

June 12, 1962

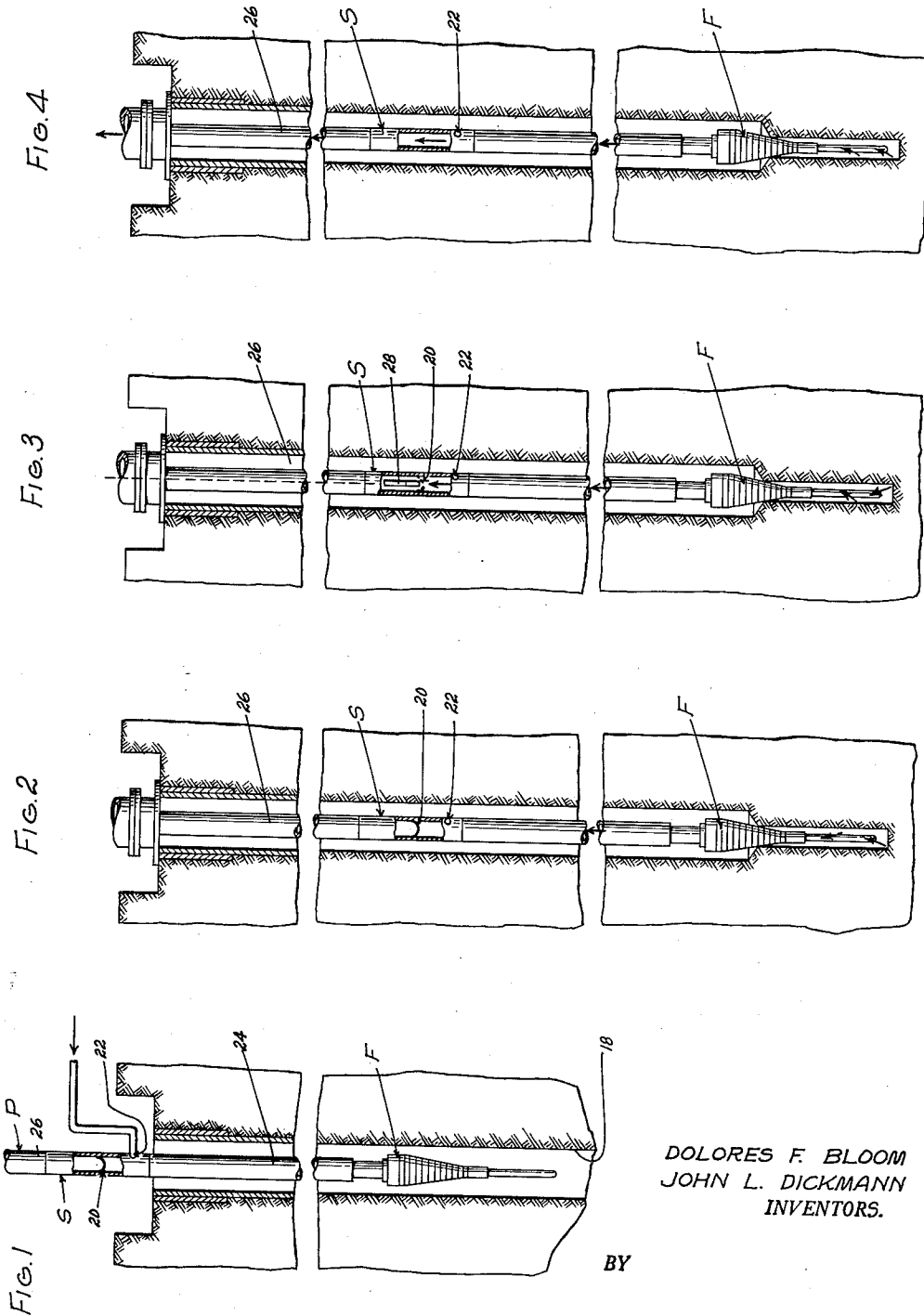
D. F. BLOOM ET AL

3,038,539

METHOD AND APPARATUS FOR SAMPLING WELL FLUIDS

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4 Sheets-Sheet 1



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METHOD AND APPARATUS FOR SAMPLING WELL FLUIDS

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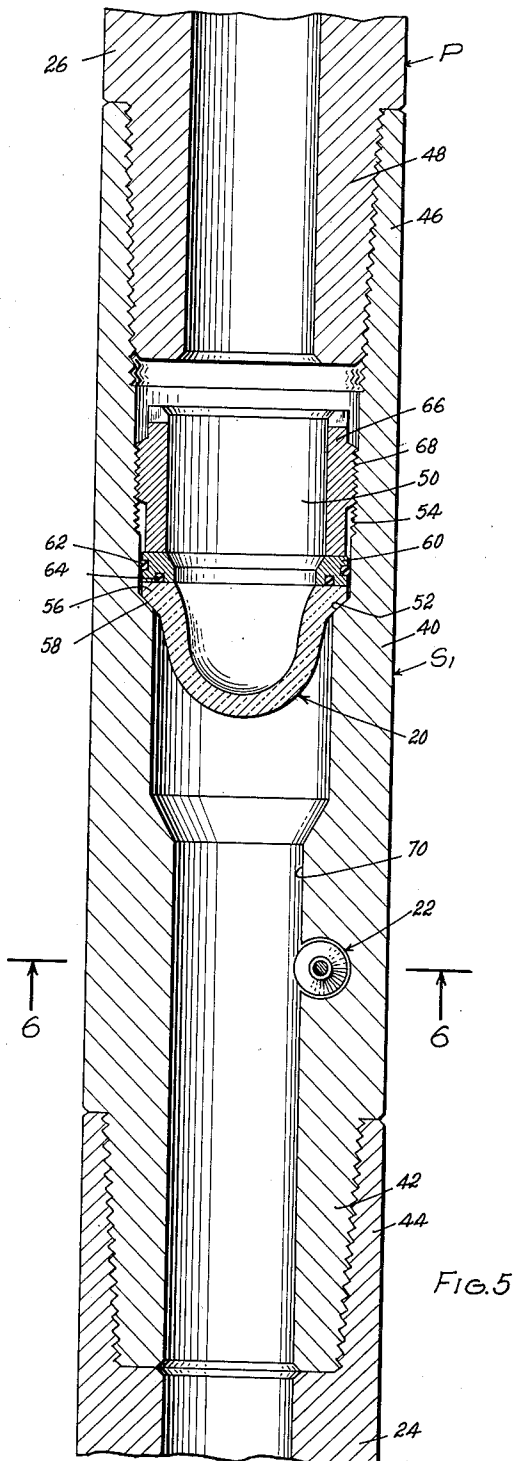


FIG.5

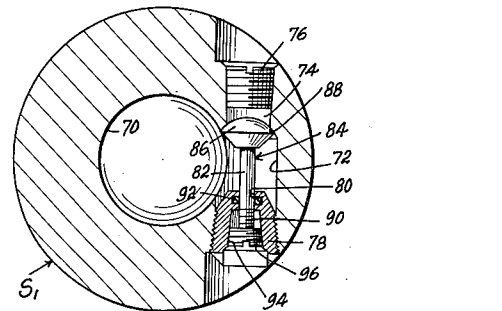


FIG. 6

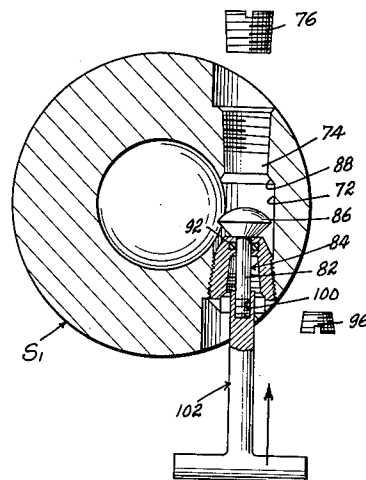


FIG. 7

DOLORES F. BLOOM
JOHN L. DICKMANN
INVENTORS.

BY

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D. F. BLOOM ET AL

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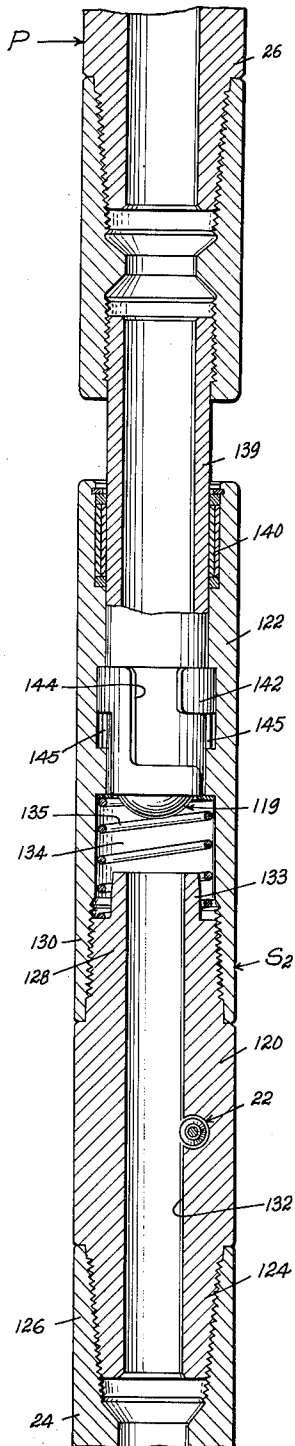


FIG. 8

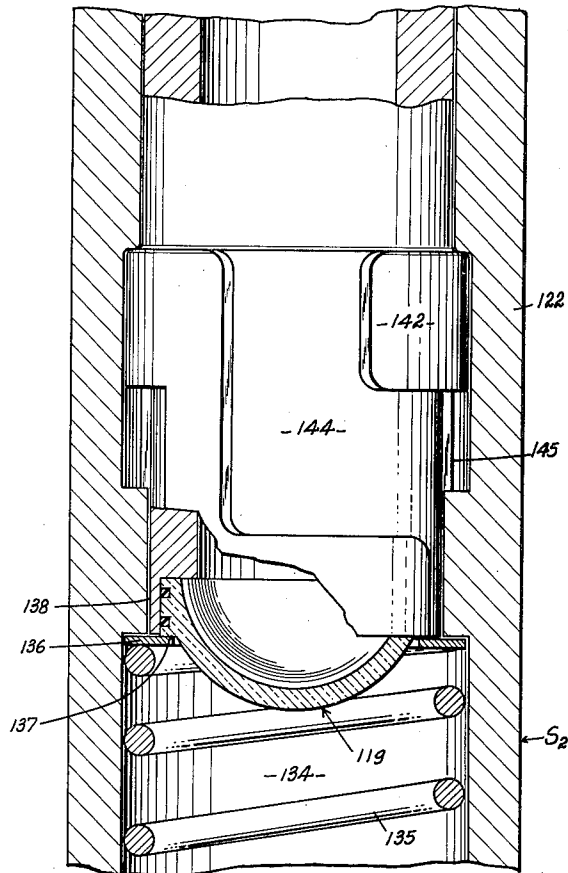


FIG. 9

DOLORES F. BLOOM
JOHN L. DICKMANN
INVENTORS.

BY

June 12, 1962

D. F. BLOOM ET AL

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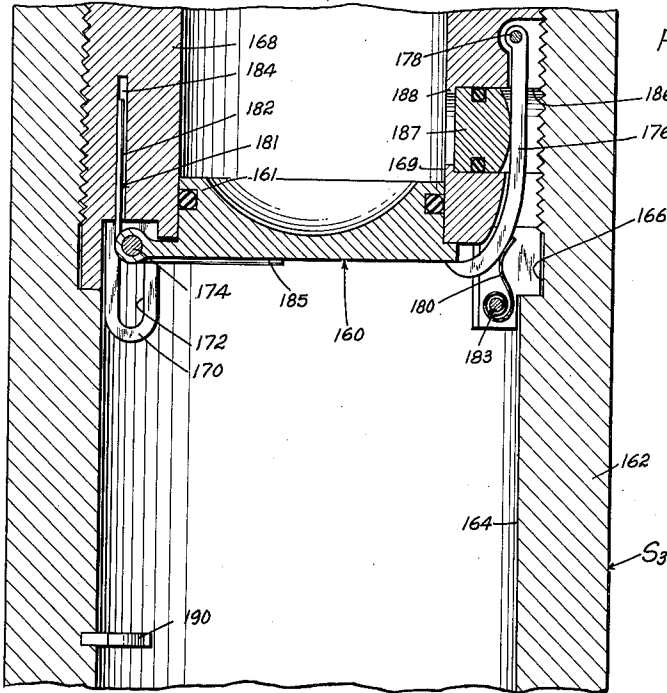


FIG. 10

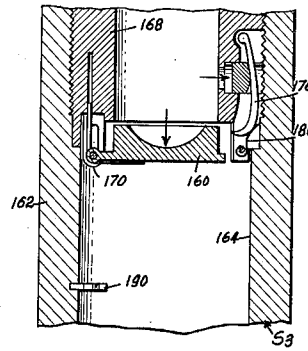


FIG. 11

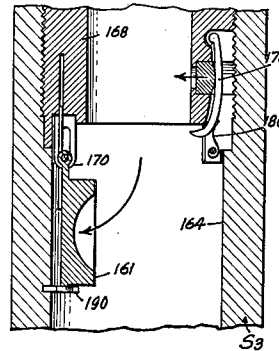


FIG. 12

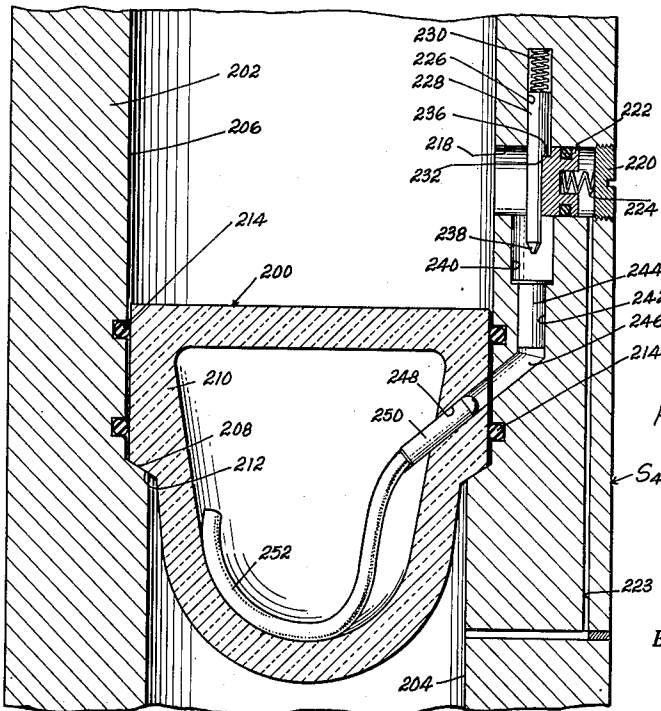


FIG. 13

DOLORES F. BLOOM
JOHN L. DICKMANN
INVENTORS.

BY

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METHOD AND APPARATUS FOR SAMPLING WELL FLUIDS

Dolores Floyd Bloom, Bakersfield, and John L. Dickmann, Whittier, Calif., assignors to Aircushion Patents Corporation, Bakersfield, Calif., a corporation of California
Filed Aug. 9, 1957, Ser. No. 677,327
1 Claim. (Cl. 166—3)

The present invention relates generally to the production of petroleum and more particularly to a new and improved method and apparatus for sampling well fluids by means of a formation tester.

A variety of techniques and special tools called "formation testers" have been developed in the petroleum industry for securing samples of the fluid contained in a given formation which has been penetrated by a well, without requiring the running and cementing of casing and without bailing or otherwise removing the drilling fluid from the well. Such techniques and tools are also utilized in testing the effectiveness of water shut-offs and may be used to determine whether casing perforations are freely admitting fluid from the formation.

As described by Uren in "Petroleum Production Engineering-Oil Field Development," 3rd Edition, 1941, such formation testers are employed in conjunction with a packer which, when properly seated against the wall of the well or casing, relieves the test interval immediately below the packer of the hydrostatic pressure of the overlying column of drilling fluid in the well. In "straddle" testing, above the bottom of a well, a second packer is employed which is located below the tester. By means of a valve located in the formation tester, fluid is permitted to flow from the formation below the packer, through the tester into a pipe string such as, for instance, drill pipe. Fluid so entering the pipe string is trapped therein by means of a valve located in the tester, so that the entrapped fluid may be withdrawn from the well with the pipe string for subsequent examination; or if the formation pressure is sufficient to cause the flow of the fluid from the formation to the surface, a sustained flow test through the pipe string will provide, in addition to the sample, a quantitative measure of the productive capacity of the formation being tested. However, one objection to the conventional methods of testing a formation is that there is no control permitted of the rate of the escape of the fluid and pressure from the formation into the pipe string because of the differential in pressure between the high rock pressure below the packer and the low pressure in the pipe string. Frequently this causes caving or collapsing of the hole immediately adjacent the packer, thereby causing the packer and the pipe string to which it is attached to become lodged within the hole.

One form of formation tester in which the valving means are actuated by a weight, or "go-devil," dropped from the surface through the drill pipe, is described by Uren at pages 562-3. Other types of formation testers, such as the Halliburton "Hydrospring" tester are also in general use which provide for control of the valve by relative movement between the pipe string and the body of the tester. Either of these testers is typical of a formation tester which may be used in carrying out the method of the present invention.

In addition to the above objection, the conventional existing formation testing techniques are additionally inadequate to meet difficult conditions encountered in certain situations. As for example, wells drilled in unconsolidated sand and caving formations, such as heaving shales, and wells drilled into a stratum which is under high pressure are especially difficult to sample without damaging the stratum being sampled or causing a blow-

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out which may be accompanied by an uncontrollable flow of gas or oil. The use of a flow bean in the tester to restrict the flow, and the use of water or drilling fluid in the pipe string to balance the formation pressure have been among the expedients used in testing such formations. A sufficiently restricted flow bean may be easily clogged. Counter pressure created by water or drilling fluid, either alone or accompanied by conventional swabbing, can never be sufficiently accurately controlled to avoid the risk of either a "dry run" if the weight of the column of fluid is excessive, or of formation damage and cavitation accompanied by a possible blowout if it is insufficient.

A method which avoids the aforesaid disadvantages is disclosed in a co-pending patent application Serial No. 729,241, filed by Dolores Floyd Bloom on March 11, 1957; now Patent No. 2,850,097 issued September 2, 1958. The method disclosed in this patent avoids dry runs while at the same time controlling the flow of fluids into the tester and pipe string in such a manner as to prevent caving of the formation, and insures against blowouts. This is accomplished, in summary, by running a pipe string carrying a formation tester, associated valve means, and packer means into the hole with the valve closed, introducing gas under pressure into the pipe string prior to opening the valve, to a pressure approaching but generally below the estimated pressure of the fluid present in the packed-off formation to be tested, maintaining the gas pressure in the pipe string until the formation pressure and the pipe string pressure approach equilibrium, and subsequently gradually bleeding off the gas pressure at the surface of the ground at such a rate as to control the rate of ingress of fluids into the tester and pipe string within desired limits and sufficiently slowly so as to prevent caving or channeling of the formation below the packer. The presence of gas pressure within the pipe string at a value lower than the pressure in the formation will not result in a blowout because, as the fluid or gas from the formation rises in the pipe string, the cushion or gas above the valve will compress until the pressure in the pipe string becomes balanced against the formation pressure. Since this compression of the gas in the pipe string cushions the rising fluids originating in the formation, shock effects which might precipitate caving or channeling of the formation are effectively avoided.

Although the method disclosed in the aforesaid Bloom patent generally affords satisfactory results when employed in a majority of well bores, it may not always prove satisfactory for use in deeper well bores and in well bores extending into formations in which higher pressures exist. The method and apparatus of the present invention are especially adapted for use under such conditions.

It is a major object of the present invention to provide a method and apparatus for effecting the stage pressurizing of a pipe string during formation or casing testing.

It is a more particular object of the present invention to provide a method and apparatus for gas pressurizing the lower portion of a pipe string used in conducting formation or casing testing separately from the upper portion of the string. The presence of pressurized gas within the lower portion of the pipe string serves to prevent the inward collapse of the pipe string while it is being lowered into the well bore. In this regard it has been determined that in deeper well bores the lower portion of the pipe string tends to collapse inwardly under the combined influence of the inwardly directed forces applied upon the external surface of the pipe by the well pressures and the inwardly directed forces present in the

pipe due to its being placed in tension. Once the formation tester reaches the testing zone and the packer means have been set, the pipe string is no longer in tension and the collapsing tendency is then appreciably reduced.

The method and apparatus of the present invention may be utilized to eliminate the necessity of pressurizing the entire length of pipe string with a high pressure gas as in the case of the method disclosed in the aforesaid Bloom patent application. Accordingly, a saving in the time required to carry out the test as well as the cost of the gas is afforded. The utilization of stage pressurizing of the pipe string likewise makes it possible to pressurize the lower portion of the string to a certain pressure, and other portions of the string to different pressures. With this arrangement the highest internal pressurization can be provided immediately above the formation tester, with the remaining portions of the pipe string pressurized to lower pressure values. In this manner, an adequate gas cushion is provided above the formation tester and yet it is not necessary to pressurize the entire length of pipe string to the desired cushion pressure.

Apparatus for carrying out the method of the present invention incorporates, essentially, one or more loading sub-units disposed at spaced intervals in the pipe string. Each of these loading subs includes a removable seal for temporarily blocking flow through the pipe string, and means providing for the introduction of gas which is utilized to pressurize the portion of the pipe string located below the seal.

In one of the illustrated embodiments of the present invention, the removable seal of the loading sub-unit takes the form of a frangible disc which may be ruptured by means of a go-devil. In another embodiment it takes the form of a frangible disc which is ruptured by controlled movement of the pipe string. In a third embodiment, the seal is in the form of a valve which is caused to open under the influence of a pressure differential between its upper and lower surfaces. In a fourth embodiment of the present invention the removable seal of the loading sub-unit takes the form of a frangible disc which is caused to rupture under the influence of a differential between its upper and lower surfaces.

Other advantages of the present invention will become apparent from the following detailed description, when taken in conjunction with the appended drawings, wherein:

FIGURES 1 through 4 provide a diagrammatic illustration of a well bore and the mode of operation of the method and apparatus embodying the present invention;

FIGURE 5 is a central longitudinal sectional view of a first form of loading sub-unit embodying the present invention;

FIGURE 6 is a horizontal sectional view taken on lines 6-6 of FIGURE 5;

FIGURE 7 is a view similar to FIGURE 6, but showing the parts thereof arranged in a different position;

FIGURE 8 is a central longitudinal sectional view of a second form of loading sub-unit embodying the present invention;

FIGURE 9 is a fragmentary enlarged view of the frangible disc utilized in the loading sub-unit of FIGURE 8;

FIGURE 10 is a fragmentary enlarged longitudinal sectional view of a third form of loading sub-unit embodying the present invention;

FIGURE 11 is a reduced view similar to FIGURE 10 but showing the seal of said loading unit, in the form of a valve, disposed in a partially open position;

FIGURE 12 is a view similar to FIGURE 11 but showing the seal disposed in a fully open position; and

FIGURE 13 is a longitudinal sectional view showing a fourth form of loading sub-unit embodying the present invention.

Referring to the drawings and particularly to FIGURES 1 through 4 thereof, the method and apparatus

of the present invention are employed in conjunction with a conventional formation tester F carried at the lower end of the pipe string P so as to be lowered into a well bore 13. Manipulation of the pipe string P is effected by conventional equipment (not shown), including the usual valve assembly, known as a "Christmas tree," such as is illustrated in the aforesaid Bloom Patent No. 2,850,097. One or more loading subs S to be fully described hereinafter are interposed in the pipe string P. Each such loading sub S includes a removable seal 20 at its intermediate portion and gas-receiving means 22 disposed below the seal 20. In carrying out the method of the present invention, the formation tester F is lowered into the well bore 13 a desired distance by means of a lower portion 24 of the pipe string P. Thereafter, the lower end of the loading sub S will be affixed to the upper end of the lower pipe string portion 24 which is then disposed within the well bore 13. An additional length of pipe 26 will then be affixed to the upper end of the loading sub S. At this time the seal 20 will block the flow of fluid through the pipe string P. Next, a suitable gas will be introduced into the portion of the loading sub S below the seal 20 by means of the gas-receiving means. The use of an inert gas is preferred because it cuts to a minimum the fire hazard present at the well head and even within the well itself. Nitrogen, an inert gas, is particularly desired because of its chemical inertness in reference to gases present in earth formations, giving a much better formation gas sample at the casing head. Sufficient nitrogen will be forced through the gas-receiving means 22 as, for instance, by conducting gas into the gas-receiving means 22 from banks of cylinders in which it may be conveniently transported to the well, to pressurize the lower portion 24 of the pipe string P to a desired pressure. Thereafter, as indicated in FIGURE 2, the pipe string P will be lowered until the formation tester F is disposed adjacent the zone to be tested. The pipe string is then packed off about the formation to be tested. The formation tester F will then be opened so as to admit well bore fluid into the lower portion 24 of the drill pipe P.

Preferably, the lower portion 24 of the pipe string will have been pressurized to a value as nearly approximately equal to the pressure in the formation to be tested as is possible before the formation tester F is opened. The precise pressure of the gas in the pipe string varies according to conditions from well to well. It has been found in actual practice that preferably this pressure should be less than the formation pressure, but under certain circumstances it may be desirable to go above this formation pressure, and the best results have been obtained when a pressure approximately equal to the formation pressure is used. On the other hand, pressures ranging from formation pressure down to approximately one fifth of the formation pressure have been employed with varying degrees of satisfactory results.

When the formation tester F is opened, the formation fluid will enter the formation tester F and the lower portion 24 of the pipe string P gradually and slowly thereby preventing caving, channeling or other damage to the formation. With reference now to FIGURE 3, the seal 20 will next be removed by any of the means hereinafter described. Means for dropping a weight to rupture a seal, while maintaining the upper end of the pipe string closed are well known in the prior art, one such arrangement being disclosed in Patent No. 2,137,296 dated November 22, 1938 issued to Macready. Thereafter, as indicated in FIGURE 4, the formation fluid entering the formation tester will rise to the earth's surface through the upper portion of the pipe string P, as the gas pressure within the entire pipe string is bled off at the surface of the ground by manipulation of the "Christmas tree" valves as described in Bloom Patent No. 2,850,097. A gradual rise through the formation tester into the pipe string of the fluid to be sampled is thereby permitted. Alternately, it

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may be desirable to first remove the seal 20 and thereafter open the formation tester F.

Referring now to FIGURES 5, 6 and 7, there is shown a first form of loading sub S1 which may be employed in carrying out the method of the present invention. The loading sub S1 includes a body 40 having an outside diameter approximating that of the pipe string P. The lower portion of the body 40 is formed with an externally threaded male coupling member 42 adapted to receive a complementary female member 44 formed on the upper end of the lower pipe section 24. The upper portion of the body 40 is formed with an internally threaded female member 46 that receives a complementary male coupling member 48 formed on the lower end of the upper pipe section 26. Below the female member 46 the body 40 is formed with a seal cavity 50, the lower end of which is defined by a downwardly tapering frusto-conical seat 52. The intermediate portion of this seal cavity 50 is formed with internal threads 54.

A seal 20 is preferably formed of a frangible material, as, for example, Pyrex glass. It is desirable that this material is capable of being fractured into relatively small particles which will not interfere with valves or other mechanisms which may be arranged within the pipe string P. The seal 20 is of a downwardly dished configuration and includes an upper mounting portion 56 having a downwardly tapered frusto-conical surface 58 which rests upon the seat 52. A seal ring 60 abuts the upper end of the seal 20. This seal ring preferably carries one or more elastic seals 62 and 64. The seal S and its sealing ring 60 are retained in place by a mounting sleeve 66, the intermediate portion of which is formed with threads 68 engageable with the threads 54 of the seal cavity 50.

Below the seal cavity 50 the body is formed with a gas-receiving bore 70. This gas-receiving bore 70 may have the same inside diameter as the pipe string P. A gas-receiving means 22 includes a transversely extending bore 72 (see FIGURE 6) formed through the body 40 so as to intersect one side of the gas-receiving bore 70. The inlet portion 74 of the bore 72 is of reduced diameter and is internally threaded so as to receive a removable plug 76. The opposite end of the bore 72 is likewise internally threaded so as to receive a valve support sleeve 78. The valve support sleeve 78 includes a coaxial bore 80 that slidably carries the stem 82 of a poppet valve 84. The head 86 of this poppet valve 84 is adapted to engage a seat 88 formed at the junction of the bore 72 and its inlet portion 74. The opposite end of the stem 82 is threaded, as indicated at 90. Preferably, a seal ring 92 will be provided in the valve support sleeve 78 so as to engage the valve stem 82. The valve support sleeve 78 includes a coaxial internally threaded cavity 94. This cavity 94 is adapted to receive a removable plug 96.

Referring now to FIGURE 7, when it is desired to force gas into the loading sub S1, the plugs 76 and 96 are removed from their respective bores. The threads 90 of the valve stem 82 are engaged by complementary threads formed within a blind bore 100 disposed at the free end of a generally T-shaped loading tool 102. During the gas loading operation the valve 84 will be maintained in its position of FIGURE 7. When the desired volume of gas has been forced into the loading sub S1, the loading tool 102 will be employed to force the head 86 of the valve 84 into a sealing engagement with the seat 88. The pressure of the gas will then maintain the valve head 86 in tight sealing engagement with the seat 88. The plug 96 will likewise be reinserted within the cavity 94 of the valve support sleeve 78 so as to positively prevent unseating of the valve 84. Finally, the plug 76 will be reinstalled within the inlet portion 74 of the bore 72. The gas-receiving means 22 will then remain closed to prevent escape of gas despite any rough handling of the sub S1.

Referring now to FIGURES 8 and 9, there is shown

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a second form of loading sub S2 which may be employed in carrying out the present invention. This loading sub S2 includes a removable seal 119 and gas-receiving means 22, the latter being similar to that shown and described in conjunction with the loading sub S1. Preferably, the seal 119 will be formed of a frangible material as in the case of the aforescribed seal 20. The lower portion of the loading sub S2 is defined by a generally tubular body 120 while the upper portion thereof is defined by a sleeve member 122. The lower portion of the body 120 is formed with a male coupling member 124 adapted to receive a complementary female member 126 formed on the upper end of the lower pipe section 24. The upper portion of the body 120 is also formed with a male coupling member 128 that is received by a complementary female member 130 formed at the lower portion of the sleeve member 122. The body 120 is coaxially formed with a gas-receiving bore 132. The lower portion of the sleeve member 122 is formed with a seal cavity 134. An upstanding coaxial boss 133 extends from the upper end of the body 120 into the lower portion of the seal cavity 134. A coil compression spring 135 is disposed within the seal cavity 134. The upper end of this spring 135 abuts a washer 136 that encompasses a shoulder 137 formed at the intermediate portion of the seal 119. In this manner the seal 119 is retained within a counter bore 138 formed at the lower end of the sleeve 122.

A tube member 139 is axially slidably supported within the sleeve member 122. Packing means 140 are provided between the upper portion of the sleeve member 122 and the intermediate portion of this tube 139. The upper end of the tube 139 is affixed to the lower end of the upper portion 26 of the pipe string P. The lower portion of the tube 139 is formed with a J-slot member 142. This J-slot member 142 is formed with slots 144 that receive complementary ears 145 formed on the inner side walls of the sleeve member 122 so as to positively lock the tube 139 against axial movement relative to the sleeve 122 so long as right-hand torque is being applied to the upper portion 26 of the pipe string P. When, however, left-hand torque is applied to the upper portion 26 of the pipe string P, the slots 144 and the ears formed on the sleeve 122 will permit the tube 139 to be moved downwardly relative to the sleeve 122. In this manner the frangible seal 20 will be fractured against the upper end of the boss 136 formed upon the upper end of the body member 120. The spring 135 serves to maintain the tube 139 in its normal upper position during transportation and assembly. When the loading sub S2 and the lower portion 24 of the pipe string P have been pressurized with gas, however, the gas pressure will assist in retaining the tube 139 in its upper position.

Referring now to FIGURES 10, 11 and 12, there is shown another form of removable seal 160 which may be utilized in carrying out the present invention. This seal 160 is shown mounted within a third form of loading sub S3. It is contemplated that the same form of gas-receiving means 22 described hereinbefore in conjunction with the description of the loading subs S1 and S2 will be employed with the loading sub S3.

The loading sub unit S3 includes a generally tubular main body 162 having a gas-receiving bore 164 formed in its lower portion. The upper end of the gas-receiving bore 164 merges into a second bore 166 of somewhat larger diameter. The upper bore 166 threadably receives a sleeve 168. The removable seal, in this embodiment, in the form of a valve plate, is mounted at the lower end of this sleeve 168 and includes a cylindrical upper portion 161 normally slidably disposed within the bore 169 of the sleeve 168. One side of the sleeve 168 is formed with a pair of aligned downwardly extending ears 170 each formed with a vertically extending slot 172. These slots 172 slidably receive a pivot pin 174 which is affixed to one side of the valve plate 160. The opposite side of the valve plate 160 is adapted to be engaged by the

lower end of a latch hook 176. The upper end of this latch hook 176 is pivotally secured to the sleeve 168 by a pin 178. The lower end of the latch hook 176 is biased radially inwardly by a spring finger 180 that is secured to the body 162 by a pin 183. The pivot pin 174 carries the center of a sear spring 181 which is biased toward the position in which it is shown in FIGURE 12. One leg 182 of this sear spring 181 is disposed within a vertically extending passage 184 formed in the lower portion of the sleeve 168. The other leg 185 of this spring 181 is affixed to the underside of the seal 160. One side of the lower portion of the sleeve 168 is formed with a radially extending bore 186 which communicates with the bore 164 through the cavity containing the latch hook 176. A piston 187 is slidably disposed within this bore 186, with its radially outer end in engagement with the intermediate portion of the latch hook 176. The piston 187 is restrained against radially inward movement beyond its position of FIGURE 10 by means of a lip 188 formed at the radially inner portion of the bore 186.

The aforescribed loading sub S3 is especially adapted for use where stage pressuring is employed to guard against collapse of the pipe string. In operation, the portion of the pipe string below the loading sub S3 is first pressurized to a predetermined value. Thereafter, additional lengths of pipe are added above the loading sub S3 until the formation tester has been lowered to the desired elevation. Thereafter, the portion of the pipe string above the loading sub S3 is pressurized until the pressure within the upper pipe string portion slightly exceeds that within the lower pipe string portion. Under the influence of this pressure differential, the piston 187 is forced radially outwardly in the bore 186 so as to effect radial outward movement of the lower end of the latch hook 176. When the lower end of the latch hook 176 has been moved radially outwardly to its position of FIGURE 11, the upper portion 161 of the valve plate 160 will be free to slide downwardly within the bore 169 of the sleeve 168. During this downward movement of the valve plate the pivot pin 174 will slide downwardly within the slot 172 while the leg 182 of the sear spring 181 slides downwardly within the passage 184 of the sleeve 168. When the pivot pin 174 reaches the lower end of the slot 172, the valve plate 160 will be free to pivot in a clockwise direction to its position of FIGURE 12. Such pivotal movement will be aided by the sear spring 181. The valve plate 160 will be retained in its open position of FIGURE 12 by means of a suitable spring latch 190 affixed to one side of the body 162 in vertical alignment with the ear 170. The provision of this latch 190 will insure that any upward fluid flow through the pipe string will not return the valve plate 160 to a position which would block such fluid flow.

Referring now to FIGURE 13, there is shown a fourth form of loading sub S4 embodying the present invention. This loading sub S4 incorporates yet another form of removable seal 200. It is contemplated that the same form of gas-receiving means 22 described hereinbefore in conjunction with the description of the loading subs S1, S2 and S3 will be employed with the loading sub S4.

The loading sub S4 includes a generally tubular body 202 having a gas-receiving bore 204 formed in its lower portion. The upper portion of the body 202 is formed with a bore 206 of somewhat larger diameter than the gas receiving bore 204. The bores 204 and 206 are connected by a downwardly tapering frusto-conical seat 208. The removable seal 200 is of hollow configuration and is preferably formed of an easily fractured or frangible material, such as Pyrex glass. The upper portion of the seal 200 includes a cylindrical mounting section 210 at the lower end of which is defined a downwardly tapering shoulder 212 that rests upon the seat 208 of the body 202, the seal being held upon said seat by means corresponding to that shown in FIGURE 5 for holding the seal 20 upon its seat 52. The lower portion of the seal 200 is of generally semi-hemispherical shape.

A pair of sealing rings 214 encircle the mounting section 210 of the seal 200, so as to prevent fluid leakage between the seal and the body 202.

One side of the body 202 is formed with a radially extending bore 218. The outer portion of this bore is normally closed by a threaded plug 220. A piston 222 is slidably disposed within the intermediate portion of the bore 218. A coil compression spring 224 is interposed between the plug 220 and the piston 222 so as to normally bias the latter radially inwardly within the bore 218, and the portion of the bore between the piston 223 and the plug 220 communicates with the gas-receiving bore 204 through a passage 223. The intermediate portion of the bore 218 is intersected by an upwardly extending latch passage 226. This latch passage 226 slidably receives a latch 228. The latch 228 is constantly biased downwardly by a coil compression spring 230 disposed within the upper portion of the latch passage 226. The intermediate portion of the latch 228 is cut away so as to define a horizontally extending shoulder 232. This shoulder 232 normally rests upon a horizontally extending abutment surface 236 formed at the upper radially inward portion of the piston 222. The lower end of the latch 228 defines a firing pin 238. This firing pin 238 is disposed within a downwardly extending cavity 240 that intersects the lower end of the radial passage 218. The lower end of the cavity 240 merges into a bore 242 wherein is disposed a firing cap 244. The lower end of the bore 242 intersects a radially inwardly and downwardly extending blast passage 246. The lower portion of the blast passage 246 is aligned with a detonator passage 248 formed in the mounting section 210 of the seal 200. A conventional detonator 250 is disposed within this passage 248. The detonator 250 is connected to the length of a conventional explosive cord 252.

The aforescribed loading sub S4 is especially adapted for use where stage pressuring is employed to guard against collapse of the pipe string. In operation, the portion of the pipe string below the loading sub S4 is first pressurized to a predetermined value. Next, additional lengths of pipe are added above the loading sub S4 until the formation tester has been lowered to the desired elevation. Thereafter, the portion of the pipe string above the loading sub S4 is pressurized until the pressure within the upper pipe string portion slightly exceeds that within the lower pipe string portion. Under the influence of this pressure differential the piston 222 is forced radially outwardly within the bore 218 against the force of the spring 224. When the radially inner end of the piston's abutment surface 236 clears the shoulder 232 formed on the latch 228, the spring 230 will snap the latch 228 downwardly. This downward movement of the latch 228 will cause the firing pin 238 to sharply engage the firing cap 244 and effect the explosion thereof. This will in turn cause the detonator 250 and its length of explosive cord 252 to be detonated. Such detonation will effect the immediate and complete fracturing of the frangible seal 200.

It should be particularly observed that any combination of the aforescribed removable seals may be provided at spaced intervals in the pipe string. With this arrangement, it is possible to remove these seals independently of one another. In this manner it is possible to pressurize various portions of the pipe string with different pressures and thereafter control the release of pressure between adjoining pipe portions. It should also be noted that it is possible to supplement the gas cushion employed in the aforescribed method with a liquid cushion. The liquid will preferably consist of water, but occasionally it may be desirable to employ drilling mud, inasmuch as the latter is heavier in specific gravity. Where such a combined "liquid-gas" cushion is employed it is possible to safely conduct formation testing even in the presence of exceedingly high formation pressures. It should also be noted that the method and apparatus of

the present invention may be successfully conducted utilizing various forms of formation testers and packers other than those shown or described hereinabove.

Various other modifications and changes may be made with respect to the foregoing description without departing from the spirit of the invention or the scope of the following claim.

We claim:

A method of testing a formation penetrated by a well comprising providing a pipe string having a valved tester and a packer at the lower end thereof; providing a seal in said pipe string adjacent the level of said tester so as to block fluid flow therethrough; pressurizing said pipe string between said tester and said seal to a pressure ranging from approximately one fifth of the pressure in the formation to be tested to approximate equality with the pressure in the formation to be tested; thereafter lowering said pipe string until the tester reaches the forma-

tion to be tested; setting said packer; opening the tester valve to permit equalization of pressure on each side of said tester valve and thereafter breaking said seal.

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