Feb. 20, 1973 G. L. SHELDON ET AL 3,717,209
REPLACEABLE WEAR-RESISTANT ELEMENT
AND METHOD FOR REPLACING SAME
Filed June 10, 1971 2 Sheets-Sheet 1

FIG. 1

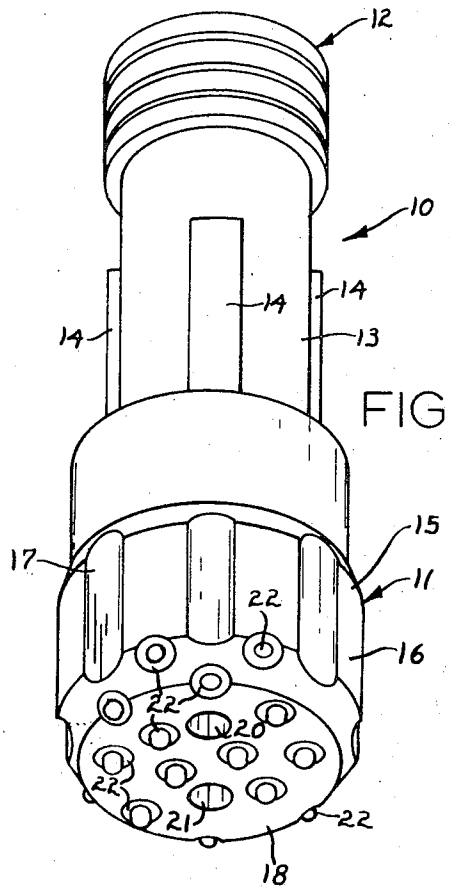


FIG. 2

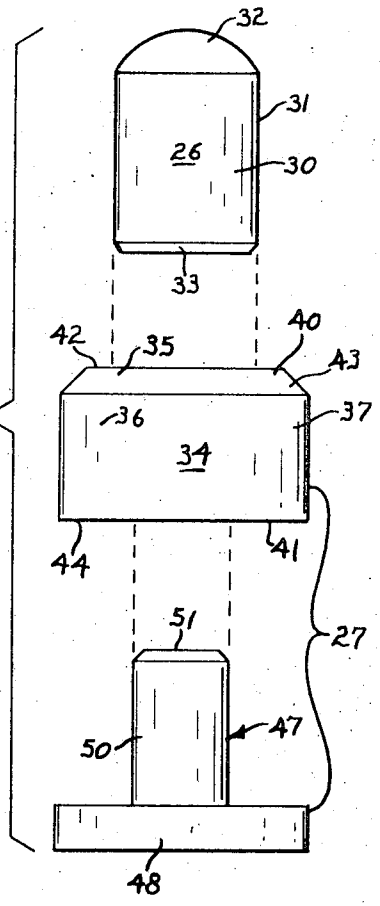


FIG. 3

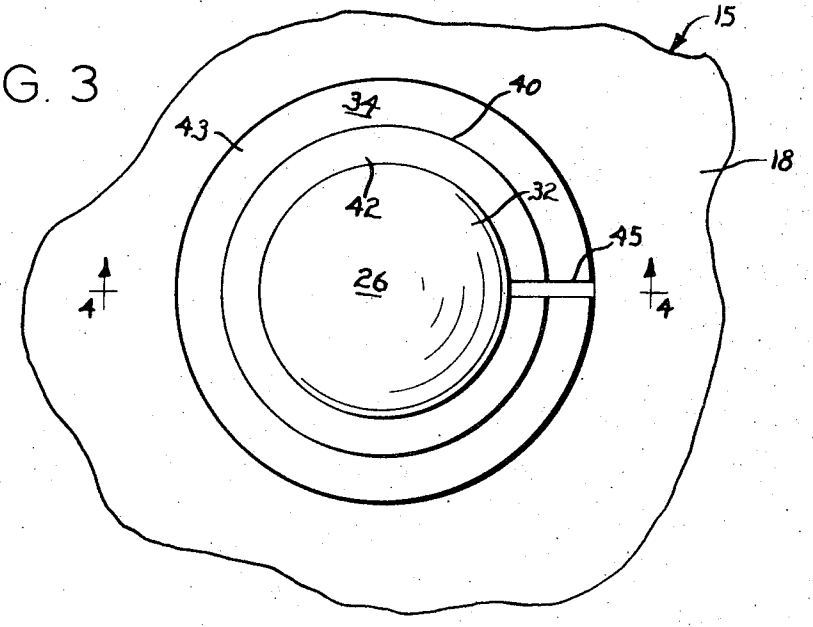
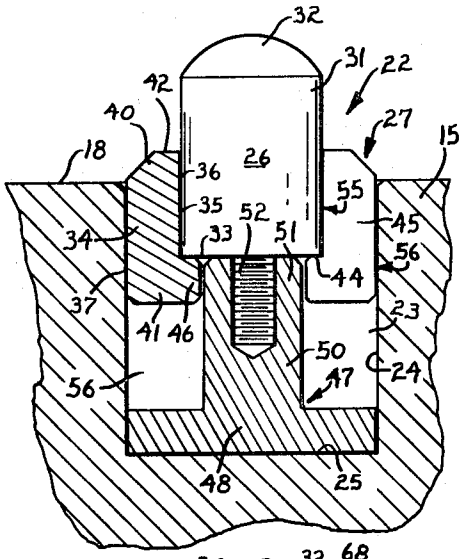


FIG. 5

FIG. 4



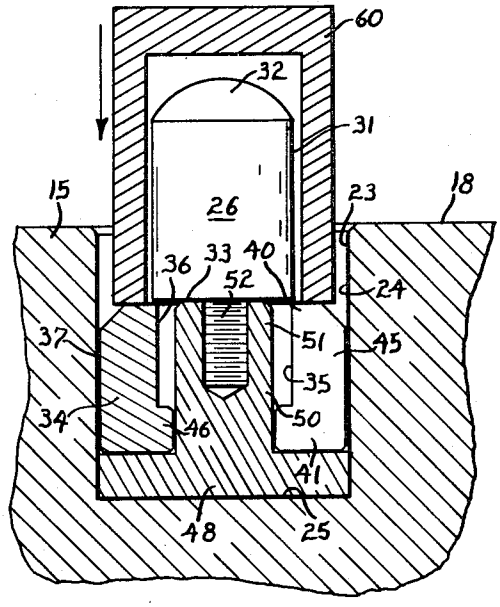


FIG. 8

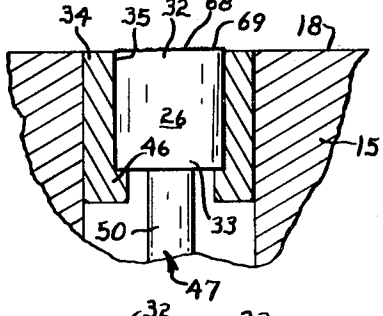


FIG. 7

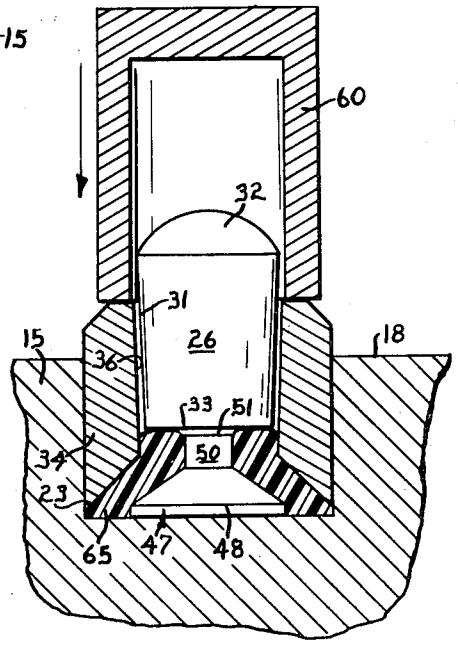
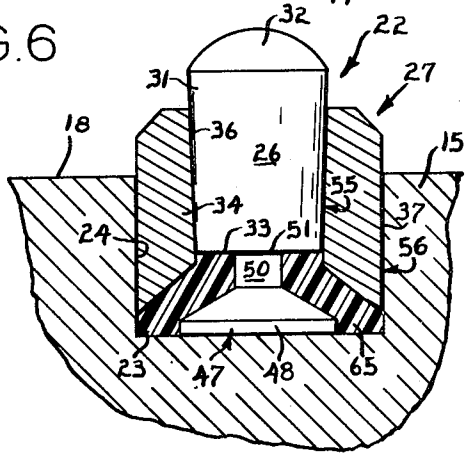


FIG. 6



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3,717,209

REPLACEABLE WEAR-RESISTANT ELEMENT AND METHOD FOR REPLACING SAME

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Int. Cl. E21c 13/00
U.S. Cl. 175—413 19 Claims

ABSTRACT OF THE DISCLOSURE

As a preferred embodiment, a drill bit is described containing a plurality of wear-resistant cutting element assemblies, each assembly having a replaceable wear-resistant cutting element support in a bit recess with a split sleeve. The recess has a space behind the sleeve and cutting element with an anvil member located therein to prevent further penetration of the cutting element, but which enables the sleeve to be pushed further into the recess to release the cutting element when a force of sufficient magnitude is applied thereto.

BACKGROUND OF THE INVENTION

This invention relates to replaceable wear-resistant elements and their method of replacement and more particularly to replaceable wear resistant elements for earth drilling, crushing and engaging equipment.

It has been found that better earth drilling performance can be obtained by fixing hard, wear-resistant cutting elements on the face of earth drilling bits. Most cutting elements are affixed by press fitting or brazing into recesses formed in the face of the bit. However, it has been very difficult to satisfactorily provide for replacement of individual cutting elements without having to throw away the entire bit. A drilling bit is a very expensive unit and its replacement represents a substantial expense. Numerous attachment configurations have been suggested to enable the cutting elements to be individually replaced when they become worn so that bit replacement would be unnecessary. Many of the cutting elements of the replaceable type are classified in United States Patent Office Class 175, entitled "Boring or Penetrating the Earth," subclasses 412 and 413.

A representative number of devices are shown in the following U.S. Pats.: 710,484; 1,228,296; 1,388,490; 1,403,711; 1,767,883; 2,022,194; 2,595,525; 2,689,109; 3,537,539; 3,139,149; 3,143,177; 3,182,736; 3,342,531; and 3,382,940.

Even though there have been many bit arrangements suggested having replaceable cutting elements, few have received commercial acceptance, particularly for application on percussion rock drilling tools. The stresses exerted on bits utilized on percussion rock drilling tools are tremendous with even the slightest stress concentrations leading to almost certain bit failure. Most replaceable cutting element arrangements seriously increase the internal stress concentrations in the bit.

Consequently, probably the most prevailing methods of removing cutting elements that are press fit or brazed into the bit is to drill the cutting elements out of the bit face. Examples of cutting elements that are removed by such a method are shown in U.S. Pats.: 2,121,202; 3,137,355 and 3,357,507. However, the method is quite expensive and less than satisfactory because most of the cutting elements are made of tungsten carbide which are difficult to machine.

One of the principal objects of this invention is to provide a replaceable wear-resistant element assembly which provides little or no modification of the supporting body in which the elements can be readily replaced when they become worn.

An additional object of this invention is to provide a wear-resistant element assembly that is very easy to originally mount in the face of a supporting body and in which the element can be readily and easily replaced when it becomes worn.

A further object of this invention is to provide a unique method for removing the wear-resistant elements from the supporting body.

An additional object of this invention is to provide a unique method of economically mounting a wear-resistant face of the body without increasing the stress concentrations in the body.

These and other objects and advantages of this invention will become apparent upon the reading of the following detailed description of a preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred and alternate embodiment of this invention is illustrated in the accompanying drawings, in which:

FIG. 1 is a perspective view of a rock drilling bit embodying the principal feature of this invention in which the bit has a plurality of cutting assemblies mounted in a face thereof;

FIG. 2 is an expanded unassembled view of the principal components of a cutting element assembly;

FIG. 3 is an enlarged front view of one of the cutting element assemblies mounted in the face of the drilling bit shown in FIG. 1;

FIG. 4 is a cross-sectional view taken along line 4—4 in FIG. 3 showing the cutting element assembly mounted in the face of the bit in which a cutting element is secured to the bit by a sleeve;

FIG. 5 is a cross-sectional view similar to FIG. 4 except showing the sleeve being moved axially further into the bit to release the cutting element;

FIG. 6 is a cross-sectional view similar to FIG. 4 except showing an alternate embodiment;

FIG. 7 is a view similar to FIG. 6 except showing the sleeve being moved axially further into the bit to release the cutting element; and

FIG. 8 is a view similar to FIG. 6 except showing a replaceable wear resistant element mounted in a supporting body.

DETAILED DESCRIPTION OF PREFERRED AND ALTERNATE EMBODIMENTS

Now, referring in detail to the drawings, there is shown in FIG. 1 as a preferred embodiment a drilling bit generally designated by the numeral **10**, which is mounted to a drilling tool to drill holes or bores into the earth's surface. Drilling bit **10** has a bit head **11** at one end and an anvil **12** at the other end. The drilling bit is normally mounted to the drilling tool with the anvil **12** extending into the drilling tool. In a percussion-type rock drilling tool, the anvil **12** is impacted with a hammer-type piston to drive the bit into the earth. The head **11** and anvil **12** are separated by a midsection **13** that has a plurality of longitudinal spines **14** formed thereon for preventing the bit from rotating with respect to the tool.

The bit **10**, may be a one-piece construction or a two-piece construction, in which the head **11** is removably mounted to the mid-section **13**. A two-piece construction is illustrated in U.S. Pats. 2,689,109 and 3,537,539 in which the head **11** is threadably mounted to the mid-section **13**.

The head **11** has a body **15** of a rather cylindrical shape with an exterior cylindrical side surface **16** and a face **18**. Side grooves **17** are formed in the side surface **16** for enabling air and fluids to flow upward past the bit head and the side wall of the hole being drilled.

Frequently, the bit **10** is constructed having a central bore (not shown) for directing air out the face **18** of the bit through air holes **20** and **21** formed therein. Air that is exhausted through the air holes **20** and **21** causes the earth cuttings to be blown upward through the side grooves **17** away from the face of the bit.

A plurality of wear-resistant element assemblies **22** are mounted in the face of the bit at various locations to perform the cutting, chipping or grinding action against the earth material during the operation of the drilling tool.

Each of the wear-resistant element assemblies **22** is mounted in separate recess or bores **23** formed into face **18**. A front view of a cutting element assembly mounted into a bore **23** is illustrated in FIG. 3. Each of the bores **23** has a side wall **24** and a back or bottom wall **25**. In a preferred embodiment the bore **23** is cylindrical in shape forming an annular or cylindrical side wall **24**. The bottom wall **25** may be flat or curved depending upon the particular application. Under certain conditions it is desirable to have the back wall relatively curved and flowing into the side wall **24** to minimze any stress concentrations being formed in the bit body **15**.

Each of the wear-resistant element assemblies **22** include an earth engaging or cutting element **26** which is generally made of a rather hard wear-resistant material such as tungsten carbide or ceramic material of a hardness considerbly greater than the bit body. In the drilling industry, the earth engaging elements **26** are frequently referred to as cutter inserts or as buttons. The wear-resistant element assembly **22** further has means **27** for mounting and releasably securing the cutting element **26** in the bore **23**.

Each of the cutting elements **26** includes a body **30** having a circular cross-section. As shown in FIGS. 4 and 5 the body has an annular peripheral surface **31**. The body **30** has a cutting end **32** for projecting outward from the face of the bit. Frequently, the end **32** has a semi-spherical shape for best performance, particularly for impact drilling. The body has an opposite base end **33** for extending into the bore **23**.

The means **27** for mounting and releasably securing a cutting element in the bore **23** includes a sleeve **34**. The sleeve is preferably constructed of a relatively tough, nonbrittle hardened alloy steel that is not as hard as the cutting element. The sleeve **34** has a central bore **35** extending therethrough, forming an inner surface **36** for receiving the peripheral surface **31** of the cutting element. The inner surface **36** is complementary in shape to the peripheral surface **31**. In FIGS. 4 and 5 the inner surface **36** and the peripheral surface **31** are cylindrical surfaces. The sleeve **34** has an outer surface **37** that is complementary in shape to the side wall **24**. In the embodiment shown in FIGS. 4 and 5, the outer surface **37** is cylindrical to match the side wall **24**. The sleeve **34** has a front end **40** and a rear end **41**. Front end **40** has an annular end surface **42** and an adjacent beveled surface **43** that extends to the outer surface **37**. When the cutting element assembly **22** is mounted in the bore **23**, the front end **40** normally projects slightly outward from the face **18** with the cutting end **32** of the element extending forward therefrom. The back end **41** of the sleeve **34** has annular end surface **44**. In the preferred embodiment illustrated in FIG. 3, sleeve **34** has a longitudinal slit **45** extending the full length for making the sleeve **34** more resilient, to permit a greater degree of circumferential expansion and contraction. In the embodiment illustrated in FIGS. 4 and 5, sleeve **34** has a shoulder **46** formed in the bore **35** to engage the base end **33** and the cutting element **26** to longitudinally position the cutting eleemnt in the sleeve.

The mounting means **27** further includes a stop or anvil means **47** for mounting in a rear section of the bore **23** to longitudinally position the cutting element and sleeve spaced from the back wall **25** in a forward section of the recess with the cutting end **32** extending from the face **18** the intended distance. The stop means **47** also enables the sleeve **34** to move axially with respect to the cutting element **26** to enable the cutting element to be released from the grip of the sleeve. The stop or anvil means **47** includes a base **48** for engaging the back wall **25** of the bore **23** and a projection or pedestal **50** that extends upward from the base **48** to engage the base end **33** of the cutting element. In the embodiment shown in FIGS. 4 and 5, the pedestal **50** has an end **51** that extends into the bore **35** of the sleeve to engage the base end **33** of the cutting element. It may be desirable to provide a threaded hole **52** axially into the end **51** to provide a convenient means for removing the anvil means **47** from the bore **23**.

When the cutting element **26** is mounted in the sleeve bore **35**, the peripheral surface **31** is connected to the inner surface **36** through a resistance connection **55**. When the cutting element assembly is mounted in the bore **23**, the outer surface **37** of the sleeve **34** is connected to the side wall **24** through a resistance connection **56** (FIG. 4). To assemble the cutting element assembly and mount the cutting element assembly **22** in the bore **23**, the cutting element **26** is initially mounted in the bore **35** with the resistance connection **55** between the peripheral surface **31** and inner surface **36** of the sleeve. The stop or anvil means **47** is mounted in the bore with the base **48** engaging the bottom wall **25**. The sleeve **34** with the cutting element **26** mounted therein is mounted axially within the bore **23** with the sleeve being connected to the body **15** through the resistance connection **56** between the side wall **24** and the outer surface **37**. The sleeve **34** and cutting element **26** are inserted into the bore until the base end **33** of the cutting element engages the end **51** of the anvil means as shown in FIG. 4.

In the preferred embodiment shown in FIGS. 4 and 5, the sleeve bore **35** has a diameter less than the diameter of the peripheral surface **31**. The outer surface **37** of the sleeve also has a diameter slightly less or equal to the diameter of the bore **23**. When the cutting element **26** is pressed into the bore **35** an interference fit is formed between the peripheral surface **31** and the inner surface **36** to provide a resistance connection between the cutting element and the sleeve. The internal pressure of the cutting element on the sleeve causes the sleeve to expand to increase the diameter of the outer surface **37** to a dimension greater than the diameter of the bore **23**. When the sleeve is pressed into the bore **23** as shown in FIG. 4, an interference fit is provided between the outer surface **37** and the side wall **24** to thereby form the resistance connection **56**. It should be noted that when the cutting element assembly is mounted in the bore **23**, the back end **41** of the sleeve is spaced from the base **48** and the back wall **25** to define an annular space **58** therebetween.

To replace a worn cutting element **26**, a removal tool **60**, is placed against the front end **40** of the sleeve. An axial force is then applied to the front end **40** of sufficient magnitude to overcome the forces of the resistance connections **55** and **56**, or more particularly to overcome the friction forces of the interference fits to cause the sleeve to move further into the bore **23** toward the back wall **25** as shown in FIG. 5. The anvil means **47** prevents the cutting element **26** from moving further into the bore **23** enabling the sleeve to move relative to the cutting element **26** to punch the cutting element out of the sleeve bore **35**. As the front end **40** clears the base end **33** the sleeve contracts to its undeformed condition with the outer surface **37** disengaging from the interference fit with the side wall **24** as shown in FIG. 5. FIG. 5 shows the removal tool applying a force sufficient to punch the cutting element free from the sleeve. The removal tool is then backed away from the sleeve and the cutting element is removed. Furthermore, the sleeve will readily slide out of the bore **23** by gravity to receive a replacement cutting element. If it is desired to remove the anvil means **47**, a bolt is inserted into the bore **23** and threaded into the threaded hole **52**. Under some conditions, it may be desirable to have the base **48** in frictional contact with

the side wall **24** so that the anvil means **47** will frictionally stay in the bore unless pulled therefrom. Alternatively, the anvil means **47** may be freely mounted in the bore engaging the back wall so that when the bit is tipped upward, the anvil means **47** would slide out of the bore by gravity.

The degree of interference fit between the cutting element **26** and the sleeve **34** and between the sleeve **34** and the side wall **24** of the bore is sufficient to hold the cutting element assembly in the bore under operating conditions yet insufficient to cause plastic deformation of the sleeve or the side wall **24**. It has been found that a diameter interference of between 0.001 of an inch and 0.005 of an inch is operable but that a diameter interference of between 0.0025 of an inch and 0.0035 is preferable.

The bore **23**, the sleeve **34** and the element **26** may have a variety of complementary cross-sections including square, circular, triangular and rectangular.

Alternatively, the resistance connections **55** and **56** may be provided by placing an adhesive between the surfaces to create an adhesive bond between the surfaces to releasably secure a cutting element assembly in the bore. To release the cutting element, an axial force is applied to the sleeve in the same manner with sufficient magnitude to break the adhesive bonds and move the sleeve relative to the cutting element.

In the embodiment shown in FIGS. 4 and 5, it is necessary to move the sleeve substantially the full length of the engagement between the surface **31** and surface **36** to release the cutting element **26**. This necessitates a bore **23** having a depth greater than the length of the sleeve.

For some bits it may be desirable to have bores **23** that are not as deep. An alternate embodiment is shown in FIGS. 6 and 7 in which both the peripheral surface **31** of the cutting element **26** and the inner surface **36** of the sleeve **34** are complementarily tapered so that the interference fit therebetween is released after only a small amount of movement of the sleeve relative to the cutting element as shown in FIG. 7. In this configuration the depth of the bore **23** may be reduced. It should be particularly noted that the depth of the bore **23** in the embodiment shown in FIGS. 6 and 7 is much less than the depth of the bore in FIGS. 4 and 5. The amount of movement of the sleeve **34** necessary to freely release the cutting element **26** is related to the degree of taper of the two surfaces.

An additional feature shown in FIGS. 6 and 7 is the mounting of a substantially noncompressible flowable material **65** in the space **58** so that when the sleeve is moved axially with respect to the cutting element **26**, the sleeve will apply a force against the material **65** tending to compress the material. In turn, the material exerts a proportional pushing force against the base end **33** of the cutting element to push the cutting element **26** forward of the anvil end **51**. The material **65** may be fluid, flowable metal, such as soft aluminum, copper or lead or a soft plastic material. The material **65** may be considered a force applying means responsive to the inward movement of the sleeve for applying a proportional outward axial force on the cutting element to move the cutting element forward to assist in freeing the cutting element.

Although not shown, the anvil means **47**, instead of being a separate part distinct from the body **15** may be formed in the body **15** when the recess **23** is formed. In such a configuration, the back wall **25** would have a projection or pedestal **50** that would extend toward the recess opening to serve as an anvil means.

As an alternate embodiment, the wear-resistant element assemblies **22** may be utilized on other parts or tools of earth drilling, crushing and engaging equipment besides drilling bits. The wear-resistant element assembly **22** may be utilized in a multitude of applications in which it is economically desirable to replace wear-resistant surfaces or elements. As shown in FIG. 8, broadly the assembly **22** may be mounted in a bore or recess **23** formed in a support body **15**. Instead of being used as a cutter, the element **26** may be used to provide a wear-resistant surface **69** on an element **26** that may be replaced as previously described. As shown in FIG. 8, the wear-resistant surface **69** is flush with the body surface. For some applications it may be desirable to slightly project the wear-resistant surface **69** forward of the body face **18**. Alternatively the wear-resistant surface **69** may include diamond particles **68** or the like affixed thereto to increase its wear-resistance.

It should be understood that the above described embodiments are simply illustrative of the principles of this invention and that numerous other embodiments may be readily devised without deviating therefrom. Therefore, only the following claims are intended to define this invention.

What is claimed is:

1. A drilling bit, comprising:

a body having a plurality of spaced bores formed in a face of the body, in which each bore is defined by an annular side wall, a back wall and an opening in the face;

a plurality of cutting element assemblies mounted in the bores, in which each cutting element assembly includes;

a sleeve mounted in one of the bores having one end adjacent the bore opening and an opposite end spaced from the back wall, in which the sleeve has an annular inner surface and an annular outer surface secured to the bore side wall through a resistance connection;

a cutting element mounted in the sleeve with a cutting end extending outward from the face of the body and an opposite base end extending into the sleeve, said cutting element having a complementary annular peripheral surface secured to the inner surface of the sleeve through a resistance connection; and

an anvil means mounted in the bore and positioned between and bearing against the base end of the cutting element and the back wall of the bore to punch the cutting element free from the sleeve when a force of sufficient magnitude is applied axially to the sleeve to overcome the resistance connections and move the sleeve inward toward the bore back wall.

2. A drilling bit as defined in claim **1** wherein the resistance connection between the peripheral surface of the cutting element and the inner surface of the sleeve is an adhesive bond formed by the placement of an adhesive material between said surfaces, in which the adhesive bond has adhesive strength characteristics that are overcome when the axial force is applied to the sleeve.

3. A drilling bit as defined in claim **1** wherein a space is defined between the sleeve and the back wall of the bore and further comprising a substantially noncompressible flowable material mounted in said space to be engaged by the sleeve when the sleeve is moved toward the back wall to squeeze the material therebetween to cause the material to apply a proportional axial force against the base end of the cutting element to push the cutting element axially outward from the sleeve.

4. A drilling bit as defined in claim **1** wherein the peripheral surface of the cutting element and the inner surface of the sleeve are resistently connected by an interference fit therebetween, in which the axial force is sufficient to overcome the frictional forces of the interference fit and to move the sleeve inward toward the back wall to punch the cutting element free from the sleeve with the aid of the anvil means.

5. A drilling bit as defined in claim **4** wherein the peripheral surface of the cutting element and the inner surface of the sleeve have complementary tapers to enable the cutting element to be punched free from the sleeve when the axial force moves the sleeve a distance less than the length of the cutting element.

6. A drilling bit as defined in claim 4 wherein the outer surface of the sleeve and the bore side wall are resistantly connected by an interference fit therebetween having a frictional resistance force that is less than the axial force applied to the sleeve.

7. A drilling bit as defined in claim 6 wherein the sleeve has a longitudinal slit running at least a portion of its length to enable said portion of the sleeve to circumventionally resiliently expand, and wherein the sleeve has an undeformed outer diameter equal to or slightly less than the diameter of the bore and an inner diameter less than an outer diameter of the cutting element so that when the cutting element is mounted in the sleeve an interference fit is formed between the inner surface of the sleeve and the peripheral surface of the cutting element and the sleeve is circumventionally expanded to increase the outer diameter of the sleeves sufficiently to form an interference fit between the outer surface of the sleeve and the bore side wall when the sleeve and cutting element are mounted in the bore and so that when the cutting element is punched from the sleeve the sleeve will contract and thereby release the interference fit to enable the sleeve to be readily removed from the bore.

8. A cutting element assembly for mounting in a recess formed in a face of a drilling bit, in which the recess is defined by a side wall and a back wall, said cutting element assembly comprising:

a cutting element having a peripheral surface between a cutting end and a base end;

means for mounting and releasably securing the cutting element in the recess with the cutting end projecting from the bit face, said mounting and securing means includes;

a sleeve having a bore therethrough defined by an inner surface complementary to the peripheral surface of the cutting element therein and an outer surface complementary to the side wall of the bit recess; and

a stop means for mounting in the bit recess against the back wall to bear aaginst the base end of the cutting element to locate the cutting element and sleeve axially within the bit recess spaced from the back wall with the cutting end projecting outward a desired distance from the bit face when the cutting element assembly is mounted in the bit recess and to further enable the sleeve to be moved axially inward toward the back wall relative to the cutting element to punch the cutting element from the sleeve bore when replacement of the cutting element is desired.

9. A cutting element assembly as defined in claim 8 wherein the cutting element and the sleeve have interfering cross-sections so that when the cutting element is received in the sleeve bore the inner surface of the sleeve engages the peripheral surface of the cutting element in an interference fit releasably securing the cutting element in the sleeve bore.

10. A cutting element assembly as defined in claim 8 wherein the inner surface of the sleeve and the peripheral surface of the cutting element have corresponding tapers to enable the cutting element to be punched free from the sleeve when the sleeve is moved axially relative to the cutting element only a short distance related to the degree of taper of said tapered surfaces.

11. A cutting element assembly as defined in claim 9 wherein the bit recess has a circular cross-section of a selected diameter and wherein the sleeve has a longitudinal slit formed therethrough so that when the cutting element is received in the sleeve bore the outer surface will expand to a diameter greater than the selected diameter to secure the outer surface of the sleeve to the side wall of the bit recess through an interference fit.

12. A method of removing a cutting element from a drilling bit when the cutting element is gripped in a sleeve in which the sleeve is mounted in a forward portion of a recess formed in a face of the drilling bit, comprising the step of:

moving the sleeve relative to the cutting element further into the recess until the cutting element is released from the grip of the sleeve.

13. A cutting element removal method as defined in claim 12 wherein the sleeve is moved relative to the cutting element further into the recess by performing the steps of:

preventing movement of the cutting element further into the recess; and

applying an axial force to one end of the sleeve of sufficient magnitude to overcome the grip of the sleeve on the cutting element to move the sleeve relative to the cutting element further into the recess until the cutting element is released.

14. A cutting element removal method as defined in claim 13 further comprising a step of:

simultaneously with the application of the axial force to the sleeve, applying an opposite axial force to the cutting element to move the cutting element relative to the sleeve.

15. Apparatus for releasably securing an element having a wear-resistant end surface in a recess formed in the face of a body in which the recess has a uniform cross-section and is defined by a side wall and a back wall, comprising:

a sleeve having a bore therethrough defining an inner surface complementary to the cross-section of the element and adapted to frictionally receive the element and an outer surface complementary to the side wall of the recess in which the cross-section of the sleeve is sufficient to provide an interference fit between the sleeve and the element to grip the element in the sleeve bore and to provide an interference fit between the sleeve and the side wall when the sleeve and gripped element are mounted in the recess to secure the element to the body; and

stop means for mounting in the recess between the back wall and the element to normally space the element and the sleeve from the back wall when the sleeve and gripped element are mounted in the recess and for enabling the sleeve to be moved inward toward the back wall relative to the element to disengage the interference fit between the element and the sleeve to release the element from the grip of the sleeve.

16. A method of removing a wear-resistant element from a body when the element is gripped in a sleeve with the sleeve mounted in a forward portion of a recess formed in a face of the body, comprising the step of:

moving the sleeve relative to the element further into the recess until the element is released from the grip of the sleeve.

17. The method as defined in claim 16 wherein the sleeve is moved relative to the element further into the recess by performing the steps of:

preventing movement of the cutting element further into the recess; and

applying an axial force to one end of the sleeve of sufficient magnitude to overcome the grip of the sleeve on the element to move the sleeve relative to the element further into the recess until the element is released.

18. An anvil for assisting in the removal of a wear-resistant element from a gripping sleeve that is mounted in a forward section of a recess in which the recess has a rear section behind the sleeve and wear-resistant element terminating in a back wall, comprising:

a base having a cross-section adapted to fit in the rear section of the recess bearing against the back wall; and

a pedestal having a reduced cross-section extending outward from the base to engage the wear-resistant element but not the sleeve to enable the sleeve to be moved relative to the wear-resistant element from the forward section to the rear section of the recess about the pedestal to release the wear-resistant element.

19. The anvil as defined in claim 18 in which the pedestal has an end for engaging the wear-resistant element, said end having a threaded hole formed therein to facilitate the removal of the anvil from the recess once the wear-resistant element is removed.

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U.S. Cl. X.R.

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