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(54) **METHOD AND APPARATUS FOR REPAIR OF WELLS UTILIZING MELTABLE REPAIR MATERIALS AND EXOTHERMIC REACTANTS AS HEATING AGENTS**

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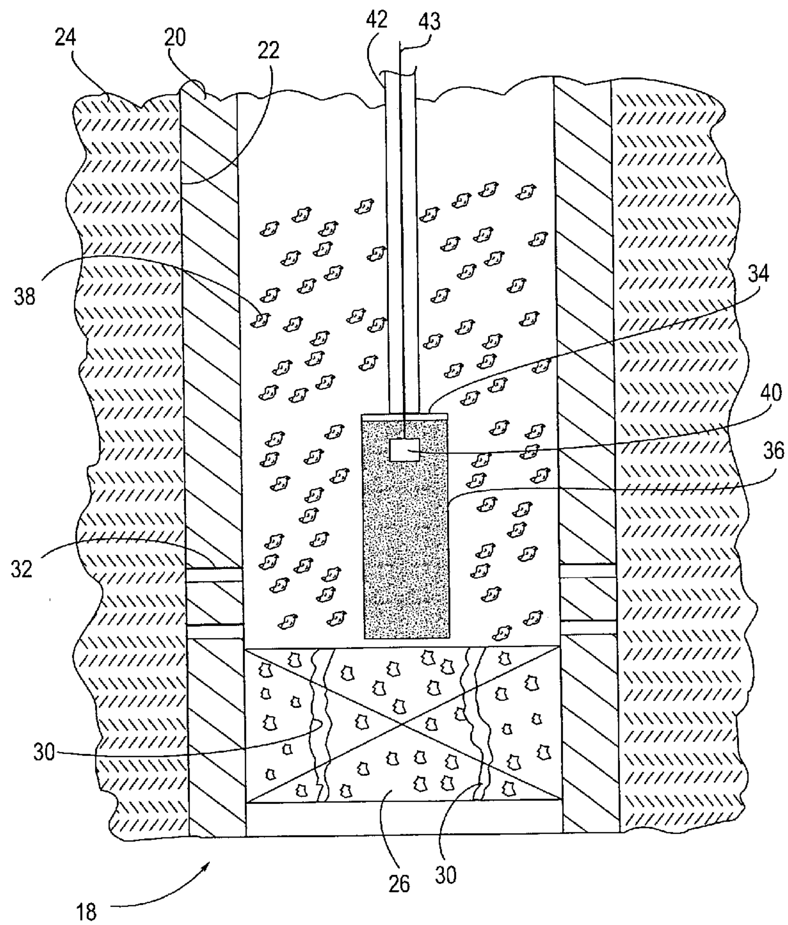
(57) **ABSTRACT**

A method and apparatus are described for creating a fluid seal in a subterranean well structure having a fluid seal defect. The method comprises introducing a meltable repair material proximate a structure in a subterranean well which has a fluid seal defect or enhanced seal capacity is required or it is desired to temporarily or permanently hydraulically isolate a portion the well or strengthen the structural integrity of well tubulars or tubular hangers. Exothermic reactant materials are located proximate the meltable repair material. The exothermic reactant material is ignited or an exothermic reaction otherwise initiated which supplies heat to and melts the meltable repair material into a molten mass. The molten mass flows and solidifies across the structure and the fluid seal defect to effect a fluid seal in the subterranean well structure or the structural integrity is enhanced. Examples of preferred exothermic reactant materials include thermite, thermate, fusible chemical reactants such as ammonium chloride and sodium nitrate, and oxidizers and accompanying hydrocarbon based fuels. Examples of preferred meltable repair materials include solder or brazing materials and eutectic metals which expand upon cooling and solidifying from a molten state.



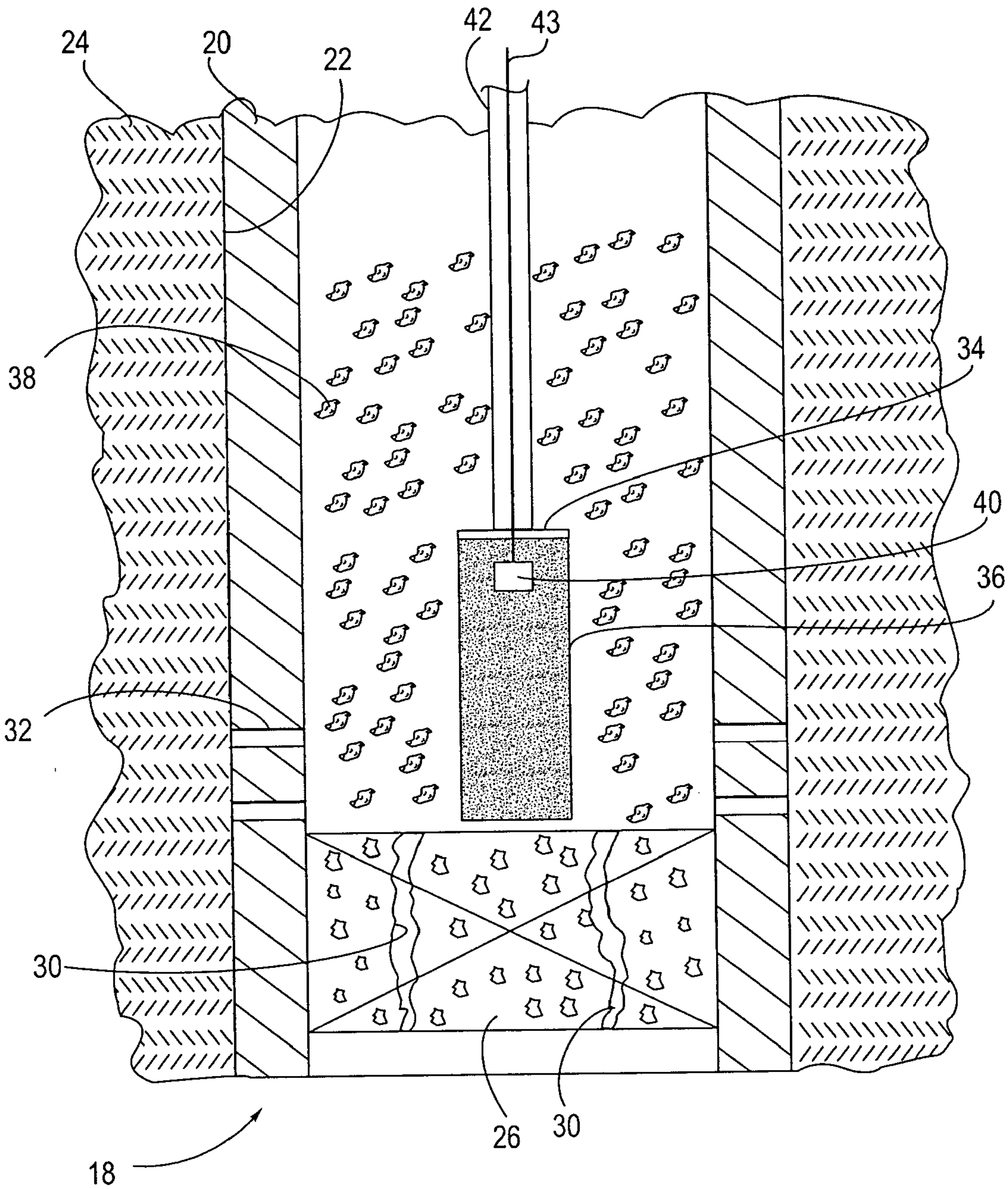


FIG. 1

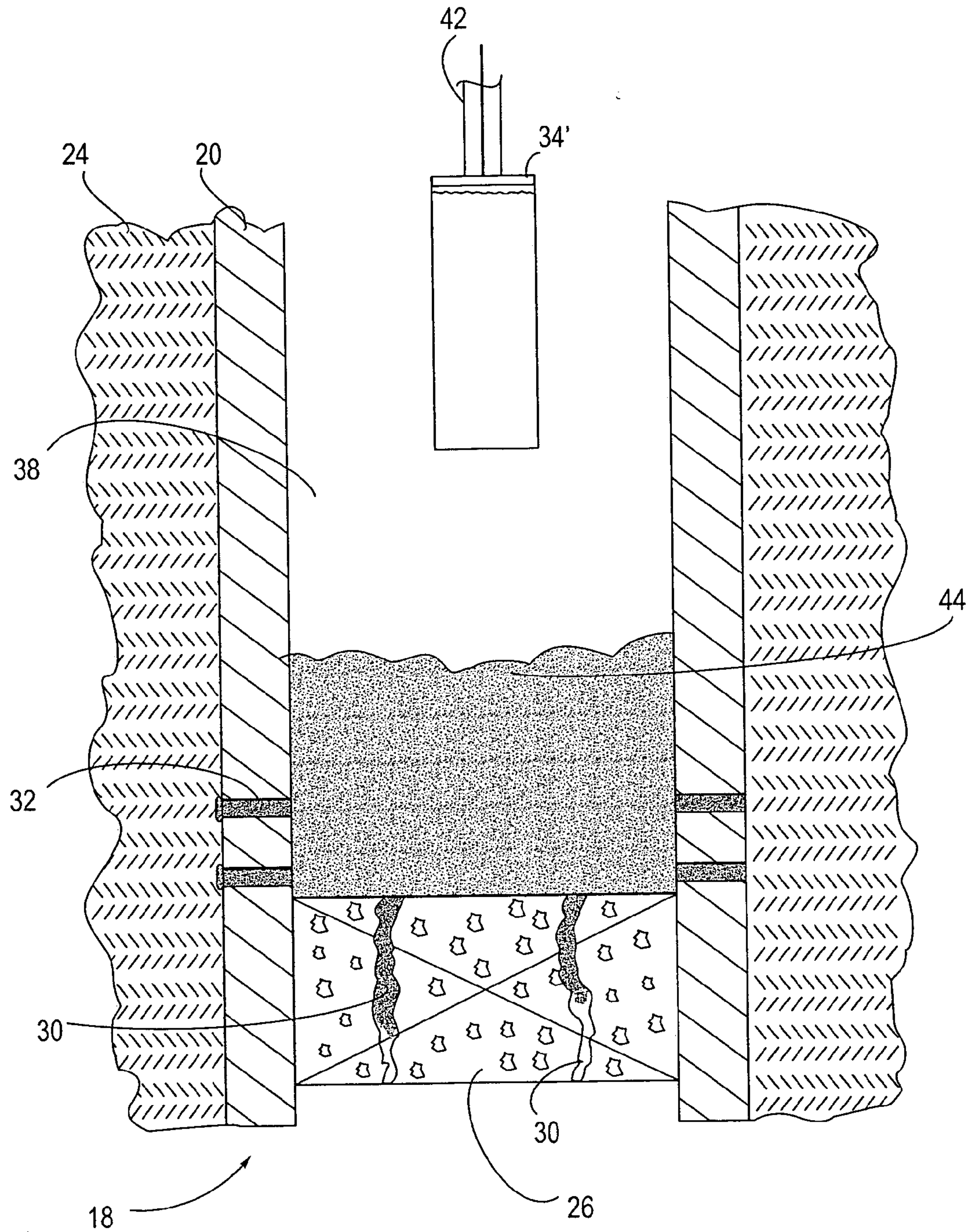


FIG. 2

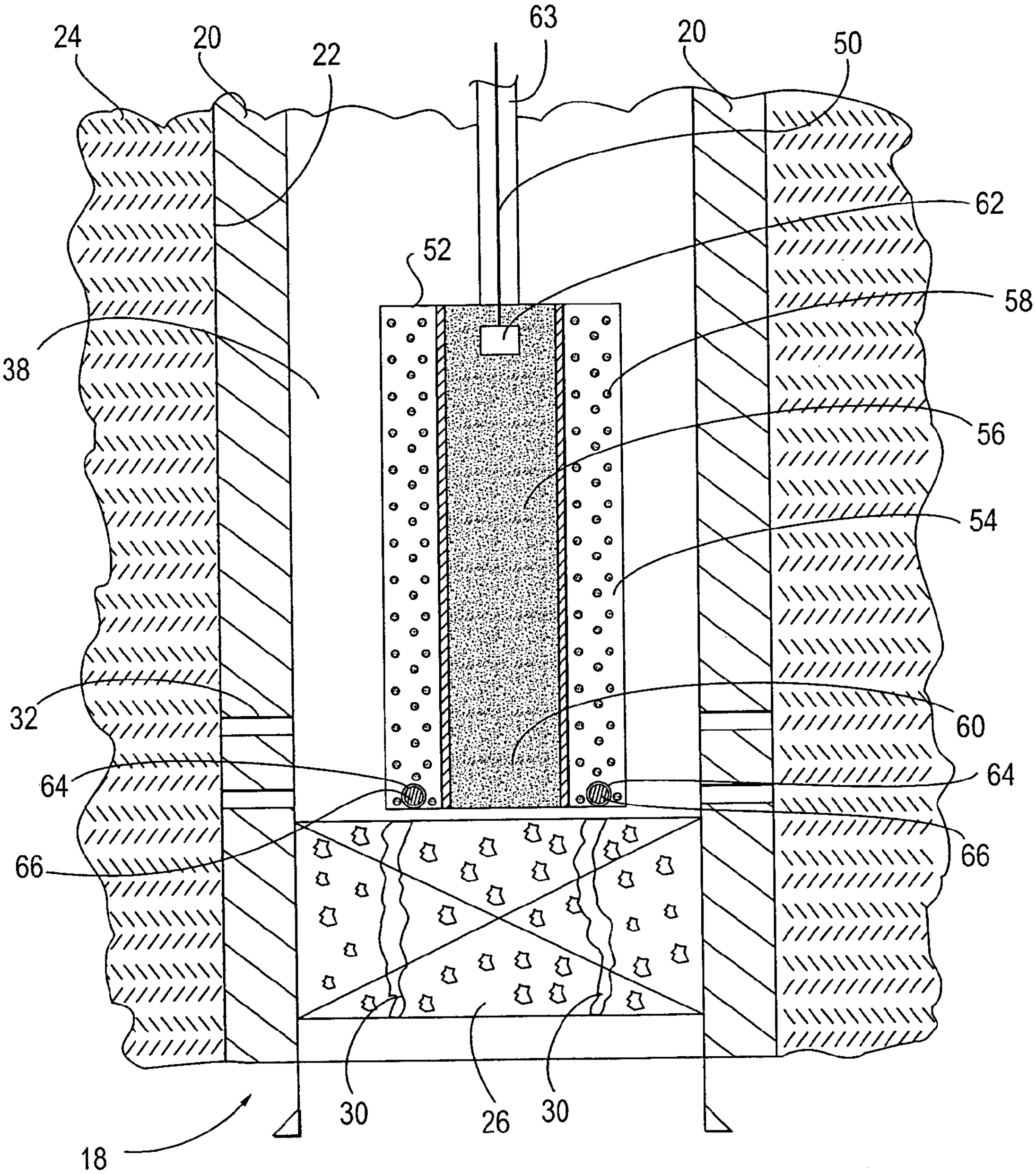


FIG. 3

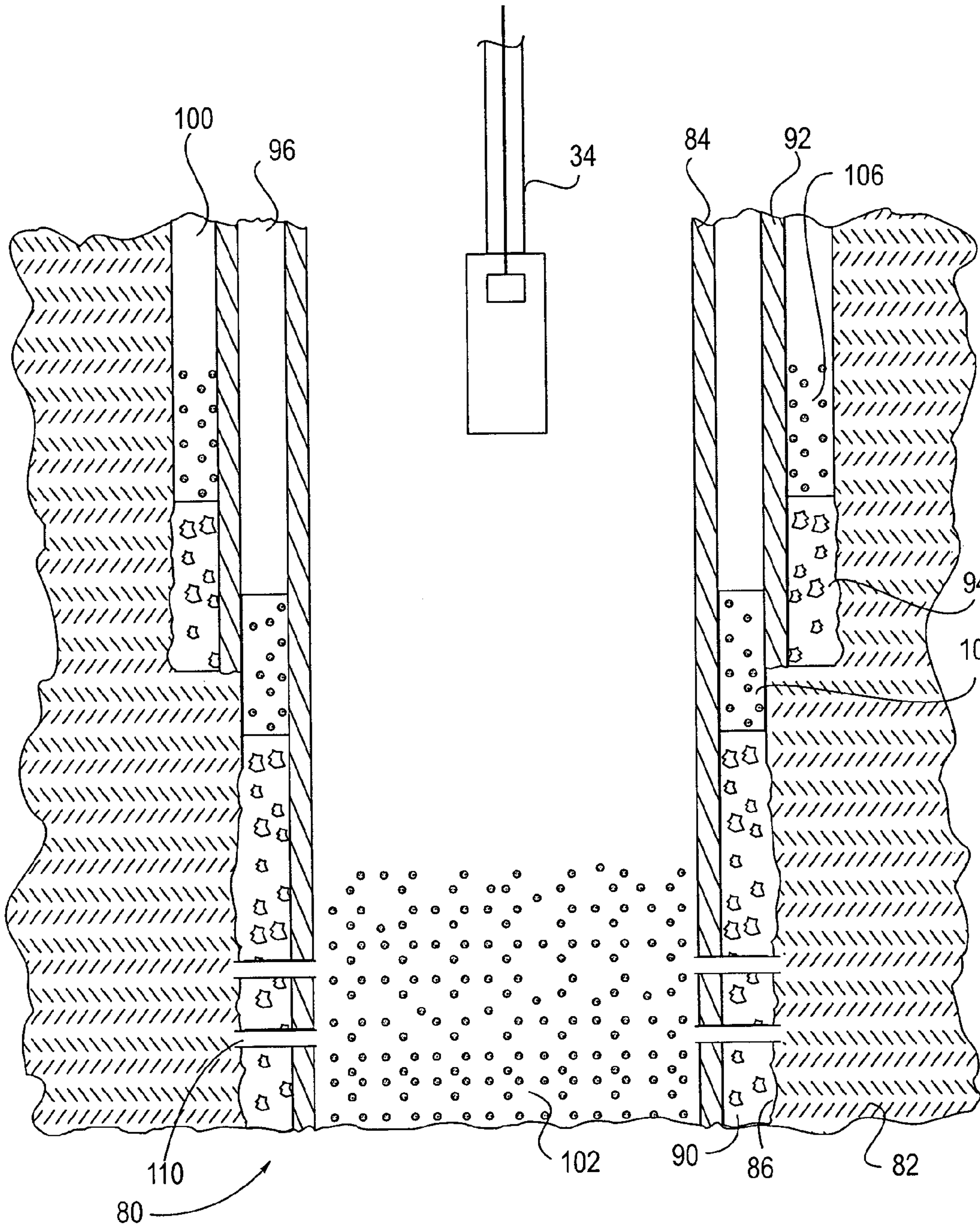


FIG. 4

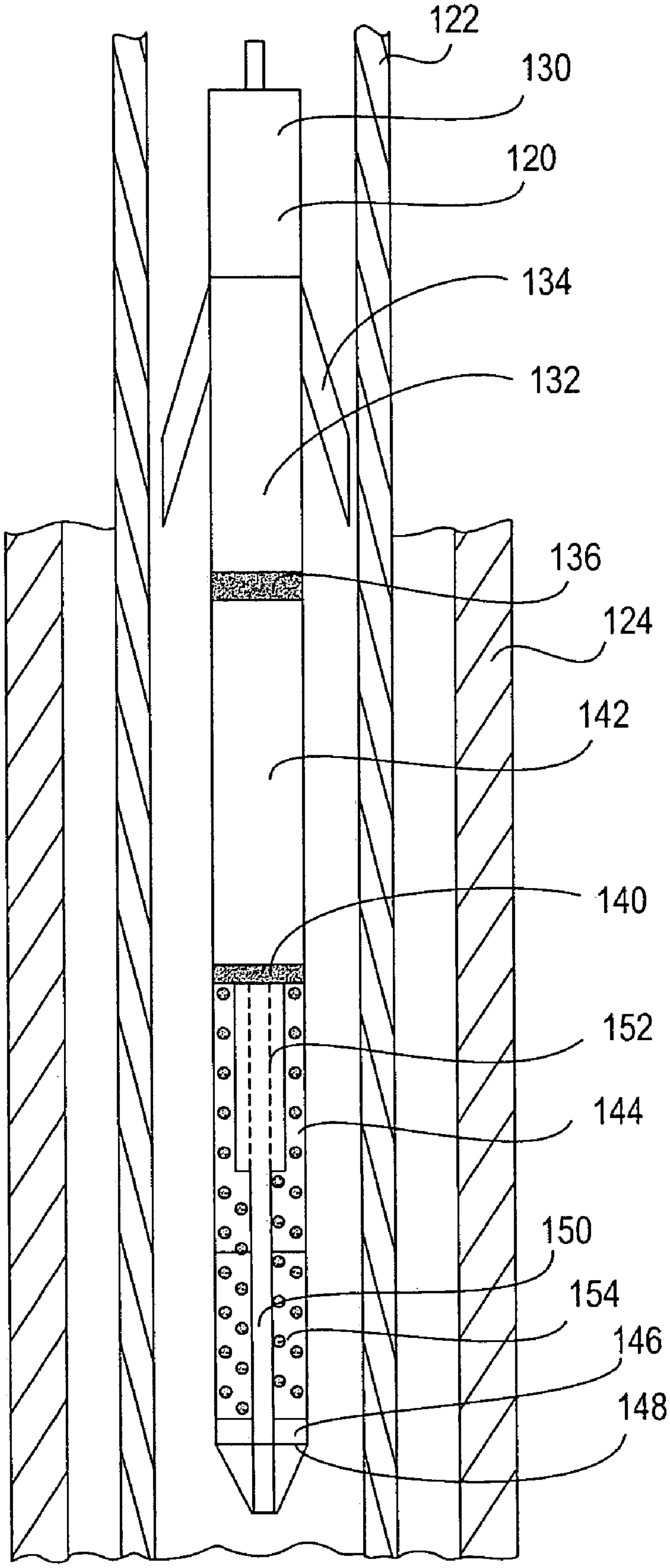


FIG. 5

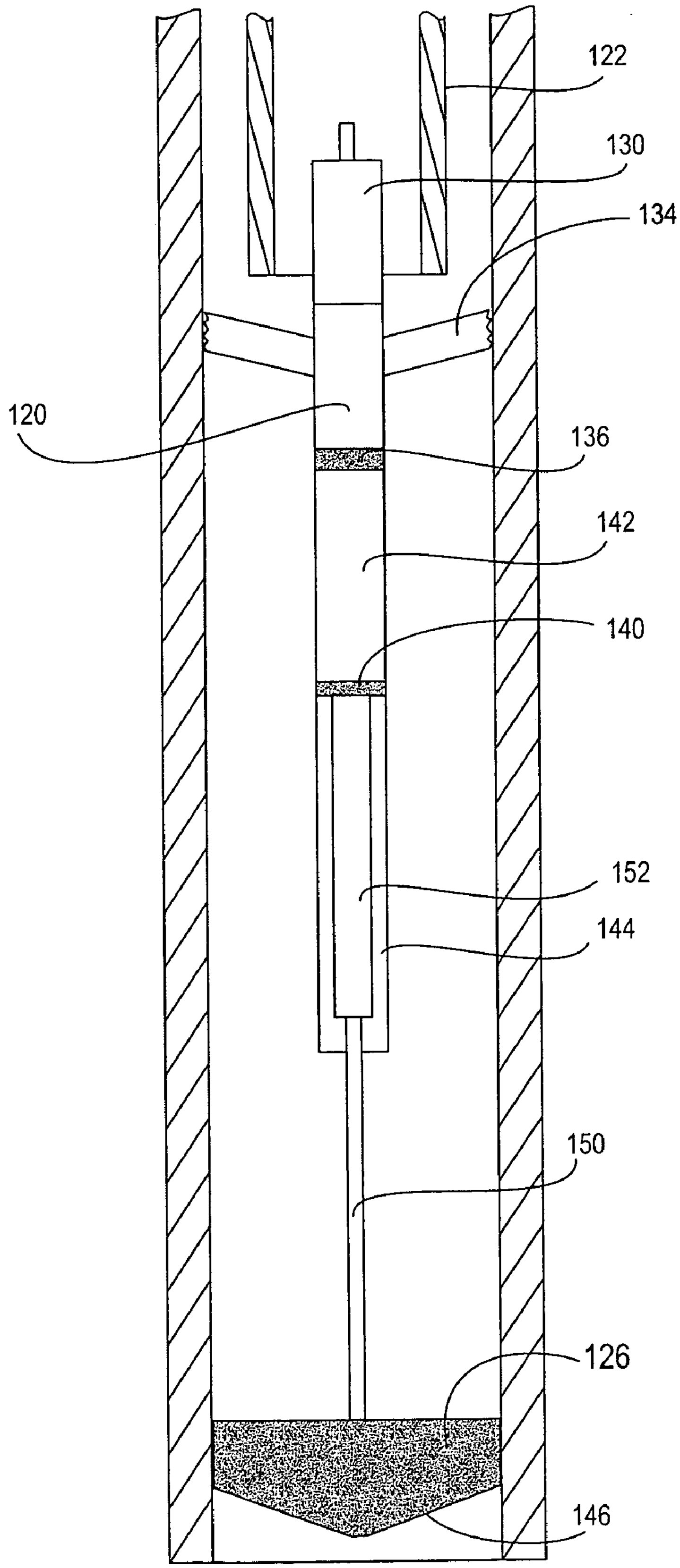


FIG. 6

METHOD AND APPARATUS FOR REPAIR OF WELLS UTILIZING MELTABLE REPAIR MATERIALS AND EXOTHERMIC REACTANTS AS HEATING AGENTS

TECHNICAL FIELD

[0001] The present invention relates generally to the repair of gas and oil wells, and more particularly, to those repairs which utilize eutectic metal plugs to seal existing leaks or to form temporary or permanent plugs for the purpose of isolating pressure within a portion of a well.

BACKGROUND OF THE INVENTION

[0002] During the life of a well, it is often necessary to isolate parts for the well to 1) shut off unwanted production of water or gas, 2) prevent communication of pressure to surface through annular communication, or 3) isolate portions of the well from acid or hydraulic stimulation to facilitate selective stimulation. Examples of structures having fluid seal defects needing repair may include leaking cemented annuli, leaking plugs such as cement and mechanical plugs, leaking abandoned or unwanted water or gas producing perforations, high pressure intervals which are to be temporarily or permanently isolated and gravel-packed production intervals which are to be shut-off from water influx.

[0003] Metal seals or plugs which are melted and then solidified in place are known to be used to effect fluid seals or plugs in defective structures in wells. For example, U.S. Pat. No. 6,474,414, to Gonzalez et al., entitled "Plug for Tubulars", describes the use of a molten metal plug which expands upon solidification to form a pressure resistant seal in a tubular such as is used in oil and gas exploration and production. The disclosure of U.S. Pat. No. 6,474,414 is hereby incorporated by reference in its entirety.

[0004] The Gonzalez et al. patent describes how eutectic metals are heated until molten and then the molten eutectic metal is introduced into confined regions of downhole structures requiring fluid sealing. The molten eutectic metal solidifies in the confined region forming a sealing plug with the structure. Because eutectic metals are preferably selected which expand upon cooling and solidifying, the sealing plugs ideally form pressure resistant seals with the cooperating structures.

[0005] As examples, the Gonzalez et al. patent describes a plug which is placed into a structure, i.e., a standard pipe connection, including a collar which uses a threaded connection to secure two joints of tubing together. A solidified eutectic plug is formed proximate the ends of the joints and within the collar. In another embodiment, the sealing of perforations in a tubing is taught. Further, another example is the repair of a defective cemented interval which was intended to seal an annulus between a tubing and casing string.

[0006] The Gonzalez et al. patent describes the use of electrical heaters to provide heat to melt the eutectic metal in a well. Use of such devices which require substantial amounts of electrical power to operate have disadvantages such as the need for power generating units, long, heavy electrical cables, and significant excess electrical capacity, particularly on off-shore structures where weight and space are at a premium. Improved methods and apparatus for heating meltable repair materials to be used in downhole well repairs and environments are needed.

SUMMARY OF THE INVENTION

[0007] A method and apparatus are described for effecting a fluid seal in a subterranean well structure. The method comprises introducing a meltable repair material proximate a structure in a subterranean well where a fluid seal is desired. Exothermic reactant materials are located proximate the meltable repair material. The exothermic reactant is ignited or otherwise initiated to create an exothermic reaction which supplies heat to and melts the meltable repair material into a molten mass. The molten mass flows and solidifies across the structure and the fluid seal defect to effect a fluid seal in the subterranean well structure. Examples of preferred exothermic reactant materials include thermite, thermate and highly exothermic chemical reactions such as the reaction between ammonium chloride and sodium nitrite. Examples of preferred meltable repair materials include solder and eutectic metals which expand upon cooling and solidifying from a molten state Also, the exothermic reactant materials may include oxidizers and separate fuels which can be combined and ignited to provide an exothermic reaction to melt the meltable repair material.

[0008] A repair tool for effecting a fluid seal in a subterranean well structure having a fluid seal defect is also disclosed. A housing contains a meltable repair material and an exothermic reactant material proximate the meltable repair material. The repair tool may be introduced into a well and proximate a structure having a fluid seal defect. The exothermic reactant materials may be ignited to melt the meltable repair material into a flowable molten mass. The molten mass can then be discharged from the housing to cool and solidify upon the structure to effect a fluid seal repair or establish an isolating plug.

[0009] It is an object of the present invention to melt a meltable repair material, such as a eutectic metal, utilizing an exothermic reactant material, such as thermite or thermate, to create a molten mass of material which can flow upon and seal with a subterranean well structure to effect a fluid seal repair or pressure isolation plug, preferable a seal which is a press-fit and is pressure resistant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] These and other objects, features and advantages of the present invention will become better understood with regard to the following description, pending claims and accompanying drawings where:

[0011] **FIG. 1** is a schematic drawing of an exothermic heating apparatus disposed within eutectic metal pellets located within a well above a cement or mechanical bridge plug or float shoe and located within the well in an area where an extreme pressure isolation bridge plug is desired or a pressure communication defect exists;

[0012] **FIG. 2** is a schematic drawing of a repaired well wherein the eutectic metal pellets have been melted and resolidified forming a press-fit plug more capably sealing the cement or mechanical bridge plug and any perforations or leaks in the tubing or casing;

[0013] **FIG. 3** is a schematic drawing of a repair tool located in a wellbore above a cement or mechanical bridge plug and adjacent tubing which is to be repaired by forming a eutectic metal plug;

[0014] **FIG. 4** is a schematic drawing of the exothermic heating apparatus which can be located adjacent eutectic metal pellets disposed at the bottom of a well, in an inner annulus or in an outer annulus of a well wherein the pellets can be melted and resolidified to form pressure-fit seals in the wellbore to prevent communication of pressure to surface;

[0015] **FIG. 5** is a schematic drawing of another embodiment of a repair tool disposed in a wellbore which can provide its own support platform for placing and supporting a solidified plug in a casing; and

[0016] **FIG. 6** is a schematic drawing of the repair tool of **FIG. 5** after being deployed to create a press-fit seal with the casing.

DETAILED DESCRIPTION OF THE INVENTION

[0017] The present invention provides apparatus and methods for repairing fluid seal defects in subterranean structures of wells using meltable repair materials which are melted using exothermic reactant materials. By way of example and not limitation, the method and apparatus can be used to repair leaking cemented annuli, cement, mechanical or other fluid sealing plugs, unwanted perforations in wells which are to be abandoned or to temporarily or permanently isolate high pressure intervals, or shut-off water influx in gravel-packed production intervals. Defects may include seals, while currently integral, are to be reinforced to further enhance the structural integrity of the seal.

[0018] As a first example, **FIG. 1** shows a casing **20** lining a wellbore **22** formed in an earth formation **24**. Located within casing **20** is a cement or mechanical bridge plug **26**. Cracks **30** in cement plug **26** and perforations **32** in casing **20** allow fluids to pass through cement plug **26** and casing **20** or the plug may need additional isolation potential or mechanical integrity to prevent future leaks. Plug **30** could be a mechanical bridge plug, a sand plug, a lead shot plug and/or an accumulation of metal particulate piled atop the bottom of wellbore **22** or set higher in well bore to temporarily or permanently isolate the interval below or effect seal repair at the chosen setting depth. Perforations **32** may have been created to provide a pathway to a producing formation which is now to be abandoned. Or else perforations **32** may be caused by stress fracturing and corrosion. In any event, these cracks **30** and perforations **32** are now defects in the corresponding structures and need to be sealed to fluidly isolate the inside of casing **20** from the wellbore beneath the cement plug **26** and from the wellbore outside casing **20**.

[0019] An exothermic heating apparatus **34** is lowered down wellbore **22** until it is near cement plug **26** and perforations **32** in casing **20**. Exothermic heating apparatus **34** comprises exothermic reactant materials **36**, preferably in solidified block form, an igniter **40** and a support line **42** for suspending and locating exothermic heating apparatus **34** in wellbore **20**. Preferably, igniter **40** is embedded within or adjacent to the exothermic reactant materials **36**. Support line **42** may be tubing or simply a wireline or e-line if venting of the reaction is not needed. An electrical conduit **44** may be included with support line **42** to provide power to igniter **40**. Alternatively, igniter **40** any other type of igniter used to ignite or initiate the exothermic reaction such as percussion type igniter activated by a falling bar or other object.

[0020] Exothermic reactant material **36** is made of a material which ideally provides a large quantity of heat when ignited. Preferably, exothermic block **36** is made of a thermite material, and most preferably, is thermate which can be ignited and burns even in water. One example of an exothermic thermite material is a granulated and cast mixture of aluminum particles with iron oxide. Also a bonding agent may be added to the thermite such as starch. Exothermic reactant material **36** is sacrificial in that it is a combustible material which sustains a slow burn for a required interval. For instance, the exothermic block may be poured with suitable inhibitors and binding agents so that it burns at 5,000 degrees F. for sufficient time to heat meltable repair materials until molten. The molten repair materials may then be cooled and used to plug fractures, perforations or other failures and defects in the downhole structures of well **18** or to enhance the seal and structural integrity of existing bridge plugs, packer sealing elements or liner hangers within the well bore.

[0021] Other exothermic reactant materials may also be used with this invention. For example, Nguyen, Duc A., in a PhD dissertation entitled, "Fused Chemical Reactions to Remediate Paraffin Plugging in Sub-Sea Pipelines", University of Michigan (2004) teaches the benefits of using ammonium chloride and sodium nitrite as reactants to create large quantities of exothermic heat. Fused chemical reactions are reactions that can be delayed by physical or chemical means. The controlled-release of an exothermic reaction can obtained by putting a polymeric, paraffin, or resin coating on an acid catalyst in a mixture of aqueous NH_4CL and $NaNO_2$ reactants. Preferred acid catalysts include common mineral acids like hydrochloric, sulfuric, and nitric, and organic acids like formic, acetic, citric, benzoic, sulfamic, etc. The acid catalyst could be released down the tubing and into the mixture of reactants to initiate an exothermic reaction. As the polymer, paraffin, or resin coating dissolves in the mixture due to temperature or solvent action, the encapsulated acid catalysts are released and an exothermic reaction is initiated.

[0022] After exothermic reactant material **36** is properly positioned, pellets **38** of the meltable repair material are introduced into casing **20** covering exothermic heating apparatus **34**. Most preferably, the meltable repair materials are made of eutectic metals which expand upon solidifying from a molten mass. While pellets **38** are preferred, the meltable repair materials may be provided in other forms such as in a solid and annular block form. Meltable repair materials suitable for use in this embodiment of the invention generally include most any material that will solidify under locally ambient conditions and form a plug having sufficient strength and bond to withstand the pressure differential across the plug. Preferably, the plug forms a tight mechanical pressure seal. This can be accomplished by either or both of selecting a molten mass of metal which expands as it solidifies and/or heating the tubing sufficiently so that it will diametrically shrink adequately to form the tight mechanical pressure seal as it cools. The former can be facilitated by selecting a soldering composition which contains least 10 parts per hundred, preferably at least 30 parts per hundred, and most preferably, at least 50 parts per hundred, of Bismuth. The second can be facilitated by heating the tubing to relatively high temperatures, such as in the range of 300-1100 F, and, if desired, employing a brazing or soldering composition to form the plug. The process may also be enhanced by incorporating a chemical flux borax or acid to improve adhesion of the solder or brazing material.

[0023] For downhole applications, locally ambient temperatures can range from about 40 to about 1,000 F (or higher, but such temperatures are not compatible with desirable liquid hydrocarbon products). Generally, downhole temperatures will range from about 32 F to about 700 F and will often be in the range of from about 100 F to about 300 F. Locally ambient pressures can range from 14.7 psi to 20,000 psi (or higher), but will generally range from about 14.7 to 15,000 psi and are usually in the range of from 14.7 to 10,000 psi.

[0024] Suitable materials will generally comprise a high percentage, generally in excess of 90% by weight of metals and will exhibit a melting point of less than 1100 F, generally in the range of 100 to 300 F. Generally speaking, it is preferable that the materials be relatively soft, so that they can be easily drilled out if necessary. Soldering compositions are generally suitable for most applications. Most suitable soldering compositions are metal alloys. As noted above, it is also desirable to have materials that expand when changing from a molten state to a solid state.

[0025] Preferred solders for use at ambient temperatures in the range of 150-600 F can comprise chiefly bismuth with optional lead, tin, cadium, antimony, and silver. Some examples from the Handbook of Chemistry and Physics, 54th edition, 1973-1974 (CRC Press, Cleveland, Ohio) include:

[0026] 25 Pb/25 Sn/50 Bi (266 F liquidus temperature),

[0027] 25 Pb/50 Sn/25 Bi (336 F liquidus temperature)

[0028] 50 Pb/37.5 Sn/12.5 Bi (374 F liquidus temperature)

[0029] 60 Pb/40 Sn (460 F/361 F liquidus/solidus temps) (AWS-ASTM classification 40A)

[0030] 85 Pb/15 Sn (550 F/440 F liquidus/solidus temps) (AWS-ASTM classification 15B)

[0031] 97.5 Pb/2.3-2.7 Ag (588 F/588 F liquidus/solidus temps) (AWS-ASTM classification

[0032] 1.5S)

[0033] In the table just given, constituents present at less than 1 part per hundred are not listed.

[0034] For applications in the 600-1000 F range, preferred solders comprise chiefly aluminum or magnesium-containing brazing materials: Examples (from CRC) include:

[0035] 11.0-13.0 Al/4.5-5.5 Zn/bal. Mg.

[0036] (liquidus/solidus temps 1050/770 F) (AWS-ASTM classification 1.5S)

[0037] 8.3-9.3 Al/1.7-2.3 Zn/bal. Mg

[0038] (liquidus/solidus temps 1110/830 F) (AWS-ASTM classification BMg-1)

[0039] 3.3-4.7 Cu/9.3-10.7 Si/bal. Al

[0040] (liquidus/solidus temps 1085/970 F) (AWS-ASTM classification BAlSi-3)

[0041] In the table just given, constituents present at less than 1 part per hundred are not listed. U.S. Pat. No. 4,561,300 discloses a wide range of suitable materials having melting points between 76 C and 351 C. Examples include:

COMPOSITION	MELTING POINT (C.)
Bi 48.5, In 41.5, Cd 10	076
In 52.34, Bi 47.66	088
Bi 52.5, Pb 32, Sn 15.5	096
Bi 54, Sn 26, Cd 20	103
Bi 67, In 33	110
In 52, Sn 48	118
Bi 56.5, Pb 43.5	126
Bi 56, Sn 40, Zn 4	133
Bi 60, Sn 40	139
Bi 60, Cd 40	147
Sn 68.35, Cd 29.25, Zn 2.4	159
Sn 71, Pb 24, Zn 5	170
Sn 67.75, Cd 32.25	175
Sn 62.5, Pb 36.15	180
Sn 61.9, Pb 38.1	184
Sn 91, Zn 9	198
Sn 91, Mg 9	205
Sn 95.8, Ag 3.5, Cu 0.7	218
Sn 96.5, Ag 3.5	222
Sn 99.5, Al 0.5	229
Sn	231
Sn 99.41, Cu 0.32, Al 0.27	234
Pb 79.7, Cd 17.7, Sb 2.6	239
Pb 84, Sb 12, Sn 4	243
Pb 82.6, Cd 17.4	249
Pb 88.9, Sb 11.1	253
Bi 97.3, Zn 2.7	256
Bi 97.5, Ag 2.5	263
Cd 82.6, Zn 17.4	265
Bi	273
Pb 91, Sb 4.68, Cd 4.32	276
Ga 92, Mg 18	285
Cd 92.45, Sb 7.55	294
Pb 96.97, Ag 2.20, Sb 0.83	301
Pb 97.5, Ag 2.5	303
Pb 97.55, Ag 1.75, Sn 0.7	311
Pb 98.1, Sb 1, Zn 0.9	315
Pb 97.4, Sn 2.6	320
Pb 98.76, Sn 1.24	325
Pb	329
Zn 92.97, Al 4.08, Mg 2.95	344
Te 70.6, Ag 29.4	351

[0042] Other suitable materials having a yield temperature over the range of 105 F to 357 F are commercially available from, for example, Cerro Metal Products Co. of Belefonte, Pa. Examples include:

COMPOSITION	YIELD TEMPERATURE (F.)
42.91 Bi/21.70 Pb/7.97 Sn/ 5.06 Cd/18.33 In/4.00 Hg	105
49.0 Bi/18.0 Pb/12.00 Sn/21.00 In	138
50.00 Bi/26.70 Pb/13.30 Sn/10.00 Cd	158
50.31 Bi/39.2 Pb/1.5 Sn/ 7.99 Cd/1.00 In	181
56.00 Bi/22.00 Pb/22.00 Sn	205
33.33 Bi/33.34 Pb/33.33 Sn	232
25.50 Bi/14.5 Pb/60.00 Sn	270
20.00 Bi/50.00 Pb/30.00 Sn	293
10.00 Bi/40.00 Pb/50.00 Sn	324
95.00 Bi/5.00 Sn	357

[0043] In the oil and gas industry, the invention will often be employed to form a seal in a tubing that extends generally downwardly into the earth. It may be desirable to remove standing liquids from the location where the plug is desired.

[0044] This can be done by the injection of gas at the wellhead. For example, the well can be bullheaded with nitrogen and the well liquids, if any, can be displaced to the perforations. Once the liquids have been removed, the invention can be carried out by positioning a platform for the molten metal in the tubing and forming a pool of the molten metal on the platform. A plastic bridge plug or other form of support such as a sand plug-back can provide a suitable platform. In a production tubing, the platform is preferably positioned slightly below a joint in the tubing, so that the molten material will flow into recesses which typically exist in the vicinity of the joints to more tightly secure the plug. In an annulus between the production tubing and the casing, the platform can be provided by the upper surface of the cement which fills the lower portion of the annulus. A column of high density particulates can also be placed ahead of eutectic material to adjust platform height or act as a bridging agent. The particulate prevents loss of the molten solder through incompetent tubing/casing packers or other leak paths. A column of high density particulate material, such as sand or barite, or iron or steel shot may also be positioned on top of the molten material, to maximize radial expansion of the material as it solidifies. Either column of particulate material or solder can be introduced into the well in dry-form or slurried in a liquid. If slurried, it can be placed in a dump bailer, through tubing, introduced at wellhead and allowed to free-fall to position, or by any other means of transport.

[0045] Referring now to **FIG. 2**, once the eutectic metal pellets are in place, igniter **40** is energized causing an exothermic reaction to occur in the exothermic reactant block **36**. Sufficient heat is produced to melt the eutectic metal pellets **38** creating a molten mass. The remainder of exothermic heating apparatus **34'** not consumed in the exothermic reaction is then removed from the molten mass of eutectic metal. Additional pressure can be applied at the surface of well **18** to aid movement of molten metal into fissures within the casing, top of the cement plug, wellbore perforations, etc. The molten mass flows into cracks **30** and perforations **32** and is then allowed to solidify forming a sealing plug **44**. Exothermic heating apparatus **34'** may optionally be withdrawn from well **18** before the plug solidifies

[0046] **FIG. 3** shows an embodiment of a repair tool **50** which is used in place of the separate eutectic metal pellets and exothermic heating apparatus **34** of **FIGS. 1 and 2**. The configuration of well **18** again includes casing **20** located within subterranean formation **24**. Also, a plug **26** is located in casing **20**. Plug **26** may include include cracks **30** or need enhancement of seal capacity and casing **20** has perforations or other leak path **32**.

[0047] Eutectic metal repair tool **50** includes a housing **52** comprising an outer annular chamber **54** filled with eutectic metal in form of pellets or a cast or machined annular ring **58** and an inner chamber **56** filled with an exothermic reactant material **60**. Tool **50** also includes an igniter **62** for igniting exothermic material **60**. A support line **64** is included to position tool **50** proximate cracks **30** and perforations **32** requiring sealing. Support line **64** may be tubing or else may be a wire line. Housing **52** includes a number of burst disks or release ports **64**. Release ports **64** are filled with release plugs **66** which release when sufficient pressure and heat are produced as a result of igniting exothermic reactant material **60** and melting eutectic pellets.

[0048] Igniter **62** is activated igniting exothermic material **60** creating an exothermic reaction releasing large quantities of heat. Heat is absorbed through the walls of housing **52** melting eutectic pellets **58** and creating a molten mass of eutectic material. Heat and pressure are produced within housing **52** as a result of the igniting of exothermic material **60** melting eutectic pellets **58** and releasing release plugs **66**. The molten mass of eutectic material exits release ports **64** and forms a pool molten metal atop plug **26**. Similar to **FIG. 2**, a portion of the molten metal solidifies within cracks **30** and perforations **32** with the remainder of the molten mass forming a press fit seal (not shown in **FIG. 3**) within casing **20**. Again, the end result will be similar to that of the plug formed in **FIG. 2**.

[0049] **FIG. 4** illustrates another embodiment of a well **80** in a subterranean formation **82** wherein the present invention may be used to effect seals between structures of the well. A production casing **84** is held in a wellbore **86** by production cement **90**. Similarly, an intermediate casing **92** is retained in wellbore **86** by intermediate cement **94**. An inner annulus **96** is formed between production casing **84** and intermediate casing **92**. An outer annulus **100** is created between intermediate casing **92** and wellbore **86**. Eutectic metal pellets **102**, **104** and **106** may be placed at any one of the bottom of wellbore **86**, atop a cement or mechanical bridge plug placed anywhere within wellbore **86**, adjacent the lower end of intermediate casing **92** in the inner annulus **96** and in outer annulus **100** or about a liner hanger or casing or tubing packer situated between two tubing. In this example, perforations **110** are shown which extend through production casing **84** and production cement **90**.

[0050] Exothermic heating apparatus **34**, as described above with respect to **FIGS. 1 and 2**, may then be used to heat any of the agglomerations of pellets **102**, **104** and **106**, depending on where a seal is desired to be formed. In the case of pellets **102** residing upon the bottom of the wellbore (or other similar support structure), exothermic heating apparatus **34** is positioned near the bottom of the wellbore prior to the introduction of pellets **102**, as was the case with the embodiment shown in **FIG. 1**. As a result, heat rising from exothermic heating apparatus **34** melts pellets **102**. Accordingly, a plug (not shown) is formed which seals production casing **84** and closes perforations **110**.

[0051] With respect to pellets **104** and **106**, exothermic heating apparatus **34** is placed generally adjacent the respective pellets **104** and **106** and the exothermic materials are ignited by igniter **40**. Heat produced by the exothermic reaction then traverses production casing **84** and intermediate casing **92** and melts pellets **104** or **106** thus creating a eutectic plug (not shown). In **FIG. 4**, exothermic apparatus **34** is shown adjacent pellets **106**. Again, the positioning of exothermic apparatus **34** will depend on where a seal plug is to be formed.

[0052] **FIGS. 5 and 6** display another repair tool **120**. In **FIG. 5**, repair tool **120** is being deployed through a tubing

122 and into a casing **124**. In **FIG. 6**, eutectic metal repair tool **120** has been actuated to form a seal plug **126** with casing **124**.

[**0053**] Referring to **FIG. 5**, eutectic metal repair tool **120** includes a slow burn pressure firing assembly **130**, a lock down hydraulic dog assembly **132** with ears **134**, a pair of rupture discs **136** and **140** sandwiching about an oxidizer cylinder **142**, a dump bailer **144** and a petal basket **146** including petals **148**. A firing tube **150** is telescopically mounted within a sliding sleeve **152**. Eutectic metal pellets **154** are contained within dump bailer **144** intermixed with a hydrocarbon based material such as an oil or grease which serves as a fuel.

[**0054**] In operation, repair tool **120** is positioned within casing **124** as shown in **FIG. 6**. The lock down hydraulic dog assembly **132** is actuated causing ears **134** to engage and grip the inner surface of casing **124** locking tool **120** in place. Next, the slow bore pressure firing assembly **130** is activated causing rupture disks **136** and **140** to burst and an oxidizer within oxidizer cylinder **142** to discharge into dump bailer **144**. The preferred oxidizer is bromium tri-fluoride. Those skilled in the art will appreciate that other oxidizers may also be used in place of the bromium tri-fluoride to provide oxygen to the fuel intermixed with the eutectic metal pellets **154**. The combination of the oxidizer and fuel combusts melting eutectic metal pellets **154** into a molten mass. The molten mass is captured by extended petals **146** and solidified in situ to form seal plug **126**.

[**0055**] While in the foregoing specification this invention has been described in relation to certain preferred embodiments thereof, and many details have been set forth for purposes of illustration, it will be apparent to those skilled in the art that the invention is susceptible to alteration and that certain other details described herein can vary considerably without departing from the basic principles of the invention. For example, fused chemical reactions could be adapted to work with any of the above embodiments.

What is claimed is:

1. A method for creating a fluid seal in a subterranean well structure having a fluid seal defect, the method comprising:

introducing a meltable repair material proximate a structure in a subterranean well which has a fluid seal defect or an isolating plug is desired;

introducing exothermic reactant materials proximate the meltable repair material;

igniting the exothermic reactant materials or otherwise initiating the exothermic reaction which supplies heat to and melts the meltable repair material into a molten mass;

flowing the molten mass to contact the structure and fluid seal defect; and

allowing the molten mass to solidify across the structure and the fluid seal defect to effect a fluid seal in the subterranean well structure.

2. The method of claim 1 wherein:

the exothermic reactant material includes thermite.

3. The method of claim 1 wherein:

the exothermic reactant material includes thermate.

4. The method of claim 1 wherein:

the exothermic reactant material includes bromine trifluoride.

5. The method of claim 1 wherein:

the exothermic reactant includes a fused chemical reaction.

6. The method of claim 5 wherein:

the fused chemical reaction includes using ammonium chloride and sodium nitrate as the exothermic reactant material and an acid catalyst acts as an igniter to initiate the exothermic reaction.

7. The method of claim 1 wherein:

the subterranean well structure which is repaired includes one of leaking cemented annuli or tubing packer or weak tubing hanger, leaking or potentially leaking plugs including cement and mechanical plugs, abandoned and unwanted perforations, high pressure intervals which are to be temporarily or permanently isolated, and gravel-packed production intervals which are to be shut-off from water influx.

8. The method of claim 1 wherein:

the meltable repair material is a solder.

9. The method of claim 1 wherein:

the meltable repair material is a eutectic metal.

10. The method of claim 1 wherein:

the meltable repair material is a eutectic metal which expands upon cooling and solidifying.

11. The method of claim 1 wherein:

the meltable repair material and the exothermic material are introduced within a single repair tool.

12. The method of claim 1 wherein;

the meltable repair material and the exothermic material are introduced sequentially proximate the structure to be repaired.

13. A repair tool for effecting a fluid seal in a subterranean well structure having a fluid seal defect, the repair tool comprising:

a housing containing a meltable repair material and an exothermic reactant material proximate the meltable repair material;

wherein the housing may be introduced into a well and proximate a structure having a fluid seal defect and the exothermic reactant material may be ignited to melt the meltable repair material into a flowable molten mass which can be discharged from the housing to cool and solidify upon the structure to effect a fluid seal.

14. The repair tool of claim 13 wherein:

the meltable repair material includes at least one of a eutectic metal, a solder, a brazing material and a flux material to promote or increase adhesion.

15. The repair tool of claim 13 wherein:

the meltable repair material is eutectic metal which expands upon cooling and solidifiying from a molten state.

16. The repair tool of claim 13 wherein:

the exothermic reactant material is thermite.

17. The repair tool of claim 13 wherein:

the exothermic reactant material is thermate.

18. The repair tool of claim 13 wherein:

the exothermic reactant material includes ammonium chloride and sodium nitrite.

19. The repair tool of claim 13 wherein:

the housing includes a dump bailer and petal basket.

20. The repair tool of claim 13 further comprising:

an igniter to ignite the exothermic reactant material.

21. The repair tool of claim 13 wherein:

the exothermic reactant material includes an oxidizing agent and the repair meltable material includes a meltable metal and a hydrocarbon-based fuel;

wherein the oxidizing agent and the hydrocarbon-based fuel may be combined and ignited to melt the meltable metal.

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