United States Patent

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[54] **WELL CIRCULATING DEVICE**
4 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **175/69,** 175/205
[51] **Int. Cl.** **E21b 21/00**
[50] **Field of Search** 175/205, 215, 69, 72, 324; 103/261

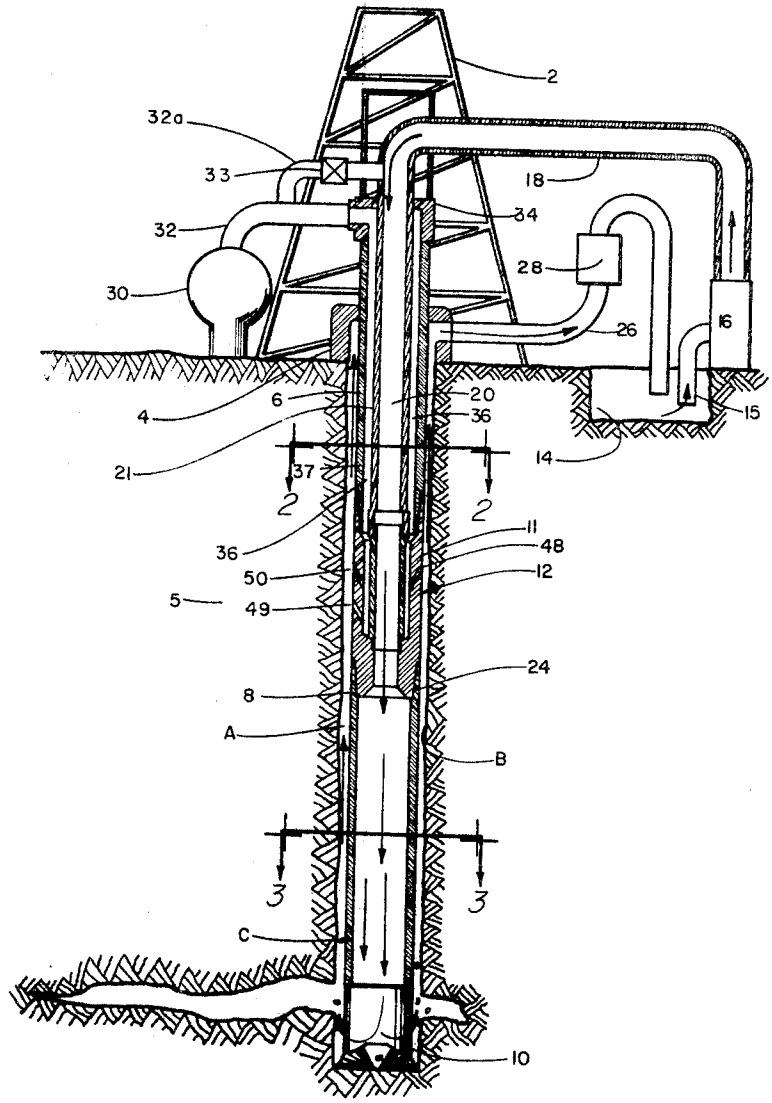
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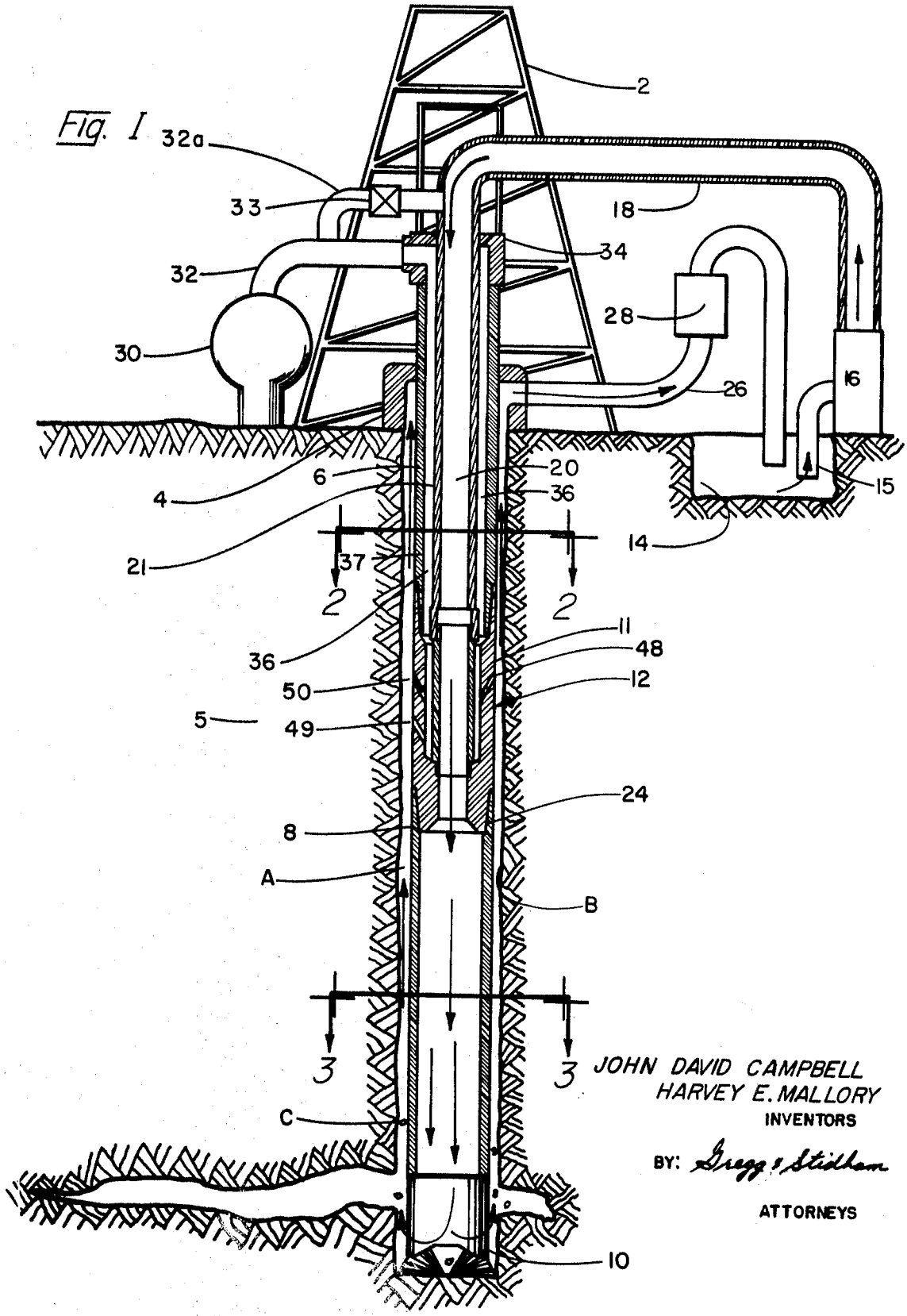
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ABSTRACT: A method and device for reducing the static head of drilling fluid acting against a subsurface formation. A circulating dual passage circulating sub is adapted to be interposed between a lower single drill pipe string and an upper, concentric dual passage pipe string. The annular passage around the inner pipe of the circulating sub is blocked off and ports are provided in the outer pipes. The drilling liquid is circulated down through the inner pipe and on through to the lower single pipe string. A gas is circulated through the outer annular passage and out through the ports of selected sizes to mix with the fluid in the bore hole annulus and, hence, reduce its density.



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Fig. 1



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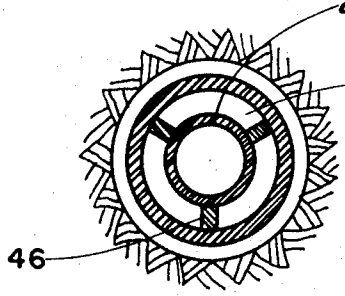
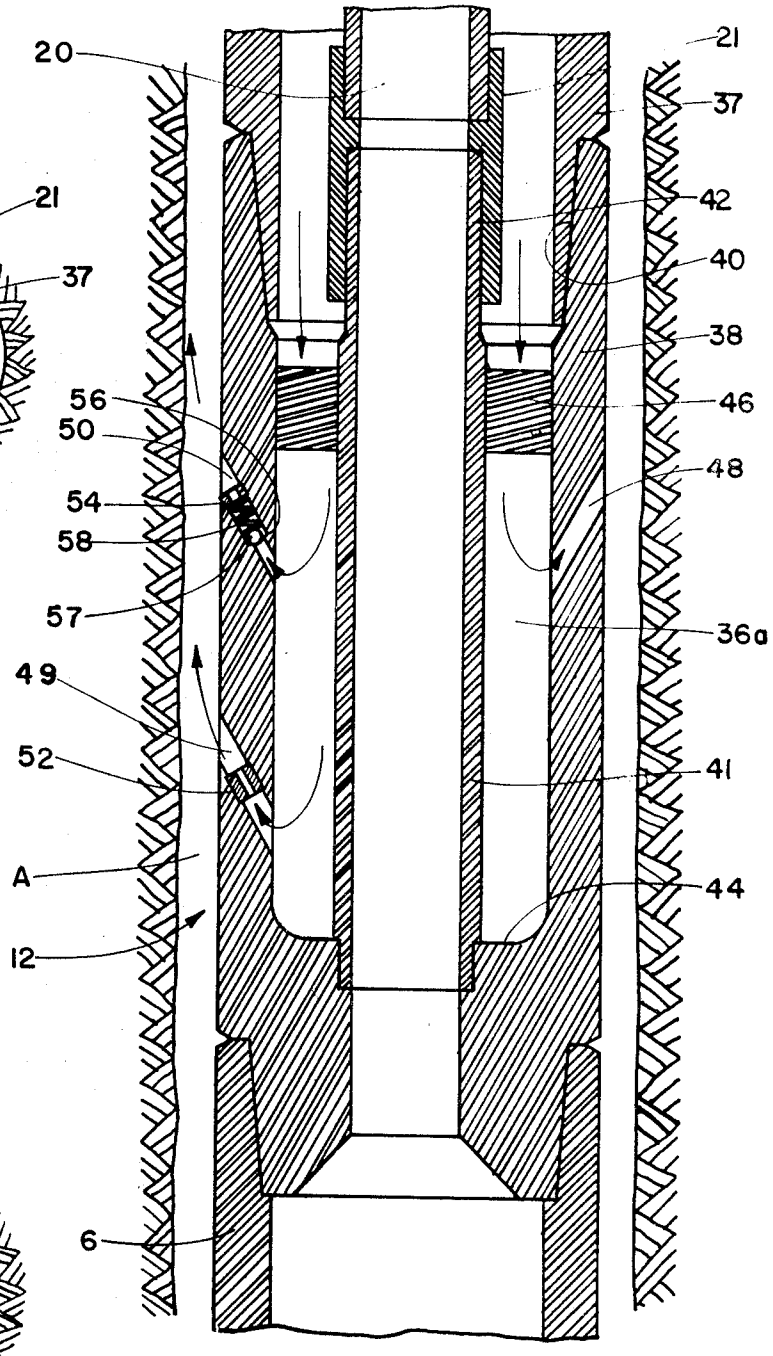


Fig 2



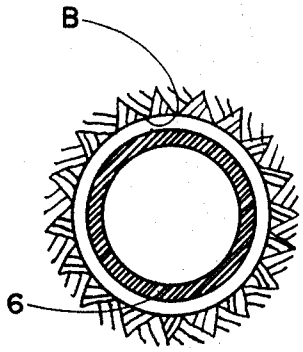


Fig 3

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Fig 4

WELL CIRCULATING DEVICE

DESCRIPTION

This invention relates to a device for circulation of well drilling fluid and, more particularly, to a device for introducing a gas into the returning fluid in the bore hole annulus in order to reduce its density and the total static head.

In conventional rotary well drilling, a single drill pipe string carrying a cutting bit at the lower end thereof is rotated at the surface of the well while a circulating fluid is pumped from the surface down through the drill string to cool the bit and carry the cuttings back to the surface through the hole annulus, *i.e.* the annular space between the drill pipe and the wall of the well bore. While air is occasionally used as a circulating medium, by far the majority of wells being drilled utilize a relatively heavy drilling fluid for circulation. Additives in such drilling fluids perform various useful functions such as caking the wall of the well bore to seal it off against seepage, and floating of cuttings to the surface. However, in a fairly deep well, the hydrostatic pressure created by the fluid column in the annulus on occasion creates more difficulties than it cures. For example, many subsurface formations are susceptible to fracturing or intrusion under high hydrostatic heads. Continued drilling in such formations may simply result in loss of a circulating fluid into the fractured or permeable formation. If this occurs, not only are the benefits of fluid circulation, including lubrication of the rotating drill pipe, lost, the escaping circulating fluid may promote additional fractures in the surrounding formation.

When the drill bit penetrates a formation which has a structural strength or resistence to permeation less than the hydrostatic head, the formation may collapse completely and slough off the walls of the well bore. With portions of the fractured formations falling into the annulus between the pipe and the well bore, the drill string may become firmly lodged in the well. If the pipe is firmly stuck in the well, both the pipe and the well may be total losses. When the drill bit penetrates an oil producing formation the oil tends to flow into the well bore for recovery. However, if the pressure of the drilling fluid exceeds the pressure of the gas which tends to force the oil into the well bore, the oil is not recovered and penetration of the oil zone may go undetected. The advantages of reducing hydrostatic head are presently known and one method involves the injection of air into the fluid system prior to pumping it down the drill pipe. However, such method requires an excessively large air compressor and has not proved economically feasible.

It is, therefore, an object of this invention to provide a device and method for reducing the hydrostatic head in the hole annulus to provide greater economy in drilling.

It is a further object of this invention to provide a method and device for reducing the hydrostatic head in the hole annulus to reduce the tendency of fluid to be forced into porous formations.

It is a further object of this invention to provide a method and device for reducing the hydrostatic head by introduction of a gas into the returning circulating fluid without requiring it to traverse the complete circulatory system.

In carrying out this invention, I provide a composite drill string which is made up of a single pipe drill string to which the bit is attached at the lower portion of the bore hole and a dual passage drill pipe at the upper portion of the hole. Interconnecting the two drill strings is a special circulating sub constituting a feature of this invention, and which constitutes essentially a dual passage drill pipe. However, the annular flow passage between the inner and outer pipes is blocked off toward the lower end of the section and a series of ports or orifices are formed in the outer wall so that the air or other gas circulating in the outer annular passage exits through the ports to mingle with the fluid rising through the hole annulus. In practicing the method of this invention, the liquid circulating medium is pumped down through the inner passage of the dual concentric drill pipe string through the circulating sub to flow into the single pipe drill string as in conventional circulation. In the outer annular passage of the dual passage drill pipe, we pump a gas such as compressed air which flows rapidly down through the annular passage to the circulating sub wherein further passage is blocked and it, therefore, flows out through the ports to flow into the rising liquid forming air bubbles which greatly reduce the density of the liquid and, hence, the hydrostatic head of the fluid in the well bore.

Other objects and advantages of this invention will become apparent from the description following when read in conjunction with the accompanying drawing wherein FIG. 1 is a more or less schematic view in vertical section showing our complete fluid circulating system with a circulating device of our invention included;

FIG. 2 is a horizontal section view taken along line 2–2 of FIG. 1;

FIG. 3 is a horizontal section view taken along line 3–3 of FIG. 1; and

FIG. 4 is an enlarged vertical section view of the special circulating sub comprising a feature of this invention.

Referring now more specifically to FIG. 1 we have illustrated a drilling mast or derrick 2 of a size and design strength to hoist a dual pipe swivel 4 together with a composite drill pipe string 5 comprising a string of dual concentric drill pipe 6 near the top of the bore B, and conventional drill string 8 on the lower portion of the bore. At the lower end of the composite string 5 is secured a conventional drill bit 10. While our invention is not restricted to any specific structure of drill pipes, the dual passage pipe is preferably of the type described in Henderson U.S. Pat. No. 3,208,539 granted Sept. 28, 1965. Interposed between the dual passage dual pipe 3 and the conventional single drill pipe string 6 is the circulation adapter sub 4 hereinafter to be described in greater detail.

In operation, drilling mud is circulated from a sludge sump 14 through the suction pipe 15 of a pump 16 to a delivery line 18 which circulates the drilling fluid through the inner tube passage 20 formed by the inner pipe 21 drill string 6. When the liquid flows through the inner tube passage 22 of the circulation adapter sub 12, it flows directly into the single drill pipe 5 which is secured to the adapter sub by a conventional threaded joint 24. From this point the circulating fluid proceeds in conventional manner through the drill bit 10, cooling the bit and collecting bit cuttings to return them to the earth surface.

The dual pipe swivel may be self-driven by hydraulic, pneumatic or mechanically powered means, or the dual passage drill pipe 6 may simply include as an upper section a dual passage kelly which may be driven by a conventional rotary table (not shown). In any event, the dual pipe swivel 4 permits rotation of dual passage drill pipe 6 by some suitable power means to transmit rotation to the dual passage drill pipe and then through the conventional single pipe 5 to rotate the bit 10.

At the earth surface the drilling fluid flows through the return line 26 and then through a suitable shaker screen 28 or the like where cuttings are separated out before the mud is returned to the sludge pit 14 for recirculation.

The method thus far described is not appreciably different from that practiced in conventional drilling, and we will now describe the method and device by which the hydrostatic head of the fluid in the hole annulus A is reduced in order to accomplish the objects set forth herein.

A source of pressurized gas, such as an air compressor 30 is connected through a gas delivery pipe 32 to an upper packing portion 34 of the rotating swivel 4 to deliver a gas to the annular passage 36 between the inner pipe 21 and the outer pipe 37 of the dual passage drill pipe. This flow of gas passes unimpeded through the annular space without mixing with the fluid until it reaches the circulating sub 12 from which it is delivered to the hole annulus. The circulating sub 12 comprises an outer pipe 38 which is threadedly connected at its upper end 40 to the outer pipe 37 of the dual passage drill pipe 6 and on inner pipe 41, the upper end of which is telescopi-

cally received in sealed engagement at **42** with the lower end of the inner tube of the lowermost dual pipe drill section.

At the lower end of the adapter sub **12**, the inner tube **40** is seated on a shoulder **44** extending radially inward from the outer pipe so that the annular outer passage **36***a* is effectively closed off at the lower end of the sub **12**. Also at the lower end of the sub, the outer pipe **38** is threaded to the upper end of the single pipe drill string **8** in a conventional drill pipe joint. Stabilizer webs or fins **46** are preferably secured to the inner pipe **41** to insure that the inner tube will be centrally and coaxially disposed within the adapter sub body **38**.

A series of circulation ports **48**, **49** and **50** are provided through the sub body **38** and the ports are preferably inclined upwardly to facilitate flow upward through the returning drill fluid in the hole annulus A. While we have illustrated ports of three different types of construction, it is to be understood that this is done for purposes of illustration only and that in practice only one type of gas exit port will be employed. Port **48** is simply a drilled hole of a predetermined diameter to provide the desired flow capacity. Port **49** is a drilled and tapped hole into which a plug **52** is threadably received. The plug **52** has an orifice drilled through it and the orifice is of a selected size so that a series of plugs may be provided to permit the driller to select the total orifice area in order to achieve the gas flow capacity desired.

Port **50** is also a drilled and tapped hole with a plug **54** having an orifice of selected size for desired flow. In addition, a counterbore provides a valve seat for a ball check valve **57** which is urged into seating engagement as by means of a spring. The spring may be adjusted by threading the plug **54** so that it will open only after a predetermined pressure is reached. In addition, the ball check **57** prevents intrusion of drilling mud into the gas passage and hence avoids the necessity of displacing the fluid before the system is functional.

Referring again to FIG. **1**, we may also provide a bypass gas flow line **32***a* with a valve **33** interposed therein so that compressed air from pump **30** may be delivered directly to the circulating mud at the mud delivery pipe **18** to decrease the density of the fluid throughout the entire circulatory system, further to decrease the static head.

In operation, the drilling liquid is delivered by the pump through the intake line **18** and then through the inner passage **20** of the dual passage drill pipe **6**. At the same time, the compressor **30** delivers compressed air through the outer annular passage **36** of the dual passage drill pipe until it reaches the circulating sub **12**. At the circulating sub, the drilling mud simply flows out the bottom into the single drill pipe string **8** and, at the bit **10**, it jets out into the hole annulus A to carry the cuttings C upward. The compressed air does not travel the full length of the composite drill pipe **5** unless a portion is admitted through bypass valve **33**, but simply flows down to the level of the circulating sub **12** and out through the ports **48**, **49** and **50** where it mixes with the circulating liquid. As the gas enters the liquid, it forms substantial air bubbles greatly to reduce the density of the liquid and, hence, the hydrostatic head, resulting in a reduced overall hydrostatic head acting against the formation throughout the depth of the well bore.

We are not restricted to any relative ratio between the dual passage pipe and the single passage pipe, *i.e.* the ratio between the lightened liquid and the circulating liquid, but we have found satisfactory results wherein a dual passage drill pipe of approximately 4,000 feet has been employed in drilling a well at a depth of approximately 12,000 feet.

We claim:

1. A device for circulation of well drilling fluid comprising:
- a dual passage drill pipe section having an outer pipe and a smaller diameter inner pipe within said outer pipe;
- said inner pipe forming an inner flow passage for a liquid drilling fluid;
- said inner and outer pipes forming between them an annular flow passage for a lighter drilling fluid;
- means on one end of said outer pipe for connecting it rigidly to the outer pipe of a dual passage drill pipe;
- means on said one end of the inner pipe for connecting it to the inner pipe of a dual passage drill pipe;
- means on the other end of said outer pipe for connecting it to a single drill pipe;
- means displaced from said one end of the inner and outer pipes blocking flow through said annular flow passage;
- means forming at least one port through the wall of said outer pipe section upstream of said flow blocking means;
- means in the port for regulating the flow of drilling fluid through the port;
- a valve seat in the port;
- a ball in said port;
- resilient means to urge the ball inwardly through the port toward the seat to allow flow through the port from the annular flow passage and to prevent flow through the port into the annular flow passage; and
- a threaded plug having an orifice therethrough in the outer end of the port in adjustable contact with the resilient means.

2. In a circulation sub for wells, the combination of:
- an outer tubular body;
- an inner tubular member disposed within the said outer tubular body, said outer tubular body and said inner tubular member being arranged to form an inner flow passage through the inner tubular member and an annular flow passage between the outer tubular body and the inner tubular member;
- means for securing the inner tubular member relative to the outer tubular body;
- means for connecting the upper end of the sub to a dual passage pipe;
- means for connecting the lower end of the sub to a downwardly extending pipe;
- said outer tubular body having an upwardly directed port through the wall thereof arranged to direct gas pumped between the outer tubular body and the inner tubular member upwardly through a well bore in which the sub is disposed; and
- an outwardly opening check valve in the port allowing flow of gas from the annular flow passage into the well bore outside of the outer tubular body, while preventing flow from the bore into the annular passage.

3. The combination called for in claim **2** with the addition of means in the upwardly directed port to regulate the flow rate of gas therethrough.

4. The combination called for in claim **2** with the addition of a plug in said port having an orifice therethrough; and wherein the outwardly opening check valve comprises, a seat in said port; a ball in said port; and a spring between said ball and said plug to urge the ball inwardly toward the seat.