Sept. 24, 1963 H. HARRISON 3,104,645

BOLT STRESS INDICATOR

Filed March 22, 1961 2 Sheets-Sheet 1

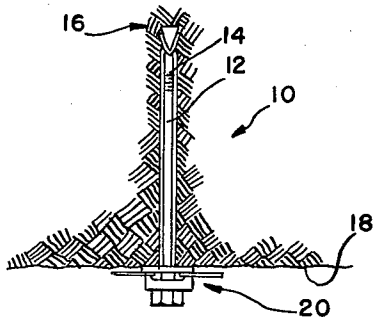


FIG.1.

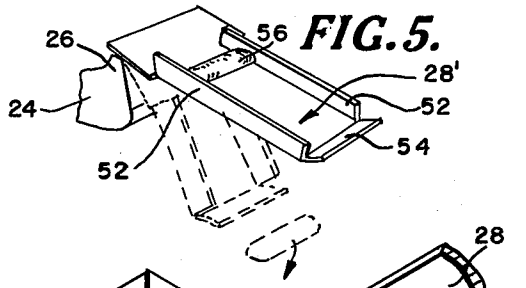


FIG.5.

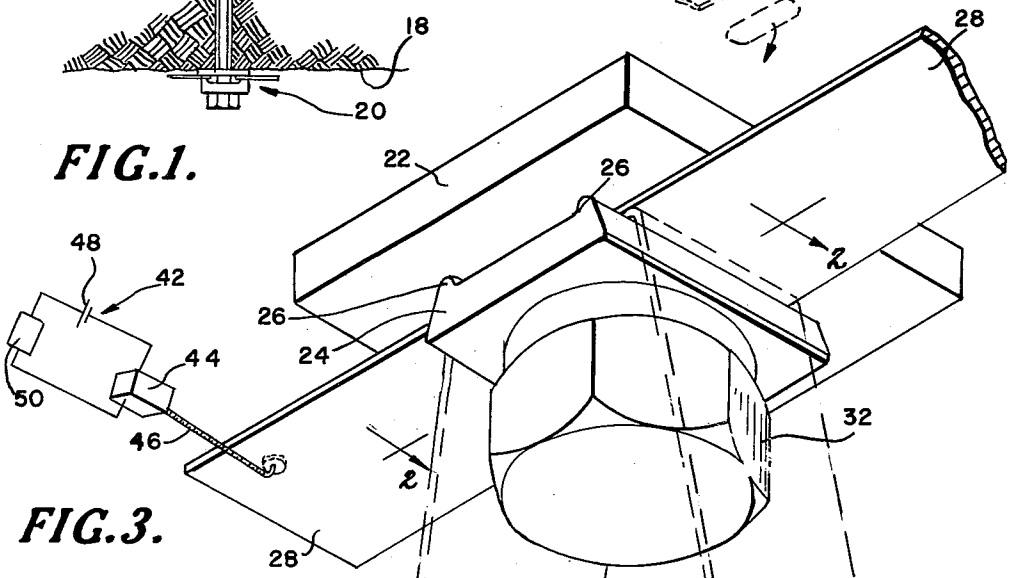


FIG.3.

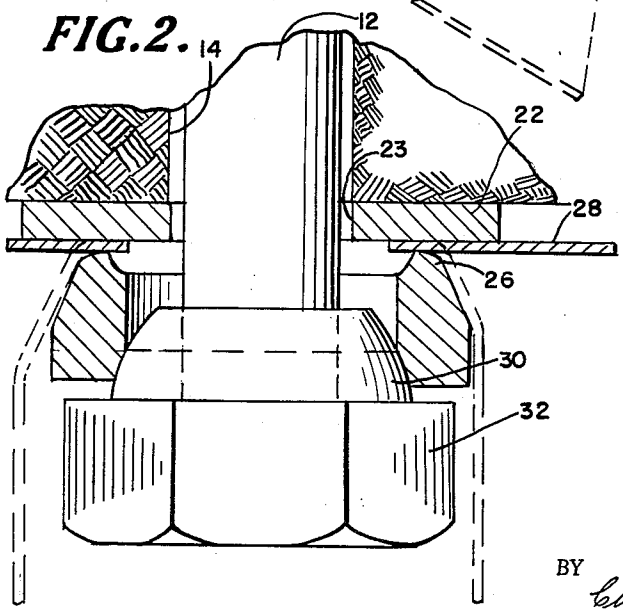


FIG.2.

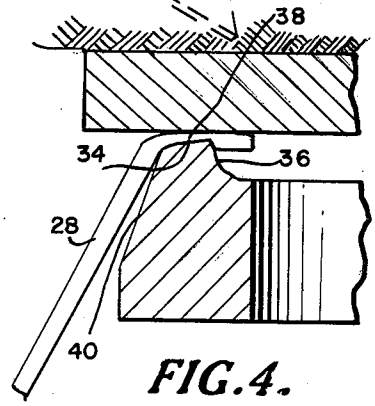


FIG.4.

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BOLT STRESS INDICATOR

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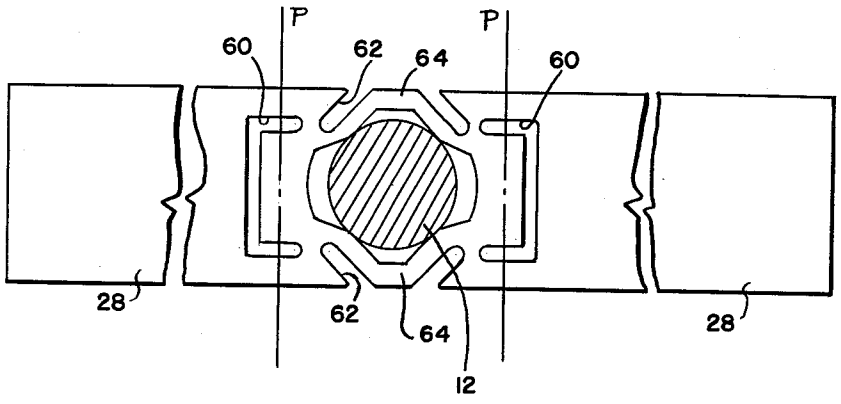


FIG.6.

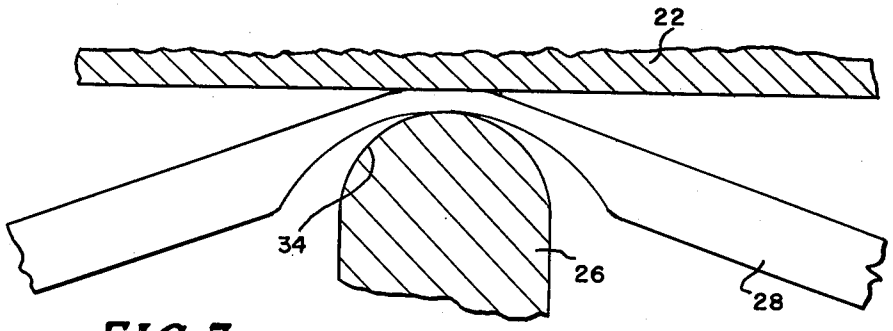


FIG.7.

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United States Patent Office 3,104,645 Patented Sept. 24, 1963

3,104,645

BOLT STRESS INDICATOR

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Filed Mar. 22, 1961, Ser. No. 103,182
18 Claims. (Cl. 116—114)

This invention relates to stress indicating devices, and has particular reference to a new and improved device for indicating when excessive stresses are imparted to a mine roof supporting bolt.

In the preparation of a mine tunnel for mining operations it is a common practice to reinforce the formation of rock above the mine roof. Conventional practice calls for drilling holes in the mine roof, and inserting bolts in the order of six feet or more in length into these holes. The bolts have an expansible anchor means on the end thereof inserted into the drilled hole, and are provided with a mounting plate which abuts against the mine roof. The bolt head is rotated, causing expansion of the anchor means against the interior of the drilled hole. Tension is imparted to the bolt by drawing up the bolt head in tight abutment with the lower surface of the mounting plate.

While this practice is widely used to bind a rock formation above a tunnel roof to inhibit the shifting of the rock, occasionally the rock formation will shift regardless of these bolts, causing grave danger to personnel working in the mine tunnel. In this regard, such a shift in the rock formation may result in a collapse of the mine tunnel roof. It is, therefore, imperative to have a positive and reliable means for ascertaining any shift in the rock formation above the tunnel roof.

When the rock formation above the tunnel roof shifts, a resulting stress is placed upon the bolts which are located within the rock, the tensile stress imparted thereto being transferred to a bolt head generally secured to the end of the bolts which is visible from within the tunnel. Thus, by measuring this resulting increase of the stress imparted on the mine roof supporting bolt, a reliable means for indicating dangerous shifts in rock formations can be realized. Such means for indicating this shifting of rock formation will, of course, only be as reliable as the means for indicating the added stresses imparted to the bolt.

This problem has thus been appreciated in the prior art and numerous devices of varying degrees of reliability have been developed. Such devices are generally affixed to the lower end of the bolt and offer a means for indicating adverse stresses which may be imparted to the bolt. Such prior art devices are generally quite expensive to manufacture and do not provide a totally reliable indicating means which readily indicates adverse bolt stresses without a very careful observation of the relative position of the various parts. A truly efficient and practical indicating means should provide a readily visible device which clearly shows dangerous stresses imparted to the bolt, with no necessity for careful measurement and observation.

This invention is accordingly directed to an improved device for indicating when excessive stresses are imparted to mine roof bolts in a simple readily observable manner, and in turn, indicating when dangerous shifts in the rock formations above the mine tunnel roof have taken place. Additionally, this invention approaches the manner of measuring the added bolt stresses by a new and unusual means.

It is therefore an object of this invention to provide a bolt stress indicator which indicates excessive stress imparted to a bolt by an extrusion and resulting deflection of cantilevered flags disposed between the mine roof ceiling and the supporting bolt.

Another object of my invention is to provide a bolt stress indicator which includes a means for extruding and deflecting cantilevered indicating means, when excessive stresses are imparted to the bolt.

Another object of my invention is to provide a bolt stress indicator which is of far simpler construction than those devices in the prior art, while affording a readily visible and inexpensive means for indicating when excessive stresses are imparted to a mine roof bolt.

Other objects and advantages of my invention will become apparent in the following description and accompanying drawing, in which:

FIGURE 1 shows the assembled stress indicating device disposed in a rock formation above a mine tunnel roof;

FIGURE 2 is an enlarged elevation view of the assembly shown in FIGURE 1;

FIGURE 3 is a perspective view thereof with an electrical indicating circuit operable therewith;

FIGURE 4 is an enlarged fragmentary elevation view of the assembly in FIGURE 2, showing an extruded cantilevered flag; and,

FIGURE 5 is a modification of the assembly in FIGURE 3, showing an additional indicating means operable therewith.

FIGURE 6 is a plan view of still another modified embodiment of the flag according to this invention; and,

FIGURE 7 is an elevation section view of a modified embodiment of the extruding surface shown in FIGURE 6.

In accordance with the novel features of this invention, there is provided a bearing extrusion member and cantilevered flags disposed thereon, resulting in an extrusion and downward deflection of these flags when excessive stresses are imparted to a mine roof bolt.

Referring to the drawings, a mine roof **10** is shown having a long retaining bolt **12** disposed within drilled hole **14**. The bolt is engaged within the rock formation by a conventional expansible anchoring shell **16**. Slidably mounted on the bolt **12** adjacent the roof **18** of the mine is a bolt stress indicator **20**. The bolt stress indicator **20** is located below a mounting plate **22** which has an aperture **23** therethrough, so as to be slidable on bolt **12** and abuts the ceiling **18** of the mine tunnel. Located beneath the mounting plate **22** and also slid on the bolt **12** is a bearing shoe **24**. The bearing shoe **24** has bearing and extrusion members **26** directed upwardly therefrom. Mounted between the mounting plate **22** and the members **26** and the bearing shoe **24** are flags **28**. The flags **28** are mounted in a cantilevered fashion, being supported solely by members **26**. A self-aligning ball-seat bearing **30** abuts against the lower surface of the bearing shoe **24**. In this regard, mine roofs generally have a rough, irregular surface, thus possibly resulting in poor alignment of the parts, unless such bearing aligning means are provided. The assembly is held in engagement by a conventional bolt head **32**, which may be an upset head integral with the bolt or may be a threaded nut.

Referring now to FIGURES 2 and 4, the flags **28** are shown secured between members **26** and mounting plate **22**. FIGURE 2 shows the flags mounted in their normal assembled position, the flags extending radially outwardly from the bolt **12** in a generally horizontal manner. FIGURE 4 shows the flags **28** extruded and deflected downwardly due to adverse stresses imparted to bolt **12**.

One side of the extruding member **26** is cut to provide a curved extruding surface **34**, while the other side of this extruding member is drastically relieved along its inner surface **36** which intersects the surface **34** at an angle. Thus, the contour of the extruding surface as

viewed in section is quite unsymmetric. Such a configuration tends to provide extrusion of the flag 28 in one direction only.

Various means can be provided to amplify the indication of excesive stress on the mine bolt, which results in the extrusion and downward deflection of the flags 28. For instance, FIGURE 3 shows an electrical circuit 42 which is responsive to the downward deflection of the flag 28. A conventional make or break switch 44 is operated by a lever 46 which closes the circuit 42, when the flag 28 is deflected downwardly. The circuit has a suitable voltage source 48, and a remote indicating means 50, such as a light bulb or an electrically operated bell.

In FIGURE 5, a modified means responsive to the extruson and downward deflection of the flag 28' is shown, the mounting plate 22 being omitted for clarity. The flag 28' has upturned side walls 52, and end wall 54. The end wall 54 is preferably bent upwardly to a lesser degree than the side walls 52, forming an acute angle with the plane of flag 28'. An easily fragible capsule 56 containing an odorous substance is placed thereon; and when the flag 28' is deflected downwardly, the capsule 56 rolls off the flag 28' and breaks, causing an odorous gas to be spread in the area. The particular configuration of the end wall 54 prevents the capsule 56 from rolling off the flag 28' until the flag 28' has been deflected downwardly through an appreciable angle.

Referring now to FIGURES 6 and 7, the flag 28'' is shown to have opposed C-shaped slots 60 across the width thereof, the legs of the slot 60 extending transversely of the lines of extrusion force P. The flag 28'' in FIGURE 6 is also provided with cut-out areas 62 defining web portions 64 adjacent the bolt 12. The web portions 64 buckle freely due to the extrusion force without noticeably resisting inward extrusion of the flag 28''. The web portions 64 additionally facilitate arrangement of flag 28'' with bolt 12 during assembly.

In FIGURE 7, the extruding surface 34 is shown to be symmetrically curved while the flag 28'' is shown partially extruded. As is appreciated, the contour of flag 28'' adjacent the surface 34 becomes flatter as the thickness is decreased due to the extrusion force.

Consideration will now be given to the extrusion of the flags 28, when adverse stresses are imparted to the bolt 12. When the stress indicator is assembled, as shown in FIGURE 2, with the bolt head 32 drawn up snugly, the normal tension on the bolt results in a compressive stress on the flags 28. The capacity of the flags 28 to withstand extrusion can be controlled by the shape of the extruding surface. The amount of stress required to extrude a flag where a knife-edge extruding surface is used is considerably less than the stress required where an arc-shaped extruding surface of a relatively large radius is utilized.

When a circular cylindrical extrusion surface 34 is provided on the extruding member 26, extrusion begins at a certain bearing force; and, if that forces is maintained the flag 28 is pinched down to a very small thickness—too small to support the force of gravity on the cantilevered flag. During the extrusion process the thickness of extruding metal decreases, so that an increased pressure is required to force it out. The width of bearing of the cylindrical surface against the flag also decreases, however, as the thickness decreases, so that the total bearing force required to extrude the flag is substantially constant. The amount of bearing force required to cause extrusion is generally proportional to the radius of curvature of the cylindrical surface of the extruding member.

When the extruding member 26 has an obtuse or acute angled edge pressing into the flag, the bearing force necessary to cause extrusion diminishes rapidly as the thickness of metal decreases. On the other hand, when it has a parallel flat bearing surface, the bearing force increases rapidly with reduction of the squeezed metal thickness. Between these two extremes, the surface 34 of the extruding member 26 can be shaped to give any desired intermediate relation between bearing force and thickness of squeezed-out metal.

The force at which extrusion takes place depends primarily on three factors: It is, as already noted, directly proportional to the radius of curvature of the extruding member; it is directly proportional to the width of the flag; and it is approximately proportional to the maximum yield strength of the material, in shear. For example, a flag of SAE 3003 aluminum alloy, pressed by extruding members having a radius of curvature of ⅛ inch, is extruded by a force of about 16,000 pounds. A low carbon steel flag of the same size, under the same conditions, supports about 56,000 pounds. The thickness of the flag before assembly and its initial condition of work hardening do not affect the total force at which extrusion takes place.

As already stated, the compressive stress in the flag which must be withstood by the parts between which it is squeezed, increases as the thickness decreases, and may reach very high values. The length, thickness, and density of a flag determine the bending moment, and thus determine how thin the flag must be squeezed before it will sag, indicating that extrusion has taken place. A flag of aluminum 1/16 inch thick and ten inches long, under the condition of the example in the above paragraph, will support itself horizontally until squeezed to less than .003 inch thickness. This corresponds to compressive stress of about 100,000 p.s.i. A flag of low carbon steel under similar geometrical conditions would have an internal compressive stress of over 300,000 p.s.i. Referring now to FIGURES 6 and 7, the modified embodiment of the invention which reduces the internal compressive stress without, at the same time, reducing the total force required for extrusion, includes the provision of C-shaped slots 60 in the flag 28 in such locations along the line P of application of extrusion pressure the area of flag 28 supporting the load is reduced, while leaving the width of flag 28 which must be extruded, unchanged. The narrower supporting width fails in bending at a greater thickness and a correspondingly smaller internal compressive stress. However, it has been found that when the bearing shoe 24 and the mounting plate 22 are of hardened steel, they will extrude even low carbon steel flags without this refinement enough to produce a clear indication.

At each of the extrusion members 26, the flag 28 is extruded both inwardly toward the bolt 12 and outwardly away from the bolt 12. In FIGURE 6, the flag 28 may be slipped over the bolt for centering, in assembly, and yet the remaining portion of the flag around the bolt buckles freely, offering negligible resistance to inward extrusion of the flag material when excessive stress occurs. Unless such provision for free buckling is made, resistance to inward extrusion may cause a substantial variation in the bolt force at which extrusion takes place.

Friction at the boundary of the flag material may also cause a variation in extruding force in the order of ±10%. To control this variable, and also to combat corrosion in the warm, humid conditions frequently found in mines, the parts of this device are thickly coated with grease at the time of assembly.

Since the extruding operation moves the flag material outward at the same time its thickness is reduced, the section of the flag becomes more or less wedge shaped, with the thinnest portion of the wedge where the extruding surface 34 is closest to the mounting plate 22. Thus, the thicker portion of the wedge limits the free deflection of the flag. To reduce this interference with downward deflection, and thus reduce the amount of stress and extrusion required for deflection of the flags to thereby give a clear indication that extrusion has occurred, the bearing shoe 24 is preferably cut off beyond a certain width as shown in the downwardly extending outside wall 40 (FIGURE 4). The thickness of the flag 28 before ex-

trusion takes place, which determines the bending strength, is equal to the height of the sector of cylindrical surface **34** bearing against it.

An explanation will now be given of the assembly and operation of the bolt stress indicator **20**. The self-aligning bearing is first slid on the rod **12**, followed by the bearing shoe, **24**, the flag strip(s) **28**, and the mounting plate **22**. The anchoring shell **16** is next assembled on the end of the rod **12**. After an appropriate hole **14** has been drilled in the formation above the mine tunnel roof, a perpendicular spotface surface may be bored at the open end of the hole. Then the rod **12** is properly inserted in the hole, with the mounting plate pressed up against the surface of the mine roof. The anchoring shell **16** is expanded by rotation of the bolt head **32**, which also results in tensioning the bolt to the desired initial tension. During this initial tightening, the extruding surfaces **34** sink slightly into the flags, until the flags support the load. This results in a small downward deflection of the flags which may be used to indicate when the bolt has sufficient initial tension. When the bolt has been properly tightened, the flags may be bent back manually to a horizontal position.

If and when the bolt **12** is subjected to adverse stress resulting from a shift of the rock formation, the stress will be imparted to the flags causing extrusion and a downward deflection of the flags **28**. It has been found, additionally, that the flags may be extruded to such an extent that they actually break off.

Thus, merely by observing the position of the flags **28**, even an unskilled person will know if a rock formation shift above the tunnel roof has taken place.

Fabrication of the elements of this indicating device is economical. The bearing shoe **24** is preferably produced as a rolled or drawn section, punched, sheared to length, and subsequently heat treated. The self-aligning bearing cup is preferably produced by forging.

While the preferred embodiment of my invention has been shown, it is readily apparent that considerable modification and additions may be made thereto without departing from the scope of the invention.

It may be seen from the description and drawing that there is provided an invention which successfully achieves the objects and advantages stated herein. Therefore, it is intended that this description be considered as illustrative only when consideration is given to the claims.

What is claimed is:

1. In a mine roof bolt assembly having an elongated bolt with an expansible anchoring means at its one end adapted for insertion in an upwardly extending hole in a mine roof with the anchoring means end-foremost, the other end of said bolt having head means thereon, a mounting plate having a roof-engaging surface and an aperture therethrough for receiving said bolt, a stress indicator comprising: first means operatively carried by said bolt responsive to adverse stress on said bolt for indicating when excessive stress is imparted to the bolt; and a second means positioned adjacent said first means for reducing the cross-sectional area of said first means thereby providing the indication of excessive bolt stress when the cross sectional area of said first means is so reduced that said first means is deflected downward appreciably.

2. The device as defined in claim 1 wherein said first means includes at least one deflectable flag extending radially outward of the bolt in cantilevered fashion.

3. The device as defined in claim 2, further including a frangible capsule disposed on the upper surface of said flag, said capsule falling from said flag, breaking and emitting an odorous gas upon appreciable downward deflection of said flag.

4. The device as defined in claim 1, further including electrical indicating means responsive to appreciable downward deflection of said first means to provide additional indication of the excessive stress on said bolt.

5. In a mine roof bolt assembly having an elongated bolt with an expansible anchoring means on one end thereof insertable in an upwardly extending hole in a mine roof, anchoring means end foremost and a mounting plate having a roof-engaging surface and a central aperture therethrough for receiving said bolt, and head means on the other end of said bolt, a stress indicator comprising: at least one cantilevered flag mountable below the mounting plate; means for extruding said flag disposed adjacent thereto, said means being responsive to excessive stress imparted to the bolt to cause a reduction in cross-sectional area and downward deflection of said flag.

6. The device as defined in claim 5, said means for extruding said flag disposed on the bolt below said flag and above the head means of the bolt.

7. The device as defined in claim 6, further including a means for aligning said extruding means between said flag and the head means of the bolt.

8. The device as defined in claim 5, said means for extruding said flag including a curved surface adjacent to at least one surface of said flag.

9. In a mine roof bolt assembly having an elongated bolt with an expansible anchoring means on one end thereof insertable in an upwardly extending hole in a mine roof, anchoring means end foremost and a mounting plate having a roof-engaging surface and a central aperture therefor receiving said bolt, and head means on the other end of said bolt, a stress indicator comprising: a plurality of flags mountable below the mounting plate in symmetric cantilevered fashion; a bearing shoe slidably disposed on the bolt adjacent thereto; said bearing shoe including an extruding means extending therefrom in abutment with said flags, said extruding means having linear flag-engaging surfaces disposed in symmetric relationship with respect to the bolt axis, said extruding means operable in response to excessive stress imparted to the bolt to reducing the cross-sectional area of said flags at a localized area thereof spaced from its free end, resulting in the downward deflection of said flag.

10. The device as described in claim 9, said bearing shoe disposed below said flags and above the head means of the bolt.

11. The device as described in claim 10, further including a self-aligning bearing slidable on the bolt between said bearing shoe and the bolt head means.

12. The device as defined in claim 9, further including a frangible capsule disposed on the upper surface of at least one of said flags, said capsule emitting an odorous gas upon extrusion and downward deflection of said flag.

13. The device as defined in claim 9, further including an electrical indicating means responsive to the extrusion and downward deflection of at least one of said flags.

14. The device as described in claim 9 wherein each of said extruding surfaces includes a downwardly and outwardly curved surface terminating at its inner extent with an inner surface transversely intersecting the inner extent of said outer surface wherein said extruding surface, in section, is unsymmetric and operative to provide, upon movement said surface toward its respective flag, an outward extrusion for reduction of the cross-section of said flag.

15. A device as defined in claim 9 wherein said plurality of flags is defined by an elongated generally rectangular plate having a central aperture for receiving said bolt, the opposed extents of said plate defining said flags.

16. A device as defined in claim 15 wherein said plate further includes opposed grooves therethrough adjacent said bolt defining web portions whereby the material of said plate in the region adjacent of said bolt is of a reduced cross-sectional area.

17. In a mine roof bolt assembly having an elongated bolt with an expansible anchoring means at its one end adapted for insertion in an upwardly extending hole in a mine roof with the anchoring means end-foremost, the other end of said bolt having head means thereon, a

mounting plate having a roof-engaging surface and an aperture therethrough for receiving said bolt, a stress indicator comprising: first means operatively carried by said bolt adjacent said mounting plate and responsive to adverse stress on said bolt for indicating when excessive stress is imparted to the bolt; and a second means positioned between said first means and said bolt head means in engagement when said first means for extruding said first means and thereby reducing the cross-sectional area to a degree such that said first means is deflected downward appreciably to provide an indication of the excessive stress in response thereto.

18. The device as defined in claim 17 wherein the configuration of the surface of said second means is operative to provide outward extrusion only of said first means whereby said first means is deflected downwardly to provide a visual indication of said adverse stress.

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