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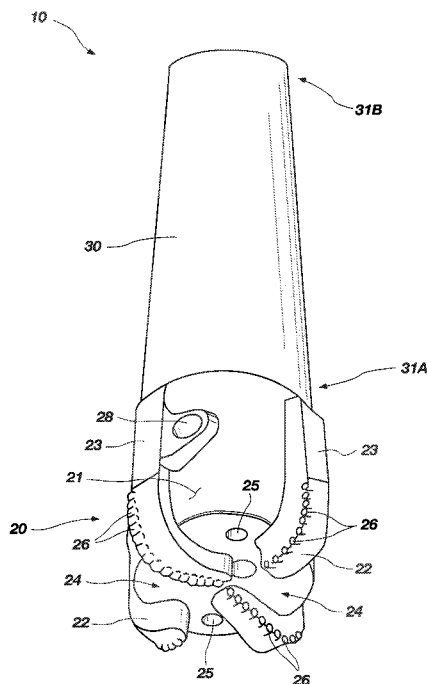


FIG. 1

(57) Abstract: Methods of attaching a crown of a boring shoe to a casing section include attaching an adaptable shank to a crown, and machining the adaptable shank to configure an end thereof for attachment to a casing section after attaching the adaptable shank to the crown. Additional methods include welding an end of an adaptable shank to a crown to form a boring shoe, selecting the adaptable shank to have an average wall thickness greater than about five percent (5%) of a maximum diameter of the crown, and configuring an opposite end of the adaptable shank for attachment to a particular type of casing section after welding the shank to the crown. Boring shoes have an adaptable shank attached to a crown, wherein the shank comprises a generally cylindrical wall having an average wall thickness greater than about five percent (5%) of a maximum diameter of the crown.



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**METHODS FOR FORMING BORING SHOES FOR
WELLBORE CASING, AND BORING SHOES AND
INTERMEDIATE STRUCTURES FORMED BY SUCH METHODS**

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PRIORITY CLAIM

This application claims the benefit of the filing date of United States Patent Application Serial No. 12/416,804, filed April 1, 2009, for "Methods For Forming Boring Shoes For Wellbore Casing, and Boring Shoes and Intermediate Structures Formed by Such Methods."

10

TECHNICAL FIELD

The present invention relates to earth-boring shoes configured for attachment to a section of wellbore casing, to methods of manufacturing such earth-boring shoes, and to methods of adapting such earth-boring shoes for attachment to a section of wellbore casing.

15

BACKGROUND

The drilling of wells for oil and gas production conventionally employs longitudinally extending sections or so-called "strings" of drill pipe to which, at one end, is secured a drill bit of a larger diameter. After a selected portion of the borehole has been drilled, the borehole is usually lined or cased with a string or section of casing. Such a casing or liner usually exhibits a larger diameter than the drill pipe and a smaller diameter than the drill bit. Therefore, drilling and casing according to the conventional process typically requires sequentially drilling the borehole using drill string with a drill bit attached thereto, removing the drill string and drill bit from the borehole, and disposing casing into the borehole. Further, often after a section of the borehole is lined with casing, which is usually cemented into place, additional drilling beyond the end of the casing may be desired.

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Unfortunately, sequential drilling and casing may be time consuming because, as may be appreciated, at the considerable depths reached during oil and gas production, the time required to implement complex retrieval procedures to recover the drill string may be considerable. Thus, such operations may be costly as well, since, for example, the beginning of profitable production can be greatly delayed. Moreover,

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control of the well may be difficult during the period of time that the drill pipe is being removed and the casing is being disposed into the borehole.

Some approaches have been developed to address the difficulties associated with conventional drilling and casing operations. Of initial interest is an apparatus which is known as a reamer shoe that has been used in conventional drilling operations. Reamer shoes have become available relatively recently and are devices that are able to drill through modest obstructions within a borehole that has been previously drilled. In addition, the reamer shoe may include an inner section manufactured from a material which is drillable by rotary drill bits. Accordingly, when cemented into place, reamer shoes usually pose no difficulty to a subsequent drill bit. For instance, U.S. Patent No. 6,062,326 to Strong et al. discloses a casing shoe or reamer shoe in which the central portion thereof may be configured to be drilled through. In addition, U.S. Patent No. 6,062,326 to Strong et al. discloses a casing shoe that may include diamond cutters over the entire face thereof, if it is not desired to drill therethrough. Such reamers that are configured for attachment to a casing string are referred to hereinafter as "reamer shoes."

As a further extension of the reamer shoe concept, in order to address the problems with sequential drilling and casing, drilling with casing is gaining popularity as a method for initially drilling a borehole, wherein the casing is used as the drilling conduit and, after drilling, the casing is cemented into and remains within the wellbore to act as the wellbore casing. Drilling with casing employs a drill bit that is configured for attachment to the casing string instead of a drill string, so that the drill bit functions not only to drill the earth formation, but also to guide the casing into the wellbore. This may be advantageous as the casing is disposed into the borehole as it is formed by the drill bit, and therefore eliminates the necessity of retrieving the drill string and drill bit after reaching a target depth where cementing is desired. Such drill bits that are configured for attachment to a casing string are referred to hereinafter as "drill shoes."

As used herein, the terms "earth-boring shoes" and "boring shoes" mean and include any device that is configured for attachment to an end of a section of casing and used for at least one of drilling a wellbore, reaming a previously drilled wellbore, and guiding casing through a previously drilled wellbore, as the section of casing to which the device is attached is advanced into a subterranean formation. Earth-boring shoes and boring shoes include, for example, drill shoes, reamer shoes, casing shoes

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configured to merely guide casing through a wellbore and ensure that the wellbore diameter remains as drilled (*i.e.*, has not decreased as sometimes occurs in reactive or sloughing formations), and shoes that both drill and ream as casing to which they are attached is advanced into a subterranean formation.

5 Commercially available casing sections are sold in a variety of different diameters and with a variety of different coupling configurations. As a result, when an earth-boring shoe is manufactured for a particular customer, a conventional boring shoe must be manufactured for the particular diameter of casing to which the boring shoe is to be attached. Furthermore, the boring shoe must be provided with a connection
10 portion that is configured (*e.g.*, with threads) to complementarily engage the particular connection portion of the casing string to which the boring shoe is to be attached.

 There is a need in the art for improved methods of coupling boring shoes to casing strings, and for improved methods of adapting boring shoes for attachment to casing strings having different connection configurations.

15

DISCLOSURE

 In some embodiments, the present invention includes methods of attaching a crown of a boring shoe to a section of casing. A first end of an adaptable shank may be attached to the crown of a boring shoe, and an opposite, second end of the adaptable
20 shank may be machined to configure the second end of the adaptable shank for attachment to a section of casing after attaching the first end of the adaptable shank to the crown.

 In additional embodiments, the present invention includes methods of attaching boring shoes to sections of casing. A first end of an adaptable shank is welded to a
25 crown to form a boring shoe. The adaptable shank is selected to have an average wall thickness greater than about five percent (5%) of a maximum diameter of the crown. An opposite, second end of the adaptable shank is configured for attachment to a particular type of casing section after welding the first end of the adaptable shank to the crown.

30 Yet further embodiments of the present invention include boring shoes having an adaptable shank attached to a crown, wherein the adaptable shank comprises a generally cylindrical wall having an average wall thickness greater than about five percent (5%) of a maximum diameter of the crown.

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BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

While the specification concludes with claims particularly pointing out and distinctly claiming that which is regarded as the present invention, the advantages of
5 embodiments of this invention may be more readily ascertained from the following description of certain embodiments of the invention when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of an embodiment of a shoe tool of the present invention that includes a crown attached to an adaptable shank;

10 FIG. 2 is a schematic illustration showing the shoe tool of FIG. 1 attached to a section of casing and disposed within a subterranean formation;

FIG. 3 is a longitudinal cross-sectional view of an embodiment of a shoe tool like that of FIG. 1 including a crown attached to an adaptable shank;

15 FIG. 4 is an enlarged cross-sectional view of an interface between the crown and the adaptable shank shown in FIG. 3;

FIG. 5 is a longitudinal cross-sectional view of the shoe tool shown in FIGS. 3 and 4 after adapting the shank for connection to casing in accordance with embodiments of methods of the present invention; and

20 FIG. 6 is a longitudinal cross-sectional view of the shoe tool shown in FIG. 5, further illustrating a section of casing coupled to the shank of the shoe tool.

MODE(S) FOR CARRYING OUT THE INVENTION

Illustrations presented herein are not meant to be actual views of any particular device or system, but are merely idealized representations which are employed to
25 describe embodiments of the present invention. Additionally, elements common between figures may retain the same numerical designation.

An embodiment of a boring shoe 10 of the present invention is shown in FIG. 1. The boring shoe 10 shown in FIG. 1 is an intermediate structure that has not yet been adapted for attachment to any particular section of casing. After formation of
30 the intermediate boring shoe 10 shown in FIG. 1, the boring shoe 10 may be adapted for attachment to a particular section of casing, as described in further detail herein below.

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The boring shoe 10 shown in FIG. 1 may be a reamer shoe or a drill shoe configured for attachment to a section of casing for use in forming a wellbore in a subterranean formation. As shown in FIG. 1, the boring shoe 10 includes a crown 20 and an adaptable shank 30 that is attached to the crown 20.

5 In some embodiments, the crown 20 may be configured to drill a wellbore in a subterranean formation. In other embodiments, the crown 20 may be configured to ream (*i.e.*, enlarge the diameter of) a previously drilled wellbore. In yet other embodiments, the crown 20 may be configured to merely guide casing through a wellbore and ensure that the wellbore diameter remains as previously drilled and has
10 not decreased as sometimes occurs in reactive or sloughing formations. In other words, the crown 20 may only ream sections of the wellbore that have an undersized diameter due, for example, to encroachment of the formation material into the wellbore.

 The crown 20 includes a body 21 that may be formed of and comprise, for example, a metal or metal alloy (*e.g.*, steel, aluminum, brass, or bronze), or a composite
15 material including particles of a relatively harder material (*e.g.*, tungsten carbide) embedded within a relatively softer metal or metal alloy (*e.g.*, steel, aluminum, brass, or bronze). The material of the body 21 may be selected to exhibit physical properties that allow the body 21 to be drilled through by another drill bit after the boring shoe 10 has been used to advance a section of casing attached thereto into a subterranean
20 formation, as known in the art.

 Drilling and/or reaming structures may be provided on exterior surfaces of the body 21 of the crown 20. For example, the crown 20 may comprise a plurality of blades 22 that define fluid courses 24 therebetween. Apertures 25 may be formed through the crown 20 for allowing fluid (*e.g.*, drilling fluid and/or cement) to be
25 pumped through the interior of the boring shoe 10, out through the apertures 25 in the crown 20, and into the annular space between the walls of the formation in which the wellbore is formed and the exterior surfaces of the boring shoe 10 and the casing sections to which the boring shoe 10 may be attached. For example, the apertures 25 may comprise fluid passageways extending through the body 21 of the crown 20.
30 Optionally, nozzles (not shown) may be secured to the crown 20 within the fluid passageways to selectively tailor the hydraulic characteristics of the boring shoe 10. Cutting element pockets may be formed in the blades 22, and cutting elements 26, such

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as, for example, polycrystalline diamond compact (PDC) cutting elements, may be secured within the cutting element pockets.

Also, each of blades 22 may include a gage region 23 that together define the largest diameter of the crown 20 and, thus, the diameter of any wellbore formed using the crown 20 and boring shoe 10. The gage regions 23 may be longitudinal extensions
5 of the blades 22. Wear-resistant structures or materials may be provided on the gage regions 23. For example, tungsten carbide inserts, cutting elements, diamonds (*e.g.*, natural or synthetic diamonds), or hardfacing material may be provided on the gage regions 23 of the crown 20.

10 In additional embodiments, the crown 20 may not include blades 22 and cutting elements 26, like those shown in FIG. 1. In such embodiments, the crown 20 may comprise other cutting and/or reaming structures such as, for example, deposits of hardfacing material (not shown) on the exterior surfaces of the crown 20. Such a hardfacing material may comprise, for example, hard and abrasive particles (*e.g.*,
15 diamond, boron nitride, silicon carbide, carbides or borides of titanium, tungsten, or tantalum, *etc.*) embedded within a metal or metal alloy matrix material (*e.g.*, an iron-based, cobalt-based, or nickel-based metal alloy). Such deposits of hardfacing material may be shaped into elongated, protruding structures on the exterior surfaces of the crown 20.

20 FIG. 2 is a simplified schematic illustration showing the boring shoe 10 attached to a section of casing 39 and disposed within a wellbore that has been formed in a subterranean formation using the boring shoe 10. As previously discussed, the casing 39, with the boring shoe 10 attached thereto, may be rotated and advanced into the subterranean formation as drilling fluid is pumped down through the interior of the casing 39, out through the apertures 25 in the crown 20, and up through the fluid
25 courses 24 (FIG. 1) and up through the annular space between the walls of the formation within the wellbore and the exterior surfaces of the casing 39 to the surface of the formation.

Once the casing 39 has been advanced to a desirable location within the
30 formation, drilling with the boring shoe 10 may be ceased, and the casing 39 may be cemented in place. To cement the casing 39 in place, cement (not shown) or another curable material may be forced through the interior of casing 39, through the apertures 25 in the crown 20, up through the fluid courses 24 (FIG. 1), and into the

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annulus between the wall of wellbore and the outer surface of the casing 39, where it may be allowed to harden. Of course, conventional float equipment may be used for controlling and delivering the cement through the boring shoe 10 and into the annulus between the wall of the wellbore and the casing 39. Cementing the casing 39 in place
5 within the wellbore may stabilize the wellbore and seal the subterranean formations penetrated by the boring shoe 10 and the casing 39.

In some instances, the size and placement of the apertures 25 that are employed for drilling operations may not be particularly desired for cementing operations. Furthermore, the apertures 25 may become plugged or otherwise obstructed during a
10 drilling operation. As shown in FIGS. 1 and 2, at least one of the crown 20 and the shank 30 of the boring shoe 10 may include one or more frangible regions 28 that can be breached (*e.g.*, a metal disc that can be fractured, perforated, ruptured, removed, *etc.*) to form one or more additional apertures that may be used to provide fluid communication between the interior and the exterior of the boring shoe 10. Drilling
15 fluid and/or cement optionally may be caused to flow through such frangible regions 28 after breaching the same.

Referring again to FIG. 1, the boring shoe 10 includes an adaptable shank 30 having a first end 31A attached to the crown 20 and a second end 31B that may be adapted and used to couple the boring shoe 10 to a section of casing (not shown in
20 FIG. 1). The shank 30 may have a size and shape that allows it to be adapted, after attachment to the crown 20, for coupling to a wide variety of different casing configurations, as discussed in further detail herein below.

FIG. 3 is a longitudinal, cross-sectional view of another embodiment of an intermediate boring shoe 50 of the present invention. The intermediate boring shoe 50
25 is similar to the boring shoe 10 shown in FIG. 1, and includes a crown 40 having a body 41 that is attached to an adaptable shank 30, as previously described in relation to FIG. 1.

The adaptable shank 30 is a cylindrical structure having a length L . By way of example and not limitation, the length L of the adaptable shank 30 may be between
30 about twenty-five (25) centimeters (about ten (10) inches) and about two hundred (200) centimeters (about seventy-nine (79) inches).

The adaptable shank 30 has a wall thickness T_w that is one-half of the difference between the outer diameter OD of the shank 30 and the inner diameter ID of

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the shank 30. The wall thickness T_w may vary, depending upon the size (*e.g.*, the diameter) of the crown 40 to which the shank 30 is attached. The wall thickness T_w of the shank 30, however, may be sufficiently large to allow the shank 30 to be adapted for use with a number of different casing sections having a variety of weights and coupling configurations that might be used with the particular size of crown 40 to which the shank 30 is attached. Although the shank 30 of FIG. 3 is shown having an outer diameter that is less than an outer diameter of the crown 40 to which the shank 30 is attached, in additional embodiments, the shank 30 may have an outer diameter that is larger than a diameter of the crown 40 to which the shank 30 is attached.

Table 1 below lists a variety of different diameters of crowns that are often used in the industry, together with the outer diameter OD, the inner diameter ID, and the wall thickness T_w of examples of adaptable shanks 30 of the present invention that may be attached to such crowns. All dimensions in Table 1 are given in inches, and dimensions in centimeters are provided in parenthesis.

TABLE 1					
Crown Diameter	Casing Diameter	Shank OD	Shank ID	Shank T_w	Shank T_w as Percentage of Crown Diameter
6.00 in (15.24 cm)	4.50 in (11.43 cm)	5.125 in (13.02 cm)	3.625 in (9.21 cm)	0.750 in (1.91 cm)	12.5 %
8.50 in (21.59 cm)	7.625 in (19.37 cm)	8.625 in (21.91 cm)	6.00 in (15.24 cm)	1.313 in (3.34 cm)	15.4 %
12.25 in (31.12 cm)	9.625 in (24.45 cm)	10.750 in (27.31 cm)	8.310 in (21.11 cm)	1.220 in (3.10 cm)	10.0 %
17.50 in (44.45 cm)	13.375 in (33.97 cm)	14.500 in (36.83 cm)	12.250 in (31.12 cm)	1.125 in (2.86 cm)	6.4 %
24.00 in (60.96 cm)	20.00 in (50.80 cm)	21.125 in (53.66 cm)	18.60 in (47.24 cm)	1.263 in (3.21 cm)	5.3 %

As shown in Table 1, in some embodiments of the present invention, the crown 40 may have a diameter that is about 12.25 inches (31.12 cm) or less, and the adaptable shank 30 may have a wall thickness that is about 10% or more of the

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diameter of the crown 40, about 12% or more of the diameter of the crown 40, or even about 15% or more of the diameter of the crown 40. As one particular non-limiting example, the crown 40 may have a diameter of about 12.25 inches (31.12 cm), the shank 30 may have an outer diameter OD of about 10.750 inches (27.31 cm), an inner diameter ID of about 8.310 inches (21.11 cm) or less, and a wall thickness T_w of about 1.220 inches (3.10 cm) or more (*i.e.*, about 10.0% or more of the diameter of the crown 40). As another particular non-limiting example, the crown 40 may have a diameter of about 8.50 inches (21.59 cm), the shank 30 may have an outer diameter OD of about 8.625 inches (21.91 cm), an inner diameter ID of about 6.00 inches (15.24 cm) or less, and a wall thickness T_w of about 1.313 inches (3.34 cm) or more (*i.e.*, about 15.4% or more of the diameter of the crown 40). As yet another particular non-limiting example, the crown 40 may have a diameter of about 6.00 inches (15.24 cm), the shank 30 may have an outer diameter OD of about 5.125 inches (13.02 cm), an inner diameter ID of about 3.625 inches (9.21 cm) or less, and a wall thickness T_w of about 0.750 inches (1.91 cm) or more (*i.e.*, about 12.5% or more of the diameter of the crown 40). Other non-limiting examples of embodiments of the invention are also set forth in Table 1 above.

As shown in Table 1, in additional embodiments of the present invention, the crown 40 may have a diameter that is greater than about 12.25 inches (31.12 cm), and the adaptable shank 30 may have a wall thickness that is about 5% or more of the diameter of the crown 40, or even about 6% or more of the diameter of the crown 40. As one particular non-limiting example, the crown 40 may have a diameter of about 17.50 inches (44.45 cm), the shank 30 may have an outer diameter OD of about 14.500 inches (36.83 cm), an inner diameter ID of about 12.250 inches (31.12 cm) or less, and a wall thickness T_w of about 1.125 inches (2.86 cm) or more (*i.e.*, about 6.4% or more of the diameter of the crown 40). As another particular non-limiting example, the crown 40 may have a diameter of about 24.00 inches (60.96 cm), the shank 30 may have an outer diameter OD of about 21.125 inches (53.66 cm), an inner diameter ID of about 18.60 inches (47.24 cm) or less, and a wall thickness T_w of about 1.263 inches (3.21 cm) or more (*i.e.*, about 5.3% or more of the diameter of the crown 40).

The adaptable shank 30 may be formed from and comprise a metal material such as, for example, an iron-based metal alloy (*e.g.*, a steel alloy). In some embodiments, the adaptable shank 30 may be formed from and comprise a material

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that exhibits a tensile yield strength of at least about 60,000 pounds per square inch (PSI), at least about 90,000 pounds per square inch (PSI), or even at least about 120,000 PSI pounds per square inch (PSI). As previously mentioned, the adaptable shank 30 may be separately formed from the crown 40 and subsequently attached thereto.

FIG. 4 is an enlarged cross-sectional view of an interface between the crown 40 and the adaptable shank 30 shown in FIG. 3. As shown in FIG. 4, the shank 30 may be attached to the crown 40 by abutting an end surface 34 of the shank 30 against an end surface 48 of the crown 40 and welding an interface between the shank 30 and the crown 40. In other words, a weld material 60 (e.g., one or more weld beads) may be provided around an exterior surface of the intermediate boring shoe 50 along the interface between the crown 40 and the shank 30. In some embodiments, the shank 30 may have a beveled, frustoconical surface 36 at the first longitudinal end 31A thereof, and the crown 40 may have a complementary beveled, frustoconical surface 49. The frustoconical surface 36 of the shank 30 and the frustoconical surface 49 of the crown 40 may define a weld groove therebetween when the shank 30 is abutted against the crown 40. A weld material 60 may be deposited in the form of one or more weld beads within the weld groove to weld the shank 30 and the crown 40 together. The shank 30 may be abutted against, and welded to, the crown 40 prior to adapting the shank 30 for attachment to a section of casing.

In additional embodiments, complementary threads (not shown) may be provided on the crown 40 and the shank 30 to allow the crown 40 and the shank 30 to be threaded together to attach the crown 40 and the shank 30 together. In such embodiments, a weld material 60 also may be provided along the interface between the crown 40 and the shank 30 to further secure the crown 40 and the shank 30 together.

Referring to FIG. 5, after attaching the shank 30 and the crown 40 together, the shank 30 may be adapted for attachment to a particular section of casing. The shank 30 may be adapted for attachment to a particular section of casing by, for example, doing one or more of the following: reducing the length L of the shank 30, reducing the wall thickness T_w of the shank 30, and providing one or more features on the shank 30, and/or shaping one or more surfaces of the shank 30, for coupling to an end of a section of casing. The wall thickness T_w of the shank 30 may be reduced by reducing the

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outer diameter of the shank 30, by increasing the inner diameter of the shank 30, or by both reducing the outer diameter and increasing the inner diameter of the shank 30.

The outer diameter of the shank 30 may be reduced, and the inner diameter of the shank 30 may be increased, as desirable, using, for example, conventional
5 machining processes such as turning processes, milling processes, and combinations of turning and milling processes.

To configure the shank 30 for coupling to a section of casing, one or more features may be provided on the shank 30, and/or one or more surfaces of the shank 30 may be provided with a certain shape, as previously mentioned. For example, an inner
10 surface 38A of the shank 30 may be formed to comprise what is referred to in the art as a "threaded box."

To form a threaded box in the inner surface 38A of the shank 30, a section of the inner surface 38A of the shank 30 at the second end 31B thereof may be formed to comprise a taper, such that the section of the inner surface 38A has a frustoconical
15 shape have a diameter that is greatest at the opening of the shank 30 at the second end 31B thereof, the diameter becoming progressively smaller moving in the longitudinal direction toward the first end 31A of the shank 30. The angle of the taper of the inner surface 38A of the shank 30 at the second end 31B may be selected to correspond to the angle of a taper on the exterior surface of a section of casing to which the shank 30
20 is to be attached. Such a taper also may be formed in the inner surface 38A using, for example, conventional machining processes such as turning processes, milling processes, and combinations of turning and milling processes.

Furthermore, threads 37 may be formed on a section of the inner surface 38A of the shank 30 at the second end 31B (*e.g.*, on a tapered section of the inner
25 surface 38A). The size (*e.g.*, dimensions), shape, and spacing (*e.g.*, pitch) of the threads 37 also may be selected to correspond to the size (*e.g.*, dimensions), shape, and spacing (*e.g.*, pitch) of complementary threads on a section of casing to which the shank 30 is to be attached. The threads 37 also may be formed in the inner surface 38A using, for example, conventional machining processes such as turning processes,
30 milling processes, and combinations of turning and milling processes. Threads may also be formed by rolling the surface to be threaded against a threading die, as known in the art, and such roll threading processes also may be employed in embodiments of the present invention.

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In some embodiments, threads 37 may be formed on the inner surface 38A of the shank 30 at the second end 31B thereof without providing any taper on the inner surface 38A. In other words, the inner surface 38A may remain at least substantially cylindrical, and a section of the cylindrical inner surface may be threaded.

5 In additional embodiments of the present invention, an outer surface 38B of the shank 30 may be formed to comprise what is referred to in the art as a “threaded pin,” which is a male pin member having threads on an exterior surface thereof that is configured to mate with, and engage, a female threaded box, as previously described herein.

10 Referring to FIG. 6, after adapting the shank 30 for attachment to a particular section of casing 61, the shank 30 and the section of casing 61 may be coupled together in preparation for drilling and/or reaming with the intermediate boring shoe 50 as the casing 61 and the intermediate boring shoe 50 are advanced into a subterranean formation.

15 In the embodiment shown in FIG. 6, a threaded box is provided on the inner surface 38A of the shank 30 at the second end 31B thereof, and the section of casing 61 has a threaded pin 62 at an end 64 thereof that is complementary to, and configured to mate with and engage, the threaded box at the second end 31B of the shank 30.

In additional embodiments of the invention, however, the shank 30 may be
20 formed to comprise a threaded pin, and the casing 61 may comprise a complementary threaded box configured to engage the threaded pin of the shank 30. In yet further embodiments, each of the shank 30 and the casing 61 may comprise a threaded pin, and a collar having a threaded box on both ends thereof may be used to couple the threaded pin of the shank 30 to the threaded pin of the casing 61. Such collars are
25 commercially available and frequently used in the art.

Thus, in accordance with some embodiments of methods of the present invention, an adaptable shank may be attached to a crown of a boring shoe prior to identifying the type of casing to which the boring shoe will ultimately be attached. As a result, a manufacturer need not fabricate a variety of different types of shanks for
30 each size of boring shoe, each type corresponding to the different types of casing to which the boring shoe might be attached. In contrast, a single, adaptable shank in accordance with embodiments of the present invention may be fabricated for each size

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of boring shoe, and the adaptable shank can be adapted, after attachment to a crown, for attachment to a particular type of casing.

Furthermore, in accordance with some embodiments of methods of the present invention, an adaptable shank may be attached to a crown of a boring shoe prior to
5 identifying the type of casing to which the boring shoe will ultimately be attached. The crown, with the adaptable shank attached thereto, may be transported to another location other than where the crown and shank were attached together (*e.g.*, the location of a distributor, the location of a drilling site, *etc.*) by way of a vehicle (*e.g.*, a truck, plane, or boat). After transporting the crown, with the adaptable shank attached
10 thereto, to another location, a particular type of casing to which the crown and adaptable shank are to be attached may be identified, and the adaptable shank may be adapted, as previously described herein, for attachment to that particular type of casing.

While the present invention has been described herein with respect to certain embodiments, those of ordinary skill in the art will recognize and appreciate that it is
15 not so limited. Rather, many additions, deletions and modifications to the embodiments described herein may be made without departing from the scope of the invention as hereinafter claimed. In addition, features from one embodiment may be combined with features of another embodiment while still being encompassed within the scope of the invention as contemplated by the inventors.

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CLAIMS

What is claimed is:

- 5 1. A method of attaching a crown of a boring shoe to a section of casing, comprising:
attaching a first end of an adaptable shank comprising a generally cylindrical structure
to the crown of the boring shoe; and
machining an opposite second end of the adaptable shank to configure the second end
10 of the adaptable shank for attachment to the section of casing after attaching the
first end of the adaptable shank to the crown.
2. The method of claim 1, further comprising forming the adaptable shank
to comprise a metal alloy material exhibiting a tensile yield strength of at least about
15 60,000 pounds per square inch.
3. The method of claim 1, further comprising forming the adaptable shank
to have a length between about twenty-five (25) centimeters (about ten (10) inches) and
about two hundred (200) centimeters (about seventy-nine (79) inches).
20
4. The method of any one of claims 1 through 3, further comprising
forming the adaptable shank to have an average wall thickness greater than about five
percent (5%) of a maximum diameter of the crown.
- 25 5. The method of claim 4, further comprising forming the average wall
thickness of the adaptable shank to be about 10% or more of the maximum diameter of
the crown.
6. The method of claim 5, further comprising forming the average wall
30 thickness of the adaptable shank to be about 12.5% or more of the maximum diameter
of the crown.

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7. The method of claim 6, further comprising forming the average wall thickness of the adaptable shank to be about 15% or more of the maximum diameter of the crown.

§ 8. The method of any one of claims 1 through 3, wherein attaching a first end of an adaptable shank to the crown of the boring shoe comprises: abutting a surface of the first end of the adaptable shank to a surface of the crown; and welding an interface between the surface of the crown and the abutting surface of the first end of the adaptable shank.

10

9. The method of any one of claims 1 through 3, wherein machining the opposite second end of the adaptable shank comprises machining threads on at least one of an interior surface and an exterior surface of the adaptable shank.

15

10. The method of any one of claims 1 through 3, further comprising: attaching the first end of the adaptable shank to the crown at a first geographic location; transporting the boring shoe from the first geographic location to a second geographic location using a vehicle; and configuring the opposite second end of the adaptable shank for attachment to the section of casing at the second geographic location.

20

11. A boring shoe, comprising:
a crown configured for at least one of drilling and reaming a wellbore; and
an adaptable shank attached to the crown, the adaptable shank comprising a generally cylindrical wall having an average wall thickness greater than about five percent (5%) of a maximum diameter of the crown.

25

12. The boring shoe of claim 11, wherein the crown is welded to the adaptable shank.

30

13. The boring shoe of claim 11 or claim 12, wherein the average wall thickness of the generally cylindrical wall is greater than about 10% of the maximum diameter of the crown.

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14. The boring shoe of claim 13, wherein the average wall thickness of the generally cylindrical wall is greater than about 12% of the maximum diameter of the crown.

5

15. The boring shoe of claim 18, wherein the average wall thickness of the generally cylindrical wall is greater than about 15% of the maximum diameter of the crown.

10 16. The boring shoe of claim 15, wherein the adaptable shank comprises a metal alloy material exhibiting a tensile yield strength of at least about 60,000 pounds per square inch.

15 17. The boring shoe of claim 11 or claim 12, wherein the adaptable shank comprises a metal alloy material exhibiting a tensile yield strength of at least about 60,000 pounds per square inch.

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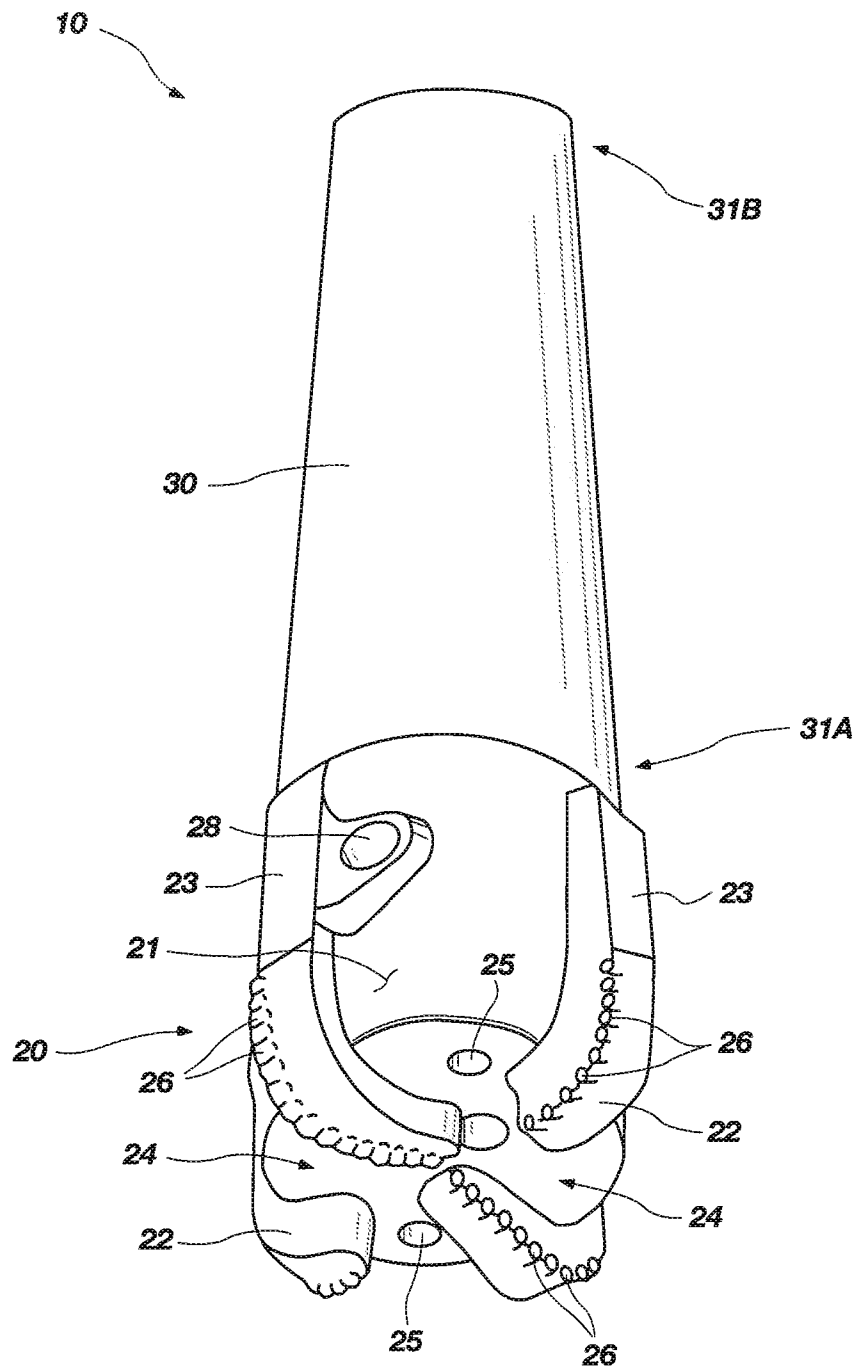


FIG. 1

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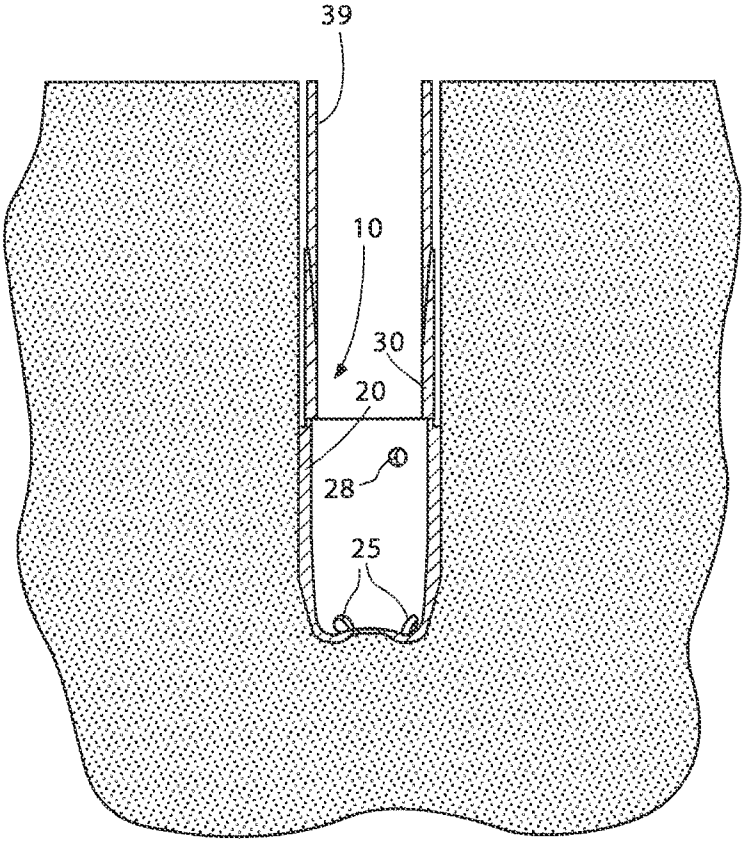


FIG. 2

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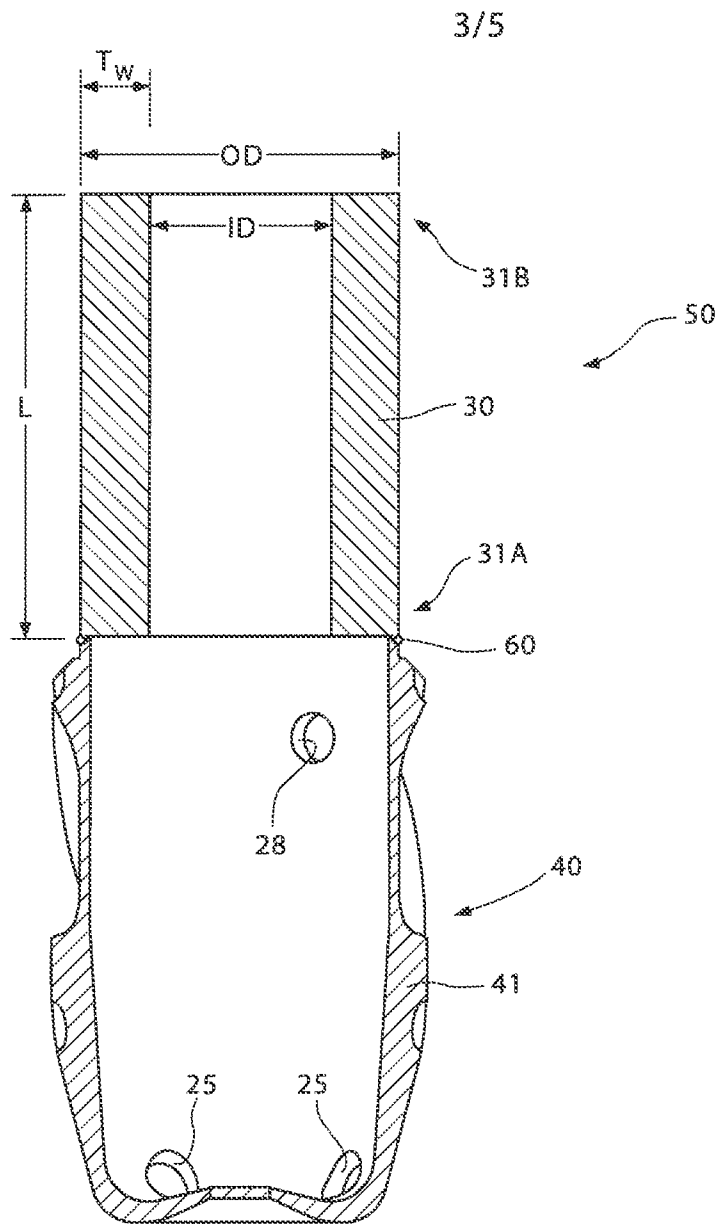


FIG. 3

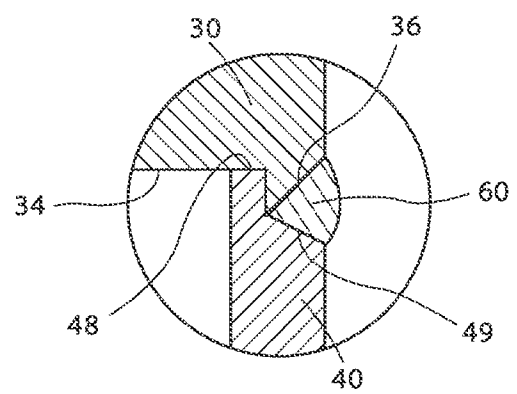


FIG. 4

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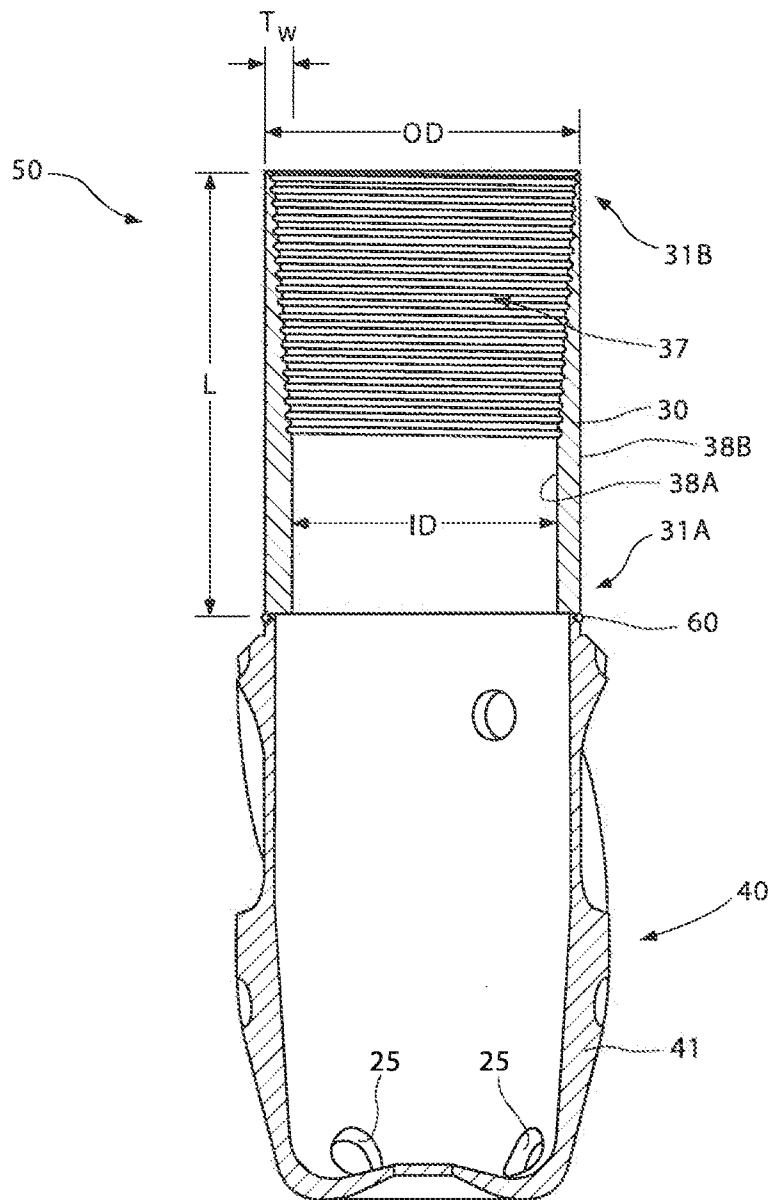


FIG. 5

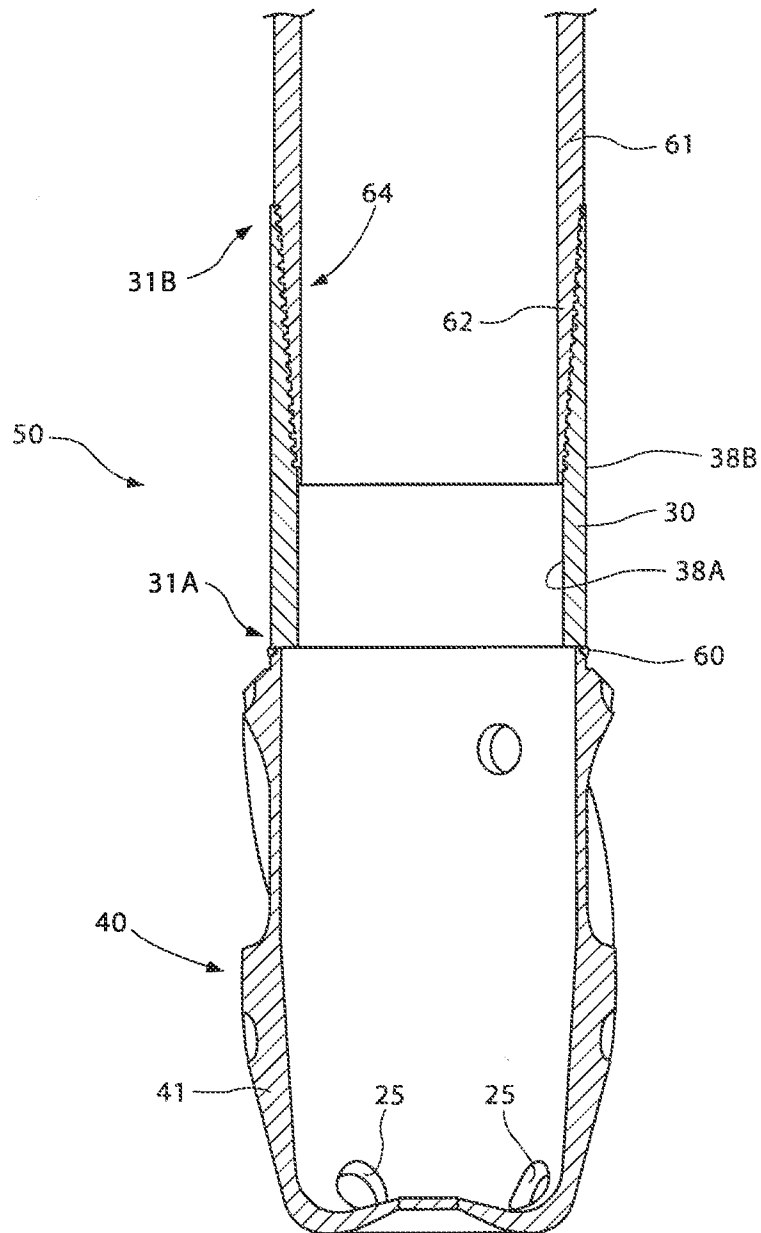


FIG. 6