June 7, 1955

M. O. JOHNSTON ET AL

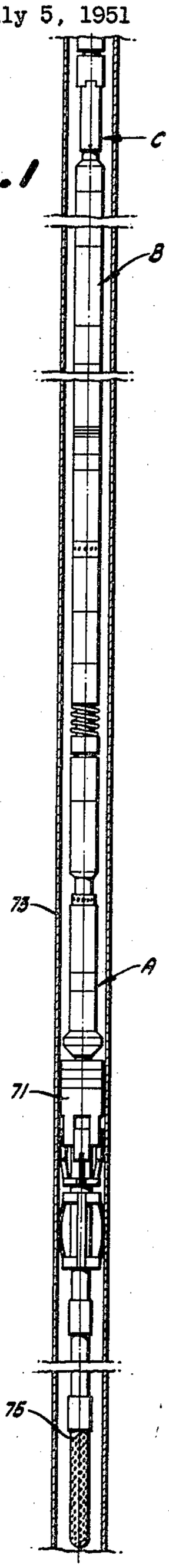
2,710,066

REVERSE CIRCULATING VALVE

Filed July 5, 1951

2 Sheets-Sheet 1

FIG. 1



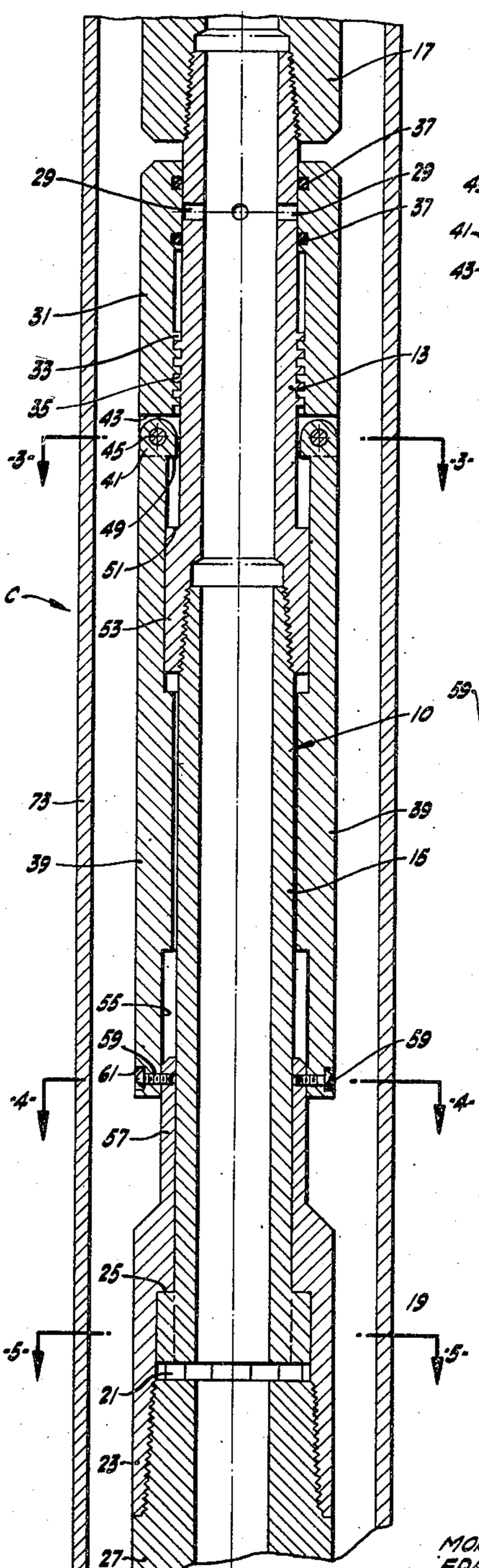


FIG. 2

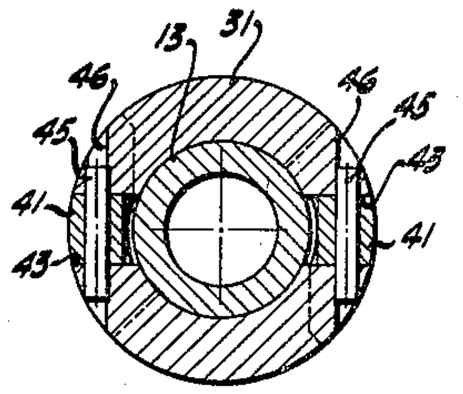


FIG. 3

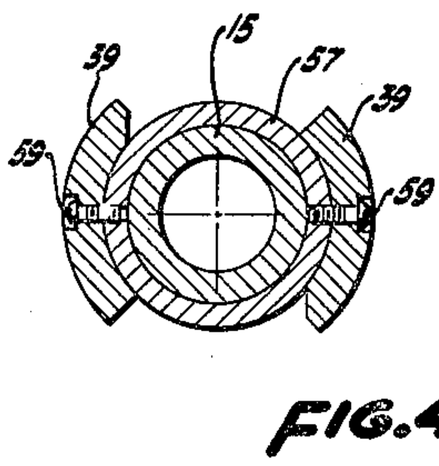


FIG. 4

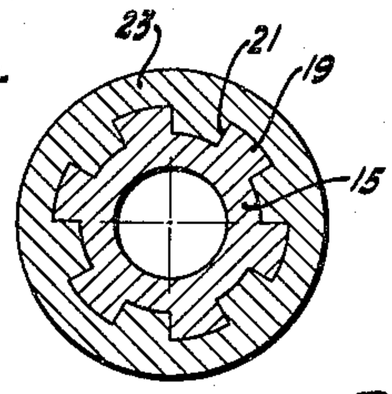


FIG. 5

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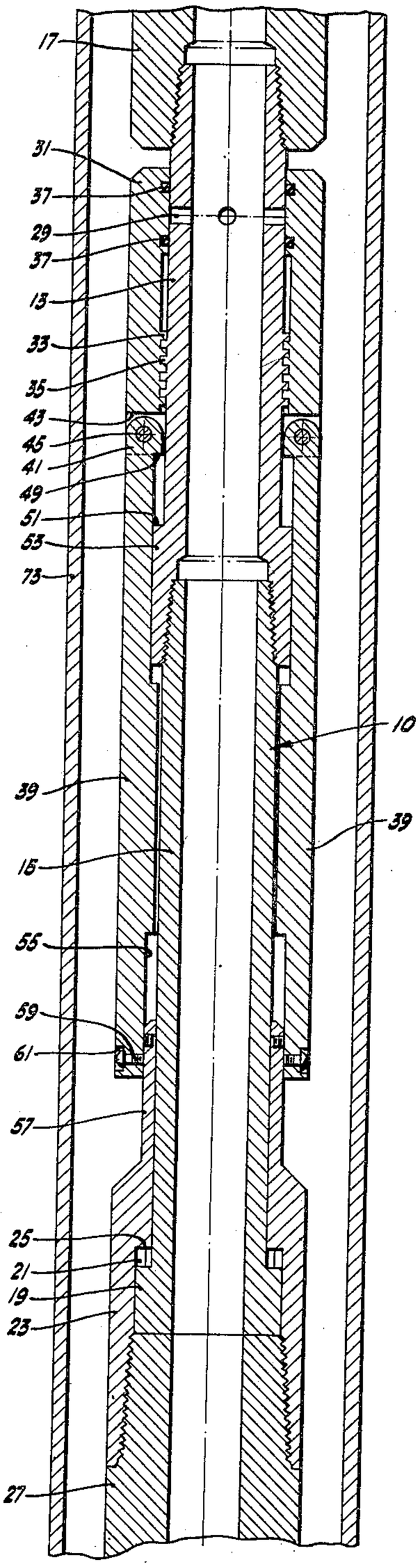

FIG. 6

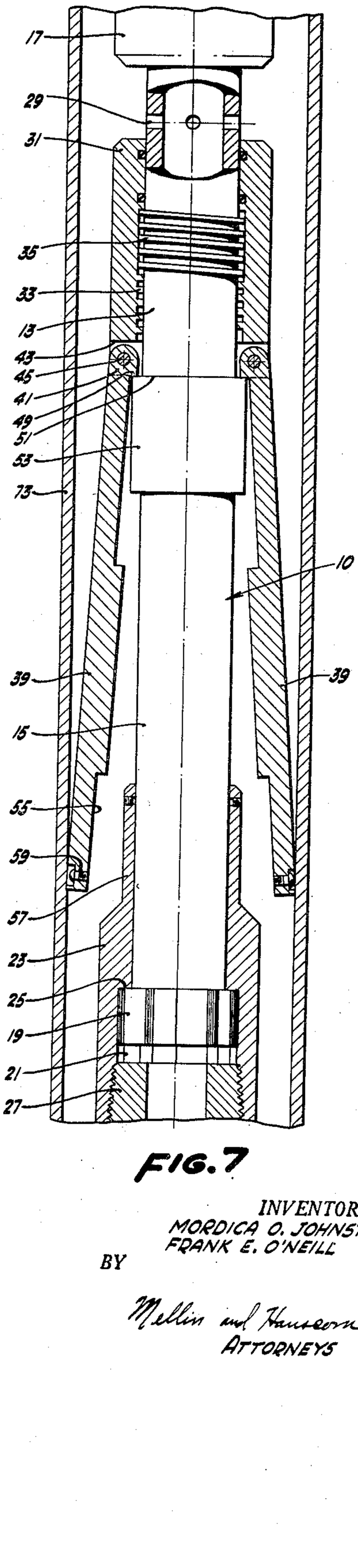

FIG. 7

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REVERSE CIRCULATING VALVE

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Application July 5, 1951, Serial No. 235,336

10 Claims. (Cl. 166—226)

This invention relates to an oil well tool, particularly to a reverse circulating or back scuttling valve.

In oil well production practice, it is necessary at various times to circulate drilling mud or other fluid down the annular space between a drill string and a casing or well bore, through a valve in the drill string and up through the drill string. Sometimes this reverse circulation is performed to back scuttle gas and oil under control from the drill string, for instance, to eliminate a fire hazard. Also, sometimes during the pulling of a drill string, it is necessary to reverse circulate to maintain control over the well, which may get somewhat out of control for various reasons, for instance, because the hydrostatic head in the well drops due to the removal of the drill string from the region of the well fluid, allowing high pressure areas previously controlled by the hydrostatic head to get somewhat out of control.

There have been previous back scuttling valves but, in general, these have been operable only when the string was bottomed or set in the well by means of a packer or slips or the like, these valves being operable by relative movement, rotation or longitudinal, between the lower part of the drill string, which is fixed in the well and carries one part of the valve, and the upper free part of the drill string which carries the other part of the valve.

When the necessity for back scuttling or reverse circulating arises, the back scuttling valve must be opened quickly to enable immediate control over the well to avoid damage and waste. In many instances, there is not time nor is it practical or in some cases possible to reset a packer or again bottom the drill string to enable opening of a back scuttling or reverse circulating valve.

It is a main object of the present invention to provide a reverse circulating valve adapted to be connected between sections of drill string, which valve can be opened when the drill string is off bottom and without setting a packer or equivalent device.

Various other objects of the present invention will be apparent from the following description taken in connection with the accompanying drawings, wherein:

Fig. 1 shows a reverse circulating valve embodying the concepts of the present invention being incorporated in a drill string having a connate sample tester on the lower end thereof.

Fig. 2 is a vertical section through the reverse circulating valve showing the reverse circulating valve in closed position.

Fig. 3 is a horizontal section taken along line 3—3 of Fig. 2 showing the manner of pivotally mounting the outwardly swinging arms of the reverse circulating valve.

Fig. 4 is a horizontal section taken along line 4—4 of Fig. 2 showing the shear pin connections between the sleeve and the outwardly swinging arms.

Fig. 5 is a horizontal section taken along line 5—5 of Fig. 2, showing the splined connection between the lower mandrel and the releasing sleeve.

Fig. 6 is a view similar to Fig. 2 but showing the shear pins or bolts as being sheared.

Fig. 7 is a view similar to Fig. 6 showing the outwardly swinging arms in engagement with the well casing and depicting the parts in a position where the nut is threaded down to uncover the valve ports.

The invention will be described with reference to a drill string having a reverse circulating valve embodying the concepts of the present invention incorporated therein and located above a connate sample tester which is connected to the lower end of the drill string below the reverse circulating valve, but this description is not intended to limit the invention but merely to illustrate a practical application of the invention. Furthermore, the reverse circulating valve of the present invention can be connected above or below a sample tester or at any point along a drill string.

Referring to the accompanying drawings, wherein similar reference characters designate similar parts throughout, the drill string disclosed in Fig. 1 includes a connate sample tester generally entitled A, having a trip valve assembly B, said parts being disposed below a reverse circulating valve assembly C, which is in turn connected to the upper portion of the drill string (not shown).

The reverse circulating valve includes a composite tubular valve member 10 composed of an upper tubular mandrel 13 and a lower tubular mandrel 15 threadedly connected together. Upper tubular mandrel 13, at its upper end, is threadedly connected to a sub 17 which is in turn connected to the upper portion of the drill string (not shown). The lower tubular mandrel 15, at its lower end, is provided with a male splined formation 19 engaging a female splined formation 21 formed on the interior of a releasing sleeve 23 which is telescopically receivable over the lower tubular mandrel 15, as is apparent from Fig. 2, and is provided with a shoulder at 25 to limit downward movement of releasing sleeve 23 relative to the male splined formation 19 on lower mandrel 15. A lower sub 27 is threadedly connected to the releasing sleeve 23. The upper end of sub 27 forms an abutment spaced from shoulder 25 a sufficient distance to allow limited upward movement of releasing sleeve 23 and sub 27 relative to lower tubular mandrel 15 before engagement of sub 27 with male splined formation 19 for purposes to be described.

By reason of the splined connection between the releasing sleeve 23 and the lower tubular mandrel 15, the rotary driving connection between the upper portion of the drill string and the portion of the drill string below the reverse circulating valve is not impaired.

Upper tubular mandrel 13 is provided at its upper end with ports 29 which serve to communicate the exterior of the composite tubular valve member 10 with the interior thereof. Ports 29 are covered by the upper portion of a nut 31 which slides on upper tubular mandrel 13, said nut having threads at 33 threadedly engaging external threads 35 provided on upper tubular mandrel 13. The interior of nut 31 at the upper end thereof is provided with annular grooves to receive O rings 37 which seal against the exterior of tubular mandrel 13 to prevent leakage of fluid into or out of the ports 29 between the nut 31 and the upper tubular mandrel 13.

Nut 31 is adapted to be held against rotation with respect to the drill string and upper tubular mandrel 13 by outwardly swinging arms 39 which are arcuate in cross section, as shown in Fig. 4, to conform to exteriors of both lower tubular mandrel 15 and upper tubular mandrel 13, as shown in Fig. 4. At their upper ends, arms 39 have upwardly extending portions 41 receivable within slots 43 formed in the lower end of nut 31, and pivotally mounted on the nut by means of pivot pins 45 receivable through bores 46 (see Fig. 3)

extending transversely of the notches 43 in the lower end of nut 31.

The upwardly extending narrow portions 41 are formed with shoulders at 49 adapted to engage shoulders 51 provided by an enlargement 53, formed on the lower end of upper tubular mandrel 13, to limit downward movement of nut 31 relative to the upper tubular mandrel 13, as clearly shown in Fig. 7, where the shoulders 49 and 51 are in abutting engagement. When shoulders 48 and 51 are in abutting engagement, the nut has moved down sufficiently to fully uncover ports 29 to allow for fluid circulation between the exterior and interior of the upper tubular mandrel 13.

The lower ends of arms 39 are recessed at 55 to accommodate an upper reduced portion 57 of releasing sleeve 23, as shown in Fig. 2. Releasing sleeve 23 and arms 39 are releasably connected together by shear pins 59 which preferably take the form of threaded bolts countersunk at 61 in arms 39 and threadedly received by upper reduced portion 57 of releasing sleeve 23.

One practical application of the reverse circulating valve C is disclosed in Fig. 1, where it is incorporated in a drill string at a point preferably 100 or 200 feet above the connate sample tester A, which may be of any suitable type.

This type of tester includes a packer assembly at 71 for setting the tester in a well casing 73 or in the formation to separate the space below the packer in which the connate fluid is located from the space above the packer to avoid as much as possible contamination of the sample to be taken, with drilling mud, fluid and other material above the packer. The tester includes a perforated anchor at 75 through which the connate fluid passes into the tester. There are various valves within the tester, not necessary here to describe, for shutting in and retaining the sample after the sample flows upwardly into the tester and drill string. The trip valve assembly B is adapted to be tripped by a go-devil dropped through the drill string from the surface to permit connate fluid to flow upwardly past the trip valve and into the drill string.

As mentioned before, the reverse circulating valve of the present invention can be located above or below the tester or other apparatus since the operation of the reverse circulating valve is for all practical purposes independent of the functioning and operation of the other mechanisms and apparatus connected in the drill string. The location above the tester, therefore, is only for purposes of illustrating a single practical application of the reverse circulating valve of the present invention.

In operation, a string as disclosed in Fig. 1 is lowered in a well, the packer 71 set. After the packer 71 is set, a subsequent downward movement of the upper portion of the drill string will operate to shear the shear pins or bolts 59 (see Fig. 6), because arms 39, being carried by the upper portion of the drill string, move downwardly relative to releasing sleeve 23 and sub 27 which are supported by the packer 71.

Upon the shearing of shear pins or bolts at 59, there is a resulting releasing or freeing of the outwardly swinging arms 39.

The various valves within the tester open to permit connate fluid to flow upwardly to the trip valve assembly B. A trip valve go-devil is then dropped down the drill string and strikes the trip valve assembly B, tripping the valve and allowing the connate fluid to flow upwardly into the drill string. The connate fluid may, and usually does, flow upwardly past the back circulating valve to a point where a state of equilibrium exists between the hydrostatic head of the fluid within the drill string and the pressure of the fluid in the formation.

After the sample is trapped, the drill spring may be removed and the sample recovered. However, connate fluid flowing into the tester may contain a high percentage of gas of a very volatile nature, and also the fluid may be under fairly high pressure, therefore, creating a fire hazard at the surface unless the connate fluid or other similar fluid is brought to the surface under control. If the conditions creating a fire hazard are realized before the packer is collapsed, a reverse circulating valve in the tester itself can be operated to communicate the annular space between the casing 73 and the tester A with the interior of the tester to allow circulating mud or fluid to be forced downwardly through the annular space between the string and casing, through the reverse circulating valve in the tester, and up the drill string to force gas and oil upwardly through the drill string to the surface under control.

It happens, however, that sometimes after the packer 71 has been collapsed and the string is in the process of being pulled up that it is necessary to back circulate to bring gas and oil to the surface under control, or to maintain complete control over the well, or for other reasons well known in the art. Under these conditions, it is frequently imperative that reverse circulation be established immediately, and there may not be time, nor may it be practical or possible to reset the packer because of the conditions in the well. Therefore, the drill string is rotated at a speed sufficient to cause the arms 39 to swing outwardly under the influence of centrifugal force and engage the casing 73, or the formation if there is no casing, and drag against the casing or formation, thereby creating relative movement between the nut 31 and the threaded mandrel 13. Upon continued rotation of the drill string, the nut threads downwardly on the threaded mandrel 13 to uncover ports 29, therefore opening the exterior of the drill string to the interior thereof and permitting drilling mud to be reversely circulated to reassume control over the well.

It is pointed out that the portion of the connate fluid below the reverse circulating valve can be recovered after the conclusion of the reverse circulating operation by removal of the drill string from the well.

By the present invention, a reverse circulating valve has been provided which can be incorporated in a drill string at a number of places therealong, above a tester or below a tester, or above or below other types of mechanisms or instruments, and which reverse circulating valve can be opened when the drill string is off bottom and without resetting a packer or equivalent device. Obviously, the reverse circulating valve shown could be used to merely open the interior of the drill string to the exterior for other purposes as desired.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising a tubular valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut for covering the port, and means connected to the nut and responsive to rotation of the drill string to engage the well casing or formation and cause relative rotation between the nut and member to cause threading of the nut to a position to carry the port covering means to port-uncovering position, the second named means including arms pivotally mounted on the nut, means for releasably locking the nut and valve member against relative rotation, the last named means including a releasing sleeve having a splined connection with the valve member to permit relative axial movement between the sleeve and valve member but providing a rotary drive therebetween, and shear pins connecting the sleeve and arms adapted to be sheared to release the arms upon relative movement between the sleeve and valve member.

2. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising a tubular valve member having a port in the wall thereof communicating the exterior of the member with the interior

thereof, a nut threadedly engaging the valve member, means carried by the nut for covering the port, and at least one centrifugal element mounted on the nut for outward swinging movement under the influence of centrifugal force to engage the walls of the casing or well bore in which the valve is positioned and by virtue of its frictional engagement with such walls to retard rotation of the nut and cause threading movement thereof along the valve member to cause uncovering of the port.

3. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising a tubular valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut for covering the port, at least one centrifugal element mounted on the nut for outward swinging movement under the influence of centrifugal force to engage the walls of the casing or well bore in which the valve is positioned and by virtue of its frictional engagement with such walls to retard rotation of the nut and cause threading movement thereof along the valve member to cause uncovering of the port and means for releasably locking the nut and valve member against relative rotation and the element from outward swinging movement.

4. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising upper and lower tubular members telescopically received within one another for relative longitudinal movement, the upper member constituting a valve member, said valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut for covering the port, at least one centrifugal element mounted on the nut for outward swinging movement under the influence of centrifugal force to engage the walls of the well casing or well bore in which the valve is positioned and by virtue of its frictional engagement with such walls to retard rotary movement of the nut and cause threading movement thereof along the valve member to cause uncovering of the port, and means connecting the element to the lower tubular member for initially preventing outward swinging movement of said element, responsive to telescopic movement of said tubular members to release said element for outward swinging movement.

5. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising upper and lower tubular members telescopically received within one another for relative longitudinal movement, the upper member constituting a valve member, said valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut for covering the port, at least one centrifugal element mounted on the nut for outward swinging movement under the influence of centrifugal force to engage the walls of the well casing or well bore in which the valve is positioned and by virtue of its frictional engagement with such walls to retard rotary movement of the nut and cause threading movement thereof along the valve member to cause uncovering of the port, and means connecting the element to the lower tubular member for initially preventing outward swinging movement of said element, responsive to telescopic movement of said tubular members to release said element for outward swinging movement, the last-named means comprising at least one shear pin.

6. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising a tubular valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut covering the port, and centrifugal arms pivotally mounted on the nut by one set of ends only for outward swinging movement under the influence of centrifugal force to engage the walls of the casing or well bore in which the valve is positioned and by virtue of their frictional engagement with such walls to retard rotary movement of the nut and cause the same to thread along the valve member to cause uncovering of the port.

7. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising a tubular valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut covering the port, centrifugal arms pivotally mounted on the nut by one set of ends only for outward swinging movement under the influence of centrifugal force to engage the walls of the casing or well bore in which the valve is positioned and by virtue of their frictional engagement with such walls to retard rotary movement of the nut and cause the same to thread along the valve member to cause uncovering of the port, and means for releasably locking the nut and valve member against relative rotation and the arms against outward swinging movement.

8. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising upper and lower tubular members telescoped one within the other for relative longitudinal movement, means preventing relative rotation between said tubular members, the upper member constituting a valve member, said valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut covering the port, centrifugal arms pivotally mounted on the nut by their upper ends only, for outward swinging movement under the influence of centrifugal force to engage the walls of the casing or well bore in which the valve is positioned and by virtue of their frictional engagement with such walls to retard rotary movement of the nut and cause threading movement thereof along the valve member to cause uncovering of the port, and means connecting the arms to the lower tubular member responsive to telescopic movement of the tubular members relative to one another to release the arms for outward swinging movement.

9. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising upper and lower tubular members telescope one within the other for relative longitudinal movement, means preventing relative rotation between said tubular members, the upper member constituting a valve member, said valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut covering the port, centrifugal arms pivotally mounted on the nut by their upper ends only, for outward swinging movement under the influence of centrifugal force to engage the walls of the casing or well bore in which the valve is positioned and by virtue of their frictional engagement with such walls to retard rotary movement of the nut and cause threading movement thereof along the valve member to cause uncovering of the port, and means connecting the arms to the lower tubular member responsive to telescopic movement of the tubular members relative to one another to release the arms for outward swinging movement, the last-named means comprising shear pins.

10. A reverse circulating valve of the type adapted to be incorporated in a drill string, comprising upper and lower tubular members telescoped one within the other for relative longitudinal movement, the upper member constituting a valve member, said valve member having a port in the wall thereof communicating the exterior of the member with the interior thereof, a nut threadedly engaging the valve member, means carried by the nut covering the port, centrifugal means on the nut responsive to rotation of the drill string to move outwardly and

engage the walls of the well casing or well bore in which the valve is positioned to retard rotary movement of the nut and cause threading movement thereof along the valve member to cause uncovering of the port, and releasable means connecting the centrifugal means to the lower tubular member responsive to telescopic movement of the members relative to one another to release the centrifugal means for outward movement.

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