ABSTRACT
A sealed mule shoe assembly for use in directional drilling, comprising an outer mule shoe and an inner housing for containing a directional measurement tool which is slidably insertable in the outer mule shoe. The mule shoe assembly advantageously has half-moon mating surfaces which advantageously allow use circumferential seals to thereby prevent ingress of abrasive materials into the landing area between the outer mule shoe and the inner housing, thereby greatly prolonging the life of the mule shoe assembly. Such seals further make use of hydrostatic forces downhole which cause locking landed engagement of the inner tool within the outer mule shoe. Cup seals or a check valve are used to allow escape of fluid when the inner tool is inserted within the outer mule shoe, and similarly prevent ingress of abrasive fluids and drill cuttings into the area of landed engagement.
SEALED AND HYDROSTATICALLY LOCKABLE RETRIVABLE MWD LANDING SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates to a component of a drill string for use in directionally drilling of oil wells, and more particularly to an improved mule shoe assembly for downhole MWD ("measurement while drilling") operations as part of a drill string, having an outer mule shoe member which receives therein a directional measurement tool having electronic sensing components and/or mud pulser units therein for sensing and transmitting, respectively, directional drilling data from downhole to surface during drilling. Due to its unique configuration the mule shoe assembly of the present invention is able to make use of seals which seal the area of mating engagement to thereby resist ingress of abrasive substances such as sand which otherwise disadvantageously causes extreme wear and ultimate loss of functionality of the mule shoe assembly, and by such configuration is further adapted to use hydrostatic forces to better retain the two components together.

BACKGROUND OF THE INVENTION

[0002] For directional drilling of oil and gas wells, a drill string generally has, at its distal end, a rotating drill bit which is energized by a hydraulically-powered "mud" motor. Such drill bit and hydraulically-powered motor are generally contained in a so-called "bent sub" used in directional drilling of wells using so-called MWD (measurement-while-drilling) tool orientation directional sensing apparatus.

[0003] A universal bottom hole orienting sub assembly ("UBHO orienting sub") containing a mule shoe assembly and which contains therein a directional measurement tool, is generally threadably coupled to the bent sub, uphole therefrom, which assists the drill operator in directional drilling, in the manner described below.

[0004] Specifically, the directional measurement tool within the mule shoe assembly which forms part of the UBHO orienting sub contains electronic circuitry for determining drill bit location and orientation and generally also information about the geology of the rock being drilled in, to thereby assist and allow the drill operator to effectively "steer" the bit in a desired direction during drilling. Such mule shoe assembly and UBHO sub together form part of the drill string bottom hole assembly ("BHA").

[0005] The UBHO sub is adapted at its downhole end to be threadably connected to the bent sub, and at its uphole end to be threadably connected to various other bottom hole assembly components, typically the non-magnetic tool collar, with the mud pulser apparatus for transmitting downhole drilling orientation information from the directional measurement tool uphole to surface sitting within the mule shoe assembly.

[0006] The UBHO sub has, as one component thereof, a hollow cylindrical outer member, colloquially known to persons of skill in the art as a "mule shoe", which typically in prior art mule shoe assemblies to date has an arcuate camming surface on an interior surface thereof for landing against a mating arcuate camming surface on an exterior surface of a directional measurement tool when such directional measurement tool is co-axially inserted and caused to nest within the outer mule shoe member, to form a mule shoe assembly. The matingly-engageable arcuate camming surfaces are adapted to engage in a manner so as to cause the angular position of the inserted (nested) directional measurement tool within the outer mule shoe member to be fixed and further precisely known relative to the outer mule shoe member in the resulting mule shoe assembly.

[0007] The mule shoe outer member of a mule shoe assembly of the prior art typically has an elongate slot (aperture) perpendicularly disposed to but extending through the outer surface of the mule shoe outer member housing and into the hollow bore of the mule shoe, which elongate slot is adapted for receiving therein a similarly shaped elongate key member which extends therethrough and further into an axially-extending channel in the directional measurement tool when the directional measurement tool is inserted within the bore of the mule shoe and the arcuate camming surfaces on the respective mule shoe member and inner directional measurement tool engage and thereby cause each of the aforesaid components to be rotated into a desired relative angular relation to one another thereby aligning the key member with the channel. The key member when inserted and pinned in such inserted position within the channel of the measurement tool fixedly keeps the angular relation of the inner directional measurement tool relative to the outer mule shoe member constant, although longitudinal movement of the measurement tool can occur by movement of the key member within the channel of the directional tool member.

[0008] To prevent such relative longitudinal movement between such two components of the mule shoe assembly a threaded set screw (or screws) or dowel member is used which extends from the mule shoe member to the inner directional measurement tool so as to secure and "lock" the directional measurement tool within the mule shoe member and prevent longitudinal movement of the directional measurement tool within the mule shoe member and thereby allow the UBHO sub (containing the mule shoe and directional measurement tool locked therewithin) and the bent sub and drill bit attached thereto to be lowered downhole so as to permit directional drilling.

[0009] Disadvantageously and problematically with such prior art mule shoe assemblies, circumferential seals are not capable of being provided within the mule shoe assembly of such designs due to the arcuate camming surfaces employed which extend longitudinally of the outer mule shoe and the directional measurement tool. As a result, abrasive materials such as drilling fines, sand and other detritus from drilling operations frequently enters the mule shoe assembly during drilling. Specifically, sand, detritus, and drilling fines invariably enters the area of mating engagement between the directional measurement tool and the outer mule shoe member. Due to extreme vibration to which the mule shoe assembly is exposed during drilling (such vibration caused by large and rapid pressure pulses created by the mud pulser which uses rapid pressure fluctuations of the drilling mud to transmit drilling data to surface) small longitudinal and/or angular movement is created between the outer mule shoe member and the directional tool component.

[0010] Such vibrational movement (albeit initially small) due to the large numbers of vibration cycles needed to transmit ever increasing quantities of data to surface, due to the highly abrasive nature of drilling fines and fluids containing such fines or sand, causes rapid and extensive wear of each of the two components at the point of coupling. Such wear leads to loss of the fixed angular orientation of the directional measurement tool relative to the outer mule shoe member,
and thus invariably leads to loss in accuracy of the measurement tool orientation and thus loss of ability to sense the direction of drilling of the drill bit.

[0011] In addition, such imparted vibration and exposure to abrasive materials causes extensive wear of the two components such that directional sensor orientation is lost, which directly results in the loss of the ability to “steer” the drilling bit from surface by rotating the drill string (and bit attached thereto) during directional drilling operations.

[0012] Either of the above scenarios necessitates the entirety of the drill string to be “tripped out” of the well being drilled in order to replace the worn mule shoe assembly.

[0013] Such frequent “tripping out” of the directional drilling drill string greatly slows the drilling process, and greatly adds to the expense of drilling.

[0014] Accordingly, a real and serious need exists in the directional drilling industry for a robust mule shoe assembly which can withstand extensive and lengthy periods of exposure to significant vibration in abrasive drilling environments, yet continue to operate effectively.

[0015] More particularly, and in addition, a real and serious need exists in the directional drilling industry for an integral mule shoe assembly which permits a directional measurement tool to be easily installed in an outer mule shoe component thereof, but at the same time when the two components are assembled and when such assembly is used downhole as part of a drill string in an abrasive environment, prevents sand and/or drilling fines from entering the assembly in the region of mating engagement between the outer mule shoe and the inner concentrically-located directional measurement tool.

[0016] U.S. Pat. No. 7,900,698 to a “Downhole Wet-Mate Connector Debris Exclusion System” teaches a downhole wet connector system, principally for connecting two fiber optic cables together (although other types of connectors could be used). Such wet connector system consists of two half-members 12, 14, each having respective orientation profile 16, 18 respectively, to ensure proper and consistent angular alignment of one half member relative to the other during coupling. US ‘798 discloses a check valve 106 (ref. col.3, line 43 and FIG. 1C). However, such check valve 106 is not for the purpose of allowing release of fluid during coupling of the two half members but appears instead, after coupling, to allow injection and subsequent retention therewithin of a cleaning/flushing fluid (preferably a fluid such as hydroxyethylcellulose) into the coupled device, wherein the fluid thereafter functions to assist in providing a presence of fluid as opposed to open space which will then hopefully discourage ingress of dirt and other contaminants. Thus the check valve 106 of US ‘798 in no way assists in coupling the two halves together by allowing egress of air out of the coupled unit so that hydrostatic force outside the half-members will assist in ensuring the half members remain coupled together.

SUMMARY OF THE INVENTION

[0017] The present invention by its novel configuration avoids the dowel or “threaded screw” arrangement of the prior art, and further avoids the arduous landing of the outer mule shoe member using a key within a slotted channel, and instead using a different landing arrangement further incorporating protective seals to protect the landing area of the mule shoe from abrasive substances so as to greatly prolong the life of the mule shoe and avoid expensive “tripping out” operations to replace worn mule shoe assemblies.

[0018] Specifically, to greatly improve the resistance of the mule shoe assembly to wear in the abrasive downhole environment in which such mule shoe apparatus operate as compared to the prior art mule shoe assemblies as described herein, the present invention provides for a mule shoe assembly making use of mating “half members”, which in a preferred embodiment are mating “half-moon” members, on respectively the outer mule shoe member and the directional tool member (the latter being concentrically located within the bore of the outer mule shoe member) which manner of mating engagement allows using seal means, specifically a pair of circumferential seals such as “o” rings or flexible “lip” or “cup” seals as further elaborated on below, respectively located at opposite ends of, and bounding, the mating “half moon” members on the outer mule shoe and the inner directional measurement tool. The seals, in conjunction with the particular configuration for landing the direction tool and housing within the mule shoe, greatly reduces sand and/or drilling fines from coming into contact with such landing area, namely with the half-moon members of the mule shoe and directional tool housing.

[0019] Accordingly, in one broad aspect of the present invention, the invention comprises a mule shoe assembly for use in directional drilling of wells, which mule shoe assembly is adapted to lockingly secure a directional measurement tool therein and further resist ingress of abrasive substances such as drilling fines coming into contact with the mule shoe landing area, comprising:

[0020] (i) an outer mule shoe member, having:

[0021] (a) a longitudinal bore, a portion of which is cylindrical;

[0022] (b) a half member located within said cylindrical portion of said longitudinal bore, fixedly secured to a circumferential portion of said longitudinal bore about at least a portion of a circumference thereof;

[0023] (ii) a cylindrical housing for containing a direction-indicating tool, said housing adapted for insertion in said longitudinal bore of said outer mule shoe member, comprising:

[0024] (a) a half member situated on an circumferential portion of an outer surface of said housing, extending longitudinally along said portion of said outer surface and protruding radially outwardly about said portion of said outer surface of said housing, adapted to matingly engage said half member located within said mule shoe member so that, when matingly engaged, angular rotation of the housing within the mule shoe member is prevented; and

[0025] (iii) a pair of circumferential seals, respectively situated proximate mutually opposite ends of said mule shoe member and said housing when said housing is inserted in said longitudinal bore, adapted to reduce ingress of drilling fines and fluids containing drilling fines into an interstitial area bounded by said pair of circumferential seals.

[0026] Advantageously, the pair of circumferential seals perform a dual function—not only do they prevent ingress of abrasive matter, including drilling fines suspended in drilling fluids, into the landed area of engagement of the inner housing and the outer mule shoe member, but they further cause, due to such created seal, hydrostatic forces to effectively exert a continual compressive force which continually forces the two members into landed engagement with each other thus better allowing the mule shoe assembly to maintain locking
landed engagement of the inner tool within the outer mule shoe despite these vibrational forces which tend to otherwise cause separation of the outer mule shoe and the inner tool. In such manner the mule shoe assembly is able to better withstand vibrationally-imported separation forces when downhole, thus reducing or eliminating relative vibrationally-induced movement between the mule shoe and the inner directional tool, thus permitting the mule shoe assembly to avoid and reduce wear on its components when used in directional drilling, thus allowing for substantially longer life of the assembly.

In a preferred embodiment of the above mule shoe assembly a check valve, (typically a ball-style check valve, but other similarly- operating check valves are contemplated as known to persons of skill in the art) is situated intermediate said pair of circumferential seals. Such check valve is used to facilitate and allow escape of trapped fluid in the interstitial space between such outer mule shoe member and inner directional measurement tool during insertion of the directional tool member concentrically within the bore of the outer mule shoe member. Conversely, such check valve resists and prevents fluids including drilling lines from entering such interstitial space and area of mating engagement, namely at the respective mating “half-moon” members. In addition, due to hydrostatic forces exerted on the individual mule shoe and directional tool housing, particularly when downhole there is large pressure differentials, the use of the check valve in such preferred embodiment serves to allow forcible locking (via allowing fluid to be extruded from within the drilling assembly and thereby allowing drilling fluid hydrostatic pressure exerted on the exterior of the outer mule shoe and directional tool housing to force the two members together) so as to prevent separation while at the same time preventing sand, grit, and drill lines from getting into the mule shoe assembly in areas which could cause wear, particularly in the area of landing of the two members together in the region of the two half-moon members located in the area between the pair of circumferential seals.

Accordingly, in a preferred embodiment of the invention the above mule shoe assembly further comprises a check valve situated in said outer mule shoe member, adapted to allow egress of fluid from within said mule shoe member upon insertion of said housing in said longitudinal bore, and configured to prevent ingress of fluid into said longitudinal bore.

In a second embodiment, mating “half-moon” members on respectively the outer mule shoe member and inner directional measurement tool are likewise employed, as are seal means disposed at respective ends of the mule shoe assembly seal, so as to seal therein the half-moon mating members. However, in such second alternative embodiment of the mule shoe assembly of the present invention, no ball-style check valve is needed or employed. Rather, in such second alternative embodiment at least one (or both) of the seal means incorporate a flexible lip seal or flapper type seal, which allows release of fluid from within the mule shoe when the directional tool is inserted into the bore of the mule shoe member, but which resists ingress of fluid into an interior of the mule shoe assembly and likewise thereby serves to hydrostatically lock the tool within the mule shoe assembly once the directional measurement tool is inserted therewith.

Accordingly, in a second embodiment of the mule shoe assembly of the present invention at least one of the circumferential seals comprises a “flapper” type seal adapted to allow egress of fluid from within said mule shoe member upon insertion of said housing in said longitudinal bore, and to prevent ingress of fluid into said longitudinal bore when said housing is inserted in the longitudinal bore and engaging such at least one circumferential seal.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate one or more exemplary embodiments of the present invention and are not to be construed as limiting the invention to these depicted embodiments:

FIG. 1A is an exploded perspective view of a mule shoe assembly of the prior art, which uses a threaded set screw to lockably (non-releasably) secure an inner tool to an outer mule shoe;

FIG. 1B is a non-exploded view of the prior art mule shoe assembly of FIG. 1A;

FIG. 2 is cross-sectional view through the prior art mule shoe assembly of FIG. 1B along section A-A thereof;

FIG. 3 is an enlarged view of encircled area “B” of FIG. 2.

FIG. 4 is an exploded perspective, partial cross-sectional view of one embodiment of the mule shoe apparatus of the present invention, shown coupled, on the right hand side thereof, to a portion of a drill string;

FIG. 5 is a side, partial cross-sectional view of the mule shoe apparatus and drill string of FIG. 4, with the housing partially inserted in the outer mule shoe;

FIG. 6 is an enlarged view of the mule shoe apparatus shown in FIG. 5, showing the housing fully inserted within the mule shoe;

FIG. 7 is a further side perspective view, in partial section, of the mule shoe apparatus of FIG. 6, showing the aperture in the half-moon member of the mule shoe member which provides fluid egress from the bore of the mule shoe member;

FIG. 8 is a perspective partial sectional view of an alternative embodiment of the mule shoe apparatus of the present invention, in which the check valve is located in a different location but still intermediate the two circumferential “o” rings situated at respectively mutually opposite ends of the mule shoe assembly;

FIG. 9 is a perspective partial sectional view of a still further alternative embodiment of the mule shoe apparatus of the present invention, in which a pair of check valves are positioned still intermediate the two circumferential “o” rings situated at respectively mutually opposite ends of the mule shoe assembly; and

FIG. 10 is a still further alternative embodiment of the present invention, which does not employ a check valve but instead utilizes a circumferential “cup” type seal means at one end of the mule shoe assembly which allows egress of fluid from between the cup seal and the “o” ring seal during insertion of the housing, but which resists ingress of fluid and thereby assists in hydrostatically locking the measurement tool within the mule shoe assembly.

DETAILED DESCRIPTION OF SOME OF THE PREFERRED EMBODIMENTS

Mule shoe assemblies 10 of the prior art, as shown in FIGS. 1A, 1B, 2, & 3 hereto, typically comprise a substantially cylindrical mule shoe member 12 having a hollow bore 28. Downhole end 13 of mule shoe 12 is adapted to be thread-
ably coupled to a mud motor and associated drill bit (not shown). Upliue end 17 thereof mule shoe 12 is adapted to be secured to additional BHA components, such as a mud pulsor (not shown).

Camming member 24 of mule shoe 12 has an arcuate camming surface 14 thereon, and is insertable within bore 28 and is typically welded in a desired location and angular orientation within interior bore 28 of mule shoe 12.

Inner cylindrical tool member 16 is adapted to be inserted within mule shoe 12, as shown in FIGS. 1A & 1B. Inner tool housing member 16 is adapted to contain within its bore 40 a directional measurement tool (not shown), which is retained in such bore 40 by threaded sleeve 42 and associated “O” ring 44.

A direction sensing tool and associated electronics, as well as a mud pulsor apparatus (not shown) are adapted to be contained within inner tool housing member 16. Inner tool housing 16 possesses an exterior arcuate camming surface 18 on an outer periphery 19 thereof, which shape is complementary to arcuate camming surface 14, and which camming surface 14 is adapted for landed engagement with camming surface 18 upon insertion of inner tool housing 16 within outer mule shoe 12.

Threaded set screws 30 are provided, adapted to be threadably inserted into apertures 32 in mule shoe 12, for the purposes of longitudinal fixation of inner tool member 16 within mule shoe 12. When inner tool housing member 16 is inserted in bore 28 of outer mule shoe 12, mutual engagement of each of arcuate camming surfaces 14 and 18 causes relative rotation of the inner tool housing member 16 relative to outer mule shoe 12, so that apertures 32 in mule shoe 12 become aligned with, and positioned directly above, respective apertures 34 in inner tool housing member 16.

Upon mutual alignment of apertures 32 with apertures 34 in inner tool housing member 16, set screws 30 may further be tightened to thereby extend into apertures 34 in inner tool housing member 16, thereby fixedly securing inner tool housing 16 (with a directional tool inserted within a bore 40 thereof) to outer mule shoe 12.

For further maintaining the angular position of inner tool housing 16 relative to outer mule shoe 12, a channel 41 is typically further provided on outer periphery 19 thereof. Upon landed engagement of the respective arcuate camming surfaces 14 and 18 of the respective mule shoe 12 and inner tool housing member 16, channel 41 becomes aligned with slot 60 in mule shoe 12. Key member 70 is then inserted in slot 60 which simultaneously engages channel 41 in inner tool member 16, thereby preventing any further insertion of inner tool housing member 16 within bore 28 of mule shoe 12.2 and further preventing any relative angular rotation of inner tool housing member 16 (and directional tool member contained therein) relative to mule shoe 12. Key member 70 may be fixedly secured in slot 60 in mule shoe 12 by means of “friction fit” pin members 80. The inner tool 16 is thus effectively landed within mule shoe 12.

Disadvantageously, however, as mentioned above, due to the arcuate camming surfaces 14, 18 used to angularly orientate and land the directional tool housing 16 within outer mule shoe member 12, circumferential seals cannot be used. Accordingly, when such mule shoe assembly 10 is downhole, abrasive substances such as drill tailings and sand enter such landing area. Due to large and rapid pressure oscillations and vibration during drilling (such vibration caused in part from operation of mud pulsers downhole within or proximate the mule shoe assembly 10 for transmitting data from the directional measurement tool to surface) small angular and/or longitudinal movement of the inner directional tool 16 relative to the mule shoe 12 occurs. Due to the highly abrasive nature of the drilling fluid, even wear on specially treated and surface-hardened metal surfaces occurs. Such initial wear has a negative cascading effect, since as wear progresses it causes greater space between mating parts, namely in the channel 14 and key member 70, and the area of landed engagement at surfaces 14, 18, which greater space allows further entry of fluids containing abrasive substances which begets still further wear, until ultimately angular fixation of the mule shoe 12 relative to the directional tool housing inner tool 16 is completely lost and/or torque cannot be transmitted, rendering effective directional steering of the downhole drill bit (not shown) impossible. “Tripping out” of the entire drill string to replace the defective mule shoe assembly 10 is then required, resulting in great loss of time and money.

Accordingly, in order to overcome the aforementioned disadvantages with the mule shoe assemblies 10 of the prior art, a mule shoe assembly 100 is provided as shown in FIGS. 4-10 inclusive.

In a first embodiment of the present invention, various views of which are shown in FIGS. 4-7, mule shoe assembly 100 comprises an outer mule shoe member 120 and a tool housing 160 for containing a direction-indicating tool therein (not shown). Outer mule shoe member 120 is provided with a longitudinal bore 280, a portion of which is cylindrical. A half-moon member 124, one embodiment of which is best shown in FIG. 4 in perspective view, is fixedly secured, typically by welding, to a circumferential portion 125 of longitudinal bore 280 about at least a portion 126 of a circumference of bore 280.

Directional tool housing 160, as shown in FIG. 4, is typically hollow and is adapted for containing therein a direction-indicating tool (not shown), such tool being retained therein via a threaded end cap member 130, which end cap member 130, as further explained below, possesses at least one circumferential seal in the form of at least one ‘O’ ring 300 extending about the circumference thereof.

Tool housing 160 and the directional tool therein (not shown) are adapted for insertion in longitudinal bore 280 of outer mule shoe member 120, as best shown (partially inserted) in FIG. 5, and fully inserted in FIG. 6.

A half-moon member 134 is provided on the directional tool housing 160, namely on a circumferential portion 135 of an outer surface 137 of tool housing 160, which half-moon member 134 extends longitudinally along portion 135 of outer surface 137 and protrudes radially outwardly from said portion 135 of outer surface 137, and is of a similar diameter to that of half-moon member 124, as may be seen from FIGS. 4 & 5.

Half-moon member 134 is adapted to matingly engage half-moon member 124 within mule shoe member 120 when tool housing 160 is inserted within longitudinal bore 280 of mule shoe member 120 so that, when each of half-moon members 124, 134 matingly engage as shown in FIG. 5, angular rotation of tool housing 160 relative to mule shoe member 120 is prevented.

A pair of circumferential seals in the form of ‘O’ rings 300 are provided in the first embodiment of the mule shoe assembly 100 of the invention, respectively situated proximate mutually opposite ends 121, 122 thereof. Such circumferential seals 300 may be situated in distal ends 161,
162 of the directional tool 160, or in distal ends 121, 122 of the outer mule shoe 120, or a combination of the foregoing whereby at one end 122 of mule shoe assembly 100 such are located within annular rings 320 located within outer mule shoe 120, and at another opposite end of mule shoe assembly 100 are located in annular rings 375 located on directional tool member 160, as shown in FIG. 5. In all instances such circumferential seals 300 which serve to prevent ingress of drilling fluids and fluids containing drilling fluids into said mule shoe assembly 100, namely into interstitial landed areas 400, 401 bounded by said pair of circumferential seals 300.

Specifically, in the first embodiment shown in FIG. 4-7, a pair of seal grooves 320 are provided proximate distal end 122 of outer mule shoe 120, in which V rings 300 may be placed. Such ‘o’ rings 300 engage distal end 162 of directional tool 160 when directional tool 160 is concentrically located in bore 280 of outer mule shoe member 120, as shown in FIG. 5 (partially inserted) and FIG. 6, 7 (fully inserted).

Similarly, a pair of seal grooves 375 may be situated at a distal end 161 of tool housing 160, in which similar ‘o’ rings 300 may similarly be placed, which sealingly engage distal end 121 of outer mule shoe member 120 when directional tool 160 is fully inserted in outer mule shoe 120, as shown in FIGS. 6, 7, so that interstitial landed area 400, 401 is sealed from abrasives, including drilling fluid containing drill tailings and sand.

Advantageously, seals 300 allow hydrostatic forces exerted on the mule shoe assembly 100 when downhole to maintain directional tool member 160 in landed engagement within mule shoe assembly 100.

In addition, however, if desired, similar set screws 30 as used in the prior art and as shown in FIG. 1A, FIG. 2, and FIG. 3 or alternatively dowel pins (not shown), may similarly be employed to assist in maintaining directional tool 160 within outer mule shoe 120, particularly when downhole hydrostatic forces may not be acting.

This first embodiment of the mule shoe apparatus 100 of the present invention shown in FIGS. 4-7 a single check valve 500 is situated within a borehole 501 located in outer mule shoe member 120. Check valve 500 contains a resiliently biased member, such as a ball 502 biased via a spring 503 over aperture 520 in outer mule shoe member 120. A bore 700 is further provided in half-moon member 124, which aligns with bore 520 in mule shoe member 120. Check valve 500 is accordingly adapted to allow egress of fluid from within said mule shoe member 120, namely egress of fluid such as air which is expelled during insertion of tool housing 160 in bore 280 and in particular during the mating engagement of half-moon members 124, 134 upon insertion of said housing 160 in said longitudinal bore 280.

Conversely, check valve 500 operates to prevent ingress of air or such fluid, including and in particular drilling fluid containing abrasive drill tailings or sand, into interstitial landed area 400, 401 via borehole 501 and bore 700.

A second embodiment of the invention is shown in FIG. 8 and similarly utilizes a half-moon member 124 situated on a portion 126 of interior of longitudinal bore 280. In such embodiment half-moon member 124 is of a slightly different configuration than that shown in FIG. 4-7, namely having eliminated therefrom the circular collar 801 (see FIG. 7). Borehole 501 is provided, which aligns with aperture 520, both of which are in fluid communication with interstitial landed area 400. Borehole 501 is adapted to contain a check valve 500 (not shown in FIG. 8) to allow egress of fluid such as air when said directional tool member 160 and associated half-moon member 134 matingly engage half-moon member 124 within mule shoe member 120. Advantageously in such second embodiment the need for a bore 700 through half-moon member 124 may be dispensed with, thus dispensing with a machining step.

FIG. 9 shows a third embodiment of the mule shoe assembly 100 of the present invention, which is further adapted to improve the ease by which fluid may be allowed to egress landed areas 400, 401 when the directional tool member 160 is inserted within mule shoe member 120, which uses two boreholes 501, each adapted to contain an associated check valve 500, and which two check valves 500 together operate to allow egress of all fluid such as air from within said mule shoe assembly 100 when said directional tool member 160 and associated half-moon member 134 matingly engage half-moon member 124 within mule shoe member 120. Again, due to the elimination of a circular collar 801 (see FIG. 7) on half moon member 124, fluid can effectively egress from within interstitial areas 400, 401 via respective check valves 500, and no bore 700 is needed within either of half moon members 124, 134.

FIG. 10 shows a separate, fourth embodiment of the mule shoe assembly 100 of the present invention which eliminates the borehole(s) 501 and ball-style check valve(s) 500, and instead utilizes, in the embodiment shown, an annular “flapper” style seal member 308 which effects a seal between distal end 161 of directional tool member 160 and mule shoe member 120 at one end 121 of mule shoe assembly 100. An externally-threaded nut 311 may be used to retain seal member 308 within outer mule shoe member 120, as shown in FIG. 10.

Advantageously, flapper style seal member 308 is of a resiliently flexible material such as synthetic rubber, and allows egress of fluid from interstitial areas 400, 401 during insertion of directional tool member 160 within mule shoe member 120, but which prevents ingress of fluid, including and in particular drilling fluid containing abrasive drill tailings or sand, into interstitial landed area 400, 401. A small borehole 603 may optionally be provided in half-moon member 124, to allow fluid communication between landed areas 400 and 401, respectively, to better allow egress of all fluid such as air which will be forcibly voided upon insertion of directional tool 160 within outer mule shoe 120.

In the embodiment shown in FIG. 10 seal member 308 in combination with seals 300 at mutually opposite end 121 of outer mule shoe 120, allow hydrostatic forces exerted on the mule shoe assembly 100 when downhole to maintain directional tool member 160 in landed engagement within mule shoe assembly 100.

The above describes preferred embodiments of the invention. Other variations will now be apparent to those of skill in the art. In view of the foregoing the scope of the claims should not be limited by the preferred embodiments set forth in the foregoing examples. Instead, the claims should be given the broadest interpretation consistent with the description as a whole, and are not to be limited to the preferred or exemplified embodiments of the invention.

1. A mule shoe assembly for use in directional drilling of wells, which mule shoe assembly is adapted to lockingly secure a directional measurement tool therein and further resists ingress into an interior of said mule shoe assembly of abrasive substances such as drilling fluids, comprising:
(i) an outer mule shoe member, having:
(a) a longitudinal bore, a portion of which is cylindrical;
(b) a half member located within said cylindrical portion of said longitudinal bore, fixedly secured to a circumferential portion of said longitudinal bore about at least a portion of a circumference thereof;
(ii) a cylindrical housing for containing a direction-indicating tool, said housing adapted for insertion in said longitudinal bore of said outer mule shoe member, comprising:
(a) a half member situated on an circumferential portion of an outer surface of said housing, extending longitudinally along said portion of said outer surface and protruding radially outwardly about said portion of said outer surface of said housing, adapted to matingly engage said half member located within said mule shoe member so that, when matingly engaged, angular rotation of the housing within the mule shoe member is prevented; and
(iii) a pair of circumferential seals, respectively situated proximate mutually opposite ends of said mule shoe member and said housing when said housing is inserted in said longitudinal bore, adapted to reduce ingress of drilling fines and fluids containing drilling fines into an interstitial area bounded by said pair of circumferential seals.

2. A mule shoe assembly as claimed in claim 1, wherein each of said half members comprise half-moon members.

3. A mule shoe assembly as claimed in claim 1 or 2, further comprising:
a check valve situated in said outer mule shoe member, adapted to allow egress of fluid from within said mule shoe member upon insertion of said housing in said longitudinal bore, and configured to prevent ingress of fluid into said longitudinal bore.

4. A mule shoe assembly as claimed in claim 1, wherein said circumferential seals comprise a pair of ‘o’ ring seals, and said half members respectively each comprise half-moon members.

5. A mule shoe assembly as claimed in claim 4, wherein said check valve is a ball-type check valve situated in said outer mule shoe between said pair of ‘o’ ring seals, having a ball resiliently biased over an aperture in said outer mule shoe member which said aperture extends therethrough to said longitudinal bore.

6. A mule shoe assembly as claimed in claim 5, wherein said check valve is positioned directly above said aperture, and said aperture in said outer mule shoe member further extends through said half-moon member situated therein into said longitudinal bore.

7. A mule shoe assembly as claimed in claim 1, further comprising a pair of check valves situated in said outer mule shoe member intermediate said pair of ‘o’ ring seals, adapted to allow egress of fluid from within said mule shoe member upon insertion of said housing in said longitudinal bore, and configured to prevent ingress of fluid into said longitudinal bore.

8. A mule shoe assembly as claimed in claim 1, wherein said at least one of said circumferential seals comprises a “flapper” type seal adapted to allow egress of fluid from within said mule shoe member upon insertion of said housing in said longitudinal bore, and to prevent ingress of fluid into said longitudinal bore.

9. A mule shoe assembly as claimed in claim 8, wherein said at least one “flapper” type seal is located in said mule shoe assembly at an end thereof most closely proximate an extremity of said housing when said housing is inserted within said longitudinal bore.