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Bauer

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[54] **METHOD OF MAKING FLAT CABLES**

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[51] **Int. Cl.**............................**B29f 3/10,** B29c 25/00

[58] **Field of Search**......................264/172, 174, 237, 264/348, 178, 176, 40

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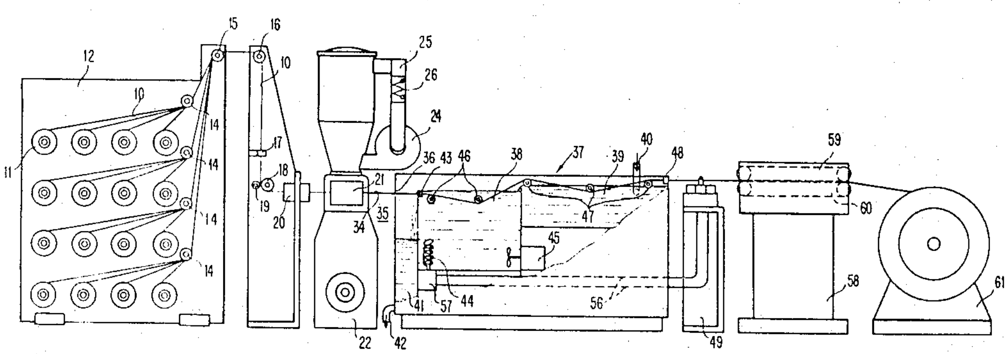
[57] **ABSTRACT**

Method of making flat cables with plastics by extrusion. For cooling, at least two cooling zones are provided. The width of the flat cable is adjusted by setting the temperature difference of the cooling zone, in which the cable sets, and of the preceding cooling zone.

5 Claims, 6 Drawing Figures



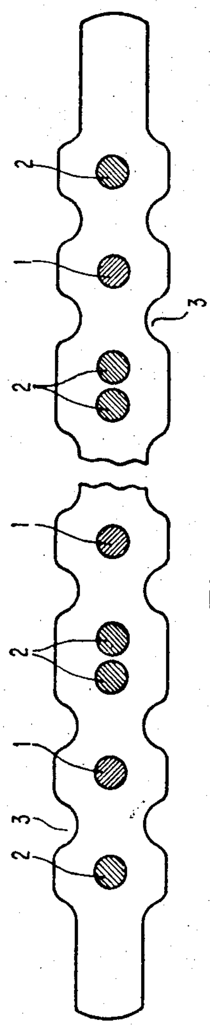


FIG.1

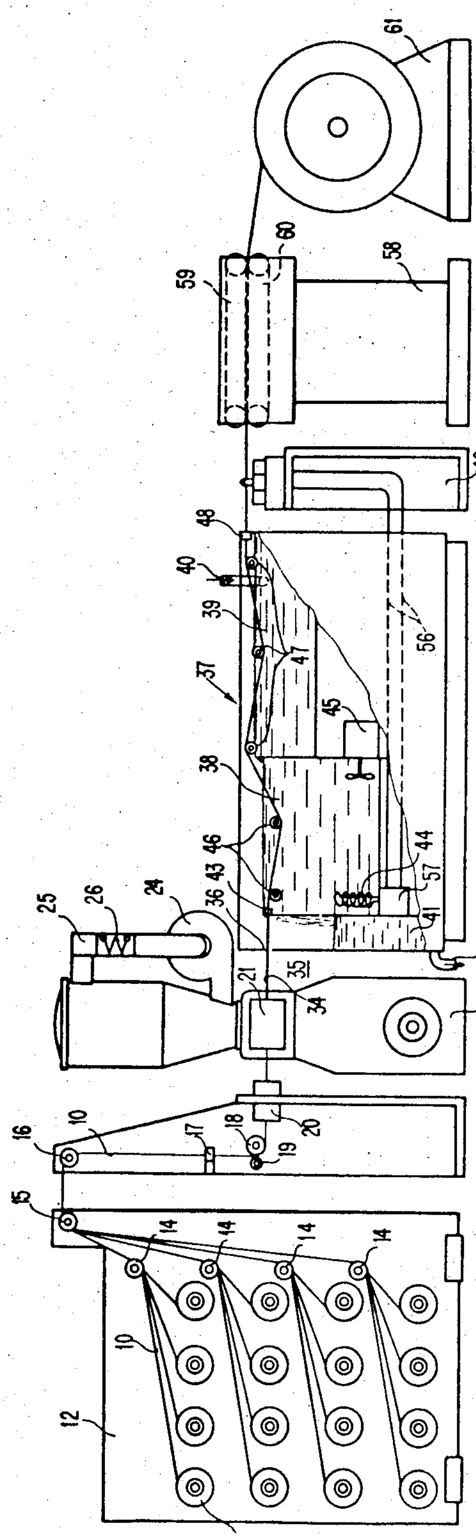


FIG.2

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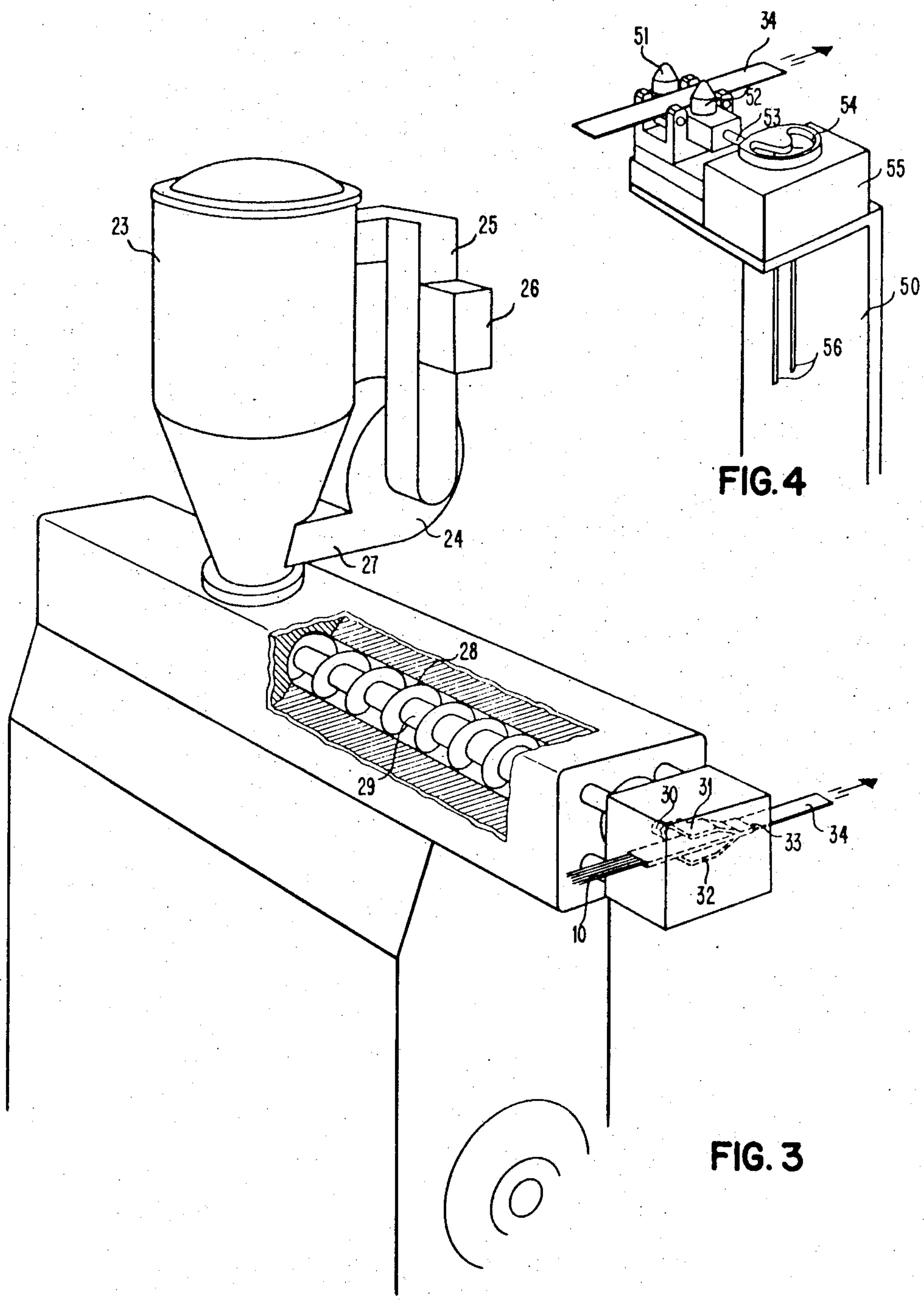

FIG. 4

FIG. 3

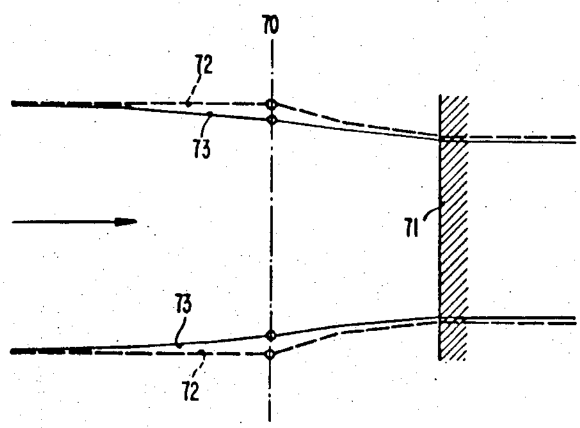
70
72
73
71
73
72

FIG. 5

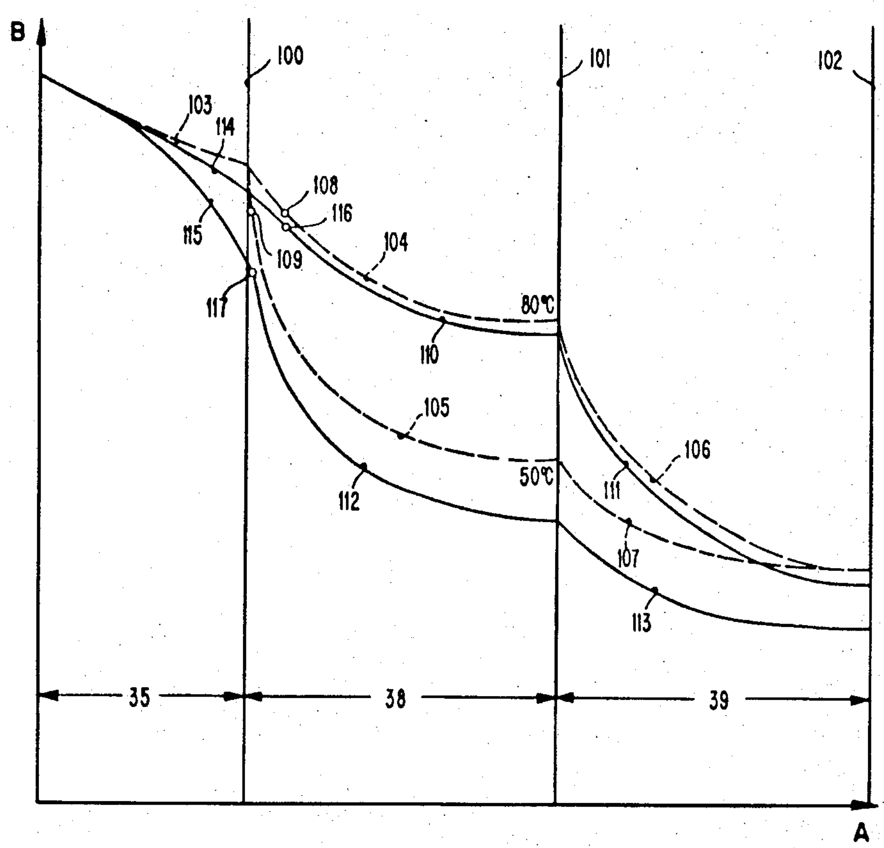
B
100
101
102
103
114
108
116
104
115
109
117
80°C
110
105
106
50°C
111
112
107
113
35
38
39
A

FIG. 6

METHOD OF MAKING FLAT CABLES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of making flat cables, particularly a method of making flat electric cables in which conductors are coated with plastic by extrusion.

2. Description of the Prior Art

Methods of and arrangements for extruding making of wires, stranded wires, conductors and cables are known from the book "Kunststoffextrudertechnik" (Plastics Extrusion Engineering) by Gerhard Schenkel, published by Hanser Verlag Munich, 1963, chapter X, pp. 354 – 373. On page 354 of the book by Gerhard Schenkel, it is stated that the diameters of the wires to be coated range from about 0.4 to 180 mm. Hitherto, any attempts at extruding flat cables, which include more than 10 wires each having a diameter of less than 0.3 mm, have been unsuccessful. Experience has shown that extrusion by known methods results in the dimensions required not being accurately observed. During extrusion variations in the dimensions of the flat cable occur which are difficult to control and which exceed the normal heat shrinkage of the plastics and the tolerances applicable to microelectronics. The cause and effect of these variations are only insufficiently known. MOreover, it is practically impossible to size flat cables.

A method of manufacturing flat cables by extrusion is described in DAS 1,075,695. By this known method, the insulation in the form of a hose is extruded onto the wires passing the extrusion die parallel to each other. Subsequently, at a reduced pressure in the space between the nozzle and the hose the insulation is applied to the conductors and bonded together. As satisfactory bonding of thermoplastic necessitates the application of pressure, the results obtained are not always perfect, which means that cavities result on the bonding surface between the conductors. Such cavities are undesirable, since the cable terminals thus produced are permeable to moisture, contaminants or soldering agents.

Another method of manufacturing flat cables is described in U. S. Pat. No. 3,082,292. According to the second paragraph of the patent specification, this method was developed in view of the great mechanical difficulties previously encountered in attempting to coat more than two or three conductors in a single assembly. By the method described in U. S. Pat. No. 3,082,292, two plastic strips are initially produced by extrusion. In a bonding apparatus, these strips are applied to the wires from both sides. Subsequently, the assembly is heated and subjected to pressure, so that the two plastic strips are fused together. After cooling, he edges of the bonded strips are cut to a uniform width.

Although in the known laminating process, any cavities are filled with plastics, since the two plastic strips are bonded together at high temperature and pressure, the pressure applied may lead to the position of the wires being changed, so that the electrical properties such as the characteristic impedance and capacitance may vary. Moreover, heating and bonding of the strips require a certain period of time, so that the pay-off speed for flat cables produced by the laminating process is very low. In practice, pay-off speeds of 2.5 m per minute have been obtained.

German Pat. No. 1,047,276 describes a method of automatically regulating the gauge and capacitance of plastics coated conductors. In accordance with this known method, the speed at which the conductor passes the screw press and the heating current for preheating the conductor are automatically and reciprocally adjusted as a function of the continuously measured gauge and capacitance. This method is used for coating individual conductors, preferably employing foam plastics. The known method is not suitable for influencing the width of a flat cable, since the adjustment provided extends in the first place to the gauge and only to a limited degree to the width of the cable.

SUMMARY OF THE INVENTION

It is the object of this invention to provide an improved method by which flat electric cables comprising a plurality of conductors can be coated with plastics by extrusion.

It is also an object of this invention to provide a method of making multiple conductor flat cables by extrusion in which shrinkage can be controlled after extrusion so that dimensional tolerances and expecially the required conductor spacings are adhered to.

It is a further object of this invention to provide a method of making multiple conductor flat cables by extrusion which is relatively simple and economical and which is capable of manufacture at speeds higher than heretofore obtainable by laminating processes and in which precise dimensional control is readily obtained.

Broadly, in accordance with this invention, the above as well as other objects are obtained by extruding dielectric material in a plastic state onto a plurality of space conductors, then cooling the plastic material to a solid state in a controlled manner to control the dimensions of the cable and the desired spacing of conductors. Specifically, the plastic material is preferably noncrosslinked polyethylene and control of the size of the plastic mass is obtained by moving the encapsulated conductors through one or more cooling zones in a manner which controls the dimensions of the cable. More particularly, the temperature and/or the length of a first cooling zone and/or the temperature of the second cooling zone is/are so adjusted that the difference in the temperature of the flat cable entering the second cooling zone and the temperature of the second zone is increased as the width of the flat cable increases and is decreased as the width of the flat cable decreases.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows an embodiment of a flat cable manufactured in accordance with the method of the invention;

FIG. **2** illustrates an apparatus useable for practicing the method of the present invention;

FIG. **3** shows certain details of an extrusion press useable in the apparatus shown in FIG. **2**;

FIG. **4** shows details of a width measuring device useful in the apparatus shown in FIG. **2**;

FIG. **5** illustrates width shrinkage of a flat cable during cooling; and

FIG. 6 is a chart showing how the width of the flat cable is influenced by the method in accordance with the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1 is the cross-sectional view of a flat cable produced to the method in accordance with the invention. The width of this cable is 29.2 mm and the gauge 0.7 mm. Each of the 60 wires arranged side by side in the flat cable has a diameter of 0.18 mm. The signal wires are identified by numeral 1. One ground wire 2 each is arranged on both sides of a signal wire for screening the latter. During extrusion of the cable through the suitably shaped nozzle, grooves 3 are formed in all those places on the cable surface where there are no wires. In the case of the preferred embodiment, polyethylene is used for plastics making the wires; also suitable for this purpose are polypropylene, polyethylene and polypropylene copolymerizates, polyvinyl chloride, silicone rubber or fluorinated ethylene propylene.

FIG. 2 shows an arrangement, by means of which the method in accordance with the invention is applied. The wires and subsequently the flat cable pass the arrangement shown in FIG. 2 from left to right. The wires 10 for the flat cable are taken off the rollers 11 which are mounted in a pay-off frame 12. The rear side of the pay-off frame 12 is provided with the same number of rollers as the front side, but the former rollers are not visible in FIG. 2. For manufacturing a flat cable comprising 60 wires, each side of the pay-off frame 12 would have to be equipped with 30 rollers, of which, for the sake of simplicity, only a limited number is shown. In order to keep the wires 10 tensioned, rollers 11 are continuously decelerated, preferably using a shoe brake. Sagging of the wires in the case of sudden stoppages is avoided by means of spiral springs arranged between the rollers 11 and the brakes and which try to turn the rollers against the pay-off direction. Deflector rollers 14 and 15 serve to preliminarily adjust wires 10. Subsequently, the wires pass onto a roller 16, which is notched on its circumference for guiding the wires. Wires 10 are then guided between electric contact plates which produce a signal in the event any of the wires rupture. Subsequently, the wires pass a further roller 18, which similar to roller 16, is provided with guiding notches. Wires 10 are forced against roller 18 by means of a rubber back-up roller 19. In the area between roller 16 and roller 18 the spacing of the wires exceeds that in the flat cable; in a comb-shaped guide 20 the wires are assembled to their final spacing in the flat cable.

Then wires 10 enter from the left the angle extrusion head 21 of an extrusion press 22. An enlarged perspective view of the extrusion press is shown in FIG. 3 to render the function of this machine readily understandable. The granulated plastics, such as, for example, polyethylene, are fed into a funnel 23. For preheating the granulate, funnel 23 is provided with a fan 24 which takes in its operating air via a tube 25. After having been heated in heater 26, the air is discharged into funnel 23 via tube 27. The preheated granulate is fed to the screw press. The screw press consists of a heated hollow cylinder 28 in which the screw 29, transferring the plastic material in the direction of the die 21, rotates. Screw 29 is driven by an electric motor of which only the covering is visible in the bottom part of the extruder. Heating, compression and friction of the granulate result in a compound which becomes increasingly plastic in the direction of the die 21. The die 21 employed is an angle extrusion head as is mostly used for coating wires. In the angle extrusion head 21 a path 30, which forms the extension of the hollow cylinder 28, is split into two paths 31, 32 which are both deflected through an angle of 90° and which then from above and below converge in the direction of the wires 10 which are led in parallel to each other. At the point of convergence of the plastic compound emerging from paths 31 and 32 the wires are densely surrounded with plastic material. On the right output of angle extrusion head 21 nozzle 33 is arranged, the cross-section of which exceeds that of the finished cable by the shrinkage in volume (e.g. by about 10 percent with regard to the width and gauge). Longitudinal shrinkage of the flat cable is prevented by the wires. The screw output, which can be adjusted as a function of the number of revolutions of the screw, is chosen so that the plastic material leaves nozzle 33 at the same speed at which the wires 10 are taken off. In the case of polyethylene, for example, the plastic material upon leaving the nozzle has a temperature of about 200°C.

After having left nozzle 33, the flat cable 34, which at that stage is still plastic, passes a first cooling zone 35 which is formed by the surrounding air. This cooling zone may be some 40 cm long. Through an aperture 36 the flat cable enters a cooling tank 37, which preferably takes the form of a water cooling tank. The cooling tank 37 comprises two cooling zones 38 and 39. The water, as it comes out of the main, is led to cooling zone 39 via an inlet tube 40. The front part of cooling zone 39 is designed as an overflow. The water overflowing from cooling zone 39 enters cooling zone 38. The front part of cooling zone 38 is also provided with an overflow. The water overflowing from this zone accumulates in basin 41 and is subsequently discharged via tube 42. Through an aperture 43, which is sealed by brushes positioned above and below the flat cable 34, the latter enters the second cooling zone 38. As will be described below, the temperature of cooling zone 38 is set to a nominal value. In the case of the present embodiment, the temperature of cooling zone 38 is, for example, 80°C. This temperature is generated by means of a heating coil 44. In order to ensure that this water temperature is kept as accurately as possible, the water is agitated by means of a circulating unit 45 which consists of a motor-driven propeller. In cooling zone 38 the flat cable is guided by means of two rollers 46. Cooling zone 39 is provided with three further rollers 47, of which the first one is so positioned in relation to the overflow that the flat cable is transferred to the second cooling zone 39 above the overflow. As has been previously stated, the water in cooling zone 39 has the temperature at which it leaves the main. This temperature is not critical. The flat cable is led out of cooling zone 39 through a foam plastic coated aperture 48, by means of which any water still adhering to the cable is wiped off.

Behind cooling tank 37 a width measuring device 49 is provided which takes the form of a feeler roll measuring unit. Needless to say, the feeler roll measuring unit can be replaced by any other measuring device, such as, for example, a measuring device working to the pneumatic principle. Details of the width measuring device **49** are shown in FIG. **4**. The actual measuring device is arranged on a frame **50**. The flat cable passes between two rollers **51** and **52**. The two rollers are resiliently mounted, so that they are laterally moved by the lateral edges of flat cable **34**. This lateral movement is transferred to pin **53** and can be indicated by means of a measuring instrument **54**. Thus, measuring instrument **54** indicates the width of the flat cable. Moreover, a circuit **55** is provided which converts the mechanical deflection of pin **53** into an electric signal on lines **56**. The mechanical deflection of pin **53** can be converted into an electric signal in one of several manners. So, for example, pin **53** can be employed to change the tap of a potentiometer, thus causing an electric current to be changed. Pin **53** can also be used to change the capacitance of a measuring bridge capacitor, whereby the change in capacitance affects a signal. If necessary, these signals can be amplified. Devices for converting mechanical movements into electric signles are, for example, described in the book "Control Engineers Handbook" published by Truxal, McGraw Hill Book Company, Inc., 1958, chapter 17 "Signal Transducers".

Lines **56** are connected to a regulating device **57**, by means of which to the method in accordance with the invention, the heating voltage of the heating coil **43** is so regulated that as the width of the flat cable on the feeler roll measuring device **49** increases, the temperature of cooling zone **38** is reduced, while the temperature of cooling zone **38** is increased as the width on feeler roll measuring device **49** decreases. The temperature of cooling zone **38** can also be set by hand. Manual adjustment of the temperature is effected in accordance with the deflection of the pointer indicator **54** on the feeler roll measuring device. How the temperature of cooling zone **38** affects the width of flat calbe **34** is described below by means of FIGS. **5** and **6**.

For taking off the finished flat cable, a take-off **58** is arranged behind the feeler roll measuring device **49**, which comprises two tractors **59** and **60**. The two tractors, embodied by two rubber bands which revolve around two rollers each, are driven by an electric motor, not shown. Finally, a coiling device **61** is provided behind the take-off **58**. The coiling device **61** is driven by means of an electric motor, not shown, which can be endecelerated to standstill.

The shrinkage of the flat cable is shown in FIG. **5** which is a plan view of the cable. In order to render the shrinking process readily understandable, the amounts of shrinkage encountered are shown in exaggerated form.

The dotted lines **72** define the outer edge of an extruded plastic strip without wires. In the area of air cooling zone **35**, cooling and shrinkage of this strip are relatively insignificant. Upon entering water cooling zone **38** at line **70**, the plastic strip is cooled relatively intensely, which results in a bend at this line the material shrinks considerably. Depending upon the temperature of cooling zone **35**, the plastic strip will shrink more or less heavily in this area. The total shrinkage of a plastic strip without longitudinal wires is invariably the same, irrespective of whether the temperature in cooling zone **35** is high or low. Beyond the straight line **71** the plastics are set, whereby it is negligible that freezing occurs over a wider area. Shrinkage beyond line **71** is almost excusively attributable to the coefficient of thermal expansion.

The shrinkage of a flat cable is slightly different from that experienced with a plastic strip (dotted line **72**). The flat cable is designated by the unbroken line **73**. It is readily recognizable that the shrinkage plot is not bent at the entry **70** to the second cooling zone, since the tensile stress of the wires prevent any abrupt change in width while the material is in a plastic state, and that the heavy shrinkage in the first cooling zone, caused by the wires, results in a more pronounced reduction in width behind the nozzle than in the case of a plastic strip.

The diagram of FIG. **6** serves to explain in detail how the shrinkage of a plastic strip with and without wires proceeds and how the width B of an extruded flat cable is influenced by changing the temperature of the second cooling zone **38**. In the diagram of FIG. **6** width B, during cooling, is shown on the abscissa with respect to the spacing A from the nozzle outlet. The three cooling zones, the first zone **35**, the second **38**, and the third **39**, are defined in relation to each other by vertical lines **100**, **101**, and **102**. First of all are considered the dotted plots which represent the reduction in width of an extruded plastic strip (without wires). Plot section **103** shows how the width of the extruded plastic strip decreases in the first cooling zone, the air cooling zone **35**. At a cooling water temperature of 80°C of the second cooling zone **38** the width of the platic strip decreases in accordance with the dotted plot **104**. If the cooling water temperature of the second cooling zone **38** is lower than that of the first, say, for example, 50°C, the reduction in width in cooling zone **38** proceeds in accordance with plot **105**. At the straight line **100**, the point where the plastic strips enter cooling basin **23**, the width plot is bent. Plots **104** and **105** are proportional to the amount of cooling. Points **108** and **109** are the freezing points. Beyond these points the plastics are set over their full cross-sectional area. In some areas setting occurs more rapidly. Beyond freezing points **108** and **109**, shrinkage of the plastics is mainly governed by the coefficient of thermal expansion and only to a very limited degree by crystallization. The degree of crystallization depends upon the temperature of cooling zone **38**. Subsequent crystallization is encountered as long as one week after cooling, producing a negligible shrinkage of some 2 percent° in the width and gauge of the material.

Straight line **101** defines the entry to cooling zone **39**. In the embodiment the temperature of this cooling zone is assumed to be 20°C. The width of the plastic strip proceeds along the dotted plot **106** if the temperature of cooling zone **38** is 80°C and along plot **107** if the temperature is 50°C. Plots **106** and **107** converge. Thus, the plastic strip has a uniform width under identical environmental and material conditions, which is independent of how cooling is effected, i.e. in this case of whether the temperature of cooling zone **38** is 80° or 50°C.

Details of the reduction in width of a flat cable during cooling after extrusion are given below. In FIG. **6** the width plots of the flat cable are represented by unbroken lines. After the plastics have set, the reduction in width of the flat cable proceeds parallel to the reduction in width of the plastic strip. At a temperature of 80°C in the second cooling zone **38**, the width of the flat cable corresponds to plot **110** and after entry into the third cooling zone **39** to plot **111**. Correspondingly, the width of a flat cable cooled to 50°C in the second cooling zone **38** decreases beyond the freezing point according to plot **112** and in cooling zone **39** to plot **113**. Plots **110** and **111** are shifted downwards in relation to plots **104** and **106** and plots **112** and **113** with respect to plots **105** and **107**. This is due to the wires being pressed together in cooling zone **38** during cooling, which results in the width of the flat cable, which is in a plastic state in cooling zone **35**, being reduced. The different widths in this area are represented by plots **114** and **115**. The reduction in width is more pronounced, the more intense the cooling in the second cooling zone **38**, i.e. the more marked the bend at the straight line **100**. Freezing points **116** and **117** of the flat cable are below freezing points **108** and **109** which apply to plastic strip.

The difference between freezing points **117** and **109** is more pronounced than between freezing points **116** and **108**. As beyond the freezing points the plots for plastic strips and flat cables proceed parallel to each other under identical cooling conditions, different widths for the flat cable result on the straight line **102** upon completion of cooling. The cable is narrower the heavier the cooling in the second cooling zone **38**. This phenomenon, which is not encountered with plastic strip, is utilized in accordance with the invention for adjusting the width of the flat cable to a constant width. By controlling the temperature of the second cooling zone **38**, variations in material and temperatures in the extruder, different output speeds and environmental influences, such as room temperature, humidity, etc. can be compensated for.

The influence of the temperature of cooling zone **38** on the final width of the cable can also be readily physically explained by means of FIG. **6**. While the actual nozzle outlet of the extruder in FIG. **6** is at abscissa **0**, one can imagine a virtual nozzle in the area of the first cooling zone in which the flat cable is still in a plastic state. Assuming the virtual nozzle is located near the vertical **100**. At this vertical the width **114** or **115** of the flat cable differs considerably, which is due to the wires being forced together by the varying amounts of shrinkage in the second cooling zone **38**. This interaction produces an effect similar to that obtainable by a real nozzle with variable cross-section. These conditions, in particular the variations in temperature in the second cooling zone, are shown in exaggerated form in FIG. **6**. In actual fact, the cooling water temperatures in an arrangement according to the invention differ only slightly, for example, by 3°C. In an extruder working to the method in accordance with the invention and which is employed for extruding 60-core polyethylene flat cables having a final width of 29.2 mm, the temperature of the controlled cooling zone is about 80°C, this value being accurately regulable within a tolerance of 0.5°C.

In general, it can be said that the reduction in width of the cable in the area of cooling zone **35** is pronounced and the final dimensions of the cable are smaller, the more marked the bent of the cooling plot of a strip without wires is under similar cooling conditions above the freezing temperature. The angle of this bent can also be influenced in a manner other than is described in the above example where the temperature of the second cooling zone, in which the plastics set, is changed. The angle of the bent can also be altered by changing the length of the first cooling zone **35**. This results in the temperature of the flat cable being changed upon entry into the second cooling zone **38**. The temperature of the flat cable upon entry into the second cooling zone can also be influenced by changing the temperature of the first cooling zone **35** (e.g. by altering the air temperature of the air flow). Finally, it is also possible to change these parameters simultaneously.

The invention is not only suitable for cooling systems consisting of air and water cooling zones, but may also be utilized for systems employing different cooling speeds before the freezing point of the plastics.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

I claim:

1. A method of making flat cables comprising moving a plurality of spaced coplanar wire elements through an extrusion device;

coating said plurality of spaced coplanar wire elements with a unitary plastic sheath by continuously extruding plastic onto said moving coplanar wire elements;

passing said plastic covered wire elements after extrusion through at least two successive cooling zones whereby said plastic is cooled in the first zone and then is set and cooled in the second zone; determining the width of said cable following cooling of said cable in said second zone and regulating the difference in the temperature of the flat cable entering the second cooling zone and the temperature of the second cooling zone to provide a final desired cable width.

2. A method in accordance with claim **1** in which said cable width is increased by decreasing said temperature difference and decreased by increasing said temperature difference.

3. A method in accordance with claim **1** which further comprises passing said cable through a third cooling zone for cooling the flat cable to a final temperature approaching an external temperature;

determining the width of said cable at said final temperature of said cable; and

regulating the temperature differential of said plastic material in said first zone and the temperature of said second zone in response to said width determination.

4. A method in accordance with claim **1** in which said plastic material is selected from the class of materials comprising polyethylene, polypropylene, copolymerizates of polyethylene and polypropylene, polyvinyl chloride, silicone rubber, or fluorinated ethylene propylene.

5. A method in accordance with claim **1** in which said plastic material is non-crosslinked polyethylene.

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