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Description

This invention relates to a method of coating a filament, for example magnet wire, and more particularly to such a method and apparatus for applying a coating of flowable, hardenable resin material to a continuously moving filament to a required thickness in a single pass. Such a filament may be magnet wire, which has usually been manufactured by passing a bare copper or aluminium conductor or a previously insulated copper or aluminium conductor through a bath of liquid enamel (a solution of resin material in a solvent) and then through an oven for driving off the solvent from the enamel and/or curing the resin material, leaving a resin material coat on the conductor. In use of this known method of manufacture, the cost of the solvent used in applying the resin material from the solution is usually significant. In addition to the cost of solvent, there is the cost of providing and maintaining pollution control equipment; since recently laws have required that the oven exhaust gas be virtually freed of solvent before the gases are exhausted to atmosphere. While various methods of burning vaporized solvent and/or reclaiming the solvent have been proposed, such methods result in further manufacturing expense.

Also, the application of a layer of resin material to a filament from solution usually requires several successive coats in order to result in a concentric coat of a required thickness. For example, six coats may be required for a 0.08 mm coating, although in some applications as many as 24 coats have been required. Also, multiple coats of some materials cannot be applied successfully from solution, due to lack of good adhesion and wetting between coats.

It is therefore desirable to provide an improved method of manufacturing magnet wire which largely avoids the use of solvent and which uses an apparatus of simple design.

Austrian Patent Specification No. 318,037 discloses an apparatus for applying insulating material to a wire: such material may be a solvent-free resin. This known apparatus has a parallel-sided wire-intake passage at the inner end of which is a simple die. This is followed in the direction of wire motion by a small chamber to which insulating material is fed. The chamber is in turn followed by a passage through which the wire is fed to another simple die.

European Patent Specification No. 0009312 discloses a method and apparatus for manufacturing magnet wire in which a metered amount of hardenable resin material is applied on to the conductor, which then passes into a frusto-conical entry zone of a die which has a throat. As the conductor with the resin material thereon passes into the entry zone the material largely fills the entry zone and forms a rotating annular support between the conductor and the inwardly convergent wall of the entry zone, so as to centre the conductor in the throat with a concentric coating of the resin material on the conductor.

According to this invention, there is provided a method of coating a filament, for example magnet wire, in which a flowable, hardenable resin material is applied to a continuously moving filament to a required thickness in a single pass whereby a filament may be drawn or otherwise formed, coated and spooled in a continuous operation, the method comprising:—

a. passing the filament through a stationary entrance die at a speed of 30.5 m/min or more;

b. passing the filament through a stationary exit die, at a speed of 30.5 m/min or more, the exit die having a throat portion, an entrance opening larger than the throat portion and connected thereto by a converging interior wall thereby defining a die cavity between the throat portion and the entrance opening and the filament and the converging interior wall, the entrance die and the exit die defining and partially enclosing a die chamber between them, the filament within the dies being spaced from them;

c. filling the die chamber with a flowable, hardenable material which includes less than 5% by weight solvent at a temperature above the melting point thereof;

d. raising the pressure of the material in the die chamber above atmospheric pressure;

e. passing the filament through the die chamber thereby applying the flowable material on to the filament;

f. centering the filament in the throat portion of the exit die solely with the material in the die chamber; and

g. wiping the excess of the flowable material from the filament leaving thereon a concentric coat of the material of a thickness meeting the requirements of ANSI-NEMA Standards Publication No. MW 1000—1977.

There is thus provided a method for manufacturing a filament, for example magnet wire, in a continuous process by which a coating of flowable, hardenable resin material may be applied concentrically to a moving filament in thicknesses of about 0.40 mm or less. The filament can be a bare copper or aluminium conductor of round or rectangular configuration, or an insulated conductor upon which a top coat or an intermediate coat of resin material is applied. Coatings of 0.013 mm or 0.025 mm can also be applied by the method of the invention. Using the method of the invention, magnet wire can be manufactured by continuously drawing the wire to size, annealing the wire if necessary, insulating the wire with one or more coats of the flowable, hardenable resin material, curing the resin material if necessary, hardening the resin material, and spooling the wire for shipment, without interruption, at speeds limited only by the filament pay-out and take-up devices used. The method of the invention uses the flowable, hardenable resin material to centre the filament in a die, and the size of the die controls the thickness of the coat to be applied. In the method of the invention, only the resin material being applied to the filament is in contact with the filament. Thus, the mechanical wear normally associated with centering dies used in extrusion processes is avoided. Further, the method of the invention can be used to apply a coating several times thinner than is possible with conventional extrusion apparatus, and a coating of a material different than those conventionally extruded onto filaments. In specific embodiments using heat softenable materials or melts, curing is no longer required; and thus the need for curing, catalytic burners and the like, as well as concern regarding atmospheric pollution, are avoided. Coated filaments, such as magnet wire, made by the method of the invention have coatings which are surprisingly concentric and continuous when compared to filaments made by conventional methods.

The invention also includes apparatus for the manufacture of a coated filament, for example magnet wire, the apparatus comprising one or two die devices, the or each die device including an entrance die and an exit die and a die block, the die block being between the dies, the entrance die having a throat portion, an entrance opening larger than the throat portion and connected thereto by a converging interior wall and an exit opening larger than the throat portion and connected thereto by a diverging interior wall, the exit die having a throat portion and an entrance opening larger than the throat portion and connected thereto by a converging interior wall, the die block having an interior passage communicating with the exit opening of the entrance die and the entrance opening of the exit die thereby defining a flowable material centering chamber between the diverging interior wall and the passage and the converging interior wall.

An embodiment of the invention will now be described by way of example, with reference to the drawings in which:—

Figure 1 is a perspective, fragmentary and diagrammatic view of one embodiment apparatus;
Figure 2 is a cross-section of a coating die substantially on the plane 2—2 in Figure 1;
Figure 3 is an elevation of the coating die as seen from the line 3—3 in Figure 1; and
Figure 4 is a cross-section of the coating die on the plane 4—4 of Figure 2.

Referring to Figure 1, the apparatus 10 includes a filament pay-out device 12, a filament heater 14, a coating material dispenser 16, a coating die 18, a hardener 20, and a filament take-up device 22. In Figure 1 the filament 24 is shown broken at 26, 28 and 30. At the break 26, when the apparatus is used to manufacture magnet wire, conventional wire drawing equipment may be inserted. Thus an oversized filament 24 may be reduced to the required size by the drawing equipment prior to coating the filament. The filament heater 14 may include an annealer whereby the effects of drawing or stretching the wire may be eliminated. In other embodiments in which magnet wire is being manufactured, additional coating dies 18 and hardeners 20 may be inserted at the break 28 such that successive coats of different coating materials may be applied in a continuous manner.

The term "filament" is used herein for all strand materials. "Filament" thus includes both copper and aluminium conductors, and also insulated copper and aluminium conductors which have been insulated with a base coat of insulating material, a tape of insulating material either spirally or longitudinally wrapped on the conductor, or other conventional insulating materials, and other strand materials desirably coated. While the embodiments herein described primarily relate to the manufacture of magnet wire, the apparatus of the invention is thought to have utility in coating other kinds of filaments than conductors or insulated conductors for the production of magnet wire.

The term "flowable material" is used herein for the general class of coating materials applied by the method and apparatus of the invention. Again, while the embodiments herein described refer to meltable coating materials which can be hardened by cooling the material to ambient temperatures, other coating materials which are flowable at elevated temperatures and pressures are contemplated as being within the general class of coating materials which can be applied. These materials include materials which are initially flowable but are later hardened by curing or thermosetting the material and also coating materials which may include up to about 5% by weight of solvent to render them flowable and later hardenable by driving the solvent from the material. In the manufacture of magnet wire, various materials can be applied. These include polyamides such as nylon, polyethylene terephthalates, polybutylene terephthalates, polyphenylene sulfide, polycarbonates, polypropylenes, polyethersulfone, polyether imides, polyether etherketone, polysulphones, epoxys, fluorcarbons including ethylene-chlorotrifluoroethylene and ethylene-tetrafluoroethylene, polyvinyl formal, phenoxys, polyvinyl butyrol, polyamide-imides, polyesters and combinations thereof.

The filament pay-out device 12 includes a first spool 32 on which the filament 24, preferably coated, is stored. The spool 32 is mounted on a spindle 34 of the pay-out device 12 so as to rotate freely in the direction of the arrow 36. The spool 32 has a brake 38 which restrains its rotation as the filament 24 is being pulled therefrom by the take-up device 22, so as to prevent entanglements. It is possible that in a magnet wire manufacturing plant where conductors are being rolled, drawn or otherwise reduced to the required filament size from ingots, the pay-out device 12 can be omitted, since the remaining apparatus can be used to coat the filament continuously in a single pass as the filament is supplied from the rolling and drawing apparatus. The spools 32 in this instance can be the reels upon which bare copper and aluminium conductors are now transported from the rolling and drawing apparatus to the magnet wire manufacturing plant. When the take-up device 12 is omitted and rolling and drawing apparatus substituted, an annealer is used to eliminate the effects of working the conductor during rolling and drawing.

A filament heater 14 may be used solely to raise the temperature of the filament prior to application of the coating material, or it may be used to anneal the filament if hard, bare wire is used, or further to reduce the effects of the rolling and drawing, if required. The filament heater 14 may be an annealer, or may be simply a filament heater. The filament heater 14 comprises a resistance coil 40, generally tubular in shape, and having opposite open ends 42 and 44. The filament 24 is trained between the payout device 12 and the take-up device 22 through the coil 40. The filament heater 14 also has a control 46 by which the temperature of the filament 24 can be controlled. The filament heater 14 may also include a filament temperature measuring device such as a radiation pyrometer. Hereinafter in specific examples, the approximate wire temperatures given have been measured by such a device.

The coating die 18 is illustrated in Figs. 1 to 4. The coating die 18 includes an entrance die 61, an exit die 62 and a die block 64. Entrance die 61 is mounted in the forward portion of die block 64 by screws 66. Exit die 62 is mounted in the rearward portion of die block 64 by screws 66'. Separating entrance die 61 and exit die 62 is an interior passage 65. Die block 64 is provided with heater bores 68 in which heaters 70 are positioned. Each heater 70 may for example be a tubular calrod heater. Additionally, the die block 64 has a thermocouple bore 72 in which a thermocouple 74 (Fig. 4) may be placed. Further, die block 64 has a nozzle bore 75 to which the nozzle 54 of material applicator 16 is connected. Hereinafter, die temperatures are given with regard to specific examples; these die temperatures are measured by the thermocouple 74. Heaters 70 are connected by conductors to a heater 76. Heater 76 is provided with paired controls 78 whereby the temperature of the entrance die 61 and the exit die 62 can each be raised above ambient temperature (for each die) and controlled, respectively, as required.

Referring to Fig. 2, the entrance die 61 includes an entrance opening 80, a throat 82 and a converging interior wall 84 which connects the throat 82 and the entrance opening 80. Entrance die 61 also has an exit opening 86 and a diverging interior wall 88 interconnecting the throat 82 and the exit opening 86. The entrance die 61 may be constructed as illustrated in two-piece fashion, having a central piece 90 including a throat portion of harder and more wear-resistant material, and exterior piece 90' which includes both the entrance opening 80 and the exit opening 86.

The exit die 62 includes an entrance opening 92, a throat 93 and a converging interior wall 94 which interconnects the throat 93 and the entrance opening 92. Converging interior wall 94 part defines a die chamber 95 as will be mentioned hereinafter. Exit die 62 also has an exit opening 96 and a diverging interior wall 97 that interconnects the throat 93 and the exit opening 96. The exit die 62 may be constructed as illustrated in two-piece fashion having a central piece 98 including a throat portion of harder and more wear resistant material than the exterior piece 98' which includes both the entrance opening 92 and exit opening 96.

The converging walls 84 and 94 define an angle A with filament 24 of from 5 to 40 degrees and throats 82 and 93 are tapered from converging walls 84 and 94 to diverging walls 88 and 97 so as to define an angle with the filament 24 of 1 to 2 degrees.

The flowable material applicator 16 (Fig. 1) has a hopper 48 by which the material is supplied to the applicator, a material reservoir 50 in which the material may be stored, and a positive displacement pump which pressurizes reservoir 50 and dispenses the flowable material through a nozzle 54. When using melts or other temperature responsive flowable materials, reservoir 50 is provided with a heater and a control device 56 by which the temperature of the material in the reservoir can be controlled. An additional control device 58 is associated with the positive displacement pump to control the amount of flowable material passing through nozzle 54. The fluid material applicator 16 may be an extrusion apparatus having the features above described. In those applications in which the flowable material is rendered more flowable by the use of a small amount of solvent, both the coating material and the solvent may be fed into the applicator via the hopper 48 and the reservoir 50 may have a mixing apparatus with a separate control 60.

The central die chamber 95 (Fig. 2) is defined by the diverging wall 88 of entrance die 61, the converging interior wall 94 of exit die 62, and the walls of interior passage 65 of die block 64. Die chamber 95 is positioned between throat 82 and throat 93. The nozzle 54 is connected to nozzle bore 75 so that coating material in reservoir 50 may be injected into the central die chamber 95 under pressure by material applicator 16. The filament 24 is trained between the pay out device 12 and the take-up device 22 through the entrance die 61, the central die chamber 95, and the exit die 62.

The hardener 20 (Fig. 1) hardens the coat of material on the filament 24 prior to spooling the coated filament or magnet wire by the take-up device 22. The hardener 20 includes a trough 100 having opposite open ends 102 and 104. The trough is positioned such that the filament 24 can be trained to enter the open end 102, pass through the trough 100, and leave at the open end 104. As shown, the trough 100 is sloped downwardly towards the open end 102 and provided with a source of cooling fluid, such as water 108, adjacent open end 104 and a drain 110 adjacent open end 102. In some cases a water quench using the hardener 20 is needed. In other cases a quench is not required and the cooling fluid is not used. In these other cases, either a flow of ambient air or of refrigerated air is trained on the coated filament 24.

In cases in which multiple coats of different materials are to be applied to the filament 24, successive, spaced coating dies 18 are used. The particular coating die used depends on the material to be applied. Each coating die will have a material applicator 16 associated with it and may also have a hardener 20 associated with it. The term "coating station" is used herein to refer to the assemblage of a material applicator 16, a coating die, and a hardener 20. In these cases, there will be a plurality of spaced apart coating stations between the pay-out device 12 and the take-up device 22. The latter comprises a second reel 32 on which the coated filament 24 is spooled for shipment. The two reels 32 may be conventional spools on which coated filaments are usually shipped. Each spool 32 is mounted for rotation on a spindle

34 and driven in the direction of the arrow 112. Connected to the second spool 32 is a spool driver 114 which drives the second spool 32 to pull the filament 24 from the first spool or reel 32.

The method of the invention will now be described with reference to the manufacture of magnet wire in a single pass whereby the filament is drawn or otherwise formed, coated and spooled in a continuous operation.

A continuous supply of the filament 24 is provided either by the pay-out device 12 as illustrated in Fig. 1, or from a rolling and drawing operation. If supplied from a rolling and drawing operation, the filament 24 is annealed to remove the effects of rolling and drawing.

The filament 24 is then heated if required, depending on the coating material used and the wire properties needed. Thus the filament 24 may be heated by the heating device 14 to a temperature from ambient temperature to the decomposition temperature of the coating material. In most applications using a melt or heat-responsive flowable material in which the coat of material is adhered to the filament 24, the filament is heated to a temperature from just below to about the melting point of the coating material. In most applications using a melt or a heat-responsive flowable material in which adhesion of the coat of material to the filament 24 is not required, the filament is maintained from the ambient temperature to slightly above ambient temperature.

The central die chamber 95 is then filled with a flowable material. The flowable material is stored in the reservoir 50 at a flowable temperature and pressure and is injected into the chamber 95 by applicator 16. Once the chamber 95 has been filled, the material therein will assume the pressure of the flowable coating material in the reservoir 50. The pump must have an adequate capacity to maintain pressures up to about 2000 psi (17,79 MPa) in reservoir 50 and chamber 95. By use of the control 58, the responsiveness to pressure changes desired can be controlled. By controls 56 and 78, the temperature of the material in the reservoir 50 and chamber 95 can be controlled. The pressurized temperature of the flowable material in the central die chamber 95 must be carefully controlled for several reasons. First, if the pressure and/or temperature of the flowable material in the chamber 95 is too great, the material may have the tendency to leak in a significant quantity from the chamber 95 through throat 82, although the filament passing through throat 82 will allow operating pressures higher than that at which the flowable material will leak from opening 80 when the filament is stationary in opening 80. Any significant leakage of material from the die block 64 is to be avoided. Secondly, both the pressure and temperature of the flowable material relate to the viscosity and/or flow characteristics of the flowable material, and must be such that the viscosity and/or flow characteristics of the flowable material performs its centering function relative to the exit die 62 and produces a concentric coating (as will be discussed), wets the filament to be coated, and adheres to the filament. Thirdly, if the pressure and the temperature of the flowable material is too low, excessive filament stretching may occur by virtue of die 18 resisting unduly the movement of the filament. It is for these reasons that the applicator 16 has the controls 56, 58, and 60.

The coating material is then applied to the filament 24 by passing it through die 18. The coating material within the die chamber functions to center the filament 24 within the throat portions 82 and 93 of dies 61 and 62. In all instances known to the applicants wherein the central die chamber 95 is properly filled with coating material 115 and the temperature and pressure therein are properly controlled, filaments 24 that are coated by the method and apparatus of the invention have a surprisingly concentric and continuous coat of coating material thereon. Conversely, in all cases in which the central die chamber 95 is not properly filled, and/or the temperature and pressure therein is not properly controlled, a non-concentric and discontinuous coating of material is applied to the filament 24. Thus proper filling of the central die chamber 95 with coating material, and control of the temperature and pressure of the coating material therein are important. Coating materials of various types have been successfully applied in accordance with the method of the invention by the above-described apparatus at viscosities from 5,000 cps to 200,000 cps.

The action of the flowable material in the central die chamber 95 is not fully understood, but it does result in filaments having coatings of virtually perfect concentricity and continuity thereon. The coating material in the central die chamber 95 is believed to have movement adjacent the throat 93 of the exit die 62.

The throat portion 82 of the entrance die 61 prevents the flowable material in the chamber 95 from leaking from die 18 through die 61. Depending upon the flow properties of the coating material, throat portion 82 will have a diameter of from 0.08 mm to 0.38 mm larger than the diameter of filament 24.

The throat portion 93 regulates the thickness of the coating material left on the filament 24 leaving the die 18.

The size of the throat portion 93 varies in accordance with the size of the filament 24 and the required thickness of the coating material to be applied. The method of the invention has been successfully used with filaments ranging from 0.25 mm diameter to 9.5 mm diameter rod. Conductors of rectangular and other cross-section can also be coated, with the throat portions 82 and 93 of the entrance die 61 and exit die 62 respectively, provided of geometrically appropriate shape. Coatings from 0.013 mm to 0.41 mm thick can be applied by the method of the invention. Depending upon the flow properties of the coating material, the throat portion 93 will have a diameter in most cases from the required diameter to a diameter which is 0.05 mm larger than the required diameter of the coated filament 24 of magnet wire.

The coated filament 24 is then passed through the hardener 20 to harden the coating material. While the structure and operation of the hardener has been described above, it should be emphasized that its operation depends upon the coating material used. A water quench or an air quench may be used. The hardener 20 may be a filament heater 14 or a conventional curing oven (not shown). In all cases, the type of hardener 20 used and the temperature of the cooling liquid, air or other fluid will depend on the coating material and the speed at which the coated filament passes through the hardener 20.

The speed at which the driver 114 drives the second spool 32 of the take-up device 22 in the embodiment of Fig. 1, is limited by the pay-out 12 and take-up 22 devices themselves when applying any of the coating materials mentioned herein. When the pay-out device 12 is omitted and conventional rolling and drawing operations are substituted, the speed at which the take-up device 22 is driven by the driver 114 is solely by the take-up device 22 itself.

Examples in which conductors of various sizes have been coated with coating material in accordance with the invention are tabulated in the following Table. The Table relates to the production of magnet wire. The Table tabulates the properties of the coating material and the conductor, the process conditions, and the physical and electrical properties of the magnet wire produced.

The magnet wire produced by the apparatus and method of the invention meets the requirements of magnet wire made by existing commercial processes. The Table tabulates the physical and electrical properties of various magnet wires manufactured in accordance with the invention. A surprising characteristic of all magnet wires made in accordance with the invention is the concentricity of the coating applied to the filament and the continuity thereof. Both the concentricity and continuity are a surprising result when compared to magnet wires made by existing commercial processes, without regard to the means by which the filament 24 is centered within the coating die 18. Magnet wire produced by known commercial processes, such as the application of coatings from solution, periodically result in non-concentric coatings and non-continuous coatings. In fact, the continuity of coatings applied from solution is such that reliance upon a single coating of magnet wire insulation is unknown; and for this reason multiple coatings are used.

Magnet wire having a single coat is a commercial reality due to the concentricity and thickness of the coatings that can be applied by the apparatus and method of the invention.

In the Examples given in the Tables various proprietary names are used, as identified below:—

"Dacron": Registered Trade Mark. Polyethylene terephthalate.
"Tefzel 280": Registered Trade Mark. Tetrafluoroethylene.
"Zytel 151": Registered Trade Mark. Nylon.
"Elexar": Registered Trade Mark. Thermoplastic rubber.
"Halar 500": Registered Trade Mark. Chlorotrifluoroethylene.
"Tefzel 200": Registered Trade Mark. Tetrafluoroethylene.
"Gafite 16022": Registered Trade Mark. Polybutylene terephthalate.
"Gafite 16000": Registered Trade Mark. Polybutylene terephthalate.

Under "Die size", the figures given for "Entry/Exit" refer to the diameter of the throat portion of the Entry die and the diameter of the throat portion of the Exit die.

TABLE

					2 Coat tandem		2 Coat tandem		2 Coat tandem		2 Coat tandem		
	Ex. 1.	Ex. 2.	Ex. 3.	Ex. 4.	Ex. 5.	Ex. 6.	Ex. 7.	Ex. 8.	Ex. 9.	Ex. 10.	Ex. 11.	Ex. 12.	Ex. 13.
Flowable Material	Nylon	Nylon	Nylon	Nylon	"Dacron"	"Dacron"	"Dacron"	"Dacron"	Polyethylene	Nylon	Polyethylene	Nylon	"Tefzel" 280
Wire Size	1 mm. Al*	1 mm Al*	1 mm Al*	1 mm Al***	1 mm Cu		Drawn FM12	1 mm Al	0,37 Copper**		0,42 Copper**		0,24 Copper
Base Coat	Polyester	Polyester	Polyester	Amideimide	"Dacron"		"Dacron"		Polyvinyl Formal		Polyvinyl Formal		Polyimide
Die Size—Entry/Exit mm.	1.37/1.105	1.37/1.105	1.37/1.105	1.37/1.105	BSCT 1.40/1.08	TOP 1.15/1.12	BSCT S. Die 1.08	TOP 1.37/1.12	BSCT 2.54/2.74	TOP 2.97/2.92	BSCT 2.21/2.68	TOP 2.82/2.77	3.91/4.03
Approx Melt Temp °C	293	293	307	293	282	282	282	282	—	—	—	—	—
Die Temp. °C	300	300	315	300	290	290	290	290	300	290	300—315	290	315
Anneal Volts.	0	0	0	0	9		5—9		0		0		0
Wire Heat Control Wheel °C	0	0	0	0	210		240—270		0		0		0
Speed m/min.	30.5	30.5	30.5	30.5	75—92		43—64		15—60		30.5—45		16—30.5
Die Press—Kg/cm²	50—53	46—53	63—74	28—35	32—35	63—70		21—26	21—35	14	21—32	18	42—70
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977)													
Build, mm.	0.09	0.09	0.08	0.08	—0.08—		—0.08—		Total 0.06		Total 0.65		Total 0.3
Smoothness Base Coat	Good	Good	Good	Good	Good		Good		Good		Good		Good
Elongation %	35	23—25	30—31	26—30	32—33		17—25		—	—	—	—	—
Flexibility BP-1X	OK	OK	OK	OK	OK		OK		OK		OK		OK
Snap	OK	OK	OK	OK	OK		OK		—	—	—	—	—
Slit Twist	72	113	85	73	263		203—260		—	—	—	—	—
Preheat Tube Oven Length mm.	1830	1830	1830	1830	—		—		—	—	—	—	—
Tube Oven Temp °C	450	450	500	—			—		—	—	—	—	—
Approx. Wire Temp °C	N/A	N/A	N/A	N/A	300—330		N/A		N/A	—	N/A	—	N/A
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)													
Dielectric Breakdown	7300/9000	8200/8600	8000/9500	7900/9000	—8800/10600—		—8000/11400—			16600/20000	20000+		10200/15400
Continuity at V-DC (Faults/30 meter) at 3000 V	2	3	4	3	2—7		1—7		—		—		—

* previously coated with polyester
** previously coated with polyvinyl formal.
*** previously coated with amide-imide.

BSCT=Base coat
TOP=Top coat.

TABLE (continued)

	Ex. 14.	Ex. 15.	Ex. 16.	Ex. 17.	Ex. 18.	Ex. 19.	Ex. 20.	Ex. 21.	Ex. 22.
Flowable Material	Polyethylene	—	—	—	—	—	—	—	—
Wire Size	0.72 mm Cu*	0.72 mm Cu*	0.57 mm Cu*	0.57 mm Cu*	0.57 mm Cu*	0.57 mm Cu*	0.57 mm Cu*	0.57 mm Cu*	0.57 mm Cu*
Base Coat PRM									
Polyethylenes	114	151	151	218	218	219	219	219	218
Die Size—Entry/Exit mm.	1.22/0.95	1.22/0.95	0.95/0.70	0.76/0.70	0.89/0.83	0.89/0.83	0.76/0.70	0.76/1.13	0.76/1.13
Die Press—Kg/cm²	Unknown	—	—	—	—	—	—	—	—
Approx. Melt Temp °C	315	260—315	260—274	274	274	274	274	274	274
Temp Die °C.	260	260—315	260—274	274	274	274	274	274	274
Anneal Volts	0	0—25	4.6—6.5	5.5	5.0	5.0	5.5	4.0	4.0
Wire Heat Control Wheel °C	Ambient	Ambient-230	200	200	200	200	200	200	200
Speed m/min	30.5—92	30.5—92	75—150	150	120	120	150	92	92
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977).									
Build, mm.	0.18—0.19	0.18—0.32	0.11	0.16	0.24—0.25	0.25	0.17	0.62—0.63	0.62—0.66
Smoothness Base Coat	Good	Good	Good	Good	Good	Good	Good	Good	Good
Elongation %	10—13	10—14	12—16	16—17	15—19	15—18	17—20	12—19	12—14
Flexibility BP-1X	OK	OK	OK	OK	OK	OK	OK	OK	OK
Snap	Lost Adhes	Lost Adhes	Lost Adhes	Lost Adhes	Lost Adhes	Lost Adhes	Lost Adhes	Lost Adhes	Lost Adhes
Slit Twist	0	0	0	0	0	0	0	0	0
Approx. Wire Temp °C	—	150—205	120—205	93—150	93—150	93—150	93—150	107—163	107—163
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)									
Dielectric Breakdown	13000/19000	9500/20000	8400/13600	7400/11000	14000/16200	12800/15300	11200/13800	18250/19600	18700/20000+
Continuity at V-DC (Faults/30 meter) at 3000 V	0—5	0—5	1	2	0—1	1	1	1	1

*Tinned

TABLE (continued)

	Ex. 23.	Ex. 24.	Ex. 25.	Ex. 26.	Ex. 27.	Ex. 28.	Ex. 29	Ex. 30
Flowable Material	Polyethylene	Polypropylene	Polyallomer	"Dacron/ Zytel 151"	"Dacron/ Zytel 151"	"Dacron/ Zytel 151"	"Dacron/ Zytel 151"	"Dacron/ Zytel 151"
Wire Size	0.64 mm Cu*	0.64 mm Cu	0.64 mm Cu	1.02 mm Cu	1.02 mm Cu	1.02 mm Cu	1.02 mm Cu	1.02 mm Cu
Base Coat PRM								
Polyethylenes	287	288	291	309	341	342	346	350
Die Size—Entry/Exit mm.	0.76/0.68	0.76/0.68	0.95/0.89	1.22/1.1	1.37/1.1	1.37/1.1	1.37/1.1	1.37/1.1
Die Press—Kg/cm²	—	—	—	—	105/112	91/98	109/116	134/141
Approx. Melt Temp °C	329	288	246	257	293	293	293	293
Temp Die °C.	329	288	288	260	290	290	290	290
Anneal Volts	6.0—8.5	8.5	8.5	5.5	9.0	9.0	9.0	9.0
Wire Heat Control Wheel °C	170—215	170	200	260	290	210	210	210
Speed m/min	30.5—92	92	92	30.5	92	92	92	92
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977).								
Build, mm.	0.04—0.71	0.03	0.25	0.13	0.08	0.08	0.08	0.08
Smoothness Base Coat	Good	S1 Orange P1	S1 Orange P1	Good	Good	Good	Good	Good
Elongation %	21—26	24—27	24—25	29—30	28—30	28—31	27—31	30—31
Flexibility BP-1X	OK	OK	OK	OK	OK	OK	OK	OK
Snap	OK	OK	OK	OK	OK	OK	OK	OK
Slit Twist	0—250	0	0	201+	237	250	259	192
Approx. Wire Temp °C	177—260	275—330	275—330	150—177	300—330	300—330	300—330	300—330
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)								
Dielectric Breakdown	1400/8900	1900/5600	17000/19000	11250/14000	7200/9200	7200/9200	7200/9200	8975/11150
Continuity at V-DC	1—19	1—100	1	3	18	5	11	2
(Faults/30 meter) at 3000 V	(500 V)	(500 V)						

* Tinned.

TABLE (continued)

	Ex. 31	Ex. 32.	Ex. 33.	Ex. 34.	Ex. 35.	Ex. 36.	Ex. 37.	Ex. 38.	Ex. 39.
Flowable Material	Nylon	Nylon	Nylon	Nylon	Nylon	Nylon	Nylon	Nylon	Nylon
Wire Size	0.81 mm Cu	0.45 mm Cu	0.91 mm Cu	0.51 mm Cu	0.51 mm Cu	0.57 mm Cu	0.72 mm Cu	0.81 mm Cu	0.91 mm Cu
Die Size-Entry/Exit mm.	0.95/0.86	0.76/0.63	1.1/1.01	0.66/0.56	0.66/0.56	0.76/0.63	0.86/0.79	0.95/0.86	1.1/1.01
Die Press Kg/cm^2	38—56	42—56	56—77	42—56	63—105	95—141	91—100	70—84	98—112
Approx. Melt Temp °C	290	290	288—293	290	274	274	274	282	278
Oven Temp Die °C	270	270	265—270	270	255	255	255	260	265
Anneal Volts	17.0	17.0—18.0	18	18	22.5	20.9—21.8	21.3—21.7	19.0	23.0
Wire Heat Control Wheel °C	230	230	230—235	230	230	230	230	200	215
Speed m/min	120	120	120	120	180	180	180	180	180
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977)									
Build, mm.	0.044	0.057	0.051—0.08	0.029	0.039	0.039	0.048	0.048	0.076
Smoothness Base Coat	Good	Good	Good	Good	Good	Good	Good	Good	Good
Elongation %	28—33	25—29	26.5—30.5	26—30	28—31	26—30	27.5—30	30—32	28—29
Flexibility 1X BP-1X	OK	OK	OK	OK	OK	OK	OK	OK	OK
Snap	OK	OK	OK	OK	OK	OK	OK	OK	OK
Slit Twist	216—265	240—325+	193—225	275—350	320—390	250—330	285—290	258	249+
Approx. Wire Temp °C	190—220	190—220	190—220	190—220	260—287	246—274	246—274	232—260	260—287
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)									
Dielectric Breakdown	3460/4900	3830/5600	5100/6600	2900/4200	4000/4800	4100/5100	4600/5300	4000/4900	6100/6400
Continuity at V-DC	1—9	0—12	1—9	4—23	0—8	1—17	2—9	3—8	8—9
(Faults/30 meter)	(1500V)	(2000V)	(1000V)	(1500V)	(1000V)	(1000V)	(1500V)	(1500V)	(3000V)

TABLE (continued)

	Ex. 40.	Ex. 41.	Ex. 42.	Ex. 43.	Ex. 44	Ex. 45.	Ex. 46.	Ex. 47.
Flowable Material	Nylon	"Tefzel 280"	Nylon	Nylon	"Dacron"	"Dacron"	"Elexar"	"Dacron"
Wire Size	0.91 mm Cu	1.02 mm Cu	0.45 mm Cu	0.45 mm Cu	1.02 mm Cu	0.45 mm Cu	1.02 mm Cu	1.02 mm Cu
Die Size-Entry/Exit mm.	1.1/1.01	1.19/1.24	0.63/0.53	0.63/0.5	1.19/1.13	0.63/0.53	1.37/1.12	1.19/1.12
Die Press Kg/cm^2	98—112	141	56—88	76—112	76—91	53—69	70	42—70
Approx. Melt Temp °C	282	360	278	263	278—295	295—310	299	327
Oven Temp Die °C	265	324	300	290	310—320	320—340	310	300
Anneal Volts	23.0	8.0	19.0—21.0	20	20—21	21	16.7	19
Wire Heat Control Wheel °C	215	220	190	165—180	65—120	130—170	232	220
Speed m/min	180	30	180	180	180	180	120	120
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977)								
Build, mm.	0.08	0.22—0.24	0.058	0.035—0.04	0.086	0.058	0.08	0.07
Smoothness Base Coat	Good	Good	Good	Good	Good	Good	Good	Good
Elongation %	26—27.5	31—33.5	24—31	28—31	27—35	25—28	28—31	29—31
Flexibility 1X BP-1X	OK	OK	OK	OK	OK	OK	OK	OK
Snap	OK	OK	OK	OK	OK	OK	OK	OK
Slit Twist	230	0	242—377	200—275	206—254	254—300+	70	240
Approx. Wire Temp °C	260—287	260—315	205—246	220—246	177—232	190—220	190—220	190—220
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)								
Dielectric Breakdown	4900/5600	16000/19000	4700/6000	4100/4400	9900/15100	6600/10800	7000/7800	10100/10900
Continuity at V-DC	5—11	1	1—28	3—13	0—6	0—11	9—11	6—7
(Faults/30 meter)	(3000V)	(3000V)	(3000V)	(1500V)	(3000V)	(3000V)	(3000V)	(3000V)

TABLE (continued)

	Ex. 48.	Ex. 49.	Ex. 50.	Ex. 51.	Ex. 52.	Ex. 53.	Ex. 54.	Ex. 55.	Ex. 56.
Flowable Material	Nylon	"Halar 500"	Polyethensulfone	Nylon	Nylon	"Tefzel 200"	"Tefzel 280"	Nylon	Nylon
Wire Size	1.02 mm Cu	1.29 mm Cu	1.29 mm Cu	1.02 mm Cu	1.02 mm Cu	1.29 mm Cu	1.29 mm Cu	1.02 mm Cu	1.02 mm Cu
Die Size—Entry/Exit mm	1.37/1.13	1.63/1.6	1.63/1.6	1.37/1.11	1.17/1.13	1.63/1.6	1.63/1.6	1.37/1.13	1.37/1.12
Die Press Kg/cm²	70—74	35—105	35—148	60—74	60—74	102—109	70—141	63—77	50—56
Approx. Melt Temp °C	304	304	343—354	277	265	310	307—327	265	293
Oven Temp Die °C	300	300	340—350	270	270	310	310—327	270	290
Anneal Volts	9.0—12.5	4.0—7.0	4.5—7.0	8.0—10.0	8.6	4.0—6.0	4.0—6.0	8.0—8.6	15.5
Wire Heat Control Wheel °C	100—205	190—290	190—290	175—200	170	180—225	180—250	175—185	152—175
Speed m/min	92—120	30.5	30.5	120	120	30.5	30.5	120	120
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977)									
Build, mm.	0.066—0.083	0.2—0.3	0.24—0.31	0.08	0.08	0.302—0.348	0.27—0.49	0.08	0.09
Smoothness Base Coat	Good	Good	Good	Good	Good	Good	Good	Good	Good
Elongation %	30—34	23—35	22—33	27—35	30—34	25—36	22—37	25—34	27—30
Flexibility BP-1X	OK	OK	OK	OK	OK	OK	OK	OK	OK
Snap	OK	OK	OK	OK	OK	OK	OK	OK	OK
Slit Twist	190—206	143—189	0	202—208	207	0	0	172—184	119—142
Approx. Wire Temp °C	287—343	107—260	107—260	260—343	274—330	107—220	107—220	260—315	162—190
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)									
Dielectric Breakdown	4900/5700	13500/2000	11400/2000	4800/6700	5800/6800	20,000+	19900/2000+	4800/5800	1600/9200
Continuity at V-DC at 3000V (Faults/30 meter)	9—14	1—5	1—22	4—10	3	2—4	1	2—7	7—10

TABLE (continued)

	Ex. 57.	Ex. 58.	Ex. 59.	Ex. 60.	Ex. 61.	Ex. 62.	Ex. 63.	Ex. 64.
Flowable Material	Nylon	Nylon	Nylon	"Dacron"	"Dacron"	"Dacron"	"Gafite 16022"	"Gafite 16000"
Wire Size	0.51 mm Cu	1.45 mm Cu	0.25 mm Cu	1.02 mm Cu	1.02 mm Cu	1.02 mm Cu	1.02 mm Cu	1.02 mm Cu
Die Size—Entry/Exit mm	0.76/0.56	1.63/1.6	0.36/0.32	1.37/1.12	1.37/1.12	1.37/1.12	1.37/1.12	1.37/1.2
Die Press Kg/cm^2	35—74	67—74	42—53	28—63	46—70	18—63	63—70	67—77
Approx. Melt Temp °C	282	288	282—288	288	288	288	288	288
Oven Temp Die °C	270	300	300	300	300	300	300	300
Anneal Volts	16.0—18.0	16.6—17.5	16.7—21.4	16.7	16.7	16.7	16.7	16.7
Wire Heat Control Wheel °C	235	180—185	230	230	230	230	230	230
Speed m/min	120	120	120—213	120	120	120	120	120
Physical Properties (ANSI-NEMA Standards Publication MW1000—1977)								
Build, mm.	0.041	0.1	0.055	0.08	0.08	0.076	0.08	0.081
Smoothness Base Coat	Good	Good	Good	Good	Good	Good	Good	Good
Elongation %	27—29.5	31.5—35	21—28	29—21	29—32	29—32.5	30—32.5	29—31
Flexibility BP-1X	OK	OK	OK	OK	OK	OK	OK	OK
Snap	OK	OK	OK	OK	OK	OK	OK	OK
Slit Twist	260—320	131—148	190—230	245—273	267—273	225—268	240	200
Approx. Wire Temp °C	205—232	190—282	205—287	190—220	190—220	190—220	190—220	190—220
Electrical Properties (ANSI-NEMA Standards Publication MW1000—1977)								
Dielectric Breakdown	3060/5000	7400/8900	3400/4000	8100/9100	7100/12300	8400/16600	8000/12100	8600/11100
Continuity at V-DC at	2—8	5—15	0—11	0—8	2—6	4	3	6
3000V (Faults/30 meter)	(1500V)		(1500V)					

Claims

1. A method of coating a filament (24), for example magnet wire, in which a flowable, hardenable resin material (115) is applied to a continuously moving filament to a required thickness in a single pass whereby a filament may be drawn or otherwise formed, coated and spooled in a continuous operation, the method comprising:—

a. passing the filament (24) through a stationary entrance die (61) at a speed of 30.5 m/min or more;

b. passing the filament through a stationary exit die (62), at a speed of 30.5 m/min or more, the exit die having a throat portion (93), an entrance opening (92) larger than the throat portion (93) and connected thereto by a converging interior wall (94) thereby defining a die cavity between the throat portion (93) and the entrance opening (92) and the filament (24) and the converging interior wall (94), the entrance die (61) and the exit die (62) defining and partially enclosing a die chamber (95) between them, the filament within the dies being spaced from them;

c. filling the die chamber (95) with a flowable hardenable material (115) which includes less than 5% by weight solvent at a temperature above the melting point thereof;

d. raising the pressure of the material (115) in the die chamber (95) above atmospheric pressure;

e. passing the filament through the die chamber (95) thereby applying the flowable material (115) on to the filament;

f. centering the filament in the throat portion (93) of the exit die (62) solely with the material (115) in the die chamber (95); and

g. wiping the excess of the flowable material from the filament leaving thereon a concentric coat of the material of a thickness meeting the requirements of ANSI-NEMA Standards Publication No. MW 1000—1977.

2. A method according to claim 1 wherein the entrance die (61) and the exit die (62) are held in a die block (64), the die block and the entrance and exit dies defining the die chamber (95), and wherein the said filling step comprises passing the material (115) through a passage (75) in the die block, the passage fluidly connecting the die chamber with a material reservoir (50).

3. A method according to claim 1 or claim 2 comprising the step of hardening the flowable material (115) on the filament (24) after the filament has left the exit die (62).

4. A method according to any preceding claim wherein the wiping step includes the step of passing the filament through the exit die (62), which has a size relationship with the size of the filament such as to control the thickness of the coating material (115) on the filament.

5. A method according to any preceding claim wherein the centering step includes the step of controlling the viscosity of the material (115) within the die chamber (95).

6. A method according to any preceding claim wherein the centering step includes the step of controlling the pressure of the material (115) within the die chamber (95).

7. A method according to any preceding claim wherein the flowable, hardenable material is a heat softenable material, and the centering step includes controlling the temperature of the dies (61, 62).

8. A method according to any preceding claim wherein the flowable, hardenable material is a heat softenable material, and the centering step includes controlling the temperature of the filament.

9. A method according to any preceding claim wherein the centering step includes causing movement of the material (115) within the die chamber (95).

10. A method according to any preceding claim wherein the filament is of the group comprising: bare copper and aluminium conductors; and insulated conductors having a previously applied base insulation.

11. A method according to any preceding claim wherein the flowable, hardenable material is of the group comprising:— nylon, polyethylene terephthalates, polybutylene terephthalates, polyphenylene sulfide, polycarbonates, polypropylenes, polyethersulfone, polyether imides, polyether etherketone, polysulphones, epoxys, fluorocarbons including ethylene-chlorotrifluoroethylene and ethylene tetrafluoroethylene, polyvinyl formal, phenoxys, polyvinyl butyrol, polyamide-imides, polyesters, and combinations thereof.

12. A method according to any preceding claim wherein the material in the die chamber has a viscosity of from 5 000 cps to 200 000 cps.

13. A method according to claim 6 wherein the said pressure is not greater than 140 Kg/cm^2 .

14. A method according to any preceding claim wherein the diameter of the filament is from 0.25 mm to 9.50 mm.

15. A method according to claim 3 wherein the thickness of the hardened material is from 0.013 mm to 0.41 mm.

16. Apparatus for the manufacture of a coated filament, for example magnet wire, the apparatus comprising one or two die devices (18), the or each die device including an entrance die (61) and an exit die (62) and a die block (64), the die block being between the dies (61, 62), the entrance die (61) having a throat portion (82), an entrance opening (80) larger than the throat portion (82) and connected thereto by a converging interior wall (84) and an exit opening (86) larger than the throat portion (82) and connected thereto by a diverging interior wall (88), the exit die (62) having a throat portion (93) and an entrance opening (92) larger than the throat portion (93) and connected thereto by a converging interior wall (94), the die block (64) having an interior passage (65) communicating with the exit opening (86) of the entrance die

(61) and the entrance opening (92) of the exit die (62) thereby defining a flowable material centering chamber (95) between the diverging interior wall (88) and the passage (65) and the converging interior wall (94).

17. Apparatus according to claim 16 comprising a filament pay-out device (12); a coated filament take-up device (22), the or each die device (18) being located between the pay-out and take-up devices; and the entrance and exit dies (61, 62) being positioned to receive a filament (24) trained between the pay-out device (12) and the take-up device (22) in the openings and throat portions thereof; a reservoir (50) of flowable, hardenable material; means (16) connected to the reservoir (50) for filling the die chamber (95) with material (115) and maintaining the material in the die chamber at elevated pressures; and means including the material in the die chamber for centering the filament in the throat portions (82, 93) of the dies (61, 62).

18. Apparatus according to claim 16 wherein the entrance die (61) is small enough to prevent leakage of the material from the die chamber (95) while the filament is passing therethrough at an elevated pressure and large enough to allow leakage when the filament is stationary in the entrance die (61) at the said pressure.

19. Apparatus according to any of claims 16 to 18 wherein the entrance opening (80) is from 0.1 mm greater in diameter than the diameter of the filament.

20. Apparatus according to claim 17 comprising:—

an applicator means (16), connected to the reservoir (50) for filling the die chamber (95) with material (115) at a desired pressure; and

when the filament (24) enters a die device (18), the interior wall (84, 88) providing a surface adjacent to which the material (115) creates a support of coating material such that the filament does not contact the die device and is centered in the die throat portions (82, 83) so as to form a continuous and concentric layer of coating material (115) on the filament.

21. Apparatus according to claim 17 including means (14) for heating the filament (24) between the pay-out device (12) and the die device (18), the heating means (14) being arranged to heat the filament over a range of temperatures from ambient temperature up to the temperature at which the material decomposes, and the heating means (14) being disposed at a position upstream of the entry of the filament into the die device (18).

22. Apparatus according to claim 17, including means (14) for heating the filament between the pay-out device and the die device, and means (76) for heating the die device (18) and the material in the reservoir (50) and the die chamber (95).

23. Apparatus according to claim 22, comprising means including the filament, the die device, and the reservoir heating means for controlling the viscosity of the material (115) within the die chamber (95).

24. Apparatus according to claim 17 wherein the die device (18), the filling and maintaining means (16), and hardening means (20) together constitute a filament coating station, the apparatus including a plurality of such coating stations in spaced-apart relationship to each other and to the take-up and pay-out devices (22, 12).

Patentansprüche

1. Ein Verfahren zum Beschichten eines Filaments (24), z.B. Trafodraht, bei welchem ein fließfähiges, härtbares Harzmaterial (115) an einem kontinuierlich bewegten Filament bis zu einer benötigten Dicke in einem einzigen Durchlauf angebracht wird, wodurch ein Filament in einem kontinuierlichen Vorgang gezogen oder in anderer Weise geformt, beschichtet und aufgespult werden kann, das Verfahren enthaltend:

a) Durchführen des Filaments (24) durch eine stationäre Eintrittsdüse (61) mit einer Geschwindigkeit von 30,5 m/min. oder mehr;

b) Durchführen des Filaments durch eine stationäre Austrittsdüse (62) mit einer Geschwindigkeit von 30,5 m/min. oder mehr, wobei die Austrittsdüse einem Kehlungsabschnitt (93) und eine Eintrittsöffnung (92) hat, die größer als der Kehlungsabschnitt (93) ist und mit diesem durch eine konvergierende Innenwand (94) verbunden ist, wodurch zwischen dem Kehlungsabschnitt (93) und der Eintrittsöffnung (92) und dem Filament (24) und der konvergierenden Innenwand (94) ein Düsenhohlraum begrenzt wird, die Eintrittsdüse (61) und die Austrittsdüse (62) eine Düsenkammer (95) zwischen sich begrenzen und teilweise umschließen und das Filament innerhalb der Düsen von ihnen Abstand hat;

c) Füllen der Düsenkammer (95) mit einem fließfähigen, härtbarem Material (115), das weniger als 5 Gewichts-% Lösungsmittel aufweist, bei einer Temperatur oberhalb des Schmelzpunkts desselben,

d) Erhöhen des Drucks des Materials (115) in der Düsenkammer über den Atmosphärendruck

e) Durchführen des Filaments durch die Kammer (95) und dadurch Anbringen des fließfähigen Materials (115) auf dem Filament;

f) Zentrieren des Filaments im Kehlungsabschnitt (93) der Austrittsdüse (62) allein durch das Material (115) in der Düsenkammer (95); und

g) Abstreifen des überflüssigen fließfähigen Materials von dem Filament, eine konzentrische Beschichtung des Materials in einer Dicke zurücklassend, die die Erfordernisse der ANSI-NEMA Normenveröffentlichung Nr. MW 1000—1977 erfüllt.

2. Ein Verfahren nach Anspruch 1, bei dem die Eintrittsdüse (61) und die Austrittsdüse (62) in einem Düsenblock (64) gehalten sind, der Düsenblock und die Eintritts- und Austrittsdüsen die Düsenkammer (95) begrenzen und bei dem der genannte Füllungsschritt das Durchleiten des Materials (115) durch einen Kanal (75) in den Düsenblock umfaßt, wobei der Kanal die Düsenkammer fluidisch mit einem Materialbehälter (50) verbindet.

3. Verfahren nach Anspruch 1 oder 2, enthaltend den Schritt des Härtens des fließfähigen Materials (115) auf dem Filament (24), nachdem das Filament die Austrittsdüse (62) verlassen hat.

4. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem der Abstreifschritt den Schritt des Durchleitens des Filaments durch die Austrittsdüse (62) umfaßt, die ein Größenverhältnis in Bezug auf die Größe des Filaments derart aufweist, daß die Dicke des Beschichtungsmaterials (115) auf dem Filament beeinflußt wird.

5. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem der Zentrierschritt den Schritt des Beeinflussens der Viskosität des Materials (115) innerhalb der Düsenkammer (95) umfaßt.

6. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem der Zentrierschritt den Schritt des Beeinflussens des Drucks des Materials (115) innerhalb der Düsenkammer (95) umfaßt.

7. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem das fließfähige, härtbare Material ein unter Hitze erweichbares Material ist und der Zentrierschritt das Beeinflussen der Temperatur der Düsen (61, 62) umfaßt.

8. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem das fließfähige, härtbare Material ein unter Hitze erweichbares Material ist und der Zentrierschritt das Beeinflussen der Temperatur des Filaments umfaßt.

9. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem der Zentrierschritt das Hervorrufen einer Bewegung des Materials (115) innerhalb der Düsenkammer (95) umfaßt.

10. Ein Verfahren nach eine der vorhergehenden Ansprüche, bei dem das Filament aus der Gruppe ist: blanke Kupfer- und Aluminiumleiter; und isolierte Leiter, die eine zuvor aufgebrachte Grundisolierung aufweisen.

11. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem fließfähige, härtbare Material aus der Gruppe ist, enthaltend: Nylon, Polyäthylen, Terephthalate, Polybutylenterephthalate, Polyphenylsulfide, Polycarbonate, Polyptopylene, Polyethersulfon- Harze, Polyetherimide, Polyether, Etherketon-Harze, Polysulphone, Epoxyharze, Fluorcarbone, einschließlich Ethylen-Chlortriflourethylene und Ethylen-Tetraflourethylene, Polyvinylformalharze, Phenoxyharze, Polyvinylbutyrolharze, Polyamide-Imide, Polyesterharze und Kombinationen derselben.

12. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem das Material in der Düsenkammer eine Viskosität zwischen 5000 cps und 200 000 cps hat.

13. Ein Verfahren nach Anspruch 6, bei dem der Druck nicht größer als 140 kg/cm^2 ist.

14. Ein Verfahren nach einem der vorhergehenden Ansprüche, bei dem der Durchmesser des Filaments zwischen 0,25 mm und 9,50 mm liegt.

15. Ein Verfahren nach Anspruch 3, bei dem Dicke des härtbaren Materials zwischen 0,013 mm und 0,41 mm liegt.

16. Vorrichtung für die Herstellung eines beschichteten Filaments, beispielsweise Trafodraht, die Vorrichtung enthaltend ein oder zwei Düseneinrichtungen (18), wobei die oder jede Düseneinrichtung eine Eintrittsdüse (61) und eine Austrittsdüse (62) und einen Düsenblock (64) enthält, der Düsenblock zwischen den Düsen (61, 62) liegt, die Eintrittsdüse (61) einen Kehlungsabschnitt (82), eine Eintrittsöffnung (80), die größer als der Kehlungsabschnitt (82) ist und mit diesem durch eine konvergierende Innenwand (84) verbunden ist, und eine Austrittsöffnung (86), die größer als der Kehlungsabschnitt (82) ist und mit diesem durch eine divergente Innenwand (88) verbunden ist, aufweist, die Austrittsdüse (62) einen Kehlungsabschnitt (93) und eine Eintrittsoffnung (92), die größer als der Kehlungsabschnitt (93) ist und mit diesem durch eine konvergierende Innenwand (94) verbunden ist, aufweist, der Düsenblock (64) einen inneren Kanal (65) aufweist, der mit der Austrittsöffnung (86) der Eintrittsdüse (61) und der Eintrittsöffnung (92) der Austrittsdüse (62) in Verbindung ist und dadurch eine Fließmaterialzentrierkammer (95) zwischen der divergierenden Innenwand (88) und dem Kanal (65) und der konvergierenden Innenwand (94) ausbildet.

17. Vorrichtung nach Anspruch 16, enthaltend eine Filamentabgabeeinrichtung (12); eine Aufnahmeeinrichtung (22) für beschichtetes Filament, wobei die oder jede Düseneinrichtung (18) zwischen den Abgabe- und Aufnahmeeinrichtungen angeordnet ist; und die Eintritts- und Austrittsdüsen (61, 62) so angeordnet sind, daß ein Filament (24), das von der Abgabeeinrichtung (12) zur Aufnahmeeinrichtung (22) gezogen wird, in den Öffnungen und den Kehlungsabschnitten derselben aufnimmt; einen Behälter (50) für fließfähiges, härtbares Material; eine mit dem Behälter (50) verbundene Einrichtung (16) zum Füllen der Düsenkammer (95) mit Material (115) und zum Aufrechterhalten des Materials in der Düsenkammer bei erhöhten Drücken; und Einrichtungen, umfassend das Material in der Düsenkammer, zum Zentrieren des Filaments in den Kehlungsabschnitten (82, 93) der Düsen (61, 62).

18. Vorrichtung nach Anspruch 16, bei der die Eintrittsdüse (61) klein genug ist, um ein Austreten von Material aus der Düsenkammer (95) zu verhindern, während das Filament hindurchwandert, bei einem erhöhten Druck, und groß genug um ein Austreten zu ermöglichen, wenn das Filament in der Eintrittsdüse (61) bei dem genannten Druck unbewegt ist.

19. Vorrichtung nach einem der Ansprüche 16 bis 18, bei der die Eintrittsöffnung (80) einen ab 0,1 mm größeren Durchmesser als der Durchmesser des Filaments hat.

20. Vorrichtung nach Anspruch 17, enthaltend:

eine Zuführeinrichtung (16), die mit dem Behälter (50) verbunden ist, zum Füllen der Düsenkammer (95) mit Material (115) bei einem gewünschten Druck; und

wenn das Filament (24) in die Düseneinrichtung (18) eintritt, die Innenwand (84, 88) eine benachbarte Oberfläche bildet, an der das Material (115) einen Träger aus Beschichtungsmaterial hervorruft derart, daß das Filament die Düseneinrichtung nicht berührt und in den Düsenkehlungsabschnitten (82, 83) zentriert ist, um eine durchgehende und konzentrische Schicht aus Beschichtungsmaterial (115) auf dem Filament auszubilden.

21. Vorrichtung nach Anspruch 17, enthaltend Einrichtungen (14) zum Heizen des Filaments (24) zwischen der Abgabeeinrichtung (12) und der Düseneinrichtung (18), wobei die Heizeinrichtung (14) dazu eingerichtet ist, das Filament auf einen Temperaturbereich aufzuheizen, der von der Umgebungstemperatur bis zu der Temperatur reicht, bei der das Material sich zersetzt, und die Heizeinrichtung (14) an einer Stelle stromaufwärts vom Eintritt des Filaments in die Düseneinrichtung (18) angeordnet ist.

22. Vorrichtung nach Anspruch 17, enthaltend Einrichtungen (14) zum Heizen des Filaments zwischen der Abgabeeinrichtung und der Düseneinrichtung, und Einrichtungen (76) zum Heizen der Düseneinrichtung (18) und des Materials im Behälter (50) und der Düsenkammer (95).

23. Vorrichtung nach Anspruch 22, enthaltend Einrichtungen, einschließlich des Filaments, der Düseneinrichtung und der Behälterheizeinrichtung zum Beeinflussen der Viskosität des Materials (115) innerhalb der Düsenkammer (95).

24. Vorrichtung nach Anspruch 17, bei dem die Düseneinrichtung (18), die Befüllungs- und Aufrechterhaltungseinrichtung (16) und die Härteinrichtung 20 zusammen eine Filamentbeschichtungsstation bilden, wobei die Vorrichtung eine Mehrzahl solcher Beschichtungsstationen im Abstand zueinander und zu den Aufnahme- und Abg abeeinrichtungen (22, 12) enthält.

Revendications

1. Procédé de revêtement d'un filament (24) par exemple d'un fil d'aimant, selon lequel une résine (115), fluide, durcissable, est appliquée sur un filament se déplaçant en continu, suivant une épaisseur adéquate au cours d'un seul passage, le filament pouvant être étiré ou fabriqué d'une autre matière, revêtu et bobiné au cours d'une opération en continu, procédé caractérisé en ce que:

a) on fait passer le filament (24) à travers une matrice d'entrée (61) fixe, à une vitesse de 30,5 m/mn ou plus;

b) on fait passer le filament à travers une matrice de sortie (62), fixe, à une vitesse de 30,5 m/mn ou plus, la matrice de sortie ayant une partie en forme de gorge (93), une ouverture d'entrée (92) supérieure à la partie de gorge (93) et reliée à celle-ci par une paroi intérieure (94) convergente de façon à définir une cavité de matrice entre la partie de gorge (93) et l'ouverture d'entrée (92) ainsi que le filament (24) et la paroi intérieure convergente (94), la matrice d'entrée (61) et la matrice de sortie (62) définissant et délimitant partiellement une chambre de matrice (95), le filament entre les matrices étant espacé par rapport à celles-ci;

c) on remplit la chambre de la matrice (95) d'une matière fluide durcissable (115) qui contient moins de 5% en poids de solvant à une température supérieure au point de fusion de cette matière;

d) on élève la pression de la matière (115) dans la chambre de matrice (95) au-dessus de la pression atmosphérique;

e) on fait passer le filament à travers la chambre de matrice (95) de façon à appliquer la matière fluide (115) sur le filament;

f) on centre le filament dans la partie de gorge (93) de la matrice de sortie (62) uniquement à l'aide de la matière (115) de la chambre de matrice (95); et

g) on enlève l'excédent de matière fluide du filament en laissant sur celui-ci un revêtement concentrique de matière d'une épaisseur satisfaisant aux conditions des normes ANSI-NEMA publiées sous la référence MW 1000—1977.

2. Procédé selon la revendication 1, caractérisé en ce que la matrice d'entrée (61) et la matrice de sortie (62) sont maintenues dans un bloc de matrice (74), le bloc de matrice, la matrice d'entrée et la matrice de sortie définissant la chambre de matrice (95) et l'étape de remplissage consiste à faire passer la matière (115) à travers un passage (75) du bloc de matrice, le passage permettant l'écoulement du fluide entre le réservoir de matière (50) et la chambre de matrice.

3. Procédé selon la revendication 1 ou la revendication 2, caractérisé en ce qu'il comporte l'étape consistant à faire durcir la matière fluide (115) sur le filament (24) après que le filament ait quitté la matrice de sortie (62).

4. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que l'opération d'essuyage consiste à faire passer le filament à travers la matrice de sortie (62) qui présente une relation de dimension par rapport à la dimension du filament de façon à régler l'épaisseur de la matière de revêtement (115) du filament.

5. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que l'étape de centrage consiste à régler la viscosité de la matière (115) dans le chambre (95).

6. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que l'étape de centrage consiste à régler la pression de la matière (115) dans la chambre de matrice (95).

7. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que la matière fluide, durcissable, est une matière thermo-plastique et l'étape de centrage consiste à régler la température des matrices (61, 62).

8. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que la matière fluide durcissable est une matière thermo-plastique et l'étape de centrage consiste à régler la température du filament.

9. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que l'étape de centrage consiste à faire déplacer la matière (115) dans la chambre de matrice (95).

10. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le filament est choisi dans le groupe comprenant des conducteurs en cuivre nu et en aluminium; des conducteurs isolés ayant reçu préalablement une isolation de base.

11. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que la matière fluide durcissable est choisie dans le groupe suivant: nylon, téréphtalates de polyéthylène, téréphtalates de polybutylène, sulfure de polyphénylène, polycarbonates, polypropylènes, polyéthersulfone, polyéther imides, polyéther éthercétone, polysulphones, époxydes, hydrocarbures fluorés comprenant l'éthylène-chloro trifluoréthylène et l'éthylène-tétrafluoréthylène, polyvinyl formal, phénoxys, polyvinyl butyrol, polyamide-imides, polyesters et les combinaisons de ces produits.

12. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que la matière dans la chambre de matrice a une viscosité comprise entre 5000 cps et 200 000 cps.

13. Procédé selon la revendication 6, caractérisé en ce que la pression n'est pas supérieure à 140 kg/cm^2.

14. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le diamètre du filament est compris entre 0,25 mm et 9,50 mm.

15. Procédé selon la revendication 3, caractérisé en ce que l'épaisseur de la matière durcie est comprise entre 0,013 mm et 0,41 mm.

16. Appareil pour la fabrication d'un filament revêtu par exemple d'un filament d'aimant, appareil caractérisé par un ou plusieurs dispositifs à matrice (18), le ou chaque dispositif à matrice comprenant une matrice d'entrée (61) et une matrice de sortie (62) ainsi qu'un bloc de matrice (64), le bloc de matrice étant compris entre les matrices (61, 62), la matrice d'entrée (61) ayant une partie de gorge (82), une ouverture d'entrée (80) supérieure à la partie de gorge (82) et reliée à celle-ci par une paroi intérieure convergente (84) et une ouverture de sortie (86) plus grande qui la partie de gorge (82) et reliée à celle-ci par une paroi intérieure divergente (88), la matrice de sortie (62) ayant une partie de gorge (93) et une ouverture d'entrée (92) plus grande que la partie de gorge (93) et reliée à celle-ci par une paroi intérieure convergente (94), le bloc de matrice (64) ayant un passage intérieur (65) communiquant avec l'ouverture de sortie (86) de la matrice d'entrée (61) et l'ouverture d'entrée (92) de la matrice de sortie (62) définissant une chambre de centrage (95) pour la matière fluide entre la paroi intérieure divergente (88), le passage (65) et la paroi intérieure convergente (94).

17. Appareil selon la revendication 16, caractérisé par un dispositif d'alimentation de filament (12), un dispositif de réception de filament (22), revêtu, le ou chaque dispositif à matrice (18) étant situé entre le dispositif d'alimentation et le dispositif de réception; et la matrice d'entrée et la matrice de sortie (61, 62) étant positionnées de façon à recevoir un filament (24) passant entre le dispositif d'alimentation (12) et le dispositif de réception (22) dans les ouvertures et les parties de gorge de ceux-ci; un réservoir (50) de matière fluide durcissable; un moyen (16) relié au réservoir (50) pour remplir la chambre de matrice (95) de matière (115) et maintenant la matière dans la chambre de matrice à des pressions élevées et un moyen incluant la matière dans la chambre de matrice pour centrer le filament dans les parties de gorge (82, 93) des matrices (61, 62).

18. Appareil selon la revendication 16, caractérisé en ce que la matrice d'entrée (61) est suffisamment petite pour éviter les fuites de matière de la chambre de matrice (95) pendant que le filament y passe à une pression élevée, en étant suffisamment grande pour permettre les fuites lorsque le filament est immobile dans la matrice d'entrée (61), à la dite pression.

19. Appareil selon l'une des revendications 16 à 18, caractérisé en ce que l'ouverture d'entrée (80) est supérieure en diamètre de 0,1 mm au diamètre du filament.

20. Appareil selon la revendication 17, caractérisé en ce qu'il comporte un moyen d'application (16) relié au réservoir (50) pour remplir la chambre de matrice (95) de matière (115) à une pression appropriée; et lorsque le filament (24) entre dans le dispositif de la matrice (18), la paroi intérieure (84, 88) donne une surface adjacente sur laquelle la matière (115) forme un support de revêtement de matière de façon que le filament n'entre pas en contact avec le dispositif à matrice et soit centré dans les parties de gorge (82, 83) pour former une couche continue, concentrique de matière de revêtement (115) du filament.

21. Appareil selon la revendication 17, caractérisé par un moyen (14) pour chauffer le filament (24) entre le dispositif d'alimentation (12) et le dispositif à matrice (18), le moyen de chauffage (14) étant prévu de façon à chauffer le filament dans une plage de températures comprise entre la température ambiante et

la température à laquelle la matière se décompose et le moyen de chauffage (14) est prévu dans une position en amont de l'entrée du filament dans le dispositif de matrice (18).

22. Appareil selon la revendication 17, caractérisé en ce qu'il comprend un moyen (14) pour chauffer le filament entre le dispositif d'alimentation et le dispositif à matrice et un moyen (76) pour chauffer le dispositif à matrice (18) et la matière dans le réservoir (50) et la chambre de matrice (95).

23. Appareil selon la revendication 22, caractérisé en ce qu'il comporte un moyen comprenant le filament, le dispositif à matrice et le moyen de chauffage du réservoir pour régler la viscosité de la matière (115) dans la chambre de matrice (95).

24. Appareil selon la revendication 17, caractérisé en ce que le dispositif à matrice (18), le moyen de remplissage et de maintien (16) et le moyen de durcissage (20) constituent ensemble un porte de revêtement de filament, l'appareil comportant un ensemble de tels postes de revêtement rapprochés les uns des autres et par rapport au dispositif d'alimentation et au dispositif de réception (22, 12).

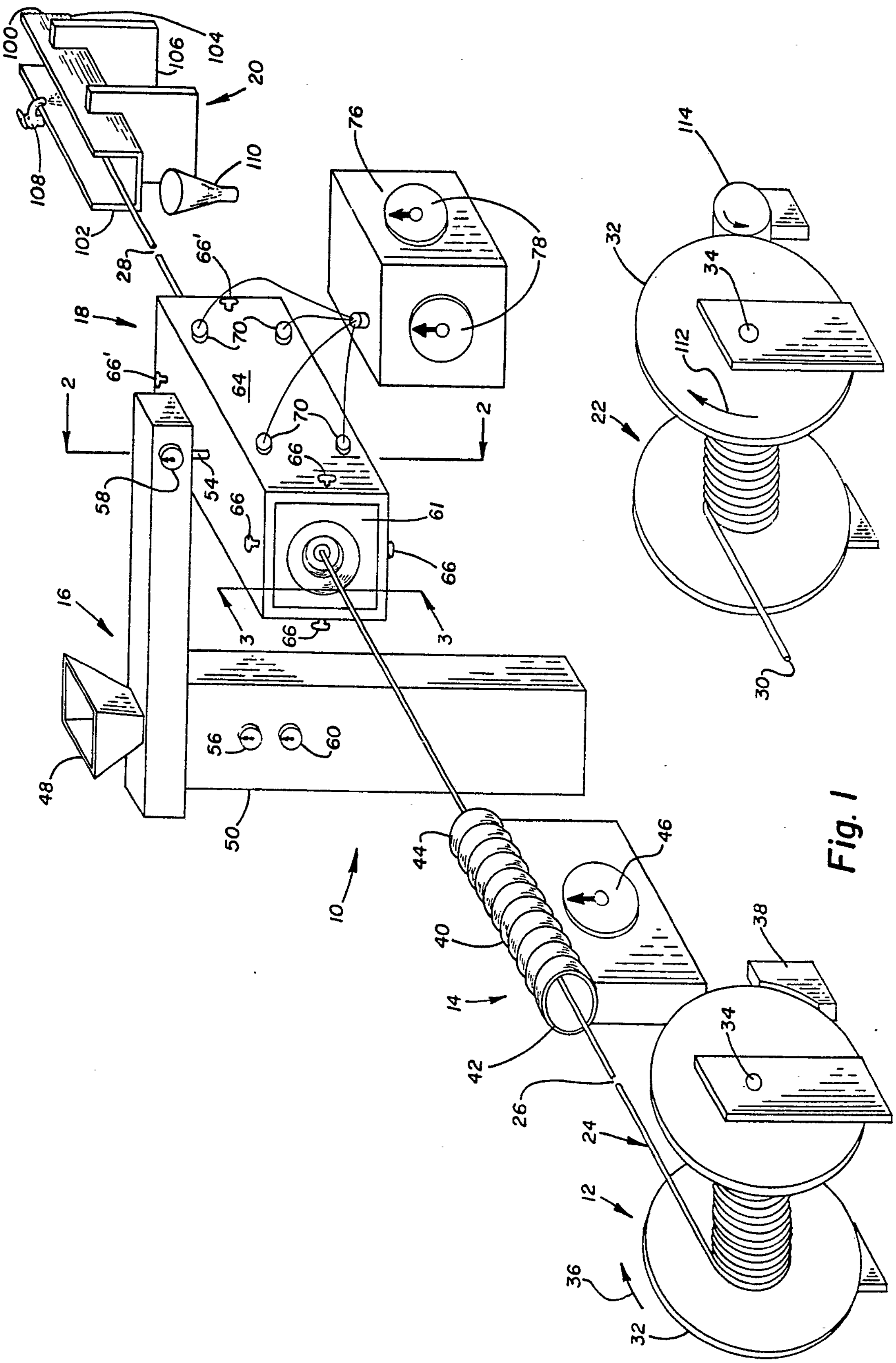
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Fig. 1

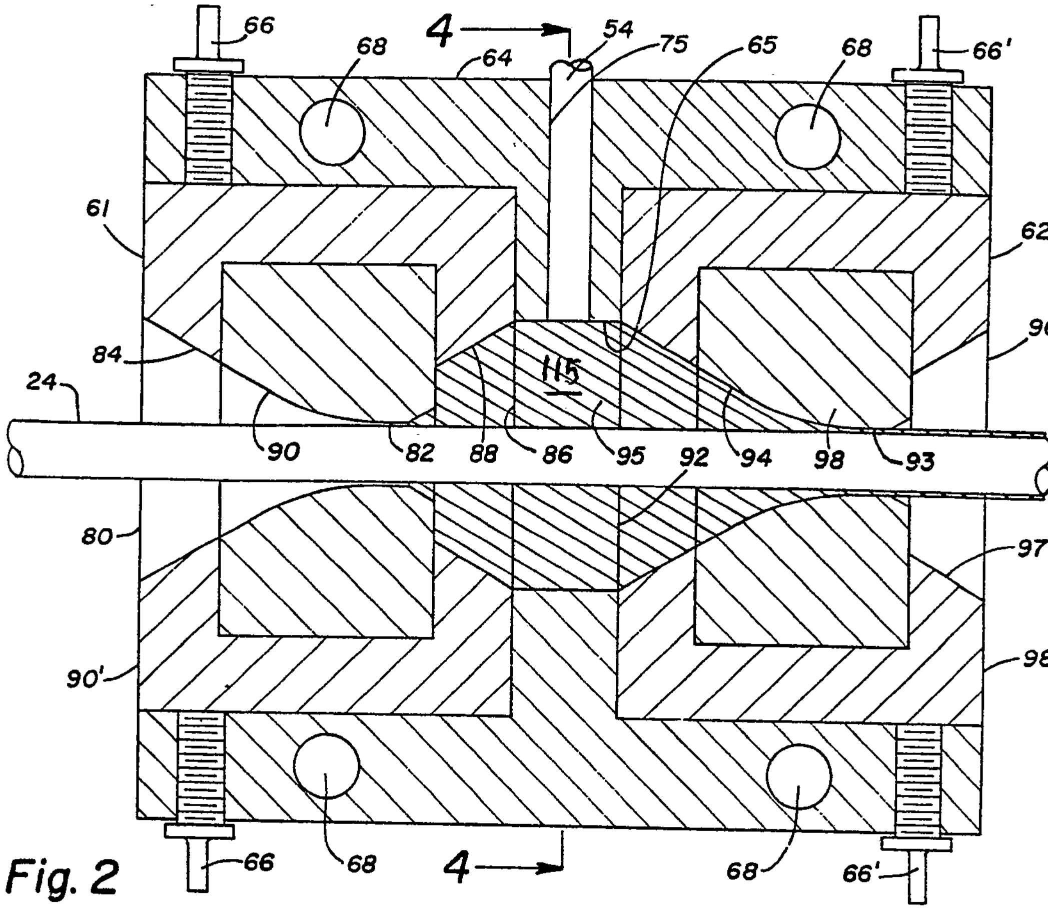
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Fig. 2

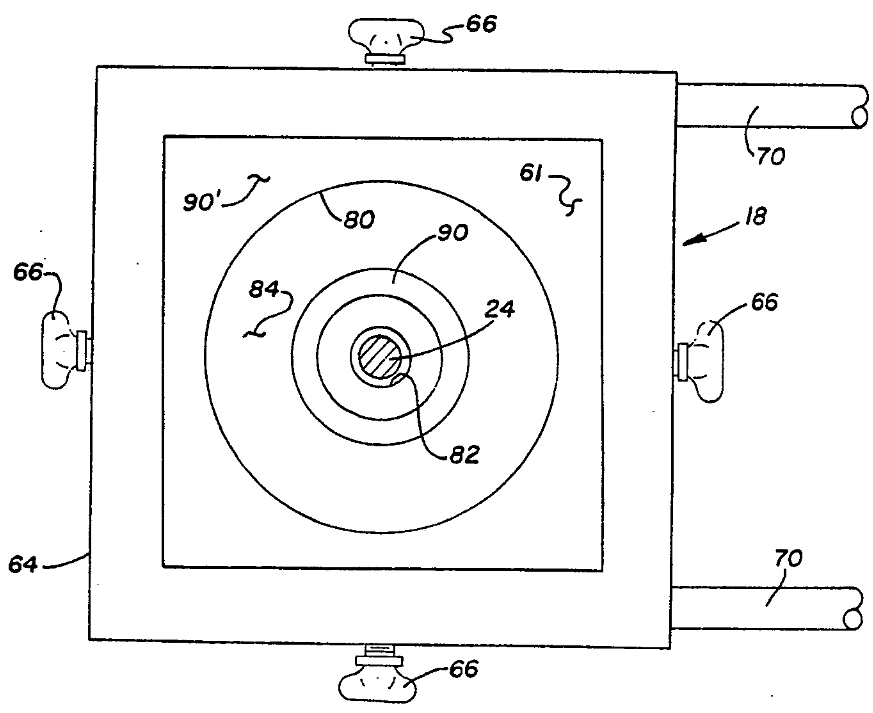
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Fig. 3

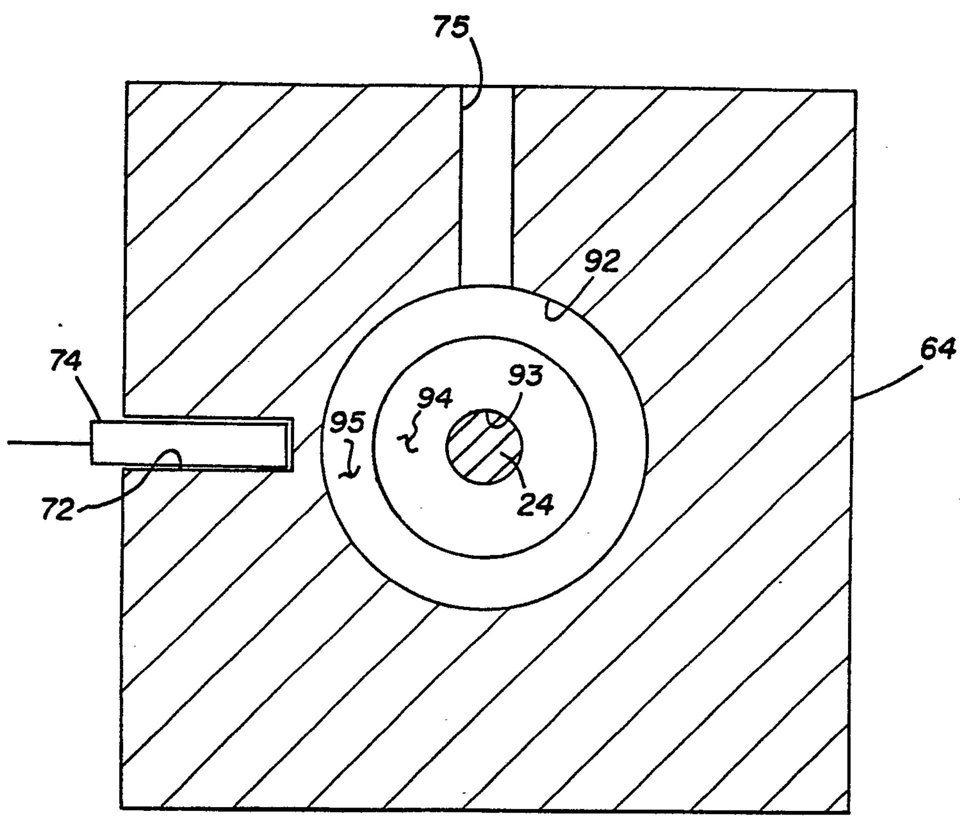

Fig. 4