Nov. 19, 1957 A. L. BARRETT 2,813,449

EXPLOSIVELY ACTUATED EXPANDING MINE ROOF FASTENER

Filed April 5, 1950 2 Sheets-Sheet 1

Fig. 1.

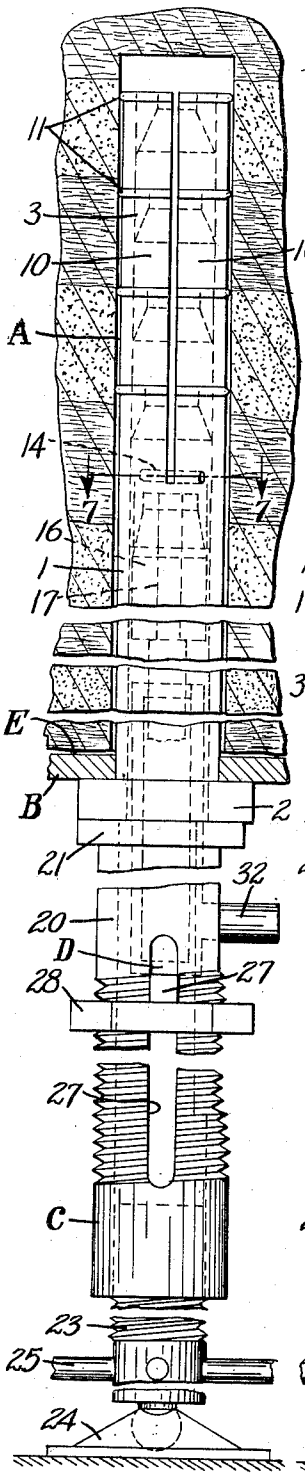


Fig. 2.

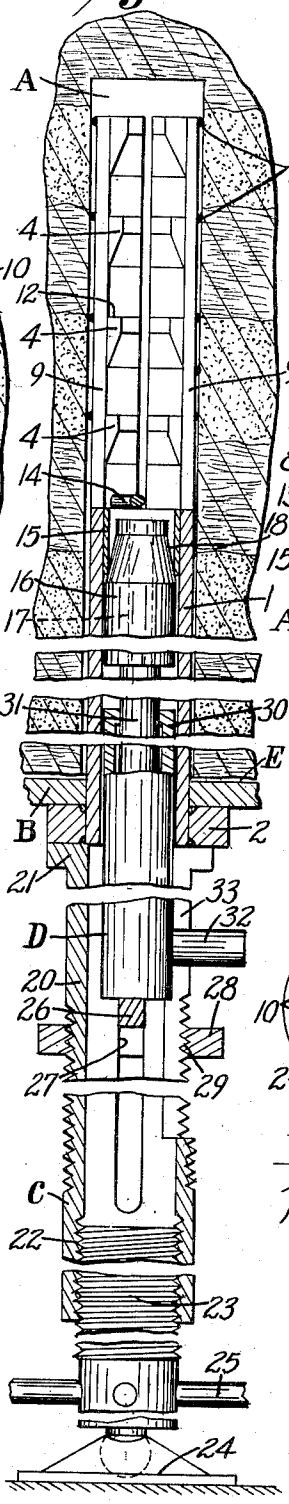


Fig. 3.

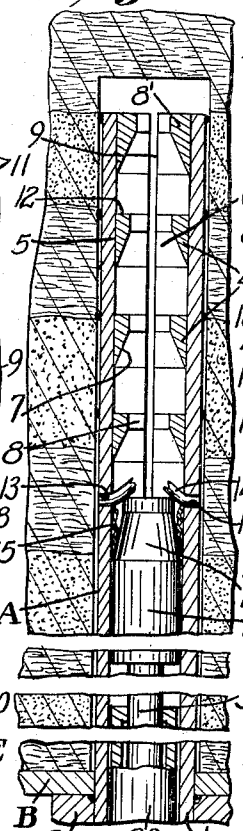


Fig. 4.

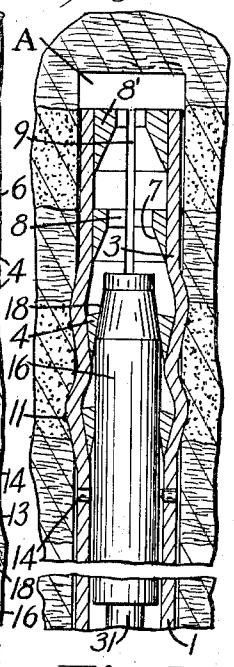


Fig. 5.

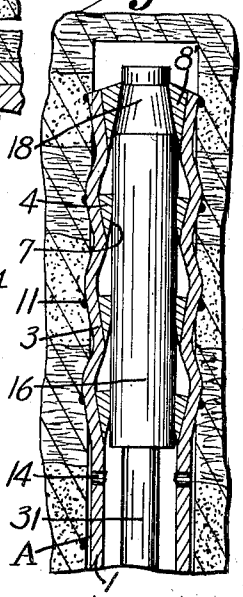


Fig. 6.

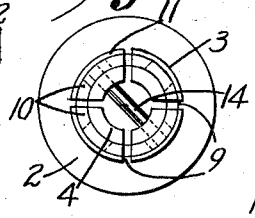
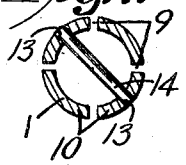


Fig. 7.



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Fig. 8.

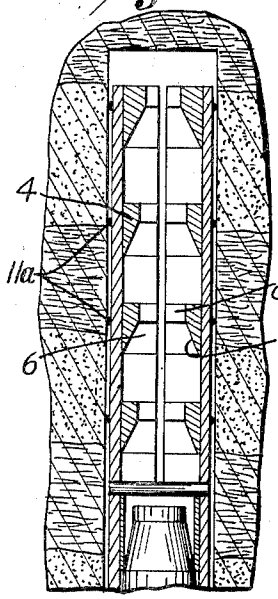


Fig. 9.

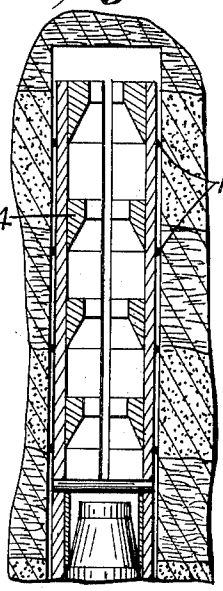


Fig. 10.

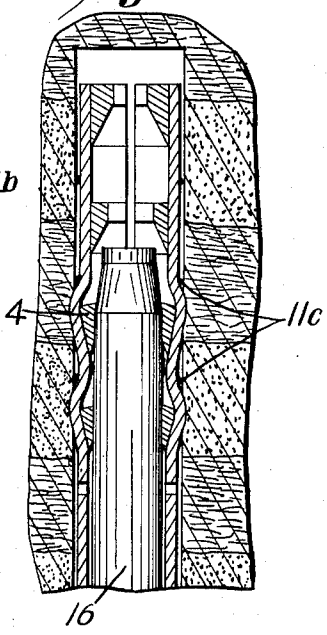


Fig. 12.

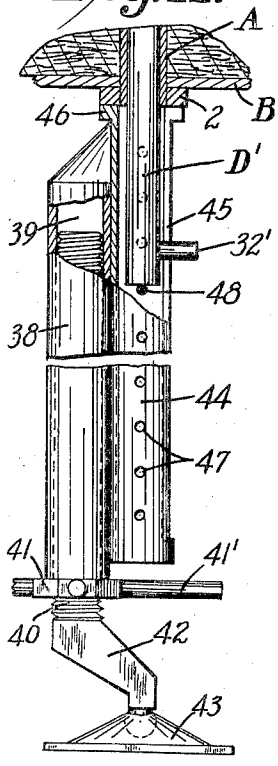
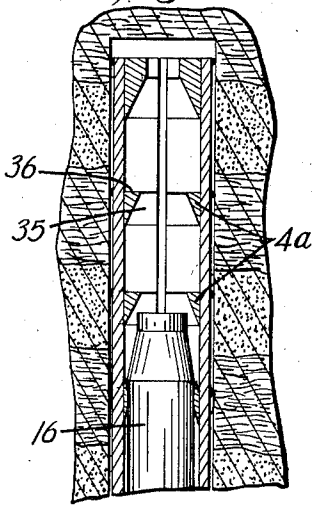


Fig. 11.



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2,813,449

EXPLOSIVELY ACTUATED EXPANDING MINE ROOF FASTENER

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Application April 5, 1950, Serial No. 154,159

1 Claim. (Cl. 85—40)

This invention relates to suspension type roof supports and more particularly to suspension type roof anchors insertible in holes formed in the roof strata of an underground mine or tunnel for binding the roof rock together to minimize flexure and thus prevent rock failure.

From one aspect the invention relates to the bolt structure and its cooperating positioning and expanding means and from another aspect relates to a jack structure for supporting the bolt and the actuator for its expanding means during anchoring of bolts of different lengths.

In underground mines or other underground workings the roof of the excavation must be supported against roof falls or cave-ins and it is becoming customary practice to support the roof strata by means of anchor bolts insertible in holes formed in the roof strata and having expansible heads for securing the bolts in position to support the roof rock. Usually such anchor bolts have expansible wedge type heads and threaded rodlike bodies and the heads are expanded to secure the bolts in position and nuts are threaded onto the bolt bodies whereby roof plates or beams may be secured against the roof. In such known types of anchor bolts the bolt heads are expanded by means of pneumatic hammer tools such as stoper drills which drive-in the bolts to effect head expansion, or the bolts may be first tightened as by power wrenches engaging the nuts to move the bolts axially to effect expansion of the heads and when the bolts are properly set in position further tightening of the nuts on the bolts effects clamping of the plates or beams against the roof, and it has been found that such methods of setting the bolts and clamping the roof plates or beams are time consuming and that proper setting of the bolts is not assured. The present invention contemplates improvements over such known types of suspension type roof anchors in that improved abutment and expansible anchoring means are provided which may be quickly and effectively operated whereby the bolt may be firmly driven axially into position in the roof strata and then expanded to effect anchoring without the use of pneumatic tools or screw and nut anchoring and tightening devices. The improved anchor bolt of the present invention embodies an improved expansible head structure which may be expanded by a free moving projectile or slug driven axially at high velocity within the tubular bolt body and the tubular bolt body has an outer end flange which when the bolt is driven axially is moved tightly against the roof plate or beam by the action on the bolt of the projectile or slug prior to expansion of the bolt head. The expansible head of the bolt has a series of internal wedge-shaped annuli secured therein and the tube is split and the projectile or slug which is driven within the annuli of the bolt to effect head expansion, when stopped, lodges within the expanded head to maintain the latter in expanded position and is held against rearward escape from the head, and stop means is provided within the head to preclude overtravel of the slug. In case the walls of the hole in the roof strata closely surround the expansible

bolt head and the roof rock is relatively hard the annuli and tube will be prevented from expanding sufficiently to permit the slug to pass therethrough and under such a condition the annuli due to their structure will deform sufficiently to permit passage of the slug into its full head expanding position. The anchor bolt of the present invention embodies novel means for first imparting a powerful inward axial thrust to the bolt to drive the latter up into the roof strata and for only thereafter expanding the bolt head to secure the bolt firmly in place, such operations performed in rapid succession. In accordance with the present invention the bolt is held up in the roof strata by a jack structure and the projectile or slug which is driven axially within the bolt is actuated by a gun adjustably supported by the jack structure and which is positioned at least partially within the tubular bolt and in which an explosive charge is fired to actuate an impact element which is movable in the bolt to effect driving of the projectile or slug with considerable force and speed inwardly within the bolt body, and the means whereby an axial driving thrust is imparted to the bolt and for expanding the bolt head are so designed as to permit the projectile or slug to move within the bolt and to lodge within the expanded bolt head to maintain the latter in expanded position. Thus, by the provision of the improved bolt driving and expanding means the roof anchors may be quickly set in place thereby greatly reducing the time consumed in and the cost of the roof supporting function.

It is a primary object of the present invention to provide an improved suspension type roof support for underground mines or tunnels whereby supporting of the roof may be easily and expeditiously effected. Another object is to provide an improved roof bolt having an improved expansible head structure whereby the bolt may be quickly set and firmly held in roof supporting position. Still another object is to provide an improved tubular anchor bolt which has an expansible head of a novel design and expander means embodying a projectile or slug which is driven inwardly within the bolt bore with considerable momentum or force to effect expansion of the bolt head. A further object is to provide improved displaceable abutment means within the bolt whereby the projectile or slug, as it is driven inwardly, first imparts an axial thrust to the bolt to effect proper positioning of the bolt in the roof strata and thereafter effects expansion of the head to set the bolt firmly in position thereby eliminating any need for readjustment of the bolt after the latter has been anchored in position. Still another object is to provide an improved anchor bolt which may be quickly set in place in the roof strata by means of a gun which is located at the outer end of the bolt to effect driving of the latter inwardly and thereafter to effect expansion of the bolt head. A still further object is to provide an improved suspension type roof support having a novel expansible head structure embodying a series of axially spaced, internal annuli welded or otherwise secured within a tube and which are engaged by a slug driven axially within the bolt to effect expansion of the bolt head thereby to embed portions of the bolt head into the roof rock, the annuli having internal sloping surfaces so designed that the slug may enter the expansible bolt head and may lodge within the head to maintain the latter in expanded position without the possibility of inadvertent release of the slug. Another object is to provide improved stop means within the expansible head of a bolt of the above character whereby overtravel of the projectile or slug is precluded. A still further object is to provide an improved expansible bolt head having a series of axially spaced wedge-shaped annuli so constructed that in the event the walls of the hole preclude sufficient expansion of the head as the

slug enters the head, the annuli will be deformed sufficiently to permit the slug to pass therethrough thereby to insure proper gripping of the hole walls. Yet another object is to provide an improved slotted expansible bolt head having elements arranged interiorly of the head at axially spaced points to provide a series of internal restrictions and into which a slug is movable to effect expansion of the head and the restriction-providing-elements being so constructed that in the event the head is prevented by the hole walls from expanding sufficiently to permit passage of the slug the elements will deform sufficiently to permit movement of the slug fully within the head. A still further object is to provide an improved adjustable jack structure for holding the bolt and gun in position during the anchoring of the bolt and designed to operate on bolts of varying lengths. These and other objects and advantages of the invention will, however, hereinafter more fully appear.

In the accompanying drawings there are shown for purposes of illustration several forms and modifications which the invention may assume in practice.

In these drawings:

Fig. 1 shows one form of the improved anchor bolt with the bolt placed in position within a hole formed in the roof strata and having the operating gun and bottom floor jack associated therewith.

Fig. 2 is a view in central longitudinal section taken through the roof bolt, gun, and floor jack of Fig. 1.

Fig. 3 is a fragmentary sectional view taken on the plane of Fig. 2, showing the projectile or slug in contact with the abutment pin, with the slug imparting an axial thrust to the bolt.

Fig. 4 is a fragmentary sectional view taken on the plane of Fig. 3 showing the projectile or slug moved part way within the expansible bolt ahead, and the expanding action partially completed.

Fig. 5 is a sectional view similar to Fig. 4 showing the bolt head in fully expanded position, and the projectile or slug at rest.

Fig. 6 is an end view of the improved anchor bolt.

Fig. 7 is a cross-sectional view taken substantially on line 7—7 of Fig. 1.

Figs. 8, 9 and 10 are sectional views taken on the plane of Fig. 2, showing several modified forms of expansible bolt heads.

Fig. 11 is a sectional view similar to those of Figs. 8, 9 and 10 showing internal annuli of modified construction within the expansible bolt head.

Fig. 12 is a view partially in side elevation and partially in vertical section, showing a modified form of jack structure for the anchor bolt and gun.

The suspension type roof support of the present invention constitutes an improvement in an anchor bolt having displaceable abutment means, an expansible head structure and associated expanding means, wherein, in a preferred embodiment, the bolt is first thrust axially by a projectile or slug to effect driving thereof tightly into its permanent position in the roof strata and thereafter the bolt head is expanded by the slug to secure the bolt in place, and stop means is embodied in the head whereby overtravel of the slug is precluded so that the slug lodges in the expanded head to maintain the latter in expanded, anchored position. The improved thrust, expansion and stop features all contribute to a common end, but each is of use, and usable, individually.

The improved anchor bolt, as shown in Figs. 1 to 7 inclusive, comprises an elongated tubular body **1** having an integral flange or collar **2** at its outer end, and having its inner end portion formed with an expansible head **3** of a novel design. The expansible bolt head comprises a series of axially spaced annuli or rings **4** secured at **5**, as by plug-welding or otherwise, within the bore of the head. These rings are of wedgelike construction and have inner frusto-conical bores or openings **6** provided by inclined walls **7** disposed at acute angles and merging upwardly into reduced axial, desirably but not necessarily cylindrical, bores **8** at their inner ends. The opening of the innermost annulus is relatively reduced as shown so that it provides a stop **8'** for the slug to preclude overtravel of the latter, as later made apparent. The bolt head is longitudinally slotted at **9**, herein desirably at four equally spaced points, to provide bendable portions **10**, and these slots cut through the annuli. Welded or otherwise secured to the outer periphery of the head are rings, exterior annular projections, or collars **11**, also split, and herein lying in or in adjacency to transverse planes including the upper surfaces **12** of the axially spaced annuli **4** as clearly shown in Fig. 2. These may be formed in any suitable manner, welding material applied to the peripheral surface of the bolt being a satisfactory construction. Secured in aligned holes **13** drilled in the walls of the bolt body are the end portions of a diametric cross pin **14** which provides a displaceable abutment as later described. Below this cross pin is a relatively thin metallic sleeve or collar **15** herein desirably composed of brass and pressed or otherwise secured within the tube bore. A free moving projectile or slug **16** of tubular construction substantially fits and is guided for movement at high velocity axially within the tube bore and has an axial opening **17** and a tapered inner end **18**. This slug is of slightly greater diameter than the diameters of the bores of the annuli **4** and the sleeve **15**, as will later be fully explained.

The anchor bolt of this embodiment is insertible in a hole A formed as by drilling in the roof strata and passes through an opening in a conventional roof plate or cross beam B and is held up in position against the roof by an adjustable screw type floor jack C. Associated with and held in position by the floor jack and projecting within the outer end portion of the tube bore is a power actuator herein a conventional gun D. There is shown, for illustrative purposes, a slight clearance at E between the plate or beam and the roof in order that a comparison of Figs. 2 and 3 may indicate that a tightening action of the bolt has taken place in Fig. 3, but it will be understood that normally, prior to the discharge of the gun, the bolt collar **2** is held up tightly against the plate or beam with the latter in engagement with the roof. The floor jack C may assume various forms, but as shown comprises a tubular body **20** having an upper flange **21** abutting the outer end of the bolt as shown in Fig. 1, and threaded at **22** within the jack body is a jack screw **23** provided with an adjustable bottom plate or swiveled foot piece **24**. A handle **25** on the screw is provided for tightening the jack to hold the anchor bolt firmly in place during the setting operation. Arranged within the jack body at its upper portion is the gun D which at its bottom rests against a cross bar or pin **26** arranged in and projecting through longitudinal slots **27** formed in the walls of the tubular jack body. A collar **28** threaded at **29** on the exterior of the jack body engages the cross bar and upon upward adjustment of the collar the gun may be firmly held in place with respect to the anchor bolt with its inner portion **30** extending upwardly within the bolt bore as clearly shown in Fig. 2. This gun may assume various forms but herein comprises an elongated actuator rod, plunger or impact element **31** which may be driven upwardly by the firing of an explosive charge and the almost instantaneous building up of a high gaseous pressure within the gun. The gun has a suitable operator **32** projecting outwardly through a longitudinal slot **33** in the jack body, whereby detonation of the explosive charge may be effected. The plunger **31** when driven suddenly upwardly drives the projectile or slug **16** upwardly axially within the bore of the anchor bolt. This slug does not attain its maximum velocity instantaneously, and as it moves axially within the bolt first enters the bore of the sleeve **15** and, since it is of larger diameter than the sleeve the latter is fractured and disintegrated, but yet there is provided an upward

thrust on the bolt. Substantially simultaneously the slug engages the cross pin **14**—while it is still in its process of acceleration and before maximum velocity is attained—thereby imparting through the cross pin a powerful axial thrust to the anchor bolt to drive the latter upwardly tightly within the hole. The cross pin **14**, as the slug exerts an upward pressure on it, is displaced, fractured or sheared off, and the released slug continues to move axially with still increasing velocity, and as the slug enters the restricted openings of the annuli or rings **4**, in the manner shown in Fig. 4, the bendable portions **10** of the split bolt head are expanded outwardly in the manner shown. The slug has imparted to it such a driving force and the annuli are so formed that the slug is driven completely within the head as shown in Fig. 5, in such manner as to enter all of the series of annuli to expand the bendable head portions, thereby to embed the exterior rings **11** firmly into the roof rock surrounding the bore hole. The acute-angle surfaces **7** are so arranged that as the slug enters the annuli a substantial lateral force is imparted to the latter and due to the inclination of these surfaces there is relatively small tendency to shearing the annuli from the tube. The projectile or slug **16** is prevented from moving too far through the head by the outer restricted annulus **8'** and by appropriate fixing of the explosive charge; and, when stopped, lodges within the expanded bolt head as shown in Fig. 5 to maintain the latter in expanded position with the bolt firmly held in place. The annuli **4** grip the periphery of the slug in such a manner that the latter is firmly secured within the upper end of the bolt and has no possible chance to be squeezed outwardly of the bore. Under certain conditions the walls of the hole formed in the roof strata closely surround the expansible head of the bolt and the roof rock is sufficiently hard to prevent full expansion of the annuli **4** and at that time the annuli due to their structure will deform sufficiently to permit passage of the slug therethrough fully within the bolt head thereby to insure proper gripping of the hole walls. When the anchor bolt is firmly set in position in the roof rock the floor jack C and gun D may be removed for reuse in the setting of other anchor bolts in an obvious manner. The anchor bolts are placed at strategic points in the roof strata so as to bind the strata together in such manner as to minimize flexure of the roof rock, thereby to prevent roof failure. The slot **33** is of sufficient width so that when the collar **28** is threaded downwardly on the jack the gun may be removed from the bolt and released bodily from the jack through the slot **33**. By proper adjustment of the collar **28** relative to the jack the gun may be positioned axially relative to the anchor bolt so as to operate on bolts of different lengths.

In the several modifications shown in Figs. 8, 9 and 10 the exterior annular projections or rings **11** of the first embodiment are arranged at different locations axially of the tube of the expansible bolt head so as to vary the gripping action of the head on the walls of the hole. In Fig. 8 external annuli or rings **11***a* are secured as by welding or otherwise upon the external periphery of the tube at points spaced oppositely from the lines along which the surfaces **7** of the frusto-conical bores **6** merge with the cylindrical axial bores **8**. With such an arrangement the external rings are located at points where the maximum lateral pressure is imparted by the slug or plunger **16** as the latter is driven into the internal annuli **4** thereby to effect firm embedding of the external annuli within the hole walls. In Fig. 9 external rings **11***b* are secured to the external periphery of the tube of the bolt head at points opposite the portions of maximum internal diameter of the internal annuli **4** so that greater flexibility is obtained in the event the external rings expand against hard rock providing the hole walls, thereby providing greater freedom of expansion or yieldability of the tube when the slug is driven into the internal annuli. In Fig. 10 external rings **11***c* are located upon the exterior periphery of the tube at points opposite the internal spaces between the internal annuli **4** so that there is provided still greater flexibility to bending of the expansible head upon driving of the slug within the internal annuli **4**. Since the external rings are disposed intermediate the internal annuli the walls of the tube are free to bend or yield inwardly, thus increasing the flexibility of the expansible head particularly when the head is positioned in hard rock. Evidently, the external rings and the internal annuli may be arranged on the tube in various other relations.

In Fig. 11 the internal annuli are somewhat modified. In this embodiment internal annuli *4a* are secured as by welding or otherwise within the bore of the tube of the split bolt head and, in this construction, the three inner annuli are wholly of wedge shape having in radial section, frusto-conical bores **35** which extend to the upper transverse surfaces **36** of the annuli. When the anchor bolt is closely fitted in a hole formed in the roof strata and the roof rock surrounding the hole is relatively hard, the slug or plunger **16** as it is driven inwardly within the bolt enters the annuli successively and when the rock prevents further expansion of the tube the internal annuli are deformed and at least partially flattened out by the slug as shown, as the slug passes therethrough. Due to the particular shape of the internal annuli, the upper portions thereof may bend or flatten as the slug enters the same. Other cross sections suited to the accomplishment of the mode of operation hereinabove described may be substituted for those particularly illustrated.

In the embodiment of the invention shown in Fig. 12 a modified jack structure for the anchor bolt and gun is disclosed. A screw type floor jack has a tubular body **38** which has an internal bore at **39** to receive a jack screw **40** telescopically arranged within the tubular body. Threadedly engaging the jack screw is an adjusting nut **41** having a handle **41'** whereby the tubular body **38** may be adjusted axially with respect to the screw. The jack screw has an offset lower portion **42** provided with a swiveled foot piece **43**. Secured as by welding to the tubular jack body and arranged in parallelism therewith is a tubular member **44** which is longitudinally slotted at **45** along its outer wall. The upper end of the tubular member **44** has an abutment plate **46** which is engageable with the collar **2** of the anchor bolt for holding the latter up in the hole A formed in the roof strata. An elongated gun D' is insertible laterally through the slot **45** in the tubular member **44** within the latter and is adapted to be moved upwardly within the bore of the anchor bolt. Formed in the walls of the tubular member along the length of the latter are spaced holes **47** and a pin **48** is insertible in the desired one of these holes to provide a bottom support for the adjustible gun D'. The operator **32'** of the gun may provide a suitable handle whereby the gun may be readily manually adjusted axially within the tubular member **44** and the anchor bolt. By the provision of this wide range of adjustment of the gun the latter may be associated with anchor bolts having a relatively wide variation in length. Other known forms of adjustment for the gun relative to the jack may be employed in lieu of the series of holes and pin.

A feature of the invention which is not perhaps as fully noted above as may be desirable, resides in the capacity of the bolt to be used in holes effectively notwithstanding there may be a reasonable variation of the hole diameter from the external diameter of the tube which forms the bolt. It will be noted that in the bolt structure of Fig. 10, the external annuli **11***c* are arranged at points intermediate the internal annuli **4**, so that when the projectile or slug **16** is driven successively into the internal annuli the split tube portion of the bolt head is expanded to bring the external annuli into firm contact with the walls of the hole, and the portions of the split tube opposite the internal annuli are bulged laterally as shown,

to embed exterior portions thereof into the walls of the hole. When the holes are formed in a relatively hard formation, and the external annuli 11c are closely fitted in the hole and expanded into contact with the hole walls, due to the location of the external annuli of this embodiment, the tube walls are free to flex. Thus, even when the hole diameter varies and the hole is formed in a relatively hard formation the bolt head may be expanded to effect an anchoring of the bolt in the roof strata, due to the arrangement noted above and as a result the need for very fine adaptation of roof drills to bolt sizes is avoided. In the forms of the invention where the external annuli are at points opposite the internal annuli 4 only very limited expansion could be effected and the internal annuli may be substantially deformed or flattened out as the slug is driven into place.

To summarize briefly, the bolt will be pressed by the jack as far as possible upwardly before the gun is discharged. When such discharge occurs, the accelerating, but still not at full velocity, projectile or slug will, through the frangible sleeve 15 and the displaceable pin 14, pull the bolt upwardly and eliminate all looseness—if there has been any—between the head 2 and the element B, and between the latter and the surface of the roof. Thereafter the slug will expand the several split rings and the portions of the split tube to which such rings are secured, the action being effected by virtue of the continued thrust of the explosive charge and the momentum of the slug at its high velocity. The explosive charge of the gun will be predetermined so that the slug will desirably expand each of the split rings, but be unable to expand the final ring sufficiently to pass through it.

As a result of this invention an improved suspension type roof support is provided which may be quickly and expeditiously set in place in the roof strata thereby greatly reducing the time consumed in and the cost of supporting the roof of an underground excavation. By the provision of the improved expansible head structure and the cooperating internal abutment means the bolt is initially moved axially—if motion is possible—so that the bolt will be so positioned in the roof strata that the plate or beam will be pressed hard against the roof, and thereafter the bolt head is expanded so that the bolt is firmly held in positon without the need of separate readjustment for tightening purposes and without the danger of appreciable slippage. The projectile or slug is driven by the gun with considerable force within the bolt bore to effect axial tightening of the bolt and expansion of the bolt head, and the projectile or slug when lodged within the head serves to maintain the latter in expanded position. By the provision of the series of internal annuli or rings secured within the bolt head and the inclined surfaces within the rings the bolt head is effectively expanded and the slug is firmly retained within the expanded head by the internal surfaces of the annuli, so that there is little tendency towards escape of the slug and inadvertent release of the bolt. The adjustable jack structure firmly holds the bolts in position in the roof strata and provides a convenient adjustable support for the expander gun whereby the latter may operate on bolts of varying lengths. These and other advantages of the invention will be clearly apparent to those skilled in the art.

While there are in this application specifically described several forms and modifications which the invention may assume in practice, it will be understood that these forms and modifications of the same are shown for purposes of illustration and that the invention may be further modified and embodied in various other forms without departing from its spirit or the scope of the appended claim.

What I claim as new and desire to secure by Letters Patent is:

In a suspension type roof support, an elongated tubular anchor bolt insertable in a hole formed in the roof strata, said bolt having an axial bore of substantial length and an expansible head at its inner end, said head having a series of axially spaced restrictions therein of smaller internal dimensions than said bore, and the innermost restriction being smaller than the others, and a free moving projectile substantially fitting said bore and movable axially with substantial speed under the influence of an expansive power charge within said bore of the bolt and said projectile engaging and progressively entering said other less-restricted restrictions to expand said head into gripping contact with the hole-walls, said projectile as it reaches the end of its travel engaging the innermost smaller restriction and the latter providing a positive stop for said projectile to preclude overtravel of the latter to cause said projectile to lodge within the expanded head to maintain the latter in expanded position.

References Cited in the file of this patent

UNITED STATES PATENTS

1,191,151	Brush	July 18, 1916
1,277,370	Bovard	Sept. 3, 1918
1,587,317	Horton	June 1, 1926
1,806,640	Ogden	May 26, 1931
1,848,142	Peirce	Mar. 8, 1932
1,918,745	Forsythe	July 18, 1933
1,994,210	Chobert	Mar. 12, 1935
2,146,923	Wahlstrom	Feb. 14, 1939
2,199,605	Baker	May 7, 1940
2,292,467	Norsell	Aug. 11, 1942
2,296,817	Gartin	Sept. 22, 1942
2,296,819	Osgood	Sept. 22, 1942
2,313,402	Turechek	Mar. 9, 1943
2,353,851	Rosan	July 18, 1944
2,421,769	Wolfe	June 10, 1947
2,448,351	Brush	Aug. 31, 1948
2,601,803	Newman	July 1, 1952