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Garrison et al.

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[54] **REVERSE CIRCULATING SUB FOR FLUID FLOW SYSTEMS**

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[52] **U.S. Cl.**..... **175/94,** 175/100, 175/107, 175/215, 166/191, 166/202

[51] **Int. Cl... E21b 3/08,** E21b 21/00, E21b 33/126

[58] **Field of Search** 175/215, 209, 325, 323, 175/92, 94, 100, 101, 107; 166/184, 185, 188, 191, 202, 51, 215, 202

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Primary Examiner—David H. Brown

[57] **ABSTRACT**

A reverse circulating device which supplies flowing carrier fluids and returns flowing fluids through a fluid conduit or string to efficiently and speedily remove the carrier fluids by providing a return conduit of less cross sectional flow area than that of the conduit or string through which the fluid is supplied. Also, and more specifically, a reverse circulating device which is connected to an inhole fluid motor so that carrier fluid can be supplied between the casing or the wall of the hole and the conduit or string and returned in the restricted fluid conduit.

9 Claims, 3 Drawing Figures

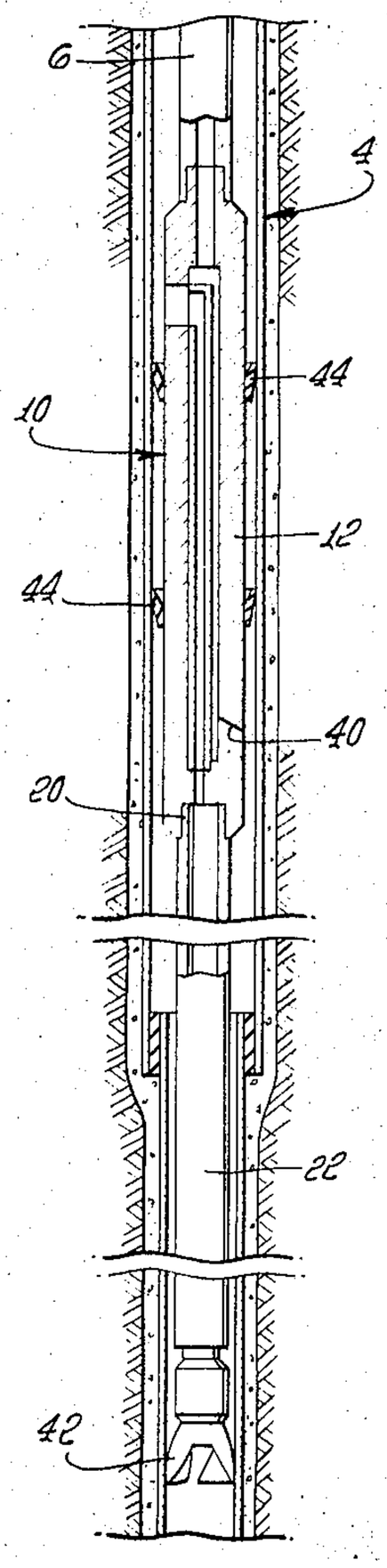


FIG. 1.

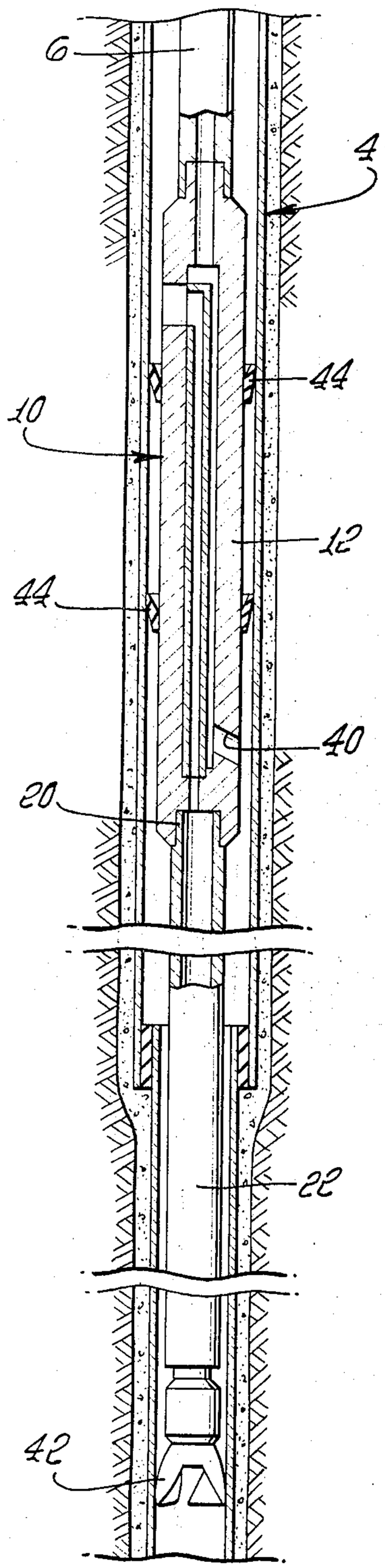


FIG. 2.

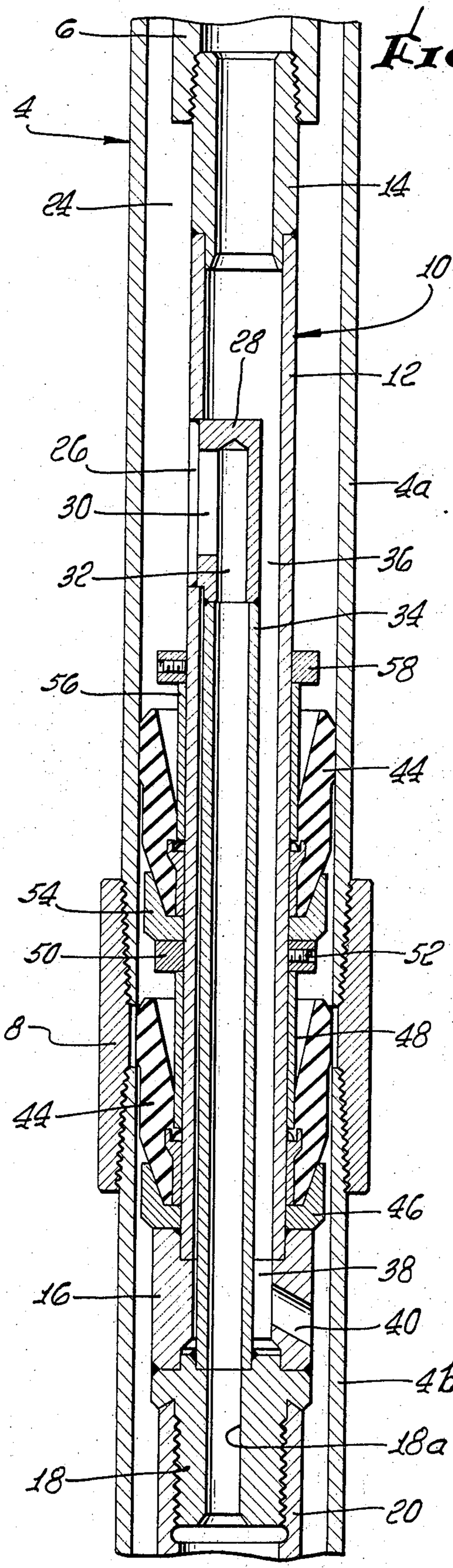
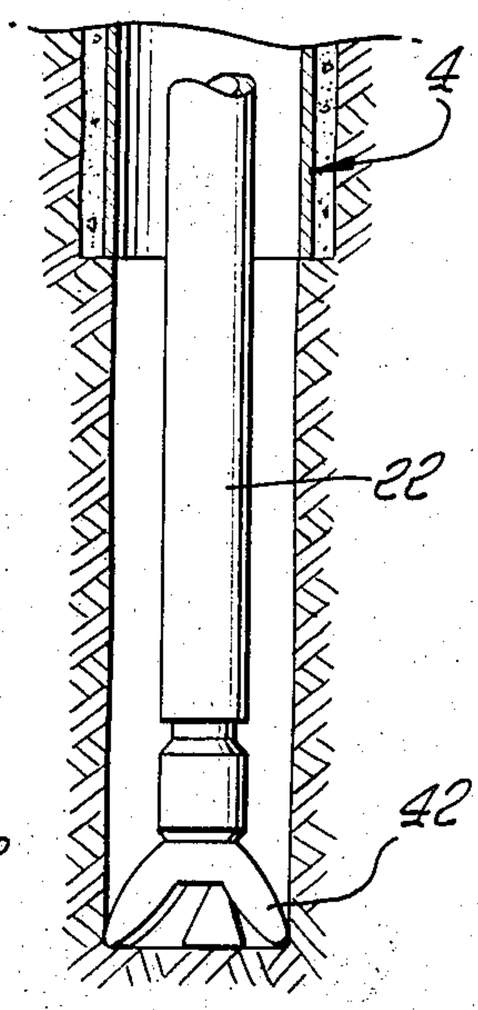


FIG. 3.



REVERSE CIRCULATING SUB FOR FLUID FLOW SYSTEMS

This invention relates to a reverse circulating device which can advantageously be used with or without in-hole fluid drilling apparatus and which is particularly adapted for use with such devices in any type of drilling or boring in which devices of suitable type are used.

It is an object of the invention to provide a pressurized carrier fluid (liquid or gaseous) in a system wherein it is supplied to a pick-up station at a relatively low speed and wherein the fluid is returned from the pick-up station laden with transported materials picked up at said station at an increased speed of flow at least as it leaves the pick-up station to give initial impetus to the transported materials in the carrier fluid.

Another object of the invention is to provide a sub which will receive carrier fluids from the space between the conduit or string and the casing or wall of the hole and which will return the fluids through the conduit or string, the more reduced cross sectional flow area of the interior of the string causing the return of the fluids at an increased rate of speed over that at which the fluids are supplied between the casing or wall of the hole and around the string, by increasing the return speed of the carrier fluids causing the fluids and materials carried thereof to be removed more efficiently and more quickly than if fluids were supplied through the string and returned between the casing or wall of the hole and the string.

Another object of the invention is to provide a reverse circulating device of the type described which will adapt it to be used with an in-hole fluid drilling apparatus, since such an apparatus requires fluids under pressure to be fed through it and exhausted adjacent the drilling apparatus.

Another object is to provide a reverse circulating device of novel construction with packer means to be located between the sub and the casing or hole formation wall and receive thrust or pressure from the supply of fluids and transmit this thrust to the conduit or string, thereby enabling the string to be tensioned to some extent to keep it from whipping and wearing against the wall of the casing or of the formation. This is particularly important where small string is used. This could be a flexible tubing or conduit attached to a takeup device at the surface or to an in-hole anchoring device so that tension can be applied in the string to act against the thrust on the packer so as to keep the string more nearly centered in the casing or hole.

The above and other objects will more fully appear from the following description in connection with the accompanying drawing.

FIG. **1** is a more or less diagrammatic view partially in vertical section of an embodiment of our device showing it associated with an in-hole fluid drilling apparatus and drill bit;

FIG. **2** is a longitudinal vertical sectional view through an embodiment of the sub per se, showing it in conjunction with a well casing and in a string including the upper portion of an in-hole fluid drilling apparatus.

FIG. **3** is a view similar to the lower portion of FIG. **1**, but with the bit working in formation below the cemented casing.

The drawing contains an adaptation of the invention to a casing **4** and a drill string conventionally used in

drilling wells. Extending downwardly from the surface in the casing is a conduit comprising the drill string, the lower end of which is indicated at **6.** The drill string may be of a conventional sectional drill pipe or it may be an elongated flexible tubing, the latter shown as macaroni and being supported from the surface by a winch or other takeup mechanism. The casing **4** is shown in two sections **4A** and **4B** connected by a coupling sleeve **8.** Connected to the lower end of the drill string section **6** is a sub generally indicated at **10.** It includes a main section of tubing **12** on the upper end of which is welded a short but slightly heavier piece of tubing or pipe **14** which is shown, is exteriorly threaded at its upper end to screw into the internally threaded lower portion of the drill string section **6.**

The lower end of the tubing **12** of the sub **10** is fitted into and welded to a mandrel **16** which in turn is welded to an exteriorly threaded connector **18** which threads into the upper end **20** of an in-hole fluid motor **22,** shown in FIG. **1.**

Between the drill string **6** and the sub **10** as a unit and the wall of the casing **4,** is a space **24** which serves as a supply conduit for drilling mud being pumped downwardly in the casing. A short distance below the upper end of the sub **10** the main tubing **12** of said sub is provided with a drilling mud inlet opening **26.** This opening communicates with an elbow-like element **28** welded inside the tubing **12** and having an inlet port **30** and an outlet port **32.** The fitting **28** has its outlet portion welded to an internal tubing **34** in the main or sub tubing **12.** The internal tubing **34** is of less diameter than the inside diameter of tubing **12** so that a space **36** is provided between the two pieces of tubing.

Tubing **34** extends downwardly in the sub through tubing **12** and through a bore **38** in said mandrel **16** and has its extreme lower end terminating in and welded to the upper portion of the connector **18** which connects with the upper end **20** of the fluid motor **22.**

In the mandrel **16** is a drilling mud and cuttings return inlet **40** which communicates through the bore **38** to the space **36** in the interior of the tubing **12,** the inlet **40,** bore **38** and space **36** provide a mud and cuttings return conduit in the sub **10** permitting flow of said mud and cuttings upwardly through the upper connector section **14** of the sub and into the drill string **6.**

The in-hole fluid motor **22** is of conventional construction known in the oil well field and in other fields as a Moineau pump. The rotor and stator of a fluid pump of this type is illustrated in U.S. Pat. No. 3,489,231, issued Jan. 13, 1970 to Garrison and Tschirky.

A pump of this type requires that the drilling mud or other fluid enter in the top of the pump and exhaust from the bottom and that the fluid return upwardly around the outer housing of the pump. Therefore, the tubing **34** which extends downwardly to conduct drilling mud downwardly from the casing space **24,** permits the pressurized mud to flow through the bore **18A** of the fluid pump connector **18** and into the pump **22.** It flows out of the bottom of the pump around the drill bit **42** and returns upwardly around the outer housing of the pump to the lower portion of the reverse circulating sub **10.**

It should be remembered that the fluid supply conduit comprising the space **24,** being greater in cross sectional area than the interior of the string **6.** In other words, the return flow in the string **6** is more restricted

than the supply flow through the space **24.** Consequently, in order for the string **6** to carry off the fluid supplied through space **24,** the return fluid carried off must travel faster in the string **6** than in space **24.** The increased flow speed provided by the invention can be used to advantage in picking up and transporting any appropriate types of materials with either liquid or gaseous carrier fluids, although it is particularly useful in drilling oil wells. The principle can be applied, however, to coal and other mining operations. It can be used in horizontal or slanting drilling operations, and even in an upwardly vertical direction. In the latter instance, an in-hole motor with a "creepy-crawler" can be utilized.

Where the terms "string" or "drill string" are used, they are meant to include any suitable conduit or conductor.

In order to separate in the casing **4** the fluid flowing downwardly in the space **24** and that flowing upwardly in the casing below the space **10,** we provide a pair of packer cups **44.** The lower cup rests in a thimble **46** on the upper end of the mandrel **16.** Each cup **44** flares upwardly and outwardly to sealingly engage with the wall of the casing **4,** or the wall of a hole being drilled, and the upper portion of each cup is spaced from the outside of the sub **10.** The lower of the cups **44** has a sleeve **48** extending into it and on the upper end of the sleeve is a packer retainer collar **50** held on the main tubing **12** of the sub **10** by a set screw **52.** The upper packer cup **40** is provided with a thimble **54** resting upon the retainer collar **50** and supporting the upper packer cup against downward movement. The upper cup is provided with a sleeve **56** similar to sleeve **48** and an upper packer retainer collar **58** is provided on the sub **10** to hold the entire packer assembly down against the mandrel **16.**

It will be noted that the two packer cups **44** lie below the inlet **26, 30** of the sub **10** and above the return mud and cuttings inlet **40,** thereby separating the downwardly flowing supply mud and the upwardly return cuttings-laden mud or other fluid. Additionally, because of the flaring of the packer cups, and more specifically the upper one, the pressure of mud or other fluid being supplied downwardly through the casing space **24** will not only press the cup into tight sealing engagement with the casing but will also exert a downward thrust of the cup on the sub **10,** and a downward pull on the drill string **6** which lies above the sub **10.** This feature results in the resistance of the tendency of the drill string to whip, particularly where the drill string **6** comprises macaroni tubing which is thinner than pipe and more flexible, and where the tubing is suspended from the surface by a takeup device which can exert a tension on tubing in the opposite direction and keep it straight.

The description of my invention makes reference to drilling tools and drilling mud. It is to be understood that the reverse circulating system must be utilized in connection with devices and materials other than drilling tools and drilling mud. The invention can be practiced in any appropriate systems for transporting flowable materials and for that reason the terms "carrier fluid" and "laden carrier fluid" are used to denote the drilling mud as well as other flowing liquids or gases used to transport other flowable materials.

Where the term "wall of the bore" is used, it is intended to include the actual wall of the hole or formation or other wall such as drill casing where well drilling or the like are undertaken with the invention.

It should be understood that various changes can be made in the form, details, arrangement and proportions of the device without departing from the spirit of the invention.

We claim:

1. A reverse circulation device for use in a bore having a hollow string therein, there being a carrier fluid supply space between the wall of the bore and the string, wherein the improvement comprises: a sub having top end means for connection with the string, a fluid motor with an upper inlet conduit connected to the bottom end of the sub, the sub having a carrier fluid supply conduit with an upper end inlet in flow communication with said carrier fluid supply space between the bore and the string and having an outlet in flow communication with the upper inlet conduit of the fluid motor, the fluid motor being of a size to lie spaced from the wall of the bore to provide a return space for the carrier fluid laden with material to be removed from a drill bit mounted at the end of the fluid motor, said sub having a laden carrier fluid return conduit with an inlet in flow communication with the laden carrier fluid return space and having an outlet at its upper end in flow communication with the hollow string to provide for removal of the laden carrier fluid from the hole.

2. The structure in claim **1,** and said string comprising flexible tubing string, and a packer cup secured about said sub between the upper carrier fluid inlet and lower laden carrier fluid inlet and flaring upwardly and flaring upwardly and outwardly to engage the wall of said bore, the flare of said cup providing an upwardly open space between the cup and the sub to provide downwardly transmitted thrust from carrier fluid above the packer cup to the cup and the sub, and through the sub and its connection with the flexible tubing string, a downward pull on said string to prevent the latter from buckling in the bore and producing wear.

3. The structure in claim **1,** and the carrier fluid supply conduit having a greater cross sectional flow capacity than that of the return space, whereby the rate of flow of return fluid is greater than the rate of flow of fluid in the supply conduit.

4. The structure in claim **1,** and means on said sub between its upper end inlet and its laden carrier fluid return inlet and extending to said bore and separating the carrier fluid supply and return spaces in said casing.

5. The structure in claim **4,** and said means for separating the carrier fluid supply and return spaces comprising a packer cup flared upwardly and outwardly to seal against the wall of the bore under pressure of carrier fluid in the casing space above the packer cup.

6. The structure in claim **4,** and said means for separating the carrier fluid supply and return spaces comprising a packer cup lying about said sub and flared to seal against the wall of the bore, a sleeve slidably fitting about said sub and having its lower end engaging the bottom of the packer cup in thrust transmitting relationship thereto, a releasable retainer on said sub above said sleeve, the cup, sleeve and retainer, when the retainer is released, being slidable upwardly over the upper carrier fluid inlet and upper end of said sub when the sub is disconnected from the string.

7. A reverse circulating device for use with a down hole motor in a bore with a string of pipe, the latter defining part of a flow conduit to the bottom of the string,

wherein the improvement comprises: a sub having first and second ends connected respectively to the string of pipe and to said down hole motor, the string of pipe and sub having a space between them and the inside of the bore, said sub having a carrier fluid supply conduit therein with an inlet communicating with said space below the upper end of the sub and with an outlet in its lower end having flow communication in said flow conduit from the first to the second end, the outlet being flow connected to said down hole motor, said sub having a laden carrier fluid return conduit with a return flow inlet arranged for communication with said space and a return flow outlet arranged for communication with the string flow conduit above said sub, and a packer cup mounted on said sub below the supply inlet and above the return flow inlet of said sub, said cup being flared upwardly and outwardly into sealing engagement with the inside wall of said bore to transmit downward pressure of carrier fluid in the bore via the cup to said sub and the down hole motor to which the sub is connected.

8. A reverse circulation device for use in a bore hole casing having a hollow drill string therein with a down hole fluid motor, there being a drilling mud supply space between the casing and the drill string, wherein the improvement comprises: a sub having top end means for connection with the drill string, a fluid motor with an upper inlet conduit connected to the bottom end of the sub, the sub having a drilling mud supply conduit with an upper end inlet in flow communication with said drilling mud supply space between the casing and the drill string and having an outlet in flow communication with the upper inlet conduit of the fluid motor, the fluid motor being spaced from said casing to provide a mud and cuttings return space from a drill bit mounted below the fluid motor, said sub having a mud and cuttings return conduit with an inlet in flow communication with the mud and cuttings return space and having an outlet at its upper end in flow communication with the hollow drill string to provide for removal of said mud and cuttings from the hole.

9. A reverse circulating device for use in a casing with a drill string, the latter defining part of a flow conduit to a down hole motor and a drill bit at the bottom of the string, wherein the improvement comprises: a drill string of pipe, a down hole motor, a drill bit drivingly connected thereto, a sub having upper and lower ends connected in the string of drill pipe in said casing and to the upper end of the down hole motor, the drill string and sub having a space between them and the inside of the casing, said sub having a drilling mud supply conduit therein with an inlet communicating with said space below the upper end of the sub and with an outlet in its lower end arranged for flow communication with said flow conduit downwardly toward a drill bit, said sub having a drilling mud return conduit with a return flow inlet arranged for communication with said space and a return flow outlet arranged for communication with said space and a return flow outlet arranged for communication with the drill string flow conduit above said sub, and a packer cup mounted on said sub below the supply inlet and above the return flow inlet of said sub, said cup being flared only upwardly and outwardly into sealing engagement with the inside wall of said casing to transmit downward pressure of drilling mud in the casing via the cup to said sub the drill string and the drill to which the sub is connected.

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