June 11, 1968 J. H. CURRENT 3,387,659

VALVED WELL PACKER AND SETTING TOOL THEREFOR

Filed Feb. 23, 1966 4 Sheets-Sheet 1

Fig. 1

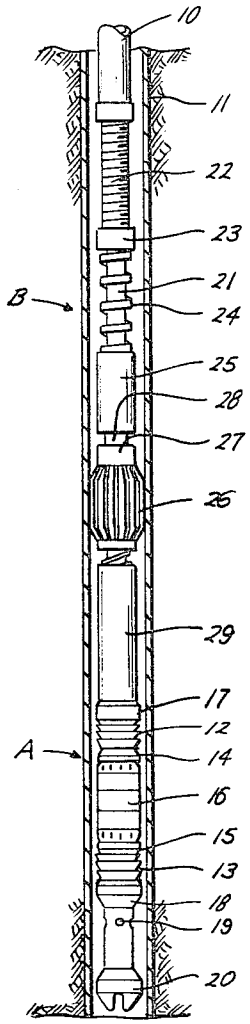


Fig. 5

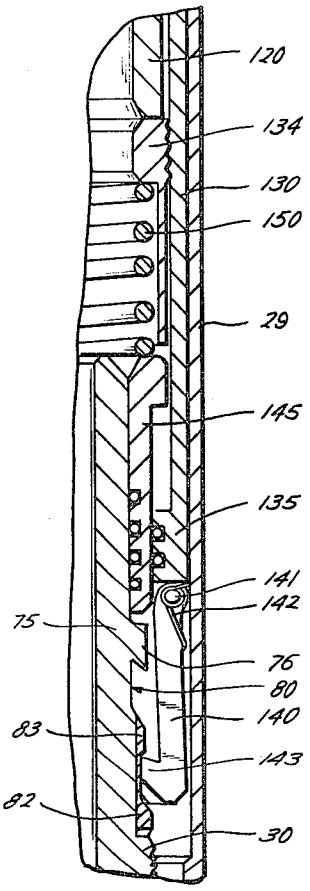
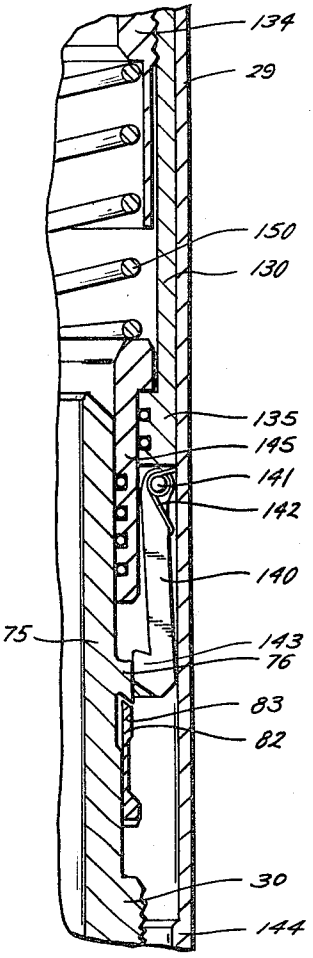


Fig. 6



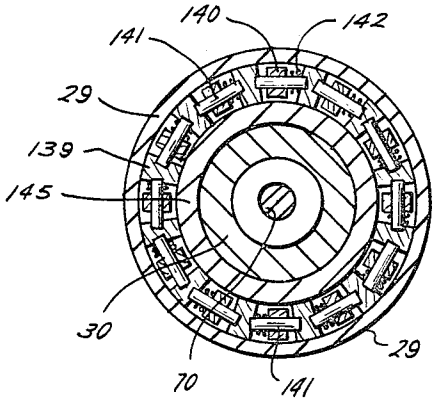


Fig. 7

James H. Current
INVENTOR.

June 11, 1968 J. H. CURRENT 3,387,659

VALVED WELL PACKER AND SETTING TOOL THEREFOR

Filed Feb. 23, 1966 4 Sheets-Sheet 2

Fig. 2A

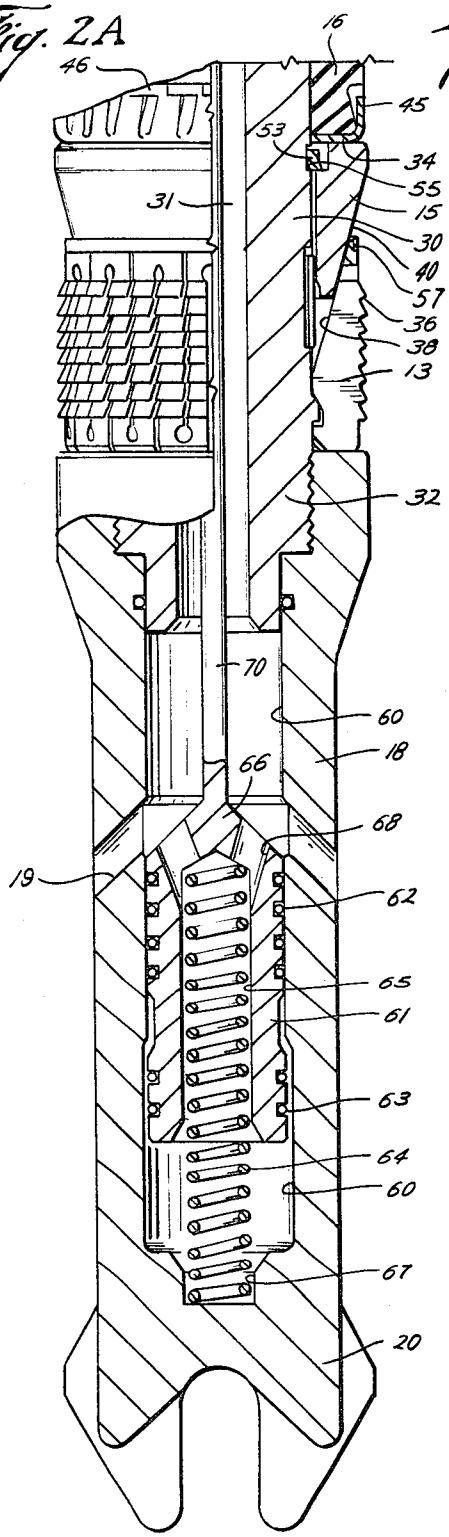
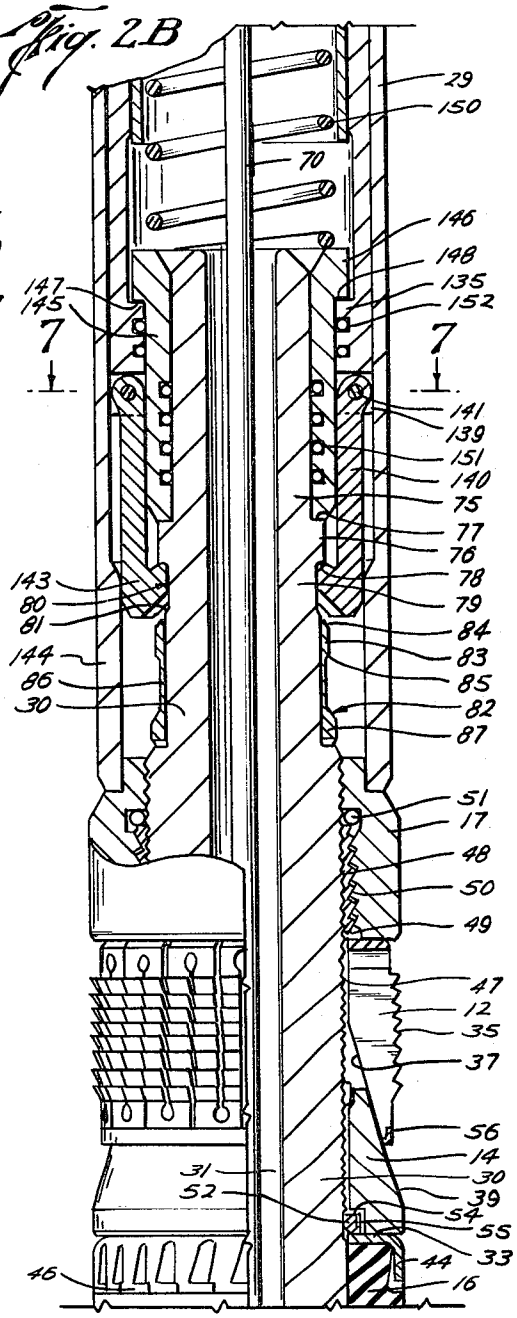


Fig. 2B



James H. Current
INVENTOR.

June 11, 1968 J. H. CURRENT 3,387,659

VALVED WELL PACKER AND SETTING TOOL THEREFOR

Filed Feb. 23, 1966 4 Sheets-Sheet 3

Fig. 3A

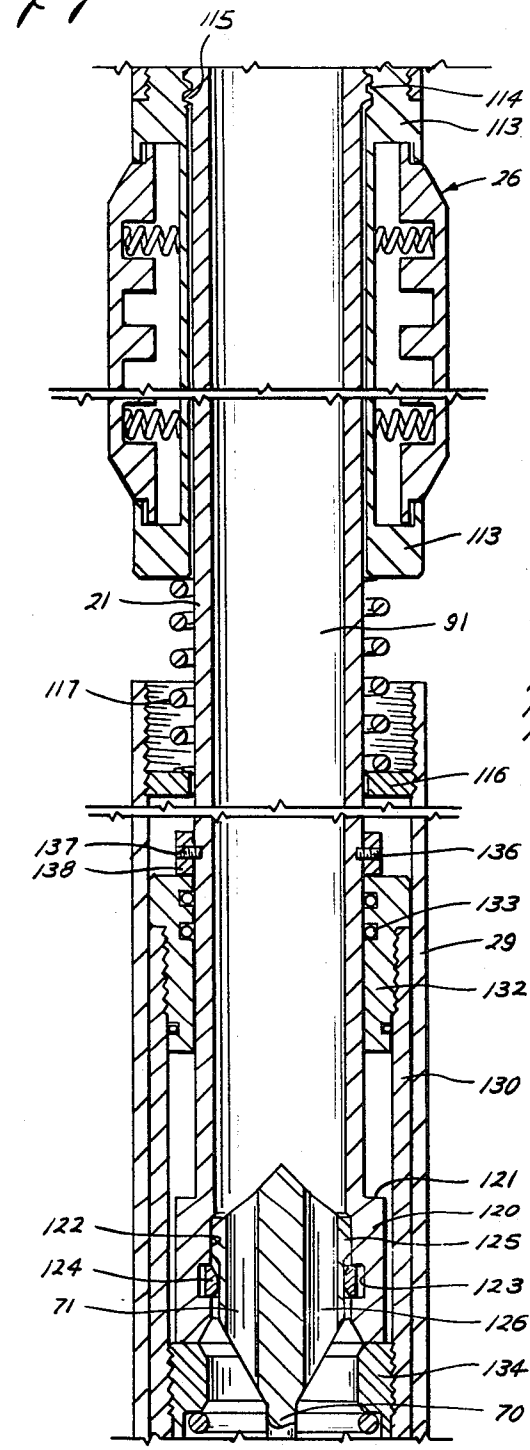
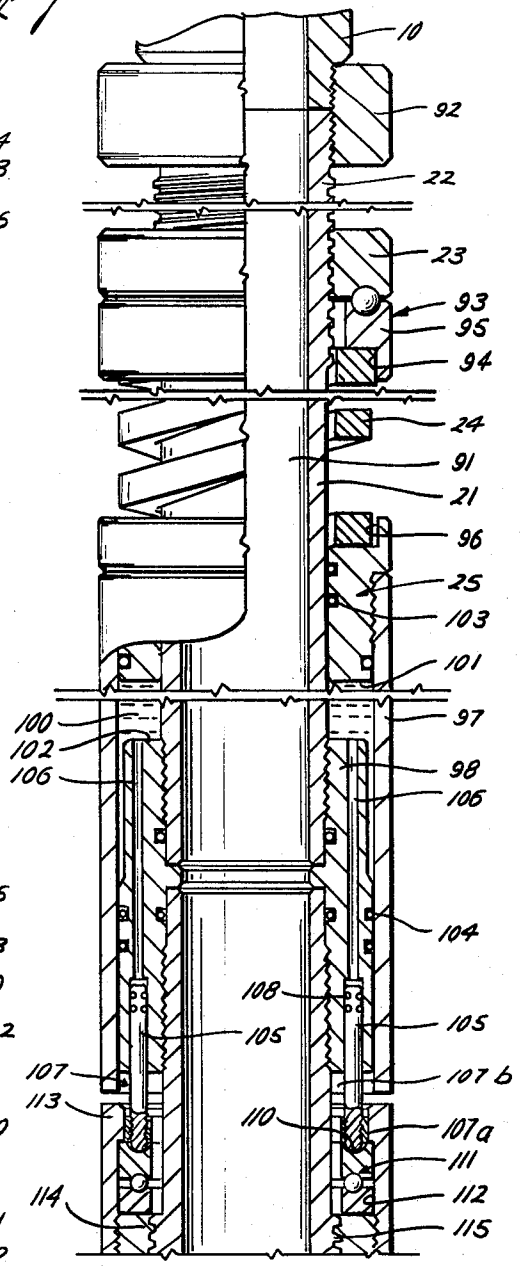


Fig. 3B



James H. Current
INVENTOR.

June 11, 1968 J. H. CURRENT 3,387,659

VALVED WELL PACKER AND SETTING TOOL THEREFOR

Filed Feb. 23, 1966 4 Sheets-Sheet 4

Fig. 4A

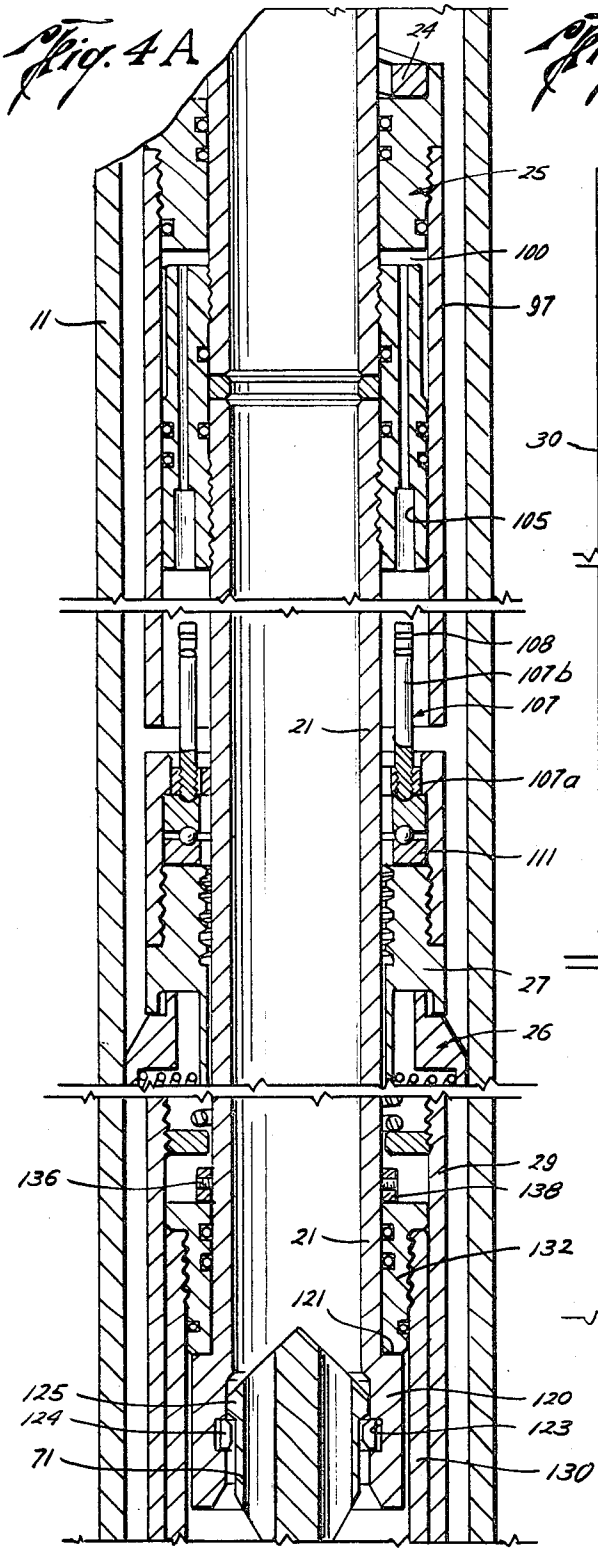
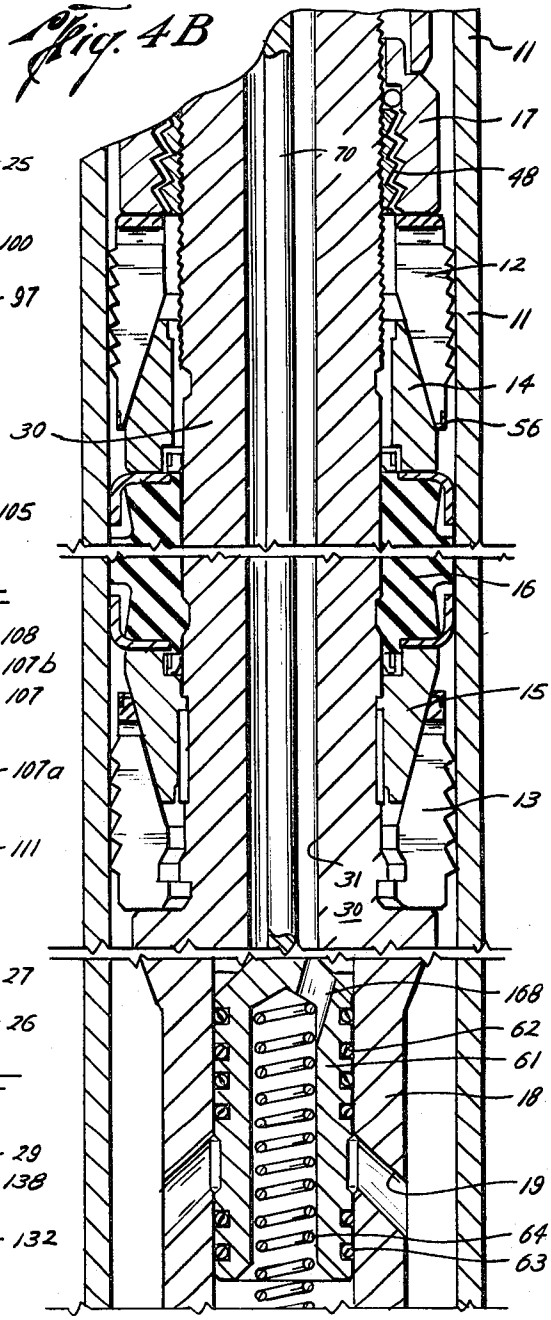


Fig. 4B



James H. Current
INVENTOR.

United States Patent Office 3,387,659 Patented June 11, 1968

3,387,659

VALVED WELL PACKER AND SETTING TOOL THEREFOR

James H. Current, Houston, Tex., assignor to Schlumberger Well Surveying Corporation, Houston, Tex., a corporation of Texas

Filed Feb. 23, 1966, Ser. No. 529,539
13 Claims. (Cl. 166—125)

ABSTRACT OF THE DISCLOSURE

A cement retainer packer and setting tool including a body member having a flow passage and valve means for opening and closing the flow passage, anchors and packing for providing an anchored pack-off in a well conduit, a valve actuator extending through said flow passage to a location above said body member, operating means releasably coupled to said actuator and sealingly engaging said body member, and means on said operating means including a structure releasably connected to said body member for applying oppositely directed setting force to expand said anchors and packing, whereupon vertical motion of the operating means can be utilized to effect corresponding motion of said valve means to open and close said flow passage as well as eventual release of said structure from the body member.

This invention relates generally to subsurface well tools and, more particularly, to well tools usable in cementing operations.

To place cement behind the well conduit such as a casing or liner, a type of well packer commonly known as a cement retainer may be set by a setting tool into the pack-off condition at a selected point in the well conduit. Cement slurry is displaced under pressure down through tubing or drill pipe and the cement retainer into open hole below the conduit or through conduit perforations. The retainer packs off the annular space between the conduit and the tubing or drill pipe and wall-engaging anchors hold the retainer against upward or downward movement in the well. Such retainers generally employ some type of valve to retain the back pressure of cement slurry which has been displaced therebelow.

It has become increasingly desirable to perform multiple operations, where applicable, with a minimum number of round trips and preferably with only one trip into the well. For example, it is often desirable to perform completion or remedial operations such as fracturing acidizing, squeeze cementing or testing in a formation zone above the cement retainer upon completion of the above-mentioned cement operations. In the past, well tools for performing such a variety of operations have not been compatible to an extent that they could be used conjunctively and the drill pipe or tubing must be removed from the well any number of times to permit change of tools, resulting in the loss of valuable rig time.

The present invention, in one aspect, provides a new and improved apparatus which is particularly adapted for cementing jobs, yet which is compatible with, and capable of conjunctive use with, other commercially available well tools whereby multiple completion or workover operations can be performed in a single trip into the well.

It is also desirable that cement retainers of the type described include valving which is open while lowering into a fluid-filled well conduit so that ample bypass area is provided for the passage of fluids past the cement retainer packing element, thereby permitting fast run-in speeds and preventing the development of abnormal and possibly damaging differential pressures across parts of the apparatus. The valve element should also be operable

in a manner which permits pressure testing of the tubing or drill pipe for leaks prior to the performance of cementing operations, and which is eventually operable to convert the cement retainer to a permanent bridge plug which can hold pressure differentials acting from either below or above upon completion of the cement job.

The present invention is accordingly directed to a new and improved cement retainer including a valve arrangement which incorporates the foregoing desirable features.

Another desirable feature in well tools of the type described resides in providing a setting device cooperable with a cement retainer for setting the cement retainer in a pack-off condition in a well conduit, the setting tool being self-contained and including a source of stored energy capable of doing the work required for such setting. For simplicity, the setting tool should be mechanically operated by means responsive to simple manipulation of the running-in string for releasing the stored energy. Thus constructed, the apparatus of the present invention is advantageously usable with companion fracturing, acidizing, squeeze cement and testing equipment including a removable center section which is generally in place when the equipment is lowered into the well conduit.

Accordingly, another aspect of the present invention concerns the provision of a new and improved setting device having energy storing means capable of doing the work required to set a cement retainer in a well conduit and which includes a mechanism responsive to simple manipulation of the running-in string to render the setting tool operable.

Another desirable feature in apparatus of the type described is that the setting tool be releasably coupled to the cement retainer in a manner percitting the establishment of circulation above the cement retainer if desired, with subsequent recoupling for further cementing operations, and eventual retrieval of the setting tool from the well conduit. Such uncoupling and recoupling can present numerous problems to the rig operator at the derrick floor, particularly in deep wells, unless some means is provided for giving a surface indication of the operation and relative position of the parts of the coupling mechanism with respect to the setting tool and cement retainer. Also, it is desirable that the operation of the coupling mechanism be responsive solely to up and down movement of the running-in string so that parts of the setting tool are not subjected to undue torsional stresses.

The present invention provides a new and improved setting tool which is releasably coupled to a cement retainer by a mechanism which permits any number of uncoupling and recoupling steps, the coupling mechanism including cooperating parts which render it possible for a surface indication to be given of the operation and relative position of the parts thereof and being responsive to longitudinal forces imparted thereto by up and down movement of the running-in string for actuation without rotation thereof.

Well tool apparatus in accordance with the present invention comprises a longitudinally passaged body which carries normally retracted slips and packing, the slips and packing being expandable to positions of engagement with a well conduit for providing an anchored pack-off in the anular space between the well conduit and the body. The body is releasably coupled to a setting tool which forms a lower continuation of a running-in string extending upwardly to the earth's surface.

Forming a lower portion of the body below the slips and packing element is a value housing having lateral ports through the wall thereof. A pressure-balanced sleeve valve is reciprocably mounted in the valve housing and is movable between positions either permitting or blocking

fluid flow through the body passage via the lateral ports. The valve element is provided with an actuator which extends upwardly through the flow passage to a location above the upper end of the body and terminates in a connector head.

A full-opening setting tool is provided for expanding the above-mentioned slips and packing into engagement with the well conduit. The setting tool includes a central operating mandrel which is coupled at its upper end to the running-in string. Means are provided for releasably coupling the lower end thereof to the retainer body, including a tubular member, a releasable latch mechanism between the tubular member and the body, and a slip joint connection between the tubular member and the operating member.

The latch mechanism includes a plurality of inwardly biased latch dogs which are cooperable with an annular latch ring on the body for coupling thereto, and are further cooperable with a release sleeve slidably disposed on the body below the latch ring for releasing the coupling therebetween upon relative movement between the tubular member and body. Coacting between the body and an abutment on the tubular member is a means, preferably a compressed spring, which is operable in response to a predetermined force to permit the relative movement between the tubular member and the body for releasing the latch mechanism. The operating mandrel is also releasably connected to the sleeve valve connector head and the limited amount of longitudinal movement permitted between the operating mandrel and tubular member by the slip-joint connection there-between is effective to move the sleeve value between the above-mentioned positions of either permitting or blocking fluid flow through the body passage via the housing ports.

Telescopically disposed about a lower portion of the mandrel is a setting sleeve which is movable relative to the mandrel and body for transmitting setting forces to the retainer during setting. Means are provided on the setting sleeve which are cooperable with the latch mechanism for locking the latch dogs against release, the means being rendered inoperable during expansion of the slips and packing element.

A setting spring is provided for applying forces to expand the slips and packing element into engagement with the well conduit. The spring is initially compressed, one end bearing against a tension nut on the operating mandrel and the other end bearing against a sleeve piston on the operating mandrel, and is held in its compressed condition by a friction drag mechanism which is threadedly coupled to the operating mandrel and which supports a valve element. The valve element initially closes a chamber formed by the sleeve piston and an annular head on the operating mandrel, the chamber containing a substantially incompressible fluid. Manipulation of the operating mandrel via the running-in string disengages the connection between the friction drag mechanism and the operating mandrel, permitting the valve element to open the chamber and thus release the energy stored in the compressed spring.

Means are provided for metering the flow of fluid from the chamber as the spring elongates to control the rate of elongation of the spring as it acts to drive the setting sleeve downwardly to expand the slips and packing element.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its structural organization and its operation, together with further aspects and advantages thereof, may be best understood by way of illustration and example of one embodiment when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view showing apparatus which embodies the present invention in connection with a well;

FIGS. 2A and 2B are longitudinal sectional views, partially in elevation, of the cement retainer embodying the present invention with its parts in the relative positions they will occupy while the apparatus is being run into a well conduit, FIG. 2A forming a lower continuation of FIG. 2B which forms a lower continuation of FIG. 3A to be described below;

FIGS. 3A and 3B are longitudinal sectional views of the setting tool embodying the present invention with its parts in the relative positions they will occupy while the apparatus is being run into a well conduit, FIG. 3A forming a lower continuation of FIG. 3B;

FIGS. 4A and 4B are longitudinal sectional views of the moving parts of the setting tool and cement retainer during expansion of the slips and packing element into engagement with the well conduit, parts of the apparatus being removed for purposes of clarity with respect to the operation of the device;

FIGS. 5 and 6 are fragmentary sectional views of the releasable coupling mechanism between the setting tool and cement retainer with parts shown in various positions of coaction during release of the coupling mechanism; and

FIG. 7 is a cross section taken on line 7—7 of FIG. 2B.

With particular reference to FIG. 1, apparatus which embodies the principles of the present invention includes a well packer A commonly known as a cement retainer which is releasably coupled to a setting tool B which forms the lower extension of a running-in string **10** extending upwardly to the earth's surface and on which the well packer and setting tool are suspended within a well conduit **11**. The cement retainer A generally includes a longitudinally-passaged tubular body which carries at each end portion thereof upper and lower slip elements **12, 13** operatively associated with frusto-conical expanders **14, 15**. An elastomeric packing element **16** is received between the expanders and the slips and packing element are expandable outwardly of the body to engate the well conduit upon relative movement of parts of the cement retainer.

A setting head **17** is carried by the body above the upper slip element and a generally tubular valve housing **18** is coupled to the lower end thereof, the valve housing having a plurality of ports **19** to provide fluid communication between the body passage and the exterior of the body below the slips and packing element. As will be described in detail hereafter, a valve element is movably disposed in the valve housing **18** and is adapted for selectively opening and closing the body passage to fluid flow therethrough. The lower end of the valve housing is closed by integral guide member **20**.

The setting tool B is operable to provide the setting forces required to expand the slips and packing element on the cement retainer A and generally includes an operating mandrel **21** which is coupled at its upper end to the running-in string **10** and means, to be particularly described hereinafter, are provided for releasably coupling the lower end thereof to the body of the cement retainer A. The operating mandrel has an upper portion **22** thereof externally threaded and receives a tension nut **23**. A compressed setting spring **24** is coiled around the operating mandrel below the tension nut and one end of the spring bears upwardly against the nut, the other end thereof bearing downwardly against a sleeve piston **25** which encloses a hydraulic chamber. Below the sleeve piston **25** is a friction drag mechanism **26** of typical construction, the drag mechanism including a housing **27** which is initially threadedly coupled to the operating mandrel **21**. The friction drag mechanism **26** supports a valve element **28** which normally coacts with a valve seat to close the above-mentioned chamber and a confined fluid in the chamber prevents elongation of the compressed setting spring **24**.

A setting sleeve **29** is slidably disposed about the lower portion of the operating mandrel **21**, the lower end thereof abutting the setting head **17** on the cement retainer A and the upper end thereof terminating a distance below the lower end of the friction drag mechanism housing **27**.

The cement retainer and associated setting tool are adapted for use in conjunction with an upper full bore retrievable packer (not shown) of the type illustrated in the 1960–61 Composite Catalogue of Oil Field Equipment and Services, vol. 2 page 3057. If so used, the running-in string 10 extends downwardly from such a retrievable packer to suspend the apparatus of the invention therebelow.

As shown in detail in FIGS. 2A and 2B, the cement retainer body 30 has a fluid passageway 31 therethrough. The body may be considered as being formed in two elements, namely a mandrel 32 and the tubular valve housing 18 threadedly coupled to the lower end of the mandrel. The mandrel 32 carries near each end portion thereof opposed, integral, expansible slip elements 12, 13 operatively engaged with frusto-conical expanders 14, 15. Positioned around the mandrel 32 and between the expanders is an annular elastomeric packing element 16, each end of the element being bonded to and confined within expansible, anti-extrusion rings 33, 34.

The slip elements 12, 13 each have a plurality of wickers or teeth 35, 36 formed on the peripheral surface thereof. The teeth are identical in shape but the teeth on the upper slip element 12 face upwardly to engage the well conduit and hold against upward movement and the teeth on the lower slip element 13 face downwardly to hold against movement in a downward direction. The slip elements each have inclined inner surfaces 37, 38 which coact with mating surfaces 39, 40 on the expanders 14, 15 to shift the slip elements outwardly of the body 30 upon relative movement therebetween.

Each slip element is made radially expansible by providing a first series of radially-cut slots 41 around the circumference thereof and providing a second series of like slots 42 alternately disposed between the first series, the slots extending from one end of each slip element to points 43 near respective opposite ends of each slip element. Although the slip elements are integrally formed, they have sufficient resiliency to be readily expanded into anchoring engagement with the well conduit wall.

The anti-extrusion rings 33, 34 include skirt portions 44, 45 having a series of imbricated fingers 46 with each finger being in overlapping relationship with the adjacent finger as shown in FIG. 2B. This particular design allows the fingers to flex radially outwardly as packing element 16 is foreshortened and expanded during setting, and thereby adapt themselves to the configuration of the well conduit. The overlapped relationship of the fingers is maintained during expansion of the packing element so that the skirt portions 44, 45 can be expanded without passages being formed therein through which portions the elastomeric packing 16 can cold flow under pressure.

An upper peripheral portion of mandrel 32 is provided with downwardly-facing ratchet teeth 47 which are cooperable with a body lock in the form of a split ratchet nut 48 received within an annular recess 49 in the setting head 17. The body lock permits the mandrel 32 to move upwardly with respect to the setting head 17 but prevents downward movement of the mandrel with respect to the setting head. The split ratchet nut 48 has a plurality of downwardly-diverging tapered surfaces 50 around the other periphery thereof which cooperate with complementarily tapered surfaces around the periphery or recess 49 in the setting head 17 to wedge the split ratchet nut more tightly against the mandrel when ever downwardly-directed forces are applied to the mandrel. An annular resilient member 51 within recess 49 maintains a biasing force on the split nut to force it downwardly around the mandrel and prevent backlashing as the nut rachets down on the mandrel during setting of the cement retainer in the well conduit.

The expanders 14, 15 are initially held in an inoperative position by expansible rings 52, 53 fitted tightly in circumferential grooves 54, 55 around the mandrel 32 and engaging the expanders. The upper expansible ring 52 and

both the slip members 12, 13 are encircled with expansible restraining bands 55, 56, 57 of predetermined strengths for releasably holding these members in their initial positions to allow various members of the cement retainer and setting tool to be selectively operated in response to setting forces of predetermined magnitudes.

As was previously mentioned, a tubular valve housing 18 forms a lower portion of the retainer body 30 below the slips and packing element. The valve housing 18 has a chamber 60 formed therein and is threadedly coupled to the lower end of mandrel 32, the lower end of the housing being closed by an integral guide member 20. A plurality of lateral ports 19 through the housing wall provided fluid communication between the body passageway 31 and the exterior of the cement retainer below the slopes and packing element. A valve element in the form of a tubular sleeve valve 61 is mounted for reciprocating movement within the chamber 60 and is movable between a first position shown in FIG. 2A wherein the lateral ports 19 are open to fluid flow therethrough and a second position shown in FIG. 4B wherein the lateral ports are sealably closed against fluid flow therethrough. Upper and lower O-rings 62, 63 or other suitable seal means are received in grooves around the periphery of the sleeve valve for sealing between the interior wall surface of the valve housing and the exterior of the sleeve valve above and below the lateral ports 19 when the valve is in the second position.

The upper end portion of a helical compression spring 64 is received within a central bore 65 of the sleeve valve 61 and bears against an upper end section 66 thereof and the lower end portion of the spring is received within a counterbore 67 at the lower end of the valve housing and bears against the integral guide member 20. The spring 64 is in a compressed condition when the sleeve valve is in the position shown in FIG. 2A and constantly tends to move the sleeve valve 61 upwardly within the valve housing chamber 60 to the above-mentioned second position wherein fluid flow through the body passageway 31 via the lateral ports 19 is blocked.

A plurality of pressure-balancing ports 68 extend through the end section 66 of the sleeve valve 61 to render the valve pressure balanced, e.g., the ports 68 permit fluid pressures in the spaces within the valve housing above and below the sleeve valve to equalize at all times so that no pressure differentials can exist across the valve which may tend to move it.

A valve actuator or stem 70 for positioning the sleeve valve 67 is integrally attached to the end section 66 thereof and extends upwardly through the body passageway 31 to a location above the upper end of the body 30, culminating in an enlarged connector head member 71 (FIG. 3A) which will be more fully described hereinafter.

The upper portion 75 of the body 30 above the upper slip element 12 is provided with means cooperable with a latch mechanism on the setting tool B for releasably coupling the cement retainer to the setting tool. An annular latch ring 76 is formed around the periphery of the upper portion 75 below the upper end thereof and has a substantially flat upper surface 77 and an inwardly and upwardly inclined lower surface 78. Immediately adjacent and below the latch ring 76 is a reduced diameter section 79 which provides an annular recess 80 around the periphery of the upper portion 75. The lower edge of the recess is downwardly-inclined to form an annular, beveled shoulder 81.

A tubular release sleeve 82 is slidably received on the upper body portion 75 below the latch ring 76 and has an upper section 83 of the same outer diameter as the latch ring. The upper section is formed such that the upper face 84 thereof is upwardly and inwardly inclined and the lower face 85 is downwardly and inwardly inclined. An intermediate section 86 of the release sleeve

82 is of relatively thin wall thickness to provide a recess between the upper section and a lower annular shoulder 87. The release sleeve is slidable between a position wherein the upper section 83 thereof is below the annular recess 89 as shown in FIG. 2B and a position wherein the upper section abuts the lower surface of the latch ring 76 as shown in FIG. 6. As will more fully appear hereafter, a latch means on the setting tool B is engageable with the latch ring 76 to releasably couple the setting tool to the body 30 and cooperable with the release sleeve 82 for disengaging the setting tool from the body.

Turning now to the setting tool B constructed in accordance with the present invention, attention is directed to FIGS. 3A and 3B. The setting tool includes a central operating mandrel 21 having a bore 91 therethrough and is coupled to the lower end of running-in string 10 by a connector sub 92. The bore 91 of operating mandrel 90 is substantially unrestricted to continue the full bore of the running-in string 10. An upper peripheral portion 22 of the operating mandrel below the connector sub is threaded and receives a tension nut 23. Below and abutting the nut member 23 is a ball thrust bearing 93 having a bore therethrough of greater diameter than the outer diameter of the threads on the operating mandrel 90.

A helical setting spring 24 is coiled around the operating mandrel 90. The upper end of the spring is received in an annular recess 94 in the lower portion of the bearing race 95 and bears upwardly against the nut member 23. The lower end of the spring bears against the annular sleeve piston 25 on the operating mandrel and is received within a recess 96 formed in the upper face thereof. It will be apparent that by threading the tension nut 23 downwardly on the operating mandrel, the setting spring 24 can be compressed or cocked, and in such compressed condition provides a means for applying the setting forces required to set the cement retaining A in the well conduit 11.

The sleeve piston 25 is slidably disposed about the operating mandrel 21 and is secured to a tubular skirt 97 extending downwardly over the exterior of an annular head member 98 formed intermediate the ends of the operating mandrel. The length of the skirt 97 is such as to provide a chamber 100 between the lower face 101 of the sleeve piston 25 and the upper face 102 of the annular head member 98. A plurality of O-rings 103–104 pressure seal the chamber 100 and the chamber is adapted to be filled with a suitable hydraulic fluid. Formed in a lower portion of the annular head member 98 are a plurality of circumferentially spaced, vertically extending bores 105, the bores providing valve seats which extend from the lower face of the head member upwardly to a point intermediate the length thereof. A plurality of vertical ports 106 are concentric with the bores 105 and provide fluid communication between the chamber 100 and the bores or valve seats 105.

A valve element indicated generally by the numeral 107 is cooperable with the valve seats 105 for closing the chamber 100. The valve element has an annular base 107*a* and a plurality of upwardly extending rods 107*b* integral with the base. Seal elements 108 are received in peripheral grooves in the rods 107*b* and fluidly seal between the rods and the walls of the valve seat 105. As shown in FIG. 3B, the valve element is in a position closing the chamber 100 so that the hydraulic fluid confined therein prevents downward movement of the sleeve piston 25 and skirt 97 relative to the operating mandrel 21. However, it will be appreciated that downward movement of the valve element 107 relative to the annular head member 98 will eventually remove the rods 107*b* from the valve seats 105 and open the chamber 100 so that the hydraulic fluid can be displaced therefrom by the force of the setting spring 24 bearing against the sleeve piston 25 and tending to move the sleeve piston downwardly. The total flow area through the ports 106 is preselected so that the flow therethrough is metered and the rate of travel of the sleeve piston 25 responsive to downwardly-directed forces applied thereto by the setting spring 24 can be predetermined.

The valve element 107 is supported in its chamber closing position shown in FIG. 3B by a friction drag mechanism indicated generally by the numeral 26. The friction drag mechanism is of typical construction and need not be described in detail. The annular base 107*a* of the valve element abuts against a ball thrust bearing 111 which is received in an annular recess 112 in the friction drag mechanism. The housing 113 of the friction drag mechanism 26 has a bore therethrough which is sized to be slidably received on the operating mandrel 21 and an upper internal portion of the housing 113 is provided with suitable left-hand threads 114 which engage complementary threads 115 on a peripheral portion of the operating mandrel 21. The threaded engagement between the housing and the operating mandrel acts to initially hold the valve element 107 in its chamber closing position and thus the setting spring 24 in its compressed condition. The friction drag mechanism will function to frictionally hold the housing 113 against rotational movement in the well conduit 11 so that rotation of the operating mandrel via the running-in string will disengage the threaded connection between the housing and the operating mandrel. As the threaded connection is thus disengaged, the friction drag mechanism 26 will move downwardly with respect to the annular head 98 and allow fluid pressure with the chamber to unseat the valve element 107 and thereby open the chamber 100 and permit elongation of the setting spring 24.

The hydraulic system comprising the sleeve piston 25, head 98 and valving 105, 107 has two primary functions. First, inasmuch as the flow of hydraulic fluid from the chamber 100 is metered as previously described, the rate of elongation of the setting spring 24 is controlled so that shock loads are not applied to the cement retainer parts during setting. Secondly, the axial load on the threaded connection between the drag housing 27 and the operating mandrel 21 is made small relative to the spring force exerted by the compressed setting spring 24 so that release of the threaded connection can be readily accomplished. The spring force will act to generate a predetermined fluid pressure in the chamber 100 and the effective area of the rods 107*b* is sufficiently small that a greatly reduced force is transmitted by the valve element to the drag housing and consequently to the threaded connection.

The tubular setting sleeve 29 is positioned for sliding movement over the operating mandrel 21 below the friction drag mechanism 26. The upper end of the setting sleeve is disposed a distance below the lower end of the friction drag mechanism housing 113 to permit sufficient relative movement of the housing with respect to the operating mandrel 21 so that the threads 114, 115 therebetween can be disengaged. The lower end of the setting sleeve abuts against the setting head 17 carried on the retainer mandrel 32, and the setting sleeve provides a means through which downwardly-directed setting forces are transmitted to the setting head for expanding the retainer slips and packing element. Intermediate the ends of the setting sleeve 29 is an inwardly-extending annular flange 116 adapted for sliding movement over the operating mandrel 21 and a suitable coil spring 117 is positioned between the upper face of the flange and the lower end of the friction drag mechanism housing 113. The spring 117 is comparatively weak but exerts a sufficient biasing force downwardly on the setting sleeve so that it will continuously abut the setting head 17 until such time as the cement retainer has been permanently set in the well conduit.

The operating mandrel 21 has provided at the lower end thereof a section 120 of increased wall thickness forming an upwardly-facing annular shoulder 121 as shown in FIG. 3A. Internally of the section 120 is a

counterbore 122 which is sized to receive the connector head 71 on the upper end of the sleeve valve actuator 70. Intermediate the length of the counterbore 122 is an annular groove 123 which receives a split snap ring 124, the snap ring cooperating with an annular cam ring 125 on the connector head 71 to provide a releasable connection between the operating mandrel 21 and the sleeve valve actuator 70. As shown in FIG. 3A, the connector head 70 has a plurality of vertical flow ports 126 therethrough providing ample flow area for the passage of fluids bidirectionally through the bore 91 of the operating mandrel 21 and the passageway 31 in the cement retainer body 30.

A tubular member 130 is slidably received about the operating mandrel 21 intermediate the operating mandrel and setting sleeve 29. An upper section of the tubular member 130 is of increased wall thickness to provide an upper, inwardly extending flange 132 and the lower section thereof is likewise of increased wall thickness to provide a lower, inwardly extending flange 135 (FIG. 2B). Seal elements 133 fluidly seal the upper flange 132 with respect to the outer surface of the operating mandrel 21. Intermediate the length of the tubular member 130 is an inwardly extending abutment ring 134 and the enlarged section 120 on the lower end of the operating mandrel 21 is received between the abutment ring 134 and the upper flange 132 of the tubular member 130. The upper face of the abutment ring 134 and the lower face of the upper flange 132 are spaced apart a distance greater than the vertical length of the enlarged section 120 on the operating mandrel 21 to provide a slip-joint type connection between the operating mandrel and the tubular member. Thus joined, a limited amount of relative longitudinal movement is permitted between the operating mandrel 21, to which the valve actuator 70 is connected, and the tubular member 130 which is releasably coupled to the retainer body 30, for moving the sleeve valve 61 between its flow permitting or blocking positions as described heretofore.

A frangible pin member 136 which is received within pin holes 137 in the operating mandrel 21 and a lug 138 integral with the tubular member 130 acts to initially secure the operating mandrel in the lower position relative to the tubular member so that the sleeve valve 61 is maintained in a position within valve housing 18 whereby fluid communication is established between the running-in string 10 and the space below the cement retainer A via the operating mandrel bore 91, the retainer body passageway 31 and the valve housing port 19. In this manner, the running-in string 10 is open to the passage of well bore fluids therethrough during downward shifting of the apparatus within the well conduit 11. As will appear more fully hereinafter, the pin member 136 is sheared during setting of the cement retainer in the well conduit and the limited amount of relative longitudinal movement permitted between the operating mandrel 21 and the tubular member 130 by the slip joint connection therebetween permits opening or closing the sleeve valve 61, once the cement retainer A is in a set condition, by imparting an up or down movement to the running-in string 10 at the earth's surface.

A plurality of circumferentially spaced legs 139 extend downwardly from the lower inwardly extending flange 135 and a plurality of latch fingers or dogs 140 are pivotally mounted between the legs of a plurality of pins 141 which are received in the legs 139 as shown in FIGS. 2B and 7. Torsion springs 147 or other suitable biasing means cooperate with each of the latch fingers or dogs 140 to bias them inwardly toward the longitudinal axis of the operating mandrel 21. Each latch finger or dog 140 has an enlarged head portion 143 which extends inwardly and engages in the annular recess 80 below the latch ring 76 on the retainer body 30. The upper faces of the enlarged head portions are upward and inwardly inclined and engage the complementary lower surface of the ring 76 to couple the setting tool B and the cement retainer A together. An inwardly extending portion 144 on the setting sleeve 29 is initially adjacent the latch dogs 140 and locks them in a latched position.

Telescopically arranged on the upper portion of the body 30 above the latch ring 76 is a sleeve member 145 having an annular flange 146 at its upper end providing a downwardly-facing shoulder 147 which abuts an upwardly-facing shoulder 148 on the tubular member 130. Suitable sealing elements 151, 152 fluidly seal the interior and exterior of the sleeve 145 with respect to upper portion 75 of the body 30 and the inwardly extending lower flange 135 on the tubular member 130 respectively. Interposed between the upper end of the sleeve member 145 and the lower face of the annular abutment ring 134 on the tubular member 130 is a compressed helical spring 150. The spring is compressed when the parts are assembled as shown in FIGS. 2B and 3A so that a predetermined downward force must be exerted via the operating mandrel 21 and abutment ring 134 on the tubular member 130 before there will be any downward movement of the tubular member with respect to the upper portion 75 of the retainer body to move the latch fingers or dogs 140 downwardly. As will appear more fully hereinafter, the compressed spring 150 makes it possible for the rig operator to have a surface indication of the position of the latch fingers 150 during disengagement or engagement of the setting tool and cement retainer.

In operation, the parts are assembled as shown in FIGS. 2 and 3 and the chamber 100 formed on setting tool B is filled with a suitable hydraulic fluid. The valve element 107 acts to close the chamber and the threaded connection between the drag mechanism housing 27 and the operating mandrel 21 prevents relative movement therebetween and maintains the valve in the closed position. The potential energy capable of doing the work required to set the cement retainer A is then stored in the setting spring 24 by threading the tension nut 23 downwardly on the operating mandrel to compress the spring a predetermined amount. Of course, it will be appreciated that any selected one of a range of setting forces may be delivered by the setting spring 24 depending upon the amount of downward threading of the tension nut on the operating mandrel. When compressed, the spring 24 will tend to move the sleeve piston 25 downwardly but such movement is precluded by the confined fluid within the chamber 100.

The setting tool B and cement retainer A are then connected to the running-in string 10 and shifted downwardly in the well conduit 11 to a predetermined setting point. During such downward shifting, whatever fluids may be in the well conduit can pass through the body 30 and into the running-in string inasmuch as the ports 19 in the valve housing 18 are above the upper seal on the sleeve valve 61. This relative position of parts is maintained by the frangible pin connection at 136 between the operating mandrel, to which the valve actuator 70 is connected by the connector head 71, and the tubular member 130, to which the retainer body and valve housing are connected.

When desired, the setting tool B is actuated to set the cement retainer A by merely rotating the running-in string 10 a few turns to the right. The cooperative relationship of parts during actuation of the setting tool for expansion of the slips and packing element is illustrated in FIGS. 4A, 4B. Since the friction drag mechanism 26 is frictionally held against rotational movement by engagement with the well conduit 11, the threaded connection between the friction drag housing 27 and the operating mandrel 21 is disengaged by the aforementioned rotation of the running-in string and such disengagement causes the friction drag mechanism to move downwardly relative to the operating mandrel, thereby permitting the valve element 107 to withdraw from the recess or seat 105 and open the chamber 100. With the chamber open and the fluid therein no longer confined, the setting spring

24 is permitted to elongate, forcing the sleeve piston 25 downwardly and pumping the hydraulic fluid from the chamber 100. Since the flow of hydraulic fluid from the chamber 100 is metered as previously described, the rate of elongation of the setting spring is controlled, thereby controlling the rate of movement of the movable parts of the cement retainer A during setting so that no shock setting loads are applied to the apparatus.

As the chamber 100 contracts, the skirt 97 moves downwardly over the operating mandrel 21 and abuts the friction drag mechanism housing 27 which in turn moves downwardly with respect to the operating mandrel to abut against the upper end of the setting sleeve 29 as shown in FIG. 4A. Further elongation of the setting spring will apply downwardly-directed setting forces to the setting head 17 on the cement retainer A and consequently to the upper slip element 12, the setting forces tending to move the slip element downwardly over the upper expander cone 15 and outwardly of the body 30.

The relative strengths of the various restraining bands 55, 56, 57 and of the shear members 136 are parameters which can be preselected in a manner to vary the operating sequence of the tools during setting. For example, the upper slip band 56 and the shear members 36 can be preselected such that the portion of the setting forces exerted by the setting spring 24 downwardly on the upper slip element and transmitted via the retainer body 30, latch ring 76 and latch dogs 140 to the tubular member 130 and consequently to the shear members 136 will cause the members to shear. In this manner, the tubular member 130 is released for downward movement over the operating mandrel 21 until the upper inwardly extending flange 132 on the tubular member abuts against the upper shoulder 121 on the enlarged section 120 of the operating mandrel. As the tubular member 130 moves downwardly, the retainer body 30, being releasably coupled thereto, also moves downward with respect to the sleeve valve actuator 70 which is coupled to operating mandrel, thereby permitting the lateral ports 19 in the valve housing 18 to be sealably closed by the sleeve valve 61. The arrangement of parts in advantageous in that the sleeve valve 61 automatically closes the housing ports 19 during setting of the cement retainer so that the running-in string 10 can be tested for leaks without further manipulation thereof. Of course, the setting spring 24 continues to elongate to apply setting forces to the slips and expanders and the packing element for relative movement therebetween.

Alternatively, the restraining band 56 and the shear members 136 may have preselected relative strengths such that the upper slip element 12 will be shifted outwardly to engage the well conduit and the pin member 136 may then be sheared by an upwardly directed force applied to the operating mandrel 21. In this case, the sleeve valve 61 can be moved upwardly with respect to the retainer body 30 to close the valve housing ports 19 by a sufficient upward movement of the running-in string 10. Of course, it will be readily appreciated that other operating sequencies are possible.

In either case, when the upper slip element 12 engages the well conduit 11, the upwardly-directed setting forces applied by setting spring 24 to the retainer body 30 via the tension nut 23, operating mandrel 21, tubular member 130, latch dogs 140 and latch ring 76 will cause upward movement of the retainer body 30 with respect to the anchored upper slip element 12 to effect outward shifting of the lower slip element 13 over its expander 15 into engagement with the well conduit 11. Also, the expanders 14, 15 will move relatively toward each other to axially compress and radially expand the elastomer packing element 16. When fully expanded, the body lock nut 48 acts to maintain the compression in the packing element and the relative positions of the slips and expanders and lock the cement retainer in an anchored and packing-off condition within the well conduit 11.

It will be appreciated that in either of the above-mentioned cases, once the upper clip element 12 has anchored against the conduit wall the operator at the rig floor can cause the running-in string 10 to be picked upwardly a sufficient distance to permit the relative movement required between the retainer body 30 and the setting head 17 for full expansion of the lower slip element 13 and the packing element 16. If need be, a predetermined upward strain can be taken on the running-in string 10 to either effect or insure such full expansion.

It will be noted that as the setting sleeve 29 moves downwardly with respect to the retainer body 30, the inwardly extending portion 144 at the lower end of the setting sleeve 29 moves downwardly past the lower end of latch fingers 140 and unlocks the fingers so that the setting tool B can be selectively released from the cement retainer in a manner to be described below.

As was previously mentioned, the housing ports 19 can be closed automatically during expansion of the slips and packing element so that the running-in string 10 can be pressure tested for leaks if desired prior to the performance of cementing operations. During such leak testing, pressure within the body passageway 31 will not act to open sleeve valve 61 because the pressure-balancing ports 63 therein transmit such pressures to the space below the sleeve valve, thereby equalizing pressures thereacross.

If the running-in spring needs repair, the setting tool B can be uncoupled from the cement retainer in a manner to be described below and the running-in string removed from the well for repair. If no such repair is needed, a batch of cement slurry may be displaced under pressure down through the running-in string and the cement retainer after opening the housing ports 19 by slacking off on the running-in string to move the operating mandrel 21 coupled to the sleeve valve 61 via the actuator 70, downwardly. Of course, the sleeve valve can be operated to open and close the housing ports any number of times once the cement retainer is anchored in the well conduit by moving the operating mandrel upwardly and downwardly by suitable manipulation of the running-in string.

If leaks are found to exist in the running-in string, or if it is desired to establish circulation above the set cement retainer, or upon completion of cementing operations, the setting tool B is released from the cement retainer in the following manner. The operator slacks off on the running-in string until the rig weight indicator begins to drop below a predetermined freepoint as the weight of the running-in string is being applied via the operating mandrel 21 and abutment ring 134 to the tubular member 130. When sufficient weight has been added to balance the upwardly acting force of the compressed indicator spring 150, the tubular member 130 will move downwardly as shown in FIG. 5, pushing the head portions of the latch fingers 140 downwardly within the recess 80 on the upper portion 75 of the retainer body 30. Eventually, the head portions 142 will be shifted outwardly over the downwardly and outwardly inclined surfaces at the lower edge of the recess 80 and the upper section of the release sleeve 82. Further downward movement will move the enlarged head portions 142 opposite the annular recess in the release sleeve 82 and the torsion springs 142 will act to pivot the latch fingers radially inwardly so that the head portions engage in the sleeve recess.

With the latch fingers so engaged, the operator can then pick up on the running-in string 10 and the engagement of the head portions 143 in the recess of the release sleeve 82 will cause the sleeve to be pulled slidably upwardly on the upper portion 75 until the upper end of the sleeve abuts the lower face of the latch ring 76 as shown in FIG. 6. Inasmuch as the upper section 83 of the release sleeve and the latch ring 76 are of the same outer diameter, the head portions 143 will ride upwardly over the upper section 83 and the latch ring 76 to release the coupling between the setting tool B and the retainer body 30.

Further upward movement on the running-in string will allow the valve actuator 70 to move upwardly until the top section of the sleeve valve 61 abuts the lower end face of the retainer mandrel 32. When the latter occurs, the cam ring 125 around the connector head 71 on the valve actuator 70 will act to move the split snap ring 124 outwardly into the groove 123 on the lower section 120 of the operating mandrel and release the valve actuator from the operating mandrel. It should be noted that whenever the setting tool B is thus released from the cement retainer A, the housing ports 19 will always be sealably closed by the sleeve valve 61 with the valve spring 64 exerting an upwardly-directed biasing force on the sleeve valve. Inasmuch as the seal areas encompassed by seal elements 62, 63 on the valve are the same, fluid pressure differentials acting across the cement retainer from either above or below will not act to move the valve and open the housing ports 19.

To re-engage the setting tool with the cement retainer after the above-mentioned leak testing or circulation, the running-in string 10 is lowered until the seal sleeve 145 on the setting tool B is received over the upper portion 75 of the cement retainer body 30 and abuts against the upper surface of the latch ring 76. A sufficient downward movement of the operating mandrel 21 will cause the lower end of the enlarged section 120 thereof to engage the inwardly extending abutment ring 134 on the tubular member 130. The operator then slacks off on the running-in string 10 to add the amount of weight to the tubular member 130 sufficient to again counterbalance the force of the indicator spring 150 plus an additional amount of weight to cause the head portions 142 of the latch fingers 140 to move downwardly and opposite the recess 80 below the latch ring 76 (the release sleeve 82 having gravitated to its lower position upon initial release of the setting tool). The torsion springs 142 will act to pivot the latch fingers 140 and their head portions 143 into the recess 80 and into a position of engagement with the latch ring 76. The setting tool is then recoupled to the cement retainer. It will be noted that a relatively simple correlation between a predetermined freepoint registered on the rig weight indicator and the known spring force of the compressed spring 150 provides the operator with a surface indication of the position of the various parts of the latch mechanism during the uncoupling or recoupling procedures.

Since the sleeve valve 61 and the actuator 70 are biased to an upper position by the spring 64, the annular cam ring 125 on the connector head 71 of the actuator will again coact with the snap ring 124 and couple the operating mandrel 21 to the valve actuator during re-engagement of the latch fingers 140 with the latch ring 76.

It will be appreciated from the foregoing that new and improved well apparatus has been provided which will effectively pack-off in the annular space between a well conduit and tubing on drill pipe to isolate a zone in a well bore for cementing operations. The apparatus is particularly adapted for conjunctive use with other well tools for fracturing, acidizing, squeeze cementing and testing which may include a retrievable center section and permits the performance of multiple workover or completion operations in a single trip into the well conduit. The cement retainer disclosed herein includes valving wihch permits fast run-in speeds, testing of the running-in string for leaks and retention of the cement slurry back pressure. Inasmuch as the valving is pressure-balanced, the cement retainer is automatically converted to a permanent bridge plug when the setting tool is removed and will hold pressure differentials acting from either above or below. The setting device disclosed herein is provided with a source of stored energy for doing the work required to expand the slips and packing element, the energy being releasable in response to a simple manipulation of the running-in string. The coupling mechanism between the setting device and cement retainer can be operated by simple up and down movement of the running-in string and permits any number of uncoupling or recoupling steps with a surface indication and relative position of the parts thereof. Also, the through bore of the setting device is full opening to accommodate any instrument or wireline device that will pass through the running-in string.

Since certain changes may be made in the above-disclosed apparatus without departing from the scope of the inventive concept involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In apparatus usable in a well conduit including a well device having a tubular body, normally retracted means on the body movable to expanded positions, and setting means for moving the normally retracted means to expanded positions, the setting means including a setting sleeve through which setting forces acting in one direction are transmitted to the well device and an operating member through which setting forces acting in a direction opposite to the one direction are transmitted to the well device, the combination of means for releasably coupling the well device to the setting means comprising: a latch ring on the body above the normally retracted means; a release sleeve slidably disposed on the body below the latch ring, the release sleeve having a portion of substantially the same outer diameter as the latch ring; a tubular member slidably joined to the operating member and extending downwardly therefrom; and a plurality of inwardly biased latch dogs pivotally mounted on the tubular member, the latch dogs being engageable with the latch ring for coupling the setting means to the well device, and being cooperable with the release sleeve for disengaging the setting means from the well device upon longitudinal relative movement between the tubular member and the body.

2. Apparatus as recited in claim 1 including means on the setting sleeve cooperable with the latch dogs for locking the latch dogs in a position of engagement with the latch ring, the locking means being rendered inoperable upon actuation of the setting means.

3. In a well tool, the combination comprising: a body having a longitudinally extending fluid passageway therethrough; normally retracted means on the body movable outwardly of the body to engage a well conduit; means for moving the normally retracted means outwardly of the body, said means including an operating member releasably coupled to the body; a valve housing on the body below the normally retracted means, said valve housing having a chamber therein and a plurality of lateral ports through the wall thereof for providing fluid communication between the body passageway and the exterior of the body below the normally retracted means; a valve element in the chamber movable between a first position wherein the lateral ports are open to fluid flow therethrough and a second position wherein the lateral ports are sealably closed against fluid flow therethrough; a valve actuator connected to the valve element for moving the valve element between the first and second positions, the actuator extending upwardly through the body passageway to a location beyond the upper end of the body; a connector head on the valve actuator; and means for releasably connecting the connector head to the operating member whereby longitudinal movement of the operating member relative to the body is effective to move the valve element between the first and second positions.

4. The combination recited in claim 3 and including means coacting between the valve element and valve housing for biasing the valve element toward the second position.

5. The combination recited in claim 4 and wherein the valve element has means providing fluid communication between the spaces in the chamber above and below the

valve element whereby fluid pressures above and below the valve element can be equalized.

6. In a well tool, a body adapted to be suspended in a well conduit by a running-in string, the body having a longitudinally extending fluid passageway therethrough; a valve housing on the body having a chamber therein and a plurality of lateral ports through the wall thereof; a valve element in the chamber movable between a first position wherein fluid flow through the body passageway via the housing ports is permitted and a second position wherein fluid flow through the body passageway via the housing ports is blocked; an actuator for the valve element extending upwardly through the body passageway to a location beyond the upper end of the body; an operating member having a bore therethrough, the operating member being movable longitudinally in the wall conduit by manipulation of the running-in string; means for releasably latching the operating member to the body including a sliding joint permitting a predetermined amount of longitudinal relative movement of the operating member with respect to the body without movement of the latch means; and means for releasably connecting the operating member to the valve actuator so that longitudinal movement of the operating member will effect movement of the valve element between the first and second positions.

7. In a well tool, the combination comprising: a body having a passageway therethrough; an operating member having a passageway in communication with the body passageway; and means for coupling the body to the operating member including a coupling member between the body and the operating member, said coupling members and operating member having a slidable connection to enable limited longitudinal movement therebetween, latch means for releasably connecting coupling member to the body, said latch means being releasable by relative longitudinal movement between the coupling member and the body, and yieldable means for preventing relative movement between the coupling member and the body except in response to a predetermined force from the operating member on the coupling member, thereby enabling selective release of the latch means.

8. The combination recited in claim 7 wherein the yieldable means includes a compressed spring.

9. The combination recited in claim 7 wherein the latch means includes a latch ring on the body, a release sleeve slidably disposed on the body below the latch ring, and a plurality of latch dogs cooperable with the latch ring for coupling the operating member to the body and further cooperable with the release sleeve for uncoupling the operating member from the body.

10. The combination recited in claim 7 and including a valve housing on the body having ports in the wall thereof; a valve element movable in the housing between a first position permitting fluid flow through the ports and a second position blocking fluid flow through the ports; a valve actuator connected to the valve element; and means releasably attaching the actuator to the operating member so that the limited longitudinal movement permitted between the operating member and coupling member is effective to move the valve element between the first and second positions.

11. In combination, a well device having normally retracted means movable to expanded positions in a well conduit; an operating member having a bore therethrough, said operating member being adapted for suspension in a well conduit in a running-in string; means for releasably coupling the operating member to the well device; a setting sleeve telescopically disposed about the operating member and cooperable with the well device for moving the normally retracted means to expanded positions; a spring on the operating member adapted to be compressed to a condition so that elongation of the spring can effect movement of the setting sleeve and expansion of the normally retracted means; means for holding the spring in a compressed condition; means responsive to rotation of the operating member for releasing the holding means so that the spring can elongate and act to move the setting sleeve, the releasing means including a friction drag mechanism engageable with the well conduit; and means cooperating between the holding means and spring for controlling the rate of elongation of the spring upon release of the holding means.

12. The combination recited in claim 11 wherein the controlling means includes a piston means telescopically slidable on the operating member and defining therebetween a fluid chamber; annular means on the operating member defining a fluid passageway communicating with the chamber, the passageway having a selected flow area whereby the flow rate of fluid from the chamber can be predetermined; and valve means coacting with the holding means for normally closing the passageway, the valve means being arranged to open the passageway upon release of the holding means.

13. The combination recited in claim 11 wherein the controlling means includes a sleeve piston slidably disposed about the operating member and against which one end of the spring bears; an annular head on the tubular member below the sleeve piston, the annular space between the sleeve piston and the head forming a chamber adapted to contain an initially confined hydraulic fluid; a valve seat in the annular head; means providing communication between the chamber and the valve seat; and a valve element cooperable with the valve seat, the valve element being supported by the holding means and arranged to open the chamber upon release of the holding means.

References Cited

UNITED STATES PATENTS

2,737,243	3/1956	Baker et al.	166—123
2,765,853	10/1956	Brown	166—134
2,884,069	4/1959	Brown	166—125 X
3,062,292	11/1962	Lowrey et al.	166—123
3,163,225	12/1964	Perkins	166—123

DAVID H. BROWN, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,387,659 June 11, 1968

James H. Current

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, lines 4 and 5, "Schlumberger Well Surveying Corporation" should read -- Schlumberger Technology Corporation --. Column 2, line 34, "percitting" should read -- permitting --. Column 3, line 32, "value" should read -- valve --. Column 4, line 36, "engate" should read -- engage --. Column 5, line 7, after "the", second occurrence, insert -- present --; line 11, after "body" insert -- 30 --; line 65, "or" should read -- of --. Column 6, line 14, "provided" should read -- provide --; line 16, "slopes" should read -- slips --; line 49, "67" should read -- 61 --. Column 7, line 36, "retaining" should read -- retainer --. Column 9, line 65, "of", first occurrence, should read -- by --. Column 12, line 2, "clip" should read -- slip --; line 27, "spring" should read -- string --. Column 14, line 3, after "indication" insert -- of the operation --. Column 15, line 16, "wall" should read -- well --. Column 16, line 8, "in" should read -- on --.

Signed and sealed this 16th day of December 1969.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents