Sept. 28, 1965 T. O. ALLEN ETAL **3,208,530**

APPARATUS FOR SETTING BRIDGE PLUGS

Filed Sept. 14, 1964 2 Sheets-Sheet 1

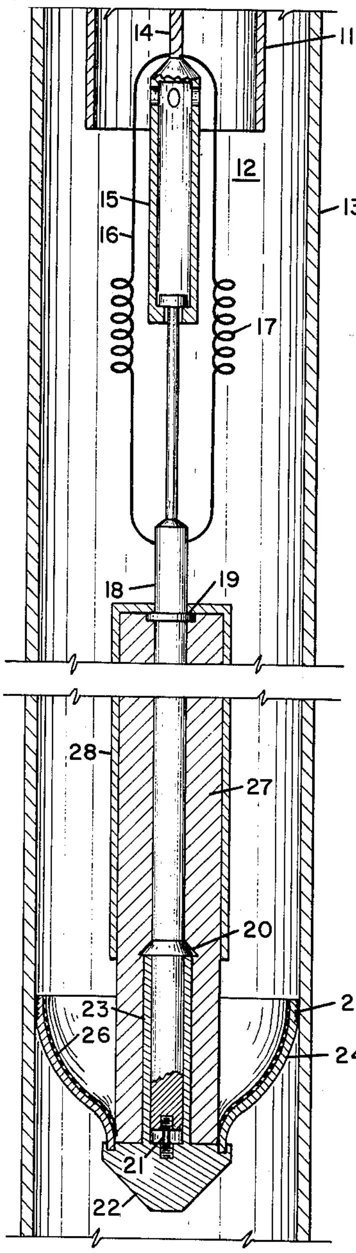

FIG. 1

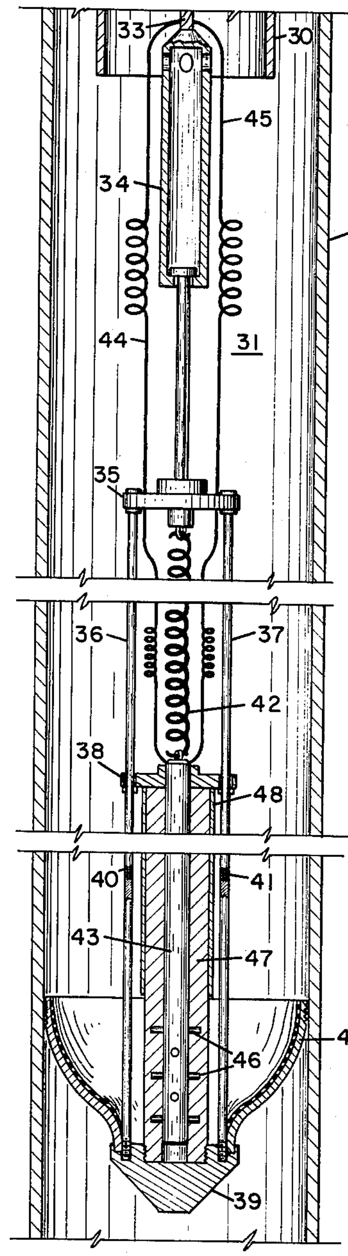

FIG. 2

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APPARATUS FOR SETTING BRIDGE PLUGS

Filed Sept. 14, 1964 2 Sheets-Sheet 2

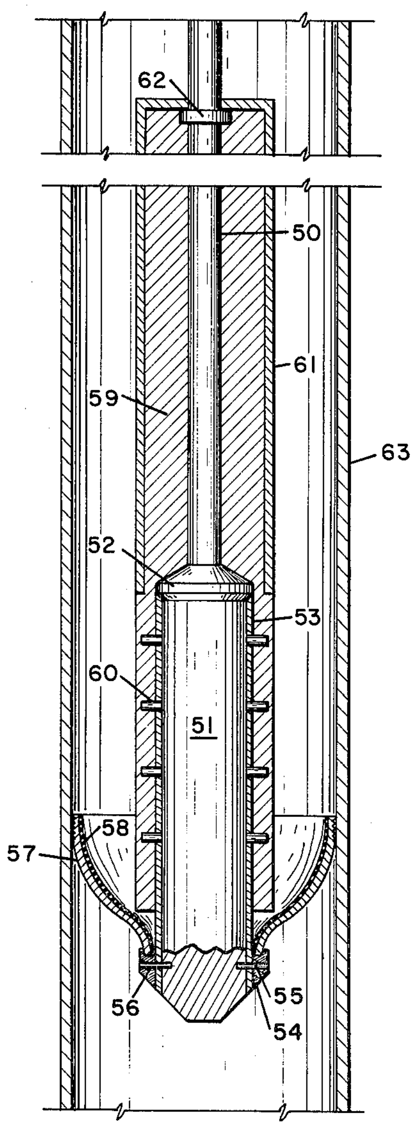

FIG. 3

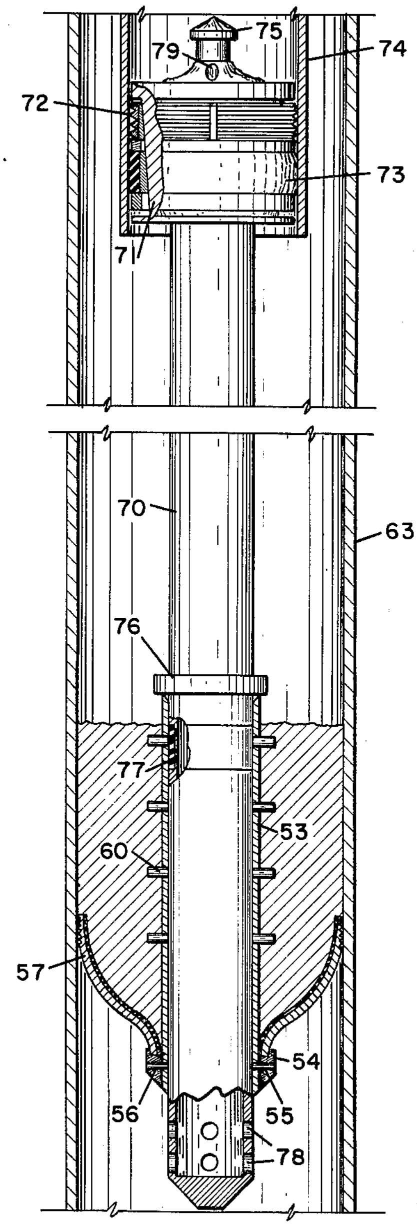

FIG. 4

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3,208,530

Patented Sept. 28, 1965

3,208,530

APPARATUS FOR SETTING BRIDGE PLUGS

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Filed Sept. 14, 1964, Ser. No. 396,335
14 Claims. (Cl. 166—60)

This application is a continuation-in-part of Serial No. 31,052, filed in the United State Patent Office on May 23, 1960 and now abandoned.

The present invention relates to apparatus useful in wells and similar boreholes and is particularly concerned with an improved assembly for setting a bridge plug below the tubing in a borehole.

Bridge plugs employed below the tubing in oil wells and similar boreholes are frequently installed by lowering an expansible basket through the tubing string, placing cement on top of the basket by means of a dump bailer and then letting the cement harden in place. The use of plugs of this type eliminates the necessity for pulling the tubing from the wellbore but has several disadvantages. Setting of the plug generally requires several hours because of the time required for the cement to harden. Fluctuations in pressure and the accumulation of fluids which may weaken the plug and cause it to fail must be avoided. An adequate bond between the cement and surrounding casing may not be obtained unless the plug is several feet thick, even though the pressure and fluid level are carefully controlled. This generally hampers the setting of the plugs between closely spaced producing zones and may present problems when access to the lower section of the borehole becomes necessary. Because of these and related difficulties, mechanical bridge plugs which require removal of the tubing from the wellbore are widely used.

The present invention provides an improved means for setting bridge plugs below the tubing in oil wells and similar boreholes which avoids many of the difficulties encountered in the past. The apparatus of the invention includes an elongated heating element and basket assembly containing an alloy or thermoplastic material which can be lowered into place without removing the tubing from the borehole. Upon activation of the heating element from the surface, the alloy or thermoplastic material melts, flows into the basket, and solidifies to form an impermeable plug. Means for retrieving the heating element are provided. Tests have shown that this apparatus permits the rapid installation of bridge plugs below the tubing, that relatively short plugs formed in this manner are capable of withstanding high differential pressures, and that such plugs can be readily drilled out or otherwise removed in the event that access to the lower portion of the borehole becomes necessary.

The nature and objects of the invention can best be understood by referring to the following detailed description of several embodiments of the apparatus and to the accompanying drawing, in which:

FIGURE 1 is a vertical section through a wellbore in which the apparatus of the invention has been lowered in place for the installation of a bridge plug;

FIGURE 2 is a vertical section through a wellbore showing an alternate embodiment of the apparatus;

FIGURE 3 is a vertical section through a wellbore illustrating a further embodiment of the apparatus for forming an annular plug; and

FIGURE 4 is a vertical section through the wellbore of FIGURE 3 following installation of the plug.

The apparatus shown in FIGURE 1 of the drawing includes a string of tubing **11** positioned in the upper part of a well or borehole **12** containing casing **13**. An electrical cable **14** connected to a suitable power source located on the earth's surface extends downwardly through the tubing into the lower part of the borehole. The cable is preferably an armored, self-supporting cable containing internal conductors but an insulated two-conductor cable supported by a separate wire line may be employed if desired. The lower end of the self-supporting portion of the cable is attached to a bumper jar **15**. The bumper jar, represented schematically in the drawing, includes an upper member and a lower member with respect to which the upper member may be moved to permit the application of impact forces to the apparatus below the jar. Any of a variety of conventional bumper jars available commercially may be employed. Insulated conductors **16** and **17** extend downwardly outside the bumper jar to provide the slack required for movement of the jar. A heavy sinker bar may be employed in lieu of a bumper jar if desired.

An elongated electrical heater **18** is connected to the lower end of the bumper jar or sinker bar and is energized by means of insulated conductors **16** and **17**. Cartridge type heaters having an outside diameter of an inch or less are available commercially from a number of manufacturers and are suitable for purposes of the invention. The power output of the heater selected will depend somewhat upon the melting point of the alloy or thermoplastic material with which it is to be used. A 4600 watt heater is adequate for use with a 350° F. melting point alloy in setting bridge plugs in 5½ inch diameter casing. Where the apparatus is intended for use in casing of larger diameter or the heat requirements are more severe for other reasons, a heavier duty heater may be more satisfactory. Generally speaking, a heater rated at from about 4 to about 10 kilowatts will be employed.

An upper collar **19** and a lower collar **20** are provided on the outer surface of the heater. These collars may be integral parts of the heater or may be bonded or otherwise held in place on the surface of the unit. A shear pin or similar member **21** designed to fail under low tensile stress is threaded into the lower end of the heating element. The lower end of the shear pin is similarly connected to hub **22** within elongated collar **23**. The elongated collar extends upwardly about the lower end of the heating element below lower collar **20**. The lower collar seats upon the upper rim of the hub collar as shown. The hub and associated parts are preferably made of brass, aluminum or a similar soft metal so that they can be readily destroyed with a bit or milling tool in the event that it becomes necessary to remove the bridge plug from the borehole. The metal selected should have a melting point well above that of the alloy or thermoplastic material utilized.

Basket ribs or expansible members **24** are attached to the upper part of the hub near the outer surface thereof and extend upwardly about the apparatus. The ribs will normally be constructed of spring steel or a similar resilient metal so that they can be compressed to permit passage of the apparatus through the tubing and will move outwardly and contact the borehole wall after the tool emerges from the lower end of the tubing. Gripping teeth **25** are preferably provided at the outer end of the ribs as shown. The teeth engage the surrounding casing or borehole wall after the basket has expanded and the plug has been formed and assist in preventing movement of the plug under high differential pressures. A basket liner **26**, made of canvas, asbestos fabric or the like, is riveted to or sewn around the ribs so that it will extend over the annular space between the hub and surrounding borehole wall or casing as shown. It is not essential that the liner fit tightly against the surrounding casing or wall. Any molten alloy or thermoplastic material which passes between the edge of the liner and casing quickly solidifies in contact with the casing below the liner and thus assists in forming a fluid-tight seal. Connate fluids normally present in the wellbore adjacent the basket limit the temperature and prevent damage to the liner fabric during the placement of the plug. A basket having metal petals which overlap in the extended position may be utilized in lieu of the fabric lined basket shown. A basket provided with ribs constructed of bimetallic strips which expand outwardly with an increase in temperature can also be used if desired. The materials employed in the bimetallic strips should be selected so that full expansion can be obtained by heating the strips to a temperature below the melting point of the alloy or thermoplastic material utilized.

Fusible element **27** composed of a low melting point alloy or thermoplastic material is supported on the outer surface of the heater and hub collar above the basket in the apparatus in FIGURE 1. The alloy or thermoplastic material employed is preferably precast or pressed into one or more hollow cylinders which can be slipped in place over the heater and basket hub as the apparatus is assembled. Alternatively, the material may be cast around the heater and hub collar in order to strengthen the assembly and help support the basket as the apparatus is lowered into the borehole. This latter procedure permits the use of a bolt or shear pin **21** which will fail readily under very light impact loads after the fusible element has melted. The size of the fusible element utilized will depend upon the diameter of the tubing through which the apparatus must pass and the size of the bridge plug to be formed. A plug from 6 to 12 inches in length is generally sufficient to withstand the pressures up to about 1500 lbs. per square inch. A somewhat longer plug may be required where higher differential pressures may be encountered and is generally preferred. The amount of fusible material required for a particular application can readily be calculated.

A variety of metals and metal alloys which melt at temperatures between about 150° F. and about 700° F. may be utilized in the fusible element. Suitable materials and their melting points include (a) 50% bismuth, 25% lead, 12.5% tin, 12.5% cadmium—150° F.; (b) 50% bismuth, 25% lead, 13% tin, 10% cadmium—158° F.; (c) 80% mercury, 20% bismuth—194° F.; (d) 53% bismuth, 32% lead, 15% tin—204° F.; (e) 45% bismuth, 17% tin, 30% lead, 8% mercury—217° F.; (f) 54% bismuth, 26% tin, 20% cadmium—232° F.; (g) 67% tin, 33% lead—356° F.; (h) 50% tin, 50% lead—432° F.; (i) 85% lead, 15% antimony—482° F.; (j) 90% tin, 10% antimony—491° F.; (k) 67% lead, 33% tin—527° F.; (l) 94% lead, 6% antimony—572° F.; (m) 80% tin, 20% antimony—608° F.; (n) 100% lead—621° F.; and the like. It will be understood that all of these metallic compositions are not equally effective for purposes of the invention and that the selection of a particular composition will depend to some extent upon the particular conditions under which the apparatus is to be utilized. In general, the materials selected should have a melting point below the boiling point of connate water at the depth at which the bridge plug is to be set. The use of alloys which melt at temperatures within the range between about 150° F. and about 350° F. and have heat capacities between about 0.03 and about 0.15 gram calories per gram within the temperature range over which they must be heated is preferred.

In addition to the metallic compositions described above, thermoplastic resins and polymers which melt at temperatures within the range between about 150° F. and about 700° F. may be utilized as the fusible material in the apparatus of the invention. Suitable materials include cellulose acetate, vinylidene chloride and methyl methacrylate polymers. These materials are not seriously affected by long contact with subsurface fluids, can be melted at relatively low temperatures, and can thereafter be solidified to form a hard impervious mass. Other thermoplastic materials having similar properties, particularly those melting at temperatures between about 150° F. and about 350° F., may also be employed.

The upper portion of the heater and fusible element are encased in or coated with an insulated jacket **28** as shown in FIGURE 1 of the drawing. This jacket, which may be made of asbestos paper, molded diatomaceous earth, insulating cement or a similar material of low thermal conductivity, reduces heat losses from the heating element and surrounding fusible material to connate fluids normally present in the wellbore. This reduces the amount of heat which must be supplied by the heating element, facilitates the use of fusible materials having higher melting points than might otherwise be feasible, and reduces the time required for installation of the bridge in the presence of connate fluids which tend to accelerate heat losses by conduction and convection. The jacket will normally rest on upper collar **19** on heater as shown but may be attached by other means if desired. The apparatus shown in FIGURE 1 of the drawing is utilized by first lowering the assembly through the tubing to the point in the wellbore where the bridge pug is to be installed. Although the assembly will generally move downwardly through the tubing without difficulty if a sufficiently heavy sinker bar is employed, impact forces may be applied to the apparatus by raising and lowering the supporting cables to actuate bumper jar **15** if necessary. The ribs extend outwardly as the apparatus emerges from the lower end of the tubing and bear against the borehole wall or surrounding casing as shown. The empty basket can generally be moved below the tubing without difficulty but in cases where gripper teeth **25** tend to impede further movement the bumper jar can again be used. After the desired location in the wellbore has been reached, the electrical heater **18** is energized from the earth's surface. The heat thus generated is transmitted into the alloy or other fusible material surrounding the heating element. Much of the heat which would otherwise be lost to the connate fluids surrounding the apparatus is retained by insulating jacket **28** and hence the alloy or other material melts rapidly. The molten material formed initially as the temperature of the heater decreases generally solidifies in the basket in the form of discrete particles. Eventually, however, a point is reached where a temperature sufficient to assure the formation of a solid, impermeable plug is reached. Melting of the fusible material continues until substantially all of the fusible material has been deposited in the basket around the hub collar. Any material which tends to escape around the basket will solidify in contact with the borehole wall or casing and thus provide a better seal. The lateral force exerted by the material in the basket tends to force the gripper teeth at the outer ends of the ribs into the wall or casing and thus further prevent movement of the apparatus.

After sufficient time for complete melting of the alloy or other fusible material has elapsed, the current to the heater is shut off at the earth's surface and the plug is allowed to cool. Cooling takes place rapidly because of the relatively low heat capacity of the alloy or other material employed. Solidification of molten material results in the formation of a strong impermeable plug which is securely bonded to the surrounding borehole wall or casing. Since the hub collar extends above the level of the solidified material, the heating element can be disengaged from the plug without difficulty. The weak tension link formed by bolt, shear pin or similar device **21** can be easily broken by pulling upwardly on the cable **14** or by applying an impact in an upward direction by means of the bumper jar. The insulating jacket will normally remain on the heater and can thus be withdrawn from the wellbore. The finished plug will normally extend upwardly a considerable distance above the basket ribs to provide a secure bond with the surrounding casing or borehole wall. In the event that access to the lower part of the wellbore is required at a later date, the plug can be drilled through rapidly with a conventional drill bit or milling tool. The overall length of the plug is short and hence such plugs are particularly useful for plugging back between thin subsurface zones.

FIGURE 2 of the drawing illustrates an alternate embodiment of the invention including means for automatically withdrawing the heating element from the fusible material before it solidifies. The apparatus shown is positioned below tubing 30 in wellbore 31 containing casing 32. The assembly depicted includes a supporting cable 33 to which bumper jar 34 is connected. An upper supporting member 35 is attached to the lower end of the bumper jar. Parallel rods 36 and 37 are connected to the outer ends of the upper supporting member and extend downwardly through holes in the outer ends of lower supporting members 38 to hub 39. The rods are made in two sections connected by weak links or shear pins 40 and 41. The lower supporting member, free to move up and down on the rods, is connected to upper member 35 by means of tension spring 42 and elongated electrical heating element 43. The lower supporting member is fixed on the upper end of the heating element which is in turn connected to the lower end of the tension spring. Insulated conductors 44 and 45 extend from cable 33 to the heating element and are coiled to supply the slack required to permit relative motion between the various parts of the apparatus. The lower end of the heating element is provided with barbs or lateral projections 46. A low melting alloy or thermoplastic material is cast or otherwise formed about the heating element and threaded into the hub below it. The barbs prevent movement of the heating element with respect to the hub until the alloy or thermoplastic material has melted. Heat shield 48 is positioned on the outer surface of the upper part of the fusible element 47. A basket 49 is mounted on the hub and extends upwardly around the fusible element to a point near the lower end of the heat shield.

The apparatus shown in FIGURE 2 of the drawing is utilized in a manner similar to that in which the apparatus of FIGURE 1 is employed. The assembly is first lowered in the borehole to a point below the lower end of the tubing where the installation of a bridge plug is required. As the apparatus emerges from the tubing, the basket extends outwardly and contacts the surrounding casing or borehole wall as shown. The bumper jar may be employed to force the apparatus downwardly if necessary.

After the apparatus has been placed in the desired position, the heating element is energized from the surface. The heat generated causes the alloy or thermoplastic material to melt and flow into the basket. Melting of the material at the lower end of fusible element 47 releases the heater and associated members and permits their movement upwardly into a position a short distance above the upper limit of the bridge plug. Any fusible material which may have been retained on the heater continues to melt and drops downwardly into the basket. A switch for deenergizing the heater in response to movement of the lower supporting member upwardly on the rods may be provided if desired. The molten alloy will fill the wellbore above the basket to a point just below weak links or shear pins 40 and 41. After sufficient time for complete solidification of the fusible material has elapsed, the upper part of the assembly is disengaged at the weak links or shear pins by pulling upwardly on the cable. The bumper jar may be employed to create a sharp upward force if necessary. The disengaged apparatus is then withdrawn from the borehole, leaving the finished bridge plug in place.

Still another embodiment of the invention is shown in FIGURES 3 and 4 of the drawing. This apparatus permits the formation of an annular plug or packer in a wellbore below a string of tubing. The upper part of the apparatus of FIGURE 3 may be similar to that of the assembly shown in FIGURE 1 and therefore does not need to be illustrated. The electrical heater employed in this embodiment includes an upper unit 50 and a lower unit 51 of larger diameter. A lower collar 52 between the two units is tapered to seat against the upper end of a sleeve 53 into which the lower unit extends. Hub 54 is bonded or otherwise connected to the lower end of the sleeve and contains holes through which shear pins 55 and 56 extend into the lower end of the heater. The hub is preferably made of an alloy having a melting point above that of the material employed in the fusible element but below the maximum operating temperature of the heating element. Alloys melting between about 450° F. and about 900° F. are generally preferred. A basket including ribs 57 and a liner 58 is attached to the hub and extends upwardly about the apparatus as in the earlier embodiments. Fusible element 59 is cast about the outer surface of the heater and is held in place by pins 60 connected to the sleeve. A heat shield 61 of asbestos or the like surrounds the upper part of the fusible element adjacent upper heater unit 50. The shield is held in place by a collar 62 mounted on the outer surface of the upper part of the heater.

Operation of the apparatus of FIGURE 3 is similar to that of the assembly shown in FIGURE 1. After the apparatus has been lowered through the tubing in the upper part of the wellbore into the desired position, the heater is energized from the earth's surface. The heat produced melts the fusible materials surrounding the heater. The heat shield provided about the upper end of the element reduces the total heat required and alleviates difficulties which may otherwise be encountered due to convection and conduction in the connate fluids present in the wellbore. As the fusible material melts, it flows into the basket and fills the space between sleeve 53 and the surrounding casing 63. The heater is then shut off at the surface and the molten material is allowed to solidify. After sufficient time for complete solidification has occurred, the heater is removed by lifting up on the cable with sufficient force to shear pins 55 and 56. Once the pins have been sheared, the heater and heat shield can be removed, leaving an impermeable plug surrounding sleeve 53. The longitudinal opening through the sleeve permits the use of a wireline production tube for producing fluids from below the plug. FIGURE 4 of the drawing shows such a tube in place.

In the installation shown in FIGURE 4 of the drawing, production tube 70 has been lowered into place in the angular plug or packer formed as described above. The tube includes at its upper end a tapered head 71 surrounded by slips 72 and seal ring 73. The seal ring and slips engage the surrounding wellbore tubing 74 upon release of the setting tool. The setting tool, not shown, grasps spear 75 at the upper end of the device. This portion of the apparatus is of conventional design and will therefore be familiar to those skilled in the art. A collar 76 located below the end of the wellbore tubing seats against the upper end of sleeve 53 as shown. Seal ring 77 provides a fluid-tight closure between the production tube and surrounding sleeve. Perforations 78 at near the lower end of the production tube permit the entry of fluids into the tube. These fluids pass upwardly through the tube and into wellbore tubing 74 through openings 79 in the upper end of the device. This permits the production of fluids from below the annular plug without their entering into the annulus surrounding the tubing above the plug. An imperforate packer plug which can be lowered into place by means of a wireline may be employed where the zone below the annular plug is to be closed off entirely.

The apparatus show in FIGURES 3 and 4 of the drawing can be readily removed from the borehole if desired. The production tube is first withdrawn to the surface by means of a conventional wireline retrieval tool. A heating element is then lowered into sleeve **53** and energized. As the temperature surrounding the heating element increases, the fusible material in the basket melts. Heating is continued until a temperature sufficient to fuse hub **54** is obtained. At this point, the basket will collapse and the molten fusible material and basket parts will drop downwardly to the bottom of the wellbore. The apparatus of FIGURE 1 can be similarly constructed with a fusible or partially fusible basket hub to permit its removal without the necessity for drilling out or milling away the component parts.

Tests of appartus constructed in accordance with the invention have demonstrated that such apparatus can readily be used to install bridge plugs in wells and in boreholes and that such plugs are capable of withstanding high differential pressures. The equipment utilized in the tests generally resembled that depicted in the drawing. The alloy employed in the first of these tests was "Cerrobend" a 150°, melting point alloy of bismuth, lead, tin and cadmium. A tube constructed of this alloy was retained about the 4600-watt electrical heater 1 inch in outside diameter by a perforated collar attached to the lower end of the heater. The alloy tube had an outer diameter of 1¾ inches and was about 48 inches long. A basket having spring steel ribs and a canvas liner was connected to the apparatus below the heater. This assembly was lowered through 2 inch tubing into a section of 5½, 17 lb. casing containing water. The heater was then energized by means of an electrical cable connected to a suitable power source. Because of its low melting point and low heat capacity, the alloy quickly melted and dropped down into the basket at the lower end of the apparatus. The droplets formed initially solidified to form loosely connected particles. As the temperature below the heater increased and additional molten metal flowed into the basket, the interstices between the previously deposited particles were filled and an impermeable plug bridging the entire cross section of the casing was formed. After the heater had been turned off and the system had cooled, it was removed from the plug by pulling upwardly on the cable to shear the pin by means of which the lower end of the heater was held in place. Examination of the bridge plug thus formed showed that only a small amount of the molten alloy had flowed around the basket and solidified on its under side. The upper surface of the plug was smooth, indicating that the alloy had melted completely and flowed into the basket after the individual particles had been deposited intially. The finished plug was approximately 4 inches thick. Pressure tests of this plug showed that it was capable of withstanding differential pressures up to about 1500 lbs. per square inch. Similar results were obtained when an alloy having a melting point of 350° F. was used in place of the 150° F. melting point alloy. Plugs capable of withstanding higher pressures can be produced by using greater quantities of the metal or alloy to form plugs of greater thickness.

It will be understood that the apparatus of the invention is not limited to the specific embodiment depicted in the drawing. In place of an electrical heater as shown, an elongated heating element containing a mixture of aluminum dust and iron oxide or a similar solid-fuel oxidizer may be used. The fuel can be ignited by means of a resistance coil energized from the earth's surface to provide the heat necessary to melt the alloy or other metal and permit it to flow downwardly into the basket. This and similar modifications will be readily apparent to those skilled in the art.

What is claimed is:

1. Apparatus for forming a bridge plug in a wellbore containing a string of tubing which comprises:

(a) an elongated heating element;

(b) means for lowering said heating element into said wellbore through said tubing at the end of a cable and energizing said element from the earth's surface;

(c) a basket supported at the lower end of said heating element, said basket including expansible members capable of passing through said tubing and expanding outwardly in contact with the surrounding wellbore wall;

(d) a fusible material having a melting point between about 150° F. and about 700° F. supported adjacent said heating element above said basket, said fusible material being present in sufficient quantity to fill said basket and form an impermeable plug above the basket after said material has melted and dropped into the basket; and,

(e) means for disconnecting said heating element from said basket within said wellbore after said impermeable plug has been formed.

2. Apparatus as defined by claim **1** including an insulating jacket surrounding the upper part of said heating element and said fusible material, said jacket permitting the flow of molten metal into said basket below said heating element.

3. Apparatus as defined by claim **1** wherein said basket includes a sleeve extending upwardly about the lower end of said heating element, said heating element being retained within said sleeve by means of a member designed to fail under an upward force applied to said heating element.

4. Apparatus as defined by claim **1** wherein said fusible material is secured to said basket and to said heating element, said apparatus including means for forcing said heating element in an upward direction with respect to said basket after said fusible material has melted.

5. Apparatus as defined by claim **1** wherein said basket includes an annular hub through which the lower end of said heating element extends.

6. Apparatus for forming a bridge plug in a wellbore below a string of tubing which comprises:

(a) an elongated electrical heating element;

(b) an expansible basket connected to the lower end of said heating element, said basket including a sleeve extending upwardly about the lower end of said heating element for isolating the heating element from material retained in said basket;

(c) a fusible material having a melting point between about 150° F. and about 700° F. supported on said sleeve and the upper part of said heating element, said fusible material being present in sufficient quantity to fill said basket and form an impermeable plug above the basket after said material has melted and dropped into the basket and the diameter of said heater, basket and fusible material being less than the diameter of said tubing;

(d) meanis for lowering said heating element, basket and fusible material into the borehole through said tubing and energizing said heating element from the earth's surface; and

(e) means for disengaging and withdrawing said heating element from said sleeve after the bridge plug has been formed.

7. Apparatus as defined by claim **6** wherein said basket includes ribs formed from bimetallic strips which expand outwardly as said strips are heated.

8. Apparatus for forming a bridge plug in a wellbore below a string of tubing which comprises:

(a) an elongated electrical heating element;

(b) an expansible basket connected to the lower end of said heating element, said basket including expansible ribs capable of passing through the tubing in said wellbore and moving outwardly into contact with the surrounding wellbore wall;

(c) an elongated fusible member mounted on said heating element above said basket, said fusible member consisting of a fusible material having a melting point between about 150° F. and about 700° F.;

(d) an insulating jacket surrounding the upper part of said fusible member above said basket, the outer

diameter of said jacket being less than the inner diameter of the tubing in said wellbore;
(e) means for lowering said heating element, basket, fusible member and insulating jacket into the wellbore through the tubing and energizing said heating element from the earth's surface; and
(f) means for disconnecting said heating element from said basket after said fusible material has melted and dropped into the basket.

9. Apparatus as defined by claim **8** wherein said fusible material is an alloy having a melting point between about 150° F. and about 350° F.

10. Apparatus as defined by claim **8** wherein said fusible material is a thermoplastic polymer.

11. Apparatus for forming a bridge plug in a wellbore below a string of tubing which comprises:
(a) an upper supporting member;
(b) an elongated electrical heating element;
(c) a lower supporting member connected to said heating element near the upper end thereof, said lower supporting member including openings therein extending parallel to the longitudinal axis of said heating element;
(d) elongated rods connected to said upper supporting member and extending through said opening in said lower supporting member to a point near the lower end of said heating element, said rods including intermediate parts designed to fail under tension and the diameters of said rods being less than the diameters of said openings in said lower supporting member,
(e) means for forcing said lower supporting member and heating element upwardly with respect to said upper supporting member and rods;
(f) an expansible basket connected to said rods below said heating element;
(g) a fusible material having a melting point between about 150° F. and about 700° F. mounted on said heating element and connected to said basket, said fusible material being present in a quantity sufficient to fill said basket and form an impermeable plug when said material is melted and said fusible material holding said heating element in a downward position with respect to said basket, rods and upper supporting member; and

(h) means for lowering said apparatus through said tubing and energizing said heating element from the earth's surface.

12. Apparatus for forming a plug in a wellbore below a string of tubing which comprises:
(a) an elongated heating element;
(b) an expansible basket connected to the lower end of said heating element, said basket including an annular hub into which the lower end of said heating element extends and a sleeve extending upwardly about said heating element to isolate the heating element from material contained in said basket;
(c) a fusible member mounted on the outer surface of said sleeve and on said heating element above said sleeve, said fusible member being constructed of a material having a melting point between about 150° F. and about 700° F.;
(d) means for disconnecting and withdrawing said heating element from said sleeve within the wellbore; and
(e) means for lowering said heating element, basket, and fusible element through the tubing in said wellbore and energizing said heating element from the earth's surface.

13. Apparatus as defined by claim **12** wherein said hub is at least in part constructed of a material having a melting point above the melting point of said material in said fusible member but below the maximum operating temperature of said heating element.

14. Apparatus as defined by claim **13** including an insulating jacket surrounding said heating element above said sleeve.

References Cited by the Examiner

UNITED STATES PATENTS

1,866,522	7/32	Jackson et al.	166—25
2,286,075	6/42	Evans	166—58
2,298,129	10/42	Irons	166—25
2,363,259	11/44	Schlumberger	166—25
2,646,845	7/53	Schillinger	166—181
2,969,839	1/61	Greene	166—63

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