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DEVICE FOR THE CONTROLLED YIELDING OF AN UNDERGROUND OPENING

Filed Dec. 21, 1967

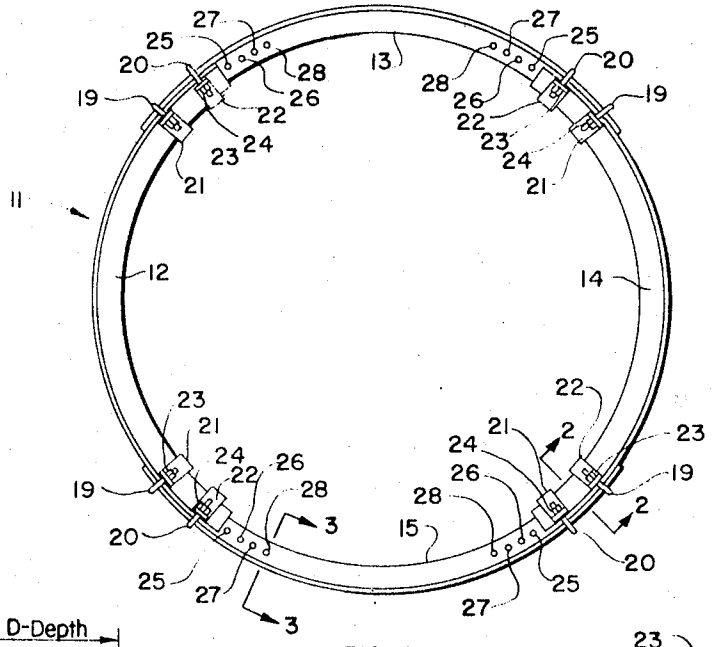


FIG. 1

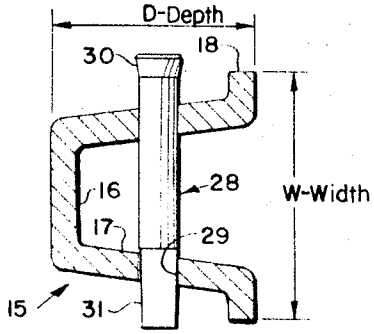


FIG. 3

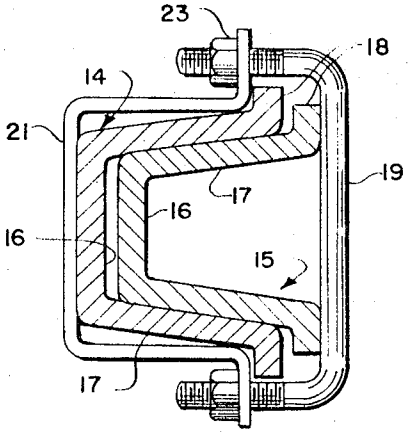


FIG. 2

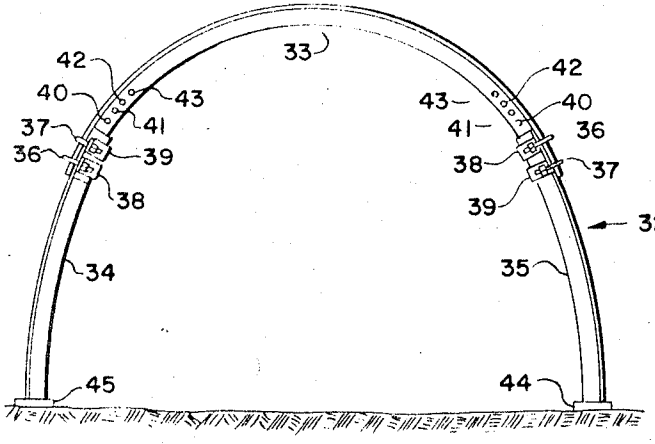


FIG. 4

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DEVICE FOR THE CONTROLLED YIELDING OF AN UNDERGROUND OPENING

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U.S. Cl. 61—45 9 Claims

ABSTRACT OF THE DISCLOSURE

A device for the controlled yielding of an underground opening which opening includes a floor, roof and ribs (or floor, back and walls), the device comprising both roof-supporting means and rib-supporting means adapted to support the roof and ribs of the opening. The roof-supporting means is slidably connected to the rib-supporting means in overlapping relationship and shearing means, extending through one of the supporting means and comprising a plurality of shear pins of known shear strength and at least one shear pin of substantially greater shear strength, is disposed adjacent the juncture of the side-supporting means with the roof-supporting means and adapted to shear when the roof-supporting means slides with respect to the rib-supporting means. The shear pin of greater shear strength is disposed further from the juncture of the rib-supporting means with the roof-supporting means than the plurality of shear pins.

BACKGROUND OF THE INVENTION

Field of the invention

The invention relates to underground mining; and, more particularly, to means for controlling the yield of an underground opening.

Description of the prior art

Yieldable support arches are used during mining operations to maintain haulage-ways in deep mines. In underground openings, such as mined-out tunnels, a tension arch exists in the roof or back of the opening. This arch generally extends upward to one-third of the width of the opening. The tension arch, or "coffin cover" as it is aptly called by German miners, is a very real hazard because of the low tensile strength of rock.

In the prior art, steel sets have been used in an attempt to support the entire weight of the rock above a tunnel without success excepting where the tunnel was relatively close to the surface. The reason for this is that the underground openings slowly settle until a natural pressure arch is formed by the surrounding formation. During this settling, the mine support arches must yield or they will be failed by the large forces. Thus, the steel sets (or the blocking of the tunnel) must either deform or yield. An ideal mine support device would be one that survives the "punch" of the peak load, "rolls with it" and remains intact to support the stable loads. Yieldable supports are used to prevent failure while the rock slowly forms its own natural arch. As the support yields, the forces are transferred to the surrounding rock which will then carry the major share of the load. Unless this transfer of load takes place under controlled conditions, the steel sets are subject to failure.

Conventional steel sets commonly used in underground mines have sliding frictional force at their overlapping joints as a yieldable feature. Accurate control of this yield is virtually impossible. As discussed hereinabove, the principle of yieldable support is to prevent failure while the ground slowly forms its own natural

arch. As the support yields, the forces are transferred to the surrounding ground, with the result that a natural pressure arch is formed which will carry the major share of the load. The successful functioning of yieldable sets depends on their ability to yield the right amount at the right time. In the mining industry, the present method of controlling the yield of these arches utilizes bolts and nuts which are tightened manually. Should the nuts be too tight, the arch sets will fail, or if they are too loose, the benefit of the arch is lost. In other words, the nuts should never be tightened excessively since the joints must be allowed to yield under heavy loads or the steel set could be destroyed. Such yieldable arches are used primarily in main and secondary haulageways in deep mines. Conventional yield supports depend on friction between the segments and this results in a wide variation in the point at which a set yields under load.

SUMMARY OF THE INVENTION

It is an object of this invention to control accurately the yield of a yieldable mine support as the ground forces of the mine are applied.

It is a further object of this invention to eliminate human error involved in the proper installation of support sets for the controlled yielding of a yieldable mine arch.

It is a still further object of this invention to prevent the failure of arch sets used in the controlled yielding of a yieldable mine arch.

It is a further object to facilitate the in situ measurement of rock strain in underground mines.

These objects are carried out by providing a device which includes roof-supporting means and rib-supporting means adapted to support the roof and ribs of an underground opening. The roof-supporting means is slidably connected to the rib-supporting means in overlapping relationship and shearing means, extending through one of the supporting means and comprising a plurality of shear pins of known shear strength and at least one shear pin of substantially greater shear strength, is disposed adjacent the juncture of the rib-supporting means and adapted to shear when the roof-supporting means slides with respect to the floor-supporting means. The shear pin of greater shear strength is disposed further from the juncture of the rib-supporting means with the roof-supporting means than the plurality of shear pins.

The device may comprise either a ring or an arch set.

BRIEF DESCRIPTION OF THE DRAWING

FIGURE 1 is an elevational view of a device in accordance with the teaching of the invention;

FIGURES 2 and 3 are sectional views taken along lines 2—2 and 3—3 of FIGURE 1, respectively; and

FIGURE 4 is an elevational view of an alternate embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, FIGURE 1 illustrates a yieldable ring support **11** adapted to be used to support the roof, ribs and floor of an underground opening as is well known in the mining art. Throughout this specification, roof, ribs and floor of an underground opening, such as a coal mine, are considered to correspond to the roof (or back), ribs (or walls) and floor of an underground opening, such as a metal mine. Actually, a plurality of rings will be used in a normal supporting operation; however, for the purposes of this invention, one such ring will be described.

Ring **11** is divided into a plurality of overlapping ring segments **12** through **15**, the exact number of such segments depending on the size of the opening, engineering

economies, etc. Ring segments **12** through **15** are preferably formed of suitable supporting material, such as rolled steel.

As can best be seen in FIGURE 2, each ring segment comprises a substantially U-shaped channel member which includes a bottom portion **16**, outwardly extending side portions **17** and outwardly extending lip portions **18** parallel to the bottom portion **16**. For purposes of illustration, the spacing between segments **14** and **15** has been exaggerated in FIGURE 2.

Each pair of overlaping ring segments is fastened together by suitable securing means, such as a pair of U-bolts **19** and **20** which overlap the lip portions and have leg portions extending into openings in U-shaped clamp bars **21** and **22**, respectively. U-bolts **19** and **20** are secured to clamp bars **21** and **22** by nuts **23** and **24**, respectively. Although a preferred type of securing means has been disclosed, obviously the ring segments **12** through **15** may be secured together in any manner that will draw the segments into overlapping arrangement so as to form an integral ring whereby one segment is slidable with relation to the other.

Each ring segment includes a plurality of spaced pins, as for example, three shear pins **25** through **27** followed by a "rigid arch" pin **28**, adjacent its juncture with a preceding ring segment. The spacing of pins **25** through **28** are varied to suit the specific mining conditions encountered as will be explained further hereinbelow.

Pins **25** through **27** are preferably ½" diameter bolts of cold rolled 0.2% C steel, having a shear strength (S_s) of approximately 120,000 p.s.i. Accordingly, a value of S_sA, where A equals the cross-sectional area of the bolt, results in a bolt having a shear strength in pounds of approximately 23,500 lbs.

Pins **28** are preferably ½" diameter bolts of oil quench 0.8% C steel having a shear strength (S_s) of approximately 300,000 p.s.i. resulting in a shear strength of approximately 48,200 lbs. Although specific values have been set forth for preferred materials of specific shear strengths, obviously, any suitable material of similar shear strength may be used depending again on the specific mining conditions encountered, engineering economies, etc.

Referring now to FIGURE 3, it can be seen that one of the pins **28** is illustrated as passing through a hole or opening **29** drilled or otherwise formed through the neutral axis of segment **15**, i.e., the axis in ring **11** where the steel fibers are not stretched or compressed. Pin **28** includes an enlarged head portion **30** and a lower tapered portion **31** so that pin **28** snugly fits in the opening **29** in segment **15**. As can be seen in FIGURE 3, the preferred dimensions for segment **15** is a width (W) of approximately 4", a depth (D) of approximately 5" and a thickness of approximately ⅜" or more. The circumference of the ring **11** will obviously depend on the size of the underground opening. The remaining pins **25** through **27** are similar to pin **28** and are disposed in segments **12** through **15** in like manner as pin **28**.

With this arrangement, a series of shear pins of known shear strength is provided which gives an accurate controlled yield of the rings and prevents their failure. The pins, as discussed hereinabove, are of extremely accurate shear strength.

The controlled yield is obtained by means of the multiple shear pins being spaced at intervals from each other. When a pin is sheared, such as pin **25**, there is provision for free movement (i.e., contraction of the ring) before the next pin **26** is encountered. This free movement facilitates a necessary and desirable transfer of forces to the underground opening with subsequent formation of a natural arch by the immediate surrounding rock. The terminology of "free movement" is used in a literal sense since there is a sliding restrictive friction force, which may be in the order of 10,000 pounds, for example, at the overlapping joints of the ring (i.e., the

overlapping ring segments). This is a desirable feature in that yielding of the set to the contact point of the next shear pin provides the so-called "roll-with-it" action.

The number, spacing and strength of pins **25** through **28** may be designed to fit actual mining conditions. The last shear pin in the sequence, that is, pin **28** in FIGURE 1, may be designed to function in any of the following ways: (1) to fail just below design strength of the ring; (2) not to fail, e.g., the last shear pin is designed as a stop point and further loading distorts the ring; and (3) a tell-tale shear pin that deforms rather than shears. This latter feature incorporates a pin comprised of two different strength steels; a soft steel to deform backed by a high strength steel to resist shear failure. A pin may be formed of an outer core of soft steel surrounded by an inner core of stronger steel. The shear pin features of this invention have the advantage of facilitating erection of rings in a uniform, consistent manner throughout mine haulage ways. The in situ measurement of rock strain of an underground opening may be facilitated by use of shear pins as measurement and reference points. The economic significance of the strain data is the indicated possibility of a much lower design base which may be safely used in rock tunneling in blocky and jointed rocks.

Although the invention has been described hereinabove with reference to a ring, the techings thereof also include arch sets, such as conventional cap and posts. This is illustrated in FIGURE 4 wherein an arch set **32** is illustrated which comprises a curved cap portion **33** adapted to abut against the underside of the roof of an underground opening and braced by a pair of curved legs or posts **34** and **35** disposed at each end of cap portion **33** adapted to abut against the ribs of the underground opening. Arch set **32** is illustrated in FIGURE 4 as comprising a cap portion and posts similar in form to the ring segments **12** through **15** described in detail hereinabove; however, obviously, the arch set may take a variety of configurations, such as linear, solid members, etc., depending on the formation to be supported.

As illustrated in FIGURE 4, cap portion **33** is fastened to posts **34** and **35** by suitable clamping means, such as U-bolts **36** and **37** and clamp bars **38** and **39**, similar in construction to bolts **19** and **20** and bars **21** and **22** previously described. Posts **34** and **35** carry shear pins **40** through **42** adjacent their juncture with cap portion **33** which conform to shear pins **25** through **27**; pin **43** conforms to the rigid arch pin **28** which may or may not shear as discussed hereinabove. Posts **34** and **35** also include base portions **44** and **45**, respectively, disposed at their lower ends and adapted to rest on the floor of the underground opening as is well known in the mining art.

Pins **40** through **43** are disposed in posts **34** and **35** in the same manner as pins **25** through **28** are disposed in segments **12** through **15** as illustrated in FIGURE 3 and discussed hereinabove. Accordingly, further discussion is deemed unnecessary.

In summary, a novel arrangement has been disclosed hereinabove for the controlled yielding of yieldable mine arch and ring sets. The shear pins of the invention may be selected from materials providing a varying degree of shear strength. Although the shear pins have been illustrated as located in specific areas on the ring and arch set of FIGURES 1 and 4, respectively, obviously, they may be located anywhere on the ring or arch set in accordance with the teachings of the inventions.

I claim as my invention:

1. A device for the controlled yielding of an underground opening which opening includes a floor, roof and ribs, the device comprising:

roof-supporting means adapted to support the roof of said opening;

rib-supporting means adapted to support the ribs of said opening;

connecting means for connecting said rib-supporting means to said roof-supporting means in overlapping sliding relationship;

shearing means extending through one of said supporting means and disposed adjacent the juncture of said rib-supporting means with said roof-supporting means and adapted to shear when said roof-supporting means slides with respect to said rib-supporting means;

said shearing means including a plurality of shear pins of known shear strength and at least one shear pin of shearing strength substantially greater than the shear strength of said plurality of shear pins; and

said shear pin of greater shear strength being disposed further from the juncture of said side-supporting means with said roof-supporting means than said plurality of shear pins.

2. The device of claim **1** wherein all of said shear pins are aligned with each other along the longitudinal axis of said device.

3. The device of claim **1** wherein all of said shear pins are disposed along the neutral axis of said roof-supporting means.

4. The device of claim **3** wherein all of said shear pins include a head portion and a tapered end portion adapted to fit snugly in openings in said roof-supporting means.

5. The device of claim **1** wherein said shear pin of greater shear strength includes failure means adapted to fail said pin of greater shear strength at a point just below the design strength of the device.

6. The device of claim **1** wherein said shear pin of greater shear strength includes non-failure means adapted not to fail said pin of greater strength until said device fails.

7. The device of claim **1** wherein said shear pin of greater shear strength comprises soft steel adapted to deform backed by high strength steel adapted to resist shear failure so that said pin of greater shear strength deforms rather than shears.

8. The device of claim **1** wherein said side-supporting

means and said roof-supporting means comprise U-shaped overlapping members of rolled steel having a depth of approximately 5" and a width of approximately 4";

said plurality of pins comprising ½" diameter cold rolled 0.2% C steel bolts having a shear strength of approximately 120,000 p.s.i.; and

said pin of greater shear strength comprising a ½" diameter oil quench 0.8% C steel bolt having a shear strength of approximately 300,00 p.s.i.

9. The device of claim **1** wherein both said roof-supporting means and said rib-supporting means comprise ring segments;

a floor-supporting means adapted to rest on the floor of said underground opening comprising a further ring segment connected to said side-supporting means in sliding relationship thereby forming a ring with said roof-supporting means and said side-supporting means; and

second shearing means similar to the first-mentioned shearing means being disposed adjacent the juncture of said rib-supporting means with said floor-supporting means and adapted to shear when said floor-supporting means slides with respect to said rib-supporting means.

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JACOB SHAPIRO, Primary Examiner

U.S. Cl. X.R.

52—232: 248—356: 285—2