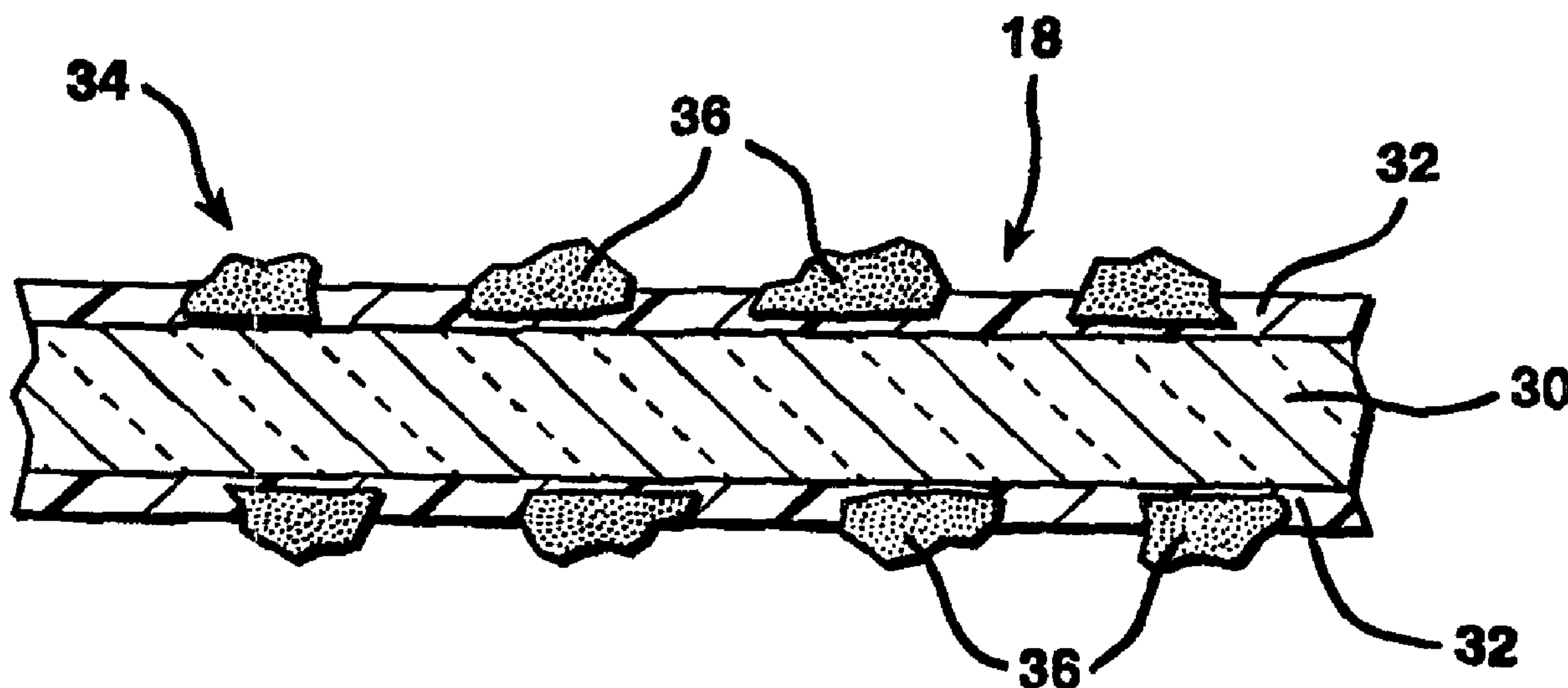




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 (54) Title: WATER BLOCKING OPTICAL CABLE REINFORCEMENT



(57) Abrégé/Abstract:

An optical cable reinforcement in the form of glass fiber strands (30) having a first coating (32) of a binding agent such as a latex mixture and a second coating (34) of particles (36) of a water-blocking agent such as a polyacrylate salt. The particles (36) of water-blocking agent are adhered to the glass fiber strands (30) by the binding agent without the binding agent entirely coating the particles of water-blocking agent. The unoccluded surface areas of water-blocking agent thus provided serve to rapidly absorb/desorb water and protect the optical cable from moisture. A unique powder coating station (60) is used to apply the particles (36) of water-blocking agent to glass fiber strands (30) which have been coated with wet binding agent so that the proper adherence of the particles (36) of water-blocking agent without complete embodiment is obtained.

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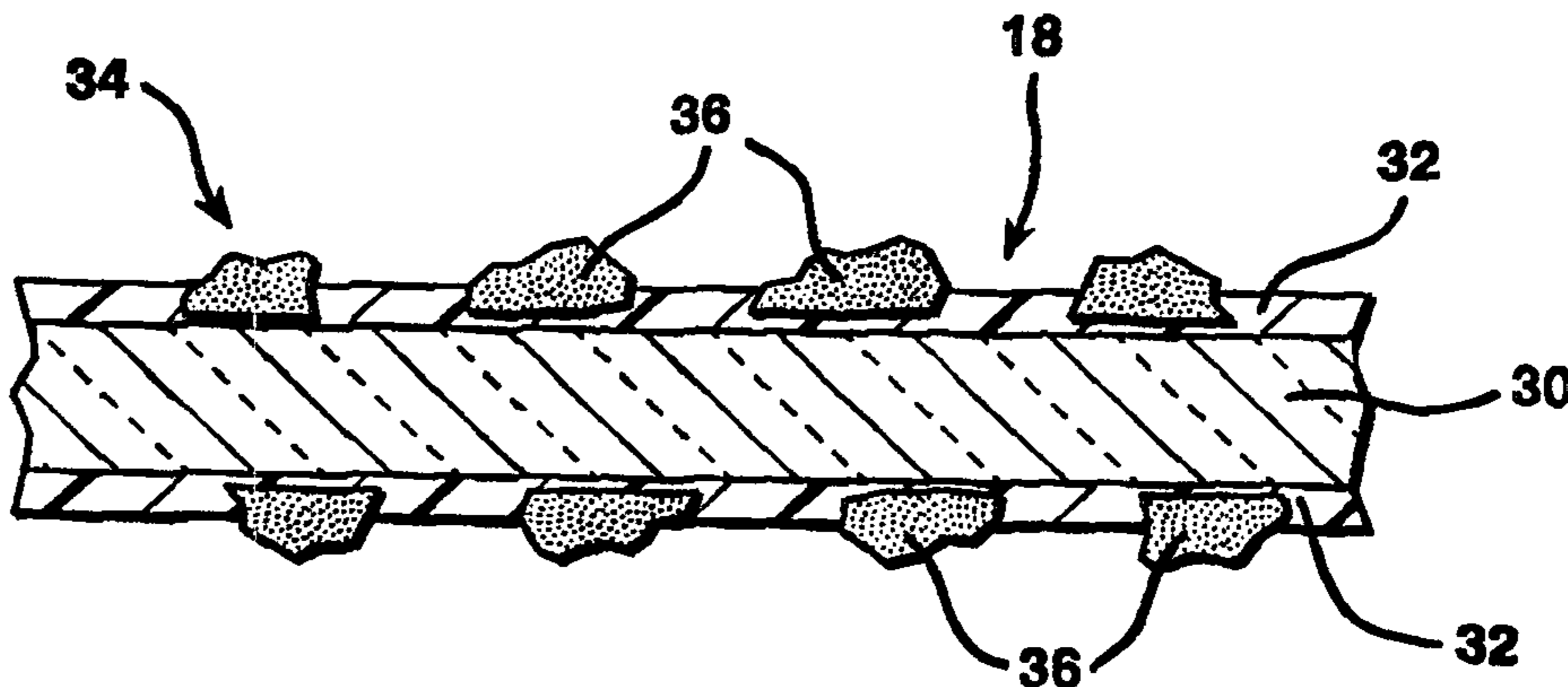
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unique powder coating station (60) is used to apply the particles (36) of water-blocking agent to glass fiber strands (30) which have been coated with wet binding agent so that the proper adherence of the particles (36) of water-blocking agent without complete embodiment is obtained.



WATER BLOCKING OPTICAL CABLE REINFORCEMENT**TECHNICAL FIELD**

The present invention relates to an optical cable reinforcement containing a
5 water-blocking agent and, more particularly, it relates to a glass fiber reinforcing material of
glass fiber strands which have been coated with a binding agent and then coated with a
water-blocking agent, and the method of making that glass fiber reinforcing material.

BACKGROUND

As is well known, moisture is a major problem for optical cables. Three
10 relatively distinct techniques have been suggested to prevent or restrict migration of
moisture along cable passageways.

In one of these techniques, water-repellent materials are included in the cable
structures. These water-repellent materials normally include hydrophobic greases or gels
which are caused to fill cable passageways containing the fibers. There are problems
15 associated with the use of greases or gels. For instance, such materials are difficult and
costly to apply into and fill cable passageways, the filling operation necessarily taking place
as parts of the cable which define the passageways are being formed. In more practical
terms, tubes are made for enclosing the fibers, the tubes being extruded around the fibers as
the fibers are guided through an extruder head together with the grease or gel which is
20 applied into the tube under pressure. Grease or gel also makes it difficult and unpleasant to
handle the fibers during installation or repair of a cable, and at low temperatures (e.g. below
0°C) change in viscosity of the grease or gel surrounding and contacting fibers may increase
signal attenuation in the fibers. A further problem is that because greases or gels may be
incompatible with economically desirable plastics which could normally be extruded as
25 tubes for containing the fibers, more expensively engineered polymers may be required for
the tubes.

In another technique for preventing or restricting migration of moisture
along the cable passageways, it has been suggested that the passageways should purposely
remain unobstructed, and pressurized gas (i.e., air) is pumped into the passageways to
30 maintain a moisture-free environment. Thus, pressurized air is caused to flow along
grooves formed in a central plastics member of the cable so that the pressurized air can
reach into spaces between tubes which surround the plastics member, each of the tubes
containing optical fibers. With such an arrangement, air flow detectors would be provided

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to sense a change in air flow rate, upon an escape of air through a damaged region in the outer elements of the cable, so as to trigger an alarm thereby signaling a need for cable repair.

While this second technique provides a means for detecting cable damage, it
5 does not provide a method for containing or preventing worsening of the damage. Hence, before repair can commence after the alarm signal, water may have entered the cable and has flowed freely in both directions from the originally damaged region. This flow does, of course, increase the length of damage along the cable and necessarily increases the cost of repair since the section of cable containing water will need to be replaced.

10 Finally, there is a technique of wrapping the optical cable in a tape which may be a composite tape structure having a metal tape layer and a layer of a water blocking agent as disclosed in Rawlyk U.S. Patent No. 5,039,197. Alternatively, as disclosed in Greveling U.S. Patent No. 5,157,752, the water-blocking material may be of filamentary structure, e.g., string or tape which acts as a carrier for the powdered water-blocking agent,
15 which extends along the optical cable passageway, rather than being wrapped around the optical cable. Aramid fibers with a water-blocking capability, by reason of application of a water-in-oil emulsion of a super-absorbing polymer on the aramid fibers, have been proposed for the same purpose.

However, as stated in Rawlyk U.S. Patent No. 5,188,883: "In the
20 manufacture of...[a] tape structure, because the water blocking material has substantially no rigidity, a binder tape needs to be wrapped around the tape layer of water blocking material immediately after it has been applied around the core so as to hold it in position before the wrapping of the shield around the water blocking material. Hence, the use of a tape layer of water swellable blocking material has necessarily included extra processes and apparatus for
25 the application of the binder together with attendant additional costs." One of the solutions to that problem mentioned in Rawlyk U.S. Pat. No. 5,188,883 is to use a particulate water blocking agent (sodium polyacrylate) in an adhesive layer or a softened polymer layer. Thus, it is disclosed that a metal tape is provided with an adhesive before passing beneath a powder applicator to bond the particles to one surface of the metal tape. Alternatively, it is
30 stated that the adhesive applicator can be replaced by a heater for softening an ethylene acrylic layer on one side of the metal tape so that the particles of sodium polyacrylate adhere to the softened layer.

While that solution to the problem is effective in adding rigidity and permanency to the water blocking material, it also tends to decrease somewhat the water-absorbing ability of the powdered water-blocking agent material because that powder is at least partially encapsulated by the adhesive layer or softened polymer. Besides, metal tape reinforcing structures of the type used in Rawlyk U.S. Pat. No. 5,188,883 do not offer the advantages of a glass fiber reinforcing material, for example.

Accordingly, the need exists for an improved optical cable reinforcement having a water-blocking agent which is permanently affixed to the reinforcing material without decreasing the water-absorbing ability of that water-blocking agent and having advantages over other types of reinforcing structures.

DISCLOSURE OF INVENTION

That need is met by the present invention which provides an optical cable reinforcement comprising a glass fiber reinforcing material of glass fiber strands which have thereon a first coating of a binding agent and a second coating of particles of water-blocking agent. The particles of water-blocking agent are adhered to the glass fiber strands by the binding agent without the binding agent entirely coating the particles of water-blocking agent. That assures that unoccluded surface areas of water-blocking agent are available to rapidly absorb water and serves to protect the optical cable from damage due to moisture. Likewise, the unoccluded surface areas of water-blocking agent permit rapid desorption of water, so that the water-blocking agent rapidly renews itself upon drying.

In accordance with another aspect of the invention, there is provided a method of making an optical cable reinforcement comprising: providing one or more lengths of glass fiber strands from a source coating the glass fiber strands with a liquid binding agent by moving the length through a coating station to form wet coated glass fiber strands, passing the wet coated glass fiber strands through a powder coating station to adhere particles of water-blocking agent to the wet coated glass fiber strands to form glass fiber strands having thereon a first coating of a binding agent and a second coating of particles of water-blocking agent with the particles of water-blocking agent being adhered to the glass fiber strands by the binding agent without the binding agent entirely coating the particles of water-blocking agent, and passing the glass fiber strands having the first

coating and the second coating thereon through an oven to dry and cure the binding agent.

The binding agent is preferably selected from the group consisting of latex polymers, such as acrylic latex polymers; latex copolymers, such as styrene-butadiene copolymer latex; and mixtures thereof. Most preferably the binding agent further includes a paraffin wax emulsion. One or more lengths of glass strands, which may be in the dozens, are preferably coated with the binding agent by passing each glass fiber strand through a bath of liquid binding agent. That strand is then passed through a stripping die to assure that relatively uniformly thick coating of binding agent is applied to the glass fiber strand. The amount of binding agent applied is 2 to 20% by dry weight of the glass fiber strand. In addition to the latex bath, a dilute latex spray may be used both before and after the glass fiber strands are coated with particulate water-blocking agent. That assures that there is enough binding agent to firmly adhere the particles of water-blocking agent to the glass fiber strand and yet not enough to completely embed the particles of water-blocking agent in the binding agent and thus not entirely coat the particles of water-blocking agent with

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binding agent. In addition to the presence of large amounts of unoccluded water-blocking agent surface area, another key feature of the present invention is the firm adherence of the particles of water-blocking agent to the glass fiber strands. The use of the preferred binding agent in the specified amounts, and otherwise practicing the preferred method as further
5 described below, enables that result.

The particles of water-blocking agent are preferably polyacrylate salt, such as sodium polyacrylate or potassium polyacrylate, particles. The desired average particle size is less than 250 microns and preferably 1 to 150 microns.

After the lengths of glass fiber strands have been coated with the binding
10 agent, and while the binding agent is still wet, each glass fiber strand is passed through one or two powder coating stations where the particles of water-blocking agent are applied. Preferably the powder coating stations provide both a fluidized bed of particles of water-blocking agent and a spray of particles of water-blocking agent. In that manner, it is possible to apply 0.1 to 10% by weight of particles of water-blocking agent.

15 The lengths of glass fiber strands are then passed through an oven which heats the glass fiber strand to approximately 450°F (232°C) so as to dry and cure the binding agent. That firmly adheres the particles of water-blocking agent to the glass fiber strand in the manner described above.

Thereafter, each length of glass fiber strand may be wound on a roll for
20 shipment to the optical cable manufacturer for use as a glass fiber reinforcing material. The optical cable manufacturer may use the glass fiber reinforcing material by helically wrapping the glass fiber strands around the optical cable core. In that manner the glass fiber reinforcing material acts as both a tensile strength member and a compressive modulus member. In addition, of course, it acts as a water-blocking material to protect the optical
25 cable from moisture. Alternatively, the optical cable manufacture might use the glass fiber reinforcing material by braiding the glass fiber strands and then wrapping the braided material around the optical cable core in the manner of the tapes which have been previously used as a water-blocking wrap.

In either event, an improved optical cable reinforcement is provided.
30 Accordingly, it is an object of the present invention to provide an improved optical cable reinforcement containing a water-blocking agent, and a unique method of making that optical cable reinforcement. These, and other objects and advantages of the present

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invention, will become apparent from the following detailed description and the accompanying claims.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is an isometric view of part of a sectional optical cable utilizing the glass fiber reinforcing material of the present invention as an optical cable reinforcement.

Figure 2 is a cross-sectional view along the length of the glass fiber reinforcing material of the present invention.

Figure 3 is a diagrammatic side elevational view of the apparatus for making the glass fiber reinforcing material of the present invention.

Figure 4 is a perspective side view of the powder coating station used in the method of making the glass fiber reinforcing material of the present invention.

MODES FOR CARRYING OUT THE INVENTION

Referring to the drawings, Figure 1 shows an optical cable 10 having a core 12 composed of elongate plastic extruded core member 14, a longitudinal extending tensile reinforcing means which may be a central strength member 16, and transmission elements 19 housed in helically extending grooves formed around the outside of the core member 14. These transmission elements are either groups of optical fibers directly inserted into the grooves or alternatively comprise flexible plastic tubes held within the grooves, the plastic tubes containing groups of optical fibers. Glass fiber reinforcing material 18 of glass fiber strands are helically wrapped around the core member 14 along with the transmission elements 19. Surrounding the core is a binding layer 20 with binding tapes 22 affixed thereto. This binding layer 20 is surrounded by a corrugated metal shield 24. Immediately surrounding the metal shield is an extruded polymeric jacket 26 such as a polyethylene jacket.

As can be better seen in Figure 2, glass fiber reinforcing material 18 is made up of glass fiber strands 30 which have thereon a first coating 32 of a binding agent and a second coating 34 of particles 36 of water-blocking agent. As shown, the particles 36 are adhered to the glass fiber strand 30 by the binding agent without the binding agent entirely coating the particles 36 of water-blocking agent. As mentioned previously, this leaves unoccluded surface areas of water-blocking agent available to rapidly absorb/desorb water.

The preferred binding agent used to form first coating 32 has as its latex solids component a mixture of: approximately 24% styrene-butadiene copolymer latex such as Dow Latex DL 216NA1 from Dow Chemical Co., Midland, Michigan; approximately

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71% acrylic latex such as Rhoplex E-32 from Rohm & Haas Co., Philadelphia, Pennsylvania; and approximately 5% paraffin wax emulsion such as Velvitol 77-70 from Rhone Poulenc Inc., Research Triangle Park, North Carolina. That latex solids mixture is added to deionized water (38% solids mixture, 62% water) to form the latex coating of binding agent. The preferred particles 36 of water-blocking agent to form second coating 34 are either sodium polyacrylate particles such as Cabloc 800HS from Stockhausen, Greensboro, North Carolina, or potassium polyacrylate particles such as Aridall 1460F from Chemdal, Palantine, Illinois.

Referring to Figure 3, a length of glass fiber strand 30 is provided from a source 40, which may be an extruder or a reel, if the glass fiber strand has already been extruded and wound on a reel as shown. Glass fiber strand 30 is preferably 1 to 2.5 mm in diameter. Glass fiber strand 30 is then moved through a coating station 50 for application of the first coating 32. Preferably that is done by passing the length of glass fiber strand 30 over roller 42, into bath 44, beneath roller 46, and through stripping die 48 which preferably has a 44 mil (1118 microns) opening. The liquid binding agent is maintained in bath 44 at room temperature. A combination of speed of travel of the length of fiber glass strand 30, which is preferably 50 to 300 ft./min (15-91 meters/min), and use of stripper die 48 assures that 5 to 30% wet binding agent is applied to the glass fiber strand, which when considered with the subsequent latex spray applications, and when then dried and cured, gives a desired dry weight percent of 2 to 20% of binding agent on the glass fiber strand.

Thereafter, latex sprayer 90A having external mix nozzles with a 0.020 inch (0.05 cm) opening is used to apply a 5% solids mix of acrylic latex such as Rhoplex E32 and deionized water at a spray rate of 80 grams/minute and an air pressure of 25 psi (1758 grams/cm²). This provides for a wetter glass fiber strand 30 and better powder deposition in the first powder coating station 60A.

Thus, the length of glass fiber strand 30 having wet binding agent coated thereon is then passed through powder coating stations 60A and 60B. Powder coating stations 60A and 60B are better shown in Figure 4. As shown, they have a chamber 52 approximately 6 inches (15.24 cm) wide, 28 inches (71.12 cm) long, and 18 inches (45.72 cm) deep which is designed to handle a single length glass strand 30 by reason of approximately 2 inch (5.08 cm) diameter entrance hole 53A and exit hole 53B each with a gate therein (not shown) in the ends thereof. If multiple lengths of glass fiber strands 30 are being coated, a wider chamber 52, having multiple entrance and exit holes therein, would be

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needed. But, it is to be understood that one or more, up to dozens, such as six dozen (72) glass fiber strands, may be coated by this method. Powder coating stations 60A and 60B also have pump blocks 54a, 54b, and 54c; pump hoses 56a, 56b, and 56c; and spray nozzles 58a, 58b, and 58c, fed by tubes 59a, 59b, and 59c; all of which operate to spray particles 36 of water-blocking agent onto glass fiber strand 30 (which is greatly exaggerated in size in Figure 4 for illustration purposes only) at 30 psi (2109 grams/cm²). In addition to the air sprays, particles 36 are fluidized in chamber 52 by reason of drawing a vacuum through vacuum ports 55a and 55b and providing inlet air ports 57a, 57b, 57c, and 57d to fluidize the bed at about 20 psi (1406 grams/cm²). That fluidizes the bed of particles 36 in chamber 52 through which the length of glass fiber strand 30 passes. The net result is application of 0.1 to 10% of the second coating 34 of water-blocking agent.

For efficient powder application, a small particle size, preferably less than 250 microns, and most preferably 1 to 150 microns, is desired. Larger particles are difficult to make into a uniform aerosol.

Next latex sprayer 90B, which is similar to latex sprayer 90A, is used to apply another 5% solids mix of acrylic latex and water, this time at 12 psi (844 grams/cm²) so as not to blow particles 36 off of glass fiber strand 30. This is a light sealer coat in one instance and a wetter coat in the other instance, i.e., with regard to powder coating station 60B which operates in the same manner as powder coating station 60A. Then, finally, latex sprayer 90C, which is similar to latex sprayers 90A and 90B, is used to apply a 10% solids mix of acrylic latex at 25 psi (1758 grams/cm²) in order to hold particles 36 on glass fiber strand 30 through oven 70 and then during custom processing.

Next, the length of glass fiber strand 30 having first coating 32 and second coating 34 thereon is passed through oven 70, which may be a three-zone oven, where it is heated to approximately 450°F (232°C) to dry and cure the binding agent of first coating 32. Thereafter, glass fiber strand 30 may be wound on a cardboard tube 82 at winder 80 such as a Lessona Winder operating at 50 feet per minute (15 meters/minute). That square-edged package of glass fiber reinforcing material is then supplied to the optical cable manufacturer for use as an optical cable reinforcement.

The result is a glass fiber reinforcing material having the characteristics set forth in Table I below:

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Table I

	Set I <u>n=7</u>	Set II <u>n=26</u>	Set III <u>n=26</u>	Set IV <u>n=9</u>	Mean of <u>Sets I-IV</u>	<u>n=</u>
Average LOI ¹	14.60%	15.94%	17.20%	15.30%	15.80%	4
5 Average % Wt. gain:						
1 Min ²	178.60%	N/A	N/A	196%	187.30%	2
Average % Wt. gain:						
5 Min ²	259.60%	N/A	N/A	280%	269.80%	2
Average % Wt. gain:						
10 1 Hour ²	289.30%	N/A	N/A	328%	308.60%	2
Average % Diameter						
Increase ³	107.43%	N/A	N/A	75%	91.20%	2

¹LOI: Loss On Ignition - Sample is weighed, burned out at 1200°F, and reweighed.

15 ²Wt. gain - Sample is weighed, then soaked in deionized water for 1, 5, and 60 minutes, and weighed at intervals.

³Diameter increase - Sample is measured before soaking for 1 minute and measured after soaking.

20 As shown in Figure 1, one form of optical cable reinforcement is to use the glass fiber reinforcing material 18 as a helical wrap with optical fibers 19 around the optical cable core 14. In that form the glass fiber reinforcing material has four features: (1) Tensile Member - carrying the tensile load of the optical cable during installation, (2) Compressive Modulus Member - supplying the cable with longitudinal compressive modulus to offset the
25 shrinking forces of the polyethylene jacket during cold temperature cycling, (3) Water Blocking - offering a "dry" cable, that is, a cable that passes the Bellcore Water Penetration Test without the use of liquid, hydrophobic greases, and (4) Immobile Water-Blocking Powder - immobilizing the particles of water-blocking agent inside the cable (loose particles
30 can dribble out of a cable end, as when two cables are being spliced in the field; those loose particles when mixed with water become hydrogels and produce a very slippery and hazardous working environment).

Alternate forms of use for the glass fiber reinforcing material include braiding it into a braided web/tape for wrapping around the optical cable core as a water-

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blocking tape layer, or running it longitudinally down the cable as in U.S. Patent No. 5,157,752. Other applications may occur to those skilled in the art.

While certain representative embodiments and details have been shown for purposes of illustrating the invention, it will be apparent to those skilled in the art that
5 various changes in the product disclosed herein may be made without departing from the scope of the invention, which is defined in the appended claims.

CLAIMS

1. An optical cable reinforcement comprising a glass fiber reinforcing material of glass fiber strands which have thereon a first coating of a binding agent and a second coating of particles of water-blocking agent, said particles of water-blocking agent being adhered to said glass fiber strands by said binding agent without said binding agent entirely coating said particles of water-blocking agent.
2. The optical cable reinforcement of claim 1 wherein said binding agent is selected from the group consisting of latex polymers, latex copolymers, and mixtures thereof.
3. The optical cable reinforcement of claim 2 wherein said binding agent is a mixture of a styrene-butadiene copolymer latex and an acrylic latex.
4. The optical cable reinforcement of claim 3 wherein said binding agent further includes a paraffin wax emulsion.
5. The optical cable reinforcement of claim 1 wherein said particles of water-blocking agent are polyacrylate salt particles.
6. The optical cable reinforcement of claim 5 wherein said polyacrylate salt is sodium polyacrylate.
7. The optical cable reinforcement of claim 5 wherein said particles of water-blocking agent have an average particle size of less than 250 microns.
8. The optical cable reinforcement of claim 1 wherein said binding agent is a mixture of a styrene-butadiene copolymer latex and an acrylic latex and said binding agent further includes a paraffin wax emulsion, and said particles of water-blocking agent are polyacrylate salt particles having an average particle size of less than 250 microns.
9. The optical cable reinforcement of claim 8 wherein said first coating of binding agent comprises 2 to 20% by dry weight, and said second coating of particles of water-blocking agent comprises 0.1 to 10% by weight.
10. The optical cable reinforcement of claim 1 wherein said glass fiber reinforcing material is in a form capable of acting both as tensile strength member and as a compressive modulus member in an optical cable.

11. The optical cable reinforcement of claim 1 wherein said glass fiber strands are braided to form a glass fiber reinforcing material which may be wrapped around an optical cable core.

12. A method of making an optical cable reinforcement comprising:
providing one or more lengths of glass fiber strands from a source
coating said glass fiber strands with a liquid binding agent by moving the length through a coating station to form wet coated glass fiber strands,
passing the wet coated glass fiber strands through a powder coating station to adhere particles of water-blocking agent to said wet coated glass fiber strands to form glass fiber strands having thereon a first coating of a binding agent and a second coating of particles of water-blocking agent with said particles of water-blocking agent being adhered to said glass fiber strands by said binding agent without said binding agent entirely coating said particles of water-blocking agent, and
passing said glass fiber strands having said first coating and said second coating thereon through an oven to dry and cure said binding agent.

13. The method of claim 12 further including the step of winding each of said lengths of glass fiber strands onto a tube after it has been passed through the oven.

14. The method of claim 13 wherein said binding agent is coated on said glass fiber strands by passing said glass fiber strands through a bath of liquid binding agent.

15. The method of claim 14 further including the step of passing said glass fiber strands through a stripping die after said glass fiber strands have been passed through said bath of liquid binding agent.

16. The method of claim 15 wherein said binding agent is selected from the group consisting of latex polymers, latex copolymers, and mixtures thereof.

17. The method of claim 13 wherein said powder coating station provides both a fluidized bed of particles of water-blocking agent and a spray of particles of water-blocking agent.

18. The method of claim 17 wherein said particles of water-blocking agent have an average particle size of less than 250 microns.

19. The method of claim 18 wherein said particles of water-blocking agent are polyacrylate salt particles.

20. The method of claim 12 wherein 5 to 30% by wet weight of said binding agent and 0.1 to 10% by weight of particles of water-blocking agent is coated on said glass fiber strands.

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FIG. 1

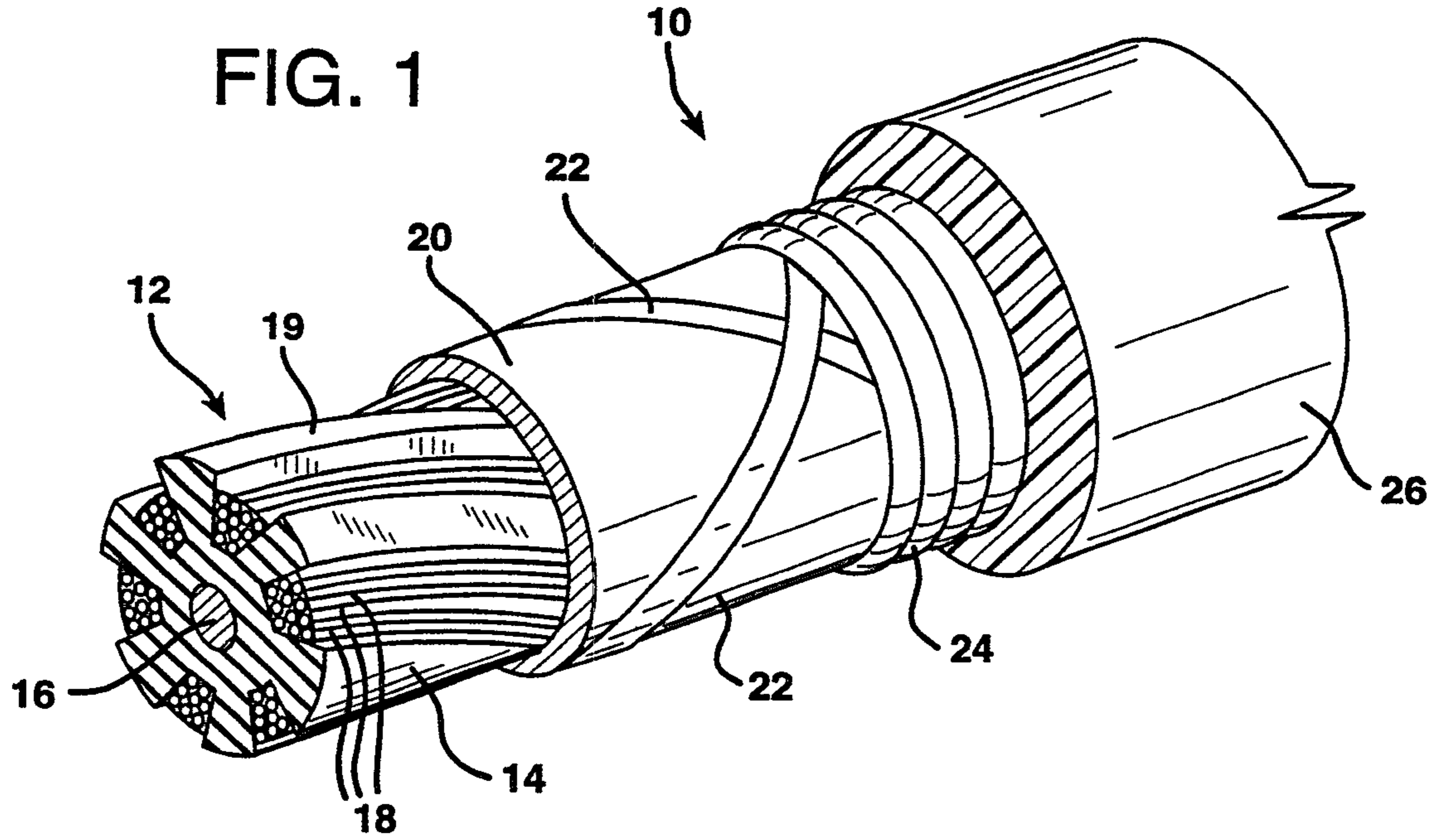
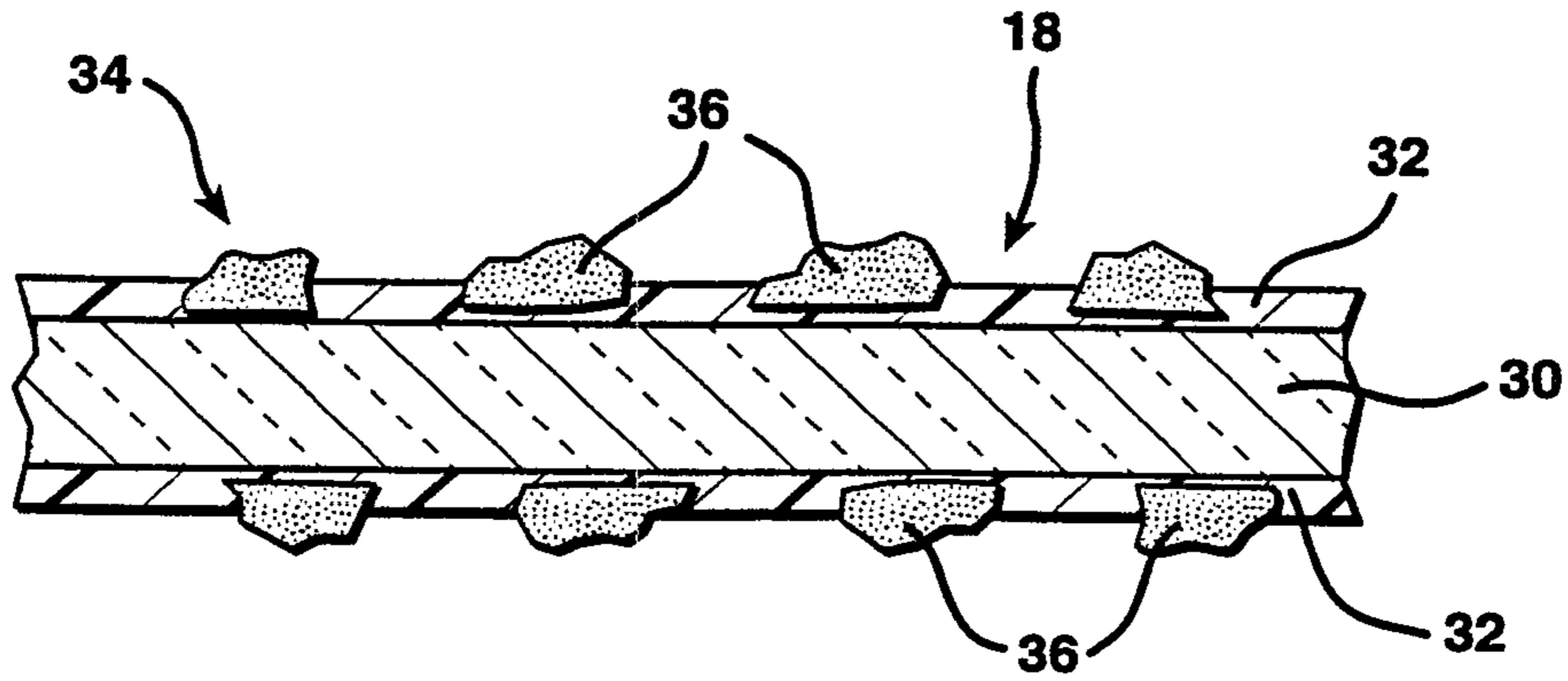
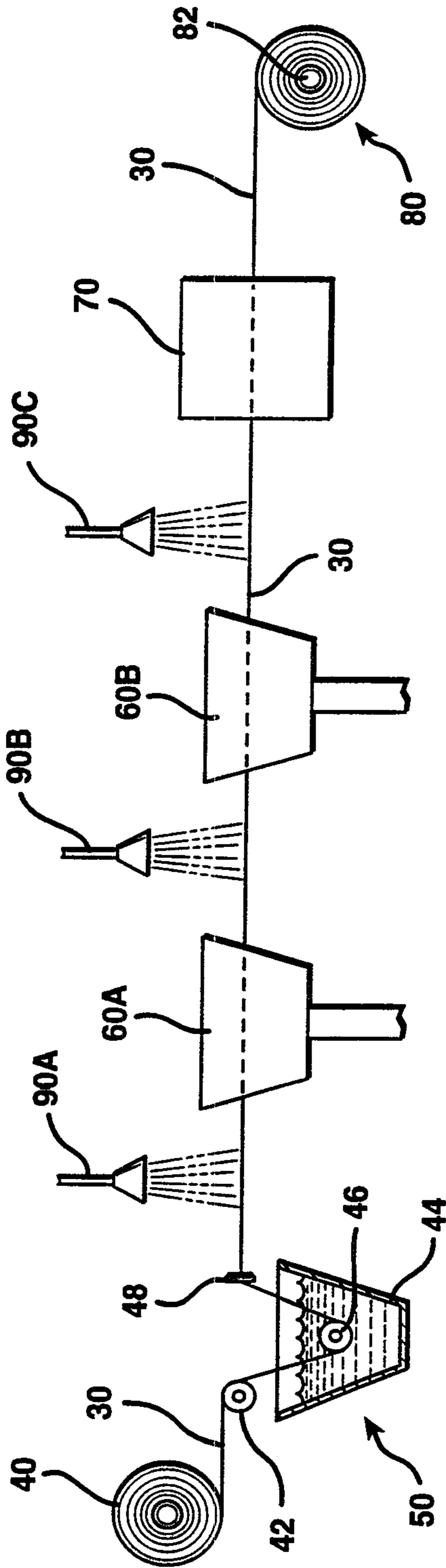


FIG. 2



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FIG. 3



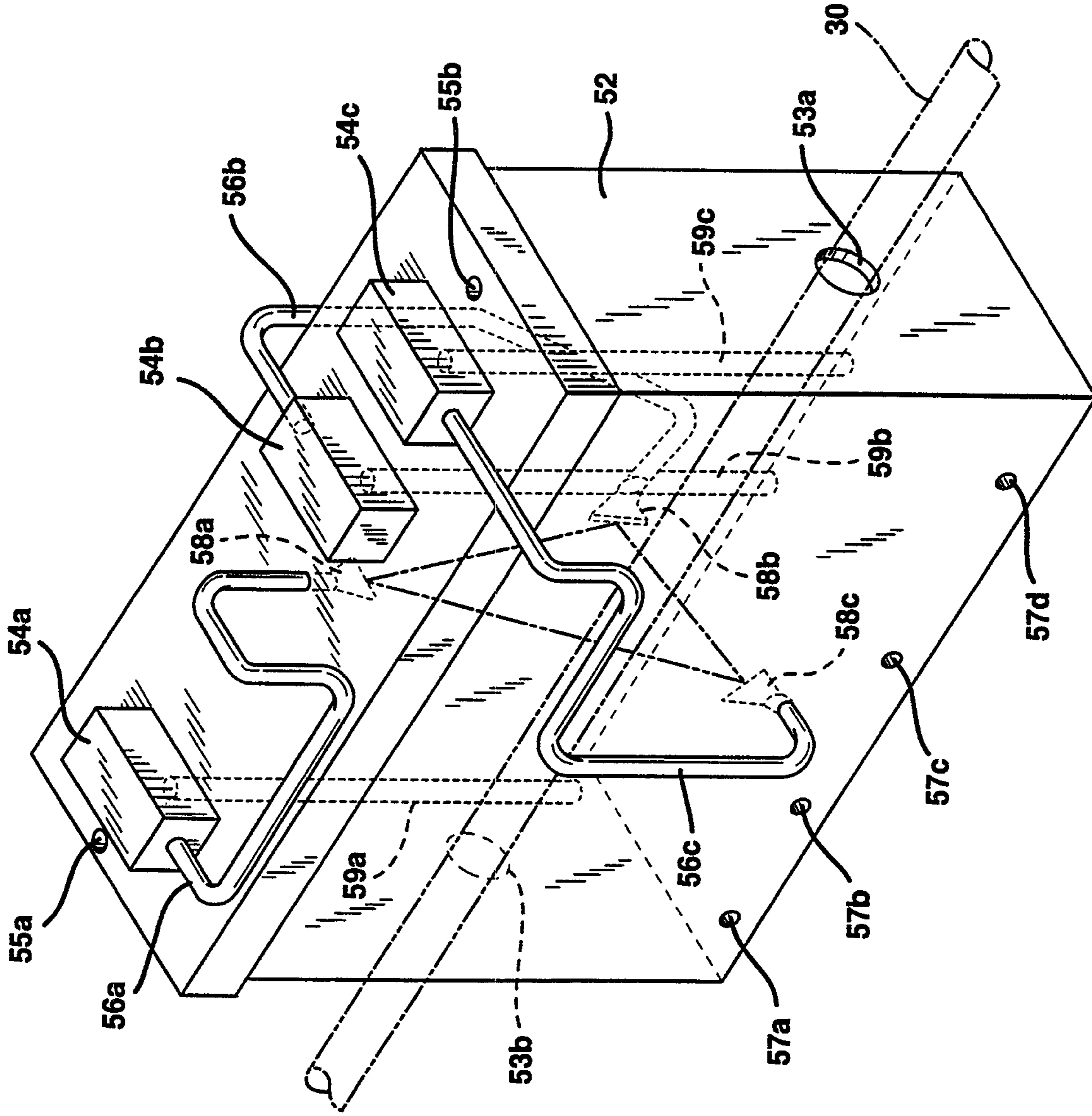


FIG. 4

