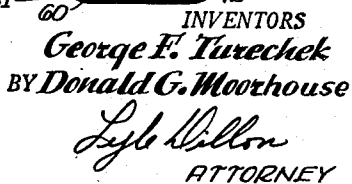


2,618,344

Filed April 20, 1946

4 Sheets-Sheet 1



Nov. 18, 1952

G. F. TURECHEK ET AL

2,618,344

BRIDGING PLUG

Filed April 20, 1946

4 Sheets-Sheet 2

Fig. 5.

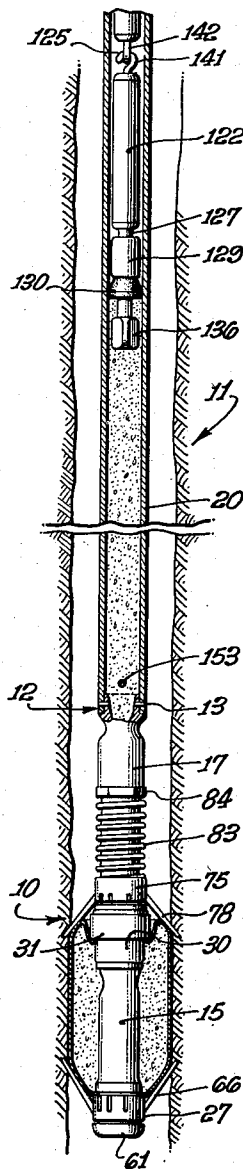
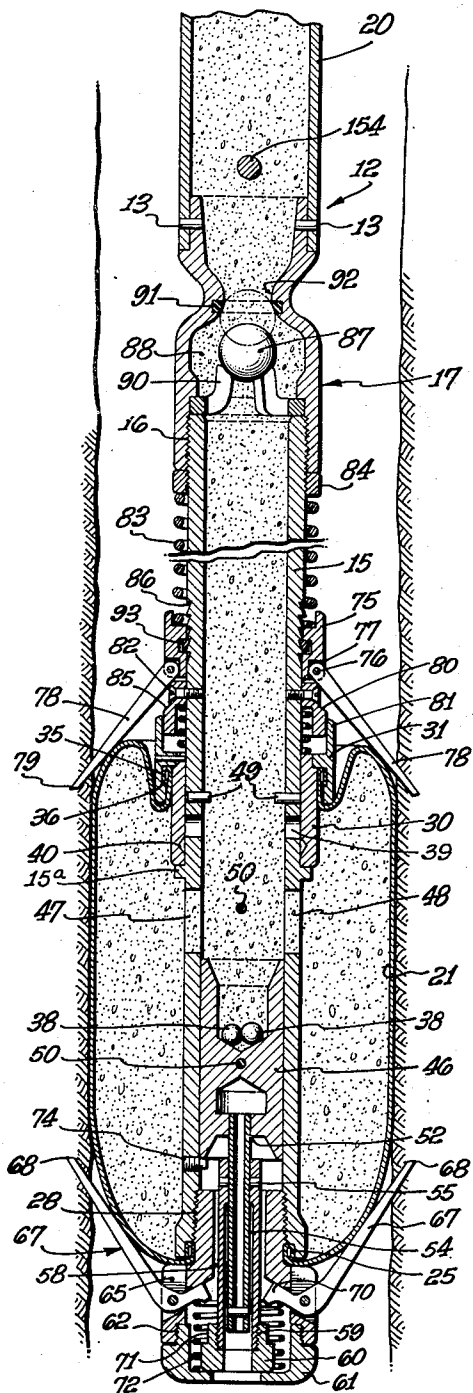


Fig. 4.

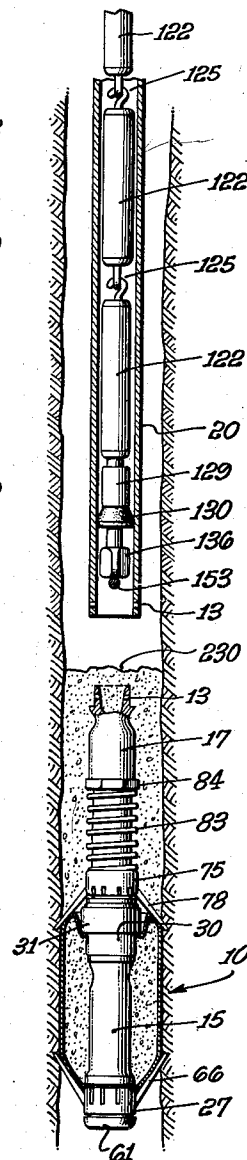


Fig. 6.

INVENTORS
George F. Turecek
BY Donald G. Moorhouse.

Lyle Dillon
ATTORNEY

Nov. 18, 1952

G. F. TURECHEK ET AL

2,618,344

BRIDGING PLUG

Filed April 20, 1946

4 Sheets-Sheet 3

Fig. 7.

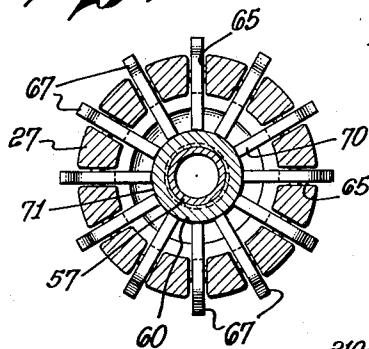


Fig. 8.

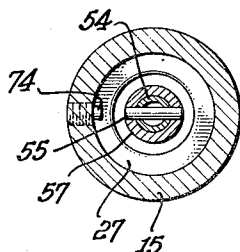


Fig. 9.

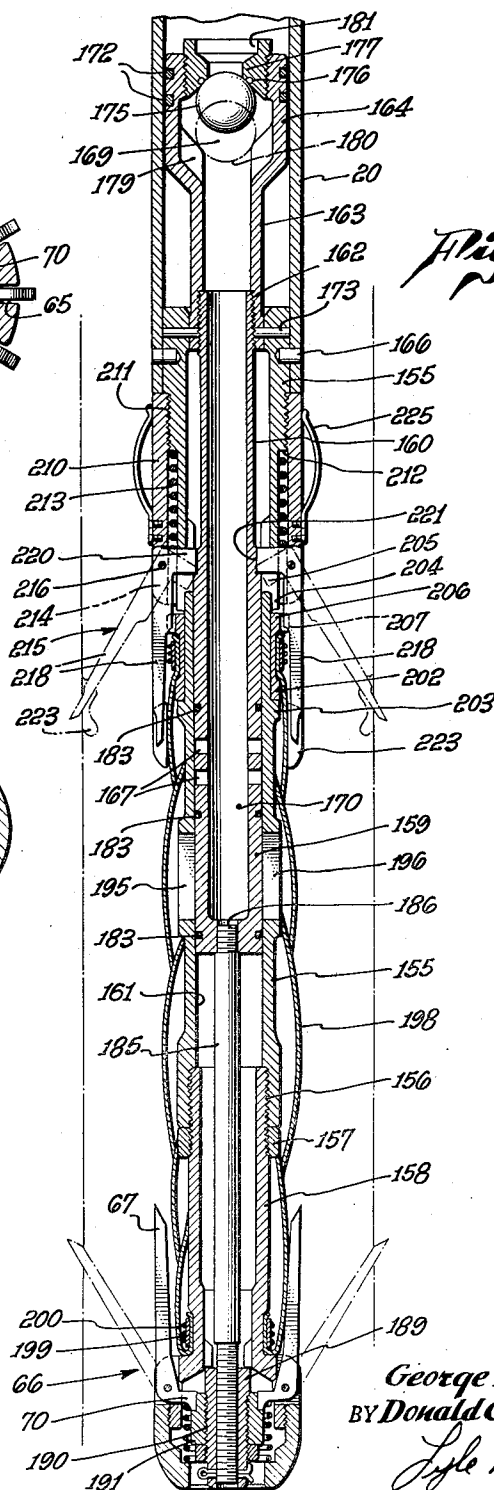
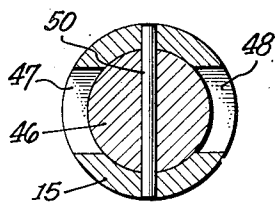


Fig. 11.

INVENTORS
George F. Turecek
BY **Donald G. Moorhouse**
Lyle Dillon
ATTORNEY

Nov. 18, 1952

G. F. TURECHEK ET AL

2,618,344

BRIDGING PLUG

Filed April 20, 1946

4 Sheets-Sheet 4

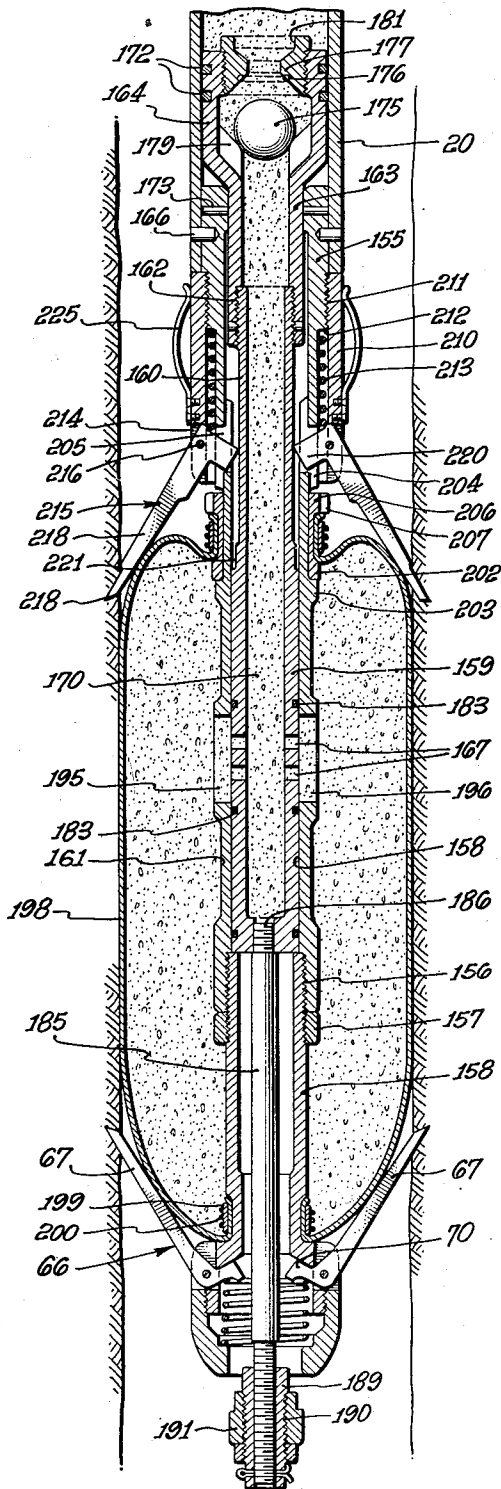


Fig. 12.

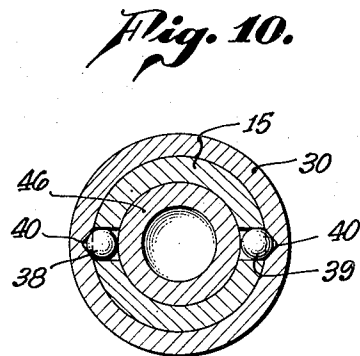


Fig. 10.

INVENTORS
George F. Turechek
BY *Donald G. Moorhouse*
Lyle Hillon
ATTORNEY

UNITED STATES PATENT OFFICE

2,618,344

BRIDGING PLUG

George F. Turechek, Los Angeles, and Donald G. Moorhouse, South Gate, Calif., assignors to Lane-Wells Company, Los Angeles, Calif., a corporation of Delaware

Application April 20, 1946, Serial No. 663,662

18 Claims. (Cl. 166—13)

1

This invention relates generally to well packers and more particularly to bridging plugs and tools for setting bridging plugs and the like devices within well bore holes.

Bridging plugs are usually employed for the well known purpose of closing or sealing off lower sections of a well bore hole. Such bridging or plugging operations are often employed, for example, when a lower zone in the well has ceased to be productive, or where the well bore hole has been drilled into water-producing measures or thief sands, or for any other such reason it is desired to plug back or close-off a lower zone and produce from a higher zone in the well. In such bridging operations it is usual practice first to position a bridging plug in the well bore hole at a point adjacent the top of the zone to be sealed off, and then to place a suitable quantity of cement on top of the plug. However, heretofore, with the bridging plugs employed for this purpose, difficulties have been encountered in adequately anchoring a plug in the bore hole and securely maintaining the plug in the desired position during the cementing operation. If care was not exercised, the plug was often driven down by the weight of the cement placed on top of it. Sometimes the formation pressure below the bridging plug rose sufficiently to force the plug upward and thus displace the plug in the well bore hole from its proper setting position. In the cementing operations heretofore employed in connection with the conventional type of bridging plugs, channeling through the cement placed in or on the bridging plug often occurred, caused by the production of fluid at the point of plugging or therebelow. Furthermore, with the conventional bridging operations heretofore employed, it was necessary to lower the bridging plug upon pipe or tubing, and finally to place the cement on the bridging plug also through tubing.

These operations heretofore employed were difficult, time-consuming and, for the reasons beforementioned, of uncertain effect and efficiency.

It is, accordingly, an object of this invention to provide a bridging plug which, when set in the bore hole, forms a fluid-tight seal and resists displacement by pressures either from above or below the setting point.

It is also an object of this invention to provide a bridging plug capable of forming a fluid-tight seal with an irregularly-shaped surrounding bore hole.

It is a further object of this invention to provide a bridging plug which will retain cement in non-channeling, sealing engagement with the walls of the surrounding bore hole.

It is a still further object of this invention to provide a bridging plug which may be rapidly lowered and positioned within the bore hole by means of a wire rope or cable which contains an electrical conductor through which the setting operations of the bridging plug may be controlled.

2

It is a still further object of this invention to provide a bridging plug of novel construction which is durable, efficient, inexpensive, simple to operate, and which will remain securely positioned in the bore hole.

It is a still further object of this invention to provide means for performing a combined bridging and cement plugging operation in one simple, quick operation.

These and other objects, advantages, and features of novelty will be evident hereinafter.

In the drawings which show by way of illustration, preferred embodiments of the invention, and in which like numerals designate the same or similar parts throughout the several views:

Figure 1 is an elevational view, partially in section, of the general assembly of the bridging plug and setting tool suspended in unset condition within a well bore hole.

Figure 2 is a detail view in longitudinal cross-section, of the setting tool portion of Figure 1.

Figure 3 is a detail view in longitudinal cross-section of the bridging plug portion of Figure 1.

Figure 4 is an elevational view partially in cross-section of the bridging plug and a portion of the setting tool as it appears in its initially set position within a well bore hole.

Figure 5 is an enlarged detail view in longitudinal cross-section of the bridging plug portion of Figure 4.

Figure 6 is an elevational view partially in cross-section of the bridging plug and a portion of the setting tool in its finally set and cemented position within a well bore hole.

Figure 7 is a cross-sectional view taken on line 7—7 of Figure 3.

Figure 8 is a cross-sectional view taken on line 8—8 of Figure 3.

Figure 9 is a cross-sectional view taken on line 9—9 of Figure 3.

Figure 10 is a cross-sectional view taken on line 10—10 of Figure 3.

Figure 11 is a cross-sectional elevation of an alternative construction of the bridging plug as it appears in unset condition.

Figure 12 is a cross-sectional elevation of the alternative bridging plug of Figure 11 as it appears in the set condition within a well bore hole.

Referring now primarily to Figures 1, 2, and 3, the bridging plug portion of the tool is shown generally at 10 and the setting portion of the tool shown at 11, the bridging plug portion and the setting tool portion being coupled together by means of a quick detachable coupling or slip joint 12 which, when assembled in the running-in position as illustrated in Figure 1, is held together in intercoupled position by means of shear pins 13.

Referring now primarily to Figures 1 and 3, the bridging plug portion of the tool comprises a generally cylindrical or tubular body 15 of somewhat irregular external diameter, which makes threaded connection at 16 at its upper end to a

3

check valve housing 17. The check valve housing 17, in turn, makes a relatively fluid-tight connection at the beforementioned detachable coupling 12 by way of shear pins 13 with the lower end of the cement chamber 20 of the setting tool 11 which will be hereinafter more fully described.

Surrounding the lower portion of the bridging plug body 15 is a packing means for closing the annular space between the plug body and a surrounding well bore hole, comprising a generally tubular or globular-shaped cementing bag 21 which, in its retracted or unfilled condition, is twisted and folded about the packer body as shown in Figures 1 and 3, such that its globular fullness is taken up to form a plurality of spiral folds which lie close to the packer body.

The lower end or neck opening of the cementing bag carries a suitable marginal beading 25 which is clamped around the lower end of the packer body 15 within a counterbored annular recess 26, the clamping being effected by means of a flared shoulder portion of a lower spider supporting body 27 which makes, at its upper end, threaded connection at 28 with the internal end portion of the packer body 15.

The upper end or neck opening of the cementing bag 21 carries a marginal beading 35 similar to that of the lower neck which makes fluid-tight connection within a bag retainer collar assembly 29 which, in turn, makes a rotatable and axial slidable fit on the exterior surface of an intermediate portion of the packer body 15.

The bag retainer collar assembly 29 comprises an inner sleeve member 30 and an exterior clamping ring 31 which makes a snug sliding fit at 32 over the shouldered upper end of the said sleeve and is held in position there by means of suitable pins as shown at 34. The beaded end 35 of the cementing bag neck is thus adapted to be clamped in a counterbored annular recess 36 formed between the lower flange 33 of the clamping ring and the sleeve 30.

When the bridging plug is in the collapsed or retracted condition as best illustrated in Figure 3, the before-described cementing bag retainer assembly 29 is restrained against both sliding and rotational motion upon the body 15 of the plug by a latching means comprising a pair of latch balls as shown at 38 which are retained in oppositely positioned holes 39 extending through the wall of the packer body 15 in such positions that each ball extends into a detent formed in the inner surface of the collar 30 as shown at 40. The balls 38 thus, in the condition illustrated in Figure 3, serve as latches to restrain the cementing bag retainer assembly 29 from both axial sliding motion and rotational movement with respect to the packer body 15.

Slidably retained within the cylindrical bore 45 of the bridging plug body 15 is a cylindrical, piston type, sliding valve 46 which, when the bridging plug is in the unset condition, as illustrated in Figure 3, covers a pair of oppositely positioned ports 47 and 48 which extend through the walls of the plug body 15. The upper limit of movement of the piston type valve 46 is determined by a pair of inwardly extending stop pins 49 and, when the valve is in its uppermost position, as illustrated in Figure 3, the before-mentioned latch balls 38 are retained by the upwardly extending skirt portion of the valve in the holes 39 in outward latching positions with respect to the detents 40, thereby, as beforemen-

4

tioned, locking the bag retainer collar assembly 29 against movement on the plug body 15.

A shear pin 50 extending cross-wise through the plug body and through the central portion of the piston valve 46, normally aids in holding the piston valve 46 in its uppermost closed position, as shown in Figure 3.

Fixed at 52 and extending axially downward from the lower end of the piston valve 46, is a tubular strut member 54. The tubular strut member 54, except for the initial retention by a shear pin 55, makes a sliding fit into and through the upper end of a lower cylindrical member 57 which, in turn, extends with substantial clearance through the bore 58 in the upper inner portion of the beforementioned spider supporting body 27. The lower end of the cylindrical member 57 makes threaded connection at 59 with a spider locking head 60. The spider locking head 60 is contained within the lower, enlarged bore of the body 27 which is closed at the lower end by means of a rounded guide cap member 61 threaded thereto internally at 62. The locking head 60 is thus normally suspended in locked position by means of the cylindrical member 57, tubular strut 54, and piston valve 46 upon the shear pin 50, when the bridging plug is in the unset or retracted position as illustrated in Figure 3.

The lower spider retainer body 27 is provided with a plurality of circumferentially spaced, radially directed slots extending from inside to outside thereof as best shown at 65 in Figures 3 and 7. Each slot is adapted to receive and to radially, pivotally support one each of the plurality of legs 66 of the spider assembly. Each leg of the spider assembly is formed with an external spike 67 carrying a sharp point 68 at its outer extremity. Each leg also carries an integrally formed, inwardly extending tongue member 70 positioned at an obtuse angle to the spike and having an inner end face adapted to abut in latching engagement with the outer cylindrical surface 71 of an annular shoulder or hub formed about the upper portion of the beforementioned locking head 60. The beforementioned abutment of the inner end faces of the tongue members 70 against the cylindrical surface 71 of the locking head hub serves to lock the legs 66 closed in their fully folded, retracted positions, as shown in Figure 3. A helical spring 72 surrounds the locking head 60 and, acting under compression between the inner bottom surface of the guide cap 61 and the lower edges of the tongues 70 of the legs 66, serves to urge the spikes 67 into their opened position, as shown in Figure 5, against the restraining locking action hereinbefore described.

A stop pin 74 extending through the wall of the bridging plug body 15 adjacent the upper end of the lower spider retainer body 27, serves to limit the downward movement of the valve 46 when it is forced to its open position, as herein-after more fully described in connection with the operation of the apparatus.

Slidable axially on the outer surface of the upper portion of the bridging plug body 15, is an upper spider retainer ring 75. Pivotaly supported by pivot pins 76 in a plurality of circumferentially spaced slots 77 located at the lower end portion of the said retainer ring 75 are a plurality of spider legs or spikes, as shown at 78. The lower end of each of the spider spikes 78 is bevelled to a sharp point as shown at 79, and in the retracted position as shown in Figure 3, the spider legs or spikes are retained in closed

position between an inner seating ring 80 fixed to the plug body by screws 82 and an annular flange 81 extending upward from the beforementioned clamping ring member 31 of the bag retainer assembly 29.

The spider retainer ring 75 is urged axially downward with respect to the body 15 by means of helical spring 83 surrounding the body 15, and acting under compression between the upper channeled edge of said spider retainer ring 75 and the lower end of a lock nut 84 carried on a thread 16 and jammed against the lower end of the check valve housing 17. The pointed ends 79 of the spider spikes 78 rest against a downwardly diverging conical surface 85 formed around the ring 80 so that under the downward force therethrough from the spring 83 acting through the retainer ring 75, the said spikes 78 will tend to slide at their bevelled ends upon the said conical surface 85 and to be forced outwardly against the inner cylindrical surface of the flange 81. The beforementioned surrounding flange 81 thus serves to retain the spider spikes 78 against movement to open positions until released as hereinafter explained.

A plurality of wickers 86 are provided around the external surface of the body 15 into which a split, bevelled locking ring 93 carried in an internal groove in the upper spider retainer ring 75 is adapted to make locking engagement, as shown in Figure 5, when released to move downward under the force of spring 83. Return movement of ring 93 and resultant retraction of the spikes 78 will thus be prevented.

A check valve ball 87 is retained within the lower chamber 28 of the check valve housing 17. A check ball stop is provided as shown at 90 upon which the check ball 87 is adapted to rest when in its open position, as indicated by dotted lines at 89.

An annular valve seat 91 is retained within a suitable, annular recess formed in the inner surface adjacent to and slightly below the necked portion 92 of the check valve housing 17, and upon which the check valve ball seats in its closed position, as shown in full lines at 87. The check ball 87 is preferably constructed of a material of sufficiently low density to be buoyant and float upward into the closed position as shown at 87, when the device is filled with cementitious material, as hereinafter described.

Referring now primarily to Figures 1 and 2, the setting tool portion 11 of the apparatus, as hereinafter mentioned, comprises two main parts connected axially end to end comprising an upper weight housing or barrel 93 and a lower elongated, cylindrical cement chamber 20. The chamber 20 is normally attached at its lower end by means of the beforementioned coupling 12 and shear pins 13 to the hereinbefore described bridging plug mechanism. Intercommunication is provided between the bore of the upper portion of the bridging plug body 15 and the lower portion of the bore of the chamber 20 through the beforedescribed check valve housing 17.

The upper end of the cement chamber body 20 is threadedly connected at 95 and 96 through an intermediate sub-connector 97 to the lower end of the elongated weight housing barrel 93.

The upper end of the weight housing barrel 93 is threadedly connected at 99 through suitable coupling apparatus to the lower end of a cable head 100, into which a suspending conductor cable 101 extends and may be anchored in conventional manner, for example, as shown

and described in Turechek 2,043,341. The conductor cable 101 may be any of the suitable conventional types of hoisting cables containing an internal, insulated conductor such as employed in connection with gun perforating operations; for example, those shown and described in Wells 2,043,400 and 2,043,401. The electrical conductor from the conductor cable 101 passes from the anchored ends of the cable through suitable insulating means and makes electrical contact with a contactor 102.

Intermediate the cable head 100 and the upper ends of the weight housing barrel 93 and making threaded connection respectively therewith at 104 and 105, is a weight barrel sub-connector 106, and electrical conductor rod 107 passes centrally through the sub-connector 106 through a suitable insulating bushing 108, and extends upward through a packing gland 109 into a cavity 110 formed between the upper, inner portion of the sub-connector 106 and the lower end of the cable head 100.

A spring-pressed contact button 111 serves to provide a quick detachable electrical contact between the terminal 102 of the conductor cable and the conductor rod 107 which passes downward through the sub-connector 106. The lower end of the conductor rod 107 terminates in an insulated button 112 contained within a powder or cartridge chamber 113.

Any suitable arrangement for making suitable electrical connections between the cable head 100 and ignition means located in the powder chamber 113 may be employed, for example, one such as shown and described in Quintrell 2,266,382 or Wells 2,076,307.

The cartridge chamber 113 is contained within a weight supporting shackle 115 which makes threaded connection at 116 with a boss 117 extending axially downward from the lower portion of the beforementioned weight barrel sub 106.

The lower end of the shackle 115 carries a clevis pin or bolt 120, over which a weight hook 121 extends. The hook 121 extends from the upper end of a cylindrical weight body 122 and serves to support a plurality of cylindrical weights within the barrel 93, the adjacent weights being hooked together end to end, as best illustrated at 125 in Figures 1, 4, and 6.

The lowermost weight in the weight cylinder 93 is provided with an axially positioned, downwardly extending, tapered shank 127 as best shown in Figure 2, which is adapted to seat within a correspondingly tapered socket 128 formed in the upper end of a plunger retainer body 129. A plunger 130 made of rubber or other suitable material is retained by means of a bolt 132 in a socket 133 formed in the bottom end of the plunger guide body 129. The plunger is formed with an outwardly flaring skirt 135 which makes a slidable sealing engagement with the inner surface of the bore of the cement chamber 20. A fluted guide head 136 is threadedly attached at 137 to the lower end of the beforementioned plunger bolt 132, and together with the body 129, serves to guide and to maintain the plunger 130 in axial alignment within the cement chamber 20 as it is moved therethrough by means of the weights 122, as hereinafter more fully described. Chamber 20 is provided with one or more plunger bleeder ports 20'.

The weights 122 may be of any suitable construction adapted to withstand the tensile and compressive forces to which they are subjected in the various stages of operation of the setting

tool. The weights 122, however, are preferably constructed as shown with an external, tubular shell 140 extending from end to end thereof. Hooks or alternate hooks and eyes may be attached to the opposite ends of the weights 122, as shown at 141 and 142 in Figure 1, these hooks and eyes being attached at the end preferably both to the beforementioned tubular shell 140 and anchored to a central rod 145. The eyelet 121, as best shown in Figure 2, is preferably formed as an upper extension of a socket 146 having outwardly extending flanges 147 adapted to be attached by suitable means, such as welding, to the upper end of the tubular shell 140. Longitudinally extending guide webs may be provided as shown at 148 radiating from the beforementioned socket 146. The socket 146 forms a recess in which a head 149 formed on the end of a central rod 145, is retained in recessed position. A plurality of perforate webs 150 welded to the rod 145 at spaced positions throughout its length, are provided to form reinforcing to the weight sections and to adequately bond with the metal with which the weight shell is filled. The weight shell comprising the space within the beforementioned tubular shell 140, is preferably filled with molten lead and allowed to solidify around the rod 145 and the webs 150, as shown at 151.

The lowermost one of the weights 122, instead of being provided with an eyelet or hook at its lower end as with the other weights, carries instead, a plug fitting 152 inserted within the end of the shell 140, and pin connected there as shown at 153.

The fitting 152 carries the tapered shank 127 hereinbefore described, which is adapted to transfer the downward pressure from the weights 122 to the plunger body 129.

A stop pin 154 is provided extending across the lower end of the bore of the cement chamber 20 against which the plunger guide 136 comes to rest at the lower limit of the downward motion of the plunger assembly.

Referring now primarily to Figure 11, in which an alternative construction of the bridging plug portion of the apparatus is illustrated, the body portion thereof comprises an upper, tubular body section 155 of stepwise irregular external diameter, adjustably connected through a threaded coupling at 156 and lock nut 157 with a lower tubular extension 158.

The upper end of the upper body portion 155 is shear pin connected as shown at 166, to the lower end of the cement chamber 20 in an arrangement similar to that described in connection with Figures 1 and 2.

The intermediate portion of the body 155 is provided with an internal bore 161 of uniform diameter in which a cylindrical piston type valve 159 is retained in axial sliding fit. An upper, tubular extension of reduced diameter 160 of the valve 159 makes threaded connection at 162 with a downwardly extending tubular element 163 of a hollow plunger body 164.

A plurality of ports are provided through the wall of the piston valve 159 as shown at 167, and a fluid-tight communicating duct is thus provided from the said ports 167 to the cavity 169 within the plunger body 164 by way of the inner bore 170 of the piston valve 159, the interior passages of the beforementioned interconnected tubular extension 160 and the plunger body 164.

Suitable packing rings are provided in annular grooves in the plunger, as shown at 172 to provide

fluid-tight sliding seal between the plunger body 164 and the bore of the lower end of the cement chamber 20.

In the unset condition of the bridging plug, as illustrated in Figure 11, the axially movable assembly comprising the piston valve 159, tubular extension 160, tubular element 163 and plunger 164, is initially maintained in its uppermost position by means of a pair of shear pins 173 which extend through the walls of the upper portion of the packer body 155 adjacent the upper end thereof and into the collared lower end of the lower portion 163 of the plunger body.

Contained within the cavity 169 of the plunger body 164, is a check ball valve 175. The check ball valve 175, as hereinbefore described in connection with the apparatus illustrated in Figure 3, is composed of a light-weight material, such as for example, Bakelite or other suitable plastic material, which will be buoyant in the cementitious fluid or cement slurry with which the apparatus is to be filled. The check ball 175, when thus buoyed by the cement slurry contents of the apparatus, is adapted to seat in fluid-tight sealing engagement with an annular packer ring 176 retained within an annular retainer recess in the valve seat 177. A plurality of radially positioned webs 179 are provided in the lower, inner portion of the cavity 169 of the plunger 164 to receive the check ball 175 when it is in its lowermost, open position, as illustrated by dotted lines 180. When the check ball 175 is thus positioned in its open position upon the webs 179, downwardly flowing fluid entering the top of the plunger through central openings 181 in the valve seat assembly, may pass around the check ball through the openings formed between the said webs 179 and flow downward into the passageway leading to the bore 170 of the piston valve 159.

A plurality of spaced packer rings set in annular recesses in the valve 159, as shown at 183, are provided for making a fluid-tight sliding seal between the piston valve 159 and the bore 161 of the bridging plug body 155.

A rod 185 extends downward from its threaded connection 186 at the lower end of the piston valve 159 coaxially through the bore of the lower portion 158 of the plug body and carries, threaded to its lowermost end, a bushing 189 which, in turn, carries externally threaded thereon at 190 a spider locking head 191 of a construction similar to that illustrated at 60 in Figure 3. The lower end portion of the body 158 into which the locking head 191 extends, is of slightly enlarged diameter and carries a plurality of slots extending radially therethrough similar to the arrangement hereinbefore described in connection with the corresponding portion of the device in Figure 3. Each of these radial slots is adapted to pivotally support a spider leg as shown at 66. Each spider leg comprises an outer spike portion 67 and an integrally formed inwardly extending tongue portion 70. The inner end faces of the tongue portions 70 of the spikes each make locking engagement with a cylindrical, shouldered surface at the top portion of the locking head 191 in the same manner as that hereinbefore described in connection with the corresponding apparatus illustrated in Figure 3.

A pair of oppositely positioned outlet ports 195 and 196 are provided through the intermediate portion of the bridging plug body 155, said outlet ports 195 and 196 being adjacent the piston type valve 159, such that they are closed thereby when

the valve 159 is in its uppermost position as illustrated in Figure 11.

Surrounding the lower portion of the bridging plug body 155 and the lower extension 158 thereof, is a packing means comprising a generally tubular or globular shaped cementing bag 198, similar to bag 21 hereinbefore described in connection with Figures 1 and 3 which, in its retracted or unfilled condition, is twisted about the tubular body such that it forms a plurality of spiral folds which lie close to the packer body.

The lower neck opening of the cementing bag 198 may be attached to the exterior of the lower body portion 158 adjacent the outer retainer assembly by any suitable means such as, for example, that hereinbefore described in connection with Figure 3. The lower neck of the cementing bag may, however, be satisfactorily attached to the bridging plug body by means of an inwardly and upwardly extending cuff-like fold as shown at 199, placed in a shallow, annular-shaped recess and bound in place by suitable clamping rings or a plurality of turns of wire, as illustrated at 200.

The upper end of the cementing bag 198 may be similarly attached to a ring member 202 which is rotatably retained upon the plug body between a lower raised shoulder 203 and the shoulder formed at the lower end of a plurality of longitudinal webs 204 formed at the outward termination of a plurality of corresponding slots 205 extending through the upper portion of the said plug body 155.

The upper end of the ring 202 is provided with a flange 206 of slightly increased diameter through which a plurality of longitudinally extending grooves have been formed, each groove being adapted to receive the inner edge of a spider spike, as shown at 207, when the spikes of the spider are retracted in their closed positions, as illustrated in full lines in Figure 11.

A downwardly extending spider retainer collar 210 is threaded at 211 onto the upper end of the plug body 155. The plug body 155 is formed with an upper section of slightly increased diameter at the point carrying the beforementioned threads 211, forming thereby a shoulder 212. The retainer collar 210 extending downward from the shoulder 212 forms inside thereof an elongated, annular-shaped recess which houses a helical spring 213. The helical spring 213 is adapted to act under compression between the shoulder 212 and the upper edges of the inwardly extending tongues 220 of the spider legs, tending to urge them pivotally into expanded position, as shown in Figure 12 and as hereinafter more fully described in connection with the operation of the apparatus.

The lower end portion of the spider retainer collar 210 is provided with a plurality of slots as shown at 214, registering with the beforementioned slots 205 which extend through the body 155. A plurality of spider legs 215 are pivotally supported in the slots 214 by suitable means such as that illustrated at 216. Each spider leg, as hereinbefore described in connection with the lower spider of Figure 11 and the lower spider of Figure 3, is provided with an outer pointed spike member 218, and an inner integrally formed, angularly-directed tongue member 220. The inner end face of each tongue member 220 is adapted to abut, when in the retracted position, against a cylindrical surface 221 formed by a shouldered section intermediate the piston valve 159 and its

upper tubular extension portion 160 of reduced diameter.

As hereinbefore mentioned, the spiral spring 213, acting under compression against the shoulder 212, applies a force downward against the top edges of the spider tongues 220, tending to rotate them about pivots 216, to move the spikes 218 radially outward into open position, as illustrated in Figure 12.

Each of the points of the spikes 218 of the upper spider is preferably covered or coated with a protective covering of a suitable material such as a soft metal or plastic, as illustrated at 223.

The operation of the apparatus of Figures 1-10, inclusive, is as follows:

First, in preparation of the apparatus for operation and prior to lowering it into a well, the cement chamber 20 is disconnected from the weight barrel 98 at the threads 96, at the upper end of the sub-connection 97. The cement chamber 20 and the depending bridging plug portion 10 are then suspended vertically by suitable means which may be conveniently clamped around the annular recess formed in the mid-portion of the sub 97. The cement chamber 20 and the bridging plug body from the top of the piston valve 46, including the space within the check valve chamber 88 are next filled with a cementitious material, such as for example, a slurry of a quick setting Portland cement or other suitable fluid or plastic cementitious material by means of which it is desired to bridge the well bore hole.

After having filled the bridging plug and the cementing chamber 20 up to a point close to the bottom threaded joint 95 of the sub 97, the plunger assembly 129 is placed in the top thereof and pushed down upon the top of the cement.

Next, the weight barrel 98 containing the weights 122 suspended by means of the shackle 115, all of which may be suspended by the conductor cable 101, is lowered onto the top of the cement chamber connecting sub 97, the tapered shank 127 of the lowermost weight inserted in the tapered socket 128 in the plunger body 129 and joint at threads 96 then made up. The tool then has the appearance illustrated in Figure 1 and is ready for lowering to the desired position within the bore hole to be bridged.

When the assembled setting tool and bridging plug have been lowered by the cable 101 to the desired level in the bore hole at which it is to be set, as shown in Figure 1, current is passed from a suitable source, such as that employed in gun perforating equipment, through the conductor cable 101 and by way of contact terminals 102 and 110, and conductor rod 107 to an ignition filament 114 contained within the powder charge or cartridge in the powder charge cavity 113 in the weight suspending shackle 115. The resultant combustion or explosion of the powder or cartridge contained in the cavity 113 breaks the shackle 115 at the intermediate section of reduced diameter surrounding the powder chamber, thereby releasing the weights 122. The weights 122 thus released from suspension move downward applying force through the shank 127 and through the body 129 to the plunger 130 and thence to the body of cement slurry contained therebelow in the cement chamber 20.

The pressure thus applied to and built up in the body of cement slurry in the cement chamber 20, is communicated through the interior of the setting tool body to the top of the piston type valve 46, which is initially in its uppermost position, as shown in Figure 3. When the pressure

11

thus transmitted to the top of valve 46 becomes sufficient to shear the pin 50, valve 46 then moves downward to the position shown in Figure 5, thereby uncovering the ports 47 and 48 through which the cement is then forced to flow into the space within the bag 21 by the continued application of pressure from the plunger 130. Simultaneously with the downward motion of the piston 46, both the upper and lower spiders are released from their retracted positions, shown in Figure 3, and moved to their opened or expanded positions, as shown in Figure 5, in the following manner:

At the initial downward motion of the piston 46, the latch balls 38 are allowed to fall inward from their retaining holes 39 in the packer body and out of engagement with the detents 40. The latch balls 38, thus released, fall into and are retained in the upper cupped end of the piston valve, as shown in Figure 5. Removal of the latch balls 38 from the detents 40 then frees the bag retainer collar comprising the inner and outer sleeves 30 and 31, to move downward against the flanged stop 15a under the impelling force of the helical spring 83, thus withdrawing the upper flange 81 of the outer collar 31 away from confining engagement with the lower ends of the upper spider spikes thereby freeing them to pivot outwardly to the open position, shown in Figure 5. The outward pivotal motion of the spider spikes 78 is caused by the spring 83 which moves the spider retainer collar 75 downward, thereby forcing the spikes 78 outward at an angle as their inner edges ride along the upper corner of the seating ring 80. The slip latching ring 93 contained within the internal recess in the spider retainer ring 75 serves to hold the ring 75 down and thus the spider spikes outward, by making latching engagement with the plurality of wickers 86 in the manner shown in Figure 5.

The removal of the latch balls 38 from the detents 40 not only releases the inner bag retainer collar sleeve 30 for downward movement on the bridging plug body as just described, but also releases it for rotation freedom, whereby, as the cement slurry is forced into the interior of the packer bag 21, the forces set up within the bag and through the spiral folds therein will result in an untwisting action throughout the length of the bag which will be permitted by the freedom for rotation of the sleeves 30. Thus, as the bag fills, sleeve 30 will rotate several turns, allowing the bag to expand to its fully filled globular shape or to the degree of filling and to the shape which is required to bring it into firm contact with the walls of the well.

The downward motion of the piston valve 46 also releases the lower spider assembly in the following manner: First, the tubular strut member 54 and the cylindrical member 57 move downward with the piston, carrying with them the locking head 60. As soon as the locking head 60 is thus moved downward a distance equal to the width of the cylindrical shoulder surface bearing against the inner ends of the tongues 70 of the spider legs and out of engagement with the inner end faces of the tongues 70, the tongues are released therefrom with freedom to pivot into the positions as shown in Figure 5.

Continued downward motion of the piston valve 46 toward the lower limits of its travel as determined by the pin 75 first brings the bottom end of the locking head 60 against the inner bottom surface of the guide head 61, at which point the pin 55 is sheared allowing the tubular strut 54 to telescope within the cylindrical member 57,

12

whereby the piston 46 may continue its downward motion to the said stop pin 74 and to the position shown in Figure 5. The ports 47 and 48 are now fully opened.

As soon as the upper and lower spider assemblies are thus released, the apparatus may be alternately raised and allowed to lower slightly with the result of more firmly forcing the pointed ends of the spikes into the walls of the bore hole, as illustrated in Figure 5, after which the bridging plug is securely anchored in place against either upward or downward motion within the bore hole. The spider assemblies thus opened and anchored into the bore hole walls serve as upper and lower reinforcing barriers for confining the ends of the expanded packing bag 21.

At this stage in the setting of the bridging plug, the cement slurry will have been partially ejected from the cement chamber 20 into the packing bag 21, at which time the plunger 130 will be in a partially lowered position as illustrated in Figure 4 with a considerable quantity of cement remaining in the cement chamber.

Following this, sufficient tension is next taken on the conductor cable 101 to shear the pins 13 and 13 allowing the joint 12 between the cement chamber and the bridging plug body to be broken and disconnected therefrom, as illustrated in Figure 6. As soon as the connection at 12 is thus broken, the remaining portion of the cement slurry in the cement chamber 20 is dumped therefrom onto the top of the bridging plug and into the annular space surrounding the top portion of the bridging plug to a suitable level thereabove, as illustrated at 230, Figure 6.

The plunger 130, in expelling the balance of the cement slurry from the cement chamber 20 after the joint 12 is broken, will have moved down into supporting contact with the pin 153, also as shown in Figure 6. Following this, the setting tool portion of the apparatus comprising the weight barrel 98 and the cement chamber 20, may be hoisted away from the bridging plug and removed from the bore hole. The bridging plug will then be left anchored in the bore hole in the manner illustrated in the lower portion of Figure 6.

The operation of the alternative apparatus illustrated in Figures 11 and 12 is similar to that described hereinbefore in connection with the apparatus of Figures 1-10, inclusive. In this latter case, the cement slurry pressure applied by means of the weights 122 through the plunger 130, is delivered to the plunger 164 and through the check valve 17 to the interior passages of the bridging plug body leading to the piston valve 159. The downward force thus applied to the plunger first shears the pins 173, allowing the piston 159 to move downward, releasing both the upper and lower spider assemblies. The lower spider assembly is released as the locking head 191 moves downward out of engagement with the inner ends of the tongues 70 of the spider legs. The upper spider assemblies are released when the cylindrical surface 221 at the top end of the piston valve 159 moves downward out of engagement with the inner end faces of the spider tongues 220.

As the upper spider legs or spikes 218 move outward into their open positions, they are disengaged from the grooves 207 formed in the outer surface of flange 206 at the top of the upper bag retainer 202, freeing it for subsequent rotation. Continued downward movement of the piston 159 brings next the ports 167 into en-

13

gagement with the outer openings 195 and 196 through the bridging plug body 155, after which the cement slurry is free to flow downward from the cement chamber 20 through the piston valve 159 out through the ports 167 and openings 195 and 196 into the space within the packer bag 198, expanding it into engagement with the walls of the bore hole and the inner edges of the upper and lower spider spike assemblies as shown in Figure 12. The opening movement of the spider legs 218 will be assisted by the action of the helical spring 213.

After the bridging plug has been anchored in the bore hole and the packer bag filled as illustrated in Figure 12, sufficient upward tension is then taken in the conductor cable, as hereinbefore mentioned in connection with Figures 1-10, inclusive, to shear the pins 166 thereby allowing the setting tool portion of the apparatus, including the weight barrel 98 and the cement chamber 20 to be withdrawn from the bridging plug and hoisted out of the bore hole. The balance of the cement slurry contained within the cement chamber will then be emptied upon the top of the bridging plug in the same manner as illustrated in Figure 6.

Advantages of the apparatus of Figures 11 and 12 over those previously shown and described reside in the smaller diameter to which the packing bag 198 may be folded and retained, and also in the greater pressure which may be exerted to actuate the setting apparatus by the plunger 164 which occupies the full diameter of the cementing chamber.

The packer bags illustrated at 21 and 198 in the drawings may be made of any suitable flexible material having the required tensile strength but the preferred material and construction found to be particularly well suited to this purpose is a bag formed with a spun glass fabric layer or a plurality of overlying or overlapped layers or laminations of spun glass fabric impregnated with natural or a suitable synthetic rubber and vulcanized in a manner similar to that employed in the formation of automobile tires.

The beading in the end necks of the packer bag may also be formed in a manner similar to that employed for forming the bead around a tire and may contain an annular reinforcing core of wound wire, or of cords of spun glass, rayon or the like material vulcanized within a cuff-like fold formed by folding back over such reinforcing core a short length of the end portion of the bag neck.

Any required number of weights of the type shown at 122 in Figures 1, 2, 4, and 6 may be employed as required to apply sufficient pressure to the cementitious fluid in the cement chamber 20. It has been found that about 4 weights each weighing 245 lbs. each acting, as illustrated, upon a plunger of 3.75 inches in diameter and thereby producing a net pressure of approximately 72 lbs. per square inch in the cement chamber allowing for buoyancy of the drilling fluid, will be adequate for expelling the ordinary cement slurry from the cement chamber, actuating the piston type valve and associated spider releasing mechanisms, and for filling and firmly inflating the packer bag, under usual fluid-containing, well bore hole conditions. For example, employing a bridging plug having a body of 4 inches in diameter and a packer bag approximately 24 inches long between necks and approximately 10% inches in diameter in its fully inflated condition, has

14

been found to form a firm seal with a surrounding bore hole of 9% inches in diameter, under the cement pressures hereinbefore specified.

The bridging plug body may be made of cast iron, the several springs and the piston valve mechanism of brass and the spider legs or spikes of malleable cast iron so that the bridging plug may be drilled-up if desired. Other suitable materials may be employed, if desired, to suit particular obtaining conditions. For example, under some conditions, it has been found desirable and satisfactory to construct the body portions of the bridging plug of a thermo-setting plastic material preferably containing a fibrous reinforcement material.

It is to be understood that the foregoing is illustrative only and that the invention is not limited thereby, but may include various modifications and changes made by those skilled in the art without departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. A bridging plug comprising: a body; a flexible bag attached to and surrounding said body; a fluid chamber connected with said body and in communication with the inside of said bag; a plunger slidable in said chamber and adapted to apply pressure to fluid therein to expel fluid therefrom into said bag; a housing connected to said chamber; a plurality of weights in said housing; suspension means initially to support said weights in said housing; means coupling said weights to said plunger; and means to release said weights from said suspension means to apply force to said plunger to expel fluid from said housing into said bag.

2. A bridging plug setting tool comprising: a fluid chamber; a plunger slidable axially in said chamber and adapted to increase the pressure therein to expel fluid therefrom; an elongated housing attached end to end in axial alignment with said chamber and in communication therewith; conductor cable means for suspending said fluid chamber and housing in a well bore hole; a weight in said housing; means to suspend said weight in said housing against axial movement therein; means to couple said weight to said plunger; and explosive means electrically controlled through said conductor cable to break said suspension means to release said weight to move said plunger in said chamber.

3. A bridging plug setting tool comprising: a fluid chamber; a plunger slidable axially in said chamber and adapted to expel fluid therefrom; an elongated housing attached end to end in axial alignment with said chamber and in communication therewith; conductor cable means for suspending said fluid chamber and housing in a well bore hole; a weight in said housing; releasable means to suspend said weight in said housing against axial movement therein; means to couple said weight to said plunger; and means electrically controlled through said conductor cable to actuate said releasable suspension means to release said weight to move said plunger in said chamber.

4. A bridging plug setting tool comprising: a fluid chamber; a housing connected to said chamber; a weight in said housing; releasable means connected to said housing to support said weight in said housing against axial movement therein; means to actuate said weight supporting means to release said weight for movement in said housing; and means connected with said weight and

15

operative by motion of said weight to vary the displacement of said chamber to force fluid from said chamber; and means to detachably couple said chamber to a bridging plug.

5. In a bridging plug, formation gripping means comprising: a substantially cylindrical body; a pair of oppositely facing, axially spaced formation gripping spiders mounted on said body, a formation engaging, flexible bag surrounding said body intermediate said spiders, said spiders each comprising a plurality of circumferentially spaced spikes each pivotally attached adjacent one end thereof to said body, said spikes being adapted when retracted, to lie in parallel, side by side circumferentially spaced positions about said body and when extended, to project outward from said body at an angle to the axis of said support in circumferentially spaced, radially directed planes intersecting the axis of said support, said spikes being thereby adapted when thus pivoted to extended positions to penetrate the wall of a surrounding bore hole, and thereby to resist axial motion of said body in either direction in said bore hole; resilient means urging said spikes into extended positions; means to lock said spikes in retracted positions; means to inflate said bags; and means to actuate said locking means to release said spikes to extended positions.

6. In a bridging plug, apparatus according to claim 5 in which the means to actuate said locking means and means to inflate said bag are actuated by a common fluid pressure means associated with said body.

7. A bridging plug comprising: a body; a pair of spaced apart, oppositely positioned, retractable formation gripping means on said body; a flexible bag attached to and surrounding said body intermediate said gripping means; means to retain said bag in deflated and closely retracted position around said body; means to retain said formation gripping means in retracted position on said body; a closed fluid reservoir associated with said body; means in said reservoir to apply pressure to fluid in said reservoir; means to conduct fluid under pressure from said reservoir to the inside of said bag and means actuated by the thus applied pressure of said fluid to release said formation gripping means and said bag retaining means to permit said bag to be inflated by said fluid.

8. A bridging plug comprising: a body; a flexible bag attached to and surrounding said body; releasable means to retain said bag in deflated and closely retracted position around said body; a closed fluid reservoir associated with said body; means in said reservoir to apply pressure to fluid in said reservoir; means to conduct fluid under pressure from said reservoir to the inside of said bag; and means actuated by the thus applied pressure of said fluid to release said retaining means to permit said bag to be inflated by said fluid.

9. A bridging plug comprising: a closed tubular body; a pair of spaced, oppositely positioned, formation gripping spiders on said body, said formation gripping spiders being adapted to move from closed to opened formation gripping positions; a flexible bag surrounding said body intermediate said spiders, said bag being sealed at its opposite ends to said body at points adjacent said gripping spiders; releasable means initially to retain said bag in retracted position closely surrounding said body; a passage providing communication between the inside of said bag and the interior of said body; a chamber communicat-

16

ing with the inside of said body; a pressure actuated valve in said body normally closing said passage, said valve being adapted to be opened upon development of a predetermined pressure in said chamber; a lock for retaining said formation gripping spiders in closed positions; means associated with and actuated by movement of said valve to release said lock; means associated with said valve and actuated by movement thereof to actuate said releasable means to release said bag from its retracted position; and means in said chamber for expelling fluid from said chamber under pressure through said body and said passage into said bag.

10. A bridging plug comprising: a tubular body; a pair of spaced, oppositely positioned, retractable formation gripping spiders on said body, said formation gripping spiders being adapted to be moved between closed and opened positions; a flexible bag surrounding said body intermediate said gripping spiders, said bag being sealed at its opposite ends to said body at points adjacent said gripping spiders; a passage providing communication between the inside of said bag and the interior of said body; a closed chamber communicating with the said interior of said body; a pressure actuated valve in said body normally closing said passage, said valve being adapted to be opened upon development of a predetermined pressure in said chamber; a releasable lock for retaining said formation gripping spiders in closed positions; means actuated by movement of said valve to release said lock; means to move said formation gripping spiders from closed to opened positions upon release of said lock; and means in said chamber for expelling fluid from said chamber under pressure through said body and said passage into said bag.

11. A bridging plug comprising: a tubular body; a pair of axially spaced, oppositely positioned, retractable formation gripping spiders on said body, said formation gripping spiders being adapted to be moved from closed to open position; a flexible bag surrounding said body intermediate said gripping spiders, said bag being sealed at its opposite ends to said body at points adjacent said gripping spiders; a passage providing communication between the inside of said bag and the interior of said body; a closed chamber communicating with the interior of said body; a pressure actuated valve in said body normally closing said passage, said valve being adapted to be opened upon development of a predetermined pressure in said chamber; a releasable lock for retaining said formation gripping spiders in closed position; means actuated by movement of said valve to release said lock to permit said spiders to move to opened positions; and means in said chamber for expelling fluid from said chamber under pressure through said body and said passage into said bag.

12. A bridging plug comprising: a tubular body; a pair of spaced, oppositely positioned, retractable, formation gripping means on said body; a flexible bag surrounding said body intermediate said gripping means, said bag being sealed at its opposite ends to said body at points adjacent said gripping means; a passage providing communication between the inside of said bag and in the interior of said body; a closed chamber communicating with the interior of said body; a pressure actuated valve in said body normally closing said passage, said valve being adapted to be opened upon development of a predetermined pressure in said chamber; a releasable

lock for retaining said formation gripping means in retracted position; means actuated by movement of said valve to release said lock; and means in said chamber for expelling fluid from said chamber under pressure through said body and said passage into said bag.

13. A bridging plug comprising: a tubular body; a pair of spaced, oppositely positioned, retractable, formation gripping means on said body; a flexible bag surrounding said body intermediate said gripping means, said bag being sealed at its opposite ends to said body at points adjacent said gripping means; a passage providing communication between the inside of said bag and the interior of said body; a closed chamber communicating with the interior of said body; a pressure actuated valve in said body normally closing said passage, said valve being adapted to be opened upon development of a predetermined pressure in said chamber; and means in said chamber for expelling fluid from said chamber under pressure through said body and said passage into said bag.

14. A bridging plug comprising: apparatus according to claim 8 in which the said releasable retaining means to retain said bag in deflated, closely retracted position around said body includes a collar rotatable upon a portion of said body; means forming a fluid tight attachment of one end opening of said bag to said collar whereby said end of said bag may be rotated with said collar with respect to the other end of said bag; means to restrain said collar from rotation with respect to said body; and in which the said means to release the said retaining means includes means to release said collar for rotation about said body.

15. A bridging plug comprising: a fluid chamber; a plunger slidable axially in said chamber and adapted to increase the pressure therein and to expel fluid therefrom; an elongated barrel attached end to end in axial alignment with said chamber and in communication therewith; conductor cable means for suspending said barrel and chamber in a well bore hole; a weight in said barrel; means initially to suspend said weight in said barrel against axial movement therein; means to couple said weight to said plunger to transfer axial movement of said weight to said plunger when said weight is released for axial movement in said barrel; explosive means electrically controlled through said conductor cable to break said suspension means to release said weight to move said plunger in said chamber; a tubular body communicating with said chamber; a pair of spaced, oppositely positioned formation gripping spiders on said body, said formation gripping spiders being adapted to be moved from closed to opened formation gripping positions; a flexible bag surrounding said body intermediate said spiders, said bag being sealed at its opposite ends to said body at points adjacent said gripping spiders; releasable means initially to retain said bag in retracted position closely surrounding said body; a port providing communication between the inside of said bag and the interior of said body; a valve in said body adapted initially to close said port and movable to open said port in response to pressure in said chamber; a releasable lock for retaining said formation gripping spiders in closed position; means carried by said body and actuated by movement of said valve to release said lock to

free said spiders to move into opened positions; and means associated with said valve and actuated by movement thereof to release said bag from its retracted position.

16. A bridging plug comprising: a body having a fluid passageway therein; a flexible bag attached to and surrounding said body; a port leading from the inside of said bag to the fluid passageway in said body; a fluid chamber connected with said body and in communication with the said fluid passageway therein; a plunger slidable in said chamber and adapted to apply pressure to fluid therein to expel fluid therefrom through said passageway and said port into said bag; a housing connected to said chamber; a plurality of weights in said housing; suspension means initially to support said weights in said housing; means coupling said weights to said plunger; and means to release said weights from said suspension means to apply force to said plunger to expel fluid from said chamber into said passageway in said body.

17. A bridging plug comprising: a hollow body; a pair of spaced, oppositely positioned, formation gripping means on said body, movable between retracted and extended formation gripping positions; resilient means to urge said formation gripping means into extended formation gripping positions; releasable means to retain said formation gripping means in retracted positions; a flexible bag attached to and surrounding said body intermediate said oppositely positioned formation gripping means; and means responsive to fluid pressure within said hollow body for inflation of said bag, to actuate said releasable means to release said formation gripping means for movement to extended formation gripping positions.

18. A bridging plug comprising: an elongated body; a pair of spaced, oppositely positioned, formation gripping means on said body; a flexible bag surrounding said body intermediate said gripping means, said bag being sealed at its opposite ends to said body at points adjacent said gripping means; a passage providing communication between the inside of said bag and the interior of said body; a closed chamber communicating with the interior of said body; fluid pressure generating means in said chamber operative for expelling fluid from said chamber under pressure through said body and said passage into said bag; means restraining said fluid pressure generating means from operating to expel fluid from said chamber; and means to release said restraining means to permit said pressure generating means to operate.

GEORGE F. TURECHEK.

DONALD G. MOORHOUSE.

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