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WELL CEMENTING APPARATUS

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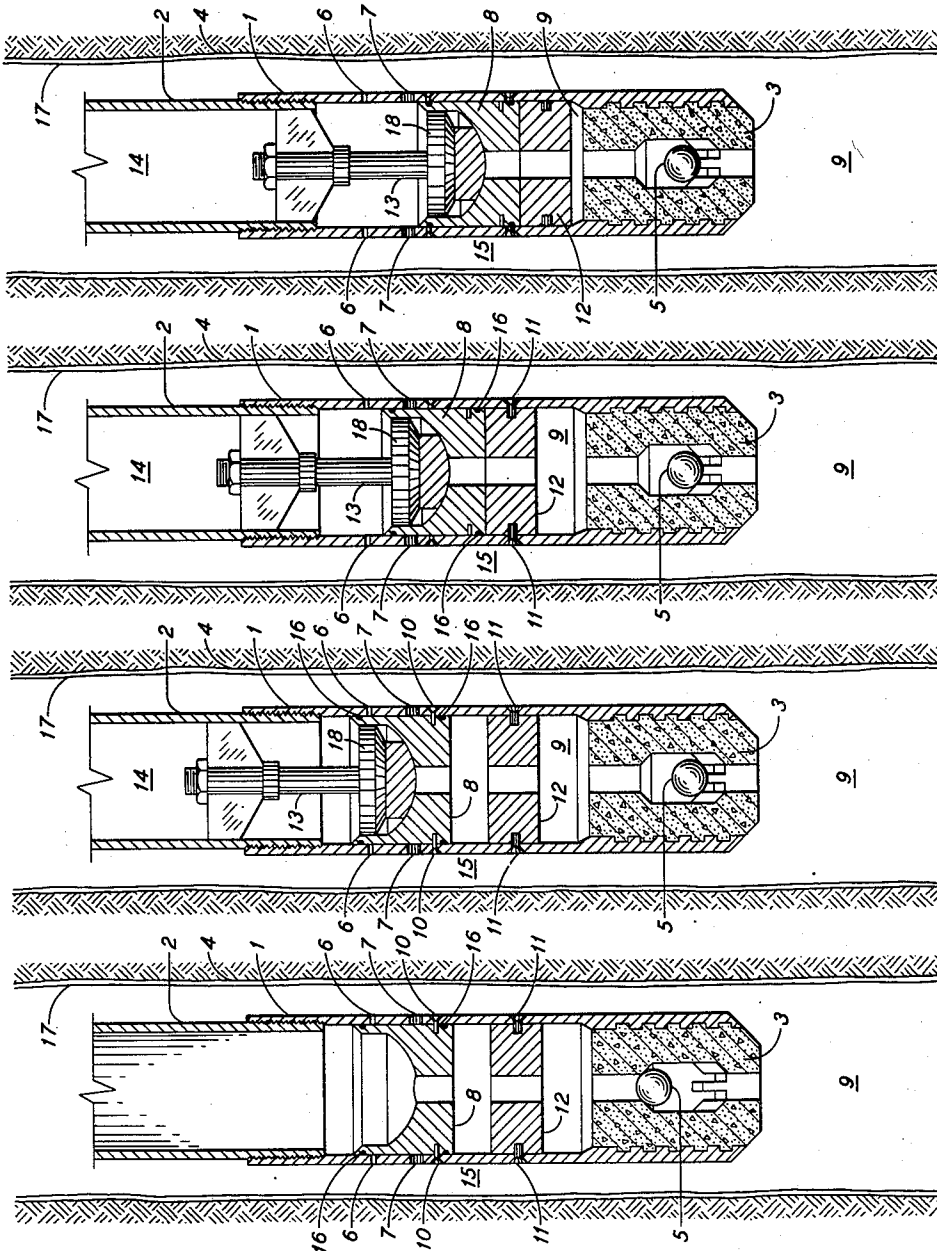


FIG. 4

FIG. 3

FIG. 2

FIG. 1

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WELL CEMENTING APPARATUS

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5 Claims. (Cl. 166—26)

This invention relates to well cementing and particularly to jet cementing operations in which cement slurry is forced with a jetting action outwardly through the circumferential wall of a well casing shoe or other well casing section into the annular space between the casing and the well bore to remove mud, filter cake, and other accumulations from the well bore wall and thereby to allow a highly effective bond to be established between the cement and the well bore wall; and an object of the invention is to provide novel methods and apparatus to enable well cementing operations to be continued after partial or complete plugging of the jet ports of the jet cementing apparatus.

The methods and apparatus of this invention are useful in connection with the sealing of a well casing with cement of the type ordinarily used in well cementing operations, but are also useful in connection with the sealing of a well casing with any other sealing material adapted to be mixed into a slurry and used for the same purpose. Therefore, as used herein, the term "cement" is intended to include cement of the type ordinarily used in well cementing operations and also any other materials adapted to be mixed into a slurry and used for the purpose of establishing a seal between the well casing and the adjacent well bore wall.

Several functions are accomplished by cement placed in the annular space between a well casing and the well bore. Perhaps the primary function is to form a permanent seal to prevent fluids in upper strata behind the casing from traveling downward around the bottom of the casing and into the well. Other functions include protecting the casing, where cemented, against collapse due to external pressures, preventing migration of fluids from one stratum to another, and preventing blowouts from high pressure gas behind the casing. Cement placed in a portion of the open hole below the casing, rather than in the annular spacing between the well casing and the well bore, is usually for the purpose of shutting off water coming from the bottom of the well or from some intermediate stratum below the bottom of the casing.

When cement is placed between the well casing and the well bore it will not satisfactorily perform its intended function unless, upon hardening, it forms a highly effective seal between the well casing and the well bore. One major obstacle to the attainment of such a highly effective seal is a cake-like coating formed on the well bore wall before the cementing operation by mud and other materials deposited by the drilling fluid. Unless this deposit layer can satisfactorily be removed prior to or during the cementing operation it will remain to prevent or weaken the desired cement seal between the casing and the well bore. It is common practice to attempt to remove this deposit layer by the use of mechanical abraders or scratchers attached to the well casing. The intended function of these abraders or scratchers is to mechanically loosen and disintegrate the deposit layer from the wall of the well bore during insertion of the

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casing into the well bore, so that the deposit layer fragments can be carried away by the circulating drilling fluid. However, this intended result can at best be only partially obtained because the abraders or scratchers cannot satisfactorily be made to engage all portions of the deposit layer. Various other methods of removing the deposit layer before or during cementing have been suggested, including chemical or semi-chemical methods in which an attempt is made to chemically loosen or dissolve the deposit layer so that it may be carried away by fluids circulating down the well casing and up the well bore or displaced by the cementing material itself. As in the case of mechanical devices for removing the deposit layer, such chemical or semi-chemical methods have disadvantages including the considerable time they require and the difficulty in maintaining the sufficient chemical activity at the deposit layer to effectively loosen and disintegrate it.

Fluids may be used to wash away loosened or dissolved portions of the deposit layer and may be made more effective by being directed into the well bore through jet ports in the well casing that give the fluids a high velocity and enable them to partially effect mechanical removal of portions of the deposit layer.

It has been suggested that the cementing material itself be jetted outwardly through jet ports in the circumferential wall of a well casing shoe or other well casing section, against the well base wall, and thus be used as the medium to remove the deposit layer during well cementing operations. This method of solving the problem of deposit layer removal does not have the disadvantage of mechanical removal methods because cement jets can be made to reach all portions of the deposit layer. This method does not have the disadvantage of chemical deposit layer removal methods because no chemical reaction time is involved and because there is no minimum level of chemical activity to be maintained. This method does not have the disadvantage inherent in the use of jetted wash fluids because the consistency of the cement being jetted precludes the infiltration dangers inherent in the use of jetted wash fluids, for example, the danger of water blocking. However, this method does have various other disadvantages. Partial or complete plugging of the jet ports with particulate material from the cement slurry will cause the cement pump discharge pressure to rise, thereby jeopardizing the safety of the cement pump and necessitating its shutdown. Further, such plugging can reduce the rate of escape of the cement slurry from the casing to the point where the slurry is not being placed quickly enough for a satisfactory cementing job. If only a portion of the jet ports become plugged, certain areas of the place cement will be weak. In extreme cases, plugged jet ports can result in complete stoppage of cement slurry flow. These results of jet port plugging can endanger the satisfactory completion of a cementing job and can necessitate costly measures to restore satisfactory flow of cement slurry. These results can also necessitate costly recementing operations.

The present invention contemplates novel methods and apparatus for using jets of the cementing material itself to remove the deposit layer, which do not have the disadvantages referred to above.

The apparatus of this invention may be used for cementing well casing at any point along the length thereof, although it is especially useful when it is embodied in a float shoe, guide shoe, or similar attachment located at the lower end of a well casing.

In the conventional single-stage cementing practice, cement slurry is forced down through the casing, around the lower or shoe end of the casing, and up in an annular column in the space between the well casing and the well bore. In this practice a highly effective cement seal

near the lower end of the casing and between the casing and the well bore is necessary to shut off the flow of fluids into the well bore from strata above or below the lower end of the well casing.

The foregoing discussion indicates the desirability of effective methods and apparatus for cementing oil wells by means of cement jets which will remove the deposit layer from the well bore during the cementing operation, and therefore an object of this invention is to provide such methods and apparatus.

A further object of this invention is to provide jet cementing methods and apparatus which allow a cementing operation to be satisfactorily continued upon partial or complete plugging of the jet cementing ports.

The foregoing objects and others ancillary thereto I prefer to accomplish as follows: According to one preferred embodiment of my invention, I provide in combination with a well casing shoe or other well casing section, jet cementing ports therethrough: additional ports of larger size than the jet cementing ports, for use as safety ports; a first and a second annular member each having an external surface adapted to closely fit the internal surface of the casing shoe or other casing section and each having an opening therethrough for the passage of drilling fluid down the casing. I support the first annular member within the casing by shear pins in a location such that the member covers all of the jet and safety ports in the casing. I dispose the second annular member within the casing below and in spaced relationship with the first annular member, and support the second annular member within the casing by a second set of shear pins adapted to shear at a higher pressure than the first set of shear pins that hold the first annular member.

After the casing has been run to the desired cementing depth and after fluid circulation has been established around the bottom of the casing shoe, and when it is desired to cement the casing by forcing cement through the jet ports therein, a cementing plug is forced down the casing ahead of the cement slurry. When the cementing plug lodges against the first annular member described above, it closes off the opening therethrough. The pump pressure is then increased to the amount necessary to shear the pins holding the first annular member. The two annular members are so located with respect to each other and with respect to the ports in the casing that, upon shearing of the first set of shear pins, holding the first annular member, that member will be released to slide downward in the casing to uncover the jet ports only, and to abut against the second annular member, in which position the first annular member will still cover the safety ports.

With the uncovering of the jet ports, the cement slurry under pressure from the cement pump will thereupon be forced through the jet ports. The cement pump pressure is so adjusted as to cause the cement jets to impinge upon the wall of the well bore with sufficient force to erode the deposit layer therefrom in the region of the jet ports. The area of deposit layer erosion in the region of the jet ports is desirably increased by reciprocating the well casing during the jet cementing operation to allow the cement jets to impinge on the deposit layer to a desired distance above and below the ultimate location of the jet ports. Simultaneously, the well casing may be rotated to further increase the eroding action of the cement jets on the deposit layer. As cement continues to flow through the jet ports under pump pressure from above, the cement will travel up and down the casing in the annular space between the casing and the well bore for distances depending upon the relative pressures existing in the annular space above and below the jet ports.

In the event that the jet ports should become plugged with particulate matter from the cement slurry so that the slurry can no longer be forced through the jet ports,

the cement pump discharge pressure will rise because it is no longer relieved by the cement escaping from the jet ports. The shear pins holding the second annular member are set to shear at a predetermined pressure below that determined to be a dangerous discharge pressure for the cement pump. After plugging of the jet cement ports to the extent that the pump discharge pressure rises to that pressure necessary to shear the pins in the second or lower annular member, such shearing will release both the first and second annular members to travel farther down the casing. In so doing, the first or upper annular member will expose the safety ports in the casing. Cement slurry can thereupon escape through these safety ports and thus allow the discharge pressure of the cement pump to remain at a safe value. In this manner, further cementing can be accomplished in a conventional manner through the safety ports without the necessity of shutting down the cement pump and stopping the cementing operation, which would result in the cement already placed setting before the cementing operation was completed. Cement escaping through the safety ports will do so in a jet of much lower velocity than cement escaping through the jet ports and thus will not operate, or would operate with reduced efficiency, to remove the deposit layer from the well bore. However, at such time as the safety ports might come into play, the jet ports will already have caused the high velocity cement jets to remove the filter layer from the well bore in the region of the ports to a degree depending upon how long the jet ports were in operation before becoming plugged.

When this invention is used in a well casing section above the casing shoe, projections may be located on the inside of the casing to stop the downward motion of the lower annular member when it has proceeded to or passed the position necessary for the first annular member to expose the safety ports. When this invention is used near the lower end of the well casing in a casing shoe such as a cement guide shoe or float shoe, the lower thickened portion of the guide shoe or float shoe may be used to stop the downward motion of the lower annular member when it has proceeded to or passed the position necessary for the first annular member to expose the safety ports. Indeed, various embodiments of the device of this invention may be constructed as combined guide or float shoes and jet cementing devices with pressure relief ports, as are the embodiments illustrated in the accompanying drawings.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention will be better understood, however, both as to the organization and method of operation, and further objects and advantages of the invention will be apparent, from the following detailed description of preferred embodiments of the invention when read in connection with the accompanying drawings in which the same reference numbers are used to illustrate similar parts in the various figures and in which:

Fig. 1 is a vertical sectional view of an embodiment of the invention as used in combination with a conventional cement float shoe, during the time that the casing is being lowered into a well bore;

Fig. 2 is a vertical sectional view of the embodiment of Fig. 1 after the casing has been lowered into the well bore to the desired setting depth and the bottom cementing plug and cement slurry have been introduced into the casing, and before the pump pressure has risen to a value great enough to shear the shear pins holding the first annular member in place;

Fig. 3 is a vertical sectional view of the embodiment of Fig. 1 after the shear pins holding the first annular member have been sheared and the jet ports have thereby been uncovered;

Fig. 4 is a vertical sectional view of the embodiment

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of Fig. 1 after the shear pins holding the second or lower annular member have been sheared and both annular members have traveled downward in the casing until stopped by the thickened portion of the cement float shoe, the first annular member having uncovered the safety ports;

Fig. 5 is a vertical sectional view of an alternate form of the invention as used in connection with a conventional cement float shoe, after the casing has been lowered into a well bore to the desired setting depth and the bottom cementing plug and cement slurry have been introduced into the casing, and before the pump pressure has risen to a value great enough to shear the shear pins holding the jet port cover member.

Referring now to Fig. 1, float shoe 1, having jet ports 6 and safety ports 7 and comprising cement float valve housing 3 and ball valve 5, is shown being lowered into well bore 4 while threadably attached to well casing joint 2. During the downward travel of the well casing string, including float shoe 1 and casing joint 2, ball valve 5 of float shoe 1 is in the position shown and the jet ports 6 and safety ports 7 are covered by first annular member 8 so that well fluid 9 cannot enter into the well casing and therefore exerts a buoyant effect thereupon, the conventional result obtained by a cement float shoe. Jet port shear pins 10 hold annular member 8 in place in float shoe 1 and are set to shear in response to a predetermined discharge pressure of the cement pump. The jet ports shear pins 10 may be set, for example, to shear at 500 p. s. i. Safety port shear pins 11 hold second annular member 12 in place in float shoe 1 and are set to shear at a pressure below that which would be dangerous for the operation of the cement pump, but greater than the pressure necessary to shear jet port shear pins 10. Safety port shear pins 11 may be set, for example, to shear at 1500 p. s. i.

Referring now to Fig. 2, float shoe 1 and casing joint 2 are shown at their final location in well bore 4 and are shown with lower cementing plug 13 in place upon first annular member 8. Cement slurry 14 is shown above lower cementing plug 13 in readiness for placing in the annular space 15 between float shoe 1 and well bore 4. Ball valve 5 is shown in its lower position and well fluid 9 is shown within float shoe 1 and a portion of casing joint 2, because after the well casing has been floated down into well bore 4 with ball valve 5 in the position shown in Fig. 1, drilling fluid must be pumped down the well casing through float shoe 1 and up annular space 15 in order to establish drilling fluid circulation before insertion of lower cementing plug 13 and cement slurry 14 into the well casing. The establishment of this circulation is necessary for several reasons including the cleaning out from annular space 15 of debris and well cuttings.

Annular sealing rings 16, which may be of any suitable material, for example, rubber, between first annular member 8 and float shoe 1, serve to prevent cement slurry 14 from passing between annular member 8 and float shoe 1 after bottom cementing plug 13 and cement slurry 14 are in place.

Referring now to Fig. 3, annular member 8 is shown in the position it has assumed after the shearing of shear pins 10 has been caused by an increase in the discharge pressure of the cementing pump. In this position annular member 8 is shown abutting against annular member 12 after having uncovered jet ports 6. Cement slurry 14 under pressure from the cementing pump is jetting through jet ports 6 at high velocity and is eroding the deposit layer 17 from well bore 4 in the region of jet ports 6 and is rising in annular space 15. An effective cement seal is thereby being formed between float shoe 1 and well bore 4, especially in the region of jet ports 6. This cement seal can be made further effective by reciprocating and rotating the well casing on which float shoe 1 is supported, in order to allow the jets of cement

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slurry 14 jetting through jet ports 6 to play on a greater area of deposit layer 17. The distance to which cement slurry 14 will travel up or down annular space 15 will depend upon the amounts of cement slurry being pumped through jet ports 6 and upon the relative well bore pressures in annular space 15 above and below jet ports 6.

Referring now to Fig. 4, upper annular member 8 and lower annular member 12 are shown after plugging or clogging or other blocking of jet ports 6 has caused the cement pump discharge pressure to rise to the value necessary to shear safety port pins 11. In traveling downward in float shoe 1 to the position shown, upper annular member 8 has uncovered safety ports 7 and has thus allowed cement slurry 14 to escape through safety ports 7, thereby reducing the pressure of cement slurry 14 on the cement pump, eliminating overload danger to the cement pump, and making possible the completion of the cementing operation.

Upper annular member 8 and lower annular member 12 may be of any material suitable for supporting in float shoe 1 in the manner described and suitable for being drilled out following cementing operations. Such material may be conventional drillable material, for example, aluminum or magnesium. Shear pins 10 and 11 may be of any suitable material for the purpose indicated, for example, copper, brass, or steel. Cementing plug 13 may be of any suitable material for the purpose described, for example, metal, rubber, or wood, but preferably is made of drillable material such as wood, aluminum or magnesium. The upper surface of annular member 8 and the lower surface of bottom cementing plug 13 are so shaped that upon shearing of upper shear pins 10 and opening of jet port 6, cementing plug 13 will travel downward with annular ring member 8 far enough so that it will not impede the travel of cement slurry 14 through jet ports 6. Cementing plug 13 may be provided with a rubber cup 18 to act as a seal between cementing plug 13 and annular ring member 8 and to receive downward pressure from cement slurry 14.

Referring now to Fig. 5, an alternate form of the invention is shown with its various parts in the positions corresponding with the Fig. 2 positions of the previously discussed embodiment of the invention, namely, after lower cementing plug 13 has been placed and before jet port shear pins 10 have been sheared. In this form of the invention first annular member 8 is constructed in two concentric parts, parts A and B, held together with safety port shear pins 11. Part A is provided with a plurality of passageways 19, each positioned to register with a safety port 7 when jet port shear pins 10 shear and annular member 8 travels downward to abut against annular member 12. In this form of the invention lower annular member 12 is not held in place in float shoe 1 with shear pins, but is permanently affixed to float shoe 1 by suitable means, for example, by welding. Alternatively, annular member 12 may be formed as an integral part of float shoe 1.

Still referring to Fig. 5, after float shoe 1 is in place in well bore 4, drilling fluid circulation has been established, lower cementing plug 13 has been placed, and cement slurry 14 has been introduced into the casing, the discharge pressure of the cementing pump is increased to the amount at which jet port shear pins 10 are set to shear, which may be, for example, 500 p. s. i. Annular member 8 will thereupon travel downward to abut against the topmost surface of annular member 12, in which position it will have uncovered jet ports 6 and in which position passageways 19 and safety ports 7 will be in register, but will still be closed to the interior of float shoe 1 by part B of annular member 8. Jet cementing will thereupon be accomplished through jet ports 6. Upon plugging or clogging of jet ports 6 to the extent that the cement discharge pressure rises to the amount at which safety port shear pins 11 are set to shear, which may be, for example, 1500 p. s. i., annular part B of

annular member 8 will travel downward to abut against the lower projecting portion of annular ring member 12, in which position both annular part B and rubber cup 18 will be below passageways 19. Thus, cement slurry 14 can escape from float shoe 1 through registering passageways 19 and safety ports 7 into annular space 15, thereby permitting completion of the cementing operation.

From the foregoing description it may be seen that the present invention operates simply and in a highly effective and novel manner to effect jet cementing to obtain complete cement sealing between a well casing and a well bore. It may also be seen that the safety port feature of the invention eliminates the danger of excessive discharge pressures on a cement pump and obviates the necessity for costly equipment shutdowns and recementing operations when jet cement ports are plugged during jet cementing of well casing. Although only preferred arrangements and modes of construction and operation have been illustrated and described, those skilled in the art will be able to perceive numerous modifications, variations and changes in this invention that could be made without departing from the spirit thereof. All such modifications, variations and changes that could be made in the arrangements, methods and modes described herein that fall within the scope of the appended claims are intended to be embraced thereby.

I claim:

1. Well cementing apparatus for positioning in a well bore as a portion of a well casing to be cemented therein, said apparatus comprising a generally tubular member secured to the casing, a plurality of jet ports through the side walls of said tubular member, a plurality of safety ports through the side walls of said tubular member, said safety ports being vertically spaced from said jet ports, the area of said safety ports being greater than that of said jet ports, vertically movable sleeve means positioned in an upper position within said tubular member and closing said jet ports and safety ports, fluid passage means through said sleeve means to permit drilling fluid to be circulated through the casing, a cementing plug for engaging the upper end of said sleeve means and closing said fluid passage means to prevent downward flow of fluid therethrough, first retaining means retaining said sleeve means in said upper position, said first retaining means being releasable by relatively low pressure of cement slurry above said sleeve means and cementing plug to permit such pressure to move said sleeve means downwardly to an intermediate position in which said jet ports are open and said safety ports remain closed by said sleeve means, second retaining means for retaining said sleeve means in said intermediate position, said second retaining means being releasable by a relatively higher pressure of cement slurry above said sleeve means and cementing plug to permit such pressure to move said sleeve means downwardly to a lower position in which said safety ports are open.

2. Well cementing apparatus for positioning in a well bore as a portion of a well casing to be cemented therein, said apparatus comprising a generally tubular member secured to the casing, a plurality of jet ports through the side walls of said tubular member, a plurality of safety ports through the side walls of said tubular member, said safety ports being positioned below said jet ports, each of said safety ports having an area greater than each of said jet ports, vertically movable sleeve means positioned in an upper position within said tubular member and closing said jet ports and safety ports, fluid passage

means through said sleeve means to permit drilling fluid to be circulated through the casing, a cementing plug for engaging the upper end of said sleeve means and closing said fluid passage means to prevent downward flow of fluid therethrough, first shear pins retaining said sleeve means in said upper position, said first shear pins being shearable by relatively low pressure of cement slurry above said sleeve means and cementing plug to permit such pressure to move said sleeve means downwardly to an intermediate position in which said jet ports are open and said safety ports remain closed by said sleeve means, second shear pins for retaining said sleeve means in said intermediate position, said second shear pins being shearable by a relatively higher pressure of cement slurry above said sleeve means and cementing plug to permit such pressure to move said sleeve means downwardly to a lower position in which said safety ports are open.

3. Well cementing apparatus for positioning in a well bore with a well casing to be cemented therein, said apparatus comprising a generally tubular casing shoe secured to the lower end of the casing, a plurality of jet ports through the side walls of said casing shoe, a plurality of safety ports through the side walls of said casing shoe, said safety ports being vertically spaced from said jet ports, each of said safety ports having an area greater than each of said jet ports, vertically movable sleeve means positioned in an upper position within said casing shoe and closing said jet ports and safety ports, fluid passage means through said sleeve means to permit drilling fluid to be circulated through the casing and casing shoe, a cementing plug for engaging the upper end of said sleeve means and closing said fluid passage means to prevent downward flow of fluid therethrough, first retaining means retaining said sleeve means in said upper position, said first retaining means being releasable by relatively low pressure of cement slurry above said sleeve means and cementing plug to permit such pressure to move said sleeve means downwardly to an intermediate position in which said jet ports are open and said safety ports remain closed by said sleeve means, second retaining means for retaining said sleeve means in said intermediate position, said second retaining means being releasable by a relatively higher pressure of cement slurry above said sleeve means and cementing plug to permit such pressure to move said sleeve means downwardly to a lower position in which said safety ports are open.

4. A method of cementing a well casing in a well bore which comprises ejecting from the interior of the casing through first flow paths into a length of the annular space between the casing and the well bore radially directed jets of cement slurry at sufficiently high velocity to erode the deposit layer of mud cake from the well bore and to replace said deposit layer with cement slurry, and continuing the ejection of slurry through second flow paths in the form of lower velocity, radially directed streams into said length of said annular space until the completion of the cementing operation.

5. The method of claim 4 wherein said jets ejected through said first flow paths are moved circumferentially and axially of said well bore.

References Cited in the file of this patent

UNITED STATES PATENTS

2,004,606	Halliburton	June 11, 1935
2,370,833	Baker	Mar. 6, 1945
2,633,916	Baker et al.	Apr. 7, 1953
2,675,082	Hall	Apr. 13, 1954