May 26, 1970 L. S. HUDSON ET AL 3,513,728

METHOD FOR MANUFACTURING APPARATUS USEFUL IN AN ABRASIVE ENVIRONMENT

Original Filed June 28, 1967 2 Sheets-Sheet 1

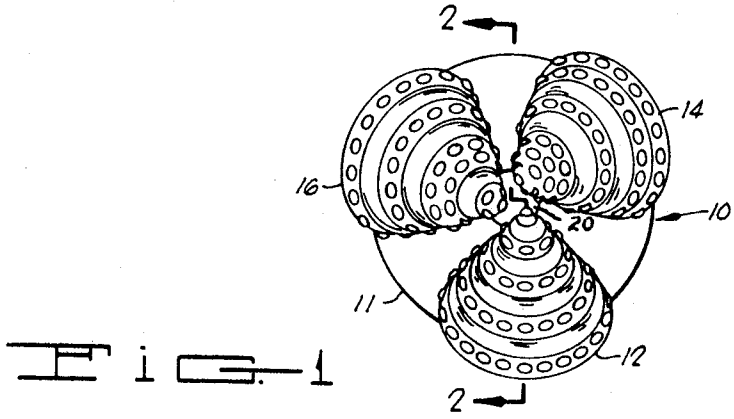


Fig. 1

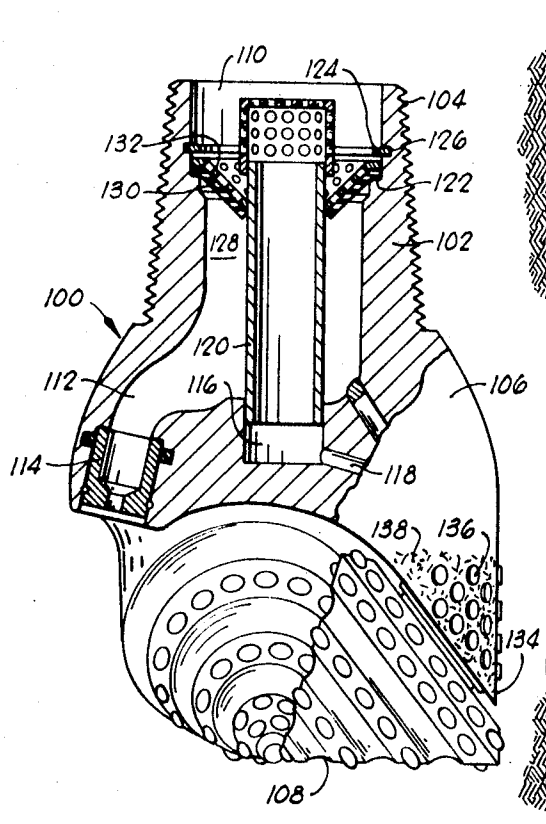


Fig. 5

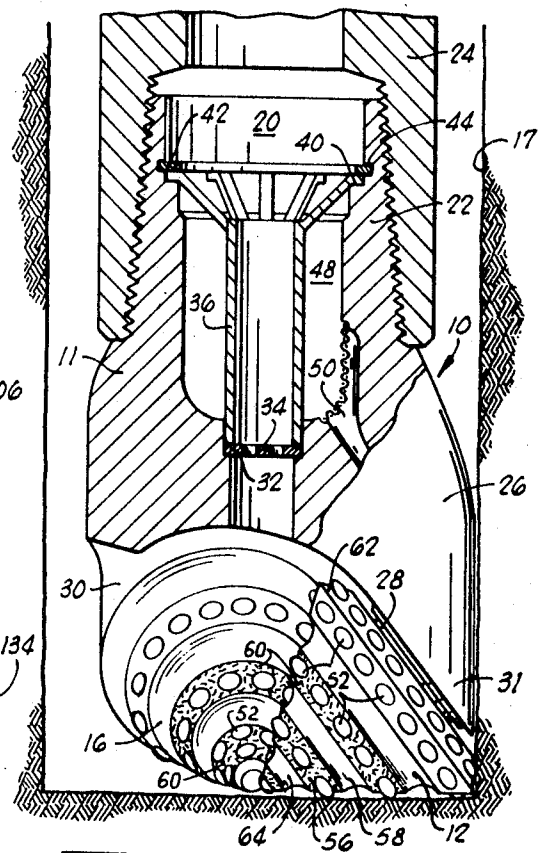


Fig. 2

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METHOD FOR MANUFACTURING APPARATUS USEFUL IN AN ABRASIVE ENVIRONMENT
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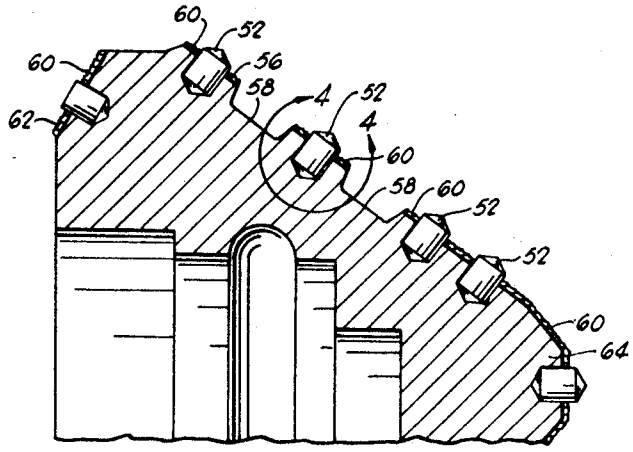


Fig. 3

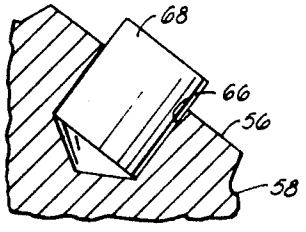


Fig. 4A

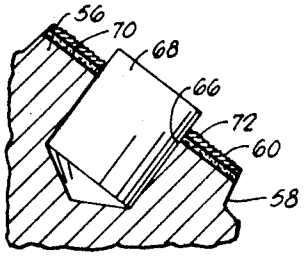


Fig. 4B

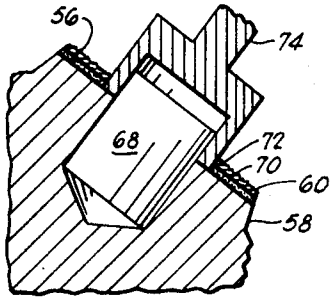


Fig. 4C

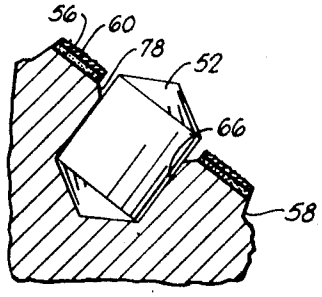


Fig. 4D

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3,513,728

METHOD FOR MANUFACTURING APPARATUS USEFUL IN AN ABRASIVE ENVIRONMENT

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Original application June 28, 1967, Ser. No. 649,638, now Patent No. 3,461,983, dated Aug. 19, 1969. Divided and this application Feb. 7, 1969, Ser. No. 822,771

Int. Cl. B21k 5/02

U.S. Cl. 76—108 3 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus that includes a member having a surface thereon exposed to an abrasive environment, the member having a relatively hard insert pressed into a hole in the member and having a hard facing material on the surface of the member surrounding the insert. A method of manufacturing the apparatus wherein the hole is plugged and hard facing material is applied to the surface around the plug. After the hard facing material has been permanently bonded to the surface, the plug is removed and the hard insert pressed into the hole to complete the apparatus.

This is a division of application Ser. No. 649,638, filed June 28, 1967, now Pat. No. 3,461,983, issued Aug. 19, 1969.

BACKGROUND OF THE INVENTION

This invention relates generally to improved apparatus useful in abrasive environments and to methods of manufacturing such apparatus. More particularly, but not by way of limitation, this invention relates to an improved apparatus useful in the drilling of oil and gas wells and the like wherein the apparatus includes a member having relatively hard inserts pressed therein and a hard facing material disposed on the surface of the member surrounding the inserts.

In the process of drilling oil and gas wells and the like, various components, particularly drilling bits and related items, operate in a highly abrasive environment. Although the abrasive conditions exist in the drilling of wells wherein a liquid is utilized as the medium for cooling the bits and carrying the cuttings from the bottom to the top of the hole, the abrasive conditions are considerably more pronounced in drilling wells utilizing air or gas as the cooling and carrying medium.

Drill bit life and efficiency are of prime importance in the drilling of oil and gas wells since the penetration rate is more or less directly related to the conduition of the bit. When harder formations are encountered in the drilling of the well, a bit having carbide inserts located in the body of the cutter members of the bit is generally utilized because of the ability of the inserts to penetrate the hard formations. However, the carbide inserts are mounted in a relatively soft member forming the body of the cutter member. When such bits are exposed to the abrasive conditions in the well, the relatively soft material of the cutter member body that holds the inserts is abraded or eroded away due to the presence of relatively fine cuttings from the formation and/or due to the direct blasting effect of the gas utilized in the drilling process. The wearing away of the cutter member body material is usually most pronounced on the nose or apex of conical cutter members. When the material supporting the inserts is eroded or abraded away to a sufficient extent, the drilling force exerted on the inserts, when they engage the formation, either breaks the inserts or forces them out of the cutter member altogether with the result that the bit is no longer effective in penetrating the formation.

The inserts utilized in such bits are retained in the cutter member by "hoop" tension generated when the insert is pressed into the relatively soft cutter member body. Thus, any method utilized in an attempt to alleviate the erosion of the cutter member must take into consideration that the "hoop" tension holding the inserts must be retained. It has been found to be impractical to press the inserts into the cutter member and then hard face the cutter member utilizing heat to adhere the hard facing material to the surface of the cutter member because the heating relieves the "hoop" tension.

Another method that has been utilized in an attempt to alleviate the erosion problem has been to hard face the cutter member before drilling the holes for the inserts. The difficulty in attempting to penetrate the hard facing material has shown this procedure to be impractical. Furthermore, and even when the holes for the inserts have been drilled successfully in the hard faced cutter member, pressing the inserts into the holes has resulted in cracks in the cutter member immediately surrounding the inserts. The cracks formed have relieved the "hoop" tension so that the inserts are not retained adequately and, therefore, are subject to being lost from the cutter member rather easily.

There are other portions of the bit, such as the lower end or "shirttail" of the arms which depend from the body to support the cutter members rotatably, that are also subject to the abrasion or erosion due to cuttings, and/or relatively high velocity gas. The shirttails of the bit also extend relatively close to the gage diameter of the drilled hole, that is, to the wall of the well bore, so that the shirttails are constantly exposed to the erosion effect of cuttings being carried upwardly by the drilling medium. If relatively large chips are discharged from the bit, the shirttail at times may actually perform a cutting or grinding action as such cuttings pass upwardly through the narrow annular space between the shirttail and the wall of the well bore. Consequently, it has been found that it is necessary to provide protection for the surface of the shirttail to prevent its wearing away.

SUMMARY OF THE INVENTION

Accordingly, this invention provides improved apparatus useful in an abrasive environment, wherein the apparatus includes a member having a surface exposed to the abrasive environment and having at least one hole formed therein, the member including: an insert element formed of a material harder than the member, forced into the hole in the surface of the member; and, a hard facing material deposited on the surface closely surrounding the insert element.

In another aspect, this invention provides an improved method of manufacturing apparatus useful in an abrasive environment including a member having a hard faced surface and at least one insert element formed of a material harder than the member forced into a preformed hole in the surface, the method comprising the steps of: placing a plug in the hole; placing hard facing material on the surface surrounding the plug; removing the plug; and, forcing the insert element into the hole.

One object of the invention is to provide an improved apparatus useful in an abrasive environment having a hard insert element in a member thereof and having a hard facing material deposited on the surface of the member surrounding the insert element to prevent erosion of the member and the subsequent loss of the insert element.

Another object of the invention is to provide an improved methot for manufacturing a member having a hard insert element therein and having hard facing material surrounding the insert element without disturbing the tension forces in the member that retain the insert element.

Still another object of the invention is to provide an improved bit for use in drilling oil and gas wells that includes a plurality of hard insert elements pressed into the cutting member of the bit and having hard facing material deposited on the surface thereof surrounding the insert elements to prevent the erosion or abrasion of the cutting member and the subsequent loss of the insert elements.

The foregoing and additional objects and advantages of the invention will become more apparent as the following detailed description is read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a bottom view of a drill bit incorporating cutting members constructed in accordance with the invention.

FIG. 2 is an enlarged cross sectional view of the drill bit disposed in a well bore, taken generally along the line 2—2 in FIG. 1.

FIG. 3 is an enlarged, partial cross sectional view of a portion of a cutting member removed from a drill bit.

FIGS. 4–A through 4–D are enlarged views of a portion of FIG. 4 defined by the line 4—4 and arranged to illustrate one method of the invention.

FIG. 5 is a view similar to FIG. 2, but illustrating a modified form of drill bit that incorporates features also in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing and to FIG. 1 in particular, shown therein and generally designated by the reference character **10** is a drill bit including a bit body **11** supporting three rotatable, conical cutter members **12**, **14** and **16** that are constructed in accordance with the invention. Each of the cutter members is arranged so that its axis of rotation is oriented generally toward the center line of the bit **10**, which coincides with the longitudinal axis of a well bore **7** as shown in FIG. 2.

A central passageway **20** extends downwardly through the bit body **11**. The bit body **11**, as shown clearly in FIG. 2, also includes an externally threaded pin portion **22** connected to the lower end of a string of hollow drill pipe **24**, a depending arm portion **26** that is provided with a journal **28** for rotatably supporting the cutter member **12**, a depending arm portion **30** that rotatably supports the cutter member **16**, and a depending arm portion (not shown) that is similarly arranged to rotatably support the cutter member **14**. Each of the arm portions terminates in a shirttail **31** that is disposed in close proximity to the wall of the well bore **17**.

The passageway **20**, which extends downwardly through the bit body **11**, has its lower end reduced in diameter forming a shoulder **32** in the body **11** that supports an orifice plate **34**. The lower end of a canister **36** engages and retains the orifice plate **34** on the shoulder **32**. The canister **36** is supported against movement in the body **11** on an upwardly facing should **40** formed in the interior f the pin portion **22** on the body **11** and by a lockring **42** that is disposed in an annular groove **44** formed in the pin portin **22** just above the shoulder **40**.

The canister **36** is arranged to divide the flow of fluid passing through the drill pipe **25** and the passageway **20** in bit **10** into two distinct streams. One of the streams flows downwardly through the interior of the canister **36**, encountering a portion of the cutter members **12**, **14** and **16** and encountering the central portion of the bottom of the well bore **17**. The other stream of air flows downwardly through an annular space **48** formed between the canister **36** and the wall of the bit body **11** into a plurality of cooling passage **50** communicating with bearings (not shown) that are operably disposed between the journal **28** and the relatively rotatable cutter members.

Comparatively, a relatively small volume of the circulating medium flows through the cooling passageways **50** to the bearing while relative large volume at high velocity flows through the orifice plate **34** cleaning the well bore **17** and carrying the cuttings to the surface.

As might be expected, the cutters **12**, **14** and **16** are subjected to the direct blast of the fluid flowing through the orifice plate **34** as well as to effect of the fluid deflected from the bottom of the well bore **17**. Also, the cutter members are rotating continuously in the cuttings generated as the cutter members engage the bottom of the well bore **17**. Thus, the cutter members are subjected to extremely abrasive and/or erosive conditions that tend to wear, erode or abrade the material forming the cutter members.

Each of the cutter member **12**, **14** and **16** is provided with a plurality of spaced, circumferential rows of inserts **52**. The inserts **52** are preferably formed from an extremely hard material, such as carbide. The inserts **52** function to penerate and, to some extent, disintegrate the formations encountered by the bit **10** during the drilling the well bore **17**.

As previously mentioned, the body of the cutter members is formed from a relatively soft material as compared to the material uesd in forming the inserts **52**. Thus, as the bit **10** encounters the abrasive and erosive conditions existing in the well bore **17**, the tendency is for the relatively soft material to be eroded or abraded away from the inserts **52** so that the inserts are either broken or lost, reducing the effectiveness of the bit **10**.

The partial, cross sectional view of FIG. 3 illustrates a typical cutter member that includes a plurality of the inserts **52**. As illustrated in the various figures of the drawing, the cutter members include a plurality of lands **56** and groove **58** with the inserts **52** located in the land **56**. As can be seen in FIGS. 1 and 2, the land **56** and grooves **58** extend circumferentially about the periphery of the conical cutter members **12**, **14** and **16**.

The surface of each of the lands **56** is covered with a hard facing material **60** by a process that will be described hereinafter. The provision of the hard facing material **60** on the lands **56** adjacent the inserts **52** serves to increase the life and effectiveness of the bit **10** by substantially reducing the abrasion and/or erosion of the relatively soft cutter member material that supports the inserts **52**.

FIG. 3 illustrates the disposition of hard facing material **60** on all exterior surfaces (excepting the grooves **58**) of the typical cutter member including a gage surface **62** and an apex surface **64**. It will be understood that the greatest wear occurs generally in the vicinity of the apex surface **64** and the adjacent two or three rows of inserts **52**. However, hard facing material can be used effectively on all surface areas of the cutter member **54** if desired.

As previously mentioned, the inserts **52** are retained in the typical cutter member by the "hoop" tension generated in the cutter member as the inserts **52** are pressed therein. FIGS. 4–A through 4–D illustrate a method utilized to successfully hard face the lands **56** in the immediate vicinity of the inserts **52** without losing the "hoop" tension.

When the cutter member has been machined to the desired configuration providing the lands **56** and grooves **58**, the lands are protectively coated and the cutter member is carburized. After annealing, the desired number and arrangement of inserts is determined and a hole **66** is drilled tightly receiving each insert in the appropriate land **56**. As shown in FIG. 4–A, a short section of a cylindrical rod **68** is then placed in the hole **66**. The rod **68** should be of a size that will be received closely in the hole **66**. The material forming the rod **68** should have sufficient structural strength to resist deformation of the hole during application of the hard facing material **60**, and, preferably, is a material that

can be removed easily after the hard facing material **60** has been applied.

After the rod **68** has been inserted in the hole **66**, the surface of the cutter member, that is, the surface of the land **56**, is pre-heated. After heating the land **56**, the surface of the land adjacent the rod **68** is painted with a bonding agent, such as a silicate **70**, covering the area that is to be hard faced. A relatively fine particulate carbide **72** is then sprinkled on the silicate **70** as shown in FIG. 4–B. Manifestly, any suitable type of hardfacing material can be utilized with or without a bonding agent as required.

As the silicate **70** begins to harden, a scraping tool **74** (see FIG. 4–C) is inserted over the exposed end of the rod **68** and rotated to remove a very small annular area of the hardfacing material **60** adjacent and encircling the rod **68**. When the hard facing material has been removed, heat is applied to the hard facing material **60** in any suitable manner, such as by the use of an atomic hydrogen or oxy-acetylene torch to permanently bond the hard facing material **60** to the surface of the land **56**.

Upon completion of the application of the hard facing material **60** and after the cutter member has been heat treated again, the rod **68** is drilled or otherwise removed from the hole **66**. A suitable tool is inserted in the hole **66** to form a very small chamfer **78** (see FIG. 4–D) in the annular area wherein the hard facing material **60** has been removed. Chamfering the hole **66** relieves any stresses that may exist along the edge of the hole **66**, removes any particles that may be in the hole and provides a lead-in or guide for the insert **52** which is pressed into the hole **66** after the chamfer **78** has been formed.

The method described hereinbefore provides for the application of the hard facing material **60** to the lands **56** to prevent their erosion or abrasion and, yet, does not destroy the ability of the cutter member **56** to provide the tension force necessary to maintain the insert **52** in the hole **66**. At the same time, the foregoing procedure avoids the formation of stress cracks that generally have occurred when other methods were attempted.

In operation, the bit **10** and the attached drill pipe **24** are lowered into the well bore **17** until the cutter members **12, 14** and **16** engage the bottom of the well bore **17**. After reaching the bottom of the well bore **17**, rotation is imparted to the drill pipe **24** and the bit **10**. As the bit **10** rotates, the drilling medium is pumped downwardly through the interior of the drill pipe **24** to the bit **10**.

Upon reaching the passageway **20** in the bit **10**, the drilling medium is divided by the canister **36** and one portion thereof flows through the annular space **48** into the cooling passageways **50**. The portion of the air flowing through the cooling passageways **50** enters the bearings (not shown), cooling the bearings as the cutter members **12, 14** and **16** rotate on their respective journals.

The second portion of the air flows through the interior of the canister **36**, through the orifice plate **34** and is discharged in a downward direction from the reduced portion of the passageway **20** in the bit **10**. As the air leaves the passageway **20**, it engages the apex portions **64** of the various cutter members and, generally, the first two or three rows of inserts **52**. When air is used as the drilling medium, the erosive effect thereof on the cutter members can be understood readily.

Also, the air or drilling medium leaving the passageway **20** encounters the central portion of the bottom of the well bore **17** resulting in a considerable turbulence therein which subjects the cutter members **12, 14** and **16** to the erosive and abrasive effects of cuttings from the bottom of the well bore **17** that are entrained in the drilling medium. The air flows past the cutter members **12, 14** and **16**, upwardly past the shirttails **31**, to the surface of the well bore **17** through the annular space between the exterior of the drill pipe **24** and the wall of the well bore **17**.

EMBODIMENT OF FIG. 5

The partial cross sectional view of FIG. 5 illustrates another embodiment of drilling bit generally designated by the reference character **100**. The bit **100** includes a bit body **102** having an externally threaded pin portion **104** and a plurality of depending arm portions **106**, each of which rotatably supports a cutter member **108** and that is preferably constructed as previously described.

The bit body **102** has a cavity **110** extending downwardly therein. The cavity **110** is in fluid communication with a plurality of jet passageways **112** that have their outlet ends located between adjacent cutter members **108**.

A jet nozzle **114** is located in the exit ends of each jet passageway **112**. The jet nozzles **114** are arranged to direct the drilling medium flowing therethrough at a relatively high velocity onto the bottom of the well bore generally between the cutter members **108**.

The cavity **110** also includes a relatively small recess **116** that is located in the lower end of the body member **102**. The recess **116** is in fluid communication with a plurality of cooling passageways **118** that are located in each of the arm portions **106** and arranged to cool the bearings (not shown) journalling the rotatable cutter members **108** on the arm portions **106**.

As shown clearly in FIG. 5, the recess **116** is sized to receive the lower end of a canister valve **120**. The canister valve **20** is supported in the bit body **102** against downward movement on an annular shoulder **122** that is formed in the upper portion of the body **102**. Movement of the canister valve **120** upwardly out of the cavity **110** is prevented by a lock-ring **124** that is located in annuluar groove **126** also formed in the bit body **102**.

The canister valve **120** functions to divide the drilling medium flowing downwardly through the cavity **110** into two separate streams. One stream flows downwardly through the interior of the canister valve **120** into the recess **116** and through the cooling passageways **118** to the bit bearings (not shown). The other flow stream passes downwardly through an annular space **128** between the exterior of the canister valve **120** and the wall of the bit body **102** into the jet pasageways **112**.

As illustrated, the canister valve **120** includes a plurality of flexible flappers **130** arranged to permit flow downwardly through the annular space **128**, but to prevent flow upwardly therethrough by the engagement of the resilient flappers **130** with a perforated portion or screen **132** of the canister valve **120**. The purpose of preventing upward flow through the annular space **128** is to prevent water, which may be encountered during the drilling of a well bore, from passing upwardly into the upper end of the cavity **110** of the bit **100** and downwardly therefrom through the interior of the canister valve **120** into the bit bearings.

Each of the arm portions **106** of the bit **100** includes a shirttail portion **134** which, during drilling of a well bore, are disposed relatively close to the wall of the well bore as previously mentioned in connection with the embodiment of FIG. 2. The shirttails **134** in the embodiment of FIG. 5 are provided with a plurality of relatively hard inserts **136** arranged in any suitable pattern thereon. Disposed on the surfaces of the shirttails **134** and closely surrounding the inserts **136** is a hard facing material **138**.

The shirttails **134**, which are disposed relatively close to the wall of the well bore, are subjected to highly erosive and abrasive conditions as the cuttings move upwardly to the surface of the well. Also, such conditions may result from the inadvertent engagement of the shirttails **134** with the wall of the well bore. Therefore, it is desirable to provide the inserts **136** and hard facing **138** on the shirttails **134** to increase the life of the bit. Particularly, the leading edge, that is, the edge of the shirttail

facing in the direction of rotation, is subjected to such extreme wear conditions.

In order to prevent loss of the inserts **136** from the shirttails **134**, it is preferred that the hard facing **138** and the inserts **136** be placed in the shirttails **134** by the process previously described in connection with FIG. 4, that is, by the process described for installing the hard facing material **160** on and the inserts **52** in the cutter members.

While the use of the inserts **136** and hard facing **138** on the shirttails **134** has been mentioned in connection with only the embodiment of FIG. 5, it will be apparent to those skilled in the art that the shirttail inserts and hard facing may be used also in the bit **10** described in connection with FIG. 2.

It will also be understood by those skilled in the art that the embodiments described in detail hereinbefore are presented by way of example only and that many changes and modifications can be made therein without departing from the spirit of the invention or the scope of the annexed claims.

Furthermore, there are numerous other well tools such as reamers, hole enlargers, big hole bits, and similar devices that are subjected to the extreme abrasive and erosive conditions encountered during the drilling of wells and the like with which the inserts and associated hard facing can be used to advantage and it will be understood that the process and apparatus described hereinbefore is intended for such use.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of manufacturing apparatus useful in an abrasive environment including a member having a hard faced surface and at least one insert element formed of a material harder than said member located in a preformed hole in said surface, the method comprising the steps of:

placing a plug in the hole;

placing hard facing material on the surface surrounding the plug;

removing the plug; and,

forcing the insert element into the hole.

2. The method of claim **1** and also including the step of removing a small portion of the hard facing material immediately adjacent the periphery of said hole.

3. The method of claim **1** wherein the step of placing hard facing material on the surface surrounding the plug includes ;

placing a silicate composition on the surface to be hardened;

placing granular hard facing material on the silicate composition;

removing a small quantity of hard facing material and silicate composition immediately adjacent the plug; and

heating the hard facing material and silicate composition whereby the hard facing material is permanently bonded to the member.

References Cited

UNITED STATES PATENTS

2,626,221	1/1953	Elliott	76—108
3,003,370	10/1961	Coulter	76—108
3,389,761	6/1968	Ott	175—374
2,973,047	2/1961	Edgar et al.	76—108 XR

BERNARD STICKNEY, Primary Examiner

U.S. Cl. X.R.

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,513,728 Dated May 26, 1970

Inventor(s) Lester S. Hudson and Eugene G. Ott

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

In Column 8, claim 3, line 14, change "hardened" to --hardfaced--.

Signed and sealed this 30th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents