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WELL BORE PLUGGING APPARATUS

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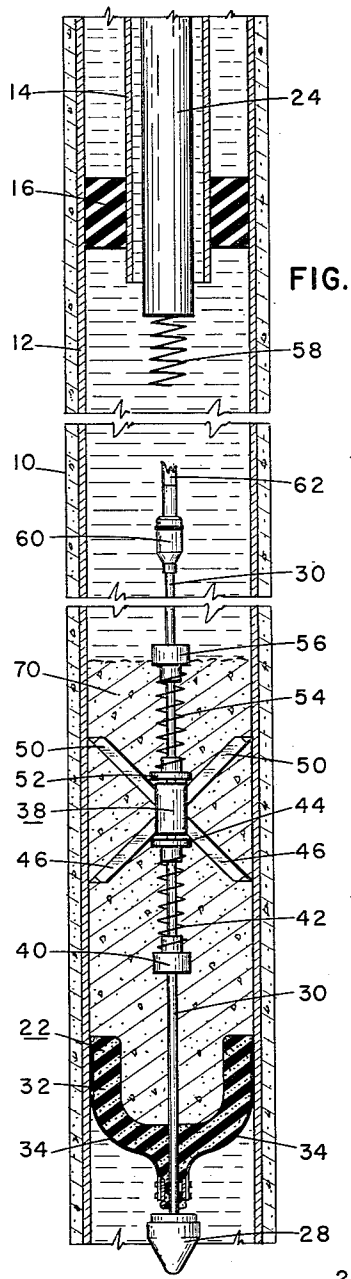


FIG. 4.

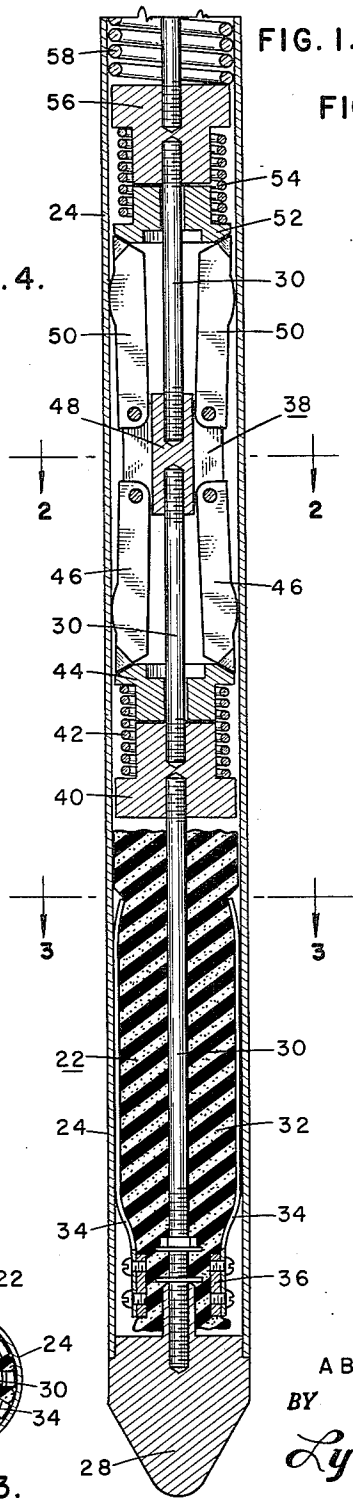


FIG. 1.

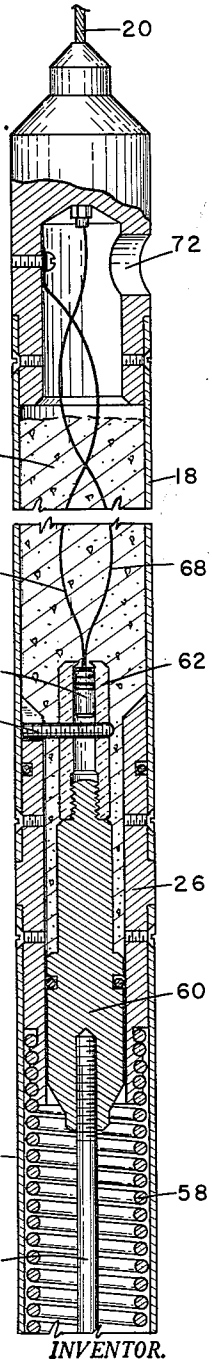


FIG. 1a.

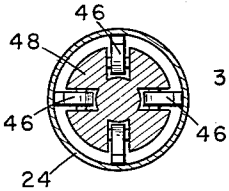


FIG. 2.

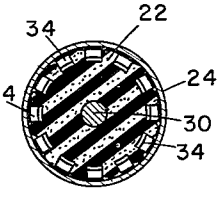


FIG. 3.

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WELL BORE PLUGGING APPARATUS

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This invention generally relates to apparatus for plugging well bores and more particularly relates to apparatus particularly suited to be passed through a well tubing of small diameter and form a well plug in a bore of much larger diameter below the tubing.

It has been previously proposed to provide a plugging apparatus in the nature of an inverted umbrella which may be lowered into a well bore in closed position and then expanded to conform with the walls of the well bore for support of a cementitious plugging material. Such apparatus has been constructed of fabric attached to expandable stays or ribs and also constructed of petal-like stays or ribs designed to overlap when in compression and to remain overlapped when expanded to the well bore walls.

These prior devices have produced satisfactory results when lowered into an open well bore of continuous diameter and expanded at a particular depth to provide the plug. There have been some disadvantages, however, in that the umbrella structure sometimes failed to fully conform to the walls of the well bore and some of the cementitious or stemming material was permitted to leak by. Further, such structures are not suitable to be lowered through well tubing of small diameter when the plug is required in the well bore of larger diameter below the tubing.

It is therefore the object of this invention to provide apparatus which may be retracted to a diameter sufficiently small to be lowered through a well tubing and which then may be expanded into conforming contact with a well bore of much larger diameter.

It is another object of this invention to provide plugging apparatus which will insure a positive seal with the well bore and which will prevent leakage of plugging material past the apparatus.

Another object of this invention is to provide plugging apparatus within which cementitious or other suitable plugging material may be carried and deposited above the plugging apparatus when the same has been extended into sealing position.

Another object of this invention is to provide plugging apparatus which may be seated within a well casing or within an open bore of a well.

It is another object of this invention to provide plugging apparatus which, when seated within a well bore, is retained against movement responsive to fluid pressure from either above or below the apparatus.

A further object of this invention is to provide plugging apparatus which may be lowered through well tubing or through well casing into a well bore and then automatically seated in the bore and covered with a body of fluid cementitious plugging material upon remote actuation from the earth's surface.

Other objects and advantages will become more apparent from study of the following detailed description taken in conjunction with the accompanying drawings in which:

FIGURES 1 and 1*a* are sectional views of the lower and upper portions respectively of the plugging apparatus in retracted position for lowering into a well bore.

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1.

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 1.

FIGURE 4 is a view, partly in section, through the well bore with a somewhat schematically shown plugging apparatus seated therein and covered by cementitious material.

Now referring to the drawing, there is illustrated a well bore 10, in which is disposed in cemented relation a casing 12. Mounted within casing 12 is a well tubing 14 which is connected to a production type packer element 16. Packer 16 seals the well casing 12 from passage of fluids above and below the packer. FIGURE 4 shows the plugging apparatus of the present invention seated in the casing below the tubing 14.

Referring to FIGURES 1–3, a container member 18, herein referred to as a bailer tube, is suspended for lowering through tubing 14, into casing 12, by means of a conductor type logging cable 20.

A projectile plug assembly 22 is compressed and retained within a plug retainer tube 24. Retainer tube 24 is attached to the bailer tube 18 by means of an adapter sleeve 26. A bottom plug 28 closes the lower end of retainer 24.

The plug assembly 22 includes a support rod 30 on which is attached a packer member 32 supported in fixed relation by means of a support ring 36. Supported in radial relation around the outer surface of packer member 32 are a plurality of support stays or ribs 34. Stays 34 may be individually attached to the support ring 36.

Packer member 32 as provided herein is a sponge-like material having fluid communication between its cellular pores and its exterior in order that fluids may enter or leave the individual cells as the packer is compressed or allowed to expand. Packer member 32, as shown in FIGURES 1 and 4, has a generally circular cup-like shape with the cup interior facing upwardly. At times the cup configuration has been substituted by a packer member of generally cylindrical shape. However, it has been found that the cup shaped member is somewhat superior in that the material removed from the bowl of the cup need not be compressed when the packer member is compressed into the plug retainer tube 24 and also, when less cellular material needs to be compressed, the cellular body may be made of tougher material.

Plug assembly 22 also includes a retaining anchor member assembly 38 connected to the support rod 30 above the packer member 32. Included within the retainer member 38 is a lower thrust spring retainer 40 connected in fixed relation to support rod 30. Retainer 40 supports the lower end of a lower thrust spring 42 mounted in slidable relation on support rod 30. Above thrust spring 42 is a lower thrust member 44 mounted on support rod 30.

Connected to support rod 30 above thrust member 44 is an anchor body 48. Connected in hinged relation to anchor body 48 are a plurality of lower anchor arms 46. Anchor arms 46 are sharpened at their extremities for purposes later described. Mounted in hinged relation to the upper end of anchor body 48 are a plurality of upper anchor arms 50. The extremities of anchor arms 50 are likewise sharpened.

An upper thrust member 52 is disposed in slidable relation on support rod 30 above anchor arms 50 and provides a support for the lower end of an upper thrust spring 54. Thrust spring 54 is supported at its upper end by an upper thrust spring retainer 56. Retainer 56 is supported in fixed relation to support rod 30.

Upper retainer 56 also serves as a lower support for a plug assembly ejection spring 58. Ejection spring 58 is supported by and connected at its upper end to adapter sleeve 26. Disposed in slidable relation within adapter sleeve 26 is an ejection piston 60. Piston 60 is connected to the upper end of support rod 30.

Piston 60 is retained within adapted sleeve 26 and ejection spring 58 is maintained in compressed relation by

means of a release member 62 and by means of support screw 64.

Release member 62 is preferably provided of some strong yet frangible material that may be broken up upon impact to release the piston 60. Various plastics have been found suitable for construction of release 62. Enclosed within or in proximity to release member 62 is an electrically actuated explosive release squib 66. Squib 66 as provided, upon application of electrical current through electrical conductors shown at 68, explodes to shatter member 62. Conductors 68 are passed upwardly through the bailer tube 18 and are electrically connected at their upper end to the conductors of the housing cable 20.

O-rings or similar seals are provided between plug 60 and adapter sleeve 26 so as to contain a cementitious material 70 within the bailer tube 18. This cementitious material is normally or desirably a slurry or fluid form of cement. Provided near the upper end of bailer tube 18 is a fluid displacement port 72. The purpose of port 72 is to allow filling of the tube 18 with cement 70 and also to allow well fluids to enter and displace the cement 70 as the same falls through the bottom of bailer tube 18 as later described.

In operation, the tool is assembled as shown in FIGURES 1 and 1*a* and the bailer 18 filled with cement through the port 72. The tool is thereon lowered through the tubing 14 and packer 16 to a level within the well bore 10 where establishment of a plug is desired.

This level may be below a particular formation which is to be tested or produced and may be either in an open hole or within casing such as shown in FIGURE 4, In the event the level is established in casing the plug may be set below a zone perforated for production or a zone to be perforated for production.

Electrical current is then transmitted from the earth's surface through cable 20 and squib leads 68 to release squib 66. Squib 66 is thereby detonated and shatters the release member 62, releasing piston 60 from support within the adapter sleeve 26.

With release of piston 60, the projectile plug assembly 22 is accelerated downwardly responsive to expansion of ejection spring 58 so that the entire projectile plug assembly 22 is ejected clear of retainer tube 24 with considerable velocity. This velocity is sufficiently great that all the anchor body portion 48 of the projectile plug assembly, together with associated anchor arms 46 and 50, is effectively ejected clear of retainer tube 24 before the anchor arm distal ends, moving outwardly responsive to the force of thrust springs 42 and 54 on the anchor arms 46 and 50 respectively, can engage the well casing 12.

When removed from retainer tube 24 the packer member 32 expands into intimate contact with the inner surface of casing 12. If provided, the support stays 34 also expand into contact with casing 12. When so expanded, stays 34 provide a basket-like support to the lower surfaces of the packer member 32. Though the stays are not required in the operation of the present invention, their provision enhances the sealing action of packer member 32 by providing additional strength to member 32 in withstanding pressures applied above member 32.

As the retaining anchor assembly is ejected from the retainer tube 24, the thrust springs 42 and 54 expand between their respective spring retainers and thrust members and urge the thrust members into contact with the upper and lower anchor arms 46 and 50. The anchor arms 46 and 50 are thus driven by the members 44 and 52 about their hinged connections with retainer body 48 into contact with well casing 12. The sharpened ends of the anchor arms 46 and 50 are provided to bite or dig into casing 12 and support the support rod and the elements connected thereto into rigidly fixed relation in respect to the casing 12.

As the piston 60 is ejected from the retainer tube 24, the cement 70 within bailer tube 18 passes from the lower end of tube 24 and flows over the packer member 32 and around the retainer anchor assembly 38.

The cement is allowed to set before the plug is pressure tested. The retaining anchor assembly 38 continues to hold the entire assembly 22 in fixed immovable relation during and after the setting of cement 70. The various rigid elements including anchor assembly 38 and support rod 30 further serve to provide reinforcement to the plug so established after the cement has set.

It is pointed out that the packer member 32 as herein provided is adapted to be compressed into an extremely small diameter during its retention in the retainer tube 24 and to expand into a large diameter then released. For example, as herein provided, the retainer tube 24 may be of one and seven-tenths inch outside diameter for passage through tubing having a two inch inside diameter. Upon release from retainer tube 24, packer member 32 is adapted to expand into sealing engagement with well casing having seven to nine inches internal diameter.

Of the elastic cellular and open celled materials provided for packer member 32, materials of the polyester family have been found most useful. An example material for packer member 32 as herein disclosed is polyester-urethane. Flexible silicone base materials have also been tried and found fairly satisfactory with exception that their tear strengths are somewhat less than those of the polyester group. It is foreseen in certain situations that the packer member 32 could be formed of natural sponge. As used herein and in the appended claims the terms "cellular" or "sponge-like" will define a member formed of materials having the characteristics generally described above.

The primary purpose for providing packer member 32 of porous nature is to allow filling of the cells of the member as it expands within a liquid. It is thus slightly permeable, when set as illustrated in FIGURE 4, to passage of clean fluids within the casing 12. However, packer member 32 is invariably used with cementitious materials which is either of considerable viscosity or more usually a suspension of very fine cement particles in water. Flow of such viscose fluids through member 32 has been found to be negligible and flow of cement slurries through the member has been found very nearly nil since such slurries form an impermeable filter cake adjacent to any porous member as the filtrate from such slurry tends to enter the porous member.

It is to be understood that various changes and alterations may be made in the details of the illustrated embodiment of this well plugging apparatus without departing from the scope of the appended claims or the spirit of the present invention.

That being claimed is:

1. In an apparatus for plugging a well bore, a projectile plug assembly comprised of an elongated member having a number of means spaced successively therealong having latching, sealing, retaining and packing functions respectively, an elongated tubular body having said projectile plug assembly housed therein, said means having said latching function functioning to fix said projectile assembly in said body and adapted in response to a signal to release said projectile assembly, biased means in interposed relationship to portions of said body and assembly, a reservoir defined in said body and closed at one end by said means having said sealing function, said means having said packing function being comprised of compressible material normally restrained in a compressed cylindrical shape having substantially uniform cross-sectional area and in coextensive contiguity with a portion of said member by said body, said means having said retaining function being normally restrained against outward bias and in generally coextensive adjacency to a portion of said member by said body, said projectile assembly adapted, when released responsive to

said signal, to be thrown from said body by said biased means to thereby open said reservoir and enable said normally restrained means having said packing and retaining functions to expand radially of said member to respectively assume a generally cup shape and a generally radial extending attitude with respect to said member, said normally restrained means when so radially expanded in a bore hole being respectively adapted to enable said projectile assembly to effectively plug said bore hole and to fix the same therein.

2. In an apparatus for plugging the well bore: a projectile plug assembly comprised of an elongated member having a number of means placed successively therealong having latching, sealing, retaining and packing functions respectively; an elongated tubular body having said projectile plug assembly housed therein; said means having said latching function functioning to fix said projectile assembly in said body and adapted in response to a signal to release said projectile assembly; a coil spring biased between and in co-axially disposed relationship to portions of said body and assembly; a reservoir defined in said body and closed at one end by said means having said sealing function; said means having said packing function being comprised of compressible material normally restrained in a compressed generally cylindrical shape having substantially uniform cross-sectional area and in coextensive contiguity with a portion of said member by said body; said means having said retaining function being normally restrained against outward bias and in generally coextensive adjacency to a portion of said member by said body; said projectile assembly adapted, when released responsive to said signal, to be thrown from said body by said coil spring to thereby open said reservoir and enable said normally restrained means having said packing and retaining functions to expand radially of said member to respectively assume a generally cup shape and a generally radial extending attitude with respect to said member, said normally restrained means when so radially extended in a borehole being respectively adapted to enable said projectile assembly to effectively plug said borehole and to fix the same therein.

3. In an apparatus for plugging a well bore: a projectile plug assembly comprised of an elongated member having a number of means spaced successively therealong having latching, sealing, retaining and packing functions respectively; an elongated tubular body having said projectile plug assembly housed therein; said means having said latching function functioning to fix said projectile assembly in said body and adapted in response to a signal to release said projectile assembly; biased means in interposed relationship to portions of said body and assembly; a reservoir defined in said body and closed at one end by said means having said sealing function; said means having said packing function being comprised of compressible material normally restrained in a compressed generally cylindrical shape having a substantially uniform cross-sectional area and in coextensive contiguity with a portion of said member by said body; said means having said retaining function being normally restrained against outward bias and in generally coextensive adjacency to a portion of said member by said body and comprising a number of arms pivotally connected with said member and a number of biased coil springs coaxially disposed with respect to said member and providing said arms with bias for radial movement with respect to said member; said projectile assembly adapted, when released responsive to said signal, to be thrown from said body by said biased means to thereby open said reservoir and enable said normally restrained means having said packing and retaining functions to extend radially of said member to respectively assume a generally cup shape and a generally radial extending attitude with respect to said member; said normally restrained means when so radially extended in a borehole being respectively adapted to enable said projectile assembly to effectively plug said borehole and to fix the same therein.

4. In an apparatus for plugging a well bore: a projectile plug assembly comprised of an elongated member having a number of means spaced successively therealong having latching, sealing, retaining and packing functions respectively; an elongated tubular body having said projectile plug assembly housed therein; said means having said latching function functioning to fix said projectile assembly in said body and adapted in response to a signal to release said projectile assembly; biased means in interposed relationship to portions of said body and assembly; a reservoir defined in said body and closed at one end by said means having said sealing function; said means having said packing function being comprised of compressible material having a permeable cellular internal structure normally restrained in a compressed generally cylindrical shape having substantially uniform cross-sectional area and in coextensive contiguity with a portion of said member by said body; said means having said retaining function being normally restrained against outward bias and in generally coextensive adjacency to a portion of said member by said body; said projectile assembly, adapted when released responsive to said signal, to be thrown from said body by said biased means to thereby open said reservoir and enable said normally restrained means having said packing and retaining functions to extend radially of said member to respectively assume a generally cup shape and a generally radial extending attitude with respect to said member; said normally restrained means when so radially extended in a borehole being respectively adapted to enable said projectile assembly to effectively plug said borehole and to fix the same therein.

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