ORIFICE SHOE FOR WELL PIPES

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This invention relates to shoes for well pipes and particularly to shoes for use on pipes which are to be cemented in a well bore.

In conventional methods of cementing pipe strings in a well, an pipe and the wall of the pipe is normally provided at its lower end with a device, commonly termed a “float shoe” in the cementing art. A conventional float shoe generally comprises a hollow body rounded at its lower end to form a guide for the lower end of the pipe and having one or more fluid passages through the wall thereof for the discharge of cement or other fluid from the bore of the pipe into the annular space between the pipe and the well bore. A back-pressure check valve of conventional design is ordinarily installed in the bore of the shoe to prevent return flow of cement or other fluid from the annular space into the interior of the pipe.

Well bores in which a pipe is to be cemented will normally be filled with drilling mud or other fluid and when a pipe string filled with a conventional shoe is inserted in the well bore, the check valve will prevent entrance of such fluid into the interior of the pipe string and will render the pipe buoyant in the fluid, hence the term “float shoe.” The pipe string must, therefore, be loaded with other fluid to overcome this buoyancy to permit the pipe string to sink into the well bore and to balance the external fluid pressure to prevent collapse of the pipe. This operation necessarily involves delay and added operations to effectively sink the pipe string into the well bore. Also, the loading fluid may often be of different character than the fluid initially present in the well and when displaced into the well bore during the course of the cementing operations, may have deleterious effects upon the wall of the well bore, particularly in open hole cementing, which may adversely affect the character of the bond subsequently formed between the cement and the wall of the well bore. Still another serious objection to the use of conventional float shoes arises from the piston effect produced on the fluids in the well bore when a pipe, having its lower end closed by such a shoe, is lowered in the well. The close clearances ordinarily provided between the inserted pipe and the well bore, or intermediate pipe string, and the usually viscous nature of the mud fluids in the well are generally responsible for producing this effect which, particularly in the case of long strings of pipe, may result in the exertion of great pressures on the fluid trapped below the conventional float shoe. Under the pressures thus developed, the viscous mud fluids may be forced so deeply into the pores and crevices of the surrounding formations, particularly those from which oil or gas production is sought, as to entirely or partially plug these formations to an extent such that when the pressure is eventually relieved, the oil or gas cannot escape into the well and may result in failure of the well to produce successfully.

The present invention has for its principal object the provision of a shoe for well pipes having a novel form of flexible orifice therein through which fluid present in the well bore is admitted at a regulated rate into the pipe string to fill the string as the pipe is lowered into the well.

An important object is the provision of a shoe having a flexible orifice which will automatically close in response to excessive velocities of fluid flow therethrough.

Other and more specific objects and advantages of this invention will become apparent from the following detailed description when read in conjunction with the accompanying drawings which illustrate a useful embodiment in accordance with this invention.

In the drawings:

Fig. 1 is a longitudinal sectional view of the shoe, showing it connected to the end of a pipe inserted in a well; and

Fig. 2 is an exploded view showing the parts of the shoe in quarter-sectional elevation.

Referring to the drawings, the shoe in accordance with this invention comprises a tubular body 18 having an internally threaded box 11 at one end for connection to a pipe 12. An externally threaded ring 13 having an axial passageway 14 therethrough is adapted to be screwed into the bottom of box 11 and to seat against an annular shoulder 15 therein. Ring 13 has a cylindrical extension 16 extending into the bore 17 of body 10 below the bottom of box 11 and of somewhat smaller diameter than bore 17. Extension 16 is provided with an annular groove 18 extending inwardly from its lower edge. The inner and outer walls of groove 18 are pierced by a plurality of radial perforations 19. Firmly connected to the lower end of ring 13 is a hollow generally conical nozzle 20, constructed of flexible resilient materials such as natural or synthetic rubber and the like. The base portion of the nozzle is molded into groove 18 and extends into perforations 19 to provide a fluid-tight and mechanically strong connec-
tion between the nozzle and ring 13. The base portion of the nozzle is provided with an outwardly extending annular flange 21 provided with a downwardly extending lip 22 and outer lip 24, of flexible character, such that when fluid pressure is exerted against the inner face of lip 22, it will be forced outwardly into fluid-tight engagement with the wall of bore 17 and form an effective seal transversely of bore 17 intermediate the ends of body 10. Nozzle 20 has an internal bore 25 registering with passageway 28 and tapering downwardly to an orifice 24 which extends axially through the apex of nozzle 20 and provides communication between bore 17 and the interior of bore 10 below lip 22. Nozzle 20 is thus provided with flexible walls 25 which taper inwardly and downwardly in bore 17. The lower end of body 10 is threaded at 26 for the attachment of a housing or cage 27 which is closed at its lower end and is adapted to enclose nozzle 20. A plurality of fluid passageways 28 are through the walls of cage 27 to provide communication between the exterior and interior thereof. The lower end of cage 27 may be provided with a plurality of downwardly directed radial flanges 29 which may be sharpened as at 30, to form cutting or milling teeth for the lower end of the cage.

The above described device is employed in the following manner: The shoe is assembled and connected to the lower end of pipe 12, as illustrated in Fig. 1. The pipe string is then inserted into a well bore 31 which will ordinarily be filled with mud fluid. As the pipe enters the fluid, the latter flows through passageways 28 and enters the interior of cage 27. The entering fluid will exert pressure against lip 22 due to the resistance set up by the restricted area of orifice 24, and will expand lip 22 tightly against the wall of bore 17, thereby constraining the fluid to flow through orifice 24 in order to enter the interior of the pipe string. The rate at which the fluid will flow back through orifice 24 will necessarily be determined by its area and the back pressure of the fluid. The restriction formed by orifice 24 will necessarily develop back pressure on the fluid which will be governed largely by the velocity at which the pipe string is lowered through the fluid. This back pressure will, of course, be exerted against the exterior of walls 25 of the orifice nozzle. Since walls 25 are flexible and inwardly tapered, as illustrated, when the fluid pressure thus exerted against the exterior of the walls exceeds some critical pressure, depending upon the flexing strength of walls 25, the walls will be caused to collapse inwardly and will thereby effectively shut-off bore 23. Accordingly, it will be evident that, if pipe 12 is lowered into the well at an excessive velocity, the nozzle walls will promptly collapse, shutting off the entrance of fluid into the pipe and immediately stop further descent of the pipe. If the rate of descent of the pipe is then reduced sufficiently, the natural resilience of walls 25 will cause them to expand and again admit fluid to the interior of the pipe, and permit further descent of the pipe into the well.

It will be seen, therefore, that by means of this novel form of orifice nozzle, a pipe string may be lowered into a well bore full of fluid at a regulated rate, which permits the pipe string to enter the fluid in the well at a controlled rate and which will eliminate the necessity for the loading operations, heretofore required and which will, at the same time, eliminate the piston effect on the surrounding earth formations produced by the use of conventional float shoes. At the same time, the pipe string may be lowered into the well at a peripheral lip 24, on the area of orifice 24, and the collapsing strength of walls 25. The area of orifice 24 will be determined generally in some suitable relation to the area of the pipe string which is calculated to allow the pipe to sink at a desired speed. The fluid pressure exerted against walls 25 of the nozzle will be less than the collapsing strength of nozzle.

When a pipe equipped with the above-described orifice shoe has been lowered, as described, to the desired depth in a well, cement or other fluid may be forced through the interior of the pipe and pass through nozzle 20 and thence through passageways 28 into the annular space between the pipe and the well bore in the conventional manner. In cementing operations, the shoe in accordance with this invention may be used with cementing plugs, such as those described in my co-invention, disclosures U.S. Patents 2,432,297 and 46,221, filed August 9, 1918 and August 26, 1948, respectively, which are designed to serve as effective back-pressure valves to prevent return flow of cement or other fluid from the annular space to the interior of the pipe. Alternatively, the orifice shoe herein described may itself serve as back-pressure valve. When a body of cement has been displaced into the annular space in the conventional manner, the hydrostatic pressure of the resulting column of cement, because its specific gravity is normally greater than the displacing fluid inside the pipe, will over-balance that of the column of displacing fluid inside the pipe and attempt to flow back into the pipe through the orifice shoe. Accordingly, if the pressure on the displacing fluid inside the pipe is suddenly relieved, as by pulling a vacuum on the pipe, the resulting sudden backward rush of cement will develop a velocity pressure exceeding the collapsing strength of nozzle 20 and cause the latter to shut-off, thereby effectively blocking the return flow of the cement, and the nozzle will remain shut-off as long as this effect is maintained or until the cement has hardened.

It will be understood that various changes and alterations may be made in the details of the illustrative embodiment herein described without departing from the scope of the appended claims but within the spirit of this invention.

What I claim and desire to secure by Letters Patent is:

1. A shoe for well pipes, comprising, a generally tubular body adapted to be connected at one end to a well pipe, a generally conical hollow nozzle member constructed of flexible resilient material axially disposed in said body with its apex directed toward the opposite end thereof and having the periphery of its base portion in sealing engagement with the wall of said body, and an axial orifice of restricted area through the apex of the said nozzle member.

2. A shoe for well pipes, comprising, a generally tubular body adapted to be connected at one end to a well pipe, a generally conical hollow nozzle member constructed of flexible resilient material axially disposed in said body with its apex directed toward the opposite end thereof and having the periphery of its base portion in sealing engagement with the wall of said body, an axial orifice of restricted area through the apex of said nozzle member, and a perforate
housing connected to said opposite end of said body and enclosing said nozzle member.

3. A shoe for well pipes, comprising, a generally tubular body adapted to be connected at one end to a well pipe, a generally conical hollow nozzle member constructed of flexible resilient material axially disposed in said body with its apex directed toward the opposite end thereof, a flexible peripheral lip about the base portion of said nozzle member expandible into sealing engagement with the wall of said body, and an axial orifice of restricted area through the apex of said nozzle member.

4. A shoe for well pipes, comprising, a generally tubular body, an internally threaded box in one end of said body for connecting said body to a pipe, an externally threaded ring inserted in said box, a generally conical hollow nozzle member disposed in said body having its base portion connected to said ring and in sealing engagement with the wall of said body and having its apex extending toward the opposite end of said body, the walls of said nozzle member being constructed of flexible resilient material, and an axial orifice of restricted area through the apex of said nozzle member.

5. A shoe for well pipes, comprising, a generally tubular body, an internally threaded box in one end of said body for connecting said body to a pipe, an externally threaded ring inserted in said box, a generally conical hollow nozzle member disposed in said body having its base portion connected to said ring and having its apex extending toward the opposite end of said body, a flexible peripheral lip about said base portion expandible into sealing engagement with the wall of said body, the walls of said nozzle member being constructed of flexible resilient material, and an axial orifice of restricted area through the apex of said nozzle member.

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