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EP A2 0015425
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Selected US specifications from IPC sub-class G02B

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(54) Self-supporting optical fibre cable element

(57) An optical fibre cable element 3A, for incorporation in an optical fibre cable 30, 31 for e.g. local area networks, comprises a plurality of optical fibres 3 held together solely by complete immersion in an adhesive at 6 which may be applied cold and air-dried at 8. A suitable adhesive material is a solvent-based acrylic copolymer system. Preferably the shape of the cable element is a ribbon.

Fig.1.

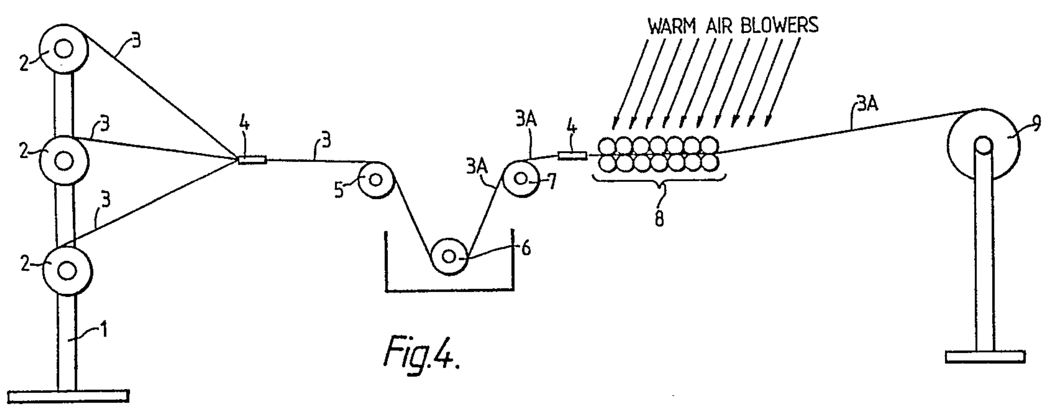

Fig.4.

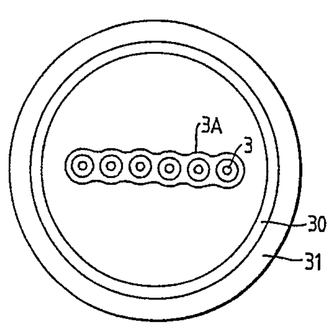

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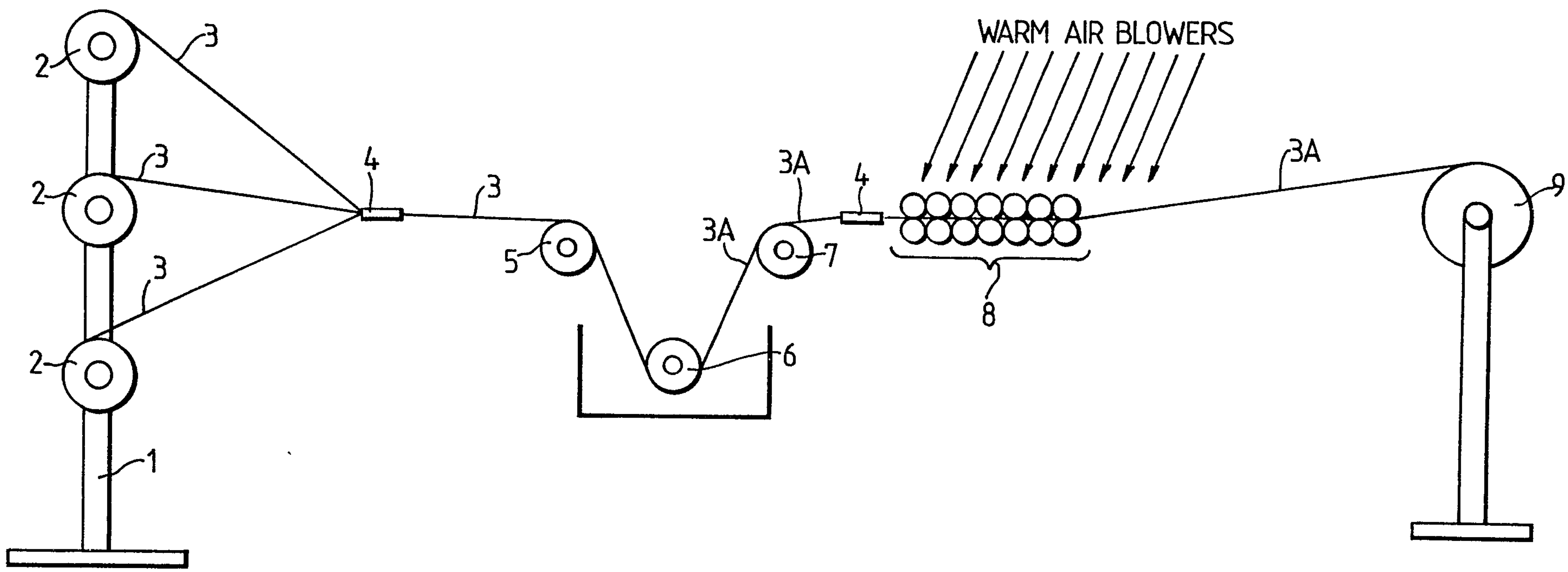
Fig.1.



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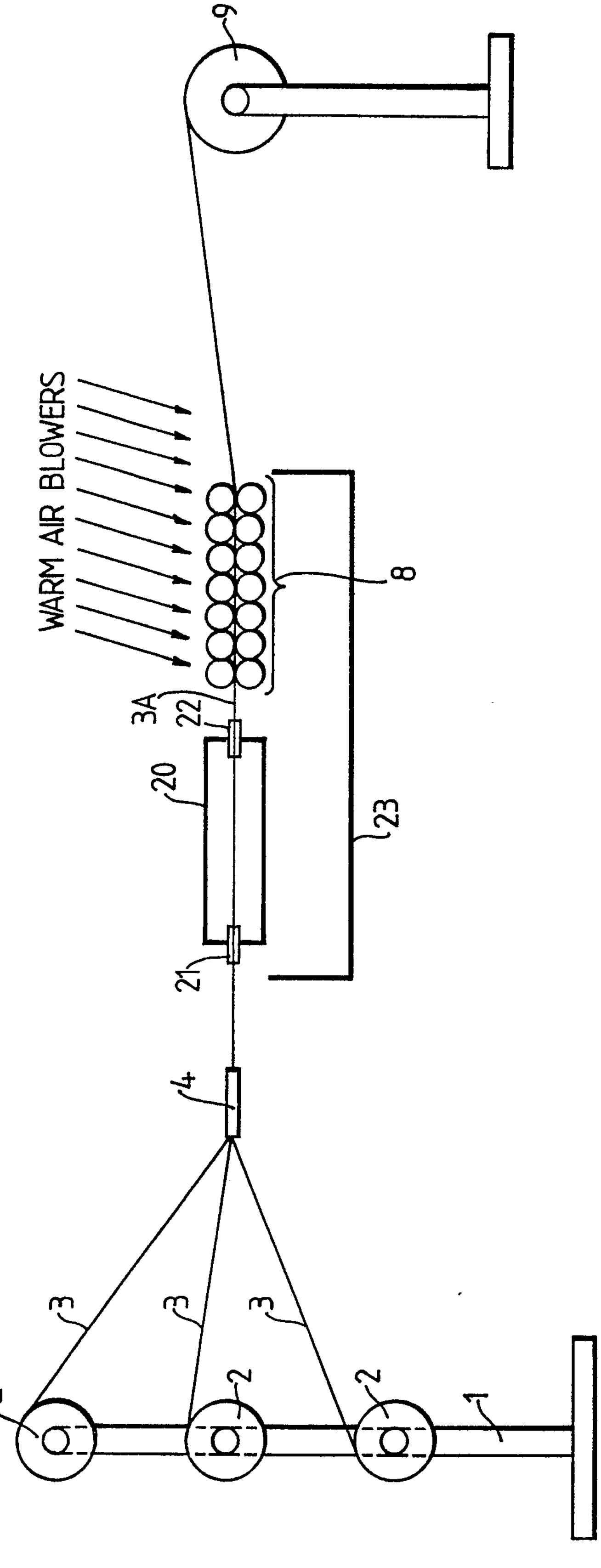


Fig. 2.

Fig.3.

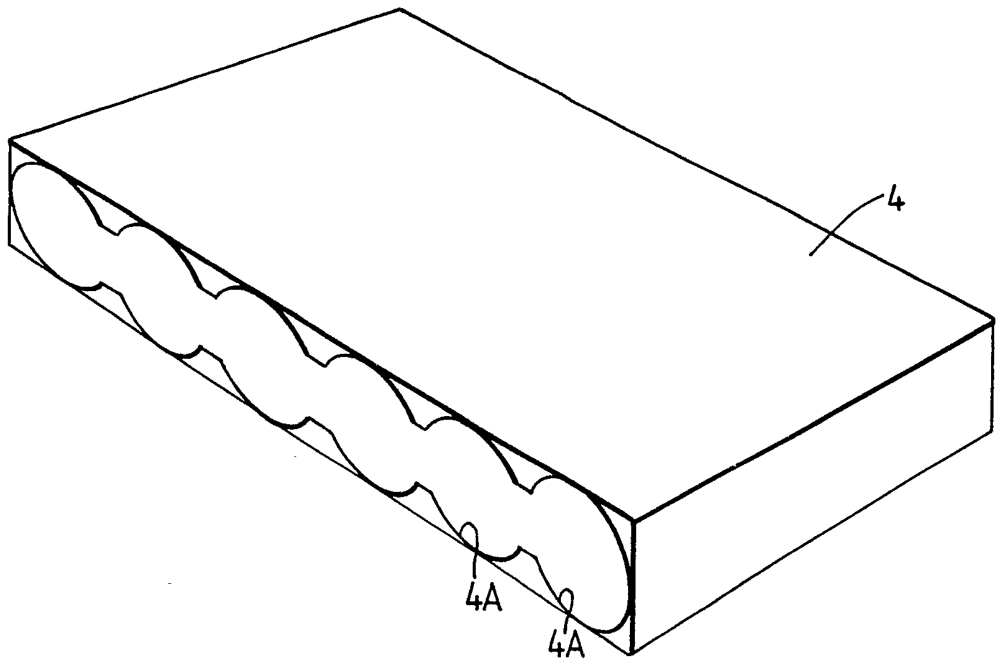
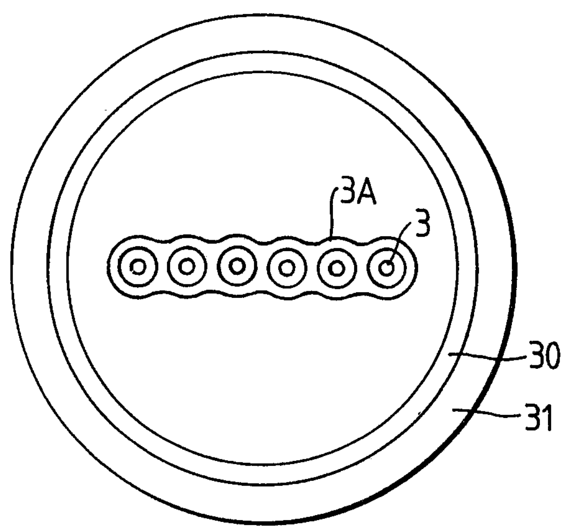
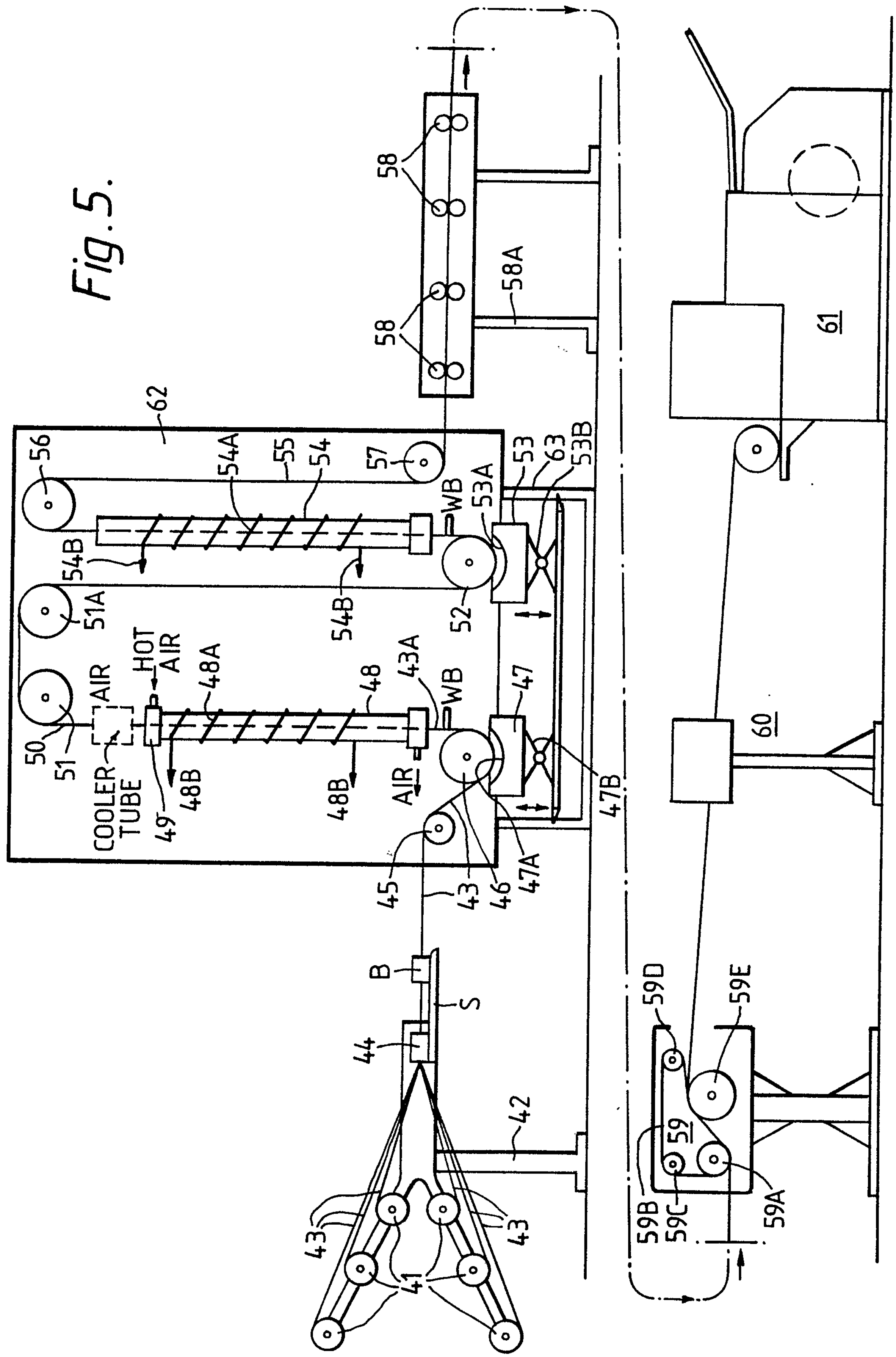


Fig.4.




62
56
54A
55
54
57
WB
53A
53
63
53B
54B
51A
52
HOT AIR
AIR
48A
48
43A
47
50
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COOLER TUBE
49
48B
AIR
47B
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43
46
47A
B
S
44
42
41
58
58A
61
60
59D
59E
59
59B
59C
59A
Fig. 5.

Fig.6A.

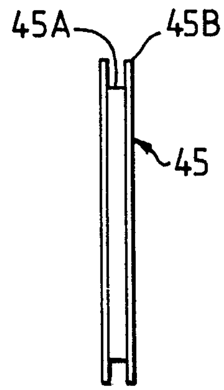


Fig.6B.

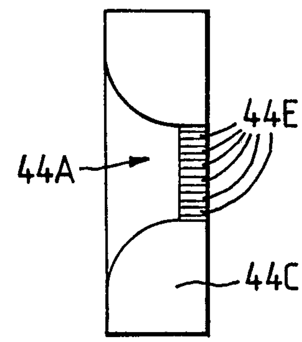


Fig.6C.

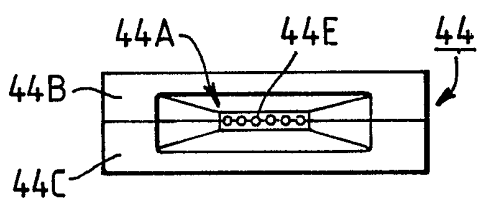


Fig.6D.

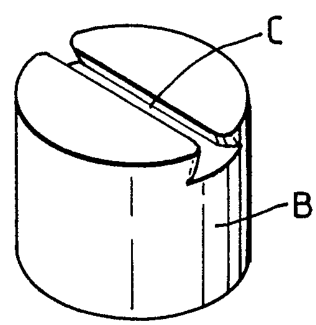


Fig. 7. GRAPH OF GLUE-COATING THICKNESS VERSUS LINE SPEED FOR UN-INKED A AND B FIBRES FOR DIFFERENT "TEMPRO" CONCENTRATIONS.

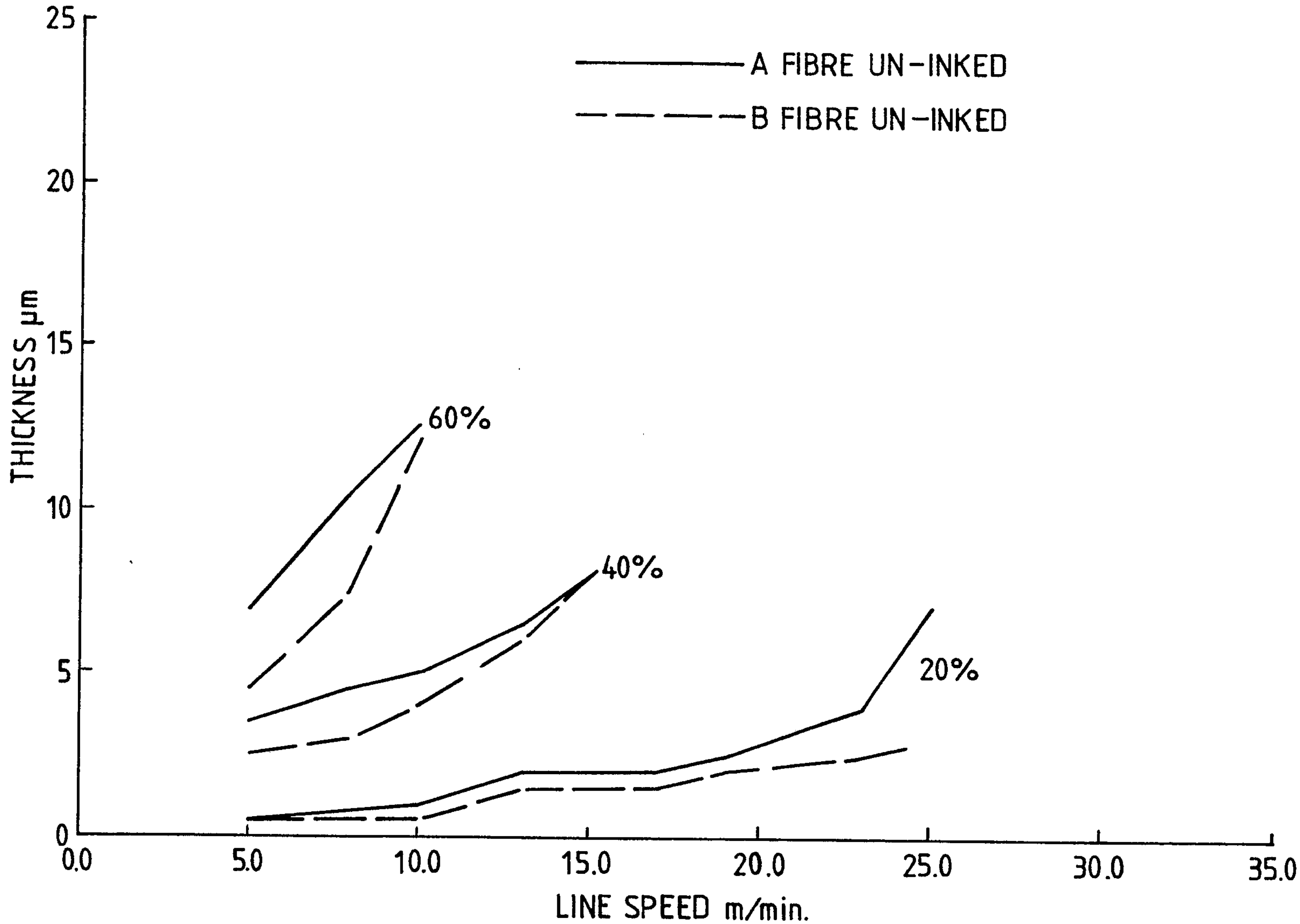
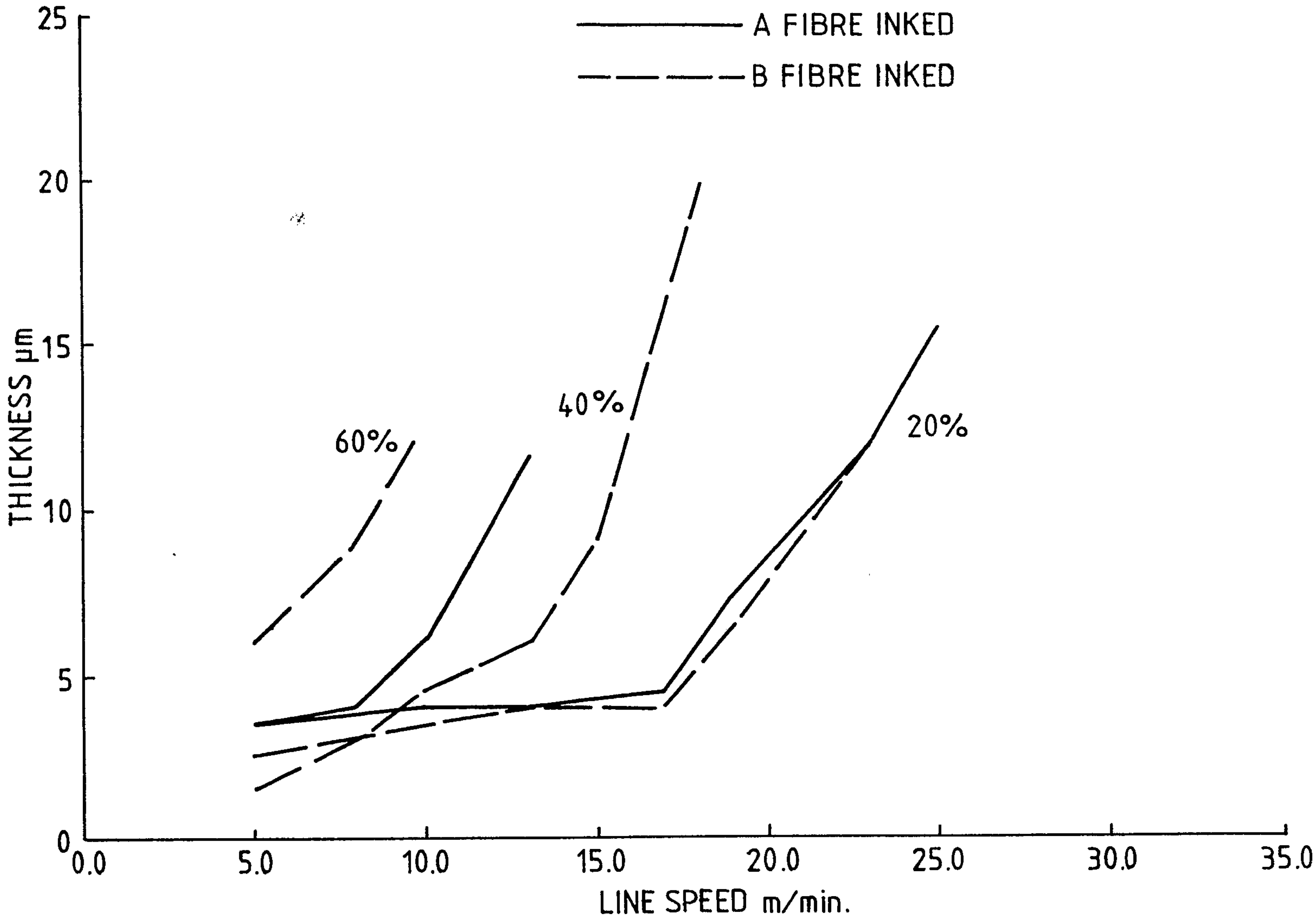


Fig.8. GRAPH OF GLUE-COATING THICKNESS VERSUS LINE SPEED FOR INKED A AND B FIBRES FOR DIFFERENT "TEMPRO" CONCENTRATIONS.



SPECIFICATION

Optical fibre cable

This invention relates to optical fibre cable, incorporating loose optical fibre elements, particularly to the manufacture of such elements.

Optical fibre cables incorporating ribbon optical fibre elements are known. For example the Bell System cable design comprises individual optical fibres coated with ultraviolet-cured epoxy-acrylate coatings and twelve parallel fibres are sandwiched between two adhesive-faced polyester tapes to make a flat ribbon. During the manufacturing process, heat is applied to the polyester tape to heat seal the lateral edges and also to cause the adhesive to adher to the fibres and cure. This could be up to 100°C, typically 70° or 80°C. These ribbons can then be stacked together and incorporated into a cable sheath, one example being a crossply circular sheath followed by a conductive shield, a stainless protection and a final bonded polyethelene jacket to provide a complete cable structure.

Another type of ribbon cable element is described in British Patent Application 2141558A and comprises a number of optical fibres each having an outer acrylate coating, being drawn in side-by-side relationship through a bath with an extrusion head which provides an overall coating of acrylate around the fibres and a pair of reinforcing elements at the extremities of the fibres, thus forming an acrylate-coated reinforced optical fibre array. This array is sandwiched between a pair of polyethylene terephthalate tapes which are squeezed onto the array which is cured by ultraviolet radiation in an oven typically 70° or 80°C. The tapes are removed and are simply used to shape and process the optical fibre ribbon array.

Another optical fibre ribbon cable element is described in British Patent Application 2036599A in which optical fibre elements are embedded in plastics material which is extruded under pressure from an extruder around the optical fibres, which are passed through the extruder head.

All these known constructions described above suffer from the disadvantage of having to apply significant heat and/or pressure to the fibres at some stage and of complex and expensive manufacturing processes and also it is not easy to separate individual fibres from the ribbon in order to effect individual splices or connection in the field.

Yet another ribbon element is known from European Patent Application 0170185A3. One way of making this element is to form (see Figure 4 thereof) a film on the surface of a drum and adhere the fibres to the film. Polymerization affected by UV radiation or in an alternative arrangement, by heating. However such an arrangement provides a very weak and flimsy element which is unlikely to be suitable for use in a loose tube optical fibre cable without additional support, so that microbending and lack of protection will result and the fibres are likely to break away from the film.

It is an object of the present invention to provide a cheap optical fibre cable element comprising a plurality of fibres held in a unitary structure particularly but not exclusively a ribbon structure, for incorporation in an optical fibre cable.

According to one present invention there is provided a method of manufacturing an optical fibre cable element comprising supporting a plurality of optical fibres in side-by-side relationship and applying an adhesive material to the fibre by completely immersing the fibres in the adhesive and solidifying and hardening the material to thereby provide a ribbon element.

According to another aspect of the present invention there is provided apparatus for manufacturing an optical fibre cable element characterised by comprising a series of fibre guides arranged to support a plurality of optical fibres in side-by-side relationship, a reservoir for containing liquid adhesive material, means for hardening the adhesive where it is in the fibres, and means for drawing the fibres over the guides, the apparatus being so constructed and arranged that the fibres will become fully immersed in the adhesive material and the adhesive will become hardened to fully encapsulate the fibres and provide a self-supporting ribbon element.

Preferably the element is in the form of a ribbon containing upto twelve optical fibres in side-by-side relationship.

Preferably the adhesive material is a solvent-based acrylic co-polymer system which is air-dried.

In order that the invention can be clearly understood reference will now be made to the accompanying drawings in which:-

Figure 1 shows a manufacturing process for a ribbon optical fibre cable element according to an embodiment of the invention;

Figure 2 shows and alternative manufacturing process for the ribbon optical fibre cable element;

Figure 3 shows part of the apparatus of Figures 1 and 2;

Figure 4 shows a cross-section through an optical fibre cable incorporating a ribbon element according to an embodiment of the present invention;

Figure 5 shows a manufacturing process for a ribbon optical fibre cable element according to a further embodiment of the present invention;

Figures 6 shows details of Figure 5, and

Figures 7 and *8* are graphs showing the variation in adhesive coating thickness with line speed for un-inked (Figure 7) and inked (Figure 8) fibres using the process shown in Figures 5 and 6.

Referring to Figure 1 a fibre payoff stand 1 carries reels 2 of acrylate coated fibres 3 which are drawn through a fibre guide 4 such as the one shown in Figure 3 of the accompanying drawings. This guide maintains the fibres in flat side-by-side relationship with their adjacent sides not quite touching.

The fibres are then drawn over a first roller 5 around a second roller 6 located in a dip tank and up and around a third roller 7. The dip tank contains an air drying adhesive material and a particularly suitable material is that sold under the trade name Tempro 20 manufactured by Imperial Chemical Industries. This particular material is a water-based acrylic copolymer system which dries in air extremely quickly to form a tough coating. It is intended as a temporary protective coating system for e.g. motor vehicles, but we have found that it is suitable as an adhesive to form a ribbon cable element.

This as the fibres are immersed in the acrylic copolymer in the dip tank they become completely coated at ambient pressure and as they leave the dip tank and pass around the roller 7 they are passed through a second fibre guide 4 similar to the first one and also as shown on a larger scale in Figure 3 of the drawings. From there the coated fibres 3A pass through a roller assembly 8 over which air is blown at ambient temperature typically in the range of 15° to 40°C as indicated by the arrows and the coated fibres in the form of a ribbon are taken up around a ribbon take up spool 9.

It is envisaged that the guide pulleys 5, 6 and 7 can be cylindrical with smooth surfaces, but it may be necessary to have grooved guide pulleys so as to maintain exactly the desired side-by-side relationship of the optical fibres in the formation of the ribbon cable element, the grooves in the pulleys having a spacing corresponding to the fibre guides 4. Likewise the roller assembly 8 may also be found to be more effective with a grooved surface to once again maintain the side-by-side alignment.

Referring to Figure 2 an alternative arrangement is shown, although similar reference numerals indicate similar parts as with Figure 1. Thus the optical fibres 3 are drawn from pulleys 2 on a fibre payoff stand 1 through a fibre guide 4. Instead of the dip tank shown in Figure 1, there is a coating bath 20 having entry and exit dies 21 and 22. These would be similar in construction to the fibres guides 4 but would also act to prevent leakage of the coating material from the coating bath 20. Once again the coating material would be the acrylic copolymer system applied at ambient temperature and pressure as described with reference to Figure 1 and any leakage or overflow is caught in the reservoir 23 and can (although not shown in the drawing) be returned to the coating bath 20. As another alternative the coating bath 20 could be replaced by a spray bath, still with the guide dies 21 and 22.

From the exit die 22, the coated fibres 3A in the form of a ribbon are drawn through the roller assembly 8 and once again air at ambient temperature, typically in the range 15° to 40°C, is blown as indicated by the arrows to allow the coating to set as quickly as possible, and the ribbon element so formed is taken up on a take up spool 9.

Referring to Figure 3 of the drawings the fibre guide comprises a PTFE block 4 defining a plurality of circular apertures 4A through which the bare optical fibres are a sliding fit and so that the adjacent surfaces of the fibres do not quite touch one another.

The acrylic copolymer described gives a coating thickness of about 6microns and it has been found that a satisfactory ribbon cable element is produced.

Referring to Figure 4 an example of an optical fibre cable incorporating a ribbon element made by the method shown in Figure 1 or Figure 2 is shown. The ribbon element comprises six acrylate coated optical fibres 3 in a ribbon format and held together solely by the acrylate copolymer system 3A around the fibres 3. The system 3A preferably has good water blocking properties to prevent water contacting the fibres. This ribbon cable element is housed in an extruded plastics sheath 30 surrounded by a strength member 31 which is optional. The strength member may be braided wires or non-metallic strength members. There could be other ribbon elements such as 3A within the cable and there could also be incorporated longitudinal water-blocking material in the cable.

One significant advantage of the present invention is the use of a cold adhesive material to form the ribbon cable element whereas all previous proposals for manufacturing ribbon cable elements have required the use of relatively high temperatures and/or pressures in order to form the ribbon element, either through the use of a high temperature extruder to extrude the material or by the use of high temperature to cause adhesion and curing of plastics material around the optical fibres.

Another significant advantage is the higher fibre count per unit volume provided by the ultra-thin system 3A causing the fibres, i.e. a coating of the order of 6 microns around the fibres and between the fibres. The ambient drying temperature chosen is that which most quickly dries the system 3A. Under some circumstances this might be as low as 5°C i.e. a cold ambient air blow.

An improved system is shown in Figure 5. Primary acrylate-coated fibres 43 are fed from braked fibre pay-off drums such as 41 supported on frame 42 via a fibre guide and die block 44 which is shown in greater detail in Figure 6B and 6C. It comprises a two-part rectangular die block of brass with a trumpet-shaped aperture 44A, and made of two similarly-shaped parts 44B, 44C which can be separated. The aperture 44A at its smaller end is formed by a stainless steel insert 44D defining size discrete grooves 44E, are for each of the six fibres.

From the die block 44 the fibres pass side-by-side into the guide channel C of a guide channel block B supported on a cantilever support S and shown in greater detail in Figure 6D. The channel has smoothly rounded ends and a flat bottom also with rounded ends, to minimise fibre bending and move the fibres with closer proximity with each other. Thus the width of channel C is less than the width of the insert defining the grooves 44E. Although only six fibres are shown, up to twelve fibres could be used.

The fibres 43 pass from the block B over a guide pulley 45 which has a cylindrical surface 45A with raised sidewalls 45B (Figure 6A) and allows the fibres to lie in the correct predetermined side-by-side relationship as determined by the block B. An applicator pulley 46 also having a cylindrical surface with raised sidewalls (Figure 6A) feeds the fibres into an adhesive dip-bath 47 still maintaining the correct side-by-side positioning. This completely coats the fibres in a water-based acrylic co-polymer system adhesive 47A "Tempro 20" in the dip bath and the coated fibres 43A then ascend within a drying tube 48 in which drying air is blown through and parallel to the fibres by an air mover 49 (Brauer) at the bottom of the tube.

This air mover 49 is designed to prevent any vibration of the fibres so that the relative positioning of the fibres in the drying tube is not disturbed by the air movement within the tube. The temperature of the tube 48 is controlled by a heater tape 48A which is wrapped around the tube and connected to an electrical supply 48B. Alternatively the heater tape can be dispensed and the air can be heated by an electric heater before it enters the tube 48. For example a hot air gun can be used to drive hot air into the tube via the airmover and the air flow is preferably from top to bottom of the tube.

Within the drying tube 48 the fibres become bonded together as a unitory ribbon element 50 by the adhesive which dries as a film completely encapsulating the fibres. The surface tension of the adhesive draws the fibres together and maintains the fibres side-by-side until the adhesive dries and the side by side posistion is fixed. The tension in the fibres prevents any of the fibres pulling over and crossing another fibre between B and 51. The element 50 emerges from the drying tube 48 and passes around an upper guide pulley 51 which is similar to that of Figure 6A.

The element 50 descends to a further pulley 52, similar in shape to pulley 46 (Figure 6A) in a second dip-bath 53 with adhesive 53A. A second drying tube 54 is used as shown for the drying of the adhesive. The second tube would be similar in all respects to the tube 48 with an air mover too. The element is then passed through the second drying tube 54 heated by heater 54A powered from supply 54B and this forms a second adherent coating on the element indicated by reference numeral 55.

The doubly coated fibres pass over pulley 56 and under pulley 57, both similar to Figure 6A, and into pairs of nip rollers 58 which are cylindrical nulon rollers which maintain the element 55 flat and warp-free prior to entry into the capstan 59. This comprises a capstan driver wheel 59A, and a fibrous belt 59b stretched between two idler pulleys 59C, 59D and co-operating with wheel 59E to draw the element 55 through.

There is a tension controller 60 to ensure that minimal tension is applied to the element during take up on take up equipment 61.

The temperature in the drying tubes is maintained at between 60°C and 80°C. This provides a thermal cure necessary to ensure a smooth tack-free coating. The temperature in the tubes can be controlled by regulating the air flow rate and the power to the heating elements 48a, 54a.

Coating trials were carried out on two different fibres, inked and uninked, for different line speeds, using only one dip bath and drying tube and taking the element 50 directly to the pulley 57 (see indication by dot-dash line 62) the following glue compositions:

	Base resin (%)	*Diluent (%) (Solvent)*
i)	20 (= 9.6% solids content	80
ii)	40	60
iii)	60	40
iv)	80	20
v)	100 (= 48% solids content	0

Figures 7 and 8 show the graphs of glue-coating thickness for increasing line speeds for different resin concentrations, for both inked and uninked on-line coated fibres respectively. Concentrations as referred to later means the amount of base resin in the mixture. The heat tube temperature was constant around 65°C. From these figures in the graphs the following deductions can be made. For a fixed resin concentration, the glue-coating thickness appears to increase non-linearly with the line speed. For a fixed resin composition and line speed, a thicker glue-coating is obtained for fibre A, both inked and uninked, compared to fibre B.

A greater coating thickness is obtained for inked fibres compared to uninked fibres, both for A and B fibres respectively. We discovered that a smooth non-tacky coating is obtained for resin concentration up to 60% for line speeds of up to 10m/min. However for 20% concentration, smooth coatings can be obtained for increased line speeds up to 15 m/min. For resin concentrations greater than 60%, globulation occurred along with tacky coating. Hence trials were limited to 60% resin concentration. We presently believe a base resin content providing a solids content in the range 15% to 20% to be ideal. The material we use preferably comprises about 50% of an iso-propanol/secondary butanol mix together with the solvent diluent containing iso-propanol/secondary butanol.

The mechanics of the line were found to be important in providing a stable coating. In particular the position and quality of the top pulley above the exit of drying tubes is critical and the alignment of the pulleys 45 and 46 with each other and with the die 44 is also critical. For this reason the whole coating and drying apparatus, including items 45 to 57, are mounted on a back plate 62 supported on a frame 63 so that all the pulleys are strictly on parallel axes and it is also very important that the feed of the side by side fibres 43 is directed exactly normal to the axes of the pulleys particularly pulley 45.

It should be noted that the coating baths 47 and 53 are on bases 47B, 53B, which can be operated (they have a scissor-like action) to raise and lower the baths.

It may in some circumstances be required to maintain the fibres in the dip baths spanning two pulleys (only one 46 is shown) so that the adhesive has easy access to all sides of the fibres. A level sensor will be incorporated in the dip baths and emerged to maintain a predetermined level of adhesion in the baths. Further a wiper brush WB is shown for wiping surplus material from the fibres prior to entry in the drying tubes. The width of the pulleys such as 45, 46 etcetera is about 6mm. The width of the ribbon is determined by the size of the fibres and the viscosity of the adhesive where surface tension draws the fibres together.

It is also proposed to provide a cooler tube about 1 metre long above the heating tube 48 and before the element 50 contacts pulley 51 and this is indicated in broken line in Figure 5. Cold air is blown through in the same way that the hot air is blown through the tube 48 and this cools the element 50 to between 0°C and 20°C to ensure that the element coating is hardened before it runs around pulley 51. This ensures that the dried adhesive is not still soft due to temperature when it touches the pulley, otherwise a slight tackiness of the dried resin may cause the pulley to stick to the element and/or damage the adhesive coating on the fibres.

Similarly a second cooler (not shown) could be used after heater tube 54 before pulley 56 is contacted.

CLAIMS

1. A method of manufacturing an optical fibre cable element comprising supporting a plurality of optical fibres in side-by-side relationship and applying an adhesive material to the fibre by completely immersing the fibres in the adhesive and solidifying and hardening the material to thereby provide a ribbon element.

2. A method as claimed in claim 1, wherein heated gas is blown over the applied adhesive material.

3. A method as claimed in claim 1 or claim 2, wherein the adhesive material is a solvent-based system which is air-dried.

4. A method as claimed in claim 3 wherein the adhesive material comprises an iso-propanol/secondary butanol mix and a solvent.

5. A method as claimed in any of claims 1 to 4 where the adhesive material is applied by dipping the optical fibres beneath the surface of a liquid bath of the adhesive material.

6. A method as claimed in any one of claims 1 to 4, wherein the adhesive is applied by drawing the fibres through a coating bath via an extrance die at one side and an exit die at the other side.

7. A method as claimed in claim 3, wherein the adhesive is a solvent-based acrylic copolymer system.

8. A method as claimed in any preceding claim wherein the adhesive is applied at or close to ambient pressure.

9. A method as claimed in claims 1 to 8, wherein the fibres are guided from supply reels through a die which is out of contact with the adhesive material and which provides the side-by-side relationship.

10. A method as claimed in claims 1 to 9, wherein the coated fibres are dried by drawing the fibres upward through a heated drying tube.

11. A method as claimed in any preceding claim wherein the fibres are held in close proximity in their side by side relationship by the surface tension of the adhesive before it dries on the fibres.

12. A method as claimed in any preceding claim, wherein the fibres are maintained under a tension while being transported during the application of the adhesive material and during curing of the material, wherein the surface tension of the adhesive draws the fibres together and the tension in the fibres prevents fibres crossing one another.

13. A method of manufacturing an optical fibre cable element, substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 3, 5, 6 and 7 of the accompanying drawings.

14. An optical fibre cable element made according to a method as claimed in any of claims 1 to 13.

15. An optical fibre cable element substantially as hereinbefore described with reference to and as illustrated in Figures 1 to 3, 5, 6 and 7 of the accompanying drawings.

16. An optical fibre cable incorporating an optical fibre cable element as claimed in or made by the method as claimed in any preceding claim.

17. An optical fibre cable substantially as hereinbefore described with reference to and as illustrated in Figure 4 of the accompanying drawings.

18. Apparatus for manufacturing an optical fibre cable element characterised by comprising a series of fibre guides arranged to support a plurality of optical fibres in side-by-side relationship, a reservoir for containg liquid adhesive material, means for hardening the adhesive where it is in the fibres, and means for drawing the fibres over the guides, the apparatus being so constructed and arranged that the fibres will become fully immersed in the adhesive material and the adhesive will become hardened to fully encapsulate the fibres and provide a self-supporting ribbon element.

19. Apparatus for manufacturing an optical fibre cable element, substantially as hereinbefore described with reference to the accompanying drawings.

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