Sept. 7, 1965 R. T. GAUT 3,204,697

GAS WELL CASING TEST PACKER

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fig. 1

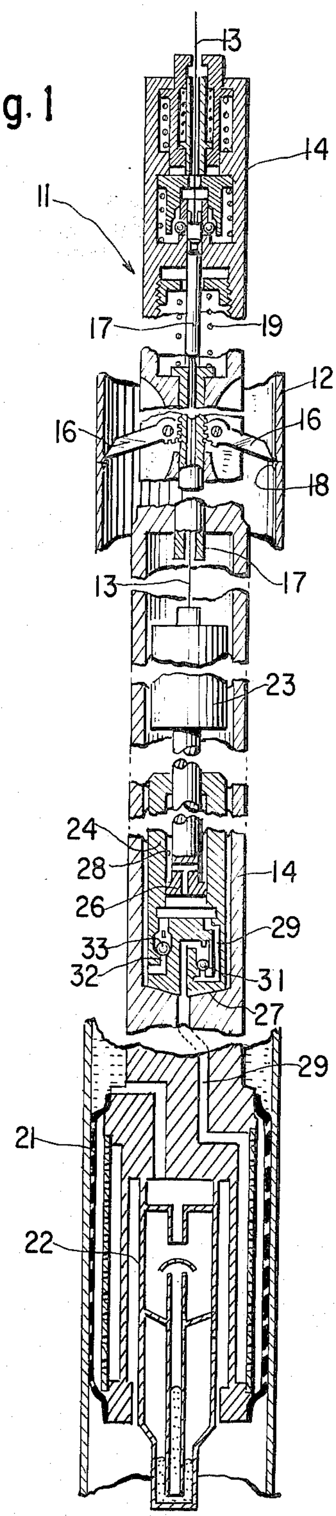
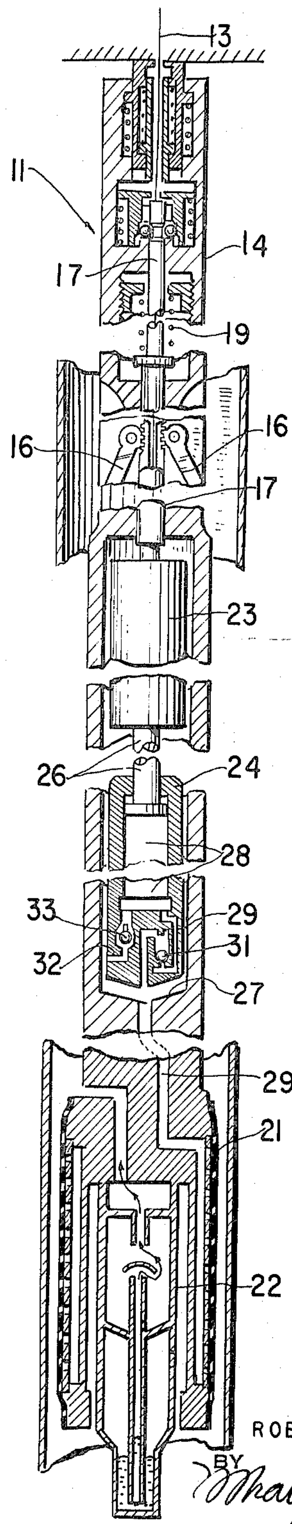


fig. 2



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GAS WELL CASING TEST PACKER

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fig.3

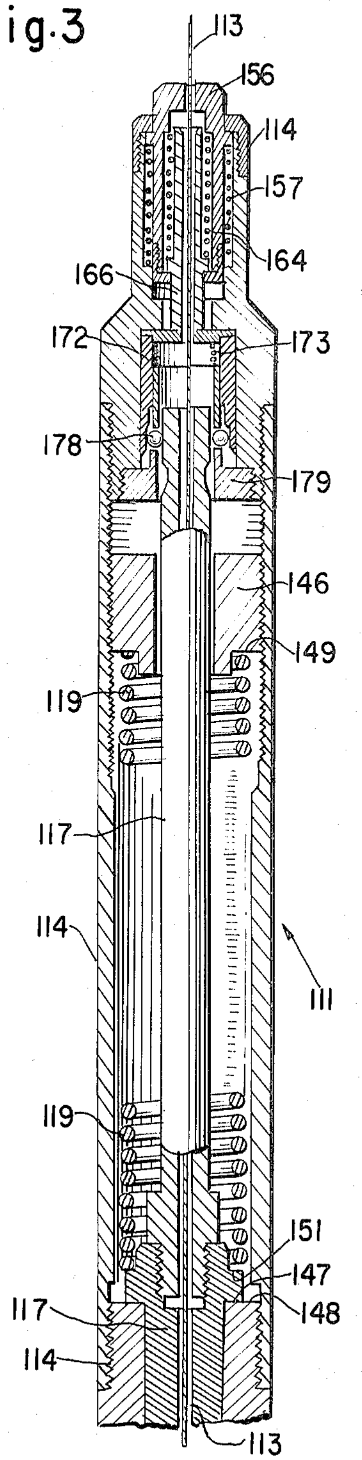
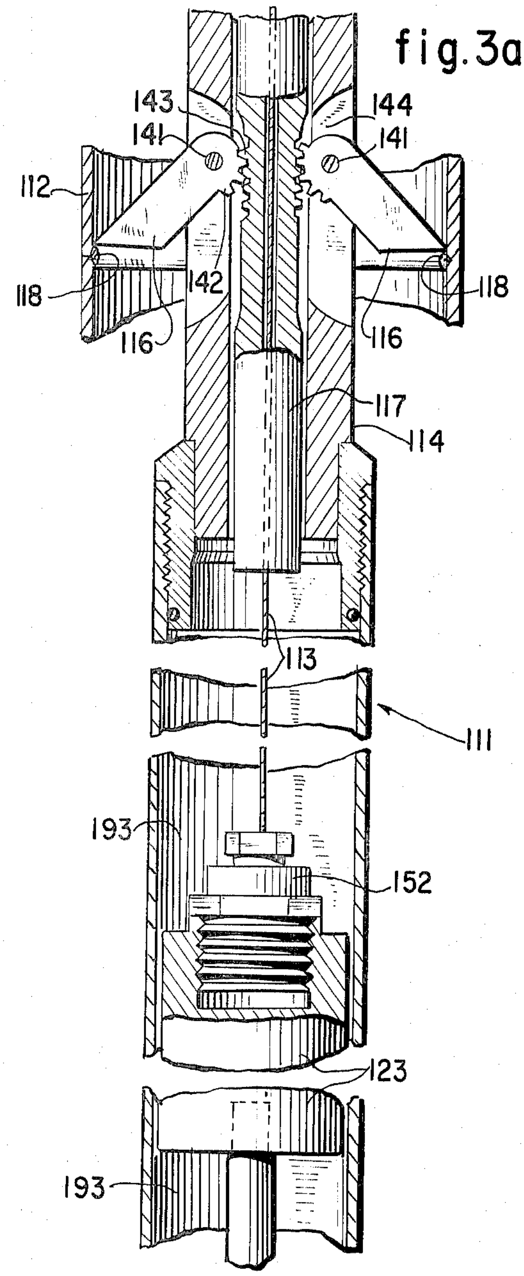


fig.3a



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GAS WELL CASING TEST PACKER

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fig.3b

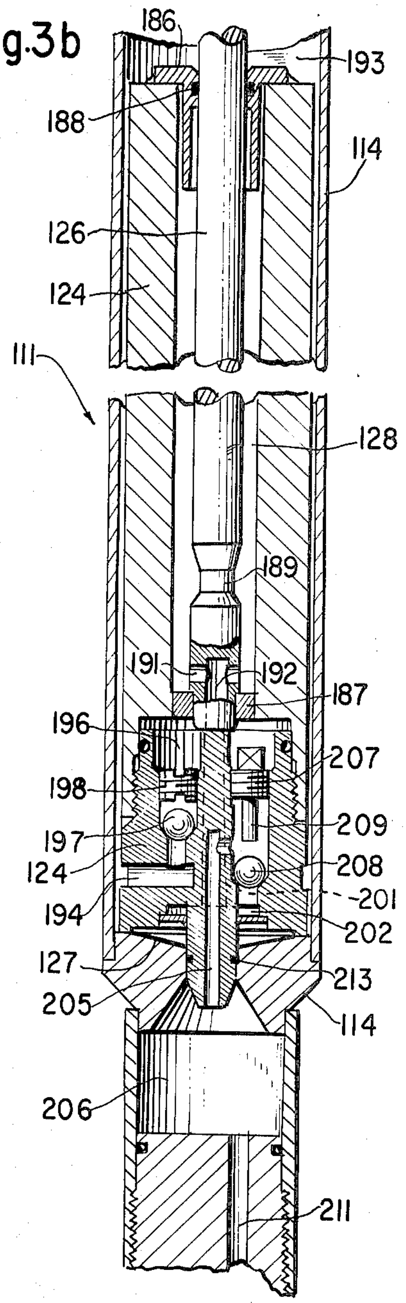
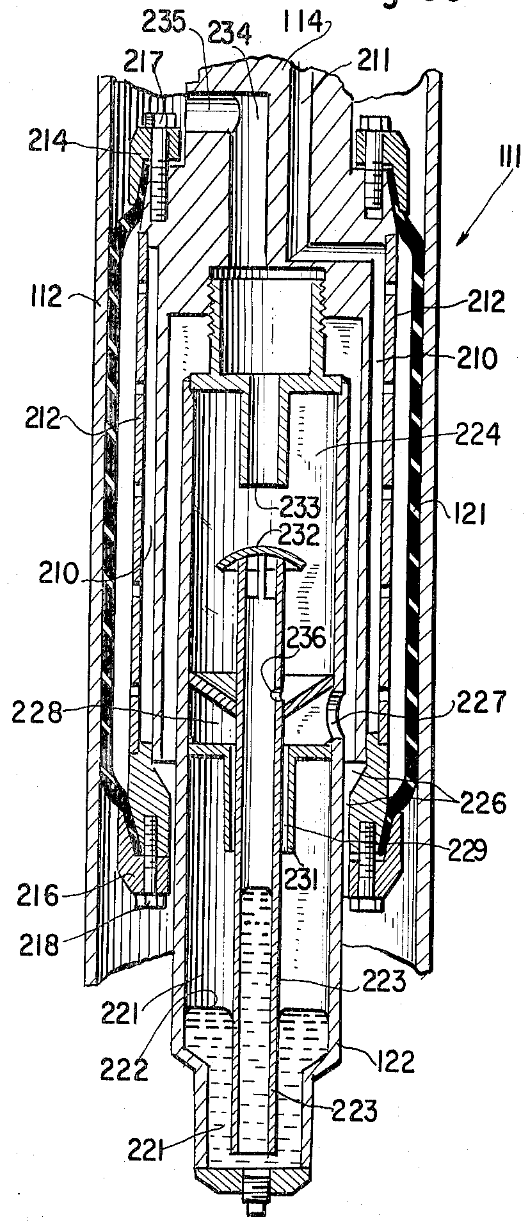


fig.3c



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GAS WELL CASING TEST PACKER

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fig.4

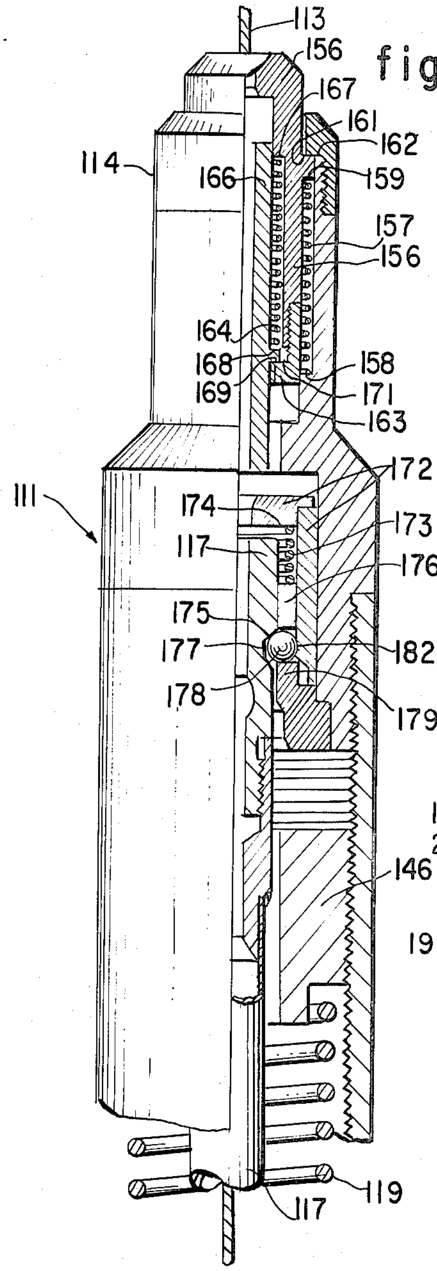


fig.5

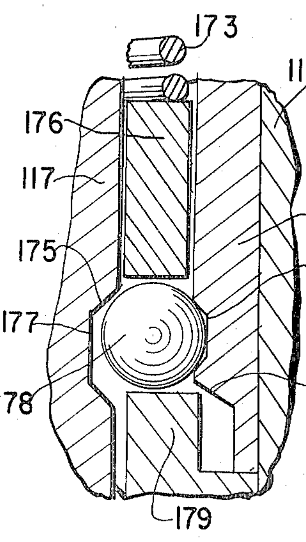


fig.6

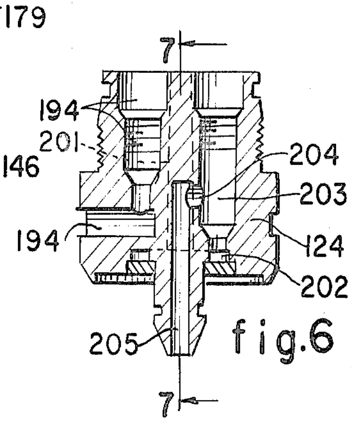


fig.7

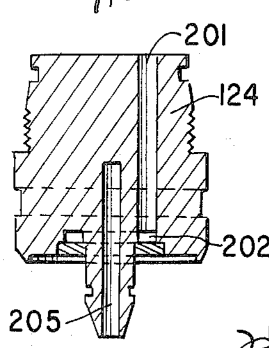
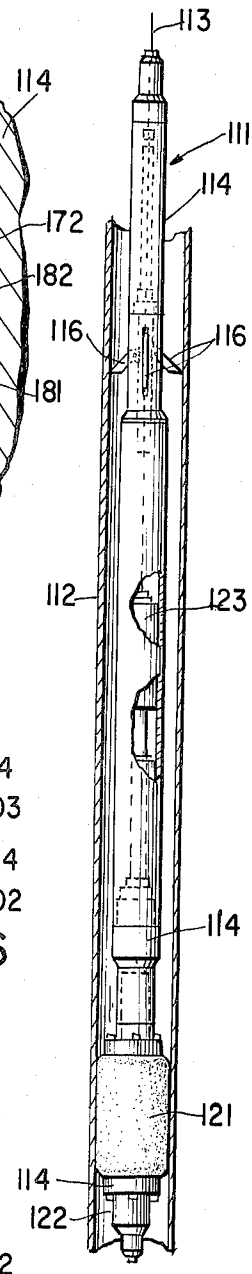


fig.8



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3,204,697
Patented Sept. 7, 1965

1

3,204,697
GAS WELL CASING TEST PACKER

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Filed May 8, 1961, Ser. No. 108,335
8 Claims. (Cl. 166—133)

This invention relates to a well packer and more particularly to a test packer which may be lowered into a well bore on a wire line.

Test packers of the type contemplated by the present invention are designed to temporarily seal a well bore so as to isolate the zone below the packer from the zone above the packer by excluding flow of fluid past the packer. While such test packers have a variety of uses they are especially useful in locating leaks in the bore of a gas well. This problem is especially acute in relatively older gas wells which are being used for storage wells. The increased severity of leakage from such older wells is frequently due to deterioration of the tubing or casing in the well bore. In order to determine the presence and severity of leaks, it is desirable to have a test packer which can be lowered to a desired depth and then set to exclude the flow of fluid past the packer. By measuring the rate at which the pressure in the zone above the packer decreases it is relatively easy to calculate the amount of leakage from this zone. In order to locate leaks more specifically, it is desirable to be able to raise the packer from its original set position and reset it periodically at intervals throughout the total depth of the well bore being tested. Previously available equipment has not been entirely satisfactory in performing such tests. In many cases it has been necessary to utilize test packers which must be run on a string of tubing. This, of course, necessitates pressuring of the well bore above the packer after the tubing has been run and involves considerably greater expenses for labor and materials than are involved in the use of a test packer which may be run on a wire line.

It is an object of the present invention to provide an improved well test packer.

Another object of the invention is to provide an improved wire line test packer which may be lowered to any desired depth in a well bore and then set at various depths within the bore.

A preferred embodiment of the present invention contemplates a test packer having a body member, an expandable packing member mounted on the body member and means for anchoring the body member in the well bore. Supporting means, preferably a wire line, are provided for supporting and operating the packer and the packer includes means for retaining the anchoring means in an inoperative position so as to allow lowering the test packer down the well bore. This retaining means is operable by the supporting means to allow the anchoring means to move into an operative position when it is desired to anchor the packer against further downward movement in the well bore. The packer also includes a pump operable by reciprocation of the supporting means to expand the packing member to seal off the well bore and is also operable by the supporting means to allow return of the packing member to unexpanded position when it is desired to shift the location of the test packer in the well bore. In order to avoid damage to the test packer due to excessive pressures on the expandable packing member, a pressure relief valve is preferably provided to allow passage of fluid through the body member past the expandable packing member whenever the pressure in the well bore below the packing member exceeds the pressure in the well bore above the packing member by more than a pre-determined amount.

For a better understanding of the invention reference should be had to the accompanying drawings in which equipment is shown in elevation and in which:

FIG. 1 is a somewhat diagrammatic illustration of a test packer constructed in accordance with a preferred embodiment of the present invention and showing the packer anchored in a well bore.

FIG. 2 is similar to FIG. 1 but shows the test packer in position to be lowered down a well bore.

FIGS. 3, 3*a*, 3*b* and 3*c* are partial sectional elevation views of a test packer constructed in accordance with a preferred embodiment of the invention and showing the packer, which is similar to that shown in FIGURE 1, with its anchoring means in an operative position for anchoring the packer in the well bore.

FIG. 4 is a partial elevation view, partly in section, showing the test packer shown in FIGS. 3, 3*a*, 3*b* and 3*c* with its component parts arranged for lowering the test packer into a well bore.

FIG. 5 is an enlargement of a portion of FIG. 4.

FIG. 6 is a fragmentary sectional elevation view of the apparatus shown in FIG. 3*b*.

FIG. 7 is a fragmentary elevation view in section taken as indicated by line 7—7 of FIG. 6.

FIG. 8 is an elevation view, partially in section, of the apparatus shown in FIGS. 3 through 7.

Referring to the drawings, FIGS. 1 and 2 show a test packer **11** positioned in a well bore **12**. The well bore **12** in which the packer **11** is positioned may be the natural wall of the formation in which the well is drilled but is more usually formed by casing or tubing. The packer is supported by suitable supporting means such as a wire line **13** and includes a body member **14** and suitable anchoring means for anchoring the body member with respect to the well bore. Such anchoring means may be of the type described in greater detail below in connection with FIGS. 3 through 8 and may include a plurality of radially outwardly movable dogs such as **16** and a rod **17** operatively connected with the dogs to expand the dogs into operative anchoring position or to retract the dogs into an inoperative position in response to longitudinal movement of the rod within the body member. The dogs **16** are shown in FIG. 1 in operative anchoring position in which they are expanded radially outwardly so as to engage recesses or projecting portions such as **18** of the well bore **12** to prevent downward movement of the packer within the well bore. FIG. 2 shows the dogs **16** in a retracted, inoperative position. The packer may be lowered down the well bore with the dogs in this position. The anchoring means might also include spring means such as a spring **19** serving to urge the dogs **16** into anchoring position. In order to allow the dogs **16** to be retained in inoperative position during lowering of the packer, suitable retaining means are provided for retaining the anchoring means in an inoperative position. Such retaining means is operable by the supporting means to allow the anchoring means to move into anchoring position, and may conveniently take the form described below in connection with FIGS. 3 through 8.

The lower portion of the body member **14** of the test packer **11** carries an expandable packing member, such as an inflatable bladder **21**, which may be expanded by suitable pump means into sealing relationship with the wall of the well bore **12** to prevent flow of fluid through the well bore past the packer. Suitable pressure relief means is preferably located within the body member **14** to allow passage of fluid through the test packer from a point in the well bore below the packing member **21** to a point above the packing member when the pressure in the well bore below the packing member exceeds the pressure in the well bore above the packing member by a pre-determined amount. Such pressure relief means may take the form of a pressure relief valve 22 of a type which will be described in detail below in connection with FIGS. 3 through 8.

The test packer 11 shown FIGS. 1 and 2 also includes suitable pump means operable by limited reciprocation of the supporting means to expand the expandable packing member when the body member is anchored as described above. The pump means is also operable by the supporting means to allow return of the packing member to unexpanded condition by unidirectional movement of the supporting means beyond such limits of reciprocation. Suitable pump means are shown somewhat diagrammatically in FIGS. 1 and 2 and will be described in greater detail in connection with FIGS. 3 through 8. Suitable pump means are shown in FIGS. 1 and 2 as including a pump weight 23, a pump body 24 and a pump piston 26.

To set the test packer 11 for lowering down a well bore (FIG. 2) the supporting wire line 13 is raised until the weight of the test packer is supported by the line 13. As shown in FIG. 2, this upward pull on the wire line causes the upper portion of the pump weight 23, to which the wire line is attached, to exert an upward force on the rod 17 which controls the operation of the dogs 16. The compression under which the spring 19 is held is then adjusted so as to just maintain the dogs 16 in an expanded position when the weight of the packer 11 is supported by the wire line 13. The dogs 16 are then retracted by upward movement of the wire line 13 while upward movement of the body member 14 is restrained, thus causing the rod 17 to be raised with respect to the body member 14 against the urging of the spring 19. When this is accomplished the retaining means acts to retain the rod 17 in its raised position and thus keep the dogs 16 in an inoperative position as shown in FIG. 2. The test packer 11 may then be lowered to a desired depth in a well bore and, as described below in connection with FIGS. 3 through 8, the anchoring means may be allowed to move into an operative position by a single sharp upward pull on the wire line 13. This returns the dogs 16 to the position shown in FIG. 1.

When the wire line 13 is again lowered, the dogs 16 engage recesses or projecting portions such as 18 of the well bore 12 and prevent further downward movement of the body member 14. As the wire line 13 is lowered further, the pump weight 23 and pump piston 26, from which is slidably suspended pump body 24, move downwardly with respect to the body member 14 until the pump body 24 comes to rest on a pump seat 27 (FIG. 1). As shown in FIGS. 1 and 2, the pump body 24 forms a cylinder 28. As the wire line 13 is lowered further, movement of the pump piston 26 downwardly through the cylinder 28 forces fluid from the cylinder 28 through suitable means, shown diagrammatically as a passageway 29 and check valve 31, to inflate the packing member 21 so as to seal the well bore against passage of fluid past the packing member. Since the amount of fluid displaced in a single downward stroke of the piston 26 is usually not sufficient to accomplish this purpose, the piston 26 may be reciprocated by limited reciprocation of the supporting wire line 13 to pump additional fluid through the passageway 29 to inflate the packing member 21. For this purpose the pump weight 23 and pump body 24 may be so constructed as to leave space for passage of fluid between the outer walls of these members and the inner wall of the body member 14 adjacent these members. The entire portion of the interior of the body member 14 in which the pump weight 23 and pump body 24 move may thus be used as a fluid reservoir. When the wire line 13, pump weight 23 and pump piston 26 are moved upwardly in such limited reciprocation, fluid from within the body member 14 may be drawn into the cylinder 28 through suitable means such as a passageway 32 and check valve 33.

When it is desired to deflate the packing member 21 so as to move the test packer 11 to a higher point in the

well bore, it is necessary only to raise the wire line 13 beyond the limits of reciprocation used in operating the pump piston 26. When this is done the pump piston 26 engages the pump body 24 and lifts the same off of the seat 27, thus allowing the fluid used to expand the packing member 21 to escape through the passageway 29 into the interior of the body member 14. Further upward movement of the wire line 13 causes the pump weight 23 to engage the lower end of the rod 17 and thus raise the entire test packer 11. Since the spring 19 is preferably set to just barely cause the dogs 16 to be extended when the weight of the test packer is supported by the wire line 13, upward movement of the test packer by pulling on the wire line 13 will cause the dogs 16 to drag along the interior of the well bore. However, if the spring 19 has been set properly the force required to overcome the drag of the dogs 16 during this upward movement will be comparatively small and will not present any difficulty. If desired, the packer may be withdrawn to the surface and reset as described above or may be reset at a lesser depth in the well bore by merely relaxing the upward pull on the line 13 so that the dogs 16 engage recesses or projections in the well bore at an appropriate depth. Once the dogs 16 have so anchored the body member 14, the wire line 13 is relaxed to allow the pump weight and pump body to move downwardly and the packing member 21 may be inflated as described above.

Referring now to FIGS. 3 through 8, a test packer 111 constructed in accordance with the present invention is shown. The design and operation of this test packer is generally similar to that of the test packer 11 described above in connection with FIGS. 1 and 2. In describing the test packer 111 in connection with FIGS. 3 through 8, the components corresponding to components of the test packer 11 which were described in connection with FIGS. 1 and 2 have been given the same numerical designations as those given to the corresponding components of packer 11 except for the prefix of the numeral 1 in each case. E.g., the test packer 111 is provided with supporting means in the form of a conventional wire line 113 which is similar in design and operation to the wire line 13 of the test packer 11 shown in FIGS. 1 and 2.

As indicated in FIGS. 3*a* and 8 the test packer 111 may be used within a well bore or casing 112 and includes a body member 114. While the body member 114 is shown as being constructed in a number of separate sections fastened together by suitable means such as welding or screw threads, it should be understood that this body member and other components of the packer 111 may be constructed either in a manner similar to that shown or in any other suitable manner. For instance, two or more of the separate sections shown may be formed as a single section.

The packer 111 also includes an expandable packing member 121 (FIGS. 3*c* and 8) which is preferably an inflatable bladder formed of suitable material such as rubber. The inflatable packing member 121 may be secured to the body member 114 by any suitable means such as clamping rings 214 and 216 and screws such as 217 and 218 (FIG. 3*c*). Anchoring means are provided for anchoring the body member 114 with respect to the well bore or casing 112 and retaining means are provided for retaining the anchoring means in an inoperative position. The retaining means are operable by the supporting means such as the wire line 113 to retain the anchoring means in an inoperative position for lowering the packer down a well bore and are also operable by the supporting means to allow the anchoring means to move into an operative position for anchoring the packer in the well bore. As best shown in FIG. 3*a*, the anchoring means may comprise wall engaging members such as radially outwardly movable dogs 116 adapted to engage recesses or projections such as projections 118 in the well bore or casing 112. Any convenient number such as three of the dogs such as 116 may be used. The dogs

116 may be pivotally mounted on the body member 114 as by pins 141 and may be provided with teeth such as 142 adapted to engage teeth such as 143 on a rod 117. Suitable openings such as 144 are provided in the body member 114 to allow for outward radial movement of the dogs into an expanded anchoring position as shown in FIG. 3*a* and inward movement into a position in which the dogs could not engage the wall of the well bore 112. It is apparent that upward movement of the rod 117 tends to move the dogs such as 116 into an inoperative retracted position while downward movement of the rod moves the dogs outwardly into an operative anchoring position to anchor the body member 114 with respect to the well bore 112. The anchoring means also includes spring means such as a spring 119 (FIG. 3) positioned within the body member 114 so as to urge the rod 117 in a downward direction with respect to the body 114. The degree of compression of the spring 119 may preferably be adjusted by suitable means such as an adjusting nut 146. In the particular form of the apparatus shown in FIGS. 3 through 8 the adjusting nut 146 is threaded to engage corresponding threads on the interior of the body member 114 and may be adjusted by removing the section of the body member 114 immediately above the adjusting nut. As indicated in FIG. 3, downward movement of the rod 117 in response to the urging of the spring 119 is limited by engagement of a projecting shoulder 147 of the rod 117 with a shoulder 148 of the body member 114. Spring 119 may conveniently bear at one end against a shoulder 149 of the adjusting nut 146 and at its other end against a shoulder 151 of the rod 117. It should be noted that the rod 117 and body member 114 may cooperate to provide a central longitudinal opening adapted to receive the wire line 113.

The test packer 111, like the test packer 11 described in connection with FIGS. 1 and 2, has pump means operable by limited reciprocation of the supporting means to expand the packing member into sealing relationship with the wall of the well bore when the body member is anchored. The pump means is also adapted to allow return of the packing member to unexpanded condition by unidirectional movement of the supporting means beyond such limits of reciprocation. As shown in FIGS. 3*a* and 3*b*, suitable pump means may include a pump weight 123 which may be attached to the supporting wire line 113 by suitable means such as a fitting 152, a pump body 124 and a pump piston 126 secured to the pump weight 123 and movable within a pump cylinder 128 of the pump body 124. As best shown in FIGS. 3 and 4, suitable retaining means of the type described briefly above for retaining the anchoring means in inoperative position may include a plunger body 156 slidably mounted for limited longitudinal movement within the body member 114. Suitable first spring means such as a spring 157 biases the plunger body upwardly with respect to the body member 114. As shown in FIG. 4 the spring 157 may be placed between a shoulder 158 of the body member 114 and a shoulder 159 of the plunger body 156. Upward movement of the plunger body may be limited by engagement of a shoulder 161 of the plunger body with a shoulder 162 of the body member 114. To facilitate assembly of the plunger body 156, the lower portion thereof may comprise a separate piece shown here as a plunger body nut 163 which is secured to the remainder of the plunger body by suitable means such as thread connections. A second spring means, shown in the drawings as a spring 164, biases a plunger 166 downwardly with respect to the plunger body 156. As best shown in FIG. 4, the spring 164 may be placed between a shoulder 167 of the plunger body 156 and a shoulder 168 of the plunger 166. Downward movement of the plunger 166 in response to the urging of the spring 164 may be limited by suitable means such as engagement between a shoulder 169 of the plunger 166 and a shoulder 171 of the plunger body nut 163. The retaining means also includes latch means, shown in FIGS. 3, 4 and 5 as a latch sleeve 172 slidable for limited longitudinal movement within the body member 114. Third spring means such as a spring 173 is provided to bias the latch sleeve 172 upwardly with respect to the body member 114. For reasons which will become apparent when the operation of the test packer 111 is described below the spring 173 should be relatively weaker than the spring 164. For instance the spring 164 may require about 15 pounds for compression while the spring 173 may require only about 5 pounds. The spring 173 may be retained in place by suitable means such as by engagement between a shoulder 174 of the latch sleeve 172 and a suitable member such as a retainer sleeve 176 which is fixed against downward movement with respect to the body member 114. As best shown in FIG. 5, the upper portion of the rod 117 is provided with suitable means such as an annular groove 177 for engaging rod engaging members shown here as spherical members such as latch balls 178. The latch balls 178 are restrained against longitudinal movement within the body member 114 by the retainer sleeve 176 and by suitable means such as a retainer nut 179 secured to the body member 114 but are free for limited radial movement as described below. The latch sleeve 172 is provided with a recessed shoulder 181 near its lower end and an annular groove 182 adapted to engage the latch balls 178 when the latch sleeve is in its extreme downward position with respect to the body member 114.

The anchoring means thus may include wall engaging members such as the dogs 116, the rod 117 and spring means such as the spring 119. Likewise the retaining means for maintaining the anchoring means in inoperative position may include a plunger body such as 156, first spring means such as spring 157, a plunger such as 166, second spring means such as spring 164, latch means such as the latch sleeve 172, third spring means such as the spring 173 and rod engaging members such as latch balls 178. The latch balls 178 cooperate with the latch sleeve and the rod to retain the anchoring means in the inoperative position.

As described in greater detail below, the operation of the pump means involves reciprocations of the pump piston 126 while the pump body 124 rests on a pump seat 127 formed for instance by a portion of the body member 114 (FIG. 3*b*). The movement of the pump piston 126 within the cylinder portion 128 of the pump body 124 is guided by suitable means such as a guide member 186 which may be secured to the upper portion of the pump body 124 by suitable means such as welding and by a guide ring 187 which may be fixed to the lower portion of the pump piston 126 by suitable means such as a press fit. The guide member 186 is preferably provided with sealing means such as an O ring 188 to prevent passage of fluid through the opening in the guide member. Suitable means such as an annular groove 189 in the lower portion of the pump piston 126 are preferably provided to allow escape of vapors from the pump cylinder 128. While the pump means and more particularly the pump body and piston may be constructed in any suitable manner, the guide ring 187 is not, in the particular form of apparatus shown in the drawings, intended to serve as a seal. In fact, provision is made for free passage of fluid through the guide ring 187 as by providing cooperative passageways 191 and 192 in the pump piston 126.

The fluid to be pumped by the pump means may conveniently be stored within the interior area of the body member 114 in which the pump weight 123 and pump body 124 move. This area may be designated as a reservoir area 193 (FIG. 3*a*). As shown in FIGS. 3*a* and 3*b*, the pump weight 123 and pump body 124 are preferably of sufficiently small diameter so that fluid within the reservoir area 193 may pass through the passageways formed by the exterior walls of the pump weight and pump body and the interior wall of the body member 114 which forms the area 193. During operation of the pump piston 126 as described below fluid is, therefore, free to pass from the area 193 to suitable pump intake means such as a passageway 194 in the lower portion of the pump body 124 (FIG. 3*b*). From the passageway 194 fluid may pass through a passageway 196 to the cylinder 128. To prevent flow of fluid in the reverse direction a check valve formed for instance with a ball 197 and retainer 198 may be provided in the passageway 196. On the downstroke of the pump piston 126, fluid passes from the pump cylinder 128 through a passageway 201 (FIG. 7) and thence through an annular passageway 202 and passageways 203, 204 and 205 (FIG. 6) into a reservoir portion 206 of the body member 114 (FIG. 3*b*). The passageway 203 is provided with suitable means such as a plug 207 to insure that the fluid passes through the passageways 204 and 205 rather than back to the pump cylinder 128. Suitable means such as a check valve comprising a ball 208 and ball stop 209 (which may form a part of the plug 207) are preferably provided to prevent flow of fluid in the reverse direction.

Referring to FIGS. 3*b* and 3*c*, when the pump piston 126 is operated, passage of fluid from the pump cylinder 128 to the reservoir area 206 as described above forces fluid from the reservoir area 206 through a passageway 211 in the body member 114. Fluid from the passageway 211 passes through an annular space 210 and a perforated portion 212 of the body member 114 and inflates the packing member 121 into sealing relationship with the wall of the well bore 112. Passage of fluid under pressure from the reservoir area 206 to the storage area 193 is prevented by suitable means such as the use of an O ring 213 to provide a seal between the pump body 124 and the portion of the body member 114 forming the pump seat 127.

Suitable means such as a pressure relief valve 122 (FIGS. 3*c* and 8) are preferably provided to prevent damage to the inflatable packing member 121 due to the buildup of an excessive pressure difference across the packing member when the same is in sealing relationship with the well bore. As best shown in FIG. 3*c*, the pressure relief valve 122 includes a reservoir 221 containing suitable fluid such as mercury to a suitable level as indicated for instance by 222. A central conduit 223 extends from the lower portion of the reservoir 221 below the level 222 to an upper overflow chamber 224. Suitable openings such as 226 in the body member 114 and a port 227 in the relief valve 122 allow free passage of gaseous material from the well bore below the packing member 121 into a chamber 228 of the relief valve 122 and thence through suitable means such as a passageway 229 into the reservoir 221. The passageway 229 preferably takes the form of an annular passageway of comparatively small dimensions formed between the outer wall of the conduit 223 and the inner wall of a downwardly extending member 231 as shown in FIG. 3*c* in order to avoid possible loss of mercury to the well bore through the chamber 228. The upper portion of the conduit 223 is preferably provided with a suitable cap such as 232 in order to prevent loss of mercury with vapors passing from the overflow chamber 224. In order to allow passage of vapors from the overflow chamber 224 to the portion of the well bore above the packing member 121, suitable means such as an opening formed by a downwardly extending cylindrical member 233 of the relief valve 122 and cooperating passageways 234 and 235 in the body member 114 may be provided. Mercury from the overflow chamber 224 is returned to the reservoir 221 by suitable means such as a port 236 in the conduit 223.

Operation

The operation of the test packer 111 described above in testing a gas well for leakage of gas through the casing of the well bore may be described as follows.

Assuming that the packer has been previously used, it is first necessary to set the packer so as to retain the anchoring means in an inoperative position to enable the packer to be lowered down the well bore for the beginning of the test. To accomplish this the wire line 113 is pulled upwardly while the plunger body 156 is restrained from upward motion. This may be conveniently accomplished by placing the packer in a conventional lubricator and pulling upward on the wire line until the top of the packer contacts the top of the lubricator. At this time the retaining means will be in the position shown generally in FIG. 3. It is assumed that the adjusting nut 146 has previously been adjusted to maintain the spring 119 under the proper degree of compression so that the spring 119 exerts just sufficient force to expand the dogs 116 when the weight of the packer 111 is supported by the wire line 113. As the wire line 113 is pulled upwardly, the pump weight 123 bears against the lower end of the rod 117 and tends to lift the entire packer 111 in an upward direction. Since upward movement of the plunger body 156 is restrained, however, the effect of the upward pull on the test packer is to force the plunger body 156 downwardly with respect to the body member 114 against the urging of the spring 157. When this is done the plunger 166 acts under the urging of the spring 164 to force tthe latch sleeve 172 downwardly against the urging of the spring 173. Movement of the latch sleeve 172 is, however, limited by engagement of the shoulder 181 with the latch balls 178. Further upward pull on the wire line 113 forces the rod 117 upwardly, thereby further compressing the spring 119 and bringing the groove 177 of the rod 117 opposite the latch balls 178. At this point the latch balls 178 are forced into the groove 177 by the camming action of the shoulder 181 of the latch sleeve and the latch sleeve is allowed to move to its extreme downward position as shown in FIG. 4, thus bringing the groove 182 of the latch sleeve into engagement with the latch balls 178. When the upward pull on the wire line 113 is reduced, the compressive force of the spring 119 pushes the rod 117 downwardly until such downward movement is stopped by engagement of a shoulder 175 of the groove 177 with the latch balls 178 as shown in FIG. 4. The shoulder 175 of the rod 117 and the groove 182 of the latch sleeve 172 thereby cooperate to retain the rod 117 in an upward position and thus retain the dogs such as 116 in a retracted, inoperative position. Reducing the upward pull on the wire line 113 also allows the plunger body 156 to return to its original position relative to the body member 114 (FIG. 4). The packer 111 is now set and may be lowered to a desired depth in the well bore for testing.

When the packer 111 has been lowered to the desired depth the wire line 113 is given a sharp upward jerk. This sudden upward pull on the wire line causes a temporary compression of the spring 119, thereby allowing the latch balls 178 to be forced further into the groove 177 by the action of the spring 173 in urging the latch sleeve 172 upwardly. With the balls 178 thus disengaged from the groove 182 the latch sleeve 172 is free to move upwardly to its uppermost position under the urging of the spring 173. Such upward movement of the latch sleeve brings the recess formed by the shoulder 181 of the latch sleeve opposite the balls 178. This allows the balls to be forced out of the groove 177 into the recess formed by the shoulder 181 by the camming action of the shoulder 175 when the temporary compression of the spring 119 is ended. With the rod 117 thus released from engagement with the balls 178, the spring 119 forces the rod 117 downward thereby moving the dogs such as 116 to an expanded operative position. Further downward movement of the packer 111 by further lowering of the wire line 113 allows the dogs such as 116 to engage a collar joint or other recess or projection such as the projection 118 in the well bore 112.

With the test packer 111 thus anchored with respect to the well bore 112 by the dogs such as 116, the wire line 113 is lowered until the pump body 124 seats on the pump seat

127. Further downward movement of the wire line allows the pump weight 123 to force the pump piston 126 downwardly through the pump cylinder 128, thereby forcing fluid from the pump cylinder to begin inflation of the inflatable packing member 121 as described above. The packing member 121 is further inflated by limited reciprocal movement of the wire line 113, which causes reciprocal motion of the pump piston 126 within the cylinder 128 and forces additional fluid from the reservoir area 193 through the perforated portion 212 of the body member 114 to inflate the packing member 121 as described above. When the packing member 121 is fully inflated into sealing relationship with the casing 112 with suitable pressure such as about 50 p.s.i., any leakage of gas from above the packing member 121 may be detected by simply measuring the decrease in pressure of the gas above the packing member 121 with passage of time. During this testing operation the relief valve 122 will operate as described above to prevent damage to the test packer due to build up of excessive pressure differential across the inflatable packing member 121. The relief valve 122 may be adjusted by simply adjusting the amount of mercury contained therein to allow bypass of gas from the well bore beneath the packing member 121 to the well bore above the packing member 121 upon reaching any suitable pressure differential such as about 5 p.s.i. As is apparent from FIG. 3c, the overflow chamber 224 of the pressure relief valve 122 is maintained at the pressure of the gas in the well bore immediately above the packing member 121 by virtue of being open thereto through the passageways 234 and 235 as decribed above. On the other hand, the reservoir 221 of the relief valve 122 is maintained at the pressure of the gas in the well bore immediately below the packing member 121 by fluid communication therewith through the opening 226, port 227, chamber 228 and passageway 229 as described above. It will be seen that the result of this is to force mercury from the reservoir 221 upwardly in the conduit 223 as the pressure in the reservoir 221 increases over that in the overflow chamber 224. When a sufficient pressure differential is reached the mercury from the conduit 223 overflows into the overflow chamber 224. When enough of the mercury has thus been forced from the reservoir 221, gas will escape from the reservoir 221 through the conduit 223 into the overflow chamber 224 from which it is free to pass to the well bore above the packing member 121 as described above. Likewise, an increase of pressure in the well bore above the packing member 121 will be transmitted through the passageways 234 and 235 to the overflow chamber 224 and conduit 223. When this pressure becomes sufficiently greater than the pressure in the well bore below the packing member 121, mercury will be forced out of the conduit 223 and gas will escape through the conduit 223, reservoir 221 and chamber 228 to the well bore below the packing member 121.

When it is desired to move the test packer from its original position in the well bore to a lesser depth, it is necessary only to raise the wire line 113 sufficiently to cause the pump weight 123 and pump piston 126 to raise the pump body 124 off of the pump seat 127. This allows escape of fluid from the vicinity of the packing member 121 back thrus the perforated portion 212 of the body member 114, passageway 211, reservoir 206 and thus to the reservoir area 193, thus allowing deflation of the packing member 121 so that it no longer exerts a sealing force against the interior of the well bore 112. Further upward movement of the wire line 113 causes the additional slight compression of the spring 119 necessary to allow the dogs such as 116 to retract sufficiently to drag along the inside wall of the well bore 112. When the test packer 111 has been raised to the desired position for the next test it is necessary only to relax the upward pull on the wire line 113 and allow the test packer to move downwardly until the dogs such as 116 engage a suitable recess or projection, thereby anchoring the test packer one again with respect to the well bore. The same procedure described above may then be followed to obtain the desired information concerning leakage of gas from points in the well bore above the location of the packing member 121.

While the operation of the test packer has been described immediately above in connection with testing a gas well for leaks, it should be understood that operation of a test packer such as the packer 111 is not limited to such applications but may be utilized for many other conventional operations. The test packers constructed in accordance with the present invention are useful in any application where it is desired to place a temporary packer in a well bore and are especially useful where it is desired to place the packer successively at different depths in the well bore without the necessity for returning the packer to the surface between successive tests at different depths. A special advantage of packers constructed in accordance with the invention is that no special setting or retrieving tools are necessary and that the packer may be supported and operated by a simple wire line run through a conventional lubricator, thereby avoiding the necessity for running a string of tubing or losing excessive amounts of gas from the well during the test.

While the invention has been described above with respect to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes and modifications are possible without departing from the spirit and scope of the invention and it is intended to cover all such changes and modifications in the appended claims.

I claim:

1. Apparatus comprising a well packer and supporting means for supporting and operating the packer, said packer comprising in combination a body member, an expandable packing member, anchoring means for anchoring said body member with respect to the wall of a well bore, pump means operable by limited reciprocation of said supporting means to expand said packing member into sealing relationship with the wall of the well bore when said body member is anchored and to allow return of said packing member to unexpanded condition by unidirectional movement of said supporting means beyond said limits of reciprocation and check valve means positioned in operative relationship with respect to said pump means so as to increase the pressure acting to expand said packing member in response to repeated reciprocation of said supporting means.

2. A well packer comprising in combination a body member, an expandable packing member, means for expanding said packing member into sealing relationship with the wall of the well and a pressure relief valve positioned so as to allow passage of fluid through said body member from a point in the well bore below said packing member to a point in the well bore above said packing member when the pressure in the well bore below said packing member exceeds the pressure in the well bore above said packing member by a predetermined amount, said pressure relief valve comprising a reservoir chamber containing mercury, mechanical means for maintaining fluid communication between said reservoir chamber and the well bore immediately below said packing member so that the reservoir chamber is maintained at the pressure of the gas in the wellbore immediately below said packing member, an overflow chamber, mechanical means for maintaining fluid communication between said overflow chamber and the wellbore immediately above said packing member, whereby said overflow chamber may be maintained at the pressure of the gas in the wellbore immediately above said packing member, a conduit extending from the lower portion of said reservoir chamber below the level of mercury to the upper overflow chamber, whereby a predetermined pressure differential across the packer will cause a sufficient movement of the mercury between said reservoir chamber and said overflow cham-

ber to permit the flow of gas through said relief valve, decreasing the pressure differential across the well packer.

3. Apparatus comprising a well packer and supporting means for supporting and operating the packer, said packer comprising a body member, anchoring means in opertive relationship with said body member for anchoring said body member with respect to the wall of a well bore, and retaining means in operative relationship with said anchoring means for retaining said anchoring means in an inoperative position, said retaining means comprising a plunger body slidable for a limited longitudinal movement within the body member, first spring means biasing said plunger body in a first direction with respect to said body member, a plunger, second spring means biasing said plunger in a second direction with respect to said plunger body, latch means slidable for limited longitudinal movement within said body member, and third spring means biasing said latch means in said first direction with respect to said body member, said third spring means being relatively weaker than said second spring means and said plunger being positioned so as to be operable by said second spring means to force said latch means in said second direction with respect to said body member against the urging of said third spring means when said plunger body is forced in said second direction with respect to said body member against the urging of said first spring means.

4. Apparatus comprising a well packer and supporting means for supporting and operating the packer, said packer comprising a body member, anchoring means in operative relationship with said body member for anchoring said body member with respect to the wall of a well bore, and retaining means in operative relationship with said anchoring means for retaining said anchoring means in an inoperative position, said retaining means comprising a plunger body slidable for a limited longitudinal movement within the body member, first spring means biasing said plunger body upwardly with respect to said body member, a plunger, second spring means biasing said plunger downwardly with respect to said plunger body, a latch sleeve slidable for limited longitudinal movement within said body member, and third spring means biasing said latch sleeve upwardly with respect to said body member, said third spring means being relatively weaker than said second spring means and said plunger being positioned so as to be operable by said second spring means to force said latch sleeve downwardly with respect to said body member against the urging of said third spring means when said plunger body is forced downwardly with respect to said body member against the urging of said first spring means.

5. Apparatus comprising a well packer and supporting means for supporting and operating the packer, said packer comprising in combination a body member, an expandable packing member, anchoring means for anchoring said body member with respect to the wall of a well bore, and pump means operable by limited reciprocation of said supporting means to expand said packing member into sealing relationship with the wall of the well bore when said body member is anchored and to allow return of said packing member to unexpanded condition by uni-directional movement of said supporting means beyond said limits of reciprocation, said body member being provided with a pump seat and the pump means comprising a pump weight secured to and depending from the supporting means and mounted for limited longitudinal movement within the body member, a pump piston rigidly secured to and depending from said pump weight and a pump body adapted to engage said pump seat including a pump cylinder adapted to receive said pump piston for limited reciprocation therein, said pump piston being adapted to engage said pump body to limit upward movement of said pump piston with respect thereto whereby said pump body may remain seated on said pump seat during said limited reciprocation of said pump piston in response to limited reciprocation of said supporting means and is lifted from said pump seat by upward movement of said supporting means beyond the limits of such reciprocation.

6. A well packer comprising a body member, anchoring means positioned in operative relationship with respect to said body member for anchoring said body member with respect to the wall of a well bore, said anchoring means comprising a plurality of wall engaging members, a rod operatively connected with said wall engaging members to move same between operative and inoperative positions in response to longitudinal movement of said rod, and spring means biasing said rod in a direction to move said wall engaging members into operative anchoring position, and retaining means in operative relationship with said anchoring means for retaining said anchoring means in an inoperative position, said retaining means comprising a plunger body slidable for limited longitudinal movement within the body member, a first spring biasing said plunger body upwardly with respect to said body member, a plunger, a second spring biasing said plunger downwardly with respect to said plunger body, a latch sleeve slidable for limited longitudinal movement within said body member, a third spring biasing said latch sleeve upwardly with respect to said body member, said third spring being relatively weaker than said second spring whereby said plunger is operable by said second spring to force said latch sleeve downwardly with respect to said body member against the urging of said third spring when said plunger body is forced downwardly with respect to said body member against the urging of said first spring, the rod associated with the anchoring means being provided with an external annular groove near the upper end thereof and said latch sleeve being provided with an internal annular groove, a plurality of spherical members positioned within said body member, said spherical members being mounted for limited radial movement only with respect to said body member and being operable by engagement with said grooves in the rod and latch sleeve to retain the rod against the urging of the spring means associated with the anchoring means to thereby maintain the wall engaging members in an inoperative position.

7. A well packer comprising a body member, anchoring means positioned in operative relatiionship with respect to said body member for anchoring said body member with respect to the wall of a well bore, said anchoring means comprising a plurality of radially outwardly movable dogs, a rod operatively connected with said dogs to expand same into operative anchoring position and to retract same into an inoperative position in response to longitudinal movement of said rod within the body member, and spring means biasing said rod in a direction to expand said dogs into operative anchoring position, and retaining means in operative relationship with said anchoring means for retaining said anchoring means in an inoperative position, said retaining means including a latch sleeve slidable for limited longitudinal movement within said body member, the rod associated with the anchoring means being provided with an external annular groove and said latch sleeve being provided with an internal annular groove, and a plurality of rod engaging members positioned within said body member, said spherical members being operable in cooperation with said grooves in the rod and latch sleeve to retain the rod against the urging of the spring means to thereby maintain the dogs in an inoperative position.

8. The apparatus of claim 7 in which the retaining means comprises a plunger body slidable for limited longitudinal movement within the body member, first spring means biasing said plunger body upwardly with respect to said body member, a plunger, second spring means biasing said plunger downwardly with respect to said plunger body, a latch sleeve slidable for limited longitudinal movement within said body member, third

spring means biasing said latch sleeve upwardly with respect to said body member, said third spring means being relatively weaker than said second spring means whereby said plunger is operable by said second spring means to force said latch sleeve downwardly with respect to said body member against the urging of said third spring means when said plunger body is forced downwardly with respect to said body member against the urging of said first spring means, the rod associated with the anchoring means being provided with an external annular groove and said latch sleeve being provided with an internal annular groove, a plurality of spherical members positioned with said body member, said spherical members being operable in cooperation with said grooves in the rod and latch sleeve to retain the rod against the urging of the spring means associated with the anchoring means to thereby maintain the dogs in an inoperative position.

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