April 24, 1934. T. F. PETERSON 1,956,199

ELECTRIC CABLE

Filed Jan. 30, 1928

Fig. 1

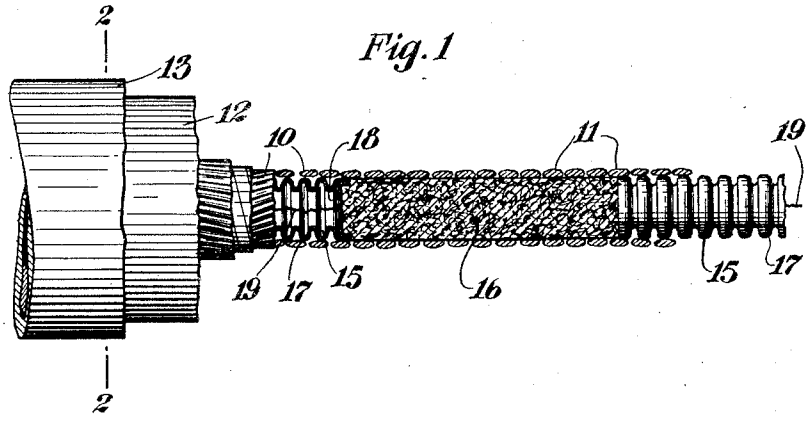


Fig. 4.

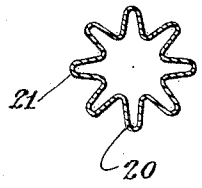


Fig. 2

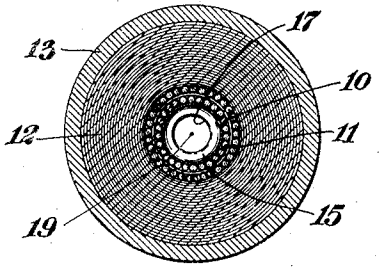


Fig. 6.

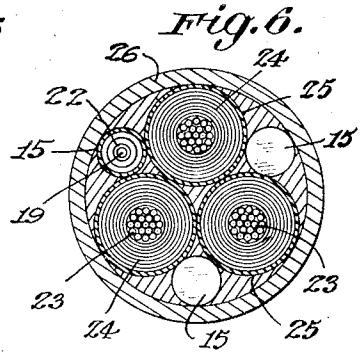


Fig. 3

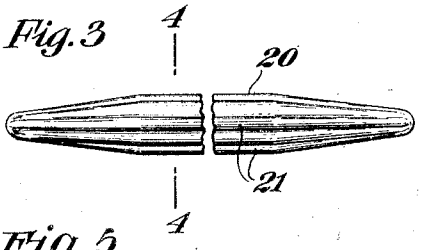
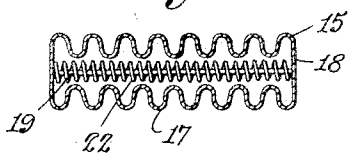


Fig. 5.



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ELECTRIC CABLE

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Application January 30, 1928, Serial No. 250,576

1 Claim. (Cl. 173—266)

This invention relates to improvements in the construction of cable used for the transmission of electrical energy at what are commonly classed as high voltages, namely, greater than 20,000 volts. Cable of this class is usually made up of one or more conductors insulated with paper and heated, evacuated, then saturated with compound and finally encased in a lead or lead alloy sheath. Though attempts are made to remove all gas before saturation some invariably remains or is occluded with the compound or oil forming bubbles or films, and these bubbles or films of gas when subjected to sufficiently high electrical stresses become ionized, breakdown and serve as starting points for complete cable failure. On account of this tendency the percentage of residual gas remaining in the cable must be kept below a very small amount, that is, less than one per cent by volume. Though bubbles or films of gas are a source of cable failure, they are on the other hand useful as serving to cushion volumetric changes in the cable and the contained compound which take place with temperature changes; but, since the percentage of allowable residual gas is so small, a slight expansion of compound creates a large increase of pressure which is apt to stretch the inelastic lead sheath. Upon contraction of the compound and release of pressure, voids are then developed within the cable, and to eliminate voids so formed or that may otherwise exist in the cable, recent practice provides the use of oil reservoirs at joints. (This subject is more fully treated in my paper published in the November 19, 1927 issue of the Electrical World). Even with oil reservoirs, however, the cycle of expansion and construction with distension of the sheath and formation of voids may occur or be repeated due to the large resistance to oil flow within the paper-insulated cable. The use of hollow cores or open-stranded conductors, slotted sheath or the like, providing a continuous channel for oil to flow longitudinally of the cable improves the distribution and tends to equalize pressures resulting from expansion; but this construction as practised necessitates the use of reservoirs, pressure tanks, towers and stop joints at intervals sufficiently near to avoid the building up of localized excessive pressures within the cable. The installation of cable with continuous oil channels furthermore requires elaborate field work to insure evacuation of gas and impregnation with oil, and the cost of this forms a very appreciable part of the total.

According to the present invention internal pressures are maintained at all times within prescribed limits, volumetric changes due to the temperatures change are compensated and wide pressure variations are substantially eliminated while voids within the cable are quickly filled with compound. Furthermore these objects are accomplished without the need of expensive tower tanks, pressure tanks or stop joints, reinforced sheaths etc. Furthermore, expansible oil reservoirs of the character described in the paper aforesaid can be used at cable joints without the danger of cumulative additions of oil to localized parts of the cable. In other words, by the present invention pressure stabilization with very short time lag, complete filling with oil at all times after leading of the cable and minimization of difficulties arising from oil migration are made possible.

The present invention comprises the inclusion within the cable of volumetric change-compensating means which also function to offer resistance to flow or migration of oil longitudinally of the cable. It is based on the principle of securing pressure stabilization slightly above atmospheric by means of a gas or compressible medium that is not within an electric field and not in contact with oil or compound; air or gas, if not so confined, may migrate to parts of cable under electrical stress or be absorbed by the oil. In the embodiments illustrated and hereinafter described it takes the form of air or gas filled sealed flexible reservoir units or cells placed at intervals along the cable length.

In the accompanying drawing

Fig. 1 is a longitudinal section of a cable showing one type of unit;

Fig. 2 is a transverse section on the line 2—2 of Fig. 1;

Fig. 3 is a side view of another type of unit;

Fig. 4 is a transverse section on the line 4—4 of Fig. 3;

Fig. 5 is a longitudinal section of a modification of the unit shown in Fig. 1; and

Fig. 6 is a transverse section of a three-conductor cable.

The cable shown in longitudinal section in Fig. 1 comprises a hollow core conductor 10 which can be formed from a plurality of helically twisted strands 11. About the conductor is the usual oil or compound impregnated insulation 12 consisting of layers of paper or other suitable material or fabric. The insulation in turn is enclosed within a lead sheath 13.

Within the hollow core of the conductor are disposed at suitable intervals pressure-compen-

sating units 15 which are preferably filled with a gas or air and sealed. They may, however, be spring fitted, as shown in Fig. 5, and sealed under vacuum. Inside the corrugated metallic cylinder 17 is a spring 22 tending to expand the unit, such expansion being limited by the wire or bond 19 connecting the ends 18 in order to prevent over-expansion or bursting.

Gas filled units of flexible material should preferably be sealed so that, when in their normal condition as regards expansion and contraction, internal pressure is somewhat above atmospheric. The core space between the units is preferably filled with some material 16 such as jute or rope, to further impede longitudinal flow of oil or compound along the cable.

The pressure-compensating units or cells can be constructed in a number of ways. As illustrated in Fig. 1, a unit comprises a flexible bellows or a circumferentially corrugated metal cylinder 17 with ends 18 secured thereto. Since the cable after construction is subject to evacuation, it may be necessary to include some means such as a loosely-stretched wire or bond 19 connecting the ends 18, so that rupture of the unit will not occur due to the pressure within it. With this type of unit the tendency is to expand or contract longitudinally as the external pressure upon it is less or greater than the gas pressure within.

Another embodiment of the pressure-compensating unit is shown in Fig. 3. In this form the unit 20 is provided with longitudinal corrugations 21. In the manufacture of this unit a phosphor bronze strip or equivalent material is corrugated, bent into cylindrical form and soldered. The ends 22 may be capped as in the first embodiment or they can be drawn into conical form and then sealed. This type of unit expands and contracts transversely and there is therefore no longitudinal displacement.

Other forms of units can be used, for example, the corrugations can be helical in which case movement of the walls of the unit due to changes in pressure will be both longitudinal and transverse, the extent of movement in each direction being governed by the pitch of the helix. Such construction lends longitudinal flexibility which may be necessary when long units are used so that the cable can be coiled or otherwise bent or curved. Materials other than phosphor bronze and the like can be used, for example collapsible materials such as lead alloys, metal coated rubber, etc., with such materials the units are preferably sealed under a reduced pressure and should be supported to withstand the application of vacuum.

The units are so proportioned and placed within the conductor as to compensate for a change in volume of the compound within the cable, measured by the distance between the centers of the units, that is caused by the changes in temperature to which the cable is subject in use preferably without a variation in pressure materially in excess of one atmosphere.

After the cable is constructed and impregnated, pressure is preferably applied before sealing the ends for shipment so that the units will be compressed and thus keep cable completely filled with oil and prevent formation of voids or spaces due to reeling and installation or loss of oil or compound during splicing. Any contraction of compound caused by a drop of temperature is likewise compensated by the application of an initial pressure. After the installation a slight pressure can be applied to the cable system by means of reservoirs at the joints. Since the core is blocked by the units and other filling, the static head of oil will not develop excessive pressure but will create very slow migration; it can be taken care of, if necessary, by the reservoirs at the joints. Development of pressures due to temperature changes resulting from cable operation will be compensated by the movement of the units within the core.

The invention is not limited to single conductor cables but can be applied to multiple conductor cables of the shielded type in which case it is preferable to place units in unstressed interstices. Such a construction is shown in Fig. 6, the conductors 23 are enclosed within a wall of insulating material 24, over the outer surface of which are the usual shielding envelopes 25. Enclosing the insulated and shielded conductors is the sheath 26, ordinarily of lead, and in the unstressed interstices, that is in the filler spaces between the insulated and shielded conductors and the sheath, are inserted the pressure compensating units 15. Since the cores or interstices of the multiple conductors are thereby filled to block longitudinal movement of compound, stop joints and expensive towers to develop pressure to balance that within the cable are not required.

I claim:

A high-tension cable including the combination of a hollow conductor, oil impregnated insulation covering said conductor, the latter being constructed to permit the passage of oil forced from said insulation, at least one expansible device in said hollow conductor and means for applying expansive forces to said device, said hollow conductor having all internal space not occupied by said expansibe device, filled with a fibrous material.

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