

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN ELECTRIC CABLES

(71) We, BRITISH INSULATED
 CALLENDER'S CABLES LIMITED, a
 British Company, of 21 Bloomsbury Street,
 London, W.C.1, do hereby declare the inven-
 tion, for which we pray that a patent may
 be granted to us, and the method by which
 it is to be performed, to be particularly des-
 cribed in and by the following statement:—

This invention relates to insulated electric
 power cables having a laminated dielectric
 made up from dielectric tapes impregnated
 with an insulating compound, and more parti-
 cularly it relates to non-draining cables.

The term "non-draining cable" as used
 herein refers to a cable that when subjected
 to the drainage test specified in Metric
 British Standard 6480 Part I 1969 exhibits
 a drainage within the limit specified in Table
 3 of that specification. It includes fully im-
 pregnated cables in which the dielectric is as
 full of impregnant as possible, at least the
 surface layer of the tapes being impregnated
 and the butt spaces between the turns and
 layers of tape being filled with insulating
 compound, the object being to ensure that the
 possibility of the existence of voids within
 the dielectric enclosed by the surrounding di-
 electric screen is reduced to a minimum, and
 pre-impregnated cables in which the butt
 spaces are not necessarily filled with com-
 pound but it does not include gas-filled cables,
 which are the subject of co-pending Appli-
 cation No. 51782/69 (Serial No. 1,311,866)
 filed on the same day as the present appli-
 cation.

It is difficult to construct a non-draining
 cable in which the possibility of migration of
 the compound under all possible working con-
 ditions, including overload conditions is
 avoided since such a cable would be inher-
 ently inflexible or the nature of the com-
 pound would be such that full impregnation
 as defined above or satisfactory pre-
 impregnation would be unattainable.

The principal object of the present inven-
 tion is to reduce the small amount of migra-

tion of compound which can take place in
 non-draining cables as at present commercially
 available.

In accordance with the present invention,
 in a non-draining cable having a laminated
 dielectric impregnated with a non-draining
 insulating compound, at least part of the
 dielectric is built up from a composite tape
 or tapes comprising a plastics film bonded
 to a sheet or sheets of fibrous insulating
 material.

The preferred form of composite tape con-
 sists of a plastics film sandwiched between
 and bonded to two layers of fibrous insulat-
 ing material. The fibrous material is prefer-
 ably paper and the paper layers are prefer-
 ably bonded to the plastics film in such a
 way as to produce a pre-stressed laminate,
 that is to say by trapping an extruded mol-
 ten web of plastics material, as it leaves an
 extruder, between two paper sheets form-
 ing part of the laminate.

The paper layers can be loaded with an
 active material of the kind described in the
 Complete Specification of United Kingdom
 Patent Specification 1,185,474, that is alu-
 minium oxide or another active metal oxide,
 hydrated metal oxide, hydroxide, carbonate
 or basic carbonate that has sorptive powers
 comparable with that of aluminium oxide, in
 order to minimise the deterioration in electri-
 cal properties due to contamination of the
 impregnant by residues from the plastics
 material.

The plastics film is preferably of polyethyl-
 ene or polypropylene but alternatively poly-
 carbonates, polysulphones, saturated linear
 polyesters (e.g. polyethylene terephthalate),
 polyphenylene oxide, poly 4-methylpentene-1,
 polytetrafluoroethylene, ethylene-propylene co-
 polymers, fluorinated ethylene-propylene co-
 polymers, polyfluorostyrene or polyvinylcar-
 bazole can be used.

Whatever the nature of the composite
 tape, we prefer to use paper as the fibrous
 material and preferably a thinner paper than

[Price 25p]

is normally used for cable insulation, that is paper of a thickness not greater than 25 μm such as insulating quality pure Kraft paper. Coil winding paper having a thickness of 20—25 μm is preferred.

Two forms of non-draining cable are at present in use, namely the mass impregnated cable (M.I.N.D.) which is a fully impregnated cable made by impregnating the insulating tapes in situ on the cable conductor with a compound which can be rendered liquid or semi-liquid at an elevated temperature, and the pre-impregnated type of cable which is made by impregnating the paper tapes in a separate process before lapping them on to the cable conductor.

An additional advantage of the present invention is that it is possible to use compounds of the kind used in M.I.N.D. cables to manufacture cables by the method normally used for making pre-impregnated non-draining cables. In the modified process, a sufficient excess of the M.I.N.D. compound or of a slipper compound (that is a waxy compound conferring low friction coefficient) can be carried on the surfaces of the pre-impregnated tapes, at least partially to fill the butt spaces. Suitable M.I.N.D. compounds are described in United Kingdom Specifications Nos. 581,830; 698,055; 757,395; and 767,836.

In non-draining cables of the pre-impregnated type having stranded conductors, it is normal to fill the or each stranded conductor of the cable with an impregnating compound but in cables of this type in accordance with the present invention, when the whole of the dielectric is built up from the composite tapes referred to above, or even the inner part of the dielectric only, it is in some circumstances possible to omit the filling of the stranded conductor since the inner layers of the composite tape provide a barrier against migration of the compound from the dielectric into the interstices between the strands of the conductor.

Also in non-draining cables in accordance with the invention, instead of using a tight fitting sheath over the dielectric screen it is possible to use a corrugated sheath, owing to the fact that the risk of migration of the compound into the spaces between the screened cable core and sheath is reduced to negligible proportions.

The plastics film will normally be swollen to some extent by contact with the impregnating compound, and this swelling is controlled in part by the resistance of the paper tapes to elongation. This function is of greater importance in outer parts of the dielectric, since inner parts will be restrained also by the overlying tapes of the outer parts. On the other hand the presence of a high pro-

portion of plastics material is most advantageous in the central part of the dielectric where the electrical stress is greatest. It may therefore be desirable to form the dielectric from a number of different composite tapes such that the proportion of the dielectric that is constituted by plastics material decreases with increasing distance from the cable conductor. The number of steps desirable will increase with the dielectric wall thickness and therefore with the working voltage of the cable.

Although it will usually be preferable at least at the lower voltages for the whole dielectric to be built up from the composite tapes specified, it may be advantageous for part only of the dielectric to be formed of such tapes, the remainder in such cases preferably being formed of paper tapes. Thus in one example, the dielectric may throughout its length comprise an inner part of the composite tape and an outer part of paper; and in another example the composite tape may be utilised only in restoring the dielectric at joints and terminations. It will usually be preferable to use the composite tape in joints or terminations whenever all or part of the original dielectric is of the composite tape, but the optimal thicknesses of the plastics and paper layers of the composite tape used in the joints and terminations may differ from the optimal thicknesses of the corresponding layers in the cable owing to the different stress distribution.

In a low voltage joint it may be desirable to use a composite tape that has been creped to increase its elasticity to facilitate application to shaped components such as ferrules that may be present in the joint.

The cable may include a conductor screen or a dielectric screen or both formed from at least one layer of laminated tape similar to that used to form the whole or part of the dielectric suitably metallised and/or loaded with conductive material.

Although, as indicated, the major advantage obtained by the present invention is the reduction in radial migration of compound, an additional advantage is that the thickness of the dielectric can be considerably reduced. The percentage reduction obtained is illustrated by the following table which refers to a 33 kV M.I.N.D. cable having a conductor of 0.3 in² (185 mm²) and of the construction shown in the accompanying drawing in which

Figure 1 is a cut-away elevation and Figure 2 is a cross-section of the cable.

In the drawing 1 is a conductor, 2 and 4 are semi-conductive screens, 3 the dielectric, 5 a binder securing the cores together, 6 a metallic sheath and 7 a protective plastics oversheath:

Insulation wall thickness mm			% reduction on total wall thickness	% dielectric wall which is laminate
Total	Laminate	Paper		
6.8	0	6.8	0	0
6.2	1.4	4.8	9	22
5.6	3.1	2.5	18	55
5.2	5.2	0	24	100

A further advantage of the cables in accordance with the present invention is that the thermal expansion coefficient of the lapped composite tape differs less from that of the impregnant than does that of conventional paper tape. This means that on heating there is less tendency to squeeze out impregnant from the dielectric. The use of composite tape thus minimises loss of impregnant by expansion coefficient mismatch as well as by drainage under gravity.

WHAT WE CLAIM IS:—

1. A non-draining cable having a laminated dielectric impregnated with a non-draining insulating compound in which at least part of the dielectric is built up from a composite tape or tapes comprising a plastics film bonded to a sheet or sheets of fibrous insulating material.

2. A non-draining cable having a laminated dielectric impregnated with a non-draining insulating compound in which at least part of the dielectric is built up from a composite tape or tapes consisting of a plastics film sandwiched between and bonded to two sheets of fibrous insulating material.

3. A non-draining cable having a laminated dielectric impregnated with a non-draining insulating compound in which at least part of the dielectric is built up from a composite tape or tapes comprising a pre-stressed laminate consisting of a plastics film sandwiched between and bonded to two sheets of fibrous insulating material.

4. A cable as claimed in any one of Claims 1 to 3 in which the said fibrous insulating material is paper.

5. A cable as claimed in Claim 4 in which the paper is an insulating quality pure Kraft paper.

6. A cable as claimed in Claim 4 or Claim 5 in which at least one paper layer of a composite tape is loaded with active aluminium oxide or with another active metal oxide, hydrated metal oxide, hydroxide, carbonate or basic carbonate that has sorptive powers comparable with that of aluminium oxide.

7. A cable as claimed in any one of the

preceding Claims in which the plastics film is of polyethylene or polypropylene.

8. A cable as claimed in any one of Claims 1 to 6 in which the plastics film is of a polycarbonate, a polysulphone, a saturated linear polyester, a polyphenylene oxide, poly 4 - methylpentene - 1, polytetrafluoroethylene, an ethylene-propylene copolymer, a fluorinated ethylene-propylene copolymer, polyfluorostyrene or polyvinylcarbazole.

9. A cable as claimed in any one of the preceding Claims including a conductor screen or a dielectric screen or both formed from at least one layer of laminated tape similar to that used to form the whole or part of the dielectric suitably metallised and/or loaded with conductive material.

10. A cable as claimed in any one of the preceding Claims in which the dielectric includes at least two different composite tapes such that the proportion of the dielectric that is constituted by plastics material decreases with increasing distance from the cable conductor.

11. A cable as claimed in any one of the preceding Claims having at least one stranded conductor in which the composite tape constitutes at least the inner part of the dielectric adjacent to the said conductor throughout the length of the cable and in which the interstices of the said conductor are free of impregnating compound.

12. A cable as claimed in any one of the preceding Claims having a corrugated sheath.

13. A cable as claimed in any one of the preceding Claims in which the part of the dielectric that is constituted by the composite tape comprises a part of the dielectric that has been restored in making a joint or termination.

14. A cable as claimed in Claim 13 for low-voltage use in which the composite tape in the joint or termination is creped.

15. A cable substantially as hereinbefore described by way of example with reference to the accompanying drawings.

16. A method of making a non-draining cable in which at least part of the dielectric is built up from a composite tape or tapes comprising bonding to a plastics film a sheet



Insulation wall thickness mm			% reduction on total wall thickness	% dielectric wall which is laminate
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WHAT WE CLAIM IS:—

1. A non-draining cable having a laminated dielectric impregnated with a non-draining insulating compound in which at least part of the dielectric is built up from a composite tape or tapes comprising a plastics film bonded to a sheet or sheets of fibrous insulating material.
2. A non-draining cable having a laminated dielectric impregnated with a non-draining insulating compound in which at least part of the dielectric is built up from a composite tape or tapes consisting of a plastics film sandwiched between and bonded to two sheets of fibrous insulating material.
3. A non-draining cable having a laminated dielectric impregnated with a non-draining insulating compound in which at least part of the dielectric is built up from a composite tape or tapes comprising a pre-stressed laminate consisting of a plastics film sandwiched between and bonded to two sheets of fibrous insulating material.
4. A cable as claimed in any one of Claims 1 to 3 in which the said fibrous insulating material is paper.
5. A cable as claimed in Claim 4 in which the paper is an insulating quality pure Kraft paper.
6. A cable as claimed in Claim 4 or Claim 5 in which at least one paper layer of a composite tape is loaded with active aluminium oxide or with another active metal oxide, hydrated metal oxide, hydroxide, carbonate or basic carbonate that has sorptive powers comparable with that of aluminium oxide.
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preceding Claims in which the plastics film is of polyethylene or polypropylene.

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14. A cable as claimed in Claim 13 for low-voltage use in which the composite tape in the joint or termination is creped.

15. A cable substantially as hereinbefore described by way of example with reference to the accompanying drawings.

16. A method of making a non-draining cable in which at least part of the dielectric is built up from a composite tape or tapes comprising bonding to a plastics film a sheet



or sheets of fibrous insulating material, pre-impregnating the fibrous insulating material with a non-draining impregnating compound and forming on the surfaces of the tapes a
5 coating of excess non-draining compound or of a slipper compound, and applying the pre-impregnated and coated tape directly or indirectly to the cable conductor.

17. A method as claimed in Claim 16 in

which the plastics film is sandwiched between two sheets of fibrous insulating material as it is extruded so as to form a pre-stressed laminate.

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