July 29, 1969 F. I. DORR, JR 3,458,643

GROUND CONNECTION AND METHOD OF MAKING THE SAME

Filed July 12, 1967 2 Sheets-Sheet 1

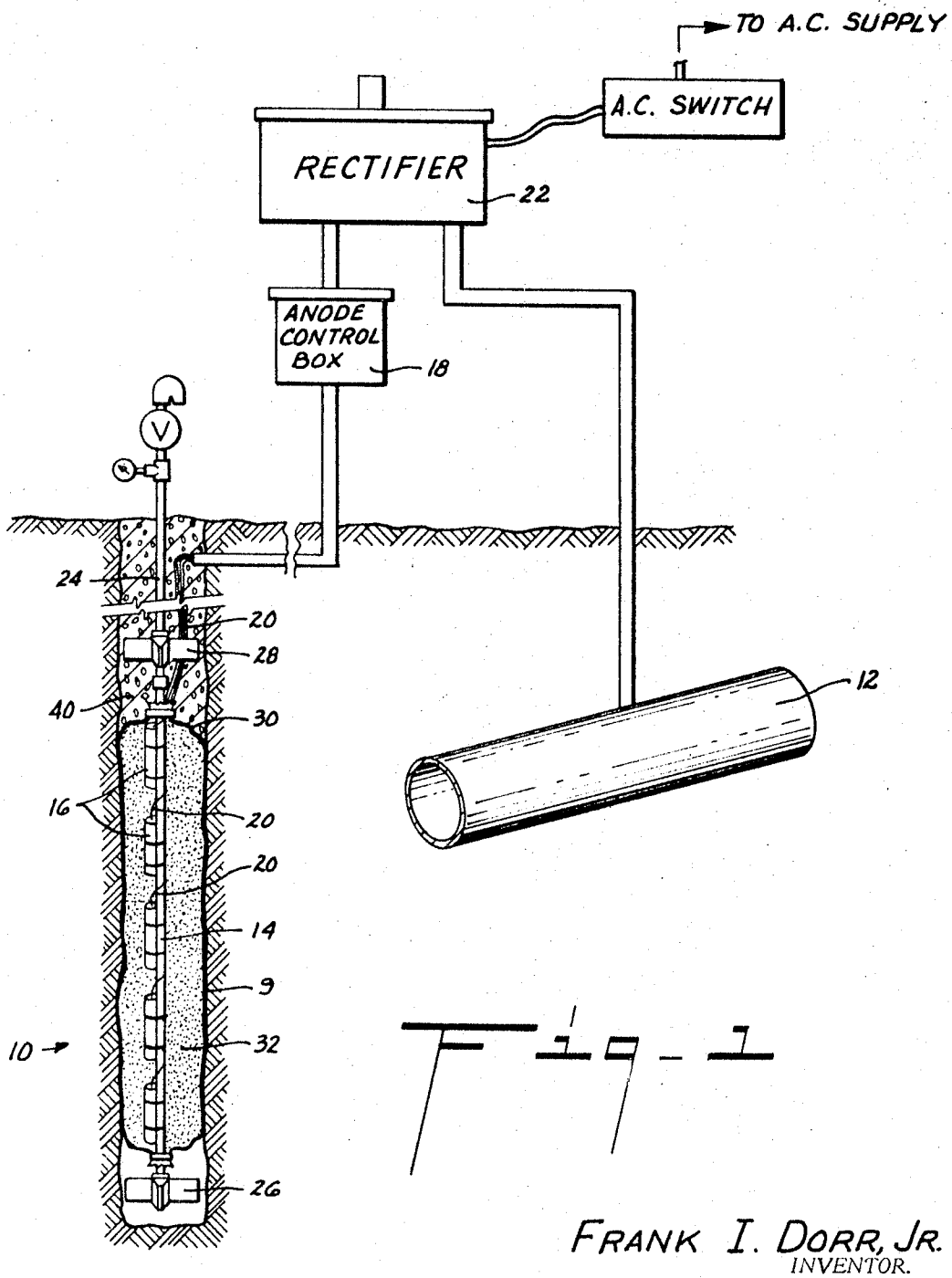


Fig. 1

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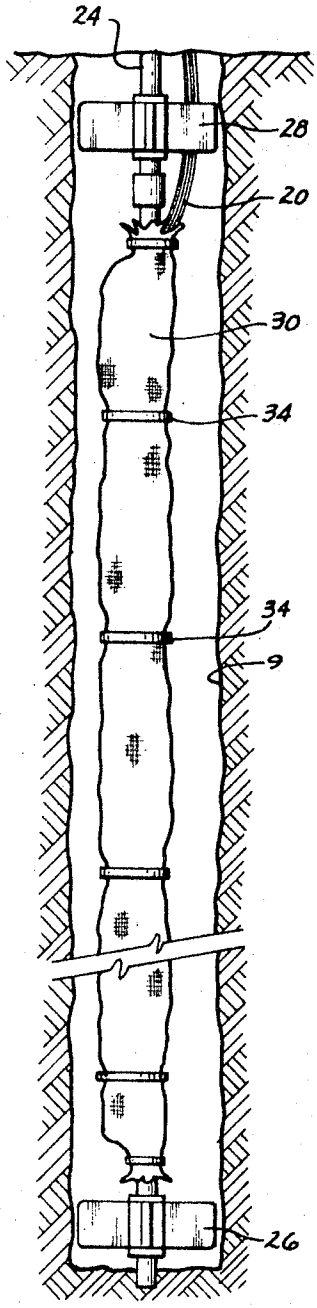


Fig. 2

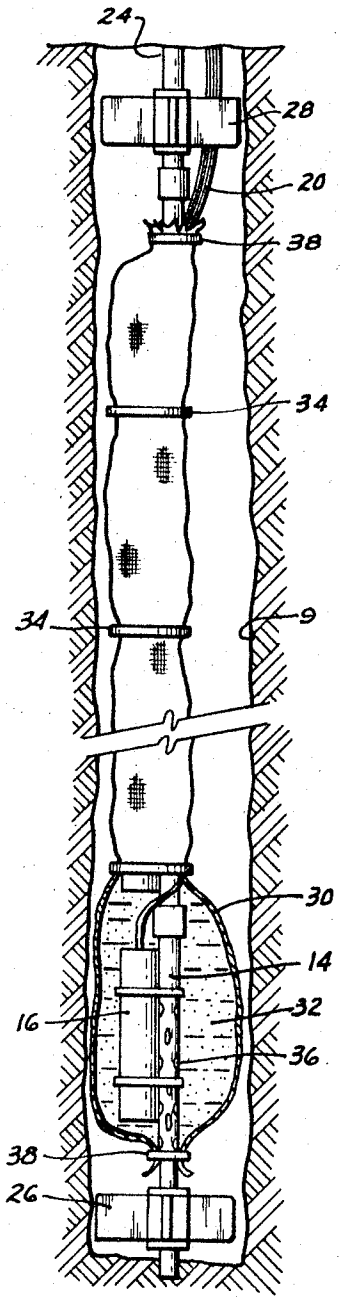


Fig. 3

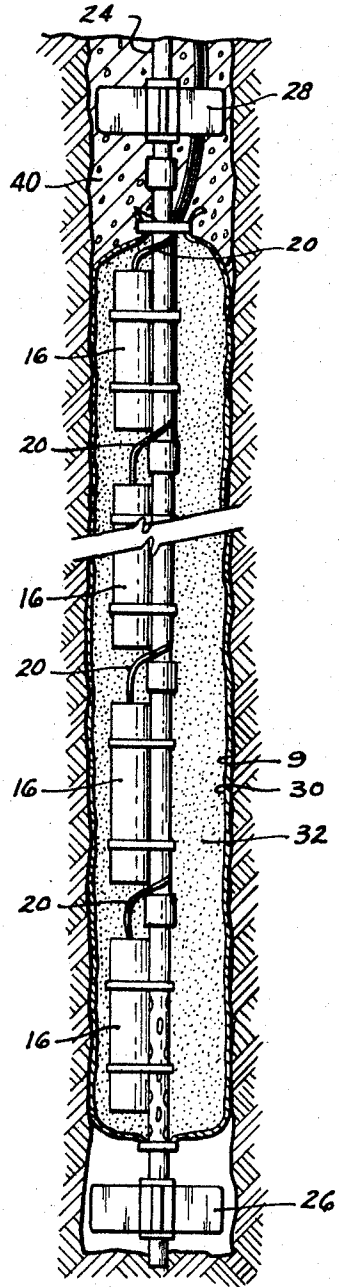


Fig. 4

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GROUND CONNECTION AND METHOD OF MAKING THE SAME

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ABSTRACT OF THE DISCLOSURE

A ground connection and a method of making it is described. The ground connection is located in a well bore and includes an elongated tubular mandrel to which is attached a plurality of electrodes. The electrodes are spaced apart along the mandrel. The electrodes and the portion of the mandrel to which they are attached are enclosed by a flexible, porous bag, which is filled with uncompacted electrically conductive particles, such as coal or metallurgical coke breeze. The bag holds the breeze in place in firm engagement with the walls of the well bore to provide an electrical connection of low resistance between the ground and the electrodes. To form the ground connection, the mandrel with the attached electrodes and porous flexible bag are lowered to the desired depth in a well bore on a pipe string. A slurry of the breeze and water is pumped down the pipe string and into the bag through an opening in the mandrel. The porosity of the bag is such that the liquid in the slurry will pass out of the bag through its walls, but the breeze material will be retained. Slurry is pumped into the bag until it is filled with breeze material and forced into firm engagement with the walls of the well bore. The pipe string to the surface is then opened to provide a gas vent for the connection.

This invention relates to ground connections, generally, and in particular, to ground connections located in a well bore well below the surface of the ground.

The ground connection of this invention can be used to ground any electrical system or equipment. It is particularly useful in forming an anode for use in an impressed current corrosion control system.

Usually, in this type system, a plurality of anodes are located in a line at increasing distances from the metallic facility the system is designed to protect. A current is impressed on the anodes and the metallic facility to render the metallic facility cathodic. This causes any corrosion that occurs because of the electrical current to consume the anodes rather than the metallic facility.

When installing these anodes in open country to protect a pipeline, there is no problem in locating them laterally away from the line to form the desired ground bed. These ground beds, as described above, may include five or six anodes spaced twenty feet apart or so in a line from the metallic facility which they are protecting. When a pipeline passes through a congested or developed area, however, such as a town or a city, the space for such ground beds is not available and the anodes for the system must be located in the right of way for the pipeline itself. It has been determined that such anodes can be located in a well bore, well below the surface of the ground, and greater protective coverage is obtained than previously with the surface type anode ground bed. Further, it was found that by placing the anodes well below ground level the current interference with surrounding unprotected structures was minimized.

Since desirably these anodes are located several hundred feet below the surface of the earth, many problems have arisen in connection with their installation and maintenance. Obviously, a low resistance, good electrical connection between the electrode of the anode and the ground is desirable. One method of obtaining this connection is to fill the annulus between the electrode and the wall of the well bore with an uncompacted electrically conductive material, such as coal or a metallurgical coke breeze. For an example of such an arrangement, see U.S. Patent No. 2,552,208, which issued May 8, 1951, and is entitled, "Grounding Device for Electrical Conductors."

When this back-fill of uncompacted electrically conductive solid particles, which shall hereafter be called "breeze" or "breeze material" for simplicity, is placed in the hole, there is no assurance that it will stay in place. Where a fissure exists in the wall of the hole, for example, the breeze can flow into the fissure. If ground water is present, it can carry off the breeze material, sometimes as fast as it can be added from the surface. Another problem is the gases generated in the breeze during the system's opertaion. If these gases are not vented, they will cause an increase in circuit resistance, which will utilmately render the installation inoperative, or economically impractical to operate at the higher voltages required to produce the current needed to supply adequate corrosion control to the metallic facility being protected.

Therefore, it is an object of this invention to provide an improved ground connection and method of forming such a ground connection wherein the breeze material employed to connect the electrode or electrodes of the connection to the ground is accurately located between the electrodes and the ground and is securely held in position during the life of the connection.

It is another object of this invention to provide a deep well ground connection and a method of forming the same which requires a minimum amount of breeze material to provide the connection between the electrodes of the connection and the ground.

It is an other object of this invention to provide a quick and efficient method of filling the annulus between the electrode of a ground connection and the wall of a well bore with breeze after the electrode is positioned on the well bore and for replenishing the supply of such material from time to time as it is consumed.

It is another object of this invention to provide a ground connection with a fill of breeze material between the electrodes of the connection and the ground in which the gases formed in the breeze material is quickly and adequately vented to the surface.

These and the other objects, advantages, and features of this invention will be apparent to those skilled in the art from this specification, attached drawings, and appended claims.

In accordance with this invention one or more electrodes are mounted on a mandrel and enclosed in a flexible, porous bag. This assembly is lowered into the well bore to the desired position and a slurry of the breeze material is pumped down through the mandrel and into the bag through an opening in the mandrel. The porosity of the bag is such that the liquid can freely escape therefrom, but the breeze material will be retained. This allows the bag to be filled with breeze material from the surface until the bag is forced outwardly into firm engagement with the walls of the well bore and the annular space between the electrodes and the walls of the well bore are completely filled with breeze material. The bag will hold the material in place so it cannot be carried away by ground water or pumped into fissures in the wall of the well bore, thereby allowing the annulus to be filled with a minimum amount of breeze material.

The preferred embodiment of the invention will now be described in connection with the attached drawings in which,

FIGURE 1 is a view in vertical section of the ground connection of this invention being employed as an anode

in an impressed current cathodic protection ground bed to protect an underground pipeline;

FIGURES 2, 3, and 4 are vertical cross sectional views through a well bore illustrating the method of forming the ground connection of this invention.

A ground connection, constructed and installed in accordance with this invention, is generally indicated by the number **10** in FIGURE 1. The ground connection is shown as part of an impressed current anode cathodic protection system being used to prevent corrosion of pipeline **12**.

The ground connection includes an elongated tubular mandrel **14** and electrodes **16**, which are spaced along and attached to the mandrel. The electrodes can be shaped in any desired way and made from any suitable material, such as metal or compacted carbon or graphite. The electrodes shown are cylindrically shaped. Each electrode is taped to the mandrel and connected to anode control box **18** at the surface through separate lead wires **20**. The anode control box is connected to rectifier **22**, which converts the AC supply current to DC current for the operation of the cathodic protection system.

Pipeline **12** is connected to the negative output termination of the rectifier so that it will be the cathode in this impressed current cathodic protection system.

Extending upwardly from the mandrel and connected thereto is pipe string **24**. This string extends to above the surface of the ground. Stabilizer **26** is connected to the lower end of mandrel **14** and stabilizer **28** is connected to the pipe string above the mandrel to hold the mandrel and the electrodes close to the center of well bore **9**.

Enclosing electrodes **16** and the portion of the mandrel to which the electrodes are attached is flexible porous bag **30**, which is filled with uncompacted electrically conductive material which we have referred to above as "breeze." One breeze material commonly used is an uncompacted, granulated carbon such as coal coke breeze. This material, indicated by the number **32**, fills flexible porous bag **30** and holds it in firm engagement with the walls of well bore **9**. This, in turn, insures firm contact between the breeze and the surrounding ground, thereby providing a low resistance electrical connection between the ground and electrodes **16**. In this type of system, the breeze material is consumed first.

The method of forming this ground connection is shown in FIGURES 2, 3, and 4. Well bore **9** is drilled to the desired depth and the electrode assembly, including mandrel **14** with attached electrodes **16** and flexible porous bag **30**, are connected to the end of pipe string **24** and lowered into position in the well bore. The porosity of bag **30** is such that liquid can freely pass out of the bag, but the uncompacted breeze material cannot. Such a bag consisting of woven nylon fibers may be purchased from the National Filter Company of Salt Lake City, Utah. Therefore, with this assembly in position, a slurry of the desired breeze material is pumped down pipe string **24** into bag **30**. The liquid phase of the slurry will pass out of the bag and the breeze will be retained. Slurry is pumped until the bag is filled with the breeze material, as shown in FIGURE 4.

Bag **30** is held around the electrodes and mandrel initially by rings **34**. These rings are designed so that they will hold the bag in close to the mandrel and the electrodes, as the electrode assembly is being positioned in the well bore, but will break under the pressure of the expanding bag when the slurry is being pumped into it. Nylon tape is one material which has been found to be satisfactory for this purpose. The upper and lower ends of the bag are held in sealing engagement with the mandrel by rings **38**. These rings are not designed to break when the bag is filled, but to maintain the seal between the bag and the mandrel throughout the life of the connection.

Preferably, the bag fills upwardly from the bottom. This can be accomplished by having rings **34** of varying strength so they will break only after the portion of the bag below them is substantially filled. Also, by locating most of openings **36** in the mandrel, through which the slurry enters the bag, adjacent the bottom of the bag, the bag will tend to fill from the bottom. Mandrel **14** is closed at the bottom, of course.

Thus, as shown in FIGURE 3, as the slurry initially enters the bottom of the bag, it will rupture lower retaining ring **34** and start to expand and fill the bag upwardly from the bottom. As the bag fills, rings **34** will be ruptured in succession until the bag is filled, as shown in FIGURE 4. Usually, pressure is held on the bag after it is filled for a short period of time to let the breeze material more or less become set in its position in the bag before the pressure is released. This also helps to dehydrate the breeze and to insure that the bag is full. After the pressure is released from the well pipe and mandrel, it is opened at the surface to provide a vent tube through which gases generated in the breeze material in the bag can escape to the surface. Also, additional filling material can be added to the bag from time to time as this material is consumed in the operation of the system.

After the ground connection has been formed in the manner described above, well bore **9** can be back filled with dirt or gravel **40**, as shown in FIGURE 4.

From the foregoing, it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus and method.

The invention having been described, what is claimed is:

1. A method of forming a ground connection comprising drilling a hole in the ground to the desired depth, lowering an electrode assembly with the electrode encased in a flexible porous bag into the well bore, the bag having a porosity such that the bag will retain most of the solids in a slurry of electrically conductive solid particles and a liquid, while allowing the liquid in the slurry to flow out of the bag through its wall, and pumping a slurry of liquid and electrically conductive solid particles into the bag to fill the bag with the particles and force it into firm engagement with the ground to electrically connect the electrode to the ground through the particles.

2. The method of claim **1** with the additional step of venting the bag to the surface after the bag is filled to allow any gases generated in the bag to escape therefrom.

3. A ground connection comprising an electrode assembly including an electrode located below the ground level in a well bore, a flexible porous bag enclosing the electrode, and particles of an uncompacted electrically conductive material filling the bag to hold the bag in firm engagement with the hole to establish an electrical connection of low resistance between the electrode and the ground thruogh the electrically conductive material filling the bag, said bag being filled with said conductive particles by pumping a liquid slurry of such particles into the bag under pressure with said bag having a porosity such that the liquid will flow out of the bag while the particles are retained in the bag.

4. The ground connection of claim **3** in which the electrode assembly includes a tubular mandrel upon which the electrode is mounted, said mandrel having a closed lower end and an opening located adjacent the electrode and within the porous bag to permit the slurry of liquid and electrically conductive material to be pumped down the mandrel into the bag through the opening.

5. The ground connection of claim **4** further provided with a pipe string that is connected to the tubular mandrel and extends to the surface through which the slurry can be pumped to fill the bag and through which gases can be vented from the bag after the bag is filled and placed into service.

6. A ground connector for installation in a well bore to provide a connection of low electrical resistance between a plurality of electrodes and the ground, said con-

nector comprising an elongated tubular mandrel adapted to be connected to a pipe string for lowering into a well bore, said mandrel having a lower opening through which material flowing downwardly through the mandrel may be discharged, a plurality of electrodes spaced longitudinally along the mandrel and attached to the mandrel to be carried thereby, means for connecting each electrode separately into an electrical circuit, and a flexible porous bag enclosing the electrodes, the portion of the mandrel to which they are attached and the lower opening in the mandrel, said bag having a porosity such that a slurry of liquid and electrically conductive particles can be pumped into the bag through the lower opening in the

mandrel and the bag will retain the conductive particles while allowing the liquid to pass out of the bag.

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U.S. Cl. X.R.

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