the lower terminals of the bolts, and means between the opposed mine roof bolts for producing uplift of the roof intermediate the bolts.

A further object is to provide a roof support of the character described wherein there is provided positive calculable relief of vertical shear stresses at the pillar line and positive calculable support for fractured roof.

A further object is to provide a roof support including reinforcing members prestressed to reach the optimum unit stress after sag or expansion of the roof.

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A still further object is to provide a roof support a plurality of which are installed transversely of a passage in a mine in spaced parallel relationship, primary and secondary supports being provided for wide passages and for diagonal installation at the intersection of passages.

Other objects will be manifest from the following description of the presently preferred forms of invention taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a plan view of the roof support of the present invention illustrating its application;

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1 looking in the direction of the arrows;

FIGURE 3 is a plan view similar to FIGURE 1 illustrating a modified form of the roof support of the present invention;

FIGURE 4 is a sectional view taken along the lines 4—4 of FIGURE 3 looking in the direction of the arrows;

FIGURE 5 is a side elevational view of a roof plate constructed in accordance with the present invention;

FIGURE 6 is a plan view of the same;

FIGURE 8 is a plan view of the same, and FIGURE 9 is a diagrammatical view of the roof support of the present invention illustrating the use thereof in an underground mine.

Referring now in greater detail to the drawings there is illustrated in FIGURE 1 an underground mine including a passage 10, a roof 12 and pillars 14, the passage being approximately 20' in width or narrower.

In accordance with the objects of the present invention holes 16 are drilled a few feet from pillars 14 at an angle to the roof line, an angle of approximately 45 degrees having been found to give optimum results. As shown in FIGURE 1, holes 16 extend an appreciable distance above pillars 14. A roof bolt 18 is inserted in each hole, the upper terminal of which bolt is engaged with an expansion shell 20 which may be of the construction set out in my previously granted Patent Number 3,104,582. The head of bolt 18 is indicated at 22. A roof plate generally designated 24 is adapted for placement against roof 12 at the locus of opening 16.

As shown to advantage in FIGURES 5 and 6 roof plate 24 includes a flat body portion 26, a central portion of which is deformed as indicated at 28 forming an angular wall 30 having an aperture 32 adapted to receive a shank portion of bolt 18 adjacent head 22. Roof plate 24 is further provided with a link 34, one terminal of which is welded or secured in any other suitable manner at 36 through a central peripheral part of body portion 26 opposite aperture 32. The terminal link 34 remote from body portion 26 is provided with a transverse aperture as indicated at 38.

In conjunction with roof bolts 18, there is provided a reinforcing assembly 40 including a pair of straps 42, one terminal of each of which is clamped to a connector generally designated 44. Connector 44 includes a pair of spaced knuckles 46 and 48 having transverse apertures 50 and 52 respectively. The space between knuckles 46 and 48 is adapted to accommodate link 34 of roof plate 24, with apertures 50, 38 and 52 aligned for the reception of a retention pin 54 for hinging roof plate 24 and connector 44.

Intermediate the length of assembly 40, at a point centrally of the passage opening 10, the free terminals of straps 42 are threaded at 56 for engagement with a turnbuckle 58. By tightening the turnbuckle, tension is exerted on strap 42 in a well known manner, in accordance with the objects of the present invention.

Bolts 18 and straps 42 are preferably of steel construc-

tion, but other materials having similar strength characteristics may be employed if desired.

The degree of desired prestressing for a particular area of a mine can be readily computed from measurements obtained of roof sag made at regular intervals up to the hour of collapse. It has been determined in certain coal mining areas in the United States that after the roof of a 15' wide room sags 3" at the middle, the roof will in all probability collapse within a few days. Therefore, the reinforcing assembly should be tightened to reach a stress of slightly less than its ultimate strength when the roof has sagged 2½". At that time, nearly all the self-supporting capabilities of the roof material itself will have been utilized before the breaking point of the reinforcing material is reached. In this way, a minimum of reinforcing members is required.

Embodiment of the invention in FIGURE 1

In FIGURE 1, there is illustrated the present invention installed in a passage of 20' or less in width. As shown, holes 16 are drilled a few feet from pillars 14, preferably at an angle of approximately 45 degrees and extending well above the pillars. Bolts 18 are inserted in hole 16 and tightened to a degree determined from experiment and calculations. Reinforcing assembly 40 is next positioned by affixing straps 42 and connectors 44 to roof plate 24. Wooden blocks 60 are interposed between straps 42 and the mine roof. Turnbuckle 58 is next tightened to a predetermined tension, which produces uplift at the wooden blocks, as indicated at A and at the locus of plates 24 as indicated at B.

The uplifting force produced is greater than support obtainable from the type of large wooden beams widely used in mines. As an example, bolt 18 was tightened to produce a tension of 30,000 lbs., the same tension being applied to reinforcing assembly 40 by tightening turnbuckle 58. The resulting force of these tensions at roof plate 24 in the direction indicated by arrows at B was 14,700 lbs. The uplift force in direction A was 5,700 lbs. The size of the reinforcing members and the prestressing determined the uplift figures for a given sag, which is of the utmost importance since to endeavor to prevent sag or displacement in most cases is futile.

The apparatus of the present invention preferably reinforces the masonry roof of mine or tunnel with prestressed steel members to produce prestressed masonry beam effects, utilizing the inherent high compressive strength of the room material in situ. The roof bolts are anchored in holes drilled in the roof and are drawn tight, then the turnbuckles are tightened until the stress in the steel produces the optimum compression or uplift in the roof rock. The optimum stress in the steel is the point at which upon further loading due to sag of the roof, both masonry and steel would be stressed to failure at the same time.

The present roof support further minimizes tensile stresses high above the pillar line and in the lowest strata at the middle of the span of the passage, since the tensile stresses are a maximum at these points. Relief of vertical shear at the pillar line results from the uplifting forces exerted on the plates at the mouth of the angular openings 16.

Embodiments of FIGURES 3 and 4

In FIGURES 3 and 4, there is illustrated the form of the present invention which is particularly adapted to support mine roofs of passages which are more than 20' in width and also to support roofs in passages of narrower width at the point of intersection of two passages.

In this embodiment of the invention, a similar arrangement to that shown in FIGURE 1 is employed and accordingly, like parts are identified by like primed numbers.

Additionally, a secondary, similar roof supporting structure is located adjacent to, but in spaced parallel relationship with the primary roof supporting structure. The sec-

ondary roof supporting structure includes roof openings 62 which are also drilled preferably at an angle of approximately 45 degrees to the mine roof and in predetermined spaced parallel relationship with respect to openings 16' of the primary roof supporting structure. Openings 62 are adapted to receive mine roof bolts 64 having expansion shells 66 and heads 68 at the opposite end adapted for engagement with roof plates 70 which are similar to roof plates 24 and 24'.

Roof plates 68 are adapted for connection with a reinforcing assembly 72, which is similar to reinforcing assembly 40 illustrated in FIGURE 1, and also reinforcing assembly 40' illustrated in the present form of the present invention. Reinforcing assembly 72 includes strap member 74 a terminal of which is engaged with a connector 74 for engaging the strap with roof bolt 64. Connector 74 is of the same construction as connector 44 and 44'. The free terminals of strap 74 are threaded for engagement with a turnbuckle 76. In the embodiment of the invention illustrated in FIGURES 3 and 4, tension is placed on reinforcing assemblies 40' and 72 and on bolts 18' and 64 to produce a stress pattern similar to a bridge truss, and illustrated by the force lines of FIGURE 3.

In this connection it is pointed out that the force lines designated C indicate the upward forces exerted by the present assembly and D the downward forces exerted thereby. The placement of the present apparatus relieves the tensile stresses in the rock while producing negligible unit compressive stresses.

In the embodiment of the invention illustrated in FIGURES 3 and 4, the secondary roof supporting system is preferably positioned approximately 6" from the primary roof supporting structure with the roof supported on 4' foot centers.

Embodiment of FIGURE 9

In FIGURE 9 there is illustrated a diagrammatic showing of a mine including a longitudinal passage 78 and transverse passages designated 80, 82, and 84. In accordance with the system of the present invention, a series of roof supports of the type illustrated in FIGURE 1 are installed transversely above passages 78, 80, 82 and 84 in spaced, parallel relation. When intersecting passages 80, 82 and 84 are cut into the main longitudinal passage 78, a greater roof area must be supported to prevent collapse at that point. Accordingly, as illustrated in FIGURE 9 at the intersection of passages 78 and 82, roof supporting structures of the type illustrated in FIGURE 3, embodying primary and secondary roof supports are installed diagonally across the intersection. After installation has been completed and the proper tension placed on the primary and secondary roof supports, then, as illustrated at the intersection of passages 78 and 84, those roof supports extending transversely of opening 78 in parallel spaced relationship may be removed, as indicated by the phantom lines at the intersection.

In this way, an effective and efficient means is provided for controlling the sag of a mine roof and, at the same time preventing roof collapse.

In installation of the roof support of the present invention, the uplift can easily be determined by placing a small hydraulic jack under the wooden blocks 60 and from this determination and the geometry of the installation, the tension and uplift at the roof plates may be determined graphically. The size of the various reinforcing members and the prestressing determine the uplift figures for a given sag.

While there have been herein shown and described preferred embodiments of the present invention, it is to be understood that various changes may be made therein such as the use of rods, plates, wires, cables or other suitable members in place of those illustrated and also the varying of the angularity of the installation of the roof bolts in the mine roof. Various other changes may be made within the scope of the claims hereto appended.

Having thus described my invention what I claim is:

1. A mine roof support including:
 - (a) anchor members installed in the mine roof above a mine passage in spaced opposed relationship,
 - (b) said anchor members extending angularly to the mine roof with the uppermost portion thereof located above the pillars of the mine passage,
 - (c) a reinforcing member extending transversely of the passage,
 - (d) the terminals of said reinforcing member being secured to said anchor members, and
 - (e) means for exerting at least approximately equal tension on said reinforcing member and anchor members under tension to prevent collapse of the mine roof.
2. The mine roof support of claim 1 wherein:
 - (a) said anchor members are installed at approximately a 45° angle to the mine roof.
3. The mine roof support of claim 1 wherein:
 - (a) said means exert substantially equal tension on said reinforcing members and anchor members.
4. The mine roof support of claim 1, with the addition of:
 - (a) anchor members installed in the mine roof inwardly of the pillars and in opposed relationship, and
 - (b) a reinforcing member extending between said inwardly installed anchor members.
5. The mine roof support of claim 1, wherein:
 - (a) a plurality of said anchor members and reinforcing members are arranged in spaced parallel relationship extending transversely of the roof in the mine passage.
6. The mine roof support of claim 1, with the addition of:
 - (a) block means interposed between said reinforcing member and the mine roof,
 - (b) said block means being spaced inwardly of said anchor members.
7. The mine roof support of claim 4, with the addition of:
 - (a) means for exerting substantially equal tension on said anchor members and reinforcing member installed inwardly of the pillars.
8. A mine roof support for a mine passage having pillars, including:
 - (a) spaced, opposed roof bolts installed in angular relationship in the mine roof,
 - (b) the upper ends of said roof bolts extending above the pillars of the mine passage,
 - (c) an expansion shell threadedly engaged with the upper terminal of each roof bolt for anchoring the bolt in position,
 - (d) a reinforcing member extending between the lower terminals of said roof bolts,

- (e) means for tightening said roof bolts to a predetermined tension, and
- (f) means for exerting tension on said reinforcing member in a direction away from the bolts,
- (g) the tension on said reinforcing member being at least approximately equal to the tension on said roof bolts.
9. The mine roof support of claim 8, wherein:
 - (a) said roof bolts are installed at approximately a 45° angle to the mine roof.
10. The mine roof support of claim 8, with the addition of:
 - (a) block means interposed between said reinforcing member and the mine roof intermediate the length of the reinforcing member, for exerting an upward force on the mine roof at that point.
11. The mine roof support of claim 8, wherein:
 - (a) said reinforcing member includes a pair of strap members, one terminal of each of which is connected to one of said roof bolts, and
 - (b) tensioning means for receiving the free terminals of said strap members.
12. The mine roof support of claim 11, wherein:
 - (a) said tensioning member is a turnbuckle.
13. A mine roof support for a mine passage having pillars, including:
 - (a) spaced, opposed roof bolts installed in angular relationship with the upper ends thereof extending above the pillars of the passage,
 - (b) an expansion shell threadedly engaged with the upper terminal of each of said roof bolts for anchoring the bolt in position,
 - (c) plate means adjacent the lower terminal of each roof bolt through which said roof bolt passes, for exerting an upward force on the mine roof,
 - (d) a reinforcing member comprising a pair of tensioning members extending between said plate means,
 - (e) means for exerting tension on said roof bolts, and
 - (f) means for exerting at least approximately equal tension on said reinforcing member in directions away from said roof bolts.

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U.S. Cl. X.R.

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