Sept. 14, 1965 W. B. STEWARD 3,206,537

ELECTRICALLY CONDUCTIVE CONDUIT

Filed Dec. 29, 1960

FIG.1.

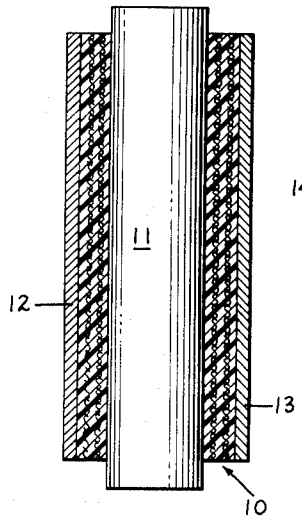


FIG.2.

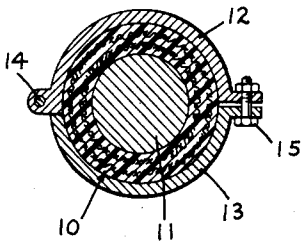


FIG.3.

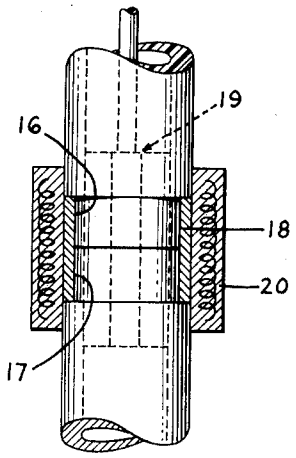


FIG.5.

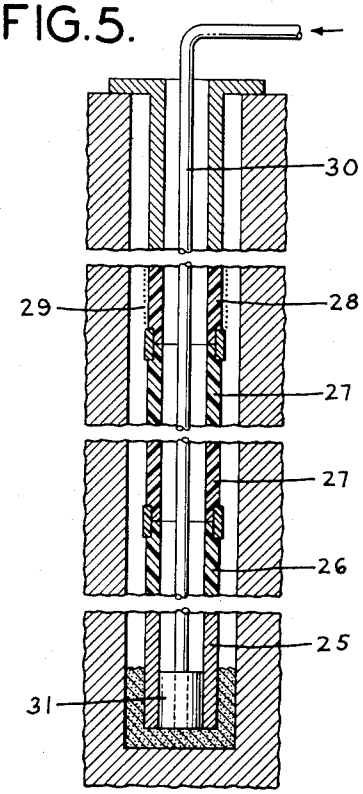
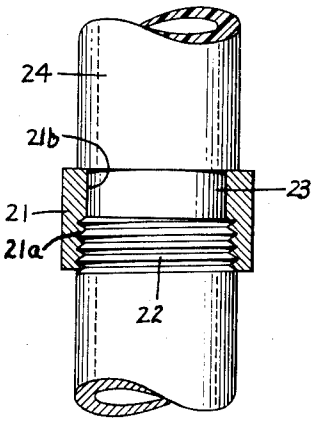


FIG.4.



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ELECTRICALLY CONDUCTIVE CONDUIT

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Filed Dec. 29, 1960, Ser. No. 79,245
5 Claims. (Cl. 174—47)

The present invention relates to conduit and more particularly to conduit having physical and electrical properties that make it particularly effective for casing wells drilled into the earth, although it is not limited to such use.

In petroleum engineering practice it is conventional, after a well has been drilled into the earth, to conduct a wide variety of tests in it for the purpose of ascertaining the nature of the surrounding earth formations. Such tests usually include the making of electrical logs which involve passing electric current into the formations and the measurement of electrical potentials in the well. Upon completion of these tests, the well is usually lined with a metal casing which serves to prevent the side walls from caving in and blocking the well. Once this casing has been set, it is no longer possible to conduct effective electrical logging operations in the well because the effects of the surrounding formations are masked by the short circuiting effect of the highly conductive well casing.

It is an object of the invention, accordingly, to provide new and improved conduit which has good physical properties and relatively low electrical conductivity.

A further object of the invention is to provide new and improved well casing which has the requisite physical properties to prevent a well from caving in and also has electrical properties enabling electrical logging operations to be carried out in the well after casing has been set therein.

These and other objects of the invention are attained by forming conduit out of fiber reinforced plastic material rendered electrically conductive to a desired degree by the incorporation of conductive materials therein. The conduit may be made in standard lengths which may be secured together at the well site and fittings may be provided for coupling it to conventional steel well casing, if desired.

For a better understanding of the invention, reference is made to the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates one possible method of constructing conduit according to the invention;

FIG. 2 is an end view of the apparatus shown in FIG. 1;

FIG. 3 illustrates one way of joining sections of conduit together according to the invention;

FIG. 4 is a schematic diagram illustrating how a section of conduit made in accordance with the invention may be joined to a section of conventional steel pipe; and

FIG. 5 illustrates a form of test well lined in part with conduit constructed according to the invention.

Conduit according to the invention may be made by wrapping several layers of coarse fibrous material **10** (FIG. 1) around a polished steel mandrel **11** and impregnating them with a plastic composition of the desired electrical conductivity until the desired wall thickness is obtained. Preferably, glass cloth grade "161" is used as the fibrous material because of its high strength, chemical inertness and compatability with the impregnating material. However, other fibrous textile materials such as cotton, linen, etc., may be employed. It is desirable that the fabric have a coarse construction

so that the electrically conductive plastic material may be easily exuded through the openings in the weave to provide good electrical continuity. Thus, any open weave cloth would be suitable.

The impregnating material may be any plastic capable of being applied in the soft state and subsequently hardened to which materials may be added for the purpose of making it electrically conductive to a desired degree.

A preferred formulation for such a conductive impregnating material is as follows:

Ingredient	Parts by weight
Epon 815	100
Carbon black	20
Xylene	5
Iron filings	135
Diethylamino propylamine	10

The Epon 815 is a low viscosity epoxy resin produced by Shell Chemical Company which is characterized by ease of handling, chemical inertness, good strength, low creep and other desirable properties. Any material, however, which will suspend the additives and which is capable of being worked as a "putty" and later hardened is suitable. The carbon black may be "acetylene black" or any other conductive carbon black such as the furnace black known as Vulcan XC–72 produced by Godfrey L. Cabot Co.

The xylene is a volatile solvent used to lower the viscosity of the resin. Other suitable solvents may be used if desired. Preferably, not more than about 5 parts of xylene should be used to 100 parts of Epon 815, otherwise defects may be caused in the final product by vaporization of the solvent during curing. The diethylamino propylamine is a curing agent for the epoxy resin.

The iron filings impart frequency stability to the resultant product, i.e., they insure a fairly constant electrical resistivity over a wide range of frequencies (5–20,000 cycles per second). They should be of suitable size and shape to be easily mixed with the other ingredients, to remain in dispersion and to exude through the weave of the fabric. Belmont's No. 50 grade iron filings, which are plate-like particles with a tarnished surface, are entirely suitable for the purpose.

Preferably, the surfaces of the iron particles should be oxidized to obtain best results. It is also desirable that the plastic conduit be constructed so that both the inner and outer surfaces have oxidized iron particles thereon. While the quantity of iron filings may be reduced below the amount given in the formulation described above, nevertheless, there must be generous amounts of oxidized iron on the surfaces of the conduit, if frequency sensitivity is to be avoided.

With no carbon black in the composition, the electrical conductivity is very low even with the addition of iron filings. The reason is that the resin coats each metal particle thereby destroying electrical continuity through the composition. By increasing the amount of carbon black or selecting one having a desired electrical conductivity, the electrical resistivity of the composition may be decreased from the maximum value to as low as .05 ohm-meters. The formulation described hereinabove gave a resistivity of .2 ohm-meters.

The glass fiber after impregnation with a plastic composition of the type described above, is then constrained, for example, in a mold comprising mold halves **12** and **13** hinged at **14** and tightly clamped together by suitable means such as the bolts **15** (FIGS. 1 and 2). The mold halves **12** and **13** should be lubricated with a suitable parting agent such as a silicone grease, for example, to facilitate their removal from the plastic after it has been cured. Alternatively, the impregnated glass fiber

may be wrapped in a suitable plastic film such as Mylar, and constrained by wrapping a layer of string tightly over it.

After the plastic is cured, the mold halves **12** and **13** are removed and the conduit section is slipped off the mandrel **11**. The outside surface is turned or ground to the desired outside diameter and the inside is roughened as by sand blasting, for example. The ends are then machined to joint dimensional requirements. Each pipe section, thus formed, should preferably be tested for leaks under a hydraulic pressure of 60 lbs. per square inch and any leaks should be closed by patching.

In order to facilitate joining adjacent sections of conduit sections together, the adjacent ends may be provided with abutting shouldered portions **16** and **17** (FIG. 3) over which a collar **18** is adapted to be received. The collar **18** may be made of steel or reinforced plastic and it may be cemented to the two adjoining conduit sections by the plastic resin composition described above. A conventional bore hole packer **19** or other similar device may be used to maintain the conduit ends in alignment and in assembled relation to the collar **18** while the resin composition is curing. Curing may be hastened by the application of heat from electrical resistance heaters **20** constructed to fit the outside diameter of the conduit and collars as shown in FIG. 3.

Where plastic conduit according to the invention is to be joined to steel casing, adapter collars **21** of the type shown in FIG. 4 may be used. The collars **21** has a lower internally threaded portion **21***a* adapted to be threaded on the upper end of a steel casing section **22** and an upper unthreaded internal portion **21***b* adapted to be cemented to the shouldered portion **23** on the lower end of a plastic conduit section **24** according to the invention. The composition described above may be used to cement the collar **21** to the section **24** except that the xylene solvent may be omitted.

FIG. 5 illustrates a test well utilizing conduit constructed according to the invention as well casing. At bottom is a length of steel casing **25** with a length of conductive plastic casing **26** constructed as previously described above it. Above the conductive section may be one or more resistive sections **27** made by omitting the lamp black in the composition described above. Then there may be a radioactive plastic conduit section **28** made by cementing a layer **29** of radioactive material such as carnotite to its outside surface, the intensity of the radioactivity being determined by the thickness of the layer. Alternatively, the radioactive material may be incorporated in the plastic composition. The several casing sections may be secured together in the manner described above.

To cement the casing string in the hole, a conductive cement of the type disclosed in copending patent application Serial No. 79,153, filed December 29, 1960, by Earl H. Barnard, and assigned to the present assignee, entitled "Electrically Conductive Concrete" may be employed. For a well 8 inches in diameter and about 800 feet deep, a batch of cement was made by adding to 28,200 pounds of neat cement 2,600 pounds of iron filings, 800 pounds of carbon black, 1,600 pounds of bentonite, and 6,800 pounds of aggregate. Water was added at the well site. To avoid contaminating the inside of the casing with cement, the slurry was pumped down the well through tubing **30** which set in a production packer **31** at bottom. It then flowed up the outside of the casing cementing it firmly in the hole. The result was a clean, cased hole which logged like an open hole.

As many and varied modifications of the subject matter of this invention will become apparent to those skilled in the art from the detailed description given herein, it should be understood that this invention is to be limited only in accordance with the appended claims.

I claim:

1. A casing for a well comprising at least one section formed of a hardened plastic material incorporating carbon black and iron filings and surrounded by a cement comprising Portland cement, aggregate, carbon black and iron filings.

2. A rigid electrically conductive conduit comprising a reinforcing core of a non-conductive porous fabric impregnated with and enveloped by a hardened plastic composition consisting essentially of, by weight, about 100 parts epoxy resin, about 135 parts of iron filings, about **10** parts of diethylamino propylamine, and a sufficient amount of carbon black to render the conduit electrically conductive to a desired degree.

3. The conduit of claim **2** above wherein said amount of carbon black in the composition constitutes about 20 parts, by weight.

4. A casing for a well comprising at least one section formed of a reinforcing core of a fibrous material impregnated with and enveloped by a hardened plastic composition incorporating carbon black and iron filings, said section being surrounded by cement.

5. A casing for a well comprising at least one section formed of a reinforcing core of a fibrous material impregnated with and enveloped by a hardened plastic composition incorporating carbon black and iron filings, said section being surrounded by a cement comprising Portland cement, aggregate, carbon black and iron filings.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,206,537 September 14, 1965

Wendell B. Steward

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 46, for "2,108,659" read -- 2,108,759 --; line 47, for "174-120" read -- 174-106 --.

Signed and sealed this 24th day of May 1966.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents