This invention relates to well cementing, and more particularly to wire line apparatus for squeeze cementing wells in the earth.

In well completion operations, it is customary to cement either a casing string or one or more production pipe strings (flow tubings) to the earth formations through which a borehole has been drilled. The purpose of the cementing operation is to prevent fluid migration between production zones when two or more zones are to be produced through the same borehole, or between the uppermost production zone and fresh water sands penetrated by the borehole. For any of a number of reasons, there may be an imperfect bond between the cement and the earth formation. For example, the mud or filter cake may have been imperfectly removed before the cementing operation, and earth formation fluids migrating to the well bore during production may have at least partially washed away the filter cake. When it is suspected that voids exist between the cement and the surrounding formations, it is customary to place a bridging plug in the pipe string, perforate the pipe string and the surrounding cement above the bridging plug, and squeeze a quantity of cement slurry through the new perforations. The cement slurry remaining in the bore of the pipe string may then be circulated out of the well by means of a tubing string lowered within the pipe string. A similar operation may be conducted to seal off perforations to a depleted formation preparatory to reperforating at a higher level in a borehole to produce another formation.

In many locations it is undesirable to circulate cement remaining in the pipe string. Under these circumstances it is desirable to lower a line running and pulling tool to the fishing head, latch on to the fishing head and pull the apparatus up the well on a wire line tool, squeeze the cement through perforations in the pipe string, and remove the excess cement from the pipe string along with the tool.

In accordance with the teachings of the present invention, there is provided an elongated mandrel having spaced-apart packer members and a frictional member surrounding the mandrel between the packer members and affixed to the packer members. The apparatus is constructed so that the packer members are movable longitudinally of the mandrel responsive to hydraulic pressure impressed on the upper member. The apparatus is further adapted to be positioned adjacent preselected perforations in the pipe string. When the apparatus is so positioned, and hydrostatic pressure is applied thereto, the upper member moves downwardly relative to the lower member, breaking the frictional annular member and squeezing cement contained in the space between the annular member and the mandrel into the perforations in the pipe string as the packer members are moved toward a closed-spaced position thereof.

Objects and features of the invention not evident from the above discussion will become apparent upon consideration of the following description of the invention when taken in connection with the accompanying drawings, wherein:

FIGS. 1 and 2 illustrate one embodiment of the invention in two operative positions thereof;

FIG. 3 illustrates another embodiment of the invention;

FIG. 4 illustrates still another embodiment of the invention.

In FIGS. 1 and 2 there is illustrated a casing string 5 cemented to the walls of well bore 1 by means of a cement sheath 3. An elongated mandrel member is provided including upper mandrel section 13 and lower mandrel section 31. A fishing head 7 is provided at the upper end of upper mandrel section 13 for the purpose of receiving a wire line pulling tool to pull apparatus out of the bore of casing 5. Packer sealing elements 19 and 21 are affixed to a packer end plate member 15 which in turn is fastened to the upper end of mandrel section 13 by means of a pin 16. Similarly, packer sealing elements 35 and 37 are secured to packer end member 33 which is fastened to lower mandrel member 31 by means of a pin 39. Ports 9 and 41 are provided in mandrel members 13 and 31, respectively, immediately above packer end plate member 15 and immediately below packer end plate member 33. A frangible cylindrical barrel 23 is secured to the lower end of packer member 15 and to the upper end of packer member 33 so as to surround the portion of the mandrel members 13 and 31 between the packer end plate members 15 and 33. A slurry 25 of fluid cement or a hardenable plastic fills the space between the frangible cylindrical barrel 23 and the mandrel members 13 and 31.

The telescoping mandrel members 13 and 31 are adapted to telescope between the least-telescoped position illustrated in FIG. 1 in which the apparatus is lowered into the well, and the most-telescoped position that will be assumed when upper packer member 15 is resting against the upper end of lower telescoping member 31.

The lower end of mandrel member 31 is elongated so as to provide a spacing nipple adapted to abut against a bull plug or other obstruction in the well pipe to place lower packer sealing elements 35 and 37 immediately below the lowermost perforations 29 in zone 27. In lieu of the spacing nipple, a collar-latching device, such as is manufactured by Pressure Services Incorporated of Dallas, Texas, may be used. The frangible barrel 23 may be formed of thin glass or porcelain. The barrel 23 should be sufficiently thin and brittle as to shatter upon application of substantial longitudinal pressure thereto.

A plug 38 is connected to the lower end of mandrel 31 for the purpose of sealing the lower end of the mandrel so that upon application of pressure, an area differential in a downward direction will be assured.

In operation, the apparatus is inserted into the well pipe or casing 5 and allowed to float. Under tension, the frangible member 23 is separated from the upper mandrel section 13 and, in zone 27, the cement begins to be forced through the perforations 29. Considerable longitudinal pressure will be exerted upon barrel 23 by packer end member 15 and will shatter the barrel 23. The packer end member 15 and the upper mandrel member 13 will move downwardly as illustrated in FIG. 2, and cement will be forced through the perforations 29. If the tool is dropped into the well in lieu of running on a wire line, then wire line pulling tool 47 (see FIG. 2) is lowered into the well to latch on to the fishing head 7 of upper mandrel member 13 to retract the apparatus from the well. When the cement in the perforations has set, other well operations may be conducted or resumed.

FIG. 3 illustrates a modification of the invention wherein in a plug 42 provided with a fishing head 43 is placed at the lower end of the lower mandrel section 31 and is affixed thereto by means of a shear pin 45. A suitable wire line running and pulling tool 49 latches on to the fishing head 43.

The apparatus of FIG. 4 differs from the apparatus...
illustrated in FIGS. 1 through 3 in that a single mandrel member 14 is provided which is permanently affixed to a wire line 51. The upper packer end member 15 is slidably supported on the mandrel 14 while the lower packer end member 33 is pinned to the mandrel in the same manner as illustrated with respect to FIGS. 1 through 3. Thus, when heavy hydraulic pressure is exerted on the upper packer end member 15, the frangible barrel 23 will shatter so that the packer end member 15 may slide downward on the mandrel 14 to force cement out through perforations 29. When the squeezing operation is completed, the apparatus is pulled out of the pipe string 5 by means of the wire line 51.

The apparatus is quite advantageous in that there is no requirement that the pipe string have a bridging plug installed therein for remedial cementing operations. Furthermore, there is no necessity for lowering a tubing string into the well for circulating out cement when the production pipe string is cemented directly to the walls of the well bore.

The invention is not necessary to be restricted to the special structural details or arrangement of parts herein set forth, as various modifications thereof may be effected without departing from the spirit and scope of the invention.

The objects and features of the invention as well as the preferred manner of carrying out the invention having been completely described above, what is desired to claim is:

1. Apparatus for squeeze cementing in a well including a production pipe string cemented to the sides of a borehole and perforated to open up fluid communication with a productive earth formation, said apparatus comprising: a tubular mandrel; first and second packer means connected to said mandrel longitudinally spaced apart therein, adapted to seal against the inner wall of the pipe string, said first and second packer means and the mandrel being connected together to permit movement of one of the packer means toward the other packer means to a close-spaced position thereof; means, including a frangible annular member, connected between said first and second packer means and surrounding said mandrel to define with said mandrel a closed container for a cementitious fluid, said frangible member being adapted to be shattered when said packer means are moved toward each other; and means connected to said mandrel, adapted to connect said mandrel to a wire line for lowering said mandrel to the depth of the perforations of the pipe string; the distance between said first and second packer means being greater than the total interval perforated in the pipe string so that said first and second packer means and said mandrel straddle the perforated interval when the packers are in the close-spaced position thereof.

2. Apparatus for squeeze cementing in a well including a production pipe string cemented to the sides of a borehole and perforated to open up fluid communication with a productive earth formation, said apparatus comprising: a tubular mandrel; first and second annular packer means connected to opposite ends of said mandrel and adapted to seal against the inner wall of the pipe string; container means, including a frangible annular member, connected between said packer means around said mandrel and defining a closed annular container for a cementitious fluid, said frangible member being adapted to be shattered when one of said packer means is moved toward the other end of said packer means; means connected to said mandrel for positioning the lower packer means at a predetermined level in the pipe string; and openings in said mandrel above and below said annular packer means for permitting fluid communication through said mandrel between the portion of the well bore above the upper packer means and below the lower packer means; said first and second packer means and said mandrel being interconnected to permit relative movement between said first and second packer means.

3. Apparatus for squeeze cementing in a well including a production pipe string cemented to the sides of a borehole and perforated to open up fluid communication with a productive earth formation, said apparatus comprising: a tubular mandrel; first and second annular packer means connected to opposite ends of said mandrel and adapted to seal against the inner wall of the pipe string; container means, including a frangible annular member, connected between said first and second packer means in a closed annular container for a cementitious fluid; means connected to said mandrel for positioning the lower packer means at a predetermined level in the pipe string; openings in said mandrel above and below said second packer means for permitting fluid communication through said mandrel between the portion of the well bore above the upper packer means and below the lower packer means; said first and second packer means and said mandrel being interconnected to permit relative movement between said first and second packer means; and a fishing head in said mandrel at the lower end thereof adapted to be seized by a wire line retraction tool.

4. Apparatus for squeeze cementing in a well including a production pipe string cemented to the sides of a borehole and perforated to open up fluid communication with a productive earth formation, said apparatus comprising: a tubular mandrel; first and second interconnected telescoping tubular members adapted for limited telescoping movement between first and second telescoping positions thereof; and first and second annular packer means connected to opposed ends of said first and second telescoping members, respectively, and adapted to seal against the inner wall of the pipe string; means, including a frangible annular member, connected between said first and second packer means, said packer means being telescoped, being greater than the total interval perforated in the pipe string so that said first and second packer means and the telescoping members straddle the perforated interval when the telescoping members are fully telescoped.

5. Apparatus for squeeze cementing in a well including a production pipe string cemented to the sides of a borehole and perforated to open up fluid communication with a productive earth formation, said apparatus comprising: a tubular mandrel; first and second interconnected telescoping tubular members adapted for limited telescoping movement between first and second telescoping positions thereof; and first and second packer means connected to opposed ends of said first and second packer means, said packer means being telescoped, being greater than the total interval perforated in the pipe string so that said first and second packer means and the telescoping members straddle the perforated interval when the telescoping members are fully telescoped.

(References on following page)
**References Cited in the file of this patent**

<table>
<thead>
<tr>
<th>Patent No.</th>
<th>Inventor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,676,785</td>
<td>Lewis</td>
<td>July 10, 1928</td>
</tr>
<tr>
<td>2,526,021</td>
<td>Fultz</td>
<td>Oct. 17, 1950</td>
</tr>
<tr>
<td>2,715,943</td>
<td>True</td>
<td>Aug. 23, 1955</td>
</tr>
<tr>
<td>2,725,940</td>
<td>Shidell</td>
<td>Dec. 6, 1955</td>
</tr>
<tr>
<td>2,740,478</td>
<td>Greene</td>
<td>Apr. 3, 1956</td>
</tr>
<tr>
<td>2,769,498</td>
<td>Huber</td>
<td>Nov. 6, 1956</td>
</tr>
<tr>
<td>2,935,133</td>
<td>Eckel</td>
<td>May 3, 1960</td>
</tr>
</tbody>
</table>