This invention relates to the supporting of roofs of mines and other underground workings, and more particularly to suspension supports or roof bolts for supporting timbering elements, or cross beams against the roof of such a mine or underground working, thereby eliminating the need of uprights or props beneath the ends of the cross timbers or beams.

In the excavation of mines and various types of subterranean tunnels, it is the customary practice, as the mine or tunnel is extended, to place cross timbers under the stratified rock or earth formation which forms the roof of the mine or tunnel to prevent roof falls or cave-ins. These cross timbers or roof supports are ordinarily held up against the roof of the mine or tunnel by vertical posts or props arranged at each side of the mine entry or tunnel beneath the ends of the cross timbers. Since the customary roof supports are usually spaced quite close together a considerable amount of timber is employed for timbering. Also since the timber is usually of substantial dimensions it reduces the useful width of the entry or tunnel and requires added clearance for mine cars, locomotives and other mining equipment.

The present invention contemplates improvements over known types of roof supports for underground mines or tunnels whereby the roof is supported in a novel manner without the use of vertical posts or props for holding the cross beams or other roof supporting members in place. Such type of prop-eliminating roof supports are particularly desirable for use with continuous mining apparatus which is becoming prominent in the continuous mining of coal or other minerals.

The present invention has for its main object to provide improved suspension supports which may be anchored in the stratified roof of the mine entry or tunnel and provide supports for the cross beams or other supporting members which are placed against the roof. Another object is to provide an improved tension bolt structure whereby the cross beams or other supporting members may be firmly held in place against the roof. A further object is to provide improved tension bolt structures which are placed in holes suitably drilled or otherwise formed in the stratified roof and firmly secured in position therein whereby the possibility of undesired release of the bolt structures is reduced to a minimum. Yet another object is to provide improved expansion bolt structures whereby the supporting bolts for the cross beams or other supporting members may be locked in place and firmly secured by cementing in position. Yet another object is to provide improved means for sealing the hole from the atmosphere after the expansion bolt is secured in place in the hole. These and other objects and advantages of the invention will, however, more fully appear,

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

In these drawings:
Fig. 1 is a fragmentary sectional view through a section of the roof strata showing the improved expansion bolt prior to securing the same in expanded position in a hole drilled in the roof strata.

Fig. 2 is a fragmentary sectional view similar to Fig. 1, showing the expansion bolt during the cementing operation.

Fig. 3 is an enlarged cross sectional view taken substantially on line 3—3 of Fig. 1.

Fig. 4 is an enlarged central longitudinal sectional view through the improved expansion bolt.

Fig. 5 is a somewhat diagrammatic cross sectional view through a mine entry or tunnel showing a cross beam secured in position by the anchor bolts against the roof.

Fig. 6 is a fragmentary sectional view similar to Fig. 5, showing a modified form of expansion bolt construction.

Fig. 7 is a view similar to Fig. 6 showing the expansion bolt in expanded position and a cementing or grouting means associated therewith.

Fig. 8 is a similar view showing the anchor bolt secured firmly in the rock strata in a position to support the cross beam against the roof.

Fig. 9 is a somewhat diagrammatic cross sectional view through a mine entry or tunnel showing a cross beam secured in position against the roof by means of the modified anchor bolts.

As shown in the drawings, A designates the side walls or ribs of a mine entry or tunnel; B is the roof, and C roof supports which may be either timbers or structural steel cross beams herein desirably the latter due to their greater compactness. The cross beams extend substantially across the full width of the entry or tunnel up against the roof, and are supported in position by the suspension supports constituting the present invention.

In the illustrative embodiment shown in Figs. 1 to 5 inclusive, the suspension supports or roof bolts are generally designated F and are each positioned in an oblique hole D suitably drilled or otherwise formed in the rock strata or earth formation which forms the roof of the entry or tunnel. Each suspension support or roof bolt com-
prises an elongated tubular body or bolt portion 2, desirably of cylindrical form, having a threaded lower end portion 3 which is threadedly engaged by a nut 4. Each cross beam C has appropriately located openings 5 through which the bolts pass, and angles washers 6 surround the bolts between the nuts 4 and the cross beam and lie against the bottom face of the latter in the manner shown. The upper end portion of the bolt is threaded at 7 and threadedly engages a wedge-shaped sleeve 8 as shown in Fig. 4. Surrounding the upper portion of the bolt and resting at its lower end against a washer 9 seated against a shoulder 10 on the bolt, is a sleeve 11 which is slotted as at 12 to provide resilient fingers 13, 15. The washer 9 and sleeve 11 provide an outwardly offset enlarged head portion on the bolt 2. The bolt may have a polygonal socket 14 or polygonal end portion adapted for engagement by a suitably rotatable instrument such as a wrench. Thus, when the bolt is suitably rotated the wedge sleeve 8 is forced inwardly within the split sleeve 11 to expand the fingers 13 thereof into firm contact with the walls of the drill hole to secure the bolt in position. The tubular bolt body has a central bore 16 and lateral openings 17 traversing the bolt a short distance below the shoulder 10 in the manner shown, and the lower end of this bore is threaded at 18 for connection of a suitable attachment 19 for a pipe or hose 20 (Fig. 2). When the bolt is secured in its expanded position in the hole D as shown in Fig. 2 wherein it firmly holds the cross beam C against the roof, a quick-hardening cement or other filler may be pumped through the pipe 20, the bore 16 in the bolt and the lateral holes 17 into the space surrounding the bolt and into the hole which receives the expansion device so that the anchor bolt is firmly held in place when the cement or filler hardens or sets. The cement also seals out air from the hole. The tubular body of the expansion bolt may be suitably corrugated along its exterior periphery or may be provided with suitable projections 21 spaced along its length to aid the enlarged head portion in securing the bolt in position in the rock strata. By tightening the nuts 4 of the bolts against the angle washers 6 the cross beam may be rigidly held in place against the roof in the manner shown in Fig. 3.

Now referring to the modified construction shown in Figs. 6 to 9 inclusive it will be noted that the anchor bolt comprises a cylindrical body portion 26 having a threaded lower end portion 28 and the upper end portion of the bolt is formed with an outwardly offset enlarged head portion 27. This head portion is longitudinally split at 28 to provide resilient fingers 29 which have tooth-like serrations 30 on their outer surfaces. The inner walls 31 of the resilient fingers 29 are relatively inclined and a wedge 32 is placed in the tapered space between the fingers as shown in Fig. 6. When the bolt is driven inwardly the wedge 32 contacts the bottom of the drill-hole so that as driving in of the bolt is continued the fingers 29 are expanded to bring the teeth thereof into firm contact with the walls of the hole. In Fig. 7 the anchor bolt is shown in expanded position and when the bolt is so arranged a yieldable hood 33 encloses the lower end of the bolt and tightly contacts the roof to provide a substantial seal at the mouth of the drill-hole. An air vent tube 35 extends through this seal into the drill-hole along the side of the bolt in the manner shown. A suitable hand gun or pump 37 which is filled with quick-hardening cement or other filler has its nozzle 38 extended through a hole 39 in the hood so that when the pump is operated the cement or grouting is discharged into the space between the bolt body and the walls of the hole. During this pumping operation any air in the hole is discharged through the vent tube 35 and as the space becomes filled with cement the vent tube may be withdrawn from the hole. When the cement becomes hardened the anchor bolt is firmly held in place in the rock strata and the hole is sealed to atmosphere. The cross beam C is then placed against the roof, the angle washer inserted in position and a nut 40 threaded on the lower end of the bolt may then be tightened to secure the cross beam firmly against the roof. In Fig. 9 the cross beam is shown secured in position against the roof of the mine entry or tunnel by means of the appropriately located anchor bolts.

In both embodiments of the invention evidently various other types of conventional expandable bolt heads may be employed in lieu of those disclosed. Moreover, in both employments, the mode of use of the suspension supports is essentially the same. The holes are first suitably formed in the desired location in the roof strata, the suspension bolts are then inserted in the holes and suitably expanded into contact with the hole's walls, and finally quick-setting cement or filler is pumped into the spaces around the bolts to secure the latter firmly in position in the rock strata and to seal the hole. When the bolts are properly fixed in place the cross beams are placed in position against the roof with the lower ends of the bolts extending through the openings in the beam, and the nuts are then threaded onto the bolts and tightened to secure the cross beams against the roof.

As a result of this invention an improved roof supporting means is provided for mines or other underground workings whereby, the usual upright timbers or props are eliminated thereby providing the mine entry or tunnel with greater useful width and increasing the roof clearance. One of the advantages of the improved roof support is that the suspension supports or roof bolts used for the purposes of the invention, are firmly supported in holes drilled in the roof strata and are thereby prevented from bending, bowing or buckling as generally occurs in the case of timber-props. Props, moreover, are liable to slip on off-center loading, just when stability is most required. Moreover, if, after the cross beam or other supporting member has been drawn into contact with the roof by the bolts, the roof sags slightly, the roof support will still be firmly held in position. Another advantage of the improved roof support is that the cross beams or other supporting members may be secured in place against the roof immediately after the coal or other material has been broken down and before its removal, before the subsidence of the roof has started. By cementing the tension bolts in the roof strata, danger of the bolts pulling loose, is substantially avoided. The cement not only firmly secures the bolts in place but also seals the drill hole of the atmosphere, thus retarding disintegration of the roof rocks, and, where water is encountered in drilling, prevents corrosion of the steel supporting bolts. Other uses and advantages of the invention will be clearly apparent to those skilled in the art.

While there are in this application specifically described two forms which the invention may assume in practice, it will be understood that these forms of the same are shown for purposes of illus-
pansion of the bolt head to secure the bolt in firm contact with the hole walls, said bolt having means for conducting a quick-setting cement into the spaces around the bolt and expanded bolt head within the hole to effect firm securing of the bolt in supporting position in the roof strata including a supply attachment mounted adjacent the lower end of the bolt comprising a flexible sealing hood enclosing the lower end of the bolt and tightly engaging the roof at points surrounding the mouth of the hole.

5. A supporting structure for the roof supports of a mine or the like, comprising a plurality of anchor bolts secured in position in holes formed in the roof strata, each bolt comprising an elongated body, an expandable head at the upper end of the body outwardly offset therefrom, mechanical means for effecting expansion of the bolt head to secure the bolt in firm contact with the hole-walls, said bolt having means for conducting a quick-setting cement into the spaces around the bolt and expanded bolt head within the hole to effect firm securing of the bolt in supporting position in the roof strata including a supply attachment mounted adjacent the lower end of the bolt comprising a flexible sealing hood enclosing the lower end of the bolt and tightly engaging the roof at points surrounding the mouth of the hole, and an air vent tube extending from the exterior of said hood into the hole.

6. A supporting structure for the roof supports of a mine or the like, comprising a plurality of anchor bolts secured in position in holes formed in the roof strata, each bolt comprising an elongated body, an expandable head at the upper end of the body outwardly offset therefrom, mechanical means for conducting cement to the hole around the bolt including a passage in the bolt communicating with the space around the bolt just below the expanded bolt head.

3. A supporting structure for the roof supports of a mine or the like, comprising a plurality of anchor bolts secured in position in holes formed in the roof strata, each bolt comprising an elongated hollow body, spaced projection means on said body, enlarged expandable head at the upper end of the body outwardly offset therefrom, mechanical means for effecting expansion of the bolt head to secure the bolt in firm contact with the hole-walls, said bolt having means for conducting a quick-setting cement into the spaces around the bolt and expanded bolt head within the hole to effect firm securing of the bolt in supporting position in the roof strata, said means for conducting cement to the hole around the bolt including a passage in the bolt communicating with the space around the bolt just below the expanded bolt head and a supply attachment associated with the lower end of the bolt.

4. A supporting structure for the roof supports of a mine or the like, comprising a plurality of anchor bolts secured in position in holes formed in the roof strata, each bolt comprising an elongated body, an expandable head at the upper end of the body, mechanical means for effecting ex-