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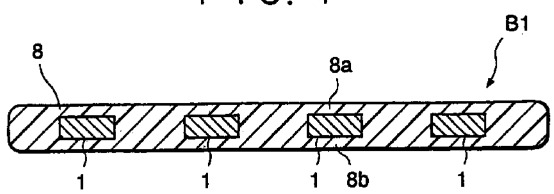
(54) FLAT CABLE AND METHOD OF MANUFACTURING THE SAME

(57) There are provided a flat cable having excellent life characteristics at the time of repeated flection and a method of manufacturing the flat cable with high productivity. In a flat cable in which a plurality of rectangular conductors arranged in parallel are buried in an insulating resin layer, the insulating resin layer in contact with at least the rectangular conductors is an extrusion coating layer formed of a thermoplastic resin with a flexural modulus of 800 to 2400 MPa. The flat cable is manufactured by feeding a plurality of rectangular conductors arranged in parallel to a cross-head of an extruder and by supplying the thermoplastic resin to extrusion coat the rectangular conductors.

F I G. 4



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Description

TECHNICAL FIELD

[0001] The present invention relates to a flat cable and a manufacturing method therefor and, especially, to a flexible flat cable which has a superior lifetime when subjected to a repetition of flection and stretch and is functional as, for example, a cable for a rotary connector on an automotive steering wheel (steering roll connector) or for a harness, and a method of manufacturing the flat cable with high productivity.

BACKGROUND ART

[0002] For example, a printing section of a printer is connected to a section for transmitting operation signals with a flat cable so that a preset printing operation is performed on receipt of the operation signal from the transmitting section. The printing operation sets the flat cable in a jerky swing from flection to stretch or the reversal. Therefore, the flat cable to be used in such a field is rehired to remain unbroken or unaffected even when being subjected to repeated flection and stretch for a long period of time.

[0003] Here, a repetition of flection and stretch implies incessant shifts and turns of bending radii or variant points of bending on a flat cable.

[0004] Conventionally, as a flat cable subjected to repeated flection and stretch as described above, a flat cable having a cross-sectional structure as shown in FIG. 1 has been known.

[0005] This flat cable A is made up of outer layers 3, 3, resin films such as electrical-insulating polyethylene terephthalate films, inner layers 2, 2, each having an adhesive resin composition such as a saturated polyester copolymer interposed between the resin films 3, 3, and a plurality (four in the FIG. 1) of rectangular conductors 1 arranged in parallel at predetermined intervals, which are embedded in the inner layers 2, 2. The foregoing inner layers 2 and outer layers 3 combine to form the insulating layer of the topical flat cable.

[0006] This flat cable A is manufactured in a production line as shown in FIG. 2.

[0007] In brief, a plurality of rectangular conductors 1 are reeled out from a bobbin 4 in a state of being arranged in parallel at predetermined intervals. On the other hand, resin films 3a and 3b which are formed with a layer 2 of adhesive resin composition are reeled out from a pair of spools 5a and 5b onto the surfaces of the rectangular conductors 1, and led to rolling surfaces of a pair of heating rolls 6a and 6b in contact with the upper and lower faces of the rectangular conductors 1. Thus all the components are heat-pressed into a flat cable A shown in FIG. 1, and is wound around a spool 7. If a thermal crosslinking type of adhesive resin composition is applied then, crosslinking takes place as concurrent with the heated bonding press in a process of passing bonding press through the heated rolls 6a and 6b.

[0008] In the aforementioned production line, a significant task (considering the flat cable's characteristics) is to set the rectangular conductor 1 in tight contact with the inner layer 2 without any split-off, and the outer layer resin films 3a and 3b in tight contact with the inner layers 2, 2, respectively. Should the setup be insufficient, a split-off occurs at the time of the aforesaid flection, inviting a loss of the intended performance of the flat cable.

[0009] When a flat cable is manufactured in the production line shown in FIG. 2, process conditions are adjusted to given manufacturing requirements, namely, a feeding rate of the rectangular conductor 1, and temperature and pressure applied to the heating rolls 6a and 6b. In principle the flat-cable productivity is enhanced by a rise in the line speed: higher feeding speeds are preferable.

[0010] However, if the line speed of the production line is increased to a certain threshold speed or higher, there arises a problem that even if temperature and pressure adjustments to the heating rolls 6a and 6b are implemented, the bonding force between the inner layers 2 in the resultant flat cable through the heating rolls lessens, where long-serviceable flat cables are unlikely to be obtained.

[0011] This is because the amount of heat supplied from the heating rolls 6a and 6b to the inner layers 2, 2 via the resin films 3a and 3b becomes short, thereby softening the adhesive resin composition of the inner layer 2 and making the resultant bonding force available insufficiently.

[0012] For this reason, an attempt has been made to manufacture the flat cable A in a production line as shown in FIG. 3.

[0013] On this production line, a pair of heating rolls 6c and 6d are further disposed on the downstream side of the heating rolls 6a and 6b in the production line shown in FIG. 2 to give a second heat bonding press to the flat cable through the heating rolls 6a and 6b. In the case of this line, since the amount of heat from the heating rolls 6c and 6d is further added to the inner layer 2, the whole line speed can be more increased than in the production line shown in FIG. 2.

[0014] However, this line faces a ceiling of several matters per minute at present, requiring a way out for higher speeds.

[0015] It is frequent that production lines for electric wires apply an extrusion coating method to overlay a conductor with insulating resin. This extrusion coating process is thought to be promising to increase the line speed of the production line for the flat cable. In fact, any of Unexamined Japanese Patent Publication No. 49-57381, Unexamined Japanese Patent Publication No. 62-206710, and Unexamined Japanese Patent Publication No. 1-276514 has disclosed a method of manufacturing the flat cable by using the extrusion coating process.

[0016] For example, Unexamined Japanese Patent Publication No. 49-57381 has proposed a method in which a hollow tube made of a resin is extruded to cover the periphery of a plurality of insulated conductors; then, the whole is led to a pair of rolls having an annular groove to thermally form the hollow tube into a flat cable.

[0017] However, this prior art requires the insulated conductors (to be prepared in advance), and the rolls having an annular groove, resulting in an increase in manufacturing cost. Further, since the whole insulating layer has a two-fold construction, consisting of the insulating layer for the insulated conductors and the layer of a formed hollow tube, not only the material cost increases, but also it is difficult to form a thin insulating layer. Therefore, this method is unsuitable as a manufacturing method for a flat cable which uses rectangular conductors as conductors and is equipped with an excellent flexing property.

[0018] Unexamined Japanese Patent Publication No. 62-206710 has proposed a method of manufacturing a flat cable, in which an ordinary round conductors are extrusion coated with a resin, and when the resin is in a semi-molten state, the structure is led to a die (forming block) having a desired cross-section to cool and set the resin.

[0019] However, this prior art can seldom employ rectangular conductors as conductors and coat them thinly and uniformly with an insulating layer. Therefore, it is actually impossible to obtain a thin flat cable having a high flexing property using this prior art.

[0020] Further, Unexamined Japanese Patent Publication No. 1-276514 has proposed a method of manufacturing a flat cable, in which when a plurality of rectangular conductors are extrusion coated with a soft insulator, gaps between the rectangular conductors are adjusted considering the degree of heat shrinkage of soft insulator in extrusion coating.

[0021] However, in this prior art, studies have not been made at all on the resistance to conductor breakage, by a repetition of flection and stretch on the obtained flat wire. Also, an embodiment in this Publication has disclosed a technology in which water cooling is performed after the extrusion coating is finished. However, in the case where the extrusion coating layer is thin, there arises a problem in that if such water cooling is performed, the whole flat cable is deflected.

[0022] Thus, in the above-described prior art items, although the flat cables manufactured by the extrusion coating process have been disclosed, it cannot be said that these flat cables has an excellent flexing property.

DISCLOSURE OF THE INVENTION

[0023] An object of the present invention is to provide a flat cable of outstanding flexibility (bending characteristics) as contrasted with a conventional flat cable and a manufacturing method for the flat cable in which an extrusion coating process is applied to realize high manufacturing rates.

[0024] To achieve the above object, the present invention provides a flat cable comprising a plurality of rectangular conductors arranged in parallel which are embedded in an insulating resin layer, the insulating resin layer in contact with at least the rectangular conductors being an extrusion coating layer formed of a thermoplastic resin with a flexural modulus of 800 to 2400 MPa. Also, the present invention provides a manufacturing method for a flat cable comprising the steps of feeding a plurality of rectangular conductors arranged in parallel to a cross-head of an extruder, supplying a thermoplastic resin with a flexural modulus of 800 to 2400 MPa, and extrusion coating the rectangular conductors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a sectional view showing a cross-sectional structure of a conventional typical flat cable A;
FIG. 2 is a brief view showing a conventional typical production line for a conventional flat cable;
FIG. 3 is a brief view showing another conventional typical production line;
FIG. 4 is a sectional view showing a cross-sectional structure of a typical flat cable B1 in accordance with the present invention;
FIG. 5 is a brief view showing a production line for a flat cable in accordance with the present invention;
FIG. 6 is a plan view showing a positional relationship between an extruding nipple and an extruding die in a cross-head;
FIG. 7 is a side view showing a positional relationship between an extruding nipple and an extruding die in a cross-head;
FIG. 8 is a sectional view showing a cross-sectional structure of another typical flat cable B2 in accordance with the present invention; and

FIG. 9 is a sectional view showing a cross-sectional structure of still another typical flat cable B3 in accordance with the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0026] FIG. 4 shows a cross-sectional structure of a first example of a flat cable in accordance with the present invention.

[0027] In this flat cable B1, rectangular conductors 1 arranged in parallel at predetermined intervals embedded in an extrusion coating layer 8 which is formed of a later-described thermoplastic resin and functions as an insulating resin layer.

[0028] In the case of this flat cable B1, the extrusion coating layer has a unitary structure, not a bonded structure of two films, unlike a conventional flat cable shown in FIG. 1. Therefore, there is no possibility that an upper portion 8a and a lower portion 8b of the extrusion coating layer 8, which is an insulating resin layer, are separated from each other. Specifically, even if the whole structure is flexed and stretched repeatedly, because a pressure applied locally to the rectangular conductor 1 is diffused moderately, there is no possibility that the extrusion coating layer 8 is made separate by a stress generated at the time of flection.

[0029] Although it is recommended that the rectangular conductor 1 and the extrusion coating layer 8 be bonded to each other, they do not necessarily need to be bonded. When the extrusion coating layer 8, described onward, is formed, the thermoplastic resin with which the rectangular conductor 1 is extrusion coated shrinks. Therefore, even if the rectangular conductor 1 and the extrusion coating layer 8 are not bonded to each other, they are in tight contact with each other, so that the flexibility is not degraded.

[0030] Also, since no adhesive layers are interposed between the rectangular conductor 1 and the extrusion coating layer 8, the separation from each other is inhibited. Further, since the extrusion coating layer 8 is formed continuously by later-described extrusion coating of the rectangular conductors 1 arranged in parallel, the flat cable can be manufactured inexpensively at a high speed. Also, the flat cable can be downsized because the mutual intervals between the rectangular conductors 1 arranged in parallel can be made shorter than in the conventional laminate system.

[0031] Preferred material examples of the rectangular conductor 1, are oxygen free copper, phosphor bronze, tough pitch copper, tin-plated copper, nickel-plated copper, if a few named off. As the rectangular conductor, a strip of copper foil, a rolled or flattened wire, or the like can be used as discretionary. Further, the rectangular conductors 1 may be varied in thickness or width according to the application of a flat cable to be manufactured.

[0032] A thermoplastic resin to form the aforementioned insulating resin layer 8, is required to have a flexural modulus of 800 to 2400 Mpa, preparatory to the later-described extrusion coating. Preferably, the flexural modulus of the thermoplastic resin should be 1000 to 2000 MPa.

[0033] If the extrusion coating layer 8 is formed by using a thermoplastic resin whose flexural modulus before extrusion coating is lower than 800 MPa, the extrusion coating layer 8 cannot sufficiently diffuse the stress applied to the flat cable during flection, so that the rectangular conductors 1 of the obtained flat cable are broken at an early stage. If the extrusion coating layer 8 is formed by using a thermoplastic resin whose flexural modulus before extrusion coating is higher than 2400 MPa, cracks and the like occur in the extrusion coating layer 8 before the life of the rectangular conductors 1 is exhausted by flection, so that the function as the flat cable cannot be maintained.

[0034] It is to be noted that the flexural modulus referred to in the present invention is defined as a value obtained by the measuring method specified in ASTM D790 (value at a temperature of 23°C).

[0035] The following resins count as preferred examples of such a thermoplastic resin.

[0036] First, there comes a polyamide resin.

[0037] The polyamide resin, having high self-lubricity and wear resistance, is suitable as a material for enhancing the life of a flat cable subjected to repetitive Election and stretch-The polyamide resin has a low natural frequency and a large logarithmic decrement, and therefore can absorb vibration, where the flat cable in motion is restrained from generating noise, so that it can preferably be used for manufacturing, for example, an automotive flat cable. In particular, it can preferably be used for a flat cable for an automotive rotary connector on a steering wheel. Further, with the polyamide resin, the extrusion coating of the rectangular conductors 1 can preferably be performed smoothly even if the line speed of the later-described production line is increased, so that a flat cable in which the aforementioned characteristics are high can preferably be manufactured with high productivity.

[0038] As the polyamide resin, high molecular compounds in which a peptide bond (-CONH-) is a repeated unit can count. Such polyamide resin includes, for example, a ring-opening polymer obtained by various types of ring-opening polymerization of ε-caprolactam, ω-laurocaprolactam, and like; a condensation polymer made of diamine such as hexamethylenediamine, methaxylylenediamine and 2,4,4- or 2,2,4-trimethylhexamethylenediamine, and a dibasic acid such as adipic acid, sebacic acid, dodecanedione acid and terephthalic acid; a condensation polymer made of amino calboxylic acid such as ω-amino undecanoic acid and 12-amino dodecanoic acid, and the like. These substances are generally known as nylon; namely, nylon 6, nylon 66, nylon 610, nylon 12, nylon 11, nylon 46, nylon MXD • 6, nylon 6/66, and nylon 1.06 can be enumerated.

[0039] Of these, nylon 12 is preferable because it has particularly higher flexibility than the aforementioned polyamide resins, also has a high adhesive property with metal, and the flexibility can be secured and the flexing property is not degraded even at low temperatures, in addition to the aforementioned properties. In particular, nylon 12 is preferably used for manufacturing automotive flat cables.

[0040] A second thermoplastic resin desirable for the extrusion coating layer 8 is a polyolefin resin.

[0041] This polyolefin resin, with exceptions, is preferable because it generally does not adhere to the rectangular conductor 1, so that the flat cable manufactured of this resin can be terminated easily.

[0042] As such a polyolefin resin, for example, polypropylene, polyethylene, ionomer can count. Of these resins, polypropylene is preferable because it has particularly high extrusion workability and a small difference in shrinkage between the longitudinal and transverse directions in an extrusion coating, in addition to the aforementioned properties, so that flat cables with intended design dimensions can be manufactured with a high yield and therefore at a low cost.

[0043] Further, a polymer alloy with a sea-island structure is also a desirable thermoplastic resin. If a polymer alloy is used, extrusion coating can be performed smoothly even if the line speed of production line is increased, and also the stresses during flection are diffused and attenuated because an island component is distributed in a sea component, so that very high repeated flection life characteristics can be obtained.

[0044] As such a polymer alloy, for example, (1) a polymer alloy in which polyamide resin is the sea component and polypropylene modified with epoxy etc. is the island component, (2) a polymer alloy in which polypropylene is the sea component and polyamide resin is compatibilized by polypropylene modified with acid etc. and is made high-molecular, (3) a polymer alloy in which ethylene-propylene copolymer is the sea component and polypropylene is the island component, (4) an ethylene-propylene block copolymer, (5) a polymer alloy in which polyamide resin is graft polymerized to modified polyphenylene ether, and (6) a polymer alloy in which modified polyphenylene ether and polybutylene terephthalate are blended with each other can count.

[0045] Of the aforementioned polymer alloys, the polymer alloy, described below, which contains polyamide resin and epoxy-modified polypropylene as main ingredients is preferable because of being capable of enhancing the life of a flat cable subjected to repetitive reflection and stretch. This polymer alloy will be explained below.

[0046] This polymer alloy contains polyamide resin as the sea component and epoxy-modified polypropylene, described later, as the island component. As the polyamide resin, the polyamide resins already exemplified as preferred examples of thermoplastic resin used in the present invention can be used.

[0047] The epoxy-modified polypropylene is synthesized by polymerizing polypropylene polymer, epoxy group-containing vinyl monomer, and aromatic vinyl monomer in the presence of a free-radical initiator.

[0048] As the polypropylene polymer used for synthesizing the epoxy-modified polypropylene, a homopolymer of propylene, or a copolymer of propylene, the main ingredient, and olefin monomer or ethylene vinyl monomer, which contains polypropylene of 75 wt% or higher is used. Specifically, isotactic polypropylene, propylene-ethylene copolymer, propylene-butene copolymer, or the like can count. These materials may be used singly or by mixing two or more kinds. Further, they may be used by mixing with other polymers unless the property is reduced.

[0049] As the epoxy group-containing vinyl monomer, for example, glycidylmethacrylate, glycidylacrylate, allylglycidylether, and methacrylglycidylether can count. These materials may be used singly or with a mixture of two or more kinds. The glycidylmethacrylate is particularly preferable.

[0050] In synthesis, the usage of the epoxy group-containing vinyl monomer should preferably be 10 parts by weight or less with respect to 100 parts by weight of the polypropylene polymer. If the usage is more than 10 parts by weight, not only the obtained epoxy-modified polypropylene becomes lower in molecular weight but also the hygroscopicity (water absorbency) is enhanced, so that the mechanical strength is lowered. The preferred usage ranges from 0.1 to 5 parts by weight with respect to 100 parts by weight of the polypropylene polymer.

[0051] The aromatic vinyl monomer is & component for increasing the graft polymerization efficiency of epoxy group-containing vinyl monomer to propylene polymer, and for increasing the compatibility between epoxy-modified polypropylene, (island component) in an intended polymer alloy, and polyamide resin, (the sea component) therein. Specifically, for example, styrene, methylstyrene, vinyltoluene, vinylxylene, ethyl vinylbenzene, isopropylstyrene, chlorostyrene, dichlorostyrene, and bromostyrene can count. These materials may be used singly or with mixture of two or more kinds.

[0052] In order to prevent the synthesized epoxy-modified polypropylene from becoming low in molecular weight and to increase the compatibility with polyamide resin, the usage of the aromatic vinyl monomer should preferably be 50 parts by weight or less with respect to 100 parts by weight of the propylene polymer. For the same reason, the usage of the aromatic vinyl monomer should preferably be equal to or more than the usage of the epoxy group-containing vinyl monomer. Specifically, the usage of the aromatic vinyl monomer should preferably be one to five times that of the epoxy group-containing vinyl monomer.

[0053] The synthesis using the aforementioned components is carried out through the use of a closed vessel such as a Banbury mixer or a kneader such as an extruder in the presence of a free-radical initiator.

[0054] For example, when the synthesis is carried out using an extruder, powder- or pellet-form propylene polymer is supplied to the extruder to be heated to a temperature of 130 to 250°C and melted under pressure. Then, predetermined quantities of free-radical initiator, epoxy group-containing vinyl monomer, and aromatic vinyl monomer are added to the melted propylene polymer and kneaded to carry out polymerization reaction. Thereafter, a strand led from a die is cooled and pelletized by a pelletizer.

[0055] As the free-radical initiator, a substance being easy to solve in each of the aforementioned monomers with a decomposition temperature of 130 to 250°C, is preferable. For example, t-butyl peroctate, bis(t-butyl peroxy)trimethyl cyclohexane, cyclohexanoneperoxide, benzoylperoxide, dicumylperoxide, t-butylperbenzoate, dimethyl-di(t-butyl peroxy)hexane, and dimethyl-di(t-butyl peroxy)hexyne can count.

[0056] The usage of the free-radical initiator should usually be 0.1 t 10 parts by weight, preferably be 1 to 5 parts by weight, with respect to 100 parts by weight of the total quantity of the epoxy group-containing vinyl monomer and the aromatic vinyl monomer.

[0057] The propylene polymer is, unlike ethylene polymer, a radical degradative polymer, of which main chains are delinked, simply when heated and melted; of which molecular weight becomes low. Therefore, at the time of the aforementioned molten polymerization reaction, it is preferable that a stabilizer incapable of retarding the aforesaid function of the epoxy group- containing vinyl monomer and aromatic vinyl monomer be further added to the reaction system.

[0058] As such a stabilizer, for example, a hindered phenol stabilizer, a phosphoric stabilizer, metallic soap, and an antiacid adsorbent, such as hydrotalcite can count. These materials may be added singly or with a mixture of two or more kinds. The quantity of addition is usually 0.01 to 1 part by weight, preferably 0.05 to 0.5 part by weight with respect to 100 parts by weight of polypropylene polymer.

[0059] By mixing the epoxy-modified polypropylene thus synthesized with the polyamide resin, the polymer alloy used for the formation of extrusion coating layer is prepared. In particular, if nylon 6 is used as the polyamide resin, the flexibility of a flat cable is enhanced, and the extrusion coating of rectangular conductors can preferably performed smoothly even if the line speed of the production line is increased.

[0060] The mixing ratio of these materials can be set at 5 to 50 wt% of an epoxy-modified polypropylene, and reciprocally 95 to 50 wt% of polyamide resin.

[0061] If the mixing ratio of an epoxy-modified polypropylene is lower than 5 wt%, the effect that the stresses exerted on the flat cable during flection and stretch are diffused sufficiently is not exhibited; consequently, the life under repetitive flection and stretch becomes insufficient. If the mixing ratio of the epoxy-modified polypropylene is higher than 50 wt%, the elongation and strength of the resultant polymer alloy at high temperatures are decreased, so that it becomes difficult to perform extrusion coating, resulting in difficulty in obtaining a flat cable with high dimensional accuracy.

[0062] It is to be noted that various types of flame retarders, carbons, glass fibers, oxidation inhibitors, and the like may be blended with the resin used in the present invention if necessary.

[0063] This flat cable B1 can be manufactured in a production line shown in FIG. 5.

[0064] In this production line, a plurality of rectangular conductors 1 are pulled off a bobbin 4 as arranged in parallel at predetermined intervals, and passes through a cross-head 10 mounted on an extruder 9, where extrusion coating of the rectangular conductors 1 is performed. The obtained flat cable B1 is reeled around a spool 7.

[0065] In the cross-head 10, an extruding nipple 11 and an extruding die 12 are arranged as shown in FIGS. 6 and 7. The extruding nipple 11 is formed with a plurality of (four in FIG. 6) nipple holes for arranging the fed rectangular conductors 1 paralleling at predetermined intervals. Also, the extruding die 12 is formed with a die hole 12a for regulating the external form of an extrusion coating layer to be formed.

[0066] The rectangular conductors 1 fed to the extrusion nipple 11 are arranged in parallel by the nipple holes 11a, coated with a thermoplastic molten resin supplied to a surrounding space 12b (inners of cross-head) in a process of passing through a space between the extruding nipple 11 and the die 12, and passes through the die hole 12a, by which the extrusion coating layer is formed on the rectangular conductors 1.

[0067] The thermoplastic resin used at this time is as described above. The molecular weight of this thermoplastic resin is generally unspecific, but the thermoplastic resin having a relative viscosity (ηrel) not lower than 0.5, preferably not lower than 2.0, is desirable because it allows smooth formation of the extrusion coating layer, and enhances the mechanical strength properties, such as toughness and elongation of the formed extrusion coating layer, so that the flexibility of the obtained flat cable is enhanced, and further the dimensional accuracy can be increased.

[0068] A distance between the nipple holes 11a of the extruding nipple 11 and the die opening (bearing) 12a of the die 12 is set at a value (space) to allow the rectangular conductors 1, a slight widthwise move so that they can be brought into the final layout before the rectangular conductors coming out of the nipple holes 11a as arranged in parallel enter the die hole 12a.

[0069] Also, it is preferable that the shape and pressure inside the die 12 be adjusted so that the pressures of molten resin exerted on the upper and lower faces of the rectangular conductors 1 fed from the nipple holes 11a are equal. This is because the obtained flat cable is prevented from being uneven in thickness; that is, the thicknesses of the extrusion coating layers overlying and underlying the rectangular conductors 1 are made more uniform.

[0070] The total thickness of the obtained flat cable is determined by the shapes and sizes of the extruding nipple 11 and the extruding die 12. However, since the molten resin somewhat shrinks after extrusion coating, it is preferable to design the shapes and sizes of the extruding nipple and extruding die, considering the amount of shrinkage.

[0071] The flat cable B1 coming out of the cross-head 10 is cooled down with disallowing the whole to curve after being cooled. For example, if the formed extrusion coating layer is thin, the flat cable may be allowed to cool in the air because the whole molten resin will uniformly set by nature in the cooling process. At this time of cooling, water cooling should be avoided because water cooling causes a difference in shrinkage between the outside and inside of the molten resin, by which the flat cable is curved as a whole, so that a flat shape cannot be obtained.

[0072] Usually, the thicknesses of the extrusion coating layers 8 in contact with the upper and lower faces of the rectangular conductor are set at 0.02 to 0.5 mm. If the thickness is less than 0.02 mm, the property to materialize an insulating layer is insufficient. If the thickness is larger than 0.5 mm, the flat cable itself becomes resistant to flection, so that the function for a flat cable lessens, and, depending on the material used, cracks occur at the time of repeated flection and stretch, which degrades the flexibility.

[0073] At the time when the extrusion coating layer is set to some degree by air cooling, water bathing or hot water bathing may be applied to supplement control over the temperature at which the flat cable is reeled around the spool finally.

[0074] In the production line shown in FIG. 5, a preheating device is interposed between the bobbin 4 and the cross-head 10, by which the rectangular conductors 1 may be preheated before being fed to the cross-head 10.

[0075] The preheat temperature is selected depending on the resin used, but it is set usually in the temperature range of 100 to 350°C, specifically in the temperature range of 120 to 280°C.

[0076] As the preheating device, a gas heating device, or a commercially available conductor heating device or high frequency induction heating device can be used.

[0077] The rectangular conductors 1 may be led to the cross-head 10 without being preheated. Alternatively, they may be led to the cross-head 10 after being heated to a temperature not exceeding the temperature of resin supplied to the cross-head 10. Such methods can improve the shape stability of flat cable.

[0078] If a silane coupling agent is applied onto the surface of the rectangular conductor before being extrusion coated, the adhesion property of the rectangular conductor with an extrusion coating layer is improved, so that the flexibility of the flat cable can be enhanced.

[0079] As the silane coupling agent used, an agent having at least one type of functional group selected from a group of epoxy group, methacryloxy group, amino group, chloro group, and mercapto group and a hydrolyzable group such as alkoxy group such as methoxy group and ethoxy group can be cited as an example.

[0080] Specifically, an epoxy type agent such as 3-glycidoxypropyltrimethoxysilane and 2-(3,4-epoxycyclohexyl) ethyltrimethoxysilane; a methacryloxy type agent such as 3-methacrylopropyltrimethoxysilane; an amino type agent such as 3-aminopropyltriethoxysilane, 3-aminopropylmethyldimethoxysilane, N-(2-aminoethyl)3-aminopropyltriethoxysilane, and N-(2-aminoethyl)3-aminopropylmethyldimethoxysilane; a chloro type agent such as 3-chloropropyltrimethoxysilane; and a mercapto type agent such as 3-mercaptopropyltrimethoxysilane can count.

[0081] The application method may be such that the silane coupling agent is diluted with a solvent such as water, methanol, ethanol, and toluene, and the resultant solution is applied by using a brush or application roll, or dipping in the same solution, followed by drying is performed.

[0082] FIG. 8 shows another flat cable B2.

[0083] This flat cable B2 is formed further with an extrusion coating layer 13 on the outside of the extrusion coating layer 8 of the flat cable B1.

[0084] This extrusion coating layer 13 may be formed of the same material as that of the extrusion coating layer 8, or formed of another material such as polvinylchloride, polyethylene, polystyrene, polycarbonate, polyethyleneterephthalate, polyacetal, polybutyleneterephthalate, modified polyphenyleneether, fluororesin, and rubber. Also, the extrusion coating layer 13 is not limited to the case where the whole periphery of the extrusion coating layer 8 is covered, and a part of periphery, for example, one face of cable or both ends thereof may be covered.

[0085] In the case of the flat cable of this type, by properly selecting the material for the extrusion coating layer 13, the flexibility is further increased, by which the flexibility can be improved.

[0086] For the flat cable of this type, the extrusion coating layer is not limited to the two-layer construction as shown in FIG. 8, and more numbers of layers may be formed. However, the extrusion coating layer directly covering the rectangular conductors 1 needs to be formed of the aforementioned thermoplastic resin.

[0087] FIG. 9 shows one more flat cable B3.

[0088] For this flat cable B3, the thickness of the extrusion coating layer 8 between the rectangular conductors 1 arranged in parallel and at both sideends is decreased.

[0089] This flat cable B3 can be manufactured by making the shape of the die hole 12a of the die 12 shown in FIGS. 6 and 7 the same as the external form of the cable B3 shown in FIG. 9. Alternatively, it can be manufactured by adjusting the amount of molten resin into the internal space 12b of the cross-head 10 in which the extruding die 12 and the extruding nipple 11, for example, shown in FIGS. 6 and 7 are disposed and by making the molten resin shrink naturally.

[0090] For the above-described flat cables in accordance with the present invention, generally, the thicker the rectangular conductors 1 are, the lower the flexibility of the manufactured flat cable is, and the thinner the rectangular conductors 1 are, the higher the flexing property of flat cable is. However, if the rectangular conductors 1 are too thin, handling is difficult to perform, and specifically extrusion coating is difficult to perform. Also, the mass-producibility of rectangular conductor decreases.

[0091] For this reason, the thickness of the rectangular conductor used should preferably be 0.02 to 0.5 mm, and particularly the thickness of 0.03 to 0.2 mm is preferable. Also, the width of the rectangular conductor 1 is determined appropriately considering the intended application of the flat cable, but it is usually about 0.9 to 4 mm.

[0092] Further, the thicknesses of an upper face portion 8a and a lower face portion 8b of the extrusion coating layer located above and below the rectangular conductor 1 each should preferably be 0.02 to 0.5 mm. If this thickness is smaller than 0.02 mm, it is difficult to perform extrusion coating and at the same time the reliability of the extrusion coating layer as an insulating layer is reduced. If this thickness is larger than 0.5 mm, the bending property is decreased remarkably, so that the function as a flat cable is reduced. The thicknesses of the extrusion coating layers 8a and 8b should more specifically be 0.030 to 0.2 mm.

<u>Examples 1 to 4, Comparative Examples 1 to 4</u>

(1) A flat cable was manufactured using the production line shown in FIG. 5 in the following manner.

[0093] First, four rectangular conductors 1 of tough pitch copper with a width of 1.0 mm and a thickness of 140 μm were sent out of the bobbin 4 being arranged in parallel, and supplied to the cross-head 10 without being preheated after the intervals thereof were set at 1.0 mm by a guide (not shown).

[0094] The mutual intervals of the nipple holes 11a of the extrusion nipple 11 in the cross-head 10 had been set at 1.0 mm.

[0095] Nylon 12 (Daiamide L2140 manufactured by DAICEL-HÜLS LTD., having a flexural modulus of 1200 MPa under the measuring conditions of a temperature of 23°C and a relative humidity of 50%) was supplied to the cross-head 10 at a temperature of 240°C, thereby performing extrusion coating of the rectangular conductors, and was cooled by air. The line speed at this time is given in Table 1.

[0096] As a result, a flat cable B3 having a cross-sectional construction shown in FIG. 9 was continuously obtained. In the formed extrusion coating layer 8, the respective thicknesses of the upper face portion 8a and the lower face portion 8b were 0.08 mm, and the thickness of the central portion between the rectangular conductors was 0.23 mm. Also, the width of the obtained flat cable B3 was 9 mm. The obtained flat cable is referred to as Example 1.

[0097] A flat cable was manufactured in the same way as Example 1 except that the resin used for forming the extrusion coating layer 8 was polypropylene (Chissopolypro 2038 manufactured by Chisso Corporation, having a flexural modulus of 1200 MPa), and the temperature of resin supplied to the cross-head was 210°C. The obtained flat cable is referred to as Example 2.

[0098] A flat cable was manufactured in the same way as Example 2 except that the resin used for forming the extrusion coating layer 8 was polypropylene (Chissopolypro 2527 manufactured by Chisso Corporation, having a flexural modulus of 1960 MPa). The obtained flat cable is referred to as Example 3.

[0099] 93 wt% of polypropylene, 2 wt% of glycidylmethacrylate, and 5 wt% of styrene were mixed, and 0.05 wt% of Irganox 1010 (a stabilizer manufactured by Ciba-Geigy Ltd.), 0.05 wt% of Phosphite 168 (manufactured by Ciba-Geigy Ltd.), and 0.1 wt% of calcium stearate were added as stabilizers, by which epoxy-modified polypropylene pellet was synthesized in the presence of 0.2 wt% of dimethyl-di(t-butyl peroxy) hexyne. A flat cable was manufactured in the same way as Example 1 except that the obtained epoxy-modified polypropylene pellet of 30 wt% and Ubenylon 1013NU2 (trade name, manufactured by Ube Industries, Ltd.) of 70 wt% were mixed, and the mixture was supplied to the cross-head at a temperature of 260°C. The obtained flat cable is referred to as Example 4.

[0100] The flexural modulus of the aforesaid mixture was 1640 MPa (measured value under the conditions of a temperature of 23°C and a relative humidity of 50%).

[0101] A flat cable was manufactured in the same way as Example 1 except that the resin used for forming the extrusion coating layer 8 was a polymer alloy (Zairon 540Z manufactured by Asahi Chemical Industry Co., Ltd., having a flexural modulus of 2450 MPa) of polystyrene and polyphenylene ether, and the temperature of the resin supplied to the cross-head was 270°C. The obtained flat cable is referred to as Comparative Example 1.

[0102] A flat cable was manufactured in the same way as Example 1 except that the resin used for forming the extrusion coating layer 8 was high-density polyethylene (J-REX-HD-C3502E manufactured by Nippon Polyolefin, having a flexural modulus of 780 MPa), and the temperature of the resin supplied to the cross-head was 210°C. The obtained flat cable is referred to as Comparative Example 2.

(2) A flat cable was manufactured by using the production line shown in FIG. 2 in the following manner.

[0103] Four rectangular conductors 1 of tough pitch copper with a width of 1.0 mm and a thickness of 140 μm were sent out of the bobbin 4 being arranged in parallel, and supplied to the heating rolls 6a, 6b after the intervals thereof were set at 1.0 mm by a guide (not shown).

[0104] At this time, polyethyleneterephthalate films 3a and 3b with a thickness of 38 μm, to each of which polyester film 2,2 with a thickness of 47 μm is laminated on the inside, were supplied to the heating rolls 6a, 6b after being adhered to the upper and lower faces of the rectangular conductors 1. The whole structure was heat-compressed under the conditions of a heating roll surface temperature of 150°C and a roll surface pressure of 5 kg/cm^2. The line speed at this time is given in Table 1.

[0105] A flat cable with a total thickness of 0.31 mm and a width of 9 mm, having a cross-sectional structure shown in FIG. 1, was obtained. This flat cable is referred to as Conventional Example 1.

(3) A flat cable was manufactured by using the production line shown in FIG. 3 in the following manner.

[0106] The operation was performed under the same conditions as those of Conventional Example 1 except that the heating rolls 6c and 6d disposed on the downstream side of the heating rolls 6a and 6b were operated under the conditions of a surface temperature of 120°C and a roll surface pressure of 5 kg/cm^2, and the line speed was increased as given in Table 1. The obtained flat cable is taken as Conventional Example 2.

[0107] On the aforementioned eight kinds of flat cables, the useful life at the time of flection and stretch was measured in the following manner.

[0108] Each flat cable was cut to a length of 400 mm to get a specimen, and the specimen was placed in a U shape with a bending diameter of 10 mm. One end thereof is fixed, and the other end was subjected to flexing motion of 100 cycles per minute with a stroke of 200 mm. The number of cycles before the first electrical breakage (including momentary breakage) occurred in the rectangular conductor was measured. The higher the value is, the longer the useful life at the time of flection of the flat cable is. The results are given in Table 1.

Table 1

	Flexural modulus of resin used (MPa)	Line speed (m/min)	Number of cycles of flexing motion (cycles)
Example 1	1200	50	180,000
Example 2	1270	50	160,000
Example 3	1960	50	410,000
Example 4	1640	50	820,000
Comparative Example 1	2450	50	40,000
Comparative Example 2	780	50	60,000
Conventional Example 1	-	2	30,000
Conventional Example 2	-	3	50,000

[0109] The following are apparent from Table 1.

(1) For the manufacture of flat cables of Examples 1 to 4, the production line speed can be increased up to 50 m/min. Also, the obtained flat cable shows a very high flexing property.

However, for both of Comparative Examples, the flexing property is far lower than that of Examples 1 to 4.

This is because for Comparative Examples, the flexural modulus of resin forming the extrusion coating layer deviates from the range of 800 to 2400 MPa.

For example, as is apparent from the comparison between Example 4 and Comparative Example 1, even if both of resins forming the extrusion coating layer are polymer alloys, the flexing property of Comparative Example is reduced significantly because the flexural modulus thereof exceeds 2400 MPa.

This reveals that the resin forming the extrusion coating layer should have a flexural modulus of 800 to 2400 MPa.

(2) On the other hand, for both of Conventional Examples 1 and 2, the line speed can be increased only up to 2 to

3 m/min, and moreover the obtained flat cable has a low flexing property. That is to say, compared with Examples, the productivity is very low, and the obtained flat cable has a low flexing property.

Examples 5 to 8

[0110] In manufacturing the flat cable of Example 1, a flat cable was manufactured by changing the thickness of the rectangular conductor used, the thicknesses of upper and lower face portions of the extrusion coating layer formed, and the line speed as shown in Table 2, and the flexing property of the obtained flat cable was investigated. The results are given in Table 2.

Table 2

	Thickness of rectangular conductor (mm)	Thickness of upper or lower face portion of extrusion coating layer (mm)	Line speed (m/min)	No. of cycles of flexing motion (cycle)
Example 5	0.14	0.04	20	140,000
Example 6	0.14	0.08	20	190,000
Example 7	0.14	0.35	20	400,000
Example 8	0.25	0.25	20	70,000

[0111] As is apparent from Table 2, for the flat cable of Example 8, in which the rectangular conductor is as thick as 0.25 mm, a decrease in flexing property is found as compared with other Examples even if the flexing property is compensated by an increase in thickness of extrusion coating layer.

INDUSTRIAL APPLICABILITY

[0112] The flat cable in accordance with the present invention has very excellent life characteristics at the time of repeated flection. According to the manufacturing method in accordance with the present invention, the line speed can be made ten or more times as high as that of the conventional production line, so that functional flat cables can be manufactured at a low cost with high productivity.

[0113] The flat cable in accordance with the present invention can be attached with a very high industrial value as a cable for applications, which force a heavy repetition of flexing motion, such as various kinds of communication equipment, household electrical appliances, photocopy equipment, computers, printers, image scanners, word processors, CD players, automotive steering-wheel roll connectors, and other automotive wires. Also, this flat cable can be used as an automotive wire harness and the like.

Claims

1. A flat cable comprising;

a plurality of rectangular conductors embedded in parallel in an insulating resin layer;
said insulating resin layer, in contact with at least said rectangular conductors, being an extruded coating layer formed of a thermoplastic resin with a flexural modulus of 800 to 2400 MPa.

2. A flat cable according to Claim 1, wherein said thermoplastic resin is a polyamide resin.

3. A flat cable according to Claim 2, wherein said polyamide resin is nylon 12.

4. A flat cable according to Claim 1, wherein said thermoplastic resin is a polyolefin resin.

5. A flat cable according to Claim 4, wherein said polyolefin resin is polypropylene.

6. A flat cable according to Claim 1, wherein said thermoplastic resin is a polymer alloy.

7. A flat cable according to Claim 6, wherein said polymer alloy is a polymer alloy with a sea-island structure whose main ingredients are polyamide resin and epoxy-modified propylene.

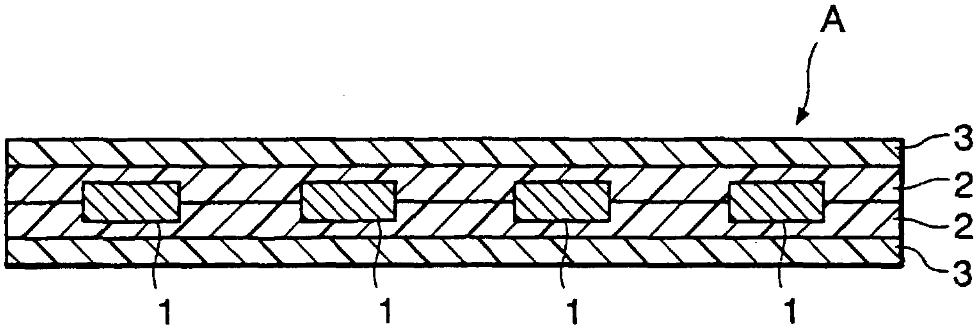
8. A flat cable according to Claim 7, wherein the mixing ratio of said polyamide resin is 50 to 95 wt%.

9. A flat cable according to Claim 1, wherein the thickness of said rectangular conductor is 0.02 to 0.5 mm, and the thickness of said insulating resin layer at a portion where said rectangular conductor is present is 0.02 to 0.5 mm.

10. A manufacturing method of a flat cable, comprising the steps of:

paralleling and feeding a plurality of rectangular conductors to a cross-head of an extruder;
supplying a thermoplastic resin with a flexural modulus of 800 to 2400 Mpa to said cross-bead; and
extrusion coating said rectangular conductors.

F I G. 1



F I G. 2

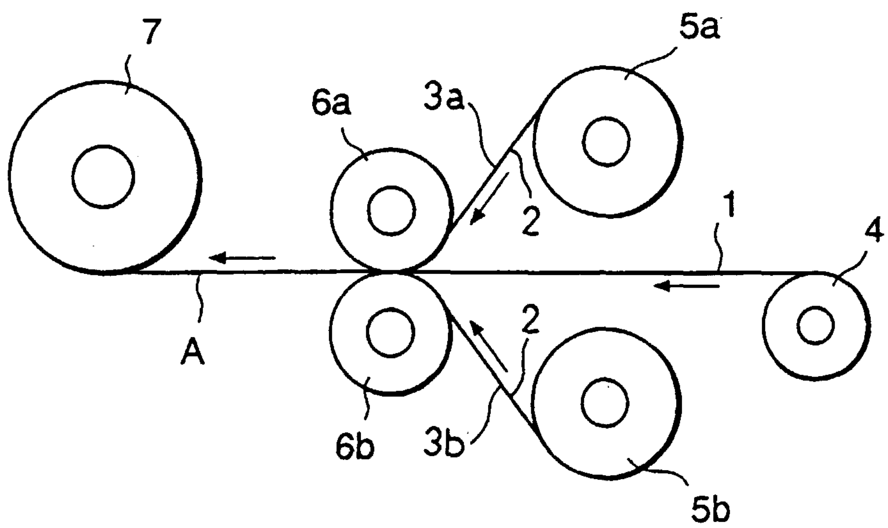


FIG. 3

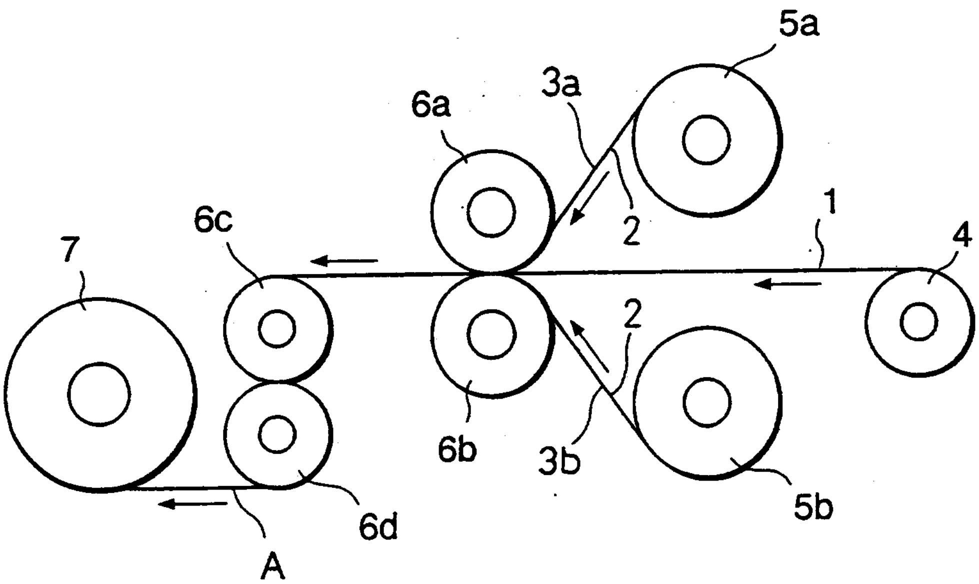


FIG. 4

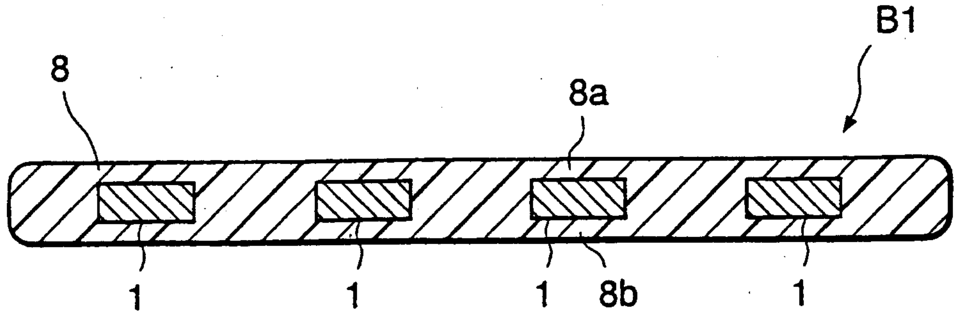


FIG. 5

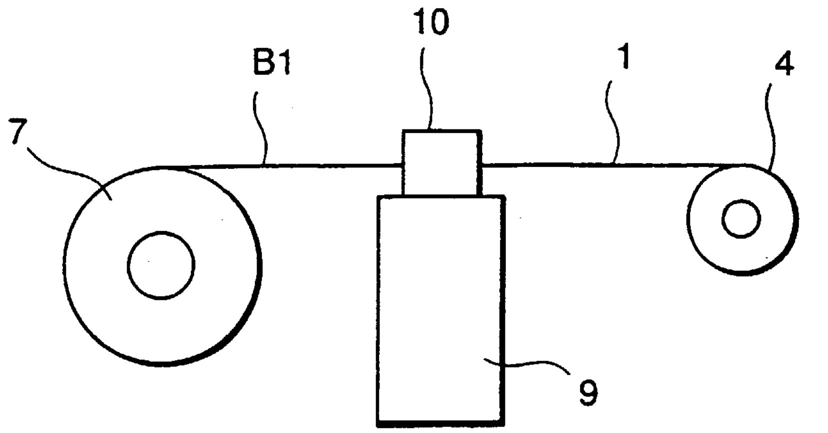


FIG. 6

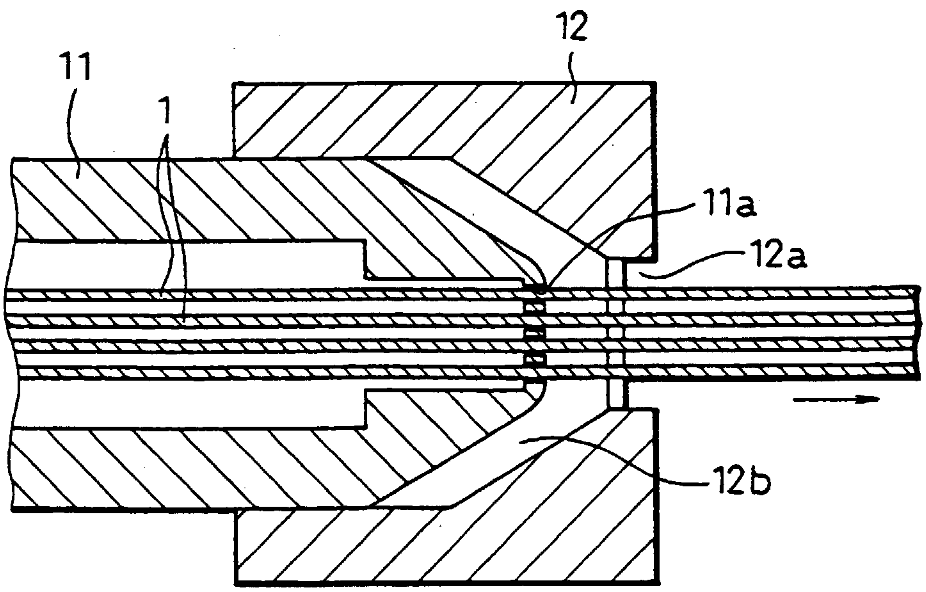


FIG. 7

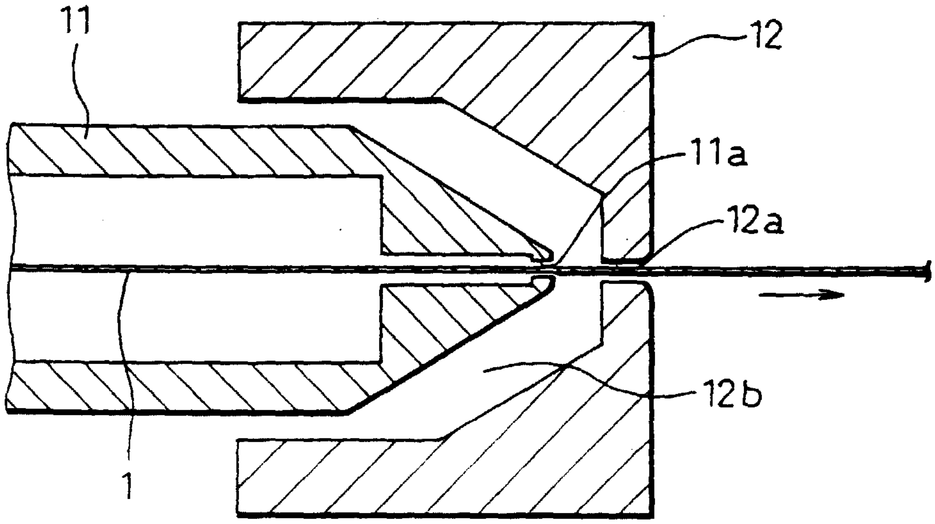


FIG. 8

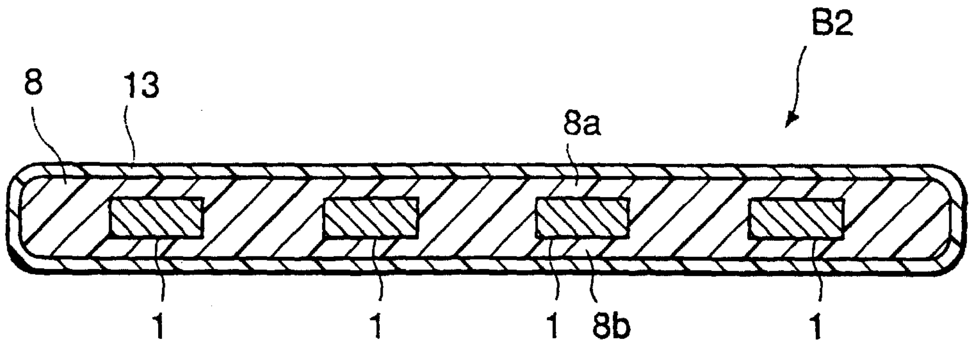
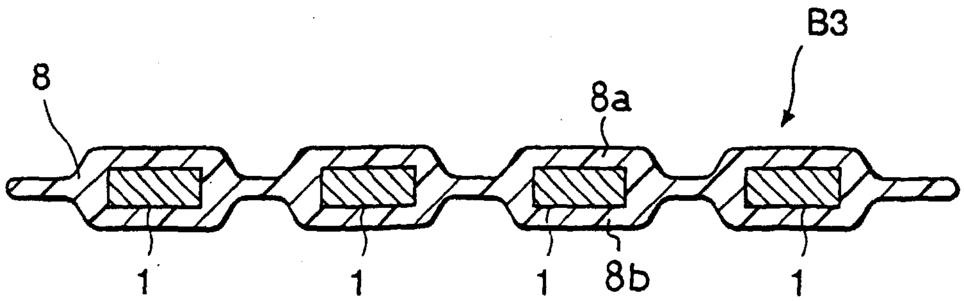


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/02145

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] H01B7/08, H01B13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[6] H01B7/08, H01B13/00, H01B3/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-1998
Kokai Jitsuyo Shinan Koho 1971-1998 Jitsuyo Shinan Toroku Koho 1996-1998

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 01-276514, A (Hitachi Cable, Ltd.), 7 November, 1989 (07. 11. 89), Claims ; page 4, upper right column, lines 4 to 13 (Family: none)	1-10
Y	JP, 05-220908, A (Sumitomo Electric Industries, Ltd.), 31 August, 1993 (31. 08. 93), Par. No. [0011] ; Tables 1, 2 (Family: none)	1-3, 9, 10
Y	JP, 06-313826, A (The Furukawa Electric Co., Ltd.), 8 November, 1994 (08. 11. 94), Par. No. [0016] ; Table 2 (Family: none)	1, 4, 5, 9, 10
Y	JP, 05-287163, A (Dainippon Ink & Chemicals, Inc.), 2 November, 1993 (02. 11. 93), Claims ; Par. Nos. [0015], [0024], [0028], [0029] ; Tables 1 to 4 (Family: none)	1, 7-10

[x] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
7 August, 1998 (07. 08. 98)	25 August, 1998 (25. 08. 98)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/02145

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 06-36619, A (Sumitomo Electric Industries, Ltd.), 10 February, 1994 (10. 02. 94) (Family: none)	1, 4, 6, 9
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 199608/1985 (Laid-open No. 109314/1987) (Dainippon Printing Co., Ltd.), 13 July, 1987 (13. 07. 87) (Family: none)	3
A	JP, 08-264019, A (Fujikura Ltd.), 11 October, 1996 (11. 10. 96) (Family: none)	1, 4, 5
A	WO, 96-20487, A1 (Polyplastics Co., Ltd.), 4 July, 1996 (04. 07. 96) (Family: none)	1, 6

Form PCT/ISA/210 (continuation of second sheet) (July 1992)