Dec. 23, 1941. N. JOHNSTON 2,267,683

USE OF FUSIBLE METALS IN DRILLING WELLS

Filed Jan. 10, 1939

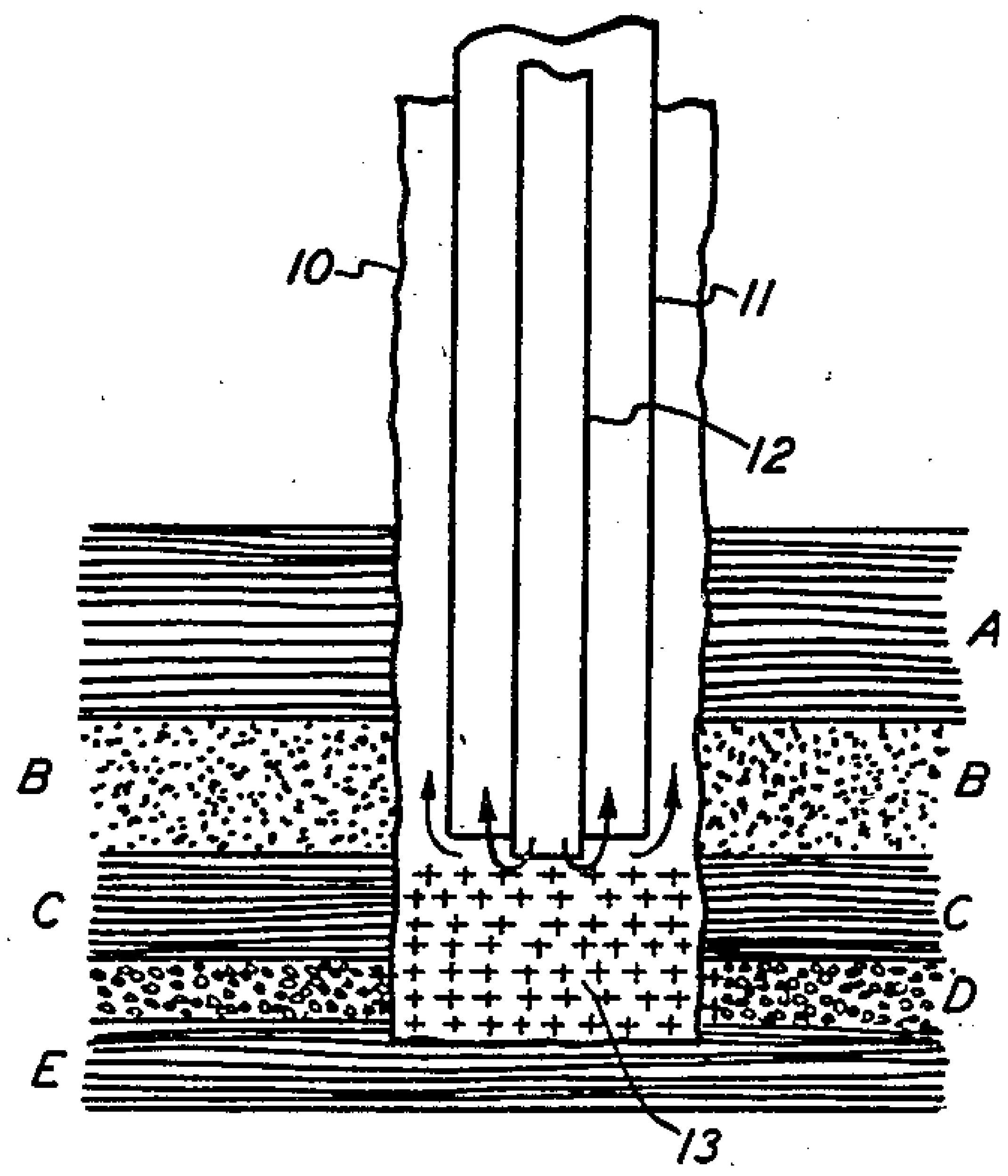

FIG. 1

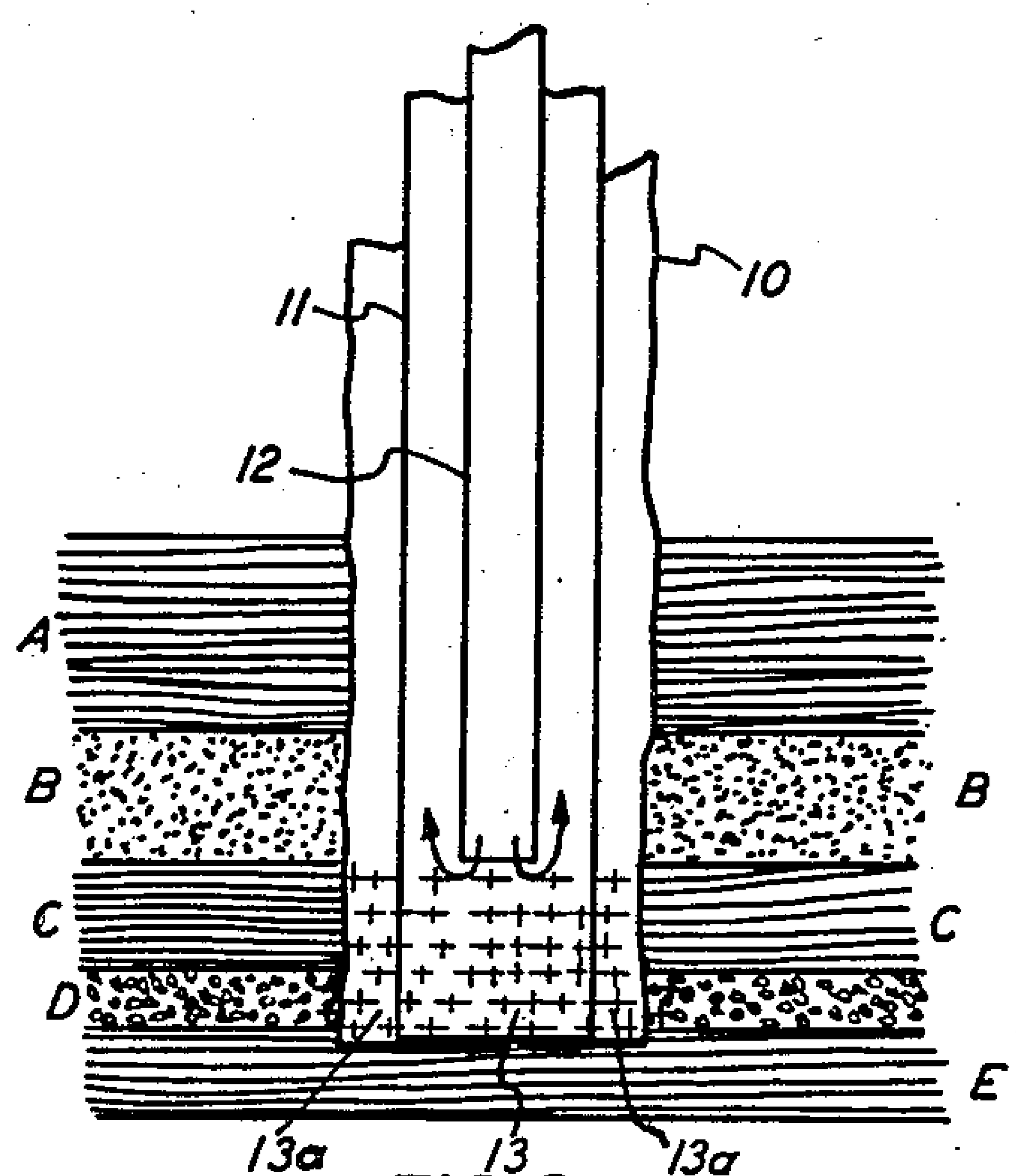

FIG. 2

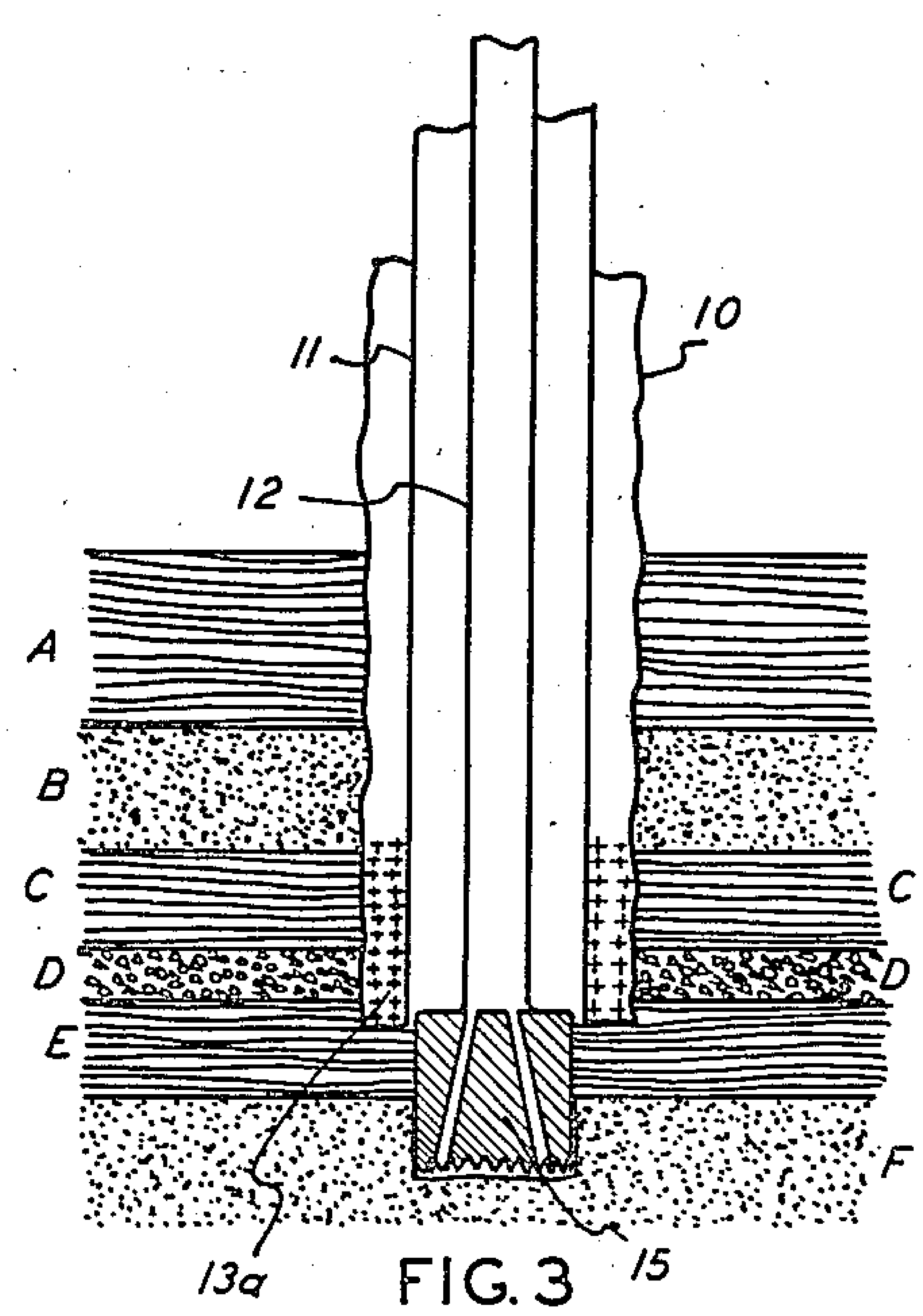

FIG. 3

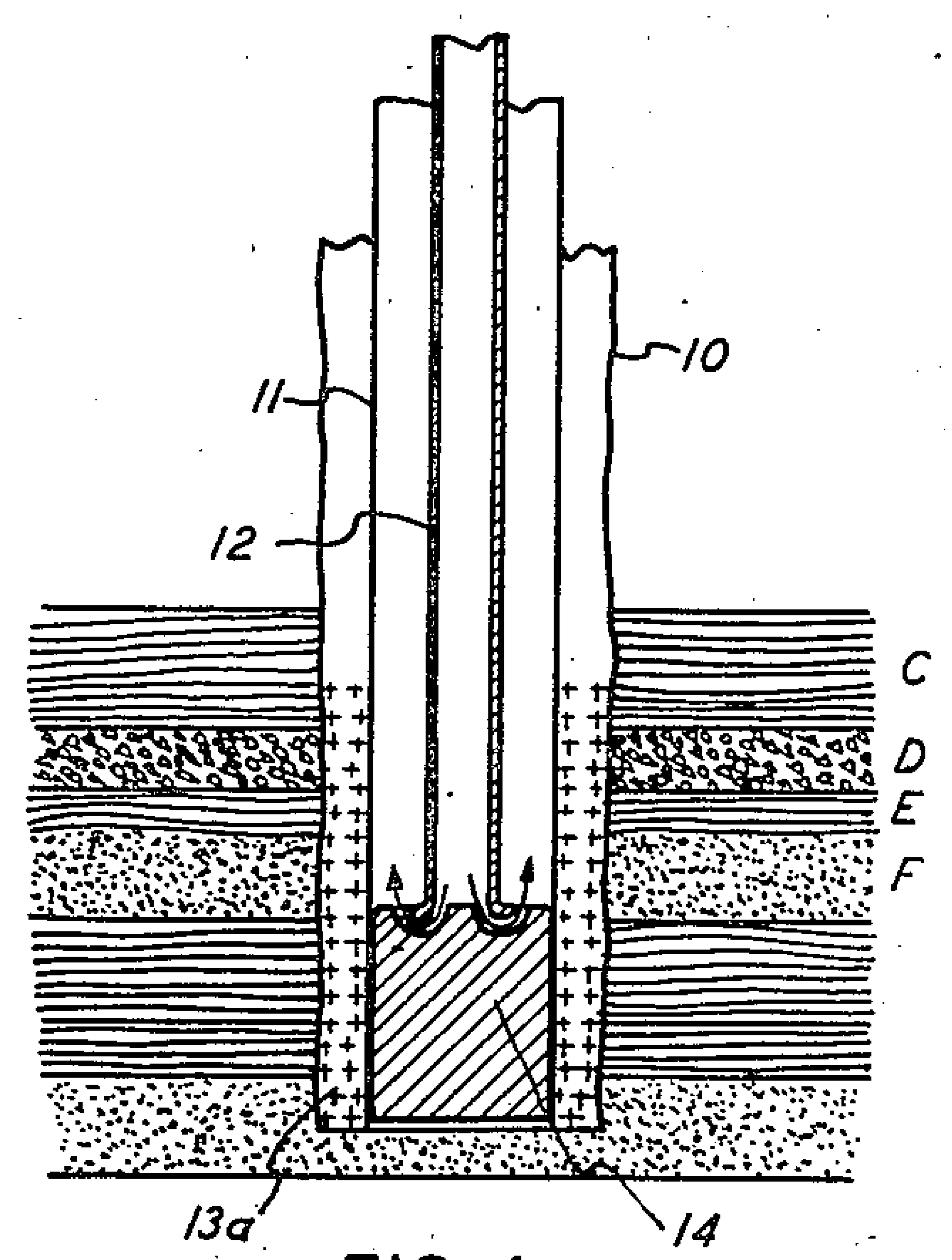

FIG. 4

NORRIS JOHNSTON
INVENTOR

ATTORNEY

Patented Dec. 23, 1941

2,267,683

UNITED STATES PATENT OFFICE

2,267,683

USE OF FUSIBLE METALS IN DRILLING WELLS

Norris Johnston, Alhambra, Calif., assignor to Socony-Vacuum Oil Company, Incorporated, New York, N. Y., a corporation of New York

Application January 10, 1939, Serial No. 250,174

7 Claims. (Cl. 166—21.1)

The present application is a continuation in part of my copending application Serial No. 210,842, filed May 31, 1938, and entitled "Method of coring to preserve fluid content."

The copending application discloses a method for taking cores during the drilling of a well which consists substantially in introducing a fusible metal into the well, raising the temperature of the circulating fluid to melt the metal and form a metallic pool in the bottom of the hole, taking a core from beneath the metallic pool, raising the core barrel to allow metal to flow into its lower end, solidifying the metal by lowering the temperature of the circulating fluid, and withdrawing the core barrel with its lower end plugged and sealed with solidified metal.

I have discovered that the general principle of the copending application may be utilized in other manners and for other purposes than those already disclosed.

For example, a fusible metal may be used for the recovery of small objects, such as bit rollers or roller bit pins, which may be lost in the hole and which are difficult to recover or drill up because they roll on the bottom of the hole. By solidifying a mass of molten metal around them, in the manner hereinafter described, such objects are maintained in a fixed position and may be milled out, or a hole may be drilled through the relatively soft metal block and the entire block, including the lost object, fished out of the well. Because the metal has, as a rule, a higher specific gravity than steel, the lost object will usually float to the surface of the molten metal and be imprisoned in the upper part of the block when the metal is solidified.

Another valuable use for the fusible metals is to effect a temporary water shut-off or the sealing of the wall of the well in cases where it is not desirable to effect a permanent sealing of the casing string into the formation, as with cement. In such cases a sufficient quantity of the metal is introduced into the well and brought to the molten condition by circulating hot fluid over its surface, the molten metal is brought to the proper position to cover the desired portion of the well wall, the metal is then solidified by circulating cold fluid over its surface, and the metal inside the casing, if any, is drilled out.

This procedure is diagrammatically illustrated in the attached drawing, in which Fig. 1 illustrates the formation of the pool of molten metal at the bottom of a hole; Fig. 2 shows the casing lowered into position before the metal solidifies; Fig. 3 shows the metal solidified and the metal inside the casing drilled out; and Fig. 4 illustrates the use of a packer for displacing the molten metal from inside the casing before it is chilled.

Referring first to Fig. 1, 10 is an earth bore passing through one or more impervious strata A, B, and C and through a porous stratum D, for instance a layer of water bearing gravel, and entering a lower impervious stratum E.

The first step is to raise the casing until its lower end is above the top of stratum D and preferably above the level to which it is desired to seal the wall of the well. A sufficient quantity of a metal of the proper melting point, as will later be described, to form a pool of the required depth, is then introduced into the well an any convenient manner, as by dropping in bars or blocks of the metal. The melting point of the metal, for this specific purpose, must be such that it will be solid at the normal temperature at the bottom of the well—which must first be accurately determined—and that it can be melted at a temperature not far above the bottom-hole temperature.

The well casing 11 and drill pipe 12 being now at more or less the positions shown in Fig. 1, the temperature of the circulating mud is raised above the melting point of the metal, as for instance by steam pipes immersed in the mud stream at the surface of the ground or by injecting direct steam into the mud stream. Circulation of the relatively hot mud is then continued until the temperature at the bottom of the hole is such as to melt the metal and to cause it to form the pool indicated at 13 in Fig. 1.

When this condition is reached, circulation is interrupted temporarily and the casing is lowered until it rests on the bottom of the hole, as shown in Fig. 2. The circulation, which initially was down the drill pipe and upwardly either inside or outside the inner casing string 11, now returns inside the casing. The drill pipe is retained in its original position, with its open end above the surface of the metal. After the lowering of the casing, circulation is resumed with mud at a temperature materially below the melting point of the metal, and continued until the metallic pool is solidified throughout. As a final step the metal remaining inside the casing is drilled out, as indicated in Fig. 3. All that is left of the metal is now a ring 13a between the casing and the wall of the well, by which stratum D and any leakage from higher strata are effectively sealed off.

Under some conditions it is possible to modify the above procedure and economize metal in the manner illustrated in Fig. 4, by displacing most of the molten metal from inside the casing by the use of a packer or plug. In this operation the pool of molten metal is formed as in Fig. 1 and the casing is lowered as in Fig. 2, until it almost but not quite touches the bottom of the hole. The packer or plug indicated at 14 in Fig. 4 is then run to the bottom of the hole, displacing the molten metal from inside the casing and forcing it upwardly outside the casing. The upper end of the packer must be provided with circulation openings for the cold fluid, and the lower end must be of such form and material that it will not be frozen in place by any solidified metal remaining inside the casing. This operation results in a considerable saving of the rather expensive fusible metal, but requires considerable more time than the method first described.

On account of the high surface tension of the molten metal it will not penetrate into fine textured formations nor to any considerable distance into even an open formation such as a water bearing gravel. It does, however, form a rigid annular layer or ring, reinforced inside by the casing and fitting into all the irregularities of the wall of the hole, by which a highly effective shut-off is produced. It is desirable to wash the wall of the hole to free it from thickened mud before applying the metal, though less rigorous cleaning is required than in the use of cement because the high specific gravity of the molten metal tends to squeeze out any mud adhering to the wall.

For the special purposes for which this process is designed, its advantage over the use of cement lies in the fact that the casing string may be freed at any desired later time without cutting the casing, provided, of course, that the string has not frozen in the formation itself. To remove the metallic seal it is necessary merely to reheat the well to a temperature above the melting point of the metal, which will cause it to flow down the space between the casing and the wall and permit its removal from the bottom of the well. Thus in case a number of thin water bearing strata are encountered it is possible to shut off repeatedly and in a minimum of time for each operation.

For some uses it is preferable to employ a metal which is molten at the normal bottom hole temperature. In such case the metal is solidified temporarily by circulating a relatively cold fluid instead of being melted by hot circulation.

It will also be obvious that the metal may be introduced in molten form, in the hot circulation or by lowering a superheated and insulated capsule containing it to the bottom of the well.

While the fusible metals are more costly than cement, they may in some cases be substituted to advantage for permanent "cementing" of casing to the wall of the well. The advantage in the use of metal lies in its high specific gravity, which tends to make it produce a sealing ring of equal height on all sides, thus completely surrounding the pipe and avoiding the channeling sometimes experienced in the use of cement.

In case the cementing operation is to be performed at a level above the well bottom, it will be obvious to use a packer to retain the metal at the proper level.

The choice of alloy melting point rests on the temperatures existing in the particular well to which the method is to be applied. For example, if the predetermined temperature at the bottom of the well is 150° Fahr. a metal having a melting point of say 160° Fahr. would be indicated. This metal would be melted with some rapidity by raising the temperature of the circulating fluid to about 185° Fahr. and would be solidified within a reasonable time by lowering the temperature of the circulating fluid to say 135° Fahr. Alloys ranging in melting point from 150° to 225° Fahr., in 5° steps, would probably cover the entire range of conditions likely to be encountered.

Alloys having definite melting points and sufficient mechanical strength to resist unbalanced hydraulic pressures are available over a wide temperature range. The compounding of fusible metals is a well known art and the manner of preparing an alloy having a melting point suitable for any specific purpose need not be described in detail. In general metals of this class are alloys of bismuth, lead, tin, cadmium, and antimony, and it is sufficient to say that the proportions of the five constituents, in the order named, would range from 50:27:13:10:0 for the lower melting point named above to 50:25:12:8:5 for the higher.

In the attached claims, the word "fusible" metal is used to denote a metal capable of being melted or maintained in the molten condition by contact with a heated aqueous fluid such as drilling mud, and more specifically, a metal having a melting point not substantially exceeding 250° Fahr.

I claim as my invention:

1. In the drilling of wells by a method involving the circulation of fluid within the well, the steps comprising: introducing into said well a "fusible" metal having a melting point below the normal temperature within said well, and temporarily solidifying said metal by circulating in heat interchange relation therewith an aqueous fluid previously cooled to a temperature below said melting point.

2. In the drilling of wells by a method involving the circulation of fluid within the well, the method of sealing the lower end of the well casing to the wall of the well which comprises: introducing into said well a "fusible" metal having a melting point above the normal temperature at the bottom of the well; maintaining said metal in the state of a molten pool at the bottom of the well by circulating within the well an aqueous fluid heated to a temperature above said melting point; setting said casing with its lower end substantially touching the bottom of the well; displacing at least part of the molten metal from within said casing into the annular space between said casing and the wall of the well, and solidifying said metal by circulating within the well a fluid having a temperature below said melting point.

3. In the drilling of wells by a method involving the circulation of fluid within the well, the steps comprising: introducing into said well a "fusible" metal; placing said metal in a liquid state at a point where a solid casting is desired; and changing said metal from the liquid state to the solid state by circulating in heat interchange relation therewith a fluid having a temperature below the melting point of said metal.

4. In the drilling of wells by a method involving the circulation of mud fluid within the well, the steps comprising: introducing into said well a "fusible" metal; placing said metal in a liquid state at a point where a solid casting is desired; and changing said metal from the liquid state to the solid state by circulating in heat interchange

relation therewith mud fluid having a temperature below the melting point of said metal.

5. In the drilling of wells by a method involving the circulation of mud fluid within the well, the steps comprising: introducing into said well a "fusible" metal having a melting point below the normal temperature within said well, and temporarily solidifying said metal by circulating in heat interchange relation therewith mud fluid previously cooled to a temperature below said melting point.

6. In the drilling of wells by a method involving the circulation of mud fluid within the well, the steps comprising: introducing into said well a "fusible" metal having a melting point above the normal temperature at the bottom of the well; bringing said metal to the state of a molten pool on the well bottom by circulating within the well mud fluid heated to a temperature above said melting point; and solidifying said metal by circulating within the well mud fluid having a temperature below said melting point.

7. In the drilling of wells by a method involving the circulation of mud fluid within the well, the method of sealing the lower end of the well casing to the wall of the well which comprises: introducing into said well a "fusible" metal having a melting point above the normal temperature at the bottom of the well; maintaining said metal in the state of a molten pool at the bottom of the well by circulating within the well mud fluid heated to a temperature above said melting point; setting said casing with its lower end substantially touching the bottom of the well; displacing at least part of the molten metal from within said casing into the annular space between said casing and the wall of the well; and solidifying said metal by circulating within the well mud fluid having a temperature below said melting point.

NORRIS JOHNSTON.