Sept. 9, 1958 E. K. RALSTON 2,850,937

SNAP TYPE BOLT TENSION INDICATOR

Filed April 28, 1955 2 Sheets-Sheet 1

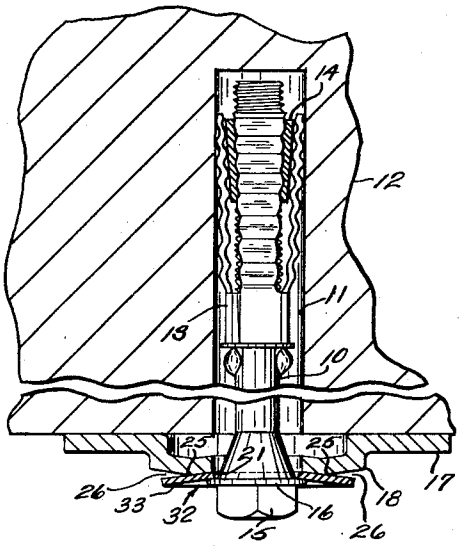


FIG. 2

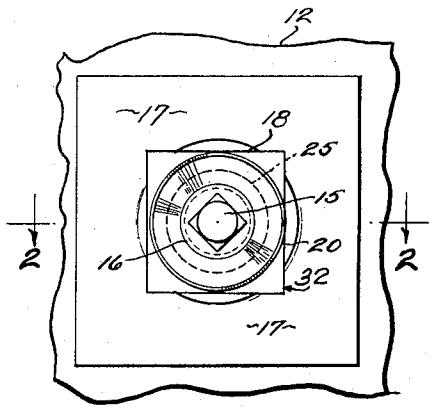


FIG. 1

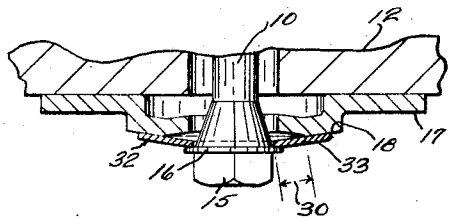


FIG. 3

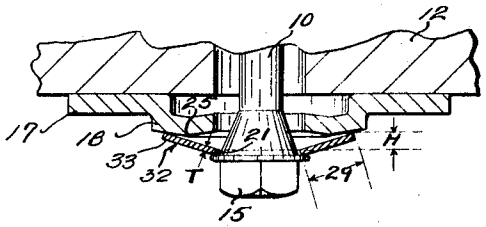


FIG. 4

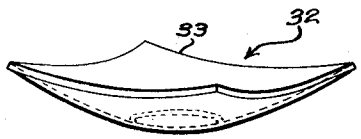


FIG. 5

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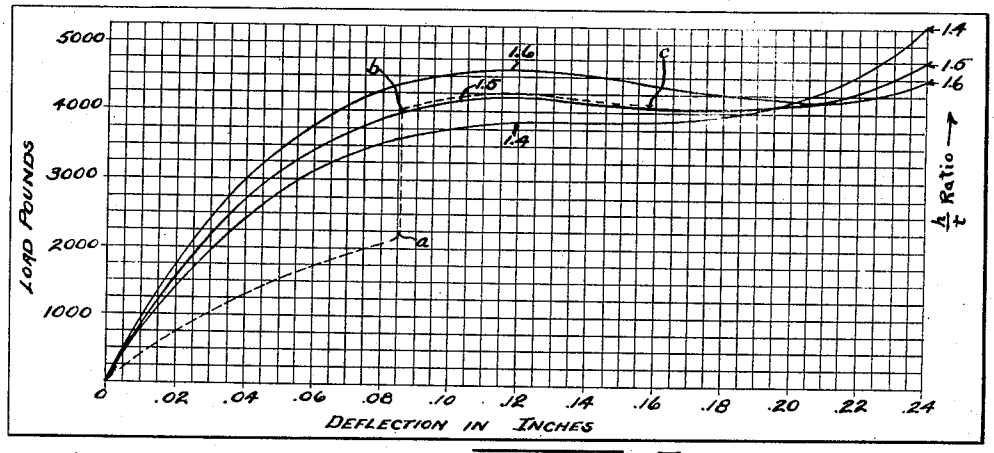


Fig. 6

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SNAP TYPE BOLT TENSION INDICATOR

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1 Claim. (Cl. 85—62)

This invention relates to tension indicators and more particularly to tension indicators for roof bolts.

An object of this invention is to provide a tension indicator for bolts, shafts, and other members which will, at a glance, quickly tell an observer whether or not the member is subject to proper tension.

Another object of this invention is to provide a bolt tension indicator of the pressure responsive type which will automatically show an operator during assembly that the bolt has been tightened a required amount, or when the tension has decreased to a prescribed limit.

Still another object of the present invention is to provide a bolt tension indicator of the pressure responsive type which will operate through a wide range of pressures while retaining its characteristics to return to its initial position.

Another object of the present invention is to provide a bolt tension indicator characterized by its structural simplicity, the ease of assembly of its parts, its strong and sturdy nature and its low manufacturing cost. Other features of this invention reside in the arrangement and design of the parts for carrying out their appropriate functions.

Other objects and advantages of the invention will be apparent from the accompanying drawings and description and the essential features will be set forth in the appended claim.

In the drawings:

Fig. 1 is a bottom plan view of a roof bolt associated with a pressure responsive tension indicator as applied in roof reinforcing construction.

Fig. 2 is a fragmentary section view, enlarged, taken along the line 2—2 of Fig. 1, showing a roof bolt anchored at one end by means of a retainer or anchor shell and having its other end depending therefrom and associated with a pressure responsive tension indicator means.

Fig. 3 is a fragmentary sectional view similar to Fig. 2 but showing the pressure responsive indicator means in an intermediate position of bolt tightening.

Fig. 4 is a fragmentary sectional view similar to Fig. 2 but showing the bolt and pressure responsive means in an initial position prior to tightening of the bolt.

Fig. 5 is an enlarged perspectvie view of a metal washer of the Belleville type having an outer perimeter which is square.

Fig. 6 is a graph illustrating a load-deflection diagram for preferred types of washers in the present invention.

Recently, it has been the practice to support mine roofs or ceilings with reinforcing plates or beams. Such reinforcing plates and beams are normally secured to the natural roof of the mine by means of roof bolts or the like. In order for safe conditions to prevail, it is imperative that each of the bolts supporting the roof carries its proper load. Many times in the past, such bolts have become loosened, unbeknown to the persons in the mine. Such bolt loosening has caused failure or collapse of many mine roofs. Such failures are often

accompanied by the loss of life and heavy property damage. It is therefore the purpose of the present invention to provide indicator means which anyone using the mine can see upon a casual glance and know immediately whether or not a particular roof bolt is supporting its designated load. Although I have shown the present embodiments of my invention in conjunction with a mine ceiling, it will be understood that I do not intend to limit myself to this particular use.

Referring now to Figs. 1 and 2, I have shown a roof bolt 10 secured within a bore 11 provided in a mine roof 12 by means of a retainer or expansion shell 13 made up of three independent separable sections which are connected together at their lower ends in such a manner as to form a generally cylindrical shell and to permit them to be readily expanded by the wedge shape nut 14 upon tightening of the roof bolt 10. The separable members are provided with corrugated surfaces so as to tightly engage the side walls of the bore 11 as said members are expanded by the wedging action of nut 14. This roof bolt and expansion anchor are commonly used for this purpose.

The lower end of the roof bolt 10 extends or depends from the lower open end of bore 11 and is provided with an enlarged head 15 having an annular flange or rim 16 provided thereon. An enlarged reinforcing plate 17 of any suitable size or shape underlies and supports the roof 12. The plate is retained in tight engagement with the lower undersurface of the roof 12 by means of the enlarged head 15 on bolt 10. For the purpose of indicating whether the bolt is subject to proper tension, the reinforcing plate 17 is provided with a raised, annular fixed seat 18 on its outer surface. The seat is preferably, but not necessarily, formed as an integral part of reinforcing plate 17, as shown in Figs. 1 through 4 and is provided with a central opening through which the bolt 10 may extend. The diameter of the opening in the seat is somewhat less than the diameter of the rim 16 on bolt head 15. Between the surface of the seat 18 and the rim 16 of bolt 10 I have provided a dished metal washer 32 of the Belleville disk type which is adapted to be compressed between the rim 16 and seat surface 18. As seen somewhat exaggerated in Fig. 5, the washer 32 is slightly frusto-conical in shape. The diameter of the inner perimeter 21 of the washer is slightly less than that of the rim 16 but slightly greater than the outer diameter of head 15 of bolt 10. The dimension between parallel sides of the outer perimeter 33 of the washer is preferably slightly less than that of the seat 18. The washer 32 is of spring characteristics and, by its very nature is adapted to warp and distort when the washer is subjected to axial compression. The fixed seat 18 provides a bearing surface for the washer 32. It will now be understood that the relative position of the washer with respect to the surface of the fixed seat 18 provides indicating means which show the amount of tension in bolt 10.

Refer now to Figs. 2, 3 and 4, wherein I have shown the bolt 10 and washer 32 in various stages of adjustment. For the purpose of providing a more readily seen indicator means, the outer surface of the fixed seat 18 is provided with a raised annular ridge or shoulder 25 at a zone substantially radially intermediate the inner and outer perimeters of the seat surface. This ridge 25 becomes a fulcrum edge for the forces distorting the washer. The surface portion radially outwardly from the annular ridge 25 is inclined away from the washer at an angle of approximately 6 to 7 degrees from a horizontal plane. The portion of the surface radially inwardly from the annular ridge 25 is inclined away from the washer 32 at an angle of approximately 2 degrees from a horizontal plane.

The washer 32 in its initial unstressed position is shown

in Fig. 4. The sides of the frusto-conical washer incline toward the base at an angle slightly greater than the 6 to 7 degrees mentioned above. The concave side of the outer periphery of the washer is in contact with the radially outermost portion of the seat **18** while the washer clears the ridge **25**. The convex side of the inner periphery of the washer is in contact with the inner surface of rim **16** on the bolt head **15**. Upon tightening of the bolt **10**, the bolt head and its associated rim **16**, exert an axial pressure directly against the underside or convex side of the washer **32** in such a manner that the washer becomes compressed and flexes or flattens, as seen in Fig. 3. The washer is pressure responsive to the tightening of the bolt **10** since substantially its entire area remains unsupported as viewed in Fig. 4, except for the substantially circular line contact its outer portion makes with the radially outermost portion of the seat surface **18**. The pressure exerted upon the washer by the bolt head **15** and rim **16** causes the washer to warp and distort. The unsupported area of the washer being unable to withstand such pressure collapses and thereby causes the inner region of the washer to become reentrant axially within the outer region. As the washer becomes more and more reentrant upon itself, the surface region of the washer adjacent its inner perimeter engages the radially innermost surface portion of the seat **18** and functions to transmit the pressure being exerted by the bolt **10** to the reinforcing plate **17** via the fixed seat **18**. The washer **32** is so designed (as will be hereinafter described) that when it reaches the position wherein the bolt **10** is subject to proper tension, as shown in Fig. 2, the surface region of the washer adjacent its inner perimeter engages the radially innermost surface of the seat and the surface of the washer adjacent its outer perimeter is disposed a spaced distance from the surface of the seat **18** radially outward from the annular ridge **25**. As the load is increased, the inner edge of the washer is clamped between the rim **16** of bolt **10** and the surface of seat **18**, thus preventing the washer from being deflected an excessive amount, which would either break or permanently deform it. By means of the space **26** (Fig. 2) between the outer perimeter of the washer **32** and the radially outermost surface portion of the seat **18** it is possible for an observer to tell, at a glance, or upon casual inspection whether or not the bolt is subject to proper tension.

For the purposes of the present invention, the washer **32** should preferably be one having an

$$\frac{h}{t}$$

ratio of from approximately 1.4 to 1.6, where h is the free or cone height of the washer and t is the thickness, as indicated in Fig. 4. While the

$$\frac{h}{t}$$

range given is for spring washers of the cone type, any other type of spring washer having a load deflection characteristic corresponding substantially to that of the cone disk within the specified

$$\frac{h}{t}$$

range may be employed. Therefore, the reference to washers in the claim is intended to include all types of disk spring washers the load deflection characteristics of which correspond to those of the present washers. It will be understood that these washers are of the type which retain their characteristics to return to their initial position. Thus, should the bolt become loosened, the washer would return to its initial position, as seen in Figs. 3 or 4, wherein no space exists between the outer perimeter of the washer and the surface of seat **18**, and thereby indicating to an observer that the particular bolt has become loosened and no longer carries its share of the load.

The size of a typical washer **32** has a dimension between its parallel sides of approximately 2¾ inches and an inner diameter of approximately 1¼ inches. The h value is equal to approximately 0.15 inch and the t or thickness is equal to approximately 0.10 inch. The outside dimension of the washer **32** may, however, be smaller due to the angular construction of the surface of the fixed seat **18**. As viewed in the position of Fig. 4, the washer is subject to a deflecting pressure from the bolt head **15** which is exerted through a lever arm **29**. As the washer flattens as the bolt is tightened, its inner concave surface comes into contact with the annular ridge **25** on the seat **18**, as seen in Fig. 3. At this point, the lever arm is substantially shortened and consists only of that distance between the point of contact with the annular ridge or fulcrum **25** and the point of contact with the head **15** as indicated by **30** in Fig. 3. Since the lever arm **30** is substantially shorter, it will be readily understood that it takes a greater pressure or force to flex the outer edges of the washer **32** after the concave surface of the washer comes into contact with the annular ridge **25** than it did when in the position as indicated in Fig. 4. I prefer to make the distance **30** equal to approximately one-half the distance **29**, however, it is to be understood that the distance **30** may fall within the range of thirty to seventy percent of distance **29** and without adversely affecting the operation of the device. Thus, by angulating the face of seat **18** and shortening the lever arm through which the washer is flexed, it is possible to decrease the overall diameter of the washer while achieving the same effect and requiring substantially as great a force or pressure, as though the washer were of substantially greater diameter. In other words, a washer of smaller diameter holds a greater load. By providing the annular ridge **25** on the seat **18**, as well as the inclined surfaces on the seat **18**, the diameter of the effective washer is reduced between the position of Fig. 4 and that of Fig. 3 and thereby increases the load-carrying capacity for the same amount of steel. Thus, it takes a substantially greater force to flex the washer **32** from the position of Fig. 3 to that of Fig. 2 than it did to flex the washer from the position shown in Fig. 4 to that shown in Fig. 3. Upon reduction of the load on the bolt **10**, the washer tends to return to its initial position wherein no space remains between its outer periphery and the seat **18**.

In Fig. 5 I have shown an enlarged perspective view of washer **32**. Its outer peripheral edge **33** is square. This gives four substantially planar side edges to washer **32**. The sharp corner portions of the washer **32** are desirable due to the fact that they produce a straight line of demarcation more discernible when they are deflected away from the seat surface **18** when assuming a fully loaded position like that in Fig. 2. It is obvious that the washer of Fig. 5, as it moves toward the fully stressed position of Fig. 2, will pass through a condition where the washer edges are straight. This is readily observed even by unskilled labor when the device is in position in a mine roof.

In Fig. 6 I have plotted values for Belleville washers having the preferred

$$\frac{h}{t}$$

ratios of 1.4, 1.5 and 1.6. The abscissae are values of disk deflection in inches. The ordinates are the load on the disk washer in pounds. Thus, Fig. 7 indicates that washers of these preferred

$$\frac{h}{t}$$

ratios will vary widely in deflection under little change in the load carried.

The dot-dash curve in Fig. 6 illustrates a typical load-deflection curve of a washer subjected to continuously increasing pressures. The "0—a" portion of the curve illustrates the deflection in the washer from an initial no-load position as shown in Fig. 4 to the point where the concave side of the washer contacts the ridge **25**, as seen

in Fig. 3. At this pont, the radial moment arm of the applied load (which previously had been the distance **29** as seen in Fig. 4) is reduced approximately in half, as indicated by the distance **30** as seen in Fig. 3, and the washer becomes effectively stronger, as illustrated in the *"a"* to *"b"* portion of the curve. Thereafter, the load deflection curve from *"b"* to *"c"* is substantially flat. A small increase in load produces a very considerable deflection in the washer and appreciable lifting of the outer perimeter of the washer until it reaches the position shown in Fig. 2, indicating that the bolt is carrying its proper load. It should be noted that when using a washer with an

$$\frac{h}{t}$$

ratio of from 1.4 to 1.6, in cooperation with the annular ridge **25**, there is no gradual lifting of the outer edge as the load is increased, but rather substantially all of the deflection occurs over a narrow load range, thus making the device very sensitive.

In view of the foregoing description taken in conjunction with the accompanying drawings, it is believed that a clear understanding of the construction, operation and advantages of the device will be quite apparent to those skilled in this art.

It is to be understood, however, that even though there is herein shown and described a preferred embodiment of the invention, the same is susceptible of certain changes fully comprehended by the spirit of the invention.

What is claimed is:

A roof bolt tension indicator comprising a bolt having one end anchored in a roof and a free end depending therefrom, the free end of said bolt being provided with a part acting as a head, a plate, underlying and supporting said roof, said plate being retained by said bolt, a raised seat on the outer surface of said plate, the components of said seat lying on a circle, a metal washer of the Belleville disk type between said bolt head portion and said seat, said washer having at least one substantially planar edge, said washer being slightly dished and adapted to warp and distort when subjected to axial compression, the apex end of said washer in unstressed condition extending away from said seat and said planar side being concave toward said roof, said seat providing a bearing surface for said washer providing a ridge intermediate the radially inner and outer edges of said washer, said bolt head exerting pressure on the inner edge of said washer to pull it toward said seat in stressed condition so that the outermost perimeter of said washer is disposed a spaced distance away from said seat to indicate the tension on said bolt, said planar edge passing through a straight line position as said washer moves from unstressed to stressed condition.

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