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ROOF BOLT WITH A FLEXIBLE TENSION MEMBER AND
CUP-SHAPED EXPANSIBLE SECURING MEANS
Filed May 28, 1959 2 Sheets-Sheet 1

Fig.1.

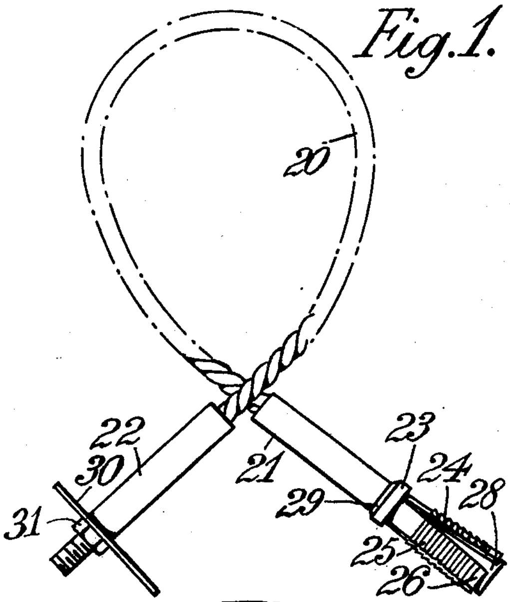


Fig.4.

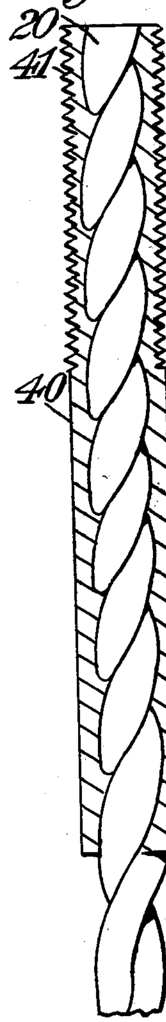


Fig.2.

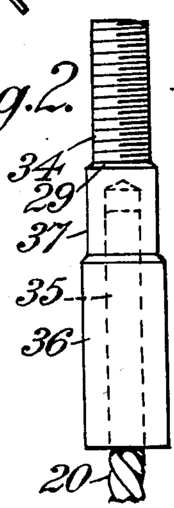
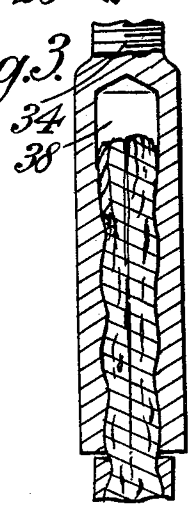


Fig.3.



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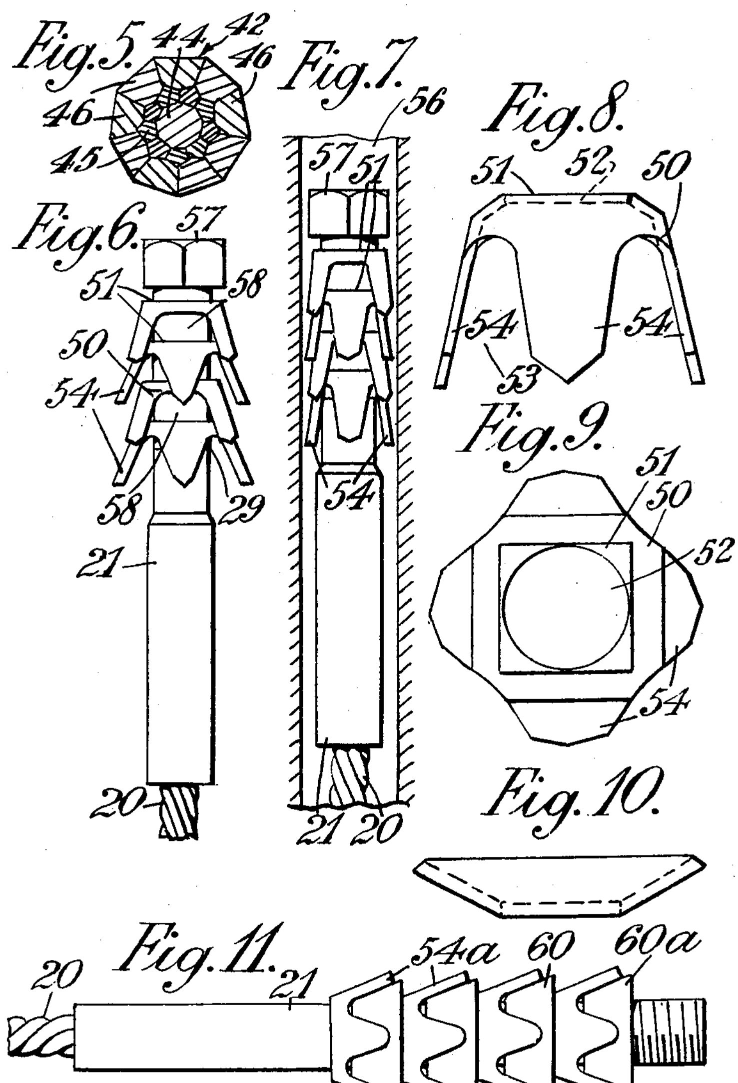

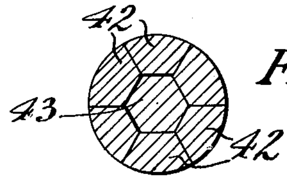

Fig.5A.

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ROOF BOLT WITH A FLEXIBLE TENSION MEMBER AND CUP-SHAPED EXPANSIBLE SECURING MEANS

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1 Claim. (Cl. 85—2.4)

The invention relates to tie-bolts of the kind having an elongated tension member for insertion into a blind hole (e.g. bored in clay, rock, stone or masonry) to one end of which member is attached an expansible securing means for making holding engagement with the walls of the hole at a position remote from the open end thereof (e.g. at or near the blind end) and at the other end, there is attached a screw compression means, arranged to bear onto the rock or other surface around the mouth of the hole and to apply pressure to this and, preferably, the surrounding area. Such tie bolts have many practical applications. They are, for example, commonly used in mines (both metalliferous and carboniferous) as roof supports, and will hereinafter be referred to as roof bolts, without intending thereby any limitation of the invention to the supporting of roofs. Roof supports are required, for example, when mining operations are being conducted in rock strata which have become badly faulted and broken up, and the bolts are employed to hold or secure the broken strata to the overlying solid rock whilst working and removal of rock, or ore, proceeds. To this end blind holes (usually several feet deep) are drilled to a prescribed pattern through the broken strata into the solid rock; the roof bolts are then inserted into the holes and the securing means in the blind hole actuated, usually by rotation of the roof bolt, to cause it to expand into holding engagement with the solid rock. The screw compression means is then tightened up against the face of the broken strata, preferably with the aid of a pneumatic torque wrench, to a prescribed ft./lbs. torque load (the amount of which is determined by the type of ground being worked), whereby the bolt acts, under tension, to secure the broken strata to the solid rock.

In roof bolts as at present constructed, the tie member is of rigid construction which, in some circumstances, makes insertion and removal of the bolts a time consuming, if not impracticable, operation, especially in confined spaces (i.e. low headings) and/or in cases, as can frequently occur, where drills have wandered and the hole is not straight.

It is an object of this invention to avoid or reduce these difficulties.

The invention provides a roof-bolt comprising an elongated tension member comprised of a length of flexible steel wire, cable or rope to each end of which is secured a screw threaded end piece, an expansion shield or other expansible securing device attached to one of the end pieces for engagement in the hole and on the other end piece a nut and a bearing plate for engagement under pressure from the nut with the surface to be supported.

Preferably the cable or rope is capable of transmitting a substantial torque load in each direction, without unlaying. Thus the rope may comprise rope strands laid one hand over core strands or core wires laid the other hand. It is further preferred that the rope has the construction described in United States Patent 2,978,860.

Various constructions of expansible securing devices may be used in the invention of which a number are later described.

The end pieces may be attached to the rope or cable in

various ways of which several examples also are given later.

Some specific embodiments of roof bolts according to the invention will now be described, by way of example, and with reference to the accompanying drawings, in which:

FIGURE 1 shows a complete roof bolt,

FIGURE 2 shows one of the end pieces in position on the rope ready for swaging,

FIGURE 3 shows, in section, the end piece and rope of FIGURE 2 after swaging,

FIGURE 4 is a section showing an alternative form of end piece on the end of a rope,

FIGURE 5 is a section through a strand rope used in the bolt,

FIGURE 5A is a quite diagrammatic view in section of a completed rope used in forming the bolt, the windings of the individual strands not being indicated since these are clearly shown in FIGURE 5,

FIGURE 6 is a side view showing one construction of expansion shield,

FIGURE 7 is a view similar to FIGURE 6 but illustrating the operation of inserting the shield into a hole,

FIGURE 8 is an elevation of one of the expansible cups used in the shield shown in FIGURES 6 and 7,

FIGURE 9 is a plan view of the cup shown in FIGURE 8,

FIGURE 10 is an elevation of another form of expansible cup, and

FIGURE 11 is a view, corresponding to FIGURE 6, showing another construction of expansion shield.

In the construction shown in FIGURE 1 the tension member is composed of a length of wire rope **20** to each end of which is secured a screw threaded end piece **21**, **22** co-axial with the end of the rope. The end piece **21** has threaded over it a gripping device, commonly known as an expansion shield, which comprises a short externally and circumferentially serrated tube-like member **23** with, in this example, four equi-spaced longitudinal slits **24** extending from one end almost to the other end, thereby forming four resilient leaves **25**. This tube is made from malelable iron in the form of a casting. In addition to the serrations, each leaf has an axial or longitudinal rib **26** near its free end to provide an anti-rotation key. Fitting within the first-mentioned end of the tube there is a cast, internally threaded, conical nut **28** which is screwed onto the starting end of the thread of the end piece **21** and is arranged, on rotation of the end piece into the nut, to enter between and expand the leaves **25**. A shoulder **29** on the end piece limits the movement of the tube **23** along the end piece.

The end piece **22** passes through a hole in a steel bearing plate **30**, which, in this example, is square or rectangular. There is also a nut **31** screwed onto the end piece.

In use, when it is required to insert the roof bolt, the conical nut **28** is screwed back to permit the leaves **25** to close in and contract to their minimum diameter.

This end of the bolt is then inserted into a prepared hole in the rock or other material it is required to support, until almost the whole length of the bolt is within the hole.

The end piece **22**, of which the screwed portion remains projecting from the hole, is rotated until sufficient torque has been transmitted (usually around 100 ft./lbs.) to draw the conical nut into the tubular member **23** and thereby to separate the leaves **25** into gripping engagement with the walls of the hole.

The bearing plate **30** is then slid over the threaded portion of the end piece **22**, followed by the nut **31**; a pneumatic torque wrench is then set to the desired load and applied to the nut. The plate **30** is thereby brought into pressure engagement with the roof, or other surface it is desired to support, and the cable acts as a tension member which supports the lower or outer structure.

In those cases where it is practicable and desirable to be able to recover the bolts when the workings are abandoned, the aforesaid roof bolt is removed by loosening the nut **31** on the bearer plate, and delivering an upward or endwise blow to the exposed end of the bolt. This drives the conical nut upwards or inwardly of the hole and releases the expansion shield. If necessary or desirable the tension member may be rotated a few turns anticlockwise before the upward blow is delivered, in order to ensure that the shoulder **29** is withdrawn from the end of the shield.

As already stated, various methods of forming and affixing the screwed end pieces to the rope or cable may be adopted. In one method, illustrated in FIGURES 2 and 3, the end piece to be attached has, at one end, an externally threaded portion **34** and at the other end an internal socket **35** coaxial with the threaded portion. Externally the socket portion has two diameters. The end of the rope **20** is inserted into the socket **35** and the portion **36** of larger diameter is swaged or pressed down to at least the size of the smaller portion **37**. This plastically deforms the metal of the socket wall into gripping relation with the rope and also tends to cause the free ends of the component wires of the rope to splay outwardly into the inner, unswaged end **38** of the socket (see FIGURE 3) and to provide an additional key or anchor.

Another method, illustrated in FIGURE 4, is to produce the end piece from a length of tube **40**, into which the end of the cable, or rope **20**, is inserted. The tube is then swaged, over its entire length, onto the cable, or rope, and finally a thread **41** is cut or rolled along the end portion of the tube.

A third method is to insert the end of the cable, or rope, into a tube for about two thirds the length thereof, and swage the tube from the end at which the rope or cable has been inserted, almost to the end of the rope, thereby gripping the rope whilst leaving the ends of the wires free to splay out as already described. A length of screwed rod is then inserted into the other end of the tube, leaving a portion projecting therefrom. Finally, the tube is swaged onto the rod, the swaging being continued until the tube has been deformed firmly into the thread, and the thread itself has been deformed into interlocking engagement with the tube.

The rope used in the above examples, and in those later described, has a cross section such as diagrammatically suggested in FIGURE 5A, comprising six outer strands **42** laid over a core strand **43**. The outer strands **42** and the core strand **43** are preferably of 9 x 9 x 1 construction, as suggested in FIGURE 5, each consisting of a suitable core **44** wound with an intermediate layer of windings **45** and an outer layer of windings **46**. The outer strands **42** are wound around the core strand **43** the opposite hand to the winding of the individual elements of the core strand **43**. The rope is capable is transmitting substantial torque in each direction of rotation and has substantial tensile strength. Furthermore it has a greater resistance to shear than a solid rod, shearing forces sometimes being applied to roof bolts due to rock strata tending to slide on one another.

FIGURES 6–9 show another construction of expansible securing device. In this construction the device comprises a succession of four cup-shaped members **50** strung or threaded loosely over the screw-threaded portion of the end piece **21** against the shoulder **29**. Each of the cup-shaped members **50** has a base **51** with a hole **52** threaded over the end piece and sides which are divided by notches **53** into tongues **54**. The tongues **54** are flexible, or flexibly connected to the base, face along the length of the rope **20** and diverge or tend to diverge, outwardly from

the base so that, as seen in FIGURE 7, the tension member may be pushed into a hole **56** with the bases **51** leading and the tongues **54** compressed against the walls of the hole but withdrawal of the member from the hole is resisted by the tongues **54** engaging the walls of the hole with a toggle action and tending to open outwardly and to dig into the walls. In this construction the expansion is effected by the pull of the cable, without rotation. The cups are held on the end-piece by a nut **57** and separated by collars or distance pieces **58**. The cups are made of a high impact elastomer such as that mentioned later.

The prongs of the several cups in the succession are staggered and they may be of varying lengths. The depth of the notches **53** may also be varied.

In a modification of the above construction, the plastic cups are, as shown in FIGURE 10, shallow and without prongs or tongues. The surface of the cups, or their outer edges may in either construction, be corrugated. Again the peripheral edges or the edge of the tongues may be toothed or serrated.

In the construction shown in FIGURE 11 the four cup-shaped members of the example shown in FIGURE 6 are reversed on the end piece so that their mouths face towards the adjacent end of the member. The tongues **54*a*** or walls of the cups are resiliently biased inwardly. Within each cup there is a tapered (frusto-conical) member **60** adapted by movement into the cup to open out the mouth of the cup (i.e. to spread the tongues). The larger end of each of the intermediate tapered members supports the base of the adjacent cup. The last such member (i.e. the one **60*a*** nearest the end of the bolt) is screwed onto the end piece **21** or there is a nut on the bolt which bears on this member. The cups may be with or without tongues, as described above. In the application of this example, the tapered members are withdrawn to permit the walls of the cups to contract inwardly. The bolt is thrust into the hole with the mouths of the cups leading. Rotation of the tension member will then screw it into the nut or last tapered member, which has the effect of expanding the cups into gripping engagement with the walls of the hole.

A suitable elastomer for the manufacture of the cups is that sold by the British Geon Co. Ltd. under the name R.A. 170 High Impact polyvinyl chloride but other elastomeric substances having similar physical and chemical characteristics may be used.

It is within the invention to replace the succession of cups in each of the constructions described by only a single cup.

The bolts according to the invention may be used for supporting roofs in mines from overlying strata or they may similarly be used for securing mine faces and floors.

We claim:

A roof bolt adapted for anchoring insertion into a blind drill hole in a mine roof or the like, said bolt comprising an elongated tension member comprising a length of flexible multi-strand steel rope, comprising a core strand the outer windings of which are laid in one hand and rope strands laid over said core strand in the hand opposite to the laying of said outer core windings, an end piece at each end of said length of rope each comprising an externally screw-threaded rod portion and a socket portion coaxial therewith, said socket portion receiving and gripping an end of said rope, a radially expansible securing device carried by one of said end pieces and adapted to be inserted first into said hole in installing the bolt and ultimately to be expanded into anchoring contact with the walls of said hole; said expansible securing device comprising a plurality of cup-shaped elements, each comprising a base portion and flaring side portions adapted when the bolt is installed to engage the walls of the hole, said cup-shaped elements being loosely threaded upon the end piece at one end of the bolt and opening toward the adjaient end of said end piece, and a plurality of tapered members loosely threaded onto said end piece one disposed between each of said cup-shaped elements and with its smaller end entering the mouth of that cup of the adjacent pair which is further from the end of the bolt, and serving to press upon and expand said cup-shaped element upon the occurrence of endwise pressure on the cup-shaped elements and connecting members, and a tapered terminal member screw-threaded onto the end piece, having its smaller end entering the end cup-shaped element and said terminal member adapted to move inwardly upon rotation of said bolt to expand its contacting cup-shaped element and to transmit wedging pressure along the succession of alternating cup-shaped elements and tapered intervening members; a bearing plate of greater radial compass than the securing device or the hole itself and having a centrally disposed opening slidably receiving the other of said end pieces and a nut screwed onto said last named end piece over said plate and adapted to be brought to bear thereupon to lock the bolt and its named associated parts in place.

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