Dec. 18, 1962 T. M. FRISBY ETAL 3,068,946

KNUCKLE JOINT

Filed Dec. 15, 1958

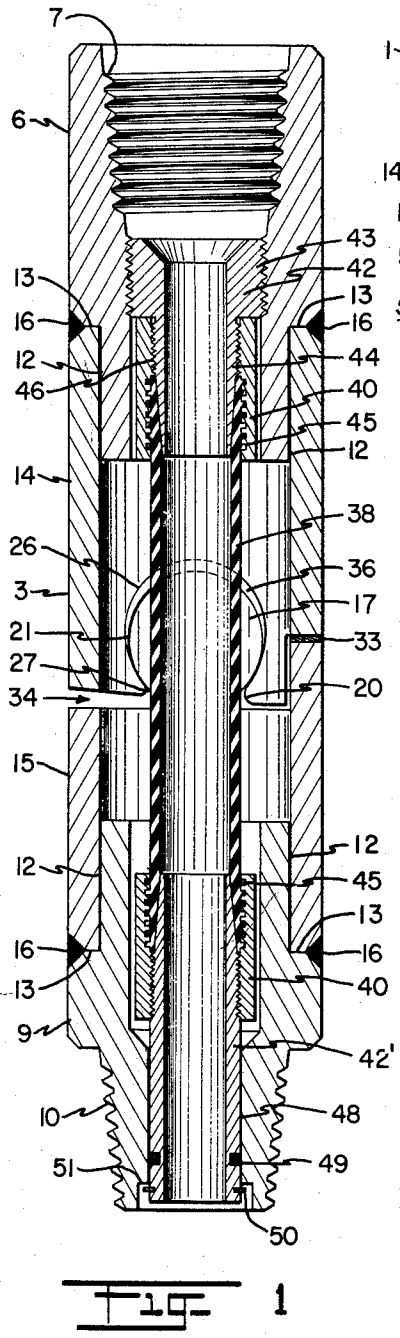

Fig. 1

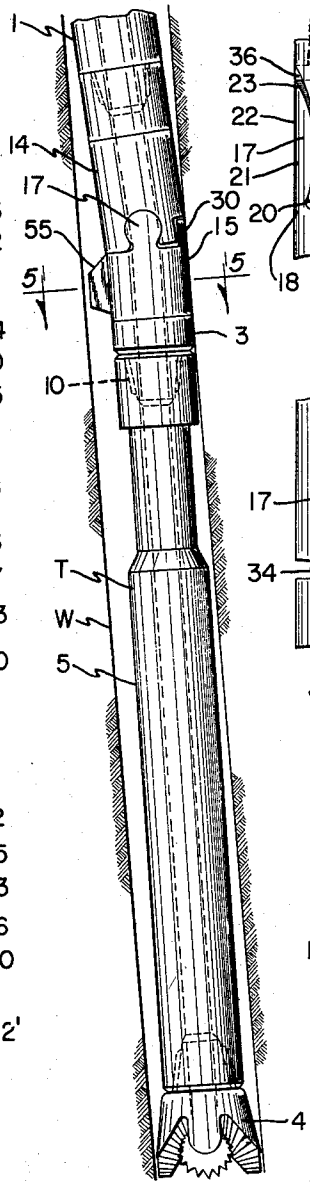

Fig. 4

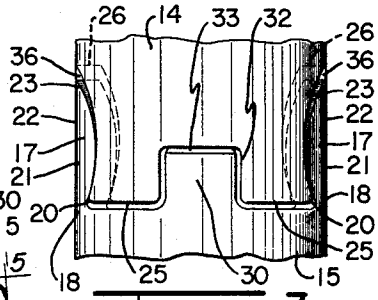

Fig. 3

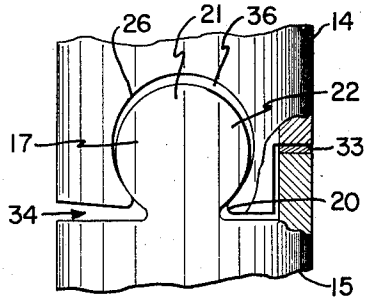

Fig. 2

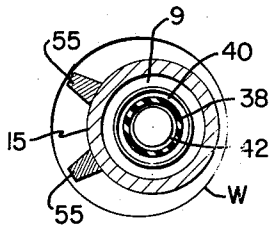

Fig. 5

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KNUCKLE JOINT

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This invention relates to a novel and improved deflecting tool, and more particularly is related to a deflecting tool of the type, commonly termed a knuckle joint, which is adapted for connection near the lower end of a drill string to selectively deflect the lowermost elements such as a turbine drilling unit and associated bit employed in directional drilling.

In the well drilling art, deflecting tools are customarily employed to cause predetermined angular displacement of the lower drilling elements on the drill string at some intermediate stage in the drilling operations. This operation is usually performed to make some predetermined change in angle of the direction of drilling and in carrying out the operation such is desirably accomplished by removing the drill string from the well base and interposing a deflecting tool just above the lower drilling elements. Thereafter the string is returned through the well and when the drill bit strikes the bottom the weight or the compressive force exerted upon the deflecting tool is utilized to cause it to be laterally displaced in the well bore and in turn to cause a predetermined change in the angle of the drill bit with respect to the upper drill string section.

In directional drilling operations employing a turbine unit as the motive force many problems are encountered. For example, to initiate lateral displacement of the deflecting tool it has been customary to employ a bent tool or sub and the like above the turbine and especially in soft formations the tool has a tendency to bind in the formation. This is also the case with respect to the use of some wedges or stabilizing members which are often employed to initiate bending of the tool at the time the drill bit strikes the bottom of the well bore. Another problem which arises with the use of deflecting tools in conjunction with turbine units is that of providing the necessary uninterrupted fluid passage through the tool to conduct the high pressure fluid used to drive the turbine unit. With the use of presently known deflecting tools, providing the necessary bore diameter especially after deflection of the tool is very difficult since very often at the point of bending the joint formed either traverses the fluid passage to partially obstruct it, or the separable elements forming the conduit at the point of bending tend to decrease the diameter of the passage upon bending. The latter problem is especially acute in turbine drilling units wherein the efficiency of the turbine largely depends upon the capacity of the fluid entering the unit and it is important that the fluid flow is not constricted so as to reduce its capacity.

Accordingly it is a principal object of the present invention to provide for an improved deflecting tool which is so constructed and arranged as to insure the reliable and accurate displacement of the lower drilling elements on a drill string for directional drilling purposes.

It is another object to provide for an improved deflecting tool adaptable to establish uni-directional predetermined angular deviation of the drill bit away from the drill string without reducing the flow of fluid therethrough.

It is a further object to provide in a well drilling apparatus a compact deflecting tool in the form of a knuckle joint for disposition in a drill string and adaptable to be lowered through a well bore without danger of sticking to the side walls of the well bore and to cause predetermined angle displacement of the lower elements on the drill string without altering or in any way obstructing the flow of fluid therethrough.

It is a still further object to provide in a turbine drilling unit deflecting means interposed in the drill string and so constructed and arranged as to provide for supporting the lower drilling elements in suspended coaxial relation with the drill string as they are lowered through the well bore and to cause predetermined angular displacement of the lower drilling elements without the use of auxiliary lateral deflecting means and in such a way as not to constrict the delivery of fluid therethrough notwithstanding the angular deviation of the deflecting tool.

The construction designed to carry out the invention will be hereinafter described in more detail together with other features and will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, in which:

FIGURE 1 is a vertical section view of the deflection tool in accordance with the present invention;

FIGURE 2 is a detailed side view partially in section of a knuckle joint in accordance with the present invention;

FIGURE 3 is a rear detailed view of the knuckle joint of the present invention;

FIGURE 4 is an elevational view illustrating the deflecting tool of the present invention set in operative position within an angular well bore; and

FIGURE 5 is a view taken along the lines 5—5 of FIGURE 4.

Referring more particularly to the drawing, there is shown by way of illustrative example in FIGURES 1 and 4 a drill string 1 adaptable for extension through a well bore W wherein the lower elements on the drill string include in succession a deflecting tool 3 for interconnection of the drill string to a turbine drilling unit T and a drill bit 4. In conventional drilling operations drilling is accomplished without the use of the deflecting tool 3 and the turbine unit T is connected directly into the drill string 1. Although, of course, the deflecting tool of the present invention is adaptable for use in various directional drilling operations or in conjunction with turbo drilling, the preferred form of invention is particularly adaptable for use in turbo drilling and in this connection various types of turbine constructions may be utilized. The turbine unit T as illustrated includes a common outer shell 5 enclosing therein a turbine section and a lower bearing section which is connected to the drill bit 4. For a more complete description of general types of turbines that may be employed reference is made to United States Patents Nos. 2,588,311, 2,613,917 and 2,340,738 and to the October, 1956, issue page 40 of the magazine "Petroleum Engineer." Understanding of the operation of a turbine drilling unit is only necessary in connection with the present invention, to note (1) the desirability of providing the necessary fluid capacity for most efficient operation of the turbine section, and (2) that the drill pipe does not rotate, but only the inner turbine shaft or rotor. As mentioned, this may become especially acute in directional drilling operations where the fluid conducting member must be angularly deflected tending to cause some constriction of the passage so as to reduce the flow capacity. As will be described hereafter in more detail, the deflecting tool construction of the present invention obviates this difficulty in a unique way and for this reason is especially desirable for use in turbo drilling operations.

In directional drilling operations the initial straight drilling is generally carried out in the absence of the deflecting tool until some intermediate point in the drilling operations is reached where it is desired to angularly

displace the drill bit and to proceed with the drilling operation at an angle away from the normal angle of drilling. At this point therefore the drill string together with the turbine drilling unit and drill bit may be removed from the well bore and the deflecting tool 3 interposed preferably between the turbine drilling unit T and the lower end of the drill string 1. The string and associated elements may then be returned through the well and at this point it will be noted that the deflecting tool as shown in FIGURE 1 is suspended in coaxial relation with the rest of the elements and does not include any lateral projection thereon. In addition, the deflecting tool must of course be of sturdy construction to support the lower elements and at the same time permit unrestricted flow of fluid therethrough upon angle displacement of the deflecting tool. For this purpose the deflecting tool 3 is broadly comprised of an upper heavy-walled coupling or tool joint 6 providing a threaded socket 7 for interconnection to the lower end of the drill string 1. At the lower end of the tool a sub or coupling 9 includes a thread pin 10 for connection into the turbine drilling unit T and in this respect it will be apparent that the couplings 6 and 9 may be formed of any conventional construction for interposition at the desired point along the drill string. In turn, the couplings are reduced in diameter at their inner ends as at 12 for accommodating a pair of heavy-walled tubular bodies including an upper tubular section 14 inserted over the inner end of the coupling 6 into abutting relation with a ledge 13 and a lower tubular section 15 inserted over the inner end of the lower coupling 9 into abutting relation with a similar ledge 13. As will be noted, the exterior surfaces of the tubular sections 14 and 15 together with the couplings are so dimensioned as to form a continuous outer cylindrical surface and at the point of contact with the ledges V-shaped circular grooves 16 are formed for the application of weld so as to form a smooth joint.

To establish angular displacement of the lower drilling elements including the turbine drilling unit T and drill bit 4, the adjacent contacting ends of the tubular sections 14 and 15 are provided with interlocking means in the form of a knuckle joint so formed together with the adjacent ends so as to permit the upward and lateral movement of the lower drilling elements with respect to the upper drill string upon the application of weight or compressive force acting to force the ends toward one another. This is accomplished in a novel and unique way by means of upwardly divergent lobes 17 projecting upwardly from lower the adjacent end 18 and including a contracted neck 20 and enlarged head portion 21. As shown in more detail in FIGURES 2 and 3, each head portion 21 is provided with an arcuate outer surface 22 conforming to the contour of the outer wall of the lower tubular section and a generally circular peripheral surface 23. In turn, the adjacent end 25 of the upper tubular section 14 is provided with correspondingly shaped lobe receiving recesses 26 which are similarly formed in diametrically opposed relation in the outer wall adjacent to the upper end section 25 and each of the recesses 26 converges at the lower end into a contracted groove 27 formed to closely engage the head 21 at the point of divergence from the neck 20. Each of the recesses 26 is made generally circular to conform generally to the shape of the peripheral surfaces 23 of the heads 21. It should be mentioned at this point that in presently constructing the knuckle joint of this invention, initially sections 14 and 15 are one tubular piece and the spacing provided between the ends, including that described and that mentioned hereinafter, to provide the two sections is formed by cutting the spaces by means of a torch or the like. As will be apparent, the lobes are held in interlocking relation by the convergent sides 27 and in effect this interlocking arrangement results in the lower section 15 being positioned as shown in FIGURE 1 when suspended in the hole.

In order to permit upward and lateral displacement of the lower drilling elements in relation to the upper drill string portion, the lower adjacent end 18 includes a tongue or key 30 protruding upwardly from the end surface at a location intermediately between the lobes 17, or at 90 degrees with respect to the lobes. An enlarged groove 32 is in turn provided in the upper end section 25 at a corresponding location and in order to establish contact between the upper edge of the key 30 and keyway slot 32 when the deflecting tool is suspended in coaxial relation with respect to the drill string, a hardened metal tip 33 is built up on the top surface of the key 30. In a manner to be described later and in more detail, this hardened portion 33 will act as a fulcrum to force angular displacement of the drilling elements. From the base of the keyway slot 32 the upper end section 25 is inclined upwardly at a predetermined angle with respect to the longitudinal axis of the tubular section 14 to form a clearance space or relieved portion 34. Similarly, the lobe receiving recesses 26 are slightly enlarged to provide a somewhat angular clearance 36 above the heads 21 so that the heads may be displaced upwardly from the interlocking position to a position abutting the upper surface of the recess 26. In addition the forward convergent sides of the grooves 27 are spaced from the forward edge of the contracted neck portions 20 a distance sufficient to allow inward angular movement of the lower adjacent end as the deflecting tool is being tilted. In forming a progressively increased clearance between the adjacent ends from the rear fulcrum side to the front it is thereby necessary only to apply an axial compressive force or weight against the ends to force the lower adjacent end section 18 upwardly and laterally into uniform end abutting engagement with the upper end section 25 and with the hardened metal surface 33 acting as a fulcrum for this lateral displacement. Moreover, it will be noted that the lobes 17 will follow the movement of the lower end sections to move into snug fitting engagement with the recessed surfaces and thus evenly distribute the stresses imposed on the deflecting tool during subsequent directional drilling operations.

An additional feature of the present invention is the manner in which the lobes 17 are formed so as to permit utilization of the entire interior bore of the tubular sections as a fluid passage. In the preferred form the fluid passage of the present invention is constituted of a flexible reinforced hose 38 supported within each inner end of the couplings 6 and 9 by means of similarly formed hose couplings 40. The upper hose coupling 40 is attached within the tool joint 6 by means of a nipple 42 which includes a hollow plug 43 for threaded engagement with the interior bore of the tool joint and a downwardly extending fitting 44 which is formed to be inserted into the end of the hose after ribbed collar 45 has been assembled upon the exterior of the hose. The nipple is further shown formed with right hand screw threading 46 on its exterior surface which upon screwing of the nipple endwise through the collar 45 causes the hose end portion to become tightly grasped by the ribbed portion of the collar.

Although the upper hose coupling 40 rigidly connects the hose to the tool joint 6, the lower coupling 40 is disposed within the sub 9 so as to be slidable within the sub and in this way permit upward displacement of the hose when the tool is bent and without imposing tension on the hose. To this end, the coupling is identical to the upper coupling except that the nipple 42' is not exteriorly threaded, but is instead smooth and extends downwardly in the form of a sleeve 48 along the hollow interior of the pin for slidable movement therealong. An O-ring 49 is provided on the sleeve 48, together with a snap ring 50 secured to the lower end of the sleeve to engage shoulder 51 of the pin and in this way prevent accidental collapse of the hose due to any back pressure developed by the high pressure fluid.

Assuming that the straight bore drilling operation has

been completed and that the drill string together with the attached deflecting tool **3** and lower drilling elements have been lowered to the bottom of the well, it is of course necessary to arrange the tool **3** for displacement in the desired direction. In accordance with conventional practice a survey instrument, not shown, may be lowered into the well to determine the radial position or azimuth of the deflecting element with respect to the well bore by known methods of bottom hole orientation as, for example, that shown in the patent to Miller No. 2,327,658 and Hyer No. 2,120,670.

In the present invention the hardened metal portion **33** may form a magnet which is in a known relationship to the deflecting tool when the same is locked against rotation on the drill string. The survey instrument is then operated and its record subsequently examined so that the compass position of the deflecting element may be readily determined after the tool has been lowered into position within the well bore. From this reading the deflecting tool may be rotated so that the lower drilling elements will become tilted in the proper direction for subsequent directional drilling operations. At this point, since the drill bit is resting at the bottom of the well, the weight of the drill string when allowed to relax will cause the lobes **21** together with the lower end **18** to move upwardly and angularly into abutting relation with the recesses **26** and upper end section **25** respectively. Of course, the extent of angular displacement of the lower drill elements with respect to the drill string may be controlled by the width or angle of relief **34** formed between the adjacent ends. During subsequent drilling the deflecting tool will of course be maintained in this angular position due to the weight of the drill string as the drill bit **4** is forced through the formation.

In a modified form as shown in FIGURES 4 and 5, the deflecting tool is conformable for use in angular hole drilling as distinguished from vertical hole drilling by the addition of centering elements **55** projecting laterally from the forward surface of the lower tubular section **15**. As shown in FIGURE 5, the lateral projections **55** may be in the form of blades which are spaced apart a sufficient angular distance to stabilize the drill string and which extend laterally from the surface of the deflecting tool a sufficient distance to hold the tool slightly off center, since otherwise the adjacent end portions **18** and **25** may tend to bend inwardly and resist proper camming or swiveling action at the joint when the weight of the drill string is applied at the joint. In this connection it will be noted that it is not necessary to extend the blades outwardly for a distance much greater than the lateral extent of the drill bit since it is only necessary to prevent undue bending of the tubular sections toward the side of the well bore and thus there is very little danger of becoming stuck in the formation.

The foregoing disclosure and description of the present invention is illustrative and explanatory thereof and various changes in the relative size, shape and materials as well as in the details of the illustrated construction may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. In a knuckle joint having upper and lower generally tubular sections arranged in end to end fluid conducting relation for suspension in a well bore, the combination of a plurality of enlarged heads diverging upwardly in spaced circumferential relation about the periphery of one adjacent end and a corresponding number of complementary recesses disposed in the other adjacent end for loosely receiving said heads, said adjacent ends, heads and recesses being angularly relieved to provide progressively increased lateral clearance space between said sections for upward and uni-directional lateral movement of said lower section with respect to said upper section upon the application of an axial compressive force to said sections.

2. A knuckle joint adapted for suspension in a well bore including upper and lower substantially tubular members disposed in end to end relation, a pair of substantially diametrically opposed lobes protruding from one adjacent end of said tubular members each including an enlarged head and contracted neck portion, a pair of corresponding lobe receiving recesses provided near the other adjacent end, said recesses being dimensioned for interlocking engagement with said lobes when said tubular members are suspended in coaxial relation in the well, a fulcrum formed on one side of said adjacent ends substantially intermediately between said lobes, said adjacent ends together with said lobes and said recesses being angularly relieved to define a clearance space between said adjacent ends diverging away from said fulcrum to provide for uni-directional angular displacement of said lower tubular member with respect to said upper tubular member upon the application of an axial compressive force thereto.

3. A knuckle joint adapted for angular displacement of the lower elements in a drill string including upper and lower substantially tubular members disposed in end to end relation, a pair of substantially diametrically opposed lobes protruding from one adjacent end of said tubular members, a pair of corresponding lobe receiving recesses provided in the wall of the other adjacent end for interlocking engagement with said lobes when said tubular members are suspended in coaxial relation in the well and with said recesses being enlarged with respect to said lobes defining an angular clearance therebetween diverging away from one side of the adjacent ends when said tubular members are suspended in coaxial relation to provide for angular displacement of said lower tubular member with respect to said upper tubular member upon the application of an axial compressive force thereto.

4. A knuckle joint adapted for interconnection in a drill string near the lower end thereof including upper and lower tubular members disposed in end to end relation, a flexible hose mounted for sealed adjustable extension through said tubular members, a pair of diametrically opposed lobes extending upwardly from the lower adjacent end each including a neck and an upwardly divergent head, a pair of lobe receiving recesses provided in the outer wall of said upper tubular member near the other adjacent end, said recesses being enlarged with respect to said heads and dimensioned for interlocking engagement with said lobes when said tubular members are suspended in coaxial relation in the well, a fulcrum formed on the periphery of the adjacent ends intermediately between said lobes, the adjacent ends being angularly relieved to define a clearance space therebetween diverging away from said fulcrum to provide for predetermined angular displacement of said lower tubular members with respect to said upper tubular member upon the application of an axial compressive force thereto and with said recesses being relieved with respect to said heads in such a way as to uniformly contact said lobes upon angular displacement of said lower tubular member into end abutting relation with said upper tubular member.

5. In a turbo drilling unit including a drill string section for suspension of a turbine section and drill bit in a well bore, the combination of a deflecting tool interposed between said drill string and said turbine including upper and lower tubular couplings, a flexible hose extending in sealed adjustable relation between said couplings, a pair of upper and lower tubular members connected in flush relation to the inner ends of said respective couplings, a pair of diametrically opposed lobes extending upwardly from the edge of the adjacent end of said lower tubular member, each lobe having a contracted neck portion and enlarged head diverging upwardly from said neck, a pair of lobe receiving recesses provided in the outer wall of said upper tubular member and converging downwardly into the adjacent end thereof, each recess conforming to the contour of said heads and being

enlarged in relation thereto, said recesses being dimensioned for interlocking engagement with said lobes when said tubular members are suspended in coaxial relation in the well bore, a key extending upwardly from the wall of the lower adjacent end intermediately between said lobes having a hardened metallic tip, the upper adjacent end including a keyway slot with the upper edge of said slot disposed to engage said tip when said tubular members are suspended in coaxial relation in the well, the upper adjacent end inclining upwardly in a direction away from said slot to provide for predetermined upward and angular displacement of said lower tubular member upon the application of an upwardly directed force thereto, and with said recesses being enlarged with respect to said heads an extent sufficient to uniformly contact the end surfaces of said heads when the adjacent ends are moved into end abutting relation.

6. In a turbo drilling unit including a drill string section for suspension of a turbine section and drill bit in a well bore, the combination of a deflecting tool interposed between said drill string and said turbine including upper and lower tubular couplings, a flexible hose including an upper end attached to the interior of said upper coupling and a lower end extending in sealed slidable relation through said lower coupling, a pair of upper and lower tubular members connected in flush relation to the inner ends of said respective couplings, a pair of diametrically opposed lobes extending upwardly from the edge of the adjacent end of said lower tubular member each lobe having a contracted neck portion and enlarged circular head diverging upwardly from said neck including an arcuate outer surface conforming to the shape of the outer wall of said lower tubular member, a pair of correspondingly shaped lobe receiving recesses provided in the outer wall of said upper tubular member and converging downwardly into the adjacent end thereof, each recess conforming to the contour of said heads and being enlarged in relation thereto, said recesses being dimensioned for interlocking engagement with said lobes when said tubular members are suspended in coaxial relation in the well, a key extending upwardly from the lower adjacent end intermediately between said lobes having a hardened metallic tip, the upper adjacent end including a keyway slot with the upper edge of said slot disposed to engage said tip when said tubular members are suspended in coaxial relation in the well, the upper adjacent end inclining upwardly in a direction away from said slot to provide for predetermined upward and angular displacement of said lower tubular member upon the application of an inwardly directed axial force thereto.

7. In a deflecting tool, a knuckle joint interconnecting upper and lower sections of a drill string arranged in end-to-end relation for suspension in a well bore, said knuckle joint comprising interlocking members disposed between the adjacent ends of said sections, the adjacent ends including said interlocking members being formed with a fulcrum adjacent the periphery thereof and with a progressively increased lateral clearance space therebetween extending from said fulcrum toward the area of said ends opposite the fulcrum when said sections are disposed in normal suspended relation to provide for lateral deflection of the lower section relative to the upper section of the drill string in a predetermined direction upon application of an axial compressive force thereto.

8. In a deflecting tool according to claim 7, wherein said fulcrum is disposed on the periphery of the adjacent ends of said sections intermediately between two of said interlocking members.

9. In a deflecting tool according to claim 7 wherein a flexible hose member is secured in fluid-conducting relation between said upper and lower sections for extension in inner concentric relation through said knuckle joint.

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