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FOREIGN PATENTS

692,742	8/1964	Canada	85/75
675,677	11/1929	France	85/85
263,008	11/1949	Switzerland	85/83
498,876	1/1920	France	85/85

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[54] **BOLT ANCHOR AND METHOD FOR MAKING SAME**
34 Claims, 16 Drawing Figs.

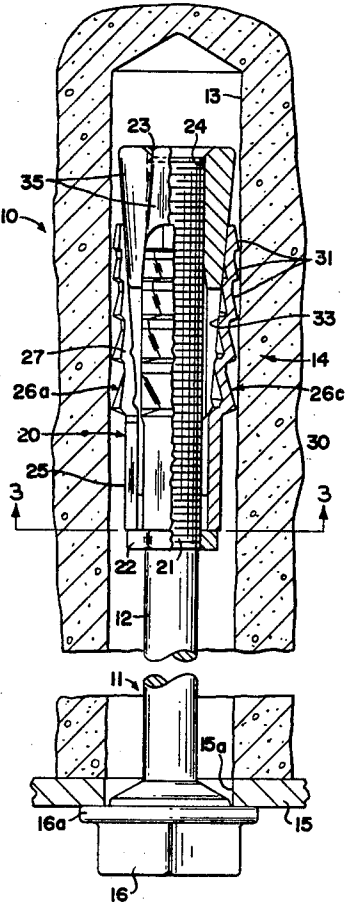
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85/85, 72/339
[51] Int. Cl. F16b 13/06
[50] Field of Search 85/67, 69,
73, 74, 75, 76, 85, 86, 87, 88, 83; 72/336, 329,
330, 337, 339; 29/(Inquired); 10/(Inquired)

[56] **References Cited**
UNITED STATES PATENTS

1,139,712	5/1915	Osborne	85/67
1,513,301	10/1924	Wahlberg	85/74
1,772,064	8/1930	Zifferer	85/76
1,802,270	4/1931	Rawlings	85/85
2,667,099	1/1954	Lewis	85/74
2,762,119	9/1956	Jackson	85/85
3,250,170	5/1966	Siegel	85/76
3,315,557	4/1967	Dickow	85/75
3,381,567	5/1968	Askey	85/75

ABSTRACT: An anchor assembly particularly adapted for use with a roof plate to support a mine roof. The assembly includes a bolt having a threaded end, a camming plug threaded on the bolt, and an expansion shell. The disclosed shell structure includes a polygonal, tubular collar portion and a plurality of fingers projecting longitudinally from the collar. In use, the fingers frictionally engage the camming plug. The fingers include a plurality of cold formed teeth which have an increasing depth and pitch proceeding along the fingers toward the collar and which are, when the assembly is installed, urged into engagement with the walls of a bore hole upon rotation of the bolt to move the camming plug toward the collar and cam the fingers into engagement with the bore.

One disclosed embodiment is provided with a wirelike bail member having a portion extending over the end of the bolt and end portions engaging shoulders formed on the expansion shell so that the unexpanded shell and the plugs are maintained in assembled position for insertion into the bore. The bail member maintains the camming plug and shell assembled until the shell has been partially expanded, after which the bail member is yielded in a manner which does not impede anchoring of the assembly in the bore or tensioning of the bolt.



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4 Sheets-Sheet 1

FIG. 1

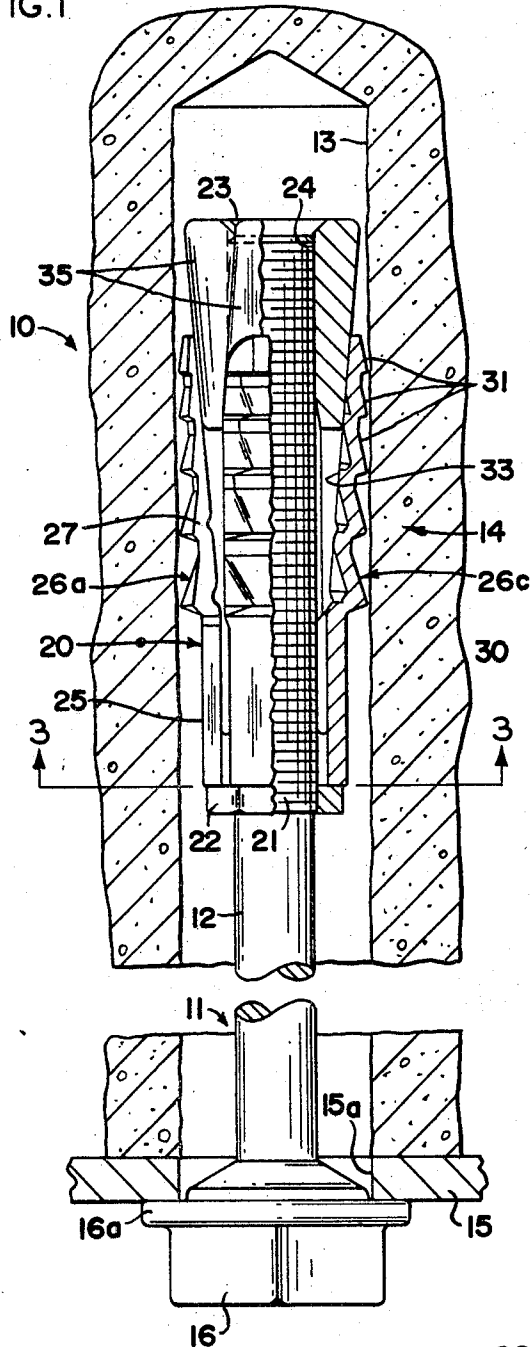
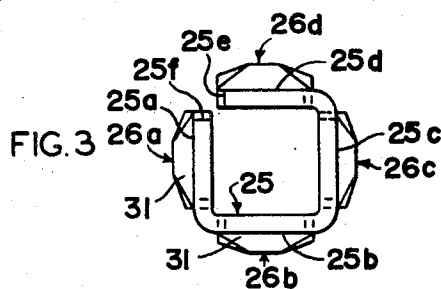
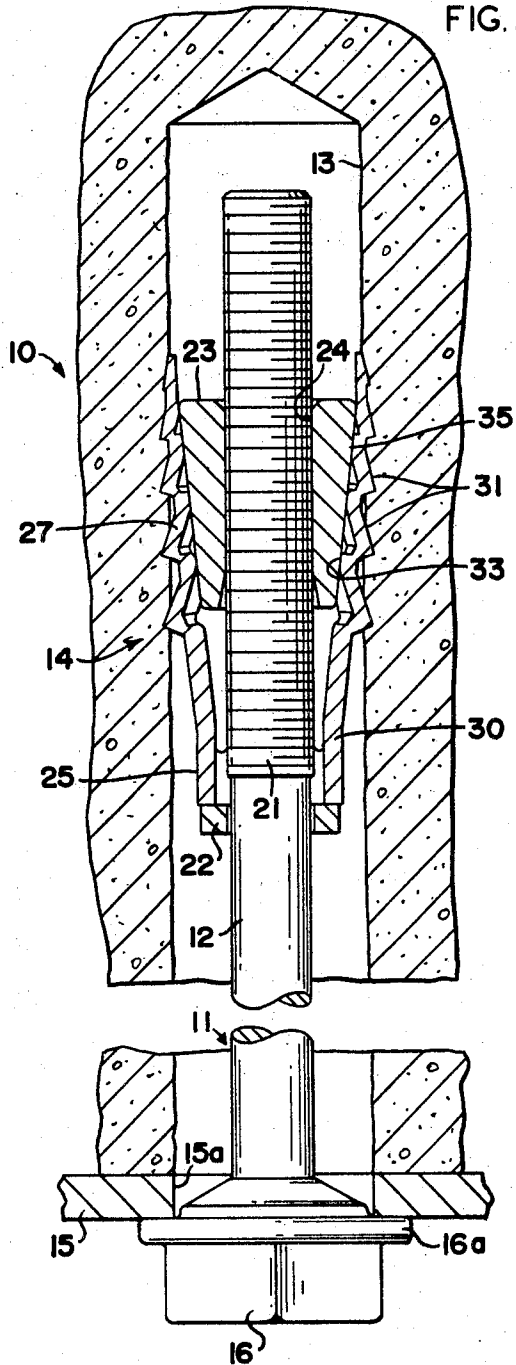
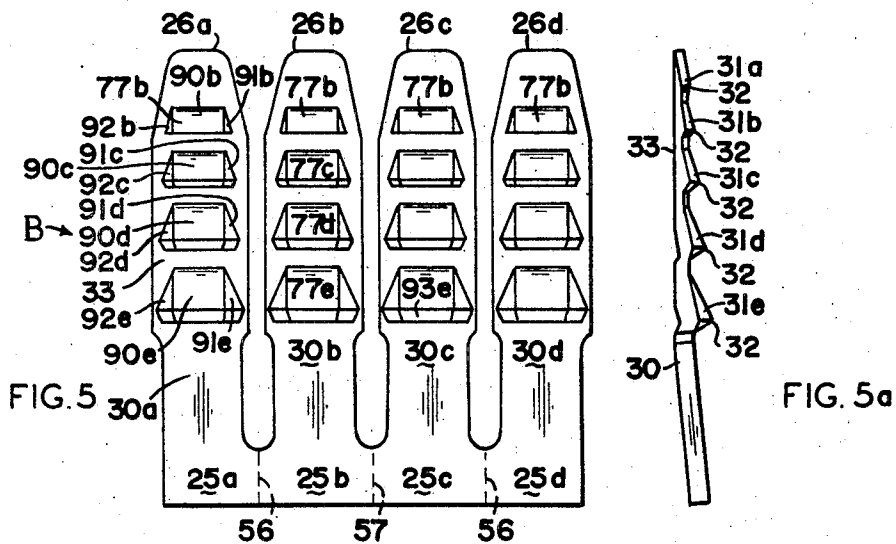
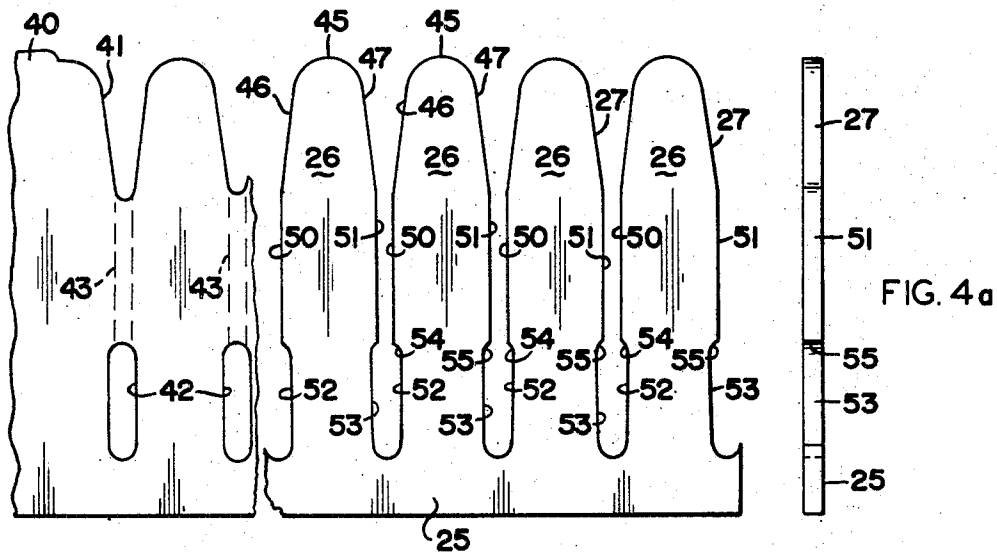


FIG. 2

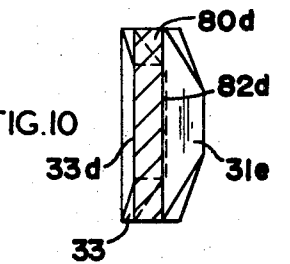
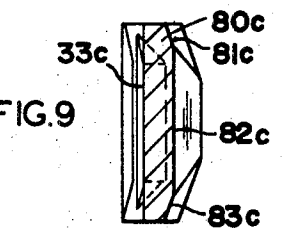
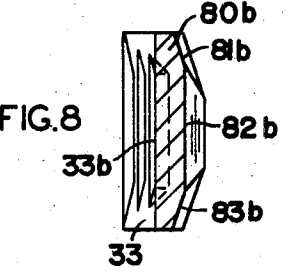
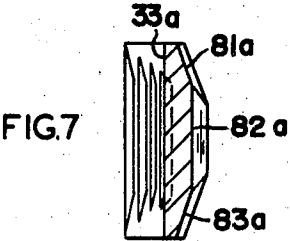
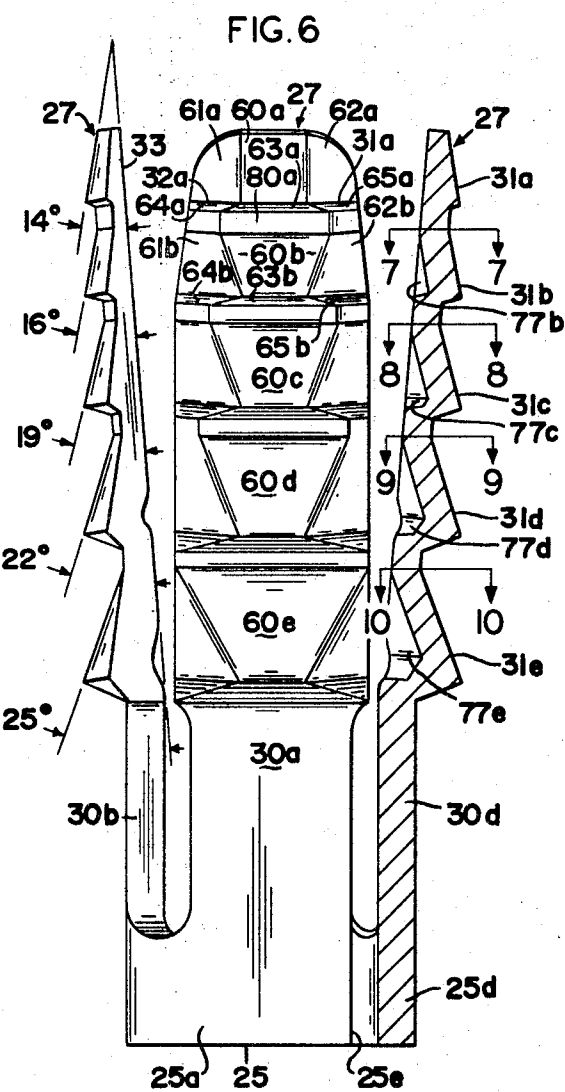


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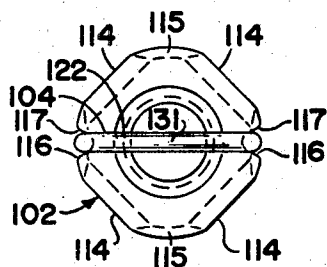
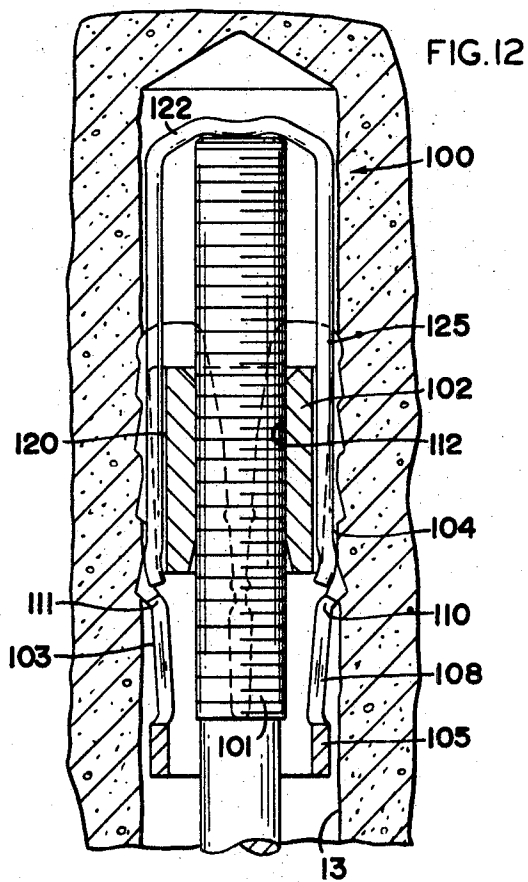
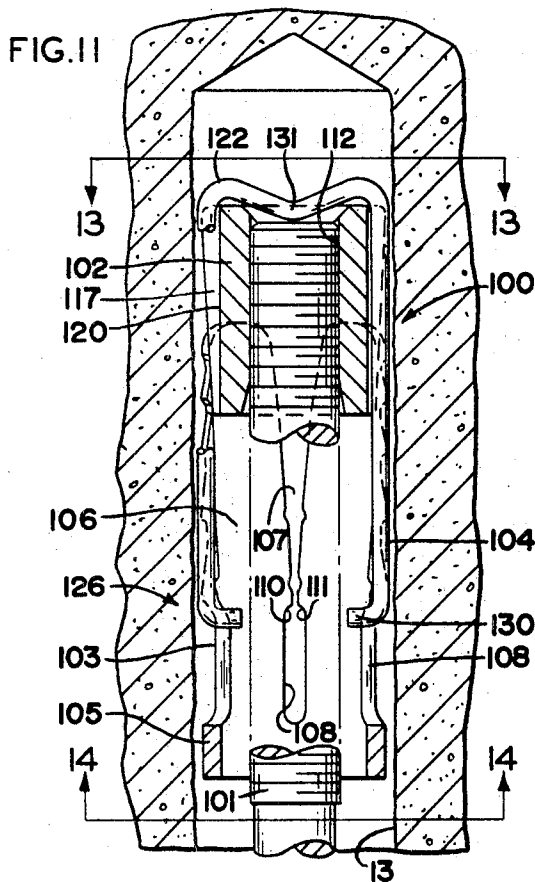


FIG. 13

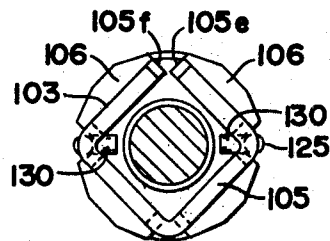


FIG. 14

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BOLT ANCHOR AND METHOD FOR MAKING SAME

BACKGROUND OF THE INVENTION

The present invention relates to expansion fasteners and more particularly relates to expansion fasteners of the type utilized to anchor a bolt for support of mine roof or the like.

Mine tunnels or underground excavations having a generally rectangular cross sectional area are known to have an "arch line" above the roof above which, in the absence of major cracks or slips, rock will not fall into the tunnel. It is therefore necessary to support the roof of the tunnel to prevent the rock disposed between the roof and this arch line from falling into the tunnel.

In the past, mine roofs have been supported by pillars, frames, etc. With the advent of automated mining equipment, it has been necessary to clear the tunnel of any obstructions which might otherwise hamper operation of automated equipment which extends through the tunnels. The usual method for supporting a mine roof in a manner which clears the tunnel is by the use of a plurality of bolts which extend upwardly into blind bore holes. These holes are formed in the mine roof. The bolts are anchored in the holes above the arch line. The anchored bolts support plate members against the roof to support the rock between the mine roof and the arch line.

The distance between the mine roof and the arch line is dependent upon the dimensions of the mine tunnel as well as the character of the rock in which the tunnel is formed. In many instances mine roof bolts are anchored a distance of five to eight feet above the mine roof and may carry a tensile loading of as much as thirty tons.

Expansion fasteners are generally considered to require accurately formed, cylindrical holes of diameters held to close tolerances. In fasteners such as those used to anchor machine tools, self-drilling fasteners are commonly used to provide accurate hole formation and close tolerance fit. With mine roofs, the nature of the rock formations and the depth of the bore holes make it substantially impossible to drill bottomed bores which are true cylinders. In addition, the nature of the rock formations is such that the firmness of the bore walls varies from bore to bore and often in a single bore. Thus, the bore holes in which the bolts and anchors are inserted are commonly noncylindrical of varying diameter and of varying wall hardness.

Accordingly, anchors for mine roof bolts must: (1) possess adequate flexibility to engage the walls of an oversize bore, i.e., a bore which is of relatively greater diameter than the normal expander anchor diameter; (2) be of sufficiently strong material to support many tons of axial force; and, (3) be capable of locking with or frictionally engaging the wall of a bore hole formed in soft or hard strata to prevent slipping of the anchor relative to the bore under high axial loadings.

THE PRIOR ART

The prior art relating to anchoring bolts in blind holes is relatively extensive. Most of such expansion fasteners are associated with bolts which are of relatively short length, insertable in an accurately formed hole, and need not carry large, static, axial loadings. Such fasteners may be formed of relatively light material which is subjected to minimal expansion to grip the walls of the bore.

Expansion bolts which are adapted for use in supporting mine roofs are generally associated with expansion anchors of either the "regular" type or the "bail" type. Both of these types of anchors commonly include a bolt having a head at one end which engages a roof supporting plate. The bolt is threaded into a camming or expansion plug which is advanced on the threads of the roof bolt as the bolt is rotated.

The standard anchor also includes a malleable iron shell. The shell has an annular body surrounding the bolt and arcuate or rounded toothed fingers extending longitudinally from the body. The fingers are wedged into engagement with the

walls of the bore by the tapered camming or expansion plug as it is advanced along the bolt threads. When the toothed fingers firmly engage the bore walls, continued rotation of the bolt tensions the bolt to maintain the roof plate in supporting engagement with the mine roof.

In many instances the bore hole is oversize or out-of-round at the location where the roof bolt is to be anchored. When the hole is oversized, or the walls are soft, the expansion plug travels an excessive distance axially before adequate tension of the bolt is obtained. When this occurs the fingers of the expansion shell are flexed excessively and the flexure is confined to relatively short portions of the fingers. As a result, the cast material forming the fingers is fractured or broken resulting in materially reduced holding power of the anchor, or complete malfunction.

Because of these difficulties of securing roof anchors, very large factors of safety are used. Usually a number of anchors in excess of the theoretical requirements is employed.

Moreover, expansion shells which are cast from malleable iron have been relatively expensive due to complex and inherently slow methods required in their manufacture. Further, such expansion shells may not be uniform in construction due to discontinuities in the material. Even perfectly formed malleable shells have less strength than the shells of this invention.

It has been proposed that an expansion anchor might be more cheaply manufactured by stamping from sheet steel material. No such proposed sheet steel construction, if practical at all, has been consistently capable of providing the necessary strength for mine roof anchors.

One mine roof anchor proposed, suggested a sheet metal expansion anchor of the bail-type. This proposal did not provide a well developed tooth structure and depended for its holding power on frictional engagement of dimplelike extrusions with the bore walls. Among other shortcomings, such a construction is limited in effective use to relatively soft rocks which it can penetrate adequately to prevent the anchor from sliding from the hole.

Other proposed expansion fasteners have suggested sheet metal expansion members with toothlike gripping ridges formed by corrugating methods in relatively thin metal. These proposals have no substantial change in wall thickness of the formed metal. The shortcomings of these proposals in failing to provide adequate anchorage for mine roof applications are the same as those noted above.

SUMMARY OF THE INVENTION

The present invention provides an expansion anchor and method of making an expansion anchor wherein a plurality of toothed fingers are fashioned from a uniform sheet of steel. The fingers are formed by cold working operations. The fingers are disposed in a generally tubular configuration. The fingers have cold worked hard, thick teeth which are adapted to be forced by a plug into firm wedging engagement with a bore hole to support loads equal to or greater than those supportable by cast iron expansion anchors and greater than loads supportable by prior proposed steel anchors. The anchor of this invention is not as dependent on close bore tolerances and limited in its application by rock consistencies as previously known mine roof anchors. Thus, this anchor is firm in holes in which malleable anchors would not hold properly or would fail completely. Further, the anchor of this invention can be produced at lower cost than known expansion anchors of the type referred to.

Accordingly, an object of the present invention is the provision of a new and improved expansion shell for a mine roof support bolt wherein fingers of an expansion device are fabricated from steel and a method of making such shells.

Another object of the invention is a novel and improved bail-type expansion fastener.

Other objects and advantages of the invention will be apparent from the following description of a preferred form of the invention, reference being made to the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a foreshortened sectional view of a mine roof anchor assembly embodying the present invention prior to expansion;

FIG. 2 illustrates the anchor of FIG. 1 in one operative condition;

FIG. 3 is a sectional view as seen from the plane indicated by the line 3-3 of FIG. 1 with parts removed;

FIG. 4 is an elevational view of an expansion shell in one phase of its manufacture;

FIG. 4a is a side elevational view of the shell of FIG. 4;

FIG. 5 is a view similar to FIG. 4 illustrating an expansion shell blank in a phase of its manufacture;

FIG. 5a is a side elevational view of the blank of FIG. 5;

FIG. 6 is an elevational view shown partly in section of an expansion shell embodying the invention;

FIG. 7 is a sectional view as seen from the plane indicated by line 7-7 of FIG. 6;

FIG. 8 is a sectional view as seen from the plane indicated by the line 8-8 of FIG. 6;

FIG. 9 is a sectional view as seen from the plane indicated by the line 9-9 of FIG. 6;

FIG. 10 is a sectional view as seen from the plane indicated by the line 10-10 of FIG. 6;

FIG. 11 is a fragmentary sectional view of a bail-type roof anchor embodying the present invention;

FIG. 12 is a view similar to the FIG. 11 illustrating the anchoring condition of the mine roof anchor of FIG. 11;

FIG. 13 is a plan view of a portion of the anchor assembly of FIG. 11 as seen from the plane indicated by the line 13-13 of FIG. 11; and,

FIG. 14 is a sectional view as seen from the plane indicated by the line 14-14 of FIG. 11.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 illustrates a mine roof anchor assembly 10 including a roof bolt 11 having a shank 12. The shank 12 is insertable into a bore hole generally designated at 13 in the roof of a mine. The assembly 10 also includes an expansion anchor 14 threaded onto and carried by threads 21 on an end portion of the shank 12. A roof support plate 15, only a part of which is illustrated, is engaged by a head 16 of the bolt 11 and compressively urged into engagement with the roof of the mine by tensioning of the bolt.

The expansion anchor 14 includes a generally polygonal tubular expansion shell 20. The anchor 14 also includes a support nut 22 threaded onto the threads 21, and a camming or expansion plug 23. The expansion plug 23 has a threaded axial bore 24 threaded on the threads 21 of the shank 12. Prior to expansion, the shell is held in place relative to the bolt 11 by the nut 22 and the plug 23.

The expansion shell 20 is formed from sheet of steel. The shell includes a body or collar portion 25 formed by a length of the sheet material which is bent in three places intermediate its ends to define a nearly "square" periphery having sides 25a-25 (see FIG. 3). Edges 25e, 25f of the collar are spaced to define a relatively narrow end gap between the sides 25a, 25d. The shell has four fingers 26a-25d respectively. Thus, the fingers 26a-d extend longitudinally from an edge of the collar 25 and engage the expansion plug 23. Each of the fingers 26a-d includes a toothed gripper 27 and a relatively stem portion 30 which connects the toothed gripper 27 to the body 25. Each stem 30 lies in the plane of the side of the collar from which it extends. The inner surface of the gripper 27 flares outwardly from the plane of the stem 30, such that inwardly facing surfaces 33 of the grippers 27 diverge in the direction of the plug 23.

The grippers 27 each include bore engaging teeth 31 which are defined by coined parts of the material to the grippers 27. The teeth have crests 32 extending generally transversely of the fingers. The teeth have successively greater height and pitch proceeding toward the collar 25. The inwardly facing surfaces 33 are bearing surfaces which extend at a slight angle,

typically 5°, from the plane of stem 30. The increasing crest height of the teeth 31 is such that a line tangent to the crest of each tooth is parallel to the plane of the stem 30. This line, if extended, intersects the plane of the bearing surface 33 at a small acute angle so that the grippers 27 may be said to be wedges or wedgelike structures.

The camming plug 23 is generally a truncated pyramid having an outer periphery which is defined in part by four planar bearing surfaces 35 arranged uniformly about the axis of the plug. The surfaces 35 are disposed at a slight angle relative to the axis of the plug so that adjacent bearing surfaces 33, 35 of the expansion shell 20 and plug 23, respectively, are complementary for sliding contact with each other upon expansion of the shell 20. The large end of the plug 23 is of larger diametrical extent than the diametrical distance between the free ends of the fingers 26 in nonexpanded condition.

Installation of the Assembly of FIG. 1

In use, the anchor assembly 10 is inserted through an aperture 15a in the roof support plate 15 and into the bore hole 13. The head 16 of the bolt 11 includes a flanged portion 16a which is maintained in engagement with the lower surface of the roof support plate 15. A suitable torque or other wrench is engaged with the bolt head 16 for rotating the assembly 10 in the bore. As the assembly 10 is turned, the teeth 31 of the expansion shell 20 engage the bore 13 and provide sufficient frictional resistance to rotation of the shell and plug 20, 23 to cause the plug to be advanced downwardly along the threads 21 as the bolt 11 and the support nut 22 turn together. This deflects the stiffly resilient stems 30 and thereby spreads the fingers 26a-d of the expansion shell 20 into engagement with the bore wall.

The camming plug 23 continues to advance downwardly along the shank 12 as the bolt is rotated until the fingers 26a-d of the expansion shell 20 have been sufficiently wedged into engagement with the bore to set the shell and prevent further movement of the plug 23. Continued rotation of the bolt 11 advances the shank 12 upwardly, stripping the threads of the support nut 22 and elongating the bolt to substantially increase the tension in the bolt resulting in a supporting force being exerted by the roof plate 15 on the roof of the mine. The torque wrench, not illustrated, may be utilized in tightening the bolt 11 to a desired tensional loading, depending upon the character of the material in which the bore hole 13 is formed.

In addition to the wedging action mentioned, the increasing tooth height and pitch along the grippers 27 permit the anchor 14 to be fixed in bores formed in a variety of different rock. When the anchor is to be fixed in exceedingly hard rock, such as granite, the uppermost and least compressible teeth on the fingers engage the rock under considerable pressure. As the camming plug is advanced the tooth crests serve as pivots and the facets or faces of the teeth are deformed outwardly about these pivots into surface engagement with the walls of the bore. A wedging friction is developed between the teeth and rock which prevents the anchor from slipping in the bore. The fingers 26 are not deflected to a great extent in such rock and the lowermost teeth of the fingers may not engage the bore. On the other hand, if such an anchor is set in relatively soft rock, such as shale, the fingers 26 are spread to a greater degree by further plug travel so that all of the teeth bite into the rock, forming lugs or ledges for supporting the mine roof.

Method of Making the Shell

In the novel method of this invention, the expansion shell 20 is formed of sheet steel material of ten gauge or heavier. FIGS. 4-10 are illustrative of the development of the expansion shell from a strip of "dead soft" sheet steel. Dead soft steel is completely annealed steel having a carbon content of not more than 0.1 percent and manganese in the range of 0.2 percent to 0.5 percent. Referring to FIG. 4, a strip of sheet steel material 40 is fed into a multistation die for performing a sequence of stamping operations. The first stage of these

stamping operations includes: (1) forming notches 41 at an edge of the strip 40; and, (2) piercing the strip 40 to form elongated openings 42. The openings 42 have straight sides and circularly curved ends. The longitudinal axes of the openings 42 are aligned with corresponding notches 41 so that "webs" 43 of material are disposed between the base of the notches 41 and the openings 42, which webs are illustrated in broken lines in FIG. 4. Subsequent to notching and piercing of the strip, the webs 43 are punched out so that the collar 25 is formed, with a plurality of blank planar fingers 26 extending from an edge of the collar.

As is seen in FIG. 4, the gripper portions 27 of the blank fingers 26 each include a generally circularly curved end 45 which terminates in tapered surfaces 46, 47 extending between the curved end 45 and parallel side surfaces 50, 51 of the fingers. The stem 30 of the fingers 26 has generally parallel side surfaces 52, 53 defining the sides of the openings 42. The stem surfaces 52, 53 are joined to the tooth portion surfaces 50, 51 by shoulders 54, 55. The stem surfaces 52, 53 are continuous with the collar 25 and are connected to the collar through circularly curved fillets formed by the circular ends of the openings 42.

Next the teeth 31 are formed in the gripper portions 27 by one stamping operation which cold works the grippers. The tooth forming operation is effected by male and female die components (not shown) disposed on opposite sides of the metal blank. The male component is effective to stamp the gripper portions 27 in a combined embossing and coining operation to effect extensive cold flowing of the material into conformity with the female component. This produces the teeth 31a—31e, illustrated in FIG. 5a, which teeth are described in greater detail presently.

During the tooth forming operation, the slight angular relationship between each bearing surface 33 and its associated stem 30 is established so that each bearing surface 33 lies in a plane, preferably approximately 5°, from the plane of its stem 30.

The steel strip 40 is sheared along shear lines aligned with the surfaces 52, 53 of the stems 30a, 30d, respectively, to produce an expansion shell blank B having four fingers 26, FIG. 5. The blank B is then bent along bend lines 56 so that the sides 25a, 25d of the collar are disposed at right angles with respect to the plane of the sides 25b, 25c and with the bearing surfaces 33 of the fingers 26 on the sides 25a, 25d facing each other so that a generally U-shaped blank structure is provided. Subsequent to bending at the lines 56, the blank B is bent at the line 57 so that the sides 25b, 25c are disposed at right angles to each other and the sides 25a, 25d of the collar are disposed adjacent each other to form the generally square tubular expansion shell 20. The shell 20 has a slight end gap between the sides 25a, 25d of the collar 25, FIG. 3. The grippers 27 diverge upwardly from the collar as described above, and which is illustrated in greater detail in FIG. 6. The gap between the sides 25a, 25d may be partially or completely welded closed if desired, but such welds do not affect the ultimate strength of an installed anchor.

The Tooth Formations

The teeth 31a—31e each have an upper side defined by three planar facets of the material which slope downwardly and outwardly relative to the plane of the bearing surface 33 of the same finger at a relatively small acute angle. These are the surfaces or facets which are pivoted about the crests 32 into bore engagement when the bore hole is in hard rock. The underside of each tooth is defined by three planar facets which slope facets which slope upwardly away from the plane of the bearing surface 33. These are the surfaces or facets which provide supporting ledges when the bore hole is in soft rock.

The facets forming the upper and under sides of the teeth intersect to define the crests of biting edges 32 of the teeth. Each crest 32 is defined by three straight line segments, each segment being formed by the intersection of the facets of the

upper and lower sides of its tooth so that each crest approximates a section of a circle having a diameter which is only slightly smaller than the diameter of the bore 13. Since the series of teeth 31a, 31e on the fingers 26 are identical, only a single series of the teeth is described in detail.

Referring to FIG. 6, the tooth 31a adjacent the end of the finger 26 includes facets 60a, 61a, 62a forming its upper side. The center facet 60a is of substantially rectangular shape and extends downwardly relative to the plane of the bearing surface 33 at an angle of about 14°. The facets 61a, 62a extend downwardly at similar angles and taper outwardly from the lateral edges of the fingers 26 so that the tooth is thickest at the portion of the tooth crest defined in part by the facet 60a.

The underside of the tooth 31a includes facets 63a, 64a, 65a, each extending outwardly and upwardly away from the finger at a relatively large acute angle with respect to the plane of the bearing surface 33. The underside crests 63a—65a, respectively, intersect the facets 60a—62a at the crest 32a. The crest 32a of the tooth 31a, therefore, is composed of three straight line segments defined by the intersection of the facets 61a, 64a; 60a, 63a; and 62a, 65a, respectively.

The metal of the gripper portion is cold flowed during the coining process during which teeth of the described configuration are formed. As the metal cold flows, the configuration of the tips of the fingers 26 is changed from the generally circularly curved shape illustrated in FIG. 4, to the relatively blunt shape shown in FIGS. 5 and 6. The flowing of the metal causes the sectional thickness of the end of the finger to be reduced to the extent that the central part of the upper end, as viewed in FIG. 5, of the fingers 27 is less than two-thirds of the thickness of the original steel strip. In the center of the crest 32a of the tooth 31a the sectional thickness is increased as much as 8 percent over the original strip thickness. This substantial cold flowing of the steel in the development of the teeth produces an extremely strong tooth.

The tooth 31b is of substantially the same form as the tooth 31a and is defined by facets 60b—62b and 63b—65b forming the upper and lower sides of the tooth respectively. The tooth 31b differs from the tooth 31a in that the facet 60b is of a generally truncated triangular shape and extends downwardly from the plane of the bearing surface 33 at an angle of about 16°. Thus, the tooth 31b is of greater height than the tooth 31a, but it should be noted that the portion of the crest 31b defined by the intersection of the facets 60b, 63b is of the same length as the corresponding portion of the crest 32a of the tooth 31a. Thus, the crest 32b, like the other crests, approximates a section of a circle having the same diameter as the circular section defined by the crest 32a.

The tooth 31b is formed in part by the male die component referred to previously which is effective to cold flow material from the finger 26 toward the crest of the tooth 32b and in so doing produces a generally wedge-shaped cavity 77b in the veering surface 33. The cavity 77b, which is illustrated in FIGS. 5 and 6 is of such size and shape that the sectional thickness of the finger around the tooth 31b is smaller than the strip thickness except in the vicinity of the crest 32b as noted above in reference to the tooth 31a.

The teeth 31a, 31b are separated by a web 80a of material having an outer surface defined by three facets 81a—83a, FIG. 7. These facets 81a—83a approximate a section of a cylinder coaxial with and of smaller diameter than the diameter of the circle approximated by the crests 32. The web 80a has an inner surface 33a paralleling the surface of the facet 82a has its maximum sectional thickness between the surfaces 33a, 82a which thickness as to displacement of material in the tooth forming operation is less than the sectional thickness of the strip from which the shell is fashioned.

The teeth 31c—31e and webs 80b—80d are of the same general construction as the teeth 31a, 31b and similar parts of these teeth are denoted by corresponding reference numerals having the appropriate letter designation. As seen in the drawings, the individual teeth differ in size and height with height of teeth in each series increasing proceeding toward the

collar 25, and accordingly the angles at which the facets 60 of the upper sides of the teeth extend relative to the plane of the bearing surface 33 increases for each successive tooth in the series. Approximate angles at which the facets 60 of the teeth extend are illustrated in FIG. 6. The teeth 31 are also of increasing axial length proceeding toward the collar 25 and therefore, the tooth pitch, i.e., the axial distance between crests of adjacent teeth, increases proceeding toward the collar 25.

The male die portions forming the teeth 31c—31e produce cavities 77c—77e. The cavities have upper surfaces formed by planar facets 90—92, FIG. 5, corresponding generally to the facets of the upper sides 60—62 of the teeth 31, and lower facets 93—95 corresponding generally to the facets 63—65 forming the lower sides of the teeth 31. The facets 90 of the cavities 77 extend downwardly from the plane of the bearing surface 33 at a slightly smaller angle than that of the facets 60 of the teeth so that the sectional thickness of the teeth increases slightly proceeding along the facets 60 toward the crest 32 from a thickness less than to a thickness greater than the original thickness of the blank. Similarly, the facets 93 of the cavities 77 extend upwardly from the plane of the bearing surface 33 at a smaller acute angle than the angle at which the facets 63 of the teeth 31 extend, providing an underside tooth section which increases in thickness, proceeding toward the crest 32, to a maximum thickness approximately equal to the original thickness of the blank. The angularity of the facets of the cavities and teeth referred to correspond to the configurations of the male and female die components. During the embossing and coining operation, a normal deficiency of embossing operations is overcome by the coining. The coining displaces and cold flows metal in all parts of the gripper portions and into tooth crests. Thus the crests of the teeth are of relatively large sectional thickness and the material of the toothed gripper portions 27 is hardened due to the cold working and flowing of the metal.

It should be appreciated from the foregoing description that the stems 30 and collar 25 remain substantially unworked upon during formation of the fingers and teeth of the expansion shell and accordingly, the stems 30 are relatively "soft" and flexible in comparison to the cold worked grippers 27. The flexibility of the stems 30 permits the fingers 26 to be spread a relatively large amount for engagement with bores which are oversized or easily indented. The holding ability of the anchor is in no way adversely affected by flexible character of the stems 30 since the stems 30 do not participate in carrying the roof supporting loads.

The Anchor of FIGS. 11—14

FIGS. 11—14 illustrate a modified expansion anchor 100 for a mine roof support which includes an anchor similar to the anchor 14. The difference resides in replacement of the support nut 22 of FIGS. 1 and 2 by a wirelike hanger member or bail. The bail maintains the anchor 100 in assembled condition for shipment and for onsite attachment to unbolt to complete the anchor assembly prior to insertion into a bore 13 in the mine roof. The anchor assembly includes the threads 101 near an end of a conventional mine roof bolt which, in the illustrated embodiment, is identical with the bolt 11 described with reference to FIGS. 1 and 2. The anchor 100 includes a camming plug 102 threaded onto the bolt. The anchor 100 also includes an expansion shell 103 and a wirelike hanger or bail 104. The bail 104 is effective to lock the expansion shell 103 and the plug 102 in an assembled position relative to each other until the anchor is secured in a bore hole 13.

The expansion shell 103 can be of any suitable construction, but for convenience is shown as being the same as the expansion shell 20 described above and therefore is not described in detail, except to say that the shell includes a collar 105 and a plurality of fingers 106 extending from the body into engagement with the bearing surfaces of the expansion plug 102. Four such fingers 106 are provided with the expansion shell

103, which fingers define slots 107 which terminate in enlarged openings 108 adjacent the collar 105. Thus, shoulders 110, 111 are formed on adjacent fingers 106 at the upper end of the enlarged openings 108.

The disclosed camming plug 102 is of the generally truncated pyramid-type having a threaded axial opening 112 threaded onto the thread 101. The plug 102 has four planar bearing surfaces 114, FIG. 13, for engaging corresponding bearing surfaces of the fingers 106. The bearing surfaces 114 lie in planes which converge downwardly with respect to the axis of the bolt as viewed in FIG. 11. The bearing surfaces 114 are of substantially the same shape and area so that the expansion plug 102 assumes a generally square configuration when viewed in plan (see FIG. 13) having a first pair of diagonal "corners" 115 formed by gently curved surfaces joining adjacent bearing surfaces 114 and with the remaining pair of diagonal "corners" 116 each having an axially extending groove 117. Each groove 117 has a base 120 which extends parallel to the axis of the expansion plug 102, and thus each groove is deeper at its upper end than at its lower end.

The bail 104 is preferably formed of a length of relatively yieldable wire having a bridge section 122 extending across the top of the camming plug 102, and legs 125 received by the grooves 117 in the camming plug 102. The legs 125 extend downwardly between adjacent fingers 106 at diametrically opposite locations relative to the tubular shell 103.

Restraining portions 126 are provided for locking the bail 104 in its position illustrated in FIG. 11. In the illustrated embodiment each restraining portion 126 includes a bend of from about 20° to the disclosed 90° and an end part 130. The end parts 130 extend through the enlarged openings 108 in the shell 103 for engagement with adjacent shoulders 110, 111. This engagement with adjacent shoulders 110, 111. This engagement provides structure for maintaining the anchor in an assembled condition.

A bridge section 122 of the hanger 104 includes a generally V-shaped bend 131. The tip of the bend 131 extends into the opening 112 in the expansion plug 102. During installation of the anchor the bend 131 is in centered thrust engagement with the rotating end of the roof bolt so that the expansion shell 103 is prevented from axial movement relative to the bolt and bore during initial shell expansion travel of the camming plug 102.

As the roof bolt is turned, the expansion plug is moved downwardly along the threads 101 to spread the fingers 106 of the expansion shell in the manner described previously, and the expansion shell 103 is maintained in position by the bail 104. When the anchor 100 has been initially set, the roof bolt advances upwardly through the expansion plug 102 to provide the necessary mine roof supporting tension in the bolt. Since the bail 104 is formed from a relatively yieldable material, the ends 130 of the bail 104 are straightened and pulled out of engagement with the shoulders 110, 111 and the bridge section 122 is deformed. The yieldable nature of the bail 104 provides no substantial impediment to the advancing movement of the roof bolt through the expansion plug 102. Furthermore, because the bail 104 extends between the fingers 106 of the expansion shell 103, the bail does not interfere with expansion or proper setting of the shell 103.

While mine roof anchors embodying the present invention have been illustrated and described herein in considerable detail, the present invention is not to be considered to be limited to the precise constructions shown. It is the intention to cover hereby all adaptations, modifications, and uses of the present invention which come within the scope of the appended claims.

I claim:

1. An expansion anchor assembly for a mine roof comprising:
 - a. a bolt including a threaded portion;
 - b. a camming plug threaded on said bolt;
 - c. a plurality of formed metal fingers disposed about said camming plug;

- d. said fingers each having a series of coined outwardly disposed teeth thereon with the height of the teeth increasing proceeding along said fingers away from said camming plug, certain of said teeth each having a recess in the obverse face thereof;
 - e. said fingers each having a planar bearing surface engageable with said expansion plug, said recesses being in said bearing surface;
 - f. an extension of a line tangent to said teeth intersecting the plane of said bearing surface at a small acute angle; and
 - g. one tooth having a wall thickness, along at least one radial line, which is greater than the wall thickness, along a corresponding radial line, of a tooth further from said collar position than said one tooth.
2. An expansion anchor assembly as defined in claim 1 wherein said teeth include a plurality of planar facets defining sides thereof, and crests of said teeth defined by intersections of facets of said tooth sides, said crests extending generally transversely of said fingers.
3. An expansion anchor assembly as defined in claim 2 wherein said crests are defined by three planar facets forming one side of said teeth and three corresponding planar facets forming said other side of said teeth, the intersections of said facets defining crests comprised of three straight line segments approximately a segment of a circle.
4. An expansion anchor assembly as defined in claim 1 and wherein said fingers are formed continuously with a sheet metal body and project cantilever fashion from said body toward said expansion plug, said fingers further including a relatively unworked flexible stem portion extending between teeth and said body.
5. An expansion anchor assembly as defined in claim 4 wherein said body is bent intermediate ends thereof so that said fingers and said body define a generally polygonal tubular expansion shell having one leaf on each side of said polygon.
6. An expansion anchor assembly as defined in claim 5 wherein said ends of said body are disposed adjacent each other to define an end gap in said body.
7. An expansion anchor comprising:
- a. a plug forming a camming member;
 - b. an expansion shell having a plurality of fingers;
 - c. each finger having a toothed portion with a camming surface in engagement with the member and teeth projecting from the obverse surface thereof;
 - d. each toothed portion having a plurality of recesses formed in its camming surface with each recess being defined by inner surfaces of a tooth;
 - e. each camming surface including an elongated, longitudinally straight, strip extending uninterruptedly, longitudinally of its toothed portion near a side of, and past both ends of, one tooth whereby to prevent longitudinal collapse of the one tooth upon application of anchoring pressure;
 - f. each camming surface also including a straight transverse strip extending transversely of its finger near an end of, and past both sides of, a certain tooth whereby to prevent transverse collapse of said certain tooth upon the application of anchoring pressure;
 - g. each finger having a base;
 - h. a selected tooth having a wall thickness as measured along a radial line greater than the wall thickness of other teeth on the same finger as measured along corresponding radial lines;
 - i. said selected tooth being closer to the base of its finger than said other teeth; and,
 - j. said shell including means joining the fingers together near the bases thereof.
8. An expansion shell as defined in claim 7 wherein said fingers further include stem portions between said collar and said teeth, said stem portions having a sectional thickness which is substantially the same as that of said collar.
9. The expansion shell of claim 7 wherein the teeth are each comprised of a series of upper and lower planar facets, the

upper facets being of greater surface area than the lower facets and being at a lesser angle with respect to the longitudinal extent of said structure than said lower facets, thereby to permit said teeth to grip varying types of strata in functional different manner.

10. The anchor of claim 7 wherein said joining means comprises a soft metal collar of square configuration in a plane transverse to said shell, said collar having spaced ends at one corner of the square.

11. The anchor of claim 7 wherein said plug has a plurality of planar camming surfaces and the camming surfaces of said fingers are complementary to the plug camming surfaces.

12. The anchor of claim 7 wherein each said longitudinal strip extends substantially the entire length of its toothed portion.

13. The anchor of claim 11 wherein each finger has two such longitudinal strips.

14. An expansion anchor assembly for a mine roof comprising:

- a. a bolt having a head and a spaced threaded portion;
- b. a camming plug threaded on the bolt and including a plurality of flat camming surfaces tapering toward said head;
- c. a sheet metal expansion shell having a collar around the bolt between the plug and the bolt head;
- d. said shell having a plurality of fingers each extending longitudinally from the collar away from the bolt head;
- e. each finger having a toothed portion connected to the collar by a stem;
- f. each toothed portion having a plurality of hardened teeth extending from an outer surface and an inner surface extending from an outer surface and an inner surface including a camming section complementary to, and in surface engagement with, one of said plug camming surfaces;
- g. certain of said teeth having surfaces defining:
 - i. as part of its toothed portion inner surface, a recess disposed outwardly of the plane of the camming section of its toothed portion;
 - ii. and as part of its toothed portion outer surface, a tooth crest; and,
 - h. each of said certain teeth having a wall thickness greater than the thickness of the metal surrounding the tooth when measured along a radial line intersecting a tooth crest.

15 The assembly of claim 14 wherein said wall thickness of each of said certain teeth as measured along such radial line through its crest is greater than the radial wall thickness of said stems.

16. An expansion anchor assembly for a mine roof comprising:

- a. a bolt including a threaded portion;
- b. a camming plug threaded on said bolt;
- c. a plurality of formed, metal fingers disposed about said camming plug;
- d. said fingers each having a series of coined, outwardly disposed teeth thereon with the height of the teeth increasing proceeding along said fingers away from said camming plug;
- e. said fingers each having a planar bearing surface engageable with said camming plug, an extension of a line tangent to said teeth intersecting the plane of said bearing surface at a small acute angle;
- f. bail means for supporting the fingers relative to said expansion plug in the end of the bolt, said bail means including a wirelike member having a middle section extending across and into the bolt and in engagement therewith;
- g. the wirelike member including leg portions extending from said middle section generally parallel to the bolt and past the plug with each leg portion being disposed between an adjacent pair of fingers;
- h. said bail means further including bent end portions on the remote ends of said leg portions overlying and engaging shoulders formed on said adjacent fingers; and,

- i. said bail means maintaining said assembly in an assembled condition and being disposed within a contour generated by the expansion shell whereby entire assembly may be inserted in the bore hole and setting of the anchor in a bore hole can be effected without detrimental interference by the bail.

17 An expansion anchor assembly comprising:

- a. a bolt;
- b. a camming plug threaded on the bolt;
- c. an expansion shell comprising a collar portion around the bolt and a plurality of spaced fingers extending longitudinally from the collar generally paralleling the bolt;
- d. said fingers having end portions in engagement with exterior surfaces of said plug and being adapted to be expanded into locking engagement with a surrounding bore hole on advance of the plug relative to the shell toward said collar;
- e. a bail retaining said assembly in an assembled condition, said bail comprising:
 - i. a bridge portion spanning an end of the plug and engaging the plug to maintain it in contact with said expansion shell;
 - ii. leg portions extending from the bridge portion toward the collar and disposed in spaces between adjacent fingers of the plugs;
 - iii. said bail including end portions at the ends of the legs remote from the spanning portion and projecting into spaces between adjacent fingers, said bent end portion engaging shoulders on said fingers whereby to maintain said assembly in an assembled condition; and
- f. said bail being disposed within a generally-cylindrical contour generated by said expansion shell, whereby to maintain said assembly in an assembled condition as it is inserted in a bore hole without interference with such insertion.

18. An expansion shell blank comprising:

- a. a soft sheet metal collar having a base;
- b. a plurality of sheet metal fingers extending longitudinally from said collar in a direction away from the base;
- c. each of said fingers including a toothed portion having a plurality of formed teeth projecting from one face thereof, and a planar camming surface on the obverse face of said fingers, said camming surface having recesses therein each aligned with a projecting tooth, said teeth increasing in height relative to said planar surface proceeding toward said collar; and
- d. one tooth having a wall thickness, along at least one radial line, which is greater than the wall thickness, along a corresponding radial line, of a tooth further from said collar portion than said one tooth.

19. A blank as defined in claim 18 wherein said fingers further include a relatively soft deflectable stem portion between said toothed portion and said collar.

20. A blank as defined in claim 19 wherein said fingers are bent at the juncture of said stem portion and said toothed portion with said camming surface extending at a slight angle with respect to the plane of said stem portion.

21. A blank as defined in claim 20 wherein a line tangent to crests of said teeth is substantially parallel to said plane of said stem portion.

22. A blank as defined in claim 21 wherein said teeth are formed by a plurality of planar facets arranged to provide tooth crests extending generally transversely across said fingers.

23. A blank as defined in claim 22 wherein said crests are defined by a plurality of straight line segments formed at intersections of said facets, and which line segments approximate a segment of a circle.

24. A blank as defined in claim 22 wherein said teeth have walls with a sectional thickness which increases proceeding longitudinally toward said crests.

25. A blank as defined in claim 19 wherein the sectional thickness of said toothed portion is less than the sectional thickness of said stem portion except in the vicinity of crests of said teeth.

26. A method of forming an expansion shell from sheet metal comprising the steps of:

- a. providing a generally planar sheetlike strip of metallic material;
- b. slotting said strip to provide a collar portion and a series of fingers extending from the collar portion;
- c. working said fingers to provide a series of teeth thereon; and
- d. said working step including deforming and flowing the material to form the teeth having an increasing height relative to the plane of said sheet of material proceeding toward said collar portion the flowing of the material being continued until one tooth has a wall thickness along at least one radial line which is greater than the wall thickness along corresponding radial lines of a tooth further from said collar portion than said one tooth.

27. A method as defined in claim 1 wherein said step of deforming and flowing said material includes the step of forming a plurality of planar facets defining tooth crests which extend generally transversely of said fingers.

28. A method as defined in claim 1 and further including the step of deforming said fingers transversely of their length between the collar portion and said teeth so that a line tangent to crests of the teeth is substantially parallel to the plane of said collar portion.

29. A method as defined in claim 1 and further including the steps of shearing said collar portion to produce ends on said collar portion, and bending said collar portion intermediate said ends to define a generally tubular, polygonal expansion shell.

30. A method as defined in claim 1 wherein said step of deforming and flowing said material includes the step of directing said flow of said material toward crests of said teeth whereby the sectional thickness of the crests of said teeth is greater than the sectional thickness of said strip.

31. The method of claim 1 wherein the working of the fingers is cold working.

32. The method of forming an expansion shell for an expansion fastener comprising:

- a. forming a shell blank from sheet metal, the blank including a collar portion and a plurality of fingers extending longitudinally in generally parallel relationship from the collar portion, the fingers each including a tooth portion and a stem portion connecting the tooth portion to the collar;
- b. working the tooth portions of said fingers while leaving the stem portions relatively unworked; and
- c. said working of the tooth portions including flowing metal into tooth parts from parts therebetween to form generally planar parts of worked metal between the tooth parts, said planar parts on completion of the working operation having a thickness less than the thickness of the original metal.

33. the process of claim 32 wherein the working of the finger portions is continued until all parallel surfaces thereof are spaced a distance less than their original spacing and all other surfaces are nonparallel.

34. The process of forming a finger for an expansion anchor comprising:

- a. forming a tooth blank including a stem portion from sheet metal;
- b. working said blank to form a plurality of teeth therein; and
- c. said working step including deforming and flowing the material to form the teeth having an increasing height relative to the plane of said sheet of material proceeding toward said stem portion the flowing of the material being continued until one tooth has a wall thickness along at least one radial line which is greater than the wall thickness along corresponding radial lines of a tooth further from said stem portion than said one tooth and greater than the thickness of said tooth blank prior to said working step.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,577,825

Dated May 4, 1971

Inventor(s) Hans E. Reusser

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 3 of first paragraph, before "mine" insert

- - a - -

Column 3, line 58, delete "25a-25" substitute - - 25a-25d - -

Column 3, line 60, after "26a" and before "-25d" insert - -

-d which extend longitudinally from the sides 25a - -

Column 3, line 63, before "27" insert - - portion - -

Column 3, line 64, before "stem" insert - - flexible - -

Column 4, line 16, delete "extend" substitute - - extent - -

✓Column 4, line 36, after "12" delete "ad" substitute - - as - -

Column 5, line 69, delete "facets which slope"

Column 6, line 33, delete "increases" substitute -- increased -

Column 6, line 37, delete "the" first occurrence, substitute

- - The - -

Column 6, line 55, delete "veering" substitute - - bearing - -

Column 6, line 66, after "82a" insert -- and forming part of
the bearing surface 33. The web 80a - -

Column 8, line 34, delete "This engagement with adjacent
shoulders 110, 111."

Claim 14, paragraph f., line 2, delete "ex-" substitute - -
in- - -

Claim 14, paragraph f., delete line 3 in its entirety.

Claims 27, 28, 29, 30, 31, line 1, delete "1" substitute
- - 26 - -

Signed and sealed this 7th day of September 1971.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents