THE EQUALIZER®
A NEW CONCEPT IN DOWNHOLE DRILLING TOOLS

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ABSTRACT

The EQUALIZER® is a totally new concept in downhole drilling string accessories. The principle of the device is much like that of a hydraulic jack as it acts as a resilient coupling between the drill string and the rock bit. Unlike spring loaded shock subs, the tool does not store energy. A series of hydraulic pistons is energized by the pressure drop generated across the jet nozzles of a rock bit by the surface mud pressure system. The mud system pressure drop is then internally utilized by the tool to provide a fluid coupling or "fluid cushion" between the bit and the drill string. At the same time, a constant weight is being transmitted to the bit. The tool has increased bit life and penetration rates, while substantially reducing shock damage to drill string components.

INTRODUCTION

The Equalizer® is a totally new concept in a shock absorbing and bit loading tool for the drilling string. Previous shock-tool designs are based on either spring-loaded or liquid-filled "hydraulic" principles. The "spring loaded" uses heavy springs to provide a cushioning effect. The "hydraulic" is a liquid filled pressure chamber baffled to cause a cushioning effect much like a car's shock absorber. Both "store" energy, and react to return it to the bit and the string when the shock load is removed.

The tool is a hydraulically actuated down-hole drilling device that maintains a closer controlled down-weight on the drill bit. It utilizes mud pump pressures currently used in good drilling practices; thus it requires no auxillary equipment or increase in rig horsepower. The available pressure generated by the mud pumps reacts on the piston areas within the tool to maintain a true dynamic fluid coupling between the bit and the drill collars. This fluid coupling not only resists bit loading variations, but also dissipates destructive forces which, if not counteracted, could damage the drill string and drill bit.

Within the tool is a series of pistons that are activated by the pressure created by the normal pressure drop across the jets in the bit. The pistons adjust themselves according to variations in bit loading to maintain an equalized and balanced weight load condition.

As the equalizer works, the anvil and pistons react, in turn to the down-weight being applied to the drill bit, and move upward to touch the next stage in the tool until the drilling mud pressure multiplied by the surface area of the affected pistons equals the down-weight being applied to the bit. This is the "equalized" balance point of the dynamic fluid coupling existing between the intended drill collar down-weight and the drill bit. Once this "equalized" condition is achieved, the tool acts to maintain its balanced condition by closely restraining weight load variations created while drilling. In addition to maintaining a controlled down-weight on the bit, its effectiveness as a shock absorber is a result of the fluid metering characteristics of the pistons and tool body which dissipate most of the destructive forces acting on the drill string and drill bit.

Unlike spring-type or pre-pressured shock tools, the tool does not store and return bit-generated forces. The tool affords the user the following advantages.

1. It maintains pre-determined weight on the bit.
2. It controls and dampens drill string vibrations.
3. It increases penetration rates.

4. It extends bit life.
5. It lengthens drill string life.

OPERATION

Figures 1 through 6 and 7 through 9 show a cross-section of the tool at various stages of operation.

Tool Open (Figure 1)

The tool is designed with its internal parts open to and in direct communication with the fluid in the hole, thus maintaining a hydrostatically balanced condition inside and outside the tool, irrespective of depth. When the mud pump is turned on, the pressure inside the drill string increases. The anvil and the pistons extend downward to their fully extended positions.

Anvil Stage (Figure 2)

As the bit begins to take weight, it will attempt to push the anvil up into the tool body. When bit

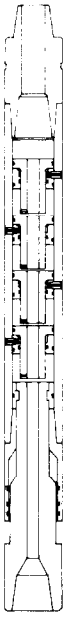


FIGURE 1 TOOL OPEN

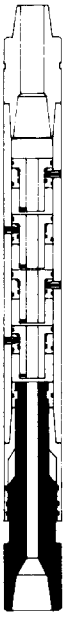


FIGURE 2—ANVIL STAGE

FIGURE 3 FIRST STAGE

FIGURE 4—SECOND STAGE

weight exceeds the downward force exerted on the anvil by the fluid pressure, the anvil will move up until it abuts the first stage piston.

First Stage (Figure 3)

When the anvil contacts the first stage piston, the downward force acting on it is added to the downward force acting on the anvil. As soon as the bit weight exceeds this combined downward force, the first stage piston will move off its seat toward the second stage piston. Annular fluid will enter the space between the piston and its seat through the flow pins.

Second Stage (Figure 4)

When the first stage piston contacts the second stage piston, the downward force acting on it is added to the combined downward forces acting on the anvil and the first stage piston. As soon as bit weight exceeds this combined downward force, the second stage piston will move off its seat toward the third stage piston. Annular fluid will enter the space between the piston and its seat through the flow pins.

Additional Stages (Figure 5)

Increasing bit weight will continue to move succeeding pistons off their respective seats until the combined downward forces exerted by the drilling fluid on the effected pistons exceeds the bit weight. When bit weight will not move another piston, the

FIGURE 5 ADDITIONAL STAGES

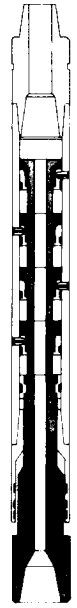
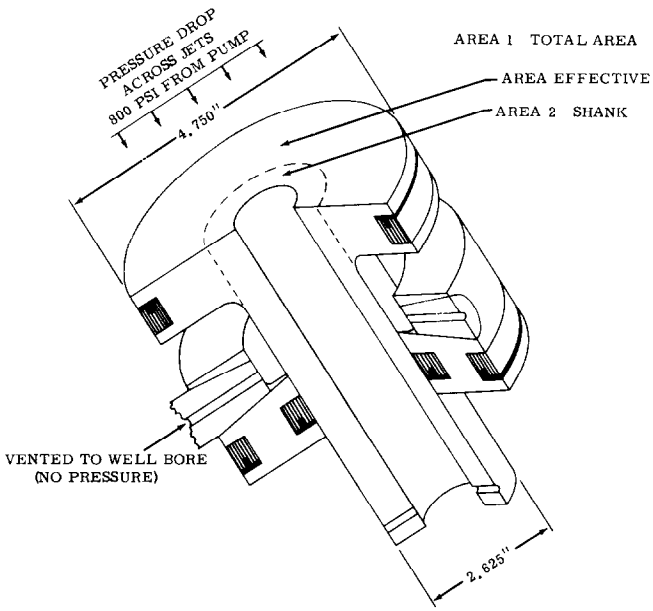


FIGURE 6 LOAD CHANGE: UP FORCE



PISTON FORCE = PSI X AREA EFFECTIVE
AREA 1 = $\pi R^2 = \pi(4.75 / 2)^2$
$A_{(1)} = 3.1416 \times (2.375)^2 = 17.72$ SQ. IN.

AREA 2 = $\pi R^2 = \pi(2.625 / 2)^2$
$A_{(2)} = 3.1416 \times (1.3125)^2 = 5.42$ SQ. IN.

AREA EFFECTIVE = $A_{(1)} - A_{(2)}$
17.72 - 5.42 = 12.3 SQ. IN. EFFECTIVE / PISTON

PISTON FORCE = PSI X $AREA_{(E)}$ = 800 PSI X 12.3 SQ IN. = 9846 1/2#S

FIGURE 7

tool is said to be "equalized" or balanced and will resist any change — in either direction — in bit loading.

Load Change: Up Force (Figure 6)

The balanced tool is free to adjust to varying drilling loads since the anvil is free to move up or down along its splined axis as necessary. Should the bit attempt to lift off the drill face, the potential downward force acting on the pistons will resist the upward movement of the bit and dampen and dissipate the upward forces and be absorbed in the fluid coupling without memory (see Figure 7).

Load Change: Down Force (Figure 8)

The combined force generated by the drilling fluid acting on the pistons will seek to constantly keep the bit against the drill face. Should a downward adjustment occur, the pistons will have to squeeze the annular fluid from between their lower sides and their respective seats through the flow pins and back into the annulus. The restricted openings in the flow pins serve to meter the annular fluid rather slowly, thereby restricting the descent speed of the bit.

Tool Closed (Figure 9)

Should the bit weight exceed the combined downward force of all the pistons, the anvil will shoulder up in the drive sub and transfer bit weight to the drill string. This eliminates the protective fluid coupling but in no way damages the tool.

DISCUSSION

Thus it is seen that the Equalizer provides a means of eliminating or greatly reducing the shock forces operating on the bit and the drilling string. Furthermore, and far more importantly, it delivers a high flexible surface controlled method for loading the bit. The new result is that both drill string life and bit life are extended, and penetration rates are simultaneously increased. The Equalizer is a drilling tool which performs most effectively when placed directly above the bit. It is ruggedly constructed to withstand the rigors of drilling the hardest formations. Despite the nature of its operation, its rigidity compares favorably with other designs; it will not create or cause undue bore-hole deviation or induce out-of-gage hole size.

This tool is available in all popular sizes and connections.

FIGURE 8 – LOAD CHANGE: DOWN FORCE

FIGURE 9 – TOOL CLOSED