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SELF-SEALING PACKER

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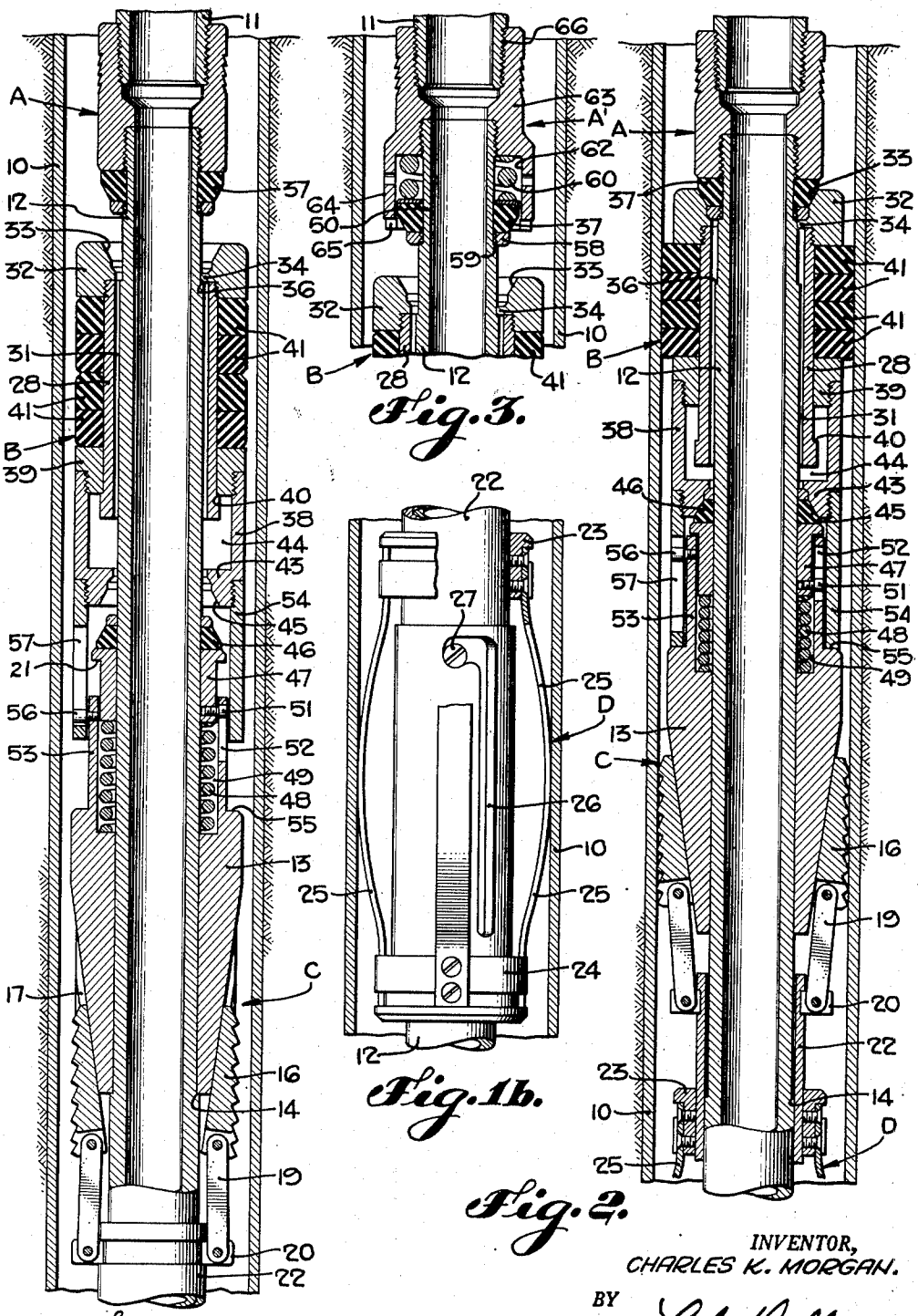


Fig. 1a.

Fig. 3.

Fig. 1b.

Fig. 2.

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SELF-SEALING PACKER

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This invention relates broadly to packing devices for well boreholes. More particularly it concerns the so-called circulation or by-pass type of packing devices for sealing the annular space between a string of tubing or casing and the surrounding wall or casing, at any desired distance from the surface or outlet of the bore and which is capable of maintaining such sealing under high differential fluid pressures.

The effective sealing or packing of the annular space in a borehole or well surrounding a centrally disposed pipe, tube or mandrel is conventionally accomplished by lowering the packing device including the packer mandrel, into the well on the lower end of a suitable length or string of tubing or casing to the desired position, while fluid, which may be present in the well, is permitted free, relative flow or movement along and past the device during the lowering operation. For example, when employing a circulation by-pass type of packer such as that disclosed in Renouf 2,005,955, the fluid present in the borehole is free to by-pass the packer both on the exterior of the unexpanded packing rings and through an annular by-pass passage provided on the interior of the packer sleeve. Upon arriving at the desired position for setting the packer in the well, a slip anchorage to the surrounding wall or casing of the well is effected and the mandrel is then lowered within the packer, first causing the circulation valve to close at one end of the fluid by-pass passage within the packer and then upon further lowering, axial force is applied to the annular packing members on the exterior of the packer by means of which they are compressed axially of the borehole and thereby expanded radially into sealing engagement with the inner surface of the borehole wall or casing and thereby block fluid movement past the packer.

Tubing or casing weight, which may or may not be augmented by mechanical or fluid pressure as desired, is applied to the mandrel in the direction to hold the by-pass valve closed and to apply axial force to keep the packing members expanded in sealing engagement against the well wall or casing. However, opposing pressure which may exist or build up in the well below the packer acts directly against the lower surface of the by-pass valve and other portions of the packer, tending to force the valve open and reduce the axial compressive force upon the packing members. Accordingly, if the holding pressure is accidentally released or overcome by such differential pressure, even in part, the secured fluid

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seal may be broken with resultant leakage and rapid destruction of the packing elements. In any case, the sealing efficiency of the device will be impaired and its repair or replacement may soon be required. Such difficulty is certain to result whenever the opposing pressure in the well balances or exceeds the pressure applied to the packing device to hold it in place.

One object of the invention is, therefore, to overcome the hereinbefore mentioned difficulties and disadvantages prevalent in, and to improve the design and operation of packers, of the so-called circulation or by-pass types.

Another object is to minimize, or to prevent entirely, loosening or impairment of the fluid seal effected by the so-called circulation or by-pass types of packing devices in wells due to the action of differential fluid or hydrostatic pressure which accumulates or is built up in the wells.

Another object is to provide means automatically to utilize the opposing fluid pressures on the opposite sides of a packing device to assist in maintaining the required fluid seal and tightness of the device in place in the well.

Other objects, advantages and features of novelty will be evident from the detailed description which follows:

The present invention is characterized by the utilization of the fluid pressure within the borehole or well beyond the packing device to improve the operation and the efficiency of the device. In other words, the force which has heretofore worked against the devices of the prior art is made use of by the present invention automatically to tighten the packing members rather than to loosen them. To this end, the packing device of the present invention is provided with a second or lower circulation by-pass valve in addition to the usual upper circulation by-pass valve. By this double arrangement of valves, each valve is shielded by the other from pressure which tends to force it open, and all passages within the packer are thereby sealed against ingress of fluid from above as well as from below the packing elements. The opposing fluid pressures are then utilized to apply their combined forces to axially compress and laterally or radially expand the packing elements into sealing engagement with the inside of the bore or well casing whereby the packer will have a self-sealing or so-called self-energizing effect. By this is meant that the packer will have a tendency to set more firmly within the bore or well casing as the pressure in either direction across the packer increases as contrasted with conventional

packers in which increased pressure from below usually tends to reduce axial pressure on the packing elements and thus to impair the sealing efficiency of the packer.

In order to illustrate the invention, one concrete embodiment thereof is shown in the accompanying drawings in which:

Figure 1*a* is a longitudinal sectional view illustrating the general assembly of the apparatus of the invention and showing the position of its parts when being lowered into a well casing prior to being set.

Figure 1*b* is similar to Figure 1*a* and is a continuation of the lower end of the latter and shows the remainder of the cage assembly in elevation except for a small part shown in section. Figures 1*a* and 1*b* taken together show the entire longitudinal section of the apparatus.

Figure 2 is a longitudinal sectional view similar to Figure 1*a* but showing the appearance of the apparatus after being set in a well casing.

Figure 3 is a detailed sectional view showing an alternative form of the upper packer head and by-pass valve portion of the apparatus.

In the drawings, Figure 1*a* and Figure 2 show, in longitudinal section, part of a borehole or well, lined by a suitable casing **10**. Suspended within the casing and from the lower threaded end **11** of a string of tubing or casing (not shown), is a packing device which comprises a centrally disposed mandrel **12** along which are mounted, respectively from top to bottom; a head A for attaching the device to the said string of tubing, a packer assembly B, a casing gripping mechanism C and a conventional cage assembly D for actuating and controlling the said casing gripping mechanism.

The casing gripping mechanism C may be of any suitable or desired type. In the form herein illustrated it consists of a conventional conical member or slip cone **13** slidable axially on mandrel **12** and initially, prior to setting as shown in Figure 1*a*, resting upon an upwardly facing stop shoulder **14** formed around the mandrel **12**. Slips **16** are slidably mounted in undercut or so-called dovetail grooves **17** formed in the conical portion of member **13** for movement relative along the sloping surface of the cone into wedging or gripping contact with the inside surface of the well casing **10**. Links or slip reins **19** are pivotally connected at their upper ends to the lower ends of slips **16** and at their lower ends to a slip rein ring **20** which is rotatably retained in an annular groove in the cage sleeve member **22** of the cage assembly D which is of the J-slot type (see Figure 1*b* and the lower end of Figure 1*a*). The cage sleeve member **22** has upper and lower cage spring collars **23** and **24** between which extend outwardly bowing cage springs **25** formed to frictionally engage the inside surface of the well casing. Cage springs **25** are secured at their opposite ends to collars **23** and **24** by suitable bolts or machine screws as indicated in Figure 1*b*. The cage sleeve member **22** has a so-called J-slot **26** through the wall thereof to receive pin **27** projecting from mandrel **12**. The cage assembly D acts in the well known manner as a drag means to assist in the packer setting and releasing operations as will be hereinafter described.

Packer assembly B is mounted on mandrel **12** between head A and conical member **13** of gripping mechanism C. The packer assembly includes a packing-ring sleeve **28** and a lower valve-seat sleeve **38** concentrically surrounding the mandrel **12** and each is spaced from the mandrel **12** to form an annular passage **31** and a cavity **44** respectively. The packing-ring sleeve **28** has secured thereto at its upper end an abutment ring member **32** having formed therein an upwardly facing, conical valve seat **33**, and a plurality of radially inwardly extending centering lugs **34** which serve to position the packing ring sleeve **28** concentrically about the mandrel **12** and to engage an upwardly facing stop shoulder **36** formed on mandrel **12**.

The head member A is provided with a conical valve head **37** of resilient material such as rubber, adapted to engage the adjacent conical valve seat **33** when closed, and thereby close off the upper end of the annular by-pass passage **31**. The lower valve seat sleeve **38** is arranged for axial, telescoping movement relative to the packing-ring sleeve **28** through the provision of a slip joint comprising an annular packing retaining ring-nut **39**, slidably engaging the exterior of the packing ring sleeve **28** between abutment ring **32** and a bottom stop shoulder **40** at the lower end of sleeve **28**. Packing means to bridge the annular clearance space between sleeve **28** and the well casing are provided, by way of example, in the form of a series of coaxial packing ring members or elements **41** of rubber or of other suitable resilient or deformable material, mounted upon the packing-ring sleeve **28**, so as substantially to occupy the axial space formed between abutment ring **32** and the retaining nut **39**.

The lower valve seat sleeve **38** is formed with an inwardly extending annular flange **43** suitably spaced from the lower end of sleeve **28** normally to provide an annular cavity or chamber **44** which is in communication with the lower end of the annular by-pass passage **31**. Flange **43** has formed therein a downwardly facing, conical, lower valve seat **45** similar in construction and arrangement to, but facing oppositely from, the upper valve seat **33**. A lower, conically shaped valve head member **46** is arranged to engage the lower valve seat **45** to seal off annular chamber **44** and the annular by-pass passage **31** from the lower side. Lower valve head **46** is mounted on the top end of a concentric tubular valve head stem **47** slidable longitudinally upon mandrel **12** and yieldably urged upward toward valve seat **45** by suitable means such as a coil spring **48** housed in a counterbore **49** in the upper end of the slip cone **13**. Stem **47** may telescope into counterbore **49** until its outwardly extending annular stop flange or shoulder **21** engages the upper end of the cylindrical, upwardly extending portion **53** of the slip cone **13**. The valve stem **47** is prevented from being thrust out of the counterbore **49** and its valve head **46** held out of contact with seat **45**, whenever the packing-ring sleeve **28** and lower valve seal sleeve **38** are in their uppermost positions as shown in Figure 1*a*, by the provision of a stop pin **51** projecting laterally from valve stem **47** and slidably received in a closed, longitudinal slot **52** formed in cylindrical walls **53** of the counterbore **49** in the top of the slip cone **13**. In order to protect valve **46** from excessive compressive forces, the lower valve seat sleeve **38** is provided with a cylindrical housing extension **54** enclosing said lower valve and telescopically slidable over the up-standing cylindrical walls **53** of the slip cone counterbore **49**. In the lowermost set position of the packing sleeve assembly, as shown in Figure 2, the lower end of the housing

extension 54 thereon will engage a stop shoulder 55 on the top of slip cone 13, and its movement upwardly therefrom is limited by stop pin 56 fixed in walls 53 and extending laterally into a closed longitudinal slot 57 in the housing extension 54. Additional slots or ports may be provided in housing extension 54 for passage of fluid through chamber 44 and annular by-pass passage 31 when upper and lower valves 37 and 46 respectively are in open positions as illustrated in Figure 1a. Similarly, additional slots or ports may be provided in walls 53 to insure free movement of fluid into and out of counterbore 49.

Referring now to Figure 3, an alternative construction of the packer head is shown at A' in which the by-pass valve head 37 is positioned upon an upper end portion 50 of the mandrel 12 which is of slightly reduced diameter. The valve head is longitudinally slidable a limited distance thereon between the lowermost position as shown in Figure 3 at which the valve head retainer ring member 58 rests upon a shoulder 59 formed around the mandrel at the point of diameter reduction. The valve head member 37 and valve head retainer ring 58 are urged downwardly towards the shoulder 59 by a short helical spring 60 which acts in compression between the top of said valve head 37 and the bottom of an annular recess 62 formed in the lower end of the body 63 of the head A'. The lower edge of the cylindrical skirt 64 forming the outer wall of the said annular recess 62 is formed with serrations or notches 65 to permit fluid passage therethrough as hereinafter described.

The tubing or casing string 11 is threadedly connected at 66 to the body 63 of head member A' in the same manner as hereinbefore described in connection with the head A of Figures 1a and 1b.

Figures 1a and 1b together show the entire apparatus and the relative positions of the parts thereof as the apparatus is being run into the casing in a bore of a well preparatory to being set therein. Valves 37 and 46 are initially open and packing elements or rings 41 are unexpanded and out of engagement with casing 10. The setting operation of the apparatus is conventional and consists in first rotating mandrel 12 in a left-hand direction sufficiently to move pin 27 out of the lateral portion into the longitudinal portion of J-slot 26 to unhook or release the cage assembly D for limited longitudinal movement relative to the mandrel 12. Mandrel 12 is then lowered by the tubing or casing, permitting slip cone 13 to move downward toward cage assembly D which by reason of the frictional engagement of the cage springs 25 with the inside of casing 10 remains stationary, thus causing slips 16 to move outward along the slip cone into wedging engagement with well casing 10 as shown in Figure 2. Further lowering of mandrel 12 next causes the lower valve seat 45 to move downward into sealing contact with the lower valve head 46 and then the upper valve head 37 to move downward into sealing contact with upper valve seat 33, as head A continues to move downward relative to the packer assembly B. At this point, the by-pass through chamber 44 and annular passage 31 between the mandrel 12 and the packing-ring sleeve 28 is thereby closed off. Further lowering of mandrel 12 next forces the lower valve head stem 47 downward into counterbore 49 thereby compressing spring 48 until the lower end of the housing extension sleeve 54 contacts the stop shoulder 55 on the top of slip cone 13 as shown in Figure 2. From this point on additional weight or downward force on the tubing string will be applied through head A to the abutment ring 32 to force it and the packer ring sleeve 28 to move downwardly relative to the packing ring retaining nut 39 and the lower valve seat sleeve 38, thereby applying longitudinal compressive force to the packing elements 41 between said abutment ring 32 and retaining ring nut 39 to cause the packing elements 41 to expand radially against the inside surface of casing 10 and thus complete the sealing of the annular space in the well between the exterior of mandrel 12 and the interior of the casing 10. The parts will then be in the position shown in Figure 2 when completely set.

High differential pressures can now exist or be created above and below packing elements 41. If head A is prevented from moving upwardly by either tubing weight or other mechanical restraint or by fluid pressure applied above packing elements 41 in the well annulus, or by any combination of these, high differential pressure may be applied or may be allowed to accumulate on the under side of the packer without any tendency to loosen the setting of the apparatus, since such pressure cannot reach the interior of telescoping sleeves 28 and 38 to act against the lower face of the upper valve head 37 to tend to force it off its seat.

On the contrary, the fluid pressure in the well annulus below the packer will act upon the annular area bounded on the inside by the mandrel 12 and bounded on the outside by the outside diameter of the sleeve 38 tending to force sleeves 38 and 28 into further telescoping relation with respect to one another thereby automatically increasing the longitudinal compressive force applied to the packing elements 41 to increase their sealing force against the casing. Since sleeve 28 is directly abutted by head A through valve 33, 37 which is restrained against upward movement by the string of tubing 11 attached thereto, lower valve seat sleeve 38 is the one which will ordinarily move upward in response to pressure in the well annulus below the packer. For this reason the lower valve head 46 and stem 47 is spring pressed to insure its maintaining sealing engagement with valve seat 45 throughout the permissive movement of sleeves 38 and 54 relative to sleeve 28 and the cylindrical walls 53. Slight outward seepage past either of valves 37 or 46 will relieve any fluid pressure which may initially be trapped or which may build up in chamber 44 and annular passage 31 from the piston action or reduction in volume therein due to the telescoping displacement of sleeve 28 relative to sleeve 38. When a spring pressed valve head is provided for the upper valve seat, as shown in Figure 3 as well as for the lower valve seat, pressure in chamber 44 produced by the beforementioned piston action or reduction in volume of chamber 44 and passage 31 will be positively relieved by either of valves 37 or 46 as soon as such pressure exceeds the combined opposing force of either of the valve springs and the respective fluid pressure upon the outer face of such valve.

In setting the packer apparatus when employing the type of packer head shown at A' in Figure 3, weight or downward force may be applied through the tubing string, as before-described, to the mandrel 12, first moving the valve head 37 into sealing engagement with the valve seat 33 and thereafter compressing helical spring 60 until the lower end of the skirt 64 is brought into abut-

ment with the adjacent upper end of the abutment ring member 32. Thereafter the force from the tubing string is transmitted positively to the mandrel 12.

As beforedescribed any excess pressure in the fluid entrapped in the cavity formed within the packer apparatus at 44 and passage 31 may be relieved by the automatic lifting of either valve head 37 or 46 against the opposing forces of springs 60 and 48 respectively, depending upon the direction of the pressure differential across the packer apparatus. This relief of pressure will permit the telescoping movement between the packer ring sleeve 28 and the valve seat sleeve 38 which is necessary for the application of longitudinal compressive force to the packing elements 41.

In removing the apparatus, mandrel 12 is lifted, first relieving the longitudinal compressive force from the packing rings 41, followed by the opening of the upper valve 37. Upon continued upward movement of mandrel 12, stop shoulder 36 on mandrel 12 will next contact lugs 34 on the abutment ring 32 to raise the packing-ring sleeve 28 relative to the valve seat sleeve 38 and thereby loosen packing ring members 41. As the lifting of the mandrel continues telescoping sleeves 28 and 38 will reach the limiting relative elongation shown in Figure 1a and lower valve seat 45 will then be pulled upward away from valve head 46 when the latter has reached the limit of its upward travel under the force of spring 48 as permitted by stop pin 51 in slot 52. Finally, stop shoulder 14 on mandrel 12 will contact the lower end of the slip cone 13 to lift the latter out of the slips 16, whereupon the wedging effect on slips 16 will be relieved and the slips will be retracted from engagement with casing 10. The entire apparatus can then be withdrawn from the well or moved to be set in another position in the same well.

From the above it will be apparent that the well packer apparatus of the present invention is so constructed that once the apparatus is set, any increase in fluid pressure on either side of the packer apparatus tends automatically to tighten and increase the sealing action of the packing elements, instead of tending to loosen them as has been the effect prevalent in packer constructions previously employed.

While the invention has been herein shown and described in what is now considered to be a preferred form, it is to be understood that the invention is not limited to the specific details thereof but covers all changes, modifications and adaptations within the scope of the appended claims.

What is claimed is:

1. Well packer apparatus comprising in combination: a mandrel for attachment to a string of tubing; gripping mechanism longitudinally slidable on said mandrel for releasably engaging a surrounding well casing; a packing assembly on said mandrel adjacent said gripping mechanism comprising a pair of longitudinally telescoping sleeves concentrically surrounding said mandrel and forming an annular passage of variable length between said mandrel and said sleeves, an annular abutment fixed to one of said sleeves, another annular abutment fixed to the other of said sleeves, and an annular packing element carried on the exterior of at least one of said sleeves between said abutments; means coupling said gripping mechanism to one of said sleeves and means coupling said mandrel to the other of said sleeves for imparting telescoping movement to said sleeves relative to one another by movement of said mandrel toward said gripping mechanism, and thereby to move one of said abutments toward the other, whereby a longitudinal compressive pressure may be applied from said mandrel through said packing element between said abutments to said gripping mechanism to expand said packing element radially into sealing engagement with such casing; initially open valve means at opposite ends of said annular passage surrounding said mandrel for controlling flow of fluid from either direction into the said annular space between said sleeves and said mandrel; whereby said valve means are closed by the said movement of said mandrel toward said casing gripping mechanism and telescopic movement of said sleeves and longitudinal compressive pressure on said packing element between said abutments are automatically increased in response to an increase in fluid pressure in the well, exterior to said annular passage.

2. Well packer apparatus comprising: a mandrel; a packing sleeve surrounding and spaced from said mandrel and forming an annular passage therebetween; casing gripping means longitudinally slidably carried on a lower portion of said mandrel for releasably gripping the inside of a surrounding casing; an upper outwardly extending annular abutment at the top portion of said packing sleeve; a lower outwardly extending annular abutment at the lower portion of said sleeve, said upper and lower abutments being movable longitudinally with respect to one another; a deformable packing element around said packing sleeve between said upper and lower abutments and adapted to be compressed longitudinally on said sleeve between said abutments by movement of said abutments toward one another; a lower, downwardly facing valve seat on said lower abutment, communicating with the lower end of said annular passage; an upper, upwardly facing valve seat on said upper abutment, communicating with the upper end of said annular passage; an upper downwardly facing valve head fixed on the upper portion of said mandrel above said upper valve seat; a lower, upwardly facing valve head slidably carried on said mandrel below said lower valve seat; means coupling said lower valve head to said casing gripping means permitting longitudinal motion of said lower valve head and casing gripping means together on said mandrel whereby downward motion of said mandrel with respect to said casing gripping means first seats said lower and upper valve heads on said lower and upper valve seats respectively, thereby closing the lower and upper ends, respectively, of said annular passage, and then applies longitudinal compressive force through said valve heads and seats and said abutments to said deformable packing element.

3. Well packer apparatus comprising: a mandrel; a packing sleeve surrounding and spaced from said mandrel and forming an annular passage therebetween; casing gripping means longitudinally slidably carried on a lower portion of said mandrel for releasably gripping the inside of a surrounding casing; an upper, outwardly extending annular abutment at the top portion of said packing sleeve; a lower, outwardly extending annular abutment at the lower portion of said sleeve, said upper and lower abutments being movable longitudinally with respect to one another; a deformable packing element around said packing sleeve between said upper and lower

abutments and adapted to be compressed longitudinally on said sleeve between said abutments by movement of said abutments toward one another, said packing element being thereby expanded radially; a lower downwardly facing valve seat member on said lower abutment, communicating with the lower end of said annular passage; an upper upwardly facing valve seat member on said upper abutment, communicating with the upper end of said annular passage; an upper downwardly facing valve head member on the upper portion of said mandrel above said upper valve seat member; a lower, upwardly facing valve head member slidably carried on said mandrel below said lower valve seat member; means coupling said lower valve head member to said casing gripping means permitting longitudinal motion of said lower valve head member and said casing gripping means together on said mandrel but permitting only limited longitudinal motion of said lower valve head member and said casing gripping means relative to one another on said mandrel; resilient means urging said lower valve head member upward relative to said casing gripping means, whereby downward motion of said mandrel with respect to said casing gripping means first seats said lower and upper valve head members on said lower and upper valve seat members respectively, thereby closing the lower and upper ends, respectively, of said annular passage, and then applies longitudinal compressive force through said valve members to said upper and lower abutments and thence to said deformable packing element on said sleeve between said abutments.

4. Well packer apparatus comprising: a mandrel; a packing sleeve surrounding and spaced from said mandrel and forming an annular passage therebetween; casing gripping means longitudinally slidably carried on a lower portion of said mandrel for releasably gripping the inside of a surrounding casing; an upper, outwardly extending annular abutment at the top portion of said packing sleeve; a lower, outwardly extending annular abutment at the lower portion of said sleeve, said upper and lower abutments being movable longitudinally with respect to one another; a deformable packing element around said packing sleeve between said upper and lower abutments and adapted to be compressed longitudinally on said sleeve between said abutments by movement of said abutments toward one another, said packing element being thereby expanded radially; a lower, downwardly facing valve seat on said lower abutment, communicating with the lower end of said annular passage; an upper, upwardly facing valve seat on said upper abutment, communicating with the upper end of said annular passage; an upper downwardly facing valve head on the upper portion of said mandrel above said upper valve seat; a lower, upwardly facing valve head slidably carried on said mandrel below said lower valve seat; means coupling said lower valve head to said casing gripping means permitting longitudinal motion of said lower valve head and said casing gripping means together on said mandrel but permitting only limited longitudinal motion of said lower valve head and said casing gripping means relative to one another on said mandrel; stop means permitting only limited relative longitudinal motion between said lower valve seat and said casing gripping means and through which longitudinal force may be transmitted from said casing gripping means to said lower abutment at the limit of said longitudinal motion of said lower valve seat and said casing gripping means towards one another, whereby downward motion of said mandrel with respect to said casing gripping means first seats said lower and upper valve heads on said lower and upper valve seats respectively, thereby closing the lower and upper ends, respectively, of said annular passage, and then causes longitudinal compressive force to be applied from said mandrel downward through said upper valve head and valve seat to said upper abutment, and upward from said casing gripping means through said stop means to said lower abutment and thence to said deformable packing element between said abutments.

5. Well packer apparatus comprising: a mandrel; a packing sleeve surrounding and spaced from said mandrel and forming an annular passage therebetween; casing gripping means longitudinally slidably carried on a lower portion of said mandrel for releasably gripping the inside of a surrounding casing; an upper, outwardly extending annular abutment at the top portion of said packing sleeve; a lower, outwardly extending annular abutment at the lower portion of said sleeve, said upper and lower abutments being movable longitudinally with respect to one another; a deformable packing element around said packing sleeve between said upper and lower abutments and adapted to be compressed longitudinally on said sleeve between said abutments by movement of said abutments toward one another, said packing element being thereby expanded radially; a lower, downwardly facing valve seat on said lower abutment, communicating with the lower end of said annular passage; an upper, upwardly facing valve seat on said upper abutment, communicating with the upper end of said annular passage; an upper, downwardly facing valve head slidably carried on the upper portion of said mandrel above said upper valve seat; means coupling said upper valve head to said mandrel for limited longitudinal motion thereon; stop means fixed to said mandrel limiting the downward motion of said mandrel relative to said upper valve seat and through which longitudinal force may be transmitted from said mandrel to said upper abutment at the limit of said longitudinal motion of said stop means and said upper abutment towards one another; a lower, upwardly facing valve head slidably carried on said mandrel below said lower valve seat; means coupling said lower valve head to said casing gripping means permitting longitudinal motion of said lower valve head and said casing gripping means together on said mandrel but permitting only limited longitudinal motion of said lower valve head and said casing gripping means relative to one another on said mandrel; stop means permitting limited relative longitudinal sliding motion between said lower valve seat and said casing gripping means and through which longitudinal force may be transmitted from said casing gripping means to said lower abutment at the limit of said longitudinal motion of said lower valve seat and said casing gripping means towards one another; and resilient means urging said lower valve head upward relative to said casing gripping means, whereby downward motion of said mandrel with respect to said casing gripping means first seats said lower and upper valve heads on said lower and upper valve seats respectively, thereby closing the lower and upper ends, respectively, of said annular passage, and then causes longitudinal compressive force to be

applied from said mandrel downward through said upper abutment, and upward from said casing gripping means through said stop means to said lower abutment and thence to said deformable packing element between said abutments.

6. Well packer apparatus comprising in combination: a mandrel; a head at one end of said mandrel for attaching the same to a string of tubing; gripping means slidable on said mandrel, remote from said head for releasably gripping the interior of a surrounding well casing to anchor said device in place therein; packing means mounted on said mandrel with freedom for limited relative longitudinal movement thereon intermediate said head and said gripping means, said packing means comprising a first sleeve surrounding said mandrel and providing on the upper end thereof an upper valve seat adjacent and facing toward said head, a second sleeve surrounding said mandrel in telescoping relation with said first named sleeve and providing on the lower end thereof a lower valve seat remote from and facing away from said head; a lower valve head slidably mounted on said mandrel to engage said lower valve seat and form a fluid seal between the outside of said mandrel and said second sleeve; an upper valve head on said mandrel to engage said upper valve seat and form a fluid seal between the outside of said mandrel and said first sleeve; packing elements surrounding said mandrel and located between elements of said sleeves in position to be compressed longitudinally and thereby expanded radially into sealing contact with such well casing by telescoping motion of said sleeves; means to seat said valves upon said seats and apply longitudinal telescoping force to said sleeves after said mandrel is moved within said gripping means sufficiently to cause both valves to engage their respective valve seats; and means on said gripping means for limiting the longitudinal movement of said lower slidable valve relative to said packing means.

CHARLES K. MORGAN.

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The following references are of record in the file of this patent:

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