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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to the manufacture of
Multi-Conductor Cables

5 We, BRITISH INSULATED CABLES LIMITED, a British Company, of 21 Bloomsbury Street, London, W.C.1., do hereby declare the invention, 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 described in and by the following statement:—

10 This invention relates to telecommunication cables of the kind comprising a multiplicity of plastics insulated conductors enclosed within a waterproof sheath. If such cables, whether buried in the ground or drawn into ducts, become locally damaged to an extent to allow
15 water to enter through the damaged sheath, the water will travel along the cable through the interstices between the insulated conductors and between the conductors and the sheath and so will have an adverse effect upon the electrical characteristics of the whole cable length, for instance by shorting of circuits via
20 pinholes in the wire insulation.

25 With the object of limiting the extent to which water that has entered through a defective sheath or a defective joint casing may travel along the cable, it has previously been proposed to incorporate barriers at intervals along the length of the cable, such barriers locally filling the interstices between the insulated conductors and those between the
30 assembly of conductors and the cable sheath. With the object of preventing water that has entered through a defective sheath or joint casing from travelling even a short distance
35 along the cable from the point of entry it has been proposed to fill the interstices between the insulated cable conductors and between them and the cable sheath throughout the

entire length of the cable with water-impermeable filling material.

40 For forming discrete barriers in a cable it is essential, and for forming a continuous barrier throughout the length of a cable it is desirable, to use a waterproof impermeable material which will not drain under the influence of gravity or such hydrostatic pressure as may arise in the event of damage to the cable sheath or joint casing but which will permit relative sliding movement of the plastics insulated conductors or group of conductors over one another during such bending of the cable as occurs during manufacture and installation of the cable. Examples of such materials are:

- (a) Microcrystalline petroleum waxes
- (b) Mixtures of microcrystalline petroleum waxes and oils, for instance petroleum jelly
- (c) Low molecular weight, high Melt Flow Index polyethylene of a semi-solid or grease-like nature

- (d) Mixtures of petroleum jelly, microcrystalline petroleum waxes, polyethylene, polyisobutylene and aluminium stearate.

65 The choice of filling material is to some extent limited by the method of introducing the filling material into the cable core and by the nature of the dielectric of the conductors forming the core.

70 In the manufacture of multi-conductor cables of the kinds described, that is to say of plastics insulated multi-conductor cables that are either furnished with discrete barriers of water-impermeable filling material or are filled throughout with such material, it is necessary to transfer such material from a storage vessel to the cable and to apply it to the

cable under superatmospheric pressure. This necessitates some form of pump. It is difficult however to pump such material in its solid condition because almost inevitably cavitation will occur within the storage vessel and cause a break in the feed to the pump. If pumping in such condition can be achieved, at the required rates of flow, for example 100 ft/min or 4 gallons/min in a one square inch pipe, some breakdown of the crystal bonds in the material will result thus degrading the material by lowering its viscosity, so rendering it less capable of forming a barrier permanently resistant to water under pressure. If the material is stored in a liquefied state and is pumped from the storage vessel to the cable core whilst in such a state degradation is avoided but it is difficult to ensure the formation of an effective barrier.

We have found that degradation of the material occasioned by pumping is reduced if pumping takes place whilst the material is at a temperature just above the temperature at which crystallisation begins. Accordingly, our invention resides in the method of providing a cable core with a barrier of sealing material which comprises pumping the sealing material from a thermostatically controlled storage vessel to a cable feeding station whilst at a temperature just above that at which crystallisation begins and cooling the material to effect crystallisation whilst transferring it from said cable feeding station to the cable core. By this method degradation is minimised and the capacity of the cooling plant required at the filling stations is reduced.

However our improved method presents the difficulty of maintaining the material at the temperature specified throughout its movement from the storage vessel to the cable feeding station. This is principally due to the difficulty of maintaining the mass of material in the storage vessel at such a temperature owing to difficulty in effecting the necessary transfer of heat through the semi-solid sealing material without either locally overheating it or degrading it by breaking down the crystal bonds by imparting movement to the material to avoid local overheating.

In accordance with a further feature of our invention we provide a multi-conductor cable core with a barrier of sealing material by a method which comprises maintaining sealing material in a thermostatically controlled storage vessel at a temperature just above that at which crystallisation begins by continuously withdrawing sealing material from the storage vessel and bringing the withdrawn material to the said temperature by pumping it through one or more than one thermostatically controlled heat exchanger and back to the storage vessel through a return pipe in which is located a cable feeding station and bleeding-off sealing materials being pumped through

the return pipe at the cable feeding station and cooling it to effect crystallisation while transferring it from the feeding station to the cable core.

A cable feeding station may be provided at each of more than one location in the return pipe from which sealing material at the controlled temperature may be led to one of a like number of stranding heads of the stranding machine in which the cable that is to be fully filled or filled at intervals along its length will be manufactured.

The storage vessel is preferably lagged to conserve heat and contains stainless steel heating coils at its lower end for use when the sealing material in the vessel has been allowed to go solid. All piping of the circulatory system is preferably lagged and provided with steam or electrical trace heating.

From what has been stated earlier, it will be apparent that on its way from each of such cable feeding stations in the return side of the circulatory system to the stranding machine the sealing material must be cooled in order that it may be in a suitable physical condition for application to the cable. As movement in such condition is likely to result in degradation, the return side of the circulatory system should be positioned adjacent the stranding machine in order that the path from each feeding station to the cable may be short, so keeping the degradation of the cooled sealing material moving into the cable to a minimum. It will be apparent that if sealing material is to be bled from this circulatory system, the rate of flow of material through the outward part of the system must substantially exceed the aggregate rate of flow from the system to the cable in order that the system may serve its purpose of maintaining the mass of sealing material in the storage vessel at the required temperature.

We prefer to circulate sealing material at a much higher rate than the aggregate rate at which it is withdrawn for feeding to the cable, for example, at a rate five to ten times as great. Such circulation is preferably effected by a pump having an intake in that part, preferably a lower part, of the storage vessel to which sealing material is returned at the required temperature by the pump. The cable feeding stations are located in the return side of the circulatory system, one near each stranding die of the stranding machine.

The invention will now be described in more detail, and by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic illustration of apparatus suitable for use in providing a multi-conductor cable core with a barrier of sealing material which extends throughout the length of the cable core, whilst the cable core is being manufactured by a conventional stranding machine;

Figure 2 is an end view of an applicator die of the apparatus diagrammatically illustrated in Figure 1, and

Figure 3 is a section on the line III—III in Figure 2.

Referring to Figure 1, the apparatus comprises a thermostatically controlled storage vessel 1 for the sealing material and, connected to the lower part of the vessel, a circulatory system 2 comprising an outward pipe 3, in which are connected a pump 5 and a heat exchanger 6, and a return pipe 4. At each of a plurality of locations spaced at intervals along the length of the return pipe 4, of which three only are shown, is a cable feeding station 11 at which sealing material is continuously bled off from the circulatory system 2 and transferred to the cable core. Each cable feeding station 11 has a metering pump 12 for controlling the rate of flow of sealing material being bled off from the system 2, a device 14 for cooling the bled-off sealing material to effect crystallisation and a die 15 for applying the cooled material to the cable core.

The storage vessel 1 and all piping of the circulatory system 2 are lagged and the piping is provided with steam trace heating. In the lower part of the storage vessel 1 there are provided stainless steel steam heating coils 7 for use when the sealing material in the vessel has been allowed to go solid, as for instance when commencing circulation of the sealing material in preparation for applying sealing material to a cable core.

When the apparatus is in use the sealing material in the thermostatically controlled storage vessel 1 is maintained at a temperature just above that at which crystallisation begins by continuously pumping the material by the pump 5 from the storage vessel, through the circulatory system 2 and back into the storage vessel. If the sealing material being pumped around the system 2 is not at the desired temperature it is brought to that temperature by the heat exchanger 6 which is thermostatically controlled in dependence upon the temperature of the circulating material by a flow regulator 8 for cooling water of the heat exchanger. At each feeding station 11 sealing material, which is at a temperature just above that at which crystallisation begins, is continuously bled off and fed through the cooling device 14 and thence into the applicator die 15 which is preferably located at, or a short distance in advance of, a stranding head of the stranding machine. The rate of flow of sealing material to each applicator die 15 is controlled by its associated meter pump 12 which is located in advance of the cooling device 14 so that movement through the pump takes place whilst the sealing material is still at the circulating temperature and so not liable to be degraded by passage through the pump. Each cooling device 14 is arranged to cool the sealing material

to a temperature at which it is in a suitable physical state for application to the cable core as it passes through the applicator die 15. Circulation of the sealing material through the circulatory system 2 is maintained at a rate five to ten times as great as the aggregate rate at which it is withdrawn from the system at the cable feeding stations 11.

Surplus material spewing from each applicator die 15 is returned to a collecting tank 16 where any loss of temperature may be compensated by trace heating the tank. From the collecting tank 16 the surplus material is pumped by a scavenge pump 18 back through a filter 17 into the circulatory system 2 from which it was withdrawn, entering the return pipe 4 on the return side of the feeding stations 11. At each feeding station 11, a pipe 19, which by-passes the cooling device 14 and applicator die 15 of the station, is provided for feeding sealing material directly from the circulatory system 2 into the collecting tank 16 when required, as for instance preparatory to starting up the sealing operation, or when using the apparatus to provide barriers of material at intervals along the length of a cable core.

As will be seen on referring to Figures 2 and 3, each of the dies 15 by which the sealing material is applied to the cable core during its manufacture comprises a body 21 having a smoothly tapering bore 22 which is bell-mouthed at its entry end and which, at its exit end, corresponds to or is somewhat greater than the circumscribing circle of the cable core passing through the die. The outer surface of the wall of the body 21 is stepped at three locations along its length to form three cylindrical portions, 23, 24 and 25. Portion 23 at the exit end of the die is externally screw threaded. In the portion 24 of the die wall are three ports 26 for entry of sealing material which are distributed uniformly around the axis of the die and are inclined to it so as to impart to the material a component of movement in the same axial direction as the direction of travel of the cable core passing through the die. A sleeve 27, which has an internal diameter corresponding to the external diameter of the cylindrical portion 25 and which has at one end an inwardly directed internally screw threaded flange 28, is screwed on to the end portion 23 of the body 21 until the sleeve fits tightly over the cylindrical portion 25 and abuts the steps thereof. A hole 29 in the wall of the sleeve 27 is bounded by an upstanding continuous wall 31 and provides access for flow of sealing material to an annular chamber 30 lying between the internal surface of the sleeve 27 and the cylindrical portion 24. The wall 31 bounding the hole 29 is internally screw threaded for connection to a pipe carrying sealing material from the cooling device 14 of a feeding station 11. Sealing material is

fed from the annular chamber 30 to the cable core passing through the die via the ports 26.

5 The rate of flow of sealing material into each die 15 is at least sufficient to maintain a "pool" of material in the annular chamber 30 and in the bell-mouth of the die. Surplus material from each die 15, if any, is allowed to fall into its associated collecting tank 16 to be reheated and pumped back into the circulatory system 2 as previously described. The temperature of the sealing material in the bell-mouth of each die 15 is sufficiently low for the heat taken from it by the cable core as the core passes through the material to result in solidification of enough material on the surface of the core to fill the interstices in the core, this solidified material being drawn through the die with the cable core. 15 The temperature is such that this action does not cause cavitation in the sealing material in the bell-mouth of the die.

Although in the foregoing description reference is made to the continuous filling of a single multi-conductor cable core during its manufacture, it will be appreciated that the circulatory system may serve two or more adjacently sited cable making machines. It will also be appreciated that the apparatus described could be simply modified for providing barriers of sealing material at intervals along the length of a cable core by incorporating in each cable feeding station a device for feeding material to the applicator die at periodic intervals, these devices being synchronised to the speed of travel of the cable core, having regard to the spacing of the applicator dies, in order to ensure that the sealing material applied to the cable core by one die coincides with the sealing material applied by the preceding die or each preceding die. 25 30 35 40

WHAT WE CLAIM IS:—

1. A method of providing a multi-conductor cable core with a barrier of sealing material which comprises pumping the sealing material from a thermostatically controlled storage vessel to a cable feeding station whilst at a temperature just above that at which crystallisation begins and cooling the material to effect crystallisation whilst transferring it from said cable feeding station to the cable core. 45 50

2. A method of providing a multi-conductor cable core with a barrier of sealing material which comprises maintaining sealing material in a thermostatically controlled storage vessel at a temperature just above that at which crystallisation begins by continuously withdrawing sealing material from the storage vessel and bringing the withdrawn material to the said temperature by pumping it through one or more than one thermostatically controlled heat exchanger and back to the storage vessel through a return pipe in which is located 55 60 65

a cable feeding station and bleeding-off sealing material being pumped through the return pipe at the cable feeding station and cooling it to effect crystallisation while transferring it from the feeding station to the cable core. 70

3. In the manufacture of a multi-conductor cable core by the conventional stranding process employing a stranding machine having one stranding head, a method of providing the cable core being manufactured with a barrier of sealing material which comprises maintaining the sealing material in a thermostatically controlled storage vessel at a temperature just above that at which crystallisation begins by continuously pumping the material from and back into the storage vessel through a circulatory system having connected therein at least one thermostatically controlled heat exchanger which brings the circulating material to the said temperature, bleeding-off sealing material being pumped through the circulatory system at at least one cable feeding station located in the return side of the system, and transferring the bled-off material from the or each cable feeding station through a separate cooling device, which cools the material to effect crystallisation, and through an applicator die to the cable core, the rate of flow of sealing material through the outward part of the circulatory system substantially exceeding the rate of flow of material from the cable feeding station, or the aggregate rate of flow of material from the cable feeding stations, to the cable core. 75 80 85 90 95

4. A method as claimed in Claim 3, wherein the sealing material flows through the outward part of the circulatory system at a rate of five to ten times as great as the rate, or aggregate rate, at which it is withdrawn from the system for feeding to the cable core. 100 105

5. A method as claimed in Claims 3 or 4, wherein the rate of flow of sealing material from the or each cable feeding station to its associated applicator die is controlled by a metering pump located between the bleed point and the cooling device. 110

6. A method as claimed in any one of Claims 3 to 5, wherein surplus sealing material spewing from the or each applicator die is returned to a collecting tank from which it is pumped back into the circulatory system, preferably entering the system on the return side of the cable feeding station or stations. 115 120

7. A method as claimed in Claim 6, wherein any loss of temperature in the surplus sealing material is compensated by trace heating the collecting tank.

8. Apparatus for use in providing a multi-conductor cable core with a barrier of sealing material comprising a thermostatically controlled storage vessel for storing the sealing material whilst at a temperature which is just above that at which crystallisation begins, a circulatory system for the sealing material 125 130



fed from the annular chamber 30 to the cable core passing through the die via the ports 26.

5 The rate of flow of sealing material into each die 15 is at least sufficient to maintain a "pool" of material in the annular chamber 30 and in the bell-mouth of the die. Surplus material from each die 15, if any, is allowed to fall into its associated collecting tank 16 to be reheated and pumped back into the circulatory system 2 as previously described. The temperature of the sealing material in the bell-mouth of each die 15 is sufficiently low for the heat taken from it by the cable core as the core passes through the material to result in solidification of enough material on the surface of the core to fill the interstices in the core, this solidified material being drawn through the die with the cable core. 20 The temperature is such that this action does not cause cavitation in the sealing material in the bell-mouth of the die.

Although in the foregoing description reference is made to the continuous filling of a single multi-conductor cable core during its manufacture, it will be appreciated that the circulatory system may serve two or more adjacently sited cable making machines. It will also be appreciated that the apparatus described could be simply modified for providing barriers of sealing material at intervals along the length of a cable core by incorporating in each cable feeding station a device for feeding material to the applicator die at periodic intervals, these devices being synchronised to the speed of travel of the cable core, having regard to the spacing of the applicator dies, in order to ensure that the sealing material applied to the cable core by one die coincides with the sealing material applied by the preceding die or each preceding die.

WHAT WE CLAIM IS:—

45 1. A method of providing a multi-conductor cable core with a barrier of sealing material which comprises pumping the sealing material from a thermostatically controlled storage vessel to a cable feeding station whilst at a temperature just above that at which crystallisation begins and cooling the material to effect crystallisation whilst transferring it from said cable feeding station to the cable core.

55 2. A method of providing a multi-conductor cable core with a barrier of sealing material which comprises maintaining sealing material in a thermostatically controlled storage vessel at a temperature just above that at which crystallisation begins by continuously withdrawing sealing material from the storage vessel and bringing the withdrawn material to the said temperature by pumping it through one or more than one thermostatically controlled heat exchanger and back to the storage vessel through a return pipe in which is located

a cable feeding station and bleeding-off sealing material being pumped through the return pipe at the cable feeding station and cooling it to effect crystallisation while transferring it from the feeding station to the cable core. 70

3. In the manufacture of a multi-conductor cable core by the conventional stranding process employing a stranding machine having one stranding head, a method of providing the cable core being manufactured with a barrier of sealing material which comprises maintaining the sealing material in a thermostatically controlled storage vessel at a temperature just above that at which crystallisation begins by continuously pumping the material from and back into the storage vessel through a circulatory system having connected therein at least one thermostatically controlled heat exchanger which brings the circulating material to the said temperature, bleeding-off sealing material being pumped through the circulatory system at at least one cable feeding station located in the return side of the system, and transferring the bled-off material from the or each cable feeding station through a separate cooling device, which cools the material to effect crystallisation, and through an applicator die to the cable core, the rate of flow of sealing material through the outward part of the circulatory system substantially exceeding the rate of flow of material from the cable feeding station, or the aggregate rate of flow of material from the cable feeding stations, to the cable core. 75 80 85 90 95

4. A method as claimed in Claim 3, wherein the sealing material flows through the outward part of the circulatory system at a rate of five to ten times as great as the rate, or aggregate rate, at which it is withdrawn from the system for feeding to the cable core. 100 105

5. A method as claimed in Claims 3 or 4, wherein the rate of flow of sealing material from the or each cable feeding station to its associated applicator die is controlled by a metering pump located between the bleed point and the cooling device. 110

6. A method as claimed in any one of Claims 3 to 5, wherein surplus sealing material spewing from the or each applicator die is returned to a collecting tank from which it is pumped back into the circulatory system, preferably entering the system on the return side of the cable feeding station or stations. 115

7. A method as claimed in Claim 6, wherein any loss of temperature in the surplus sealing material is compensated by trace heating the collecting tank. 120

8. Apparatus for use in providing a multi-conductor cable core with a barrier of sealing material comprising a thermostatically controlled storage vessel for storing the sealing material whilst at a temperature which is just above that at which crystallisation begins, a circulatory system for the sealing material 125 130

in which are connected means for continuously withdrawing sealing material from the storage vessel, driving it through the system and back into the vessel and means for bringing the material flowing through the system to the said temperature and, at one or at each of more than one location in the return side of the system, a cable feeding station at which sealing material is bled-off from the system, the feeding station having means for cooling the bled-off sealing material to effect crystallisation and means for applying the material to the cable core.

9. Apparatus for use in providing a multi-conductor cable core with a barrier of sealing material comprising a thermostatically controlled storage vessel for storing the sealing material whilst at a temperature just above that at which crystallisation begins, a circulatory system for the sealing material in which are connected a pump for continuously withdrawing sealing material from the storage vessel, driving it through the system and back into the vessel and at least one thermostatically controlled heat exchanger for bringing the material flowing through the system to the said temperature and, at one or at each of more than one location in the return side of the system, a cable feeding station having a metering pump for controlling the supply of sealing material being bled-off from the system, a device for cooling the bled-off sealing material to effect crystallisation and a die for applying the material to the cable core.

10. Apparatus as claimed in Claim 9, wherein a heated tank is associated with the or each applicator die for collecting surplus material spewing from the die, a pipe extends from the collecting tank and is connected to the circulatory system on the return side of the cable feeding station or stations, and a scavenge pump is provided for pumping the surplus material from the tank back into the system.

11. Apparatus as claimed in Claim 10, wherein provision is made for by-passing the applicator die and feeding sealing material directly from the circulatory system into the collecting tank as required.

12. Apparatus as claimed in any one of Claims 9 to 11, wherein the or each applicator die has a smoothly tapering bore which at its exit end corresponds to or is somewhat greater than the circumscribing circle of the

cable core passing therethrough, the wall of the bore having a number of ports for entry of sealing material.

13. Apparatus as claimed in Claim 12, wherein the ports of the applicator die extend between the bore and an annular chamber bounded by a part of the outer surface of the die wall and an outer sleeve which is in screw-threaded engagement with the die and which has in its wall a hole for entry of sealing material into the annular chamber.

14. Apparatus as claimed in Claim 12 or 13, wherein the ports of the applicator die are distributed uniformly around the axis of the die and are inclined to it so as to impart to sealing material entering the die a component of movement in the same axial direction as the direction of travel of the cable core.

15. Apparatus as claimed in any one of Claims 8 to 14, wherein all piping of the circulatory system is lagged and at least some of the piping is provided with steam or electrical trace heating.

16. Apparatus as claimed in any one of Claims 8 to 15, wherein the storage vessel is lagged and contains heating coils at its lower end for use when the sealing material in the vessel has been allowed to go solid.

17. Apparatus as claimed in any one of Claims 8 to 16, wherein the return side of the circulatory system is positioned adjacent a stranding machine by which the cable core is being manufactured in order that the path from the or each cable feeding station to the cable core is short.

18. Apparatus as claimed in Claim 17, wherein the or each applicator die is located at or near a stranding head of the stranding machine.

19. Apparatus for use in providing a multi-conductor cable core with a barrier of sealing material substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

20. A method of providing a multi-conductor cable core with a barrier of sealing material substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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