

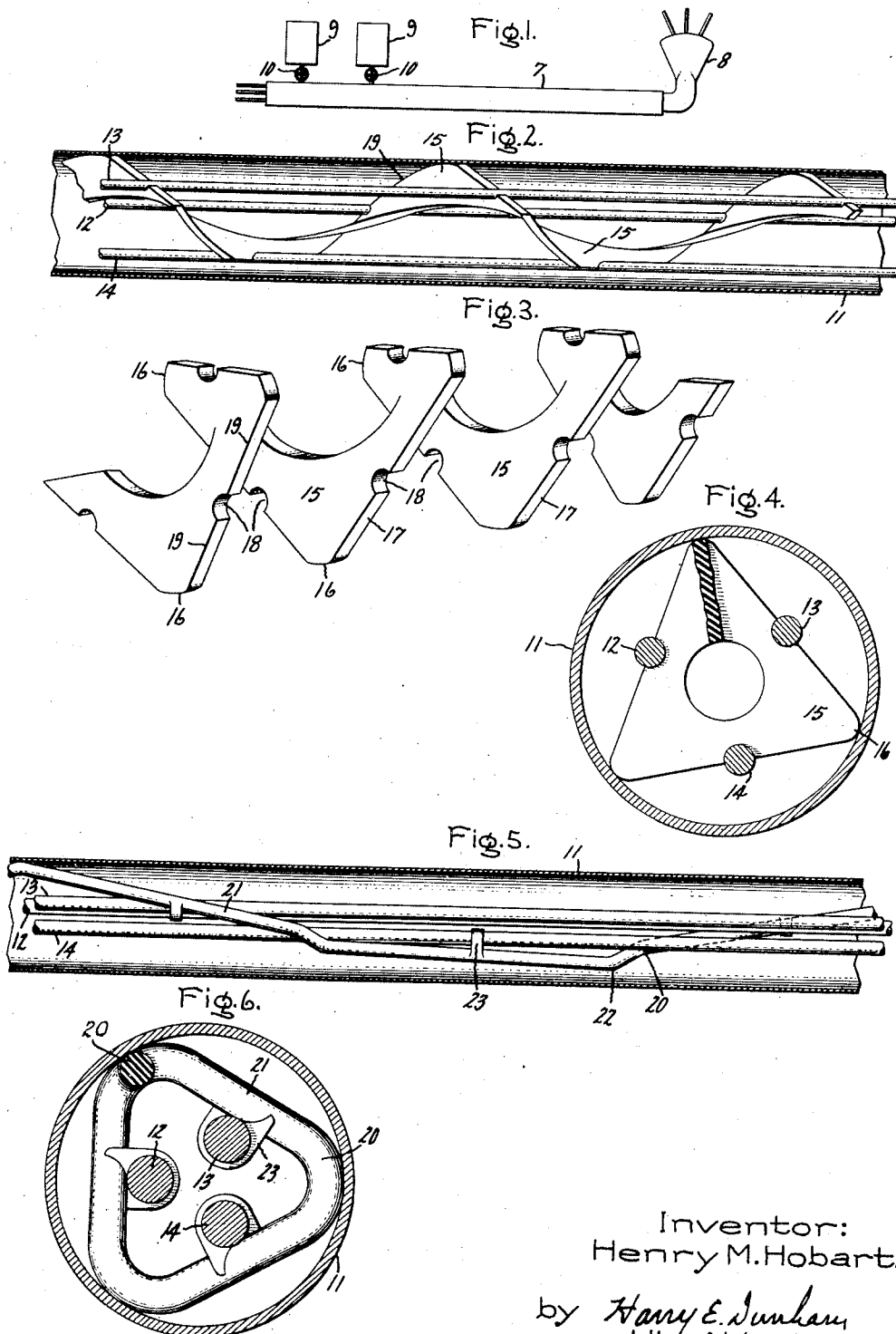
Sept. 17, 1940.

H. M. HOBART

2,215,290

HIGH PRESSURE GAS FILLED CABLE

Filed June 9, 1937



Inventor:
Henry M. Hobart,
by *Harry E. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,215,290

HIGH PRESSURE GAS FILLED CABLE

Henry M. Hobart, Niskayuna, N. Y., assignor to
General Electric Company, a corporation of
New York

Application June 9, 1937, Serial No. 147,288

5 Claims. (Cl. 174—27)

The present invention relates to a type of cable comprising a strong walled pipe inside of which are supported bare or uninsulated conductors, said pipe being filled with an insulating gas which is continuously maintained under high pressure. In such a cable, it is necessary to employ mechanical means composed of solid insulating material to support the conductors within the pipe in spaced relation to each other and to the wall of the pipe. The specific disruptive voltage, expressed in volts per mil, of insulating gases under high pressure is much greater than the disruptive voltage similarly expressed of solid insulation of suitable character for the required purpose and of the necessary dimensions, shapes and mechanical strength. Stated another way, if for example the radial spacing or distance of the conductor from the wall of the pipe is two inches and the gas pressure is high enough effectively to insulate the conductors, then the solid supporting insulation to have the necessary insulating effect must be much greater than said length. The extent to which it must be greater is much more for alternating current cable than for a direct current cable and is more for a high periodicity system than for a system employing low periodicity. Since these differences due to the kind of current are very great (varying in any materials to such extents as 5 or more to 1), it is impossible to make a brief quantitative statement. To ensure that the solid insulation shall have a life of many years when subjected to a 60 cycle voltage stress, the volts per mil should be very low indeed, in many cases well below 100 volts, whereas for suitable conditions with compressed gases, stresses of many hundreds of volts per mil may be employed. Because the pipe for reasons of initial cost and of installation should be as small in diameter as possible and because the radial distance between conductors and pipe is limited, it follows that the solid insulation to be effective cannot be located in a plane perpendicular to the axis of the pipe but must be otherwise disposed. The problem is thus presented of devising ways and means whereby the solid insulation may be so disposed or arranged within the pipe that its resistance to the passage of the high tension current from conductor to conductor and from a conductor to the pipe shall be of approximately the same order as that of the compressed gas.

The object of my invention is the provision of an improved high tension cable in which bare or uninsulated conductors are mechanically supported by solid insulators within a metallic en-

closing pipe which is filled with insulating gas under high pressure, said insulators being of such character as to interpose to the passage of high tension current through their mass located between conductors and between the conductors and the pipe a resistance which is approximately of the same order of magnitude as the resistance interposed by said gas.

For a consideration of what I believe to be novel and my invention, attention is directed to the accompanying description and the claims appended thereto.

In the attached drawing which is illustrative of my invention, Fig. 1 illustrates a length of three conductor gas-filled cable; Fig. 2 is a sectional view of a portion of such cable; Fig. 3 is a perspective and partially diagrammatic view of the solid insulator for supporting the conductors inside of the pipe; Fig. 4 is an end view partly in section of the structure shown in Fig. 2; Fig. 5 illustrates a modified form of solid insulator for the conductors, and Fig. 6 is an end view, partly in section, of the structure shown in Fig. 5.

In Fig. 1, 1 illustrates a length of gas-filled pipe cable containing bare conductors. At one or both ends is a terminal structure 8 through which the conductors enter or leave the pipe, and 9 indicates tanks or other apparatus for supplying highly compressed insulating gas to the pipe line. As an example, I may use clean and dry nitrogen gas which is cheap and has fairly high dielectric strength under the required conditions and is chemically suitable, but other gases having favorable characteristics may be employed. 10 indicates controlling valves of suitable construction interposed between the gas supply apparatus and the pipe line.

Referring to Fig. 2, 11 indicates a pipe made of steel or other suitable material capable of withstanding the pressure of the insulating gas that is used to insulate the conductors 12, 13 and 14. The conductors are bare or at least are not covered with any material which is effective as an insulator for the high voltages to which the conductors are subjected. The conductors are spaced 120° apart as best shown in Fig. 4. The conductors are supported in spaced relation to each other and to the wall of the pipe by means composed of solid insulating material of high dielectric strength. Solid insulations are subject to two kinds of limits: (1) creepage over their surface due to limiting surface resistance, and (2) disruptive breakdown due to the passage of current through their mass. As previously stated, the high pressure gas has high dielectric

strength per mil of thickness, much higher than any solid insulation in use at the present time. In order to approximate the insulating value of the gas, it follows that the length of the leakage path for current through or over the solid insulation must be many times greater than the radial distance between conductors and between conductors and the wall of the pipe. This is attained by so constructing the solid insulation that relatively long distances are provided between the conductors and the pipe. A desirable way to attain this result is to make the solid insulation in the form of a long pitch spiral or helix of special shape. The helical insulator may be molded to its final form or otherwise constructed to attain the desired longitudinal spacing between points of support and the bare conductors. Because substantial distance between conducting parts is required, it follows that the points or areas where the helix engages the pipe should be as small as possible consistent with the load to be carried as represented by the weight of the conductors, and the electrodynamic stresses occasioned between them by the currents they carry. This is best shown in the more or less diagrammatic Fig. 3 where the turns of the helix are shown as relatively close to each other. In other words, the pitch of the helix has been shortened for simplicity of illustration and description. The outer surface of the helix is arranged to touch the wall of the pipe at small widely separated points, or areas only as indicated at 16. The portions of the insulator between the small curved or suitably shaped areas 16 are straight as indicated at 17 and each of these portions is tangent to a conductor so that, except at the ends, they are in spaced relation to the wall of the pipe. Each straight portion in effect forms a chord, said chord being inclined to the axis of the pipe. In each of the straight or chord portions of each turn of the helix is a socket 18 to receive and support a conductor. The effective insulation for each conductor is the part of the insulator 19 located between the socket 18 and the adjacent curved parts 16 which engage the wall of the pipe. From one point of view, that portion of the solid insulation 17 between its points of support 16 forms a bridge, and in order to obtain the necessary length of material to properly insulate as well as support the conductor, it is inclined at an angle to the axis of the pipe. By changing the length of the bridge which also means a change of angle, the amount of length of solid material between conducting parts can be increased or decreased to suit the requirements.

Figs. 2 and 3 are good illustrations of the fact that the construction is capable of use for different voltages and this over a wide range. In Fig. 2, the pitch is relatively long, being of the order of three feet while in partially diagrammatic Fig. 3, it is much less. Obviously, increasing the linear distance between the sockets 18 and the areas 16 of contact of the turns with the pipe means that the insulation may thereby be increased. The effect of a mass of solid insulation of greater length can also be obtained by supporting the conductors not by every turn of the spiral but by every other turn, or by even greater spacing. In general, it is desirable to support the conductors at intervals by solid insulation throughout their entire length but where for any reason this is not necessary or desirable, the spirals may be made in relatively short lengths and the lengths arranged in spaced relation. Fig.

3 may be taken as an illustration of such an arrangement.

It will be seen that the desired results are obtained by the provision of solid insulation having relatively great length in a direction which is generally axial to the pipe as distinguished from an insulating means located between the conductor and the pipe in a plane perpendicular to said axis where the mass in a radial direction is necessarily relatively small. Stated another way, there is interposed between the conductor and the pipe a relatively great length of solid insulation whereby the volts per mil stress are reduced to a value well below the disruptive value corresponding to the kind of current used and to freedom from aging deterioration during an economically long period of years of service. The reason that the radial dimension of the body of gas between the conductor and the pipe may be so much less than the linear dimension of the solid insulator is found in the fact that high pressure gas has much higher dielectric strength than the solid material, that it may be maintained dry and clean, and in the unanticipated event of any contamination or other depreciation, can be cheaply replaced with a fresh supply.

In Figs. 5 and 6 is illustrated a modification of my invention wherein the advantages of long paths for creepage over or discharge through the solid insulation by the current are obtained but the specific means for accomplishing the result are different. In these figures, the solid insulation is in the form of a rod 20 made to form a series of chords 21, each chord progressing 120 degrees around the axis of the pipe and being tangent to the conductors. The areas of contact with the pipe as indicated at 22 are small for the same reason that the curved parts 16 of Fig. 3 are small. To stand firmly within the pipe, the chords of insulation should be of a length at least twice the pitch of the spiral. The conductors are each supported by the chords by means of saddles 23 which are firmly secured thereto. The rods may be made of comparatively short lengths with abutting ends or in long lengths as best suits the conditions of a particular cable. In this form of the invention the conductors are located inside of the solid insulation whereas in the other form they are located between the insulation and the pipe.

It will be seen that the characteristic features of my improved construction reside in the fact that the mass of solid insulation between each high voltage conductor and another is long as compared with the radial distance between a conductor and the wall of the pipe and as compared with the direct normal spacing between any two conductors, that the contact area between the insulation and the pipe is small, that the shape of the insulation embodies a trend to a very long pitch helix to give the necessary length to the through disruptive path and to the creepage surface, and that high pressure gas is employed to fill the pipe and to act as insulation. Since the dielectric constant of a gas is unity, a cable made in accordance with my invention has much lower capacitance than a cable insulated with solid or liquid material and thus has much less charging current for a given voltage between conductors.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A cable for transmitting high tension electric current for power purposes comprising an uninsulated conductor, an enclosing pipe, a filling

of gas for the pipe under such pressure as to have high insulating properties, a solid insulator for supporting the conductor inside of the pipe, the insulator being in the form of a long pitch helix composed of a series of relatively long thin members defining chords, each chord having a length substantially greater than the pipe diameter and inclined at an angle to the axis of the pipe, there being parts of small surface area uniting the adjacent ends of the thin members and forming the sole areas of contact with the inner wall of the pipe, the portion of each chord between the conductor and pipe being of such length as to interpose a resistance to the passage of high tension current through its mass of the same order of magnitude as that of the gas.

2. A cable for transmitting high tension electric current for power purposes comprising parallel uninsulated conductors, a filling of gas for the pipe under high pressure, a solid insulator for supporting the conductors inside of the pipe in spaced relation to each other and to the inner wall of the pipe, the insulator being in the form of a long pitch helix made up of long thin members defining chords, each chord being inclined at an angle to the axis of the pipe, there being parts of small surface area uniting adjacent ends of the chords and constituting the sole areas of contact with the inner wall of the pipe, and conductor holding sockets in the chords midway between the connecting parts of small surface area, the material in each chord between a conduct and the nearest portions of small surface area interposing through its mass a resistance to the passage of high tension current of the same order of magnitude as that of the gas.

3. A cable for transmitting high tension electric current for power purposes comprising three uninsulated conductors arranged in 120° relation to each other, an enclosing metal pipe for the conductors, a plurality of individual self supporting solid insulators extending longitudinally of the pipe for supporting the conductors, each insulator being in the form of an open helix to permit passage of gas, the pitch of the helix being greater than the diameter of the pipe, the helix having axially extending members, each defining a chord inclined at an angle to the axis of the

pipe, each two members being connected at their adjacent ends by a part of small surface area which is the only area of contact with the inner wall of the pipe, sockets for supporting the conductors located one in each of the axially extending members midway between its ends, the sockets holding the conductors in angular spaced relation to each other and the pipe, a filling of gas for the pipe under such pressure that its value as an insulating medium is greater per unit of thickness measured between conducting parts than that of the parts of the insulator located between each socket and the small areas of contact with the pipe, and means for maintaining the gas under high pressure.

4. A cable for transmitting high tension electric current comprising electric conductors, an enclosing pipe for the conductors, a rod of solid insulation of relatively small cross-section located within the pipe and extending lengthwise thereof, the rod being shaped to form a series of connected chords, the chords progressing in an axial direction about the axis of the pipe and diagonally with respect to the conductors, the connecting portions of the chords having small areas of contact at spaced intervals with the inner wall of the pipe, axially spaced sockets located on inner surface parts of the chords between the contact areas for supporting the conductors, and a filling of high pressure insulating gas for the pipe.

5. A cable for transmitting high tension electric current for power purposes comprising a bare conductor, an enclosing pipe, a filling of gas for the pipe under high pressure, a solid insulator for supporting the conductor inside of the pipe, said insulator being in the form of a long pitch helix consisting of a series of thin sections joined together, each section having a length substantially greater than the pipe diameter, the junction points of said thin sections providing bearing surfaces of small area constituting the sole points of contact with the inner surface of said pipe, the portion of each thin section between the conductor and pipe interposing a resistance through its mass to the passage of high tension current of the same order of magnitude as a direct path through the gas space.

HENRY M. HOBART.

CERTIFICATE OF CORRECTION.

Patent No. 2,215,290.

September 17, 1940.

HENRY M. HOBART.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 33, claim 2, for the word "conduct" read --conductor--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office. Signed and sealed this 29th day of October, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

CERTIFICATE OF CORRECTION.

Patent No. 2,215,290.

September 17, 1940.

HENRY M. HOBART.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 33, claim 2, for the word "conduct" read --conductor--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of October, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.