US 20100044113A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2010/0044113 A1

(43) Pub. Date: Feb. 25, 2010

LEBLANC et al.

(54) **CONNECTION FOR WELL BORE DRILLING TOOLS**

(75) Inventors: **Randy LEBLANC**, Lafayette, LA (US); **Carl LEBLANC**, Lafayette, LA (US)

Correspondence Address:
FISH & RICHARDSON P.C.
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022 (US)

(73) Assignee: **Coiled Tubing Rental Tools, Inc.**, Broussard, LA (US)

(21) Appl. No.: **12/196,954**

(22) Filed: **Aug. 22, 2008**

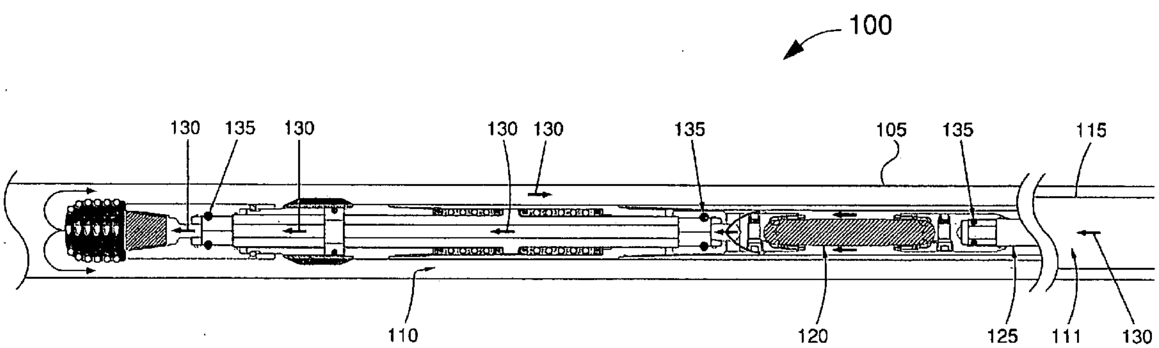
Publication Classification

(51) **Int. Cl.**
E21B 17/043 (2006.01)

(52) **U.S. Cl.** **175/325.2**

(57) **ABSTRACT**

A drilling tool connection includes a male pin, a female box connector, and a locking pin. The male pin includes a hexagonal outer perimeter, at least a portion of the pin having a cylindrical bore along a longitudinal axis of the pin, where the pin has a transverse slot formed transverse to the longitudinal axis of the pin. The box connector element includes a circular outer perimeter, where at least a portion of the box connector element has a hexagonal aperture aligned with a longitudinal axis of the box. The box connector element has at least one transverse bore formed in the box transverse to the longitudinal axis of the box, and the hexagonal aperture of the box is adapted to receive the hexagonal portion of the male pin. The locking pin is insertable through an aperture defined by the slot of the pin and the bore of the box.



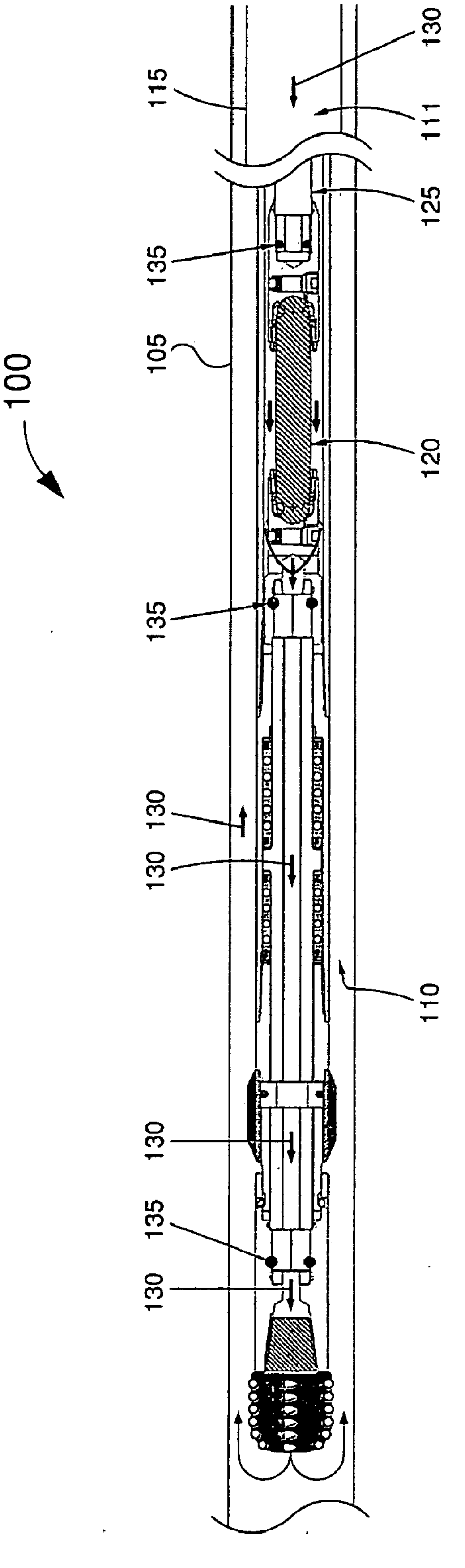


Fig 1

Fig 2A

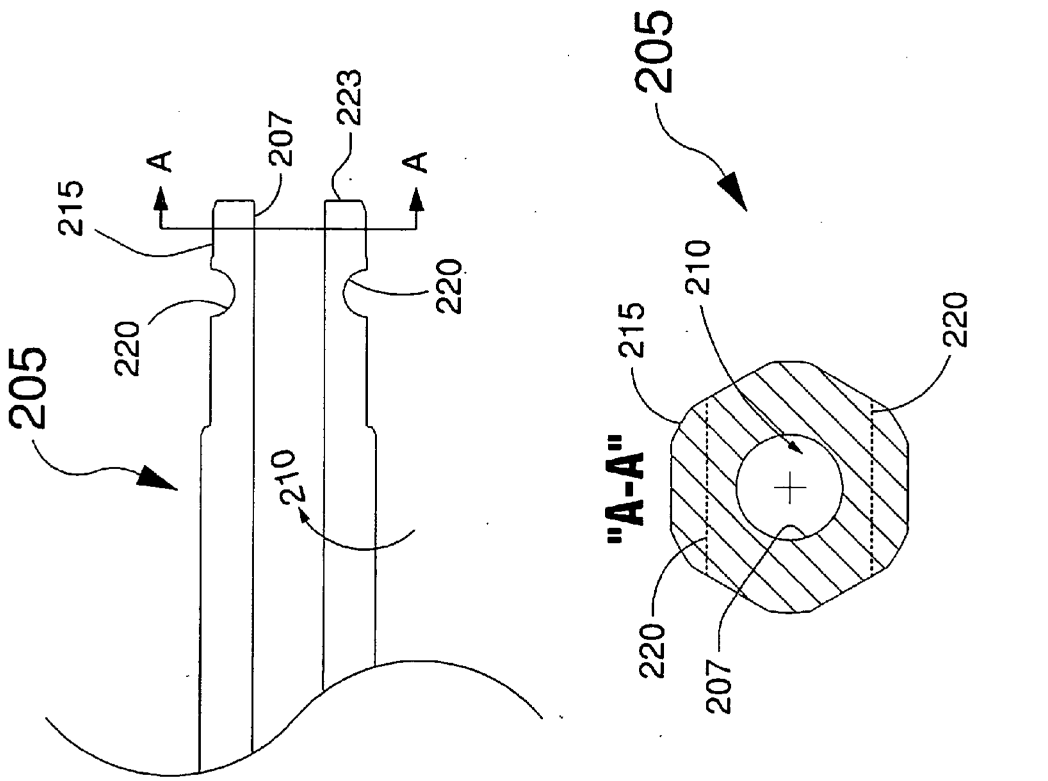


Fig 2B

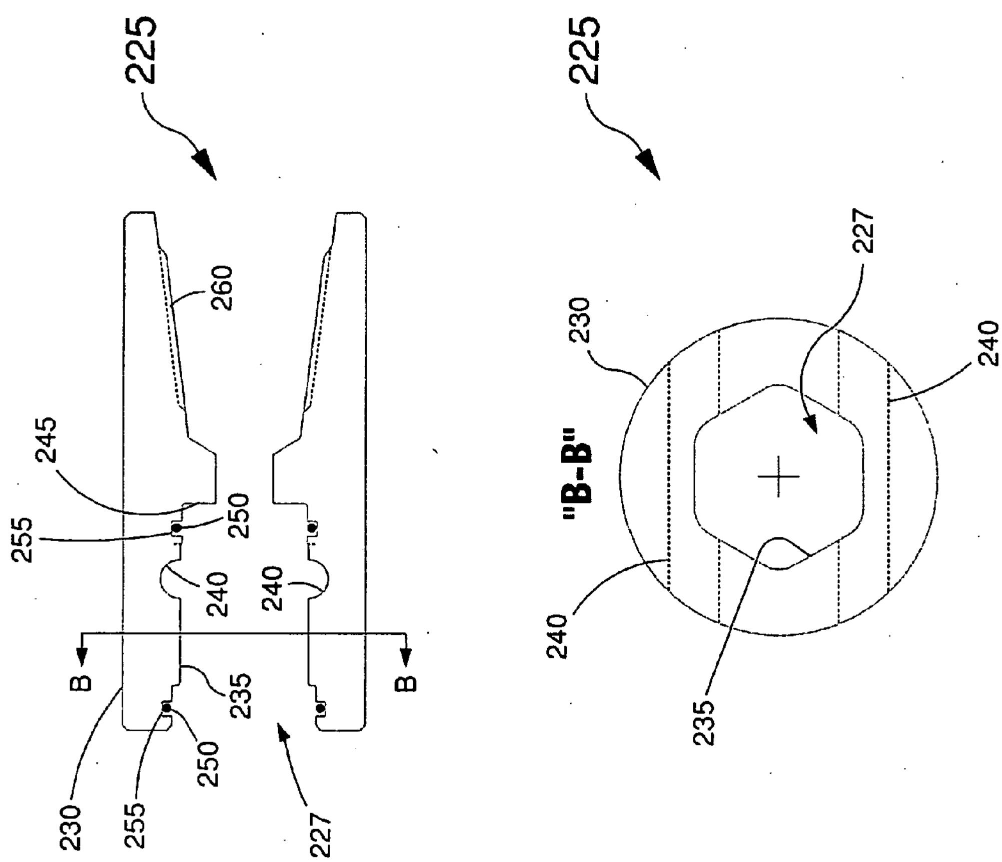
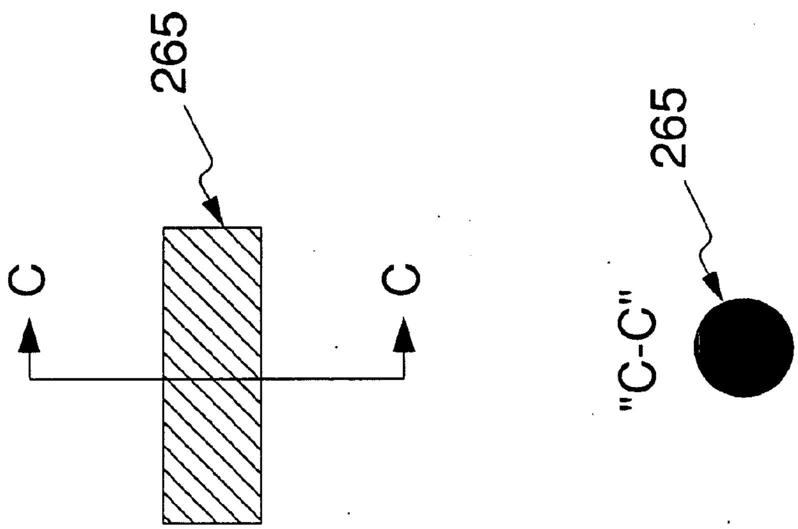

225
260
245
255
250
240
240
B
B
235
230
255
250
227
225
"B-B"
227
230
240
240
235

Fig 2C



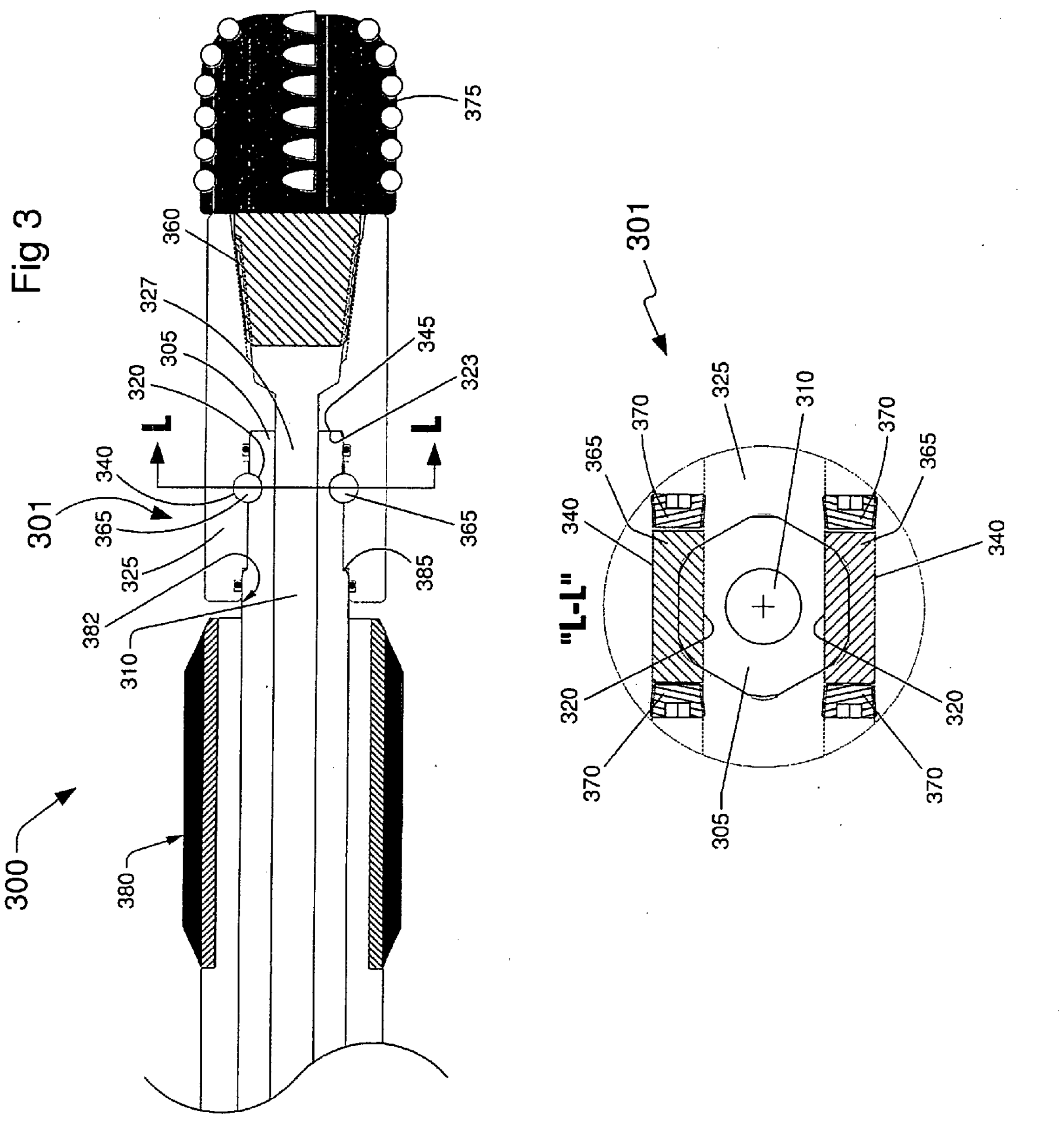
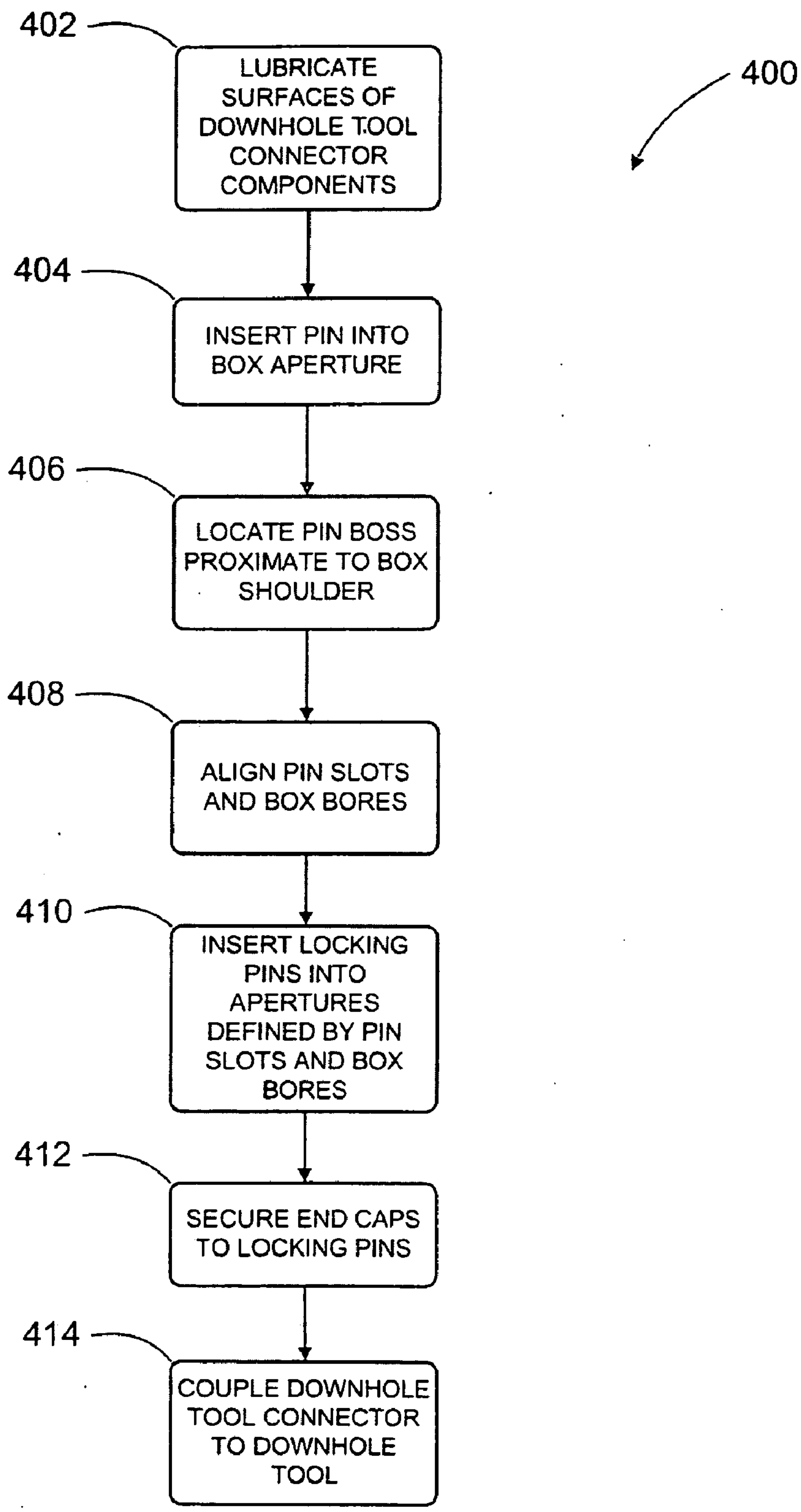

300
301
305
310
320
323
325
327
340
345
360
365
370
375
380
382
385
L
"L-L"

Fig 3

FIG. 4



400
402
LUBRICATE SURFACES OF DOWNHOLE TOOL CONNECTOR COMPONENTS
404
INSERT PIN INTO BOX APERTURE
406
LOCATE PIN BOSS PROXIMATE TO BOX SHOULDER
408
ALIGN PIN SLOTS AND BOX BORES
410
INSERT LOCKING PINS INTO APERTURES DEFINED BY PIN SLOTS AND BOX BORES
412
SECURE END CAPS TO LOCKING PINS
414
COUPLE DOWNHOLE TOOL CONNECTOR TO DOWNHOLE TOOL

CONNECTION FOR WELL BORE DRILLING TOOLS

TECHNICAL BACKGROUND

[0001] This disclosure relates to well bore equipment and, more particularly, to connections for various downhole tools used for drilling well bores.

BACKGROUND

[0002] Downhole drilling motors have been used for many years in the drilling of oil and gas wells and other wells. In a usual mode of operation, the rotational power output shaft of the motor and the drill bit will rotate with respect to the housing of the motor. The housing, in turn, is connected to a conventional drill string composed of drill collars and sections of drill pipe. This drill string extends to the surface. Drilling fluid is pumped down through the drill string, to the bottom of the hole and back tip the annulus between the drill string and the wall of the bore hole. The drilling fluid cools the drill bit and removes the cuttings resulting from the drilling operation.

[0003] Since the inception of downhole drilling motors, the rotational power output from the motors has increased. The rotational power output of the motor is transferred to the drill bit, in typical fashions through a tool joint, which may couple the output drilling motor to the drill bit or other appropriate sections of a downhole drilling apparatus. In certain instances, the tool joint may employ a threaded connection, such as a male/female API or other threaded tapered connections. Such types of connections may be designed to handle the mechanical stress and shear force associated with drilling operations. These connections, however may encounter forces and resistance within the well bore that are greater than those forces for which they are designed. For example, rotational torque output from a drilling motor may generate a shear force on the tool joint. Typically, such a shear force, if great enough, may cause the tool joint to fail (e.g., shear off at various threaded connections). Further, due to the nature of threaded connections, the rotational torque may cause such a connection to decouple (e.g., unscrew) apart from a mechanical failure.

[0004] One or more components of a downhole drilling apparatus may come uncoupled and are lost or stuck in the well bore due to tool joint failure. For instance, drill bits, downhole motors, impact jars, MWD/LVD or sections thereof are commonly among the downhole drilling components lost in the well bore, possibly requiring the initiation of "fishing" operations (i.e., downhole tool retrieval) for the lost tool.

SUMMARY

[0005] This disclosure relates to well bore equipment and, more particularly, to connections for various downhole tools used for drilling well bores.

[0006] In accordance with one general implementation, a drilling tool connection includes a male pin connector element, a female box connector element, and a locking pin. The male pin connector element is disposed on a first downhole drilling device and includes a substantially hexagonal outer perimeter, at least a portion of the pin having a substantially cylindrical bore along a longitudinal axis of the pin, where the pin has at least one transverse slot formed transverse to the longitudinal axis of the pin. The female box connector element is disposed on a second downhole drilling device and includes a substantially circular outer perimeter, where at least a portion of the box connector element has a substantially hexagonal aperture aligned with a longitudinal axis of the box. The female box connector element has at least one transverse bore formed in the box transverse to the longitudinal axis of the box, and the substantially hexagonal aperture of the female box is adapted to receive the substantial hexagonal portions of the male pin connector element. Tile locking pin is insertable through an aperture defined by the at least one transverse slot of the pin and the at least one transverse bore of the box upon alignment of the transverse slot with the transverse bore.

[0007] In some specific aspects, the substantially cylindrical longitudinal aperture may be adapted to direct drilling fluid through the second downhole drilling device. Further, the locking pin may be substantially cylindrical. The drilling tool connection may further include all end cap configured to fasten to the locking pin and substantially prevent the locking pin from being removed from the aperture defined by the first slot and the second slot. In certain aspects, the drilling tool connection further includes an end cap configured to fasten to the aperture formed by the transverse slot and the transverse bore by a threaded connection. The aperture defined by the transverse slot and the transverse bore may be substantially cylindrical.

[0008] In certain aspects, the drilling tool connection may include a first box seal disposed within a box seal groove, where the box seal groove may be formed in an interior surface of the box defining the substantially hexagonal aperture. In some aspects, the locking pin may be a first locking pin and the drilling tool connection further includes a second transverse slot formed proximal to the distal end of the pin transverse to the longitudinal axis of the pin; a second transverse bore formed in the box transverse to the longitudinal axis of the box; and a second locking pin insertable through a second aperture defined by the second transverse slot and the second transverse bore upon alignment of the second transverse slot with the second transverse.

[0009] In specific aspects, the first and the second downhole drilling devices may be selected from the group consisting of a downhole drilling motor; a stabilizer; a universal joint assembly; a drill bit; a drill collar; a drill pipe; or a bearing mandrel. Additionally, the female box connector element may further include a shoulder formed in the box at a distal end of the substantially hexagonal aperture while the pin may further include a substantially planar surface formed at the distal end of the pin. The male pin connector element may be configured to transmit thrust to the shoulder substantially parallel to the longitudinal axes of the pin and the box.

[0010] In another general implementation, a male pin disposed on a first downhole drilling device, a female box connector element, and a locking pin. The male pin includes a pin perimeter of a first geometric shape, where at least a portion of the pin has a substantially cylindrical bore along a longitudinal axis of the pin. The male pin has at least one transverse slot formed in the pin perimeter transverse to the longitudinal axis of the pin. The female box connector element is disposed on a second downhole drilling device with at least a portion of the box having a box aperture of a second geometric shape aligned with a longitudinal axis of the box. The box aperture is adapted to receive the first geometric shape portion of the male pin and has at least one transverse bore formed in the box transverse to the longitudinal axis of the box. The locking pin is insertable into an aperture defined by the at least one transverse slot of the pin and the at least one transverse bore of the box upon alignment of the transverse slot with the transverse bore.

[0011] In some specific aspects, tile first and second geometric shapes may be one of a hexagon; an octagon; a nonagon; or a decagon. Further, the longitudinal aperture may be adapted to direct drilling fluid through the second downhole drilling device. Also, the well bore tool coupling device may include an end cap configured to fasten to the locking pin and substantially prevent the locking pin from being removed from the aperture defined by the first slot and the second slot. The device may include an end cap configured to fasten to the aperture formed by the slot and transverse bore by a threaded connection. In certain aspects, the aperture defined by the slot and the transverse bore may be substantially cylindrical.

[0012] The well bore tool coupling device may also include a first box seal disposed within a box seal groove, where the box seal groove may be formed in an interior surface of the box defining the box aperture. Further, the locking pin may be a first locking pin, and the well bore tool coupling device may further include a second transverse slot formed at tile distal end of the pin transverse to the longitudinal axis of the pin; a second transverse bore formed in the box transverse to the longitudinal axis of the box; and a second locking pin insertable through a second aperture defined by the second transverse slot and the second transverse bore upon alignment of the second slot with the second transverse bore. The female box connector element may further include a shoulder formed in the box at a distal end of the aperture of the second geometric shape and the pin may further include a substantially planar surface formed at the distal end of the pin and configured to transmit thrust to the shoulder substantially parallel to the longitudinal axes of the pin and the box. The female box connector element may also include a ledge proximate to a distal end of the box.

[0013] Various implementations of a drilling tool connection according to the present disclosure may include one or more of the following features. For example, the drilling tool connection may be able to withstand greater rotational torque as compared to other types of threaded tool joints, thereby decreasing a possibility of mechanical failure or shearing. As another example, the drilling tool connection may allow for greater time and cost efficiency in assembling a downhole tool apparatus for drilling operations. As a further example, the drilling tool connection may allow for a downhole tool to remain coupled to, for example, another downhole tool such as a downhole drilling motor or drill bit, a drill string section, or a universal joint assembly. As yet another benefit, the drilling tool connection may be substantially free of stress risers and galling as encountered in threaded connections, thereby allowing greater torque to be output by the downhole drilling motor without mechanical failure in the drilling apparatus. Further, the drilling tool connection may allow for a greater axial force to be applied to a downhole drilling apparatus by the drill string in attempting to back off the apparatus from the well bore, thereby increasing the likelihood that the apparatus may be removed from the well bore. The drilling tool connection may, therefore, decrease the number of fishing trips down the well bore to recover lost downhole tools.

[0014] These general and specific aspects may be implemented using a device, system or method, or any combinations of devices, systems, or methods. The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and front the claims.

DESCRIPTION OF DRAWINGS

[0015] FIG. **1** illustrates a downhole drilling apparatus incorporating a drilling tool connection in accordance with the present disclosure;

[0016] FIG. **2**A illustrates a male end of a drilling tool connection in accordance with the present disclosure;

[0017] FIG. **2**B illustrates a portion of a downhole drilling apparatus incorporating a female end of a drilling tool connection in accordance with the present disclosure:

[0018] FIG. **2**C illustrates a locking pin of a drilling tool connection in accordance with the present disclosure;

[0019] FIG. **3** illustrates the male connector of FIG. **2**A assembled to the female connector of FIG. **2**B with the locking pin of FIG. **2**C; and

[0020] FIG. **4** illustrates one method of assembling a drilling tool connection in accordance with the present disclosure.

[0021] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0022] A drilling tool connection may be used to couple together various downhole drilling devices, such as downhole drilling motors, impact jars, MWD/LWD tools, drill bits, universal joint assemblies, bearing sections, drill string sections, and the like. The drilling tool connection, generally, includes a male end with an elongated pin including a longitudinal bore disposed along a longitudinal axis of the pin; a female end with a box including an aperture designed to receive the pin, and one or more locking pins designed to be inserted through apertures in the wall of the box into a semi-circular pin slot on the exterior surface of the pin, thereby securing the pin and the box together. The pin includes one or more transverse pin slots while the box includes one or more corresponding transverse semi-cylindrical box bores, such that upon insertion of the pin into the box, cylindrical apertures are created by alignment of the transverse pin slots with the corresponding transverse box bores. The drilling tool connection also includes one or more end caps designed to be secured to each end of the locking pins, thereby substantially preventing the locking pins from being unintentionally removed from the apertures during a drilling/retrieving operation (e.g., by rotational inertia).

[0023] In operation, the pin may transmit rotational torque to the female box through an outer surface flats of the pin in contact with the aperture designed to receive the pin in the box. Further, the pin may transmit an axial thrust force to the box at a shoulder of the box proximate to one end surface of the pin. Additionally, the locking pins of the drilling tool connection may be designed to withstand a shear force applied to such locking pins upon removal of the downhole drilling devices from a well bore.

[0024] FIG. **1** illustrates a downhole drilling apparatus **100** incorporating a drilling tool connection **135** in accordance with the present disclosure. Downhole drilling apparatus **100**, typically, is used to form a well bore **105** through one or more subterranean formations, such as shale, sandstone, coal, or other geologic zones occurring at sub-surface depths. Such zones may be desirable to access from the surface due to deposits of petroleum natural resources (e.g., oil, natural gas) contained therein. In some aspects, the downhole drilling apparatus **100** may be used as a directional drilling apparatus to form directional (e.g., horizontal, slant) well bores. The downhole drilling apparatus **100** includes a drill string **115**, a downhole drilling motor **125** (partially shown in FIG. **1**), a universal joint assembly **120**, and one or more drilling tool connections **135**. The downhole drilling apparatus **100**, generally, also includes a drilling fluid **130** flowing through the drill string **115** and also the sections of the drilling apparatus **100** toward a drill bit section (not shown) coupled to a distal end of the downhole drilling apparatus **100**. In typical embodiments of the downhole drilling apparatus **100**, the aforementioned apparatus sections and any other appropriate sections are connected to the drill string **115**. The drill string **115** generally consists of multiple sections of threaded pipe anchor threaded drill collars coupled to each other and extending to the surface.

[0025] In order to advance the downhole drilling apparatus **100** further into the sub-surface zones to form the well bore **105** to a specified depth, drilling fluid **130** is typically pumped in a central bore **111** from the surface through the drill string **115**. The drilling fluid **130** may be different substances depending on, for instance, the application of the downhole drilling apparatus **100**, the subterranean zones being penetrated by the downhole drilling apparatus **100**, and the pressure of such zones relative to the pressure of the drilling fluid **130**. For example, the drilling fluid **130** may be air, a mixture of air and water, water, “drilling mud,” such as water or other fluid mixed with a polymer or clay substance, or a form of synthetic fluid, to name but a few. Drilling fluid **130** is used for several purposes, namely, to provide hydraulic power to the downhole drilling motor **125** (as described below), cool and lubricate the drill bit section as it cuts through the geologic formation being drilled, and remove the drilled formation cuttings to the surface. For instance, once the drilling fluid **130** exits the drill bit section and picks up the formation cuttings (e.g., bits of rock), the drilling fluid **130** travels back to the surface via the annulus **110** between the downhole drilling apparatus **100** and the well bore **105**.

[0026] The downhole drilling motor **125**, generally, supplies rotational power that is transferred to the drill bit section through one or more drilling tool connections **135** and the universal joint assembly **120**, such rotation allowing the drill bit section to create the well bore **105**. The rotational power supplied by the drilling motor **125** may be generated by the drilling fluid **130**, which is pumped at a specified flow rate through the drill string **115** and into the drilling motor **125**. The drilling motor **125** may include a rotor that is turned by the flowing drilling fluid **130** at a speed proportional to the volume of the drilling fluid **130** passing through the drilling motor **125**. In some embodiments, the drilling motor **125** may be a moineau-style downhole motor power section or alternatively, a turbine-style downhole motor.

[0027] The universal joint assembly **120** is coupled between the drilling motor **125** and the drill bit section. The universal joint assembly **120** may convert eccentric rotation from the drilling motor **125** to concentric rotation to supply to the drill bit section. The universal joint assembly **120** is coupled to the drilling motor **125** and the drill bit section via drilling tool connections **135**. Alternatively, the universal joint assembly **120** may be coupled to one or more drilling sections via another connection, such as a threaded connection.

[0028] The drilling tool connections **135** couple together various sections of the downhole drilling apparatus **100**. For example, as illustrated in FIG. **1**, a drilling tool connection **135** may couple the downhole drilling motor **125** to an uphole device (e.g., a impact jar, MWD/LWD tool, drill collar), as well as the universal joint assembly **120**. A drilling tool connection **135** may also couple the universal joint assembly **120** to, for example, a bearing section (not shown). A drilling tool connection **135** may also couple a bearing section of the downhole drilling apparatus **100** to the drill bit section. Generally, the drilling tool connection **135** transmits rotational torque generated by the downhole drilling motor **125** to another downhole drilling tool, such as the drill bit section. Further, the drilling tool connection **135** may allow for multiple downhole drilling devices to remain coupled together when withdrawing the downhole drilling apparatus **100** from the well bore **105**.

[0029] In some embodiments of the downhole drilling apparatus **100**, the drilling tool connection **135** may be utilized in place of a more traditional coupling technique, such as, for example, a threaded connection (e.g., male/female NPT). In such embodiments, the drilling tool connection **135** may allow the coupled drilling tools to remain coupled even when resistance is encountered by the drilling apparatus (e.g., a counter-directional torque on the drill bit).

[0030] FIGS. **2**A-C illustrate particular components of a drilling tool connection in accordance with the present disclosure. More specifically, FIGS. **2**A-C illustrate a male pin **205**, a female box **225**, and a locking pin **265** (respectively), which, in part, combine to form the drilling tool connection. The drilling tool connection formed in part by the male pin **205**, the female box **225**, and the locking pin **265** may be utilized as the drilling tool connection **135** in the downhole drilling apparatus **100** shown in FIG. **1**. Alternatively, the drilling tool connection formed in part by the male pin **205**, the female box **225**, and the locking pin **265** may be utilized in other various down hole drilling apparatuses, devices, or systems. Generally, the drilling tool connection formed in part by the male pin **205**, the female box **225**, and the locking pin **265** may be used to couple various sections of a downhole drilling apparatus such as, for example a downhole drilling motor, bearing mandrel, universal assembly joint, and drill bit, to name but a few.

[0031] Turning particularly to FIG. **2**A, a side view and cross-sectional view of the male pin **205** is illustrated. The male pin **205**, generally, is an elongated shaft of, for example, machined steel, which transmits torque generated by a downhole drilling motor to the female box **225** shown in FIG. **2**B. The male pin **205** includes a longitudinal pin bore **210** disposed along a longitudinal axis of the male pin **205** and a pin perimeter **215** defining all outer shape of the male pin **205**. In some implementations, the pin perimeter **215** is substantially hexagonal in shape, thereby providing six substantially flat outer surfaces of the male pill **205**. The pin perimeter **215**, thus, provides the surface from which the torque is transmitted to the female box **225**. The pin perimeter **215**, however, may be alternatively shaped in various other geometric configurations. For instance, the pin perimeter **215** may be substantially octagonal, decagonal (i.e., ten-sided), or nonagonal (i.e., nine-sided). Regardless, the pin perimeter **215** may be a geometric shape having an equivalent number of sides in the male pin **205** and the internal configuration of female box **225**.

[0032] Pin bore **210** includes a pin circumference **207** (i.e., a cylindrical interior surface), which extends the length of the male pin **205**. In some implementations, the pin circumference **207** is substantially smooth to provide a reduced-friction surface for drilling fluid to flow past. The pin circumference **207** also defines the pin bore **210**. The pin bore **210** extends through the male pin **205** such that a longitudinal axis of the pin bore **210** is aligned with a longitudinal axis of the male pin **205** itself. In some implementations, the pin bore **210** is substantially cylindrical with a substantially circular cross-sectional area. Alternatively, the pin bore **210** (and pin circumference **207**) may be any appropriate shape for the drilling application. During downhole drilling operations, a drilling fluid used to, for example, provide hydraulic power to the downhole drilling motor, cool the drilling bit as it drills a geological formation and return drilled cuttings to the surface through an annulus between the well bore and the drill string, may flow through the pill bore **210**. Thus, in some embodiments, the pin bore **210** may provide a raceway for drilling fluid communication between and among downhole drilling devices.

[0033] The male pin **205** includes at least one locking pin slot **220**. For example, the embodiment of the male pill **205** illustrated in FIG. **2**A includes two locking pill slots **220**. The locking pin slots **220** are formed in the pin perimeter **215** near an end of the male pill **205** including a pin boss **223**. The locking pin slots **220** may, in some embodiments, be cast/forged in the male pin **205**. Alternatively, the locking pin slots **220** may be machined in the male pin **205** after manufacture. As described below in more detail with reference to FIG. **3**, each locking pin slot **220** may at least partially receive a locking pin designed to couple the male pin **205** and a female box (such as the female box **225** shown in FIG. **2**B) together.

[0034] Locking pin slots **220**, as illustrated, may be semi-cylindrical in shape, thereby creating a cutout through a width of the male pin **205** extending transverse to the longitudinal axis of the male pin **205**. Alternatively, the locking pin slots **220** may form cutouts through the male pin **205** having any appropriate cross-sectional area, such as, for example, triangular, square, or rectangular.

[0035] Turning now to FIG. **2**B, this figure illustrates a side view and cross-sectional view of the female box **225** of the drilling tool connection. The female box **225** includes a box aperture **227** defined by a box circumference **235**, a box perimeter **230**, and one or more box bores **240** disposed in the box circumference **235**. Generally, the female box **225** receives the male pin **205** into the box aperture **227** until the pin boss **223** butts against a box shoulder **245**, such that the locking pin slots **220** and box bores **240** are substantially aligned, forming substantially cylindrical apertures transverse to the longitudinal axes of the male pin **205** and female box **225**. The female box **225**, further, includes a box connector **260**, which may be coupled to another downhole drilling device, such as a drill bit section, universal joint assembly, a bearing section, or a downhole drilling motor, to name a few. In some embodiments, the box connector **260** may be a threaded-type connection, but the box connector **260** may be any appropriate type of connection depending on, for instance, the type of downhole drilling device coupled or connected to the female box **225**.

[0036] The box perimeter **230**, in some embodiments, is substantially circular thereby giving the female box **225** a substantially circular cross-sectional area. Disposed within the female box **225** through at least a portion of a longitudinal length of the female box **225** is the box aperture **227**. The box aperture **227** extends from a distal end of the female box **225** towards the box shoulder **245**. Typically, the box aperture **227** is shaped to substantially mate to the shape of the pin perimeter **215**, thereby allowing the box aperture **227** to securely receive the male pin **205**. Further, the box aperture **227** may be shaped or sized for minimal tolerance between the pin perimeter **215** and the box circumference **235**. In such fashion, a concentricity between the male pin **205** and the female box **225** may be achieved. The shape of the box aperture **227**, as illustrated in FIG. **2**B, may be substantially hexagonal to mate to the pin perimeter **215**. Alternatively, the shape of the box aperture **227** may be substantially octagonal, decagonal (i.e., ten-sided), or nonagonal (i.e., nine-sided). In any event, in some embodiments, the pin perimeter **215** and the box aperture **227** may be substantially identical in shape.

[0037] In some embodiments of the female box **225**, one or more seal grooves **255** may be formed in the box circumference **235**. For example, FIG. **2**B illustrates one embodiment of the female box **225** having two seal grooves **255** machined into the box circumference **235**. Alternatively, more (or fewer) seal grooves may be utilized. The seal grooves **255**, typically, are disposed around the entire box circumference **235** and receive a box seal **250** therein. The box seal **250** may be a continuous ring having substantially circular cross-section and formed of rubber, neoprene, or other pliable material. In some implementations, the box seal **250** may alternatively be integral to or part of the male pin **205**. In any event, the box seal **250** may operate in substantially similar fashion regardless of whether it is included as part of the male pin **205** or female box **225**.

[0038] In operation, the box seal **250** may be in substantially constant contact with the female box **225** and the male pin **205** when the male pin **205** is inserted into the box aperture **227** and coupled to the female box **225**, thereby providing a fluid-tight seal between the male pin **205** and the female box **225**. Fluid, such as drilling fluid, therefore, may be substantially prevented from entering the box aperture **227** due to the box seal **250** during drilling operations or also during non-activity of the downhole drilling apparatus (e.g., trips into or out of the well bore).

[0039] The female box **225** also includes one or more box bores **240** disposed through the female box **225** transverse to the longitudinal axis of the female box **225**. For example, some embodiments of the female box **225** may include two box bores **240**, as illustrated in FIG. **2**B. Alternatively, more or fewer box bores may be formed in a box, such as the female box **225**. Typically, when the male pin **205** is inserted into the box aperture **227** such that the pin boss **223** rests against the box shoulder **245**, the locking pin slots **220** are substantially aligned with the locking slot **240**. When aligned or substantially aligned, each locking pin slot **220** and corresponding box locking slot **240** for, for example, a substantially cylindrical aperture transversely disposed through the male pin **205** and female box **225**. As described more fully with reference to FIG. **2**C, a locking pin may then be inserted through the substantially cylindrical aperture defined by the slots **220** and bore **240**. As with the locking pin slots **220**, the box bores **240** may be substantially semi-cylindrical in shape, thereby creating a cutout through the width of the female box **225**. Alternatively, the box bores **240** may form cutouts through the female box **225** having any appropriate cross-sectional area, such as, for example, triangular, square, or rectangular.

Regardless, in their usual configurations, the locking pin slots **220** and the locking slot **240** have substantially identical cross-sectional areas.

[0040] FIG. **2**C illustrates a side view and cross-sectional view of a locking pin **265**. The locking pin **265**, typically, is inserted through an aperture defined by the pin slot **220** and the corresponding locking slot **240** when the male pin **205** is inserted into the box aperture **227** such that the pin boss **223** is in contact with the box shoulder **245**. In some embodiments, as described above, the male pin **205** includes two locking pin slots **220** and the female box **225** includes two box bores **240**. In such embodiments, generally, two locking pins **265** may be used such that a single locking pin **265** is inserted through each aperture defined by a particular pin slot **220** and corresponding locking slot **240**. The locking pin **265** may be made of a high-strength material such as, for example, stainless steel, titanium, or other alloy steel. Regardless, in certain embodiments, the locking pin **265** may have good shear strength characteristics. For instance, in some implementations, the locking pin **265** may bear all or substantially all of an axial force transmitted to the male pin **205** in order to pull the downhole drilling apparatus out of the well bore. The locking pin **265**, therefore, may exhibit a high shear strength to withstand the axial force in order to keep the male pin **205** and the female box **225** coupled during the drilling apparatus trip out of the well bore.

[0041] The locking pin **265** is illustrated with a substantially circular cross-section, thereby making it insertable into the aperture defined by the pin slot **220** and the corresponding locking slot **240** as illustrated in FIGS. **2**A-B. Alternatively, the locking pin **265** may have any appropriate cross-sectional configuration depending on the configurations of the locking pin slots **220** and the box bores **240**. As one example, if the aperture defined by the pin slot **220** and the corresponding locking slot **240** is substantially square in cross-section upon alignment of the male pin **205** into the box aperture **227**, then the locking pin **265** may have a substantially square cross-section as well. Generally, the locking pill **265** may be designated to be inserted into such an aperture with little tolerance, thereby ensuring a snug fit within the aperture. In such embodiments (as well as others), lubricant may be applied to tie locking pin **265** in order to insert it into the aperture.

[0042] FIG. **3** illustrates a portion of a downhole drilling apparatus **300** incorporating a drilling tool connection **301** in accordance with the present disclosure. The downhole drilling apparatus **300** includes a downhole tool **380**, a drilling tool connection **301** and a drill bit **375**. Generally, the drilling tool connection **301** couples the downhole tool **380** with the drill bit **375** and transmits rotational torque generated by a downhole drilling motor to the drill bit **375** during drilling operations. Further, the drilling tool connection **301** may transmit an upward axial force to the drill bit **375** when the downhole drilling apparatus **300** is pulled out of a well bore such that the drill bit **375** remains coupled to the downhole tool **380**. Alternatively, a downward force maybe transmitted via the tool connection **301**. In certain embodiments, the drilling tool connection **301** may be substantially similar to the drilling tool connection **135** illustrated in FIG. **1**, as well as a drilling tool connection including a pin, a box, and one or more locking pins as those components are illustrated in FIGS. **2**A-C.

[0043] The drilling tool connection **301** includes a male pin **305**, a female box **325**, one or more locking pins **365**, and one or more end caps **370**. Generally, such components of the drilling tool connection **301**, for example, the male pin **305**, the female box **325**, and the locking pin **365**, may be substantially similar to corresponding components described with reference to FIGS. **2**A-C. FIG. **3** illustrates the male pin **305** inserted into a box aperture **327** such that a pin boss **323** is proximate to with a box shoulder **345**. Further, two locking pins **365** are inserted into the apertures defined by locking pin slots **320** and corresponding box bore **340** upon alignment of the locking pin slots **320** and the box bores **340**. End caps **370** are coupled to each end of the locking pins **365**, thereby securing the locking pins **365** within the apertures. When secured, the male pin **305** and the female box **325** are securely coupled together during all movement of the drilling tool connection **301**, such as rotational movement during a drilling operation or axial movement (e.g., movement substantially parallel to the well bore) during trips in or out of the well bore.

[0044] More specifically, the male pin **305** may be substantially hexagonal in cross-sectional shape with a substantially circular longitudinal bore **310** aligned with a longitudinal axis of the male pin **305**. The longitudinal bore **310** (as well as the box aperture **327**) may, for example, provide a channel through which drilling fluid flows to the drill bit **375** from the downhole drilling motor, thereby cooling the drill bit **375** and removing drilled cuttings from the bit **375**. Further, the male pin **305** may also include a secondary outer circumference **382**, which is at least slightly greater in dimension than the portion of the male pin **305** inserted into the box aperture **327**. In some embodiments, for example, the secondary outer circumference **382** may be sized such that when the male pin **305** is inserted into the box aperture **327**, the secondary outer circumference **382** may stop against a box ledge **385** formed in the female box **325**. In such a fashion, the six substantially planar outer surfaces of the male pin **305** may transmit all or substantially all of the rotational torque generated by the downhole drilling motor to the female box **325** and, therefore, the drill bit **375**.

[0045] As noted above, when the male pin **305** is fully inserted into the box aperture **327**, the locking pin slots **320** are aligned with the box bores **340**, thereby allowing the locking pins **365** to be inserted into the apertures defined by the slots **320** and bores **340**. The end caps **370** may then be attached to the distal ends of the locking pins **365**. For instance, the end caps may be threaded onto the locking pins **365** (e.g., male/female NPT) or snapped into place through an alternate coupling mechanism (e.g., set screws or snap rings) as appropriate. Regardless, the end caps **370** may securely attach to the distal ends of the locking pins **365** to ensure that the locking pins **365** may not be removed or come Out of the apertures in which the pins **365** reside during drilling operations. In some embodiments, the end caps **370** may require a specialized tool for attachment to and removal from the locking pins **365**.

[0046] The female box **325** includes the box aperture **327** to receive the male pin **305**, as well as a box connector **360**. The box connector **360** may allow a downhole tool, such as the drill bit **375**, to be coupled to the drilling tool connection **301**. The female box **325** also includes the box shoulder **345**, which may absorb an axial thrust force transmitted through the pin boss **323** and transmit such force to the drill bit **375**. For example, a drill string which includes the downhole drilling apparatus **300** may include multiple sections of drill pipe extending to the surface and multiple drill collars attached to such drill pipe closer to the downhole drilling apparatus **300**.

The drill collars may, by design, exert a downward axial force on the downhole drilling apparatus **300** due to the weight of the drill collars. In such fashion, the drill bit **375** may be urged deeper into a subterranean formation. Such axial force, in some embodiments of the drilling tool connection **301**, may be transmitted through the box shoulder **345** to the drill bit **375** rather than, for example, the locking pins **365**. In such embodiments, the locking pins **365** may be utilized to withstand a shear force applied to such locking pins **365** and keep the male pin **305** coupled to the female box **325** when the downhole drilling apparatus **300** is removed from the well bore.

[0047] FIG. **4** illustrates one method **400** of assembling a drilling tool connection in accordance with the present disclosure. Method **400** may be used with, for example, the drilling tool connection **135** shown in FIG. **1**, the drilling tool connection including the male pin **205**, the female box **225**, and the locking pins **265** illustrated in FIGS. **2**A-C, or the drilling tool connection **301** shown in FIG. **3**. In any event, method **400**, alternatively, may be used with other embodiments of a drilling tool connection according to the present disclosure including such components as a pin, a box, one or more locking pins, and one or more end caps. Method **400** may begin with a user of the drilling tool connection lubricating the surfaces of the drilling tool connection components [**402**]. For example, the user may lubricate the outer surface of the pin, the inner surface of the box, the locking pins, as well as the pin slots and the box bores. In such fashion, these components may be more easily assembled while ensuring tight tolerances between the components.

[0048] The user may then insert the pin into the box aperture [**404**]. After the pin is inserted into the box aperture, the user may locate a pin boss on the pin proximate to a box shoulder of the box [**406**]. Such proximity may ensure, for example, that rotational torque generated by a downhole drilling motor and transmitted to the pin is further transmitted to the box primarily through substantially planar outer surfaces of the pin. Such proximity may also ensure a correct alignment of the pin slots and the box bores, but in any event, the user may align the pin slots with the box bores [**408**]. For example, the pin slots and the box bores may be semi-cylindrical and be disposed through the pin and the box, respectively, transverse to longitudinal axes of the pin and the box. When aligned properly, the pin slots and the box bores may define substantially cylindrical apertures. Alternatively, the pin slots and the box bores, when aligned properly, may define apertures of different cross-sectional configurations (e.g., square, rectangular) depending on the shape of the pin slots and the box bores.

[0049] Continuing with method **400**, the user may then insert locking pins into the apertures defined by the aligned pin slots and box bores [**410**]. For instance, the locking pins may be substantially cylindrical to fit into such apertures defined by the semi-cylindrical pin slots and box bores. The user may then secure end caps to the end portions of the locking pins

[0050] For instance, the ends caps may be threaded or snapped into place on the locking pins, thus preventing the locking pins from being removed from the apertures. Next, the user may then couple the assembled drilling tool connection to one or more downhole tools [**414**]. In some cases, the downhole tool may be a downhole drilling motor, a drill bit, a universal joint assembly, and the like.

[0051] A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made. For example, method **400** may include more or fewer steps without departing from the present disclosure. Further, the illustrated steps of method **400** may be performed in substantially the same order presented or in various other orders, as appropriate. Accordingly, other implementations are within the scope of the following claims.

What is claimed is:

1. A drilling tool connection, comprising:

a male pin connector element disposed on a first downhole drilling device, the male pin connector element comprising a substantially hexagonal outer perimeter, at least a portion of the pin having a substantially cylindrical bore along a longitudinal axis of the pin, the pin having at least one transverse slot formed transverse to the longitudinal axis of the pin;

a female box connector element disposed on a second downhole drilling device comprising a substantially circular outer perimeter at least a portion of the box having a substantially hexagonal aperture aligned with a longitudinal axis of the box, the box having at least one transverse bore formed in the box transverse to the longitudinal axis of the box, the substantially hexagonal aperture of the female box adapted to receive the substantial hexagonal portions of the male pin; and

a locking pin insertable through an aperture defined by the at least one transverse slot of the pin and the at least one transverse bore of the box upon alignment of the transverse slot with the transverse bore.

2. The drilling tool connection of claim **1**, wherein the substantially cylindrical longitudinal aperture is adapted to direct drilling fluid through the second downhole drilling device.

3. The drilling tool connection of claim **1**, wherein the locking pin is substantially cylindrical.

4. The drilling tool connection of claim **1** further comprising an end cap configured to fasten to the locking pin and substantially prevent the locking pin from being removed from the aperture defined by the transverse slot and the transverse bore.

5. The drilling tool connection of claim **1**, further comprising an end cap configured to fasten to the aperture formed by the transverse slot and the transverse bore by a threaded connection.

6. The drilling tool connection of claim **1**, wherein the aperture defined by the transverse slot and the transverse bore is substantially cylindrical.

7. The drilling tool connection of claim **1** further comprising a first box seal disposed within a box seal groove, the box seal groove formed in an interior surface of the box defining the substantially hexagonal aperture.

8. The drilling tool connection of claim **1**, wherein the locking pin is a first locking pin, the drilling tool connection further comprising:

a second transverse slot formed proximal to the distal end of the pin transverse to the longitudinal axis of the pin;

a second transverse bore formed in the box transverse to the longitudinal axis of the box; and

a second locking pin insertable through a second aperture defined by the second transverse slot and the second transverse bore upon alignment of the second transverse slot with the second transverse bore.

9. The drilling, tool connection of claim **1**, wherein the first downhole drilling device is selected from the group consisting of:

a downhole drilling motor;
a stabilizer;
a universal joint assembly;
a drill bit;
a drill collar;
a drill pipe; or a bearing mandrel.

10. The drilling tool connection of claim **1**, wherein the second downhole drilling device is selected form the group consisting of:

a downhole drilling motor;
a stabilizer;
a universal joint assembly;
a drill bit; or
a bearing mandrel.

11. The drilling tool connection of claim **1**, wherein the box further comprises a shoulder formed in the box at a distal end of the substantially hexagonal aperture and the pin further comprises a substantially planar surface formed at the distal end of the pin and configured to transmit thrust to the shoulder substantially parallel to the longitudinal axes of the pin and the box.

12. A well bore tool coupling device, comprising:

a male pin disposed on a first downhole drilling device, the male pin comprising a pin perimeter of a first geometric shape, at least a portion of the pin having a substantially cylindrical bore along a longitudinal axis of the pin, the pin having at least one transverse slot formed in the pin perimeter transverse to the longitudinal axis of the pin;

a female box connector element disposed on a second downhole drilling device comprising at least a portion of the box having a box aperture of a second geometric shape aligned with a longitudinal axis of the box, said box aperture adapted to receive the first geometric shape portion of the male pin, the box having at least one transverse bore formed in the box transverse to the longitudinal axis of the box; and

a locking pin insertable into an aperture defined by the at least one transverse slot of the pin and the at least one transverse bore of the box upon alignment of the transverse slot with the transverse bore.

13. The well bore tool coupling device of claim **12**, wherein the first and second geometric shapes selected from the group consisting of:

a hexagon;
an octagon;
a nonagon; or
a decagon.

14. The well bore tool coupling device of claim **12**, wherein the longitudinal aperture is adapted to direct drilling fluid through the second downhole drilling device.

15. The well bore tool coupling device of claim **12** further comprising an end cap configured to fasten to the locking pin and substantially prevent the locking pin from being removed from the aperture defined by the transverse slot and the transverse bore.

16. The well bore tool coupling device of claim **12**, further comprising an end cap configured to fasten to the aperture formed by the transverse slot and transverse bore by a threaded connection.

17. The well bore tool coupling device of claim **12**, wherein the aperture defined by the transverse slot and the transverse bore is substantially cylindrical.

18. The well bore tool coupling device of claim **12** further comprising a first box seal disposed within a box seal groove, the box seal groove formed in an interior surface of the box defining the box aperture.

19. The well bore tool coupling device of claim **12**, wherein the locking pin is a first locking pin, the well bore tool coupling device further comprising:

a second transverse slot formed at the distal end of the pin transverse to the longitudinal axis of the pin;

a second transverse bore formed in the box transverse to the longitudinal axis of the box; and

a second locking pin insertable through a second aperture defined by the second transverse slot and the second transverse bore upon alignment of the second transverse slot with the second transverse bore.

20. The well bore tool coupling device of claim **12**, wherein the female box connector element further comprises a shoulder formed in the box at a distal end of the aperture of the second geometric shape and the pin further comprises a substantially planar surface formed at the distal end of the pin and configured to transmit thrust to the shoulder substantially parallel to the longitudinal axes of the pin and the box connector element.

21. The well bore tool coupling device of claim **12**, wherein the female box connector element further comprises a ledge proximate to a distal end of the box connector element.

* * * * *