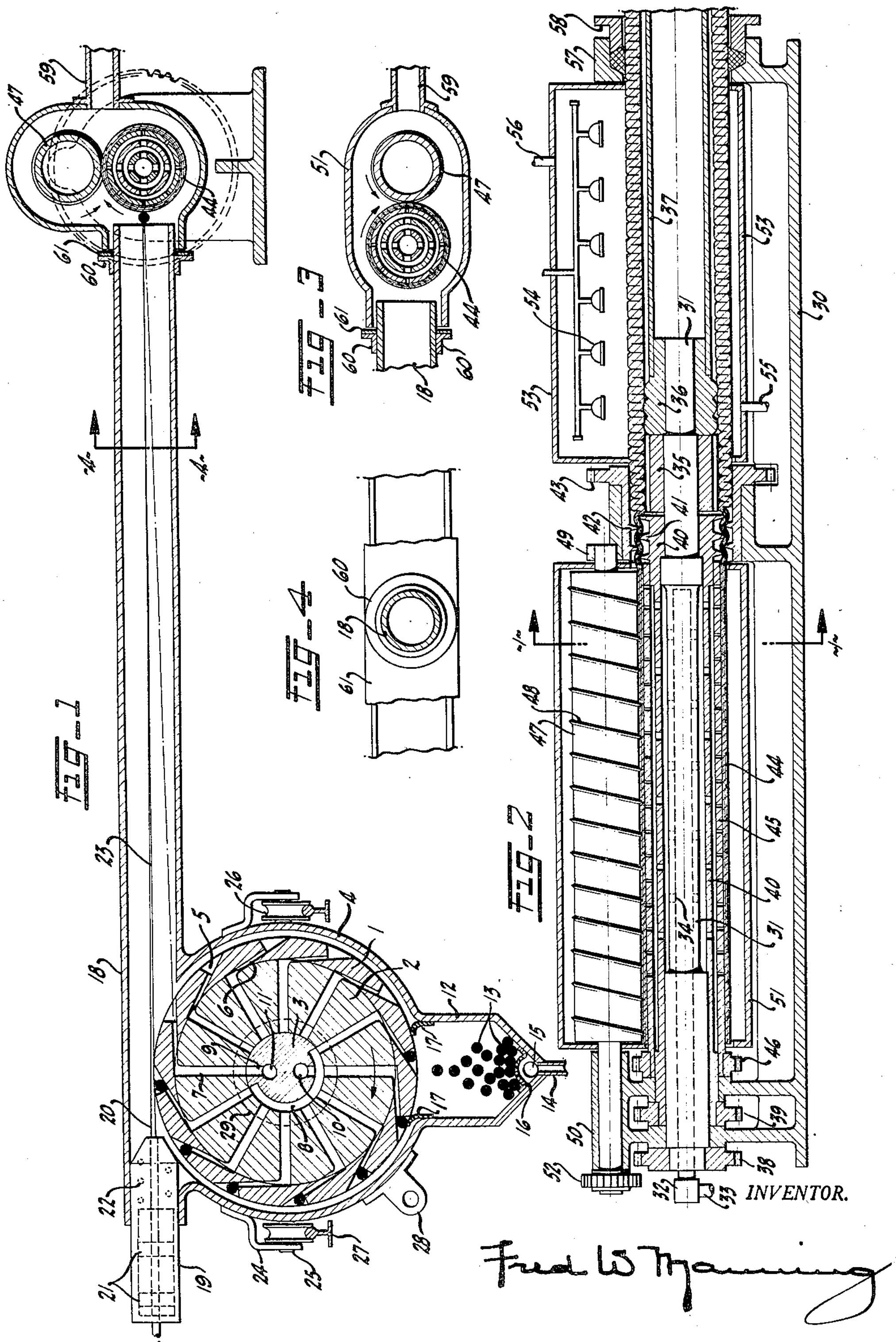
June 21, 1960 F. W. MANNING 2,941,915

METHOD OF MAKING REINFORCED COMPOSITE PIPE

Filed Dec. 28, 1954 2 Sheets-Sheet 1



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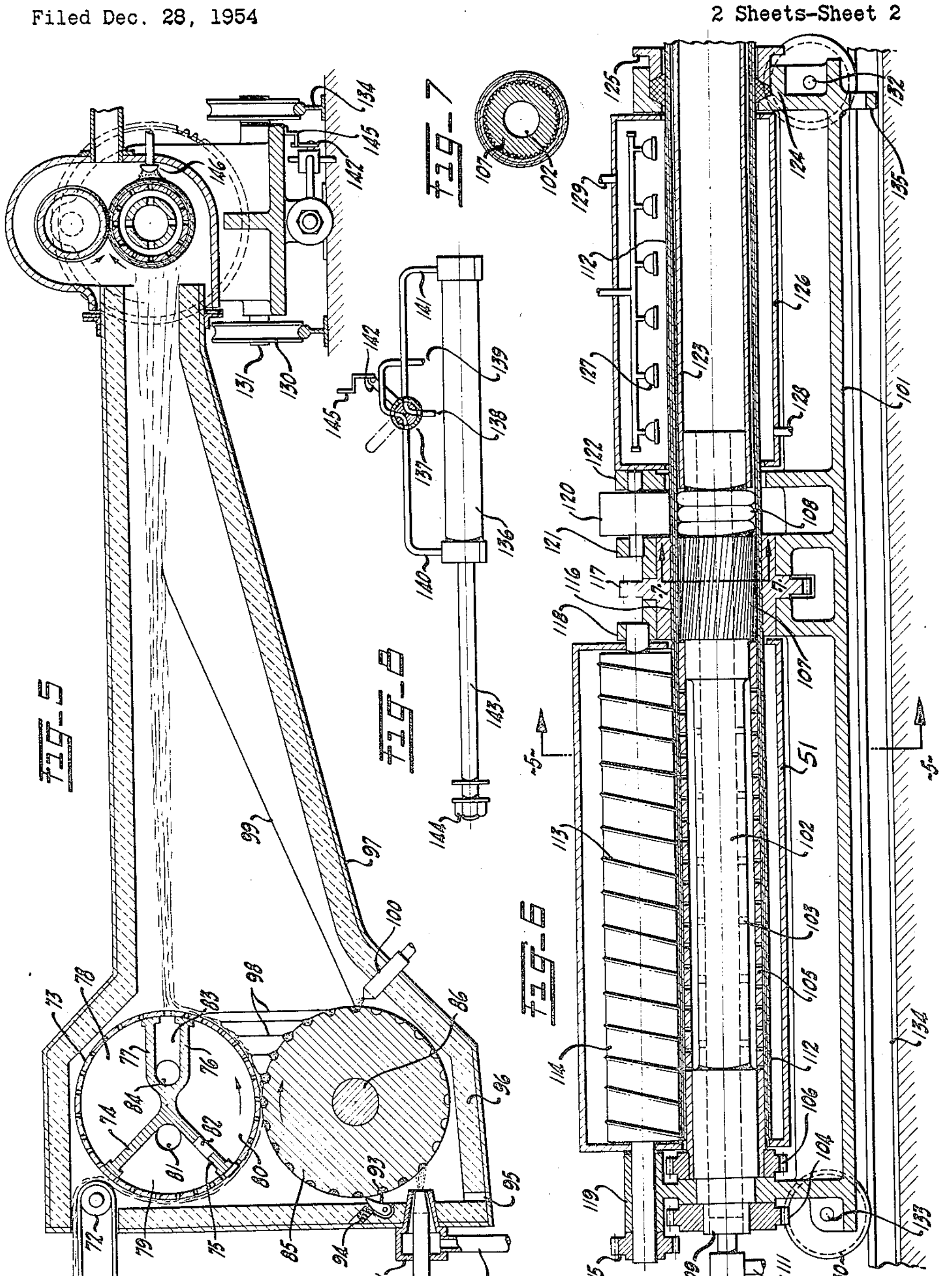

INVENTOR.

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METHOD OF MAKING REINFORCED COMPOSITE PIPE

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My invention relates to hollow structures, such as standards for electric lighting fixtures, parking meters, etc.; more particularly it relates to piping and tubing, and methods and apparatus for their construction. This application is a continuation-in-part of my copending applications, Serial Nos. 384,882, and 444,510, filed October 8, 1953, and July 20, 1954, respectively, now Patent Nos. 2,750,317 and 2,749,965, respectively.

It has been the practice heretofore to form reinforced plastic pipe by winding continuous filaments or tapes about a mandrel, coating and bonding the windings by a suitable resin to form a pipe of the required diameter, curing the pipe, and removing it from the mandrel, all in separate operations.

The primary purpose of the present invention is to combine the several operations of prior practice to produce light weight plastic pipe reinforced by stretch-oriented discontinuous filaments of substantial length and strength in one continuous operation.

A further object is to provide a method and apparatus for producing light weight reinforced plastic pipe in either rigid or flexible form.

Other objects will become apparent from the following description.

In accordance with one aspect of my invention, the reinforcing fibre-forming material is forced or flows from an extrusion device, melting furnace, or other feeding device, in finely divided portions, threads, or streams onto the periphery of a rotor which is preferably coated with or enclosed by an antiadhesive material, such as polytetrafluoroethylene. The movement of the rotor brings discrete solids held in the pockets of its peripheral wall into adherent contact with the fibre-forming portions. The latter are then preferably pulled a predetermined distance and attenuated into filaments before the solids are blasted from the pockets through a stretching and directing barrel.

The fibre-forming streams are in an adhesive condition at the time of contact is made with the discrete solids. The temperature and force of the propulsion fluid are such that the solids, upon being propelled from the rotor, attenuate the comparatively short length adhesive filaments into filaments of substantial length and strength compared with filaments normally produced by force of elastic fluid streams without the aid of pulling solids.

The filaments may be only a few inches in length for a short length barrel and a close-up depositing surface, or they may be many feet in length for the usual length of barrel, or they may be continuous. The propulsion fluid temperature may be atmospheric for cold-drawn filaments, or it may be the adhesive temperature of the filaments if the latter are to be deposited in an adhesive condition. The propelling fluid pressure may be the few ounces per square inch used in an ordinary blowing machine, or it may be 50 to 100 lbs. or more per square inch when the solids are to be propelled great distances, as when a web is to be spun over a fruit tree.

Stretch-orientation of a filament ordinarily commences

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at the moment a filament can be sufficiently tensioned to assume a substantially straight line between horizontal holding and pulling means without the aid of support between the two said means. This may be at the moment it leaves the extrusion device, and for sometime thereafter the filament may continue to be in a plastic and an adhesive condition, as indicated by the distance usually maintained between a spinneret and the first wind-up bobbin to prevent sticking of adjacent filaments; and so long as a filament is maintained in this plastic and adhesive condition, or is attached to a source of supply in this plastic and adhesive condition, the filament or source of supply may be drawn out indefinitely. However, once the filament has become set, additional stretching will usually bring it to its initial point of elasticity, and from there until its elastic limit has been reached it may be truly elastic, returning to its initial point of elasticity when the stretching force has been removed.

Therefore, if the entire length of a filament is cold-drawn between a pulling pellet and a succeeding pellet and its elastic limit has been reached, the filament will usually break at the succeeding pellets; if the inner end of a filament remains adhesively connected to a succeeding pellet, or the former has not reached its elastic limit, the succeeding pellet can usually be shot from the rotor without any breakage in the filament, thus producing a continuous filament with adherent pellets spaced at regular intervals along its length. In other words, propulsion temperatures, pressures and distances can be so regulated that a discontinuous filament can be produced if cold-drawn by a pellet beyond its maximum strength and elastic limit; a continuous filament can be produced if stretched by a pellet within its maximum strength and elastic limit, and the rotating mandrel on which the filament is deposited will function as a wind-up drum.

To prevent adherence to the gun barrel of filaments or pellets during propulsion, the pellets are usually shot centrally through the barrel in a line that is tangential to the peripheral movement of the rotor. The inside of the barrel can also be coated or lined with an anti-adhesive enamel or tubing, such as polytetrafluoroethylene. This will normally prevent adherence. However, if because of high temperature and/or pressure a finely divided portion of fibre-forming material is disrupted into a multitude of adhesive filaments and the filaments dispersed sufficiently to contact the sides of a barrel before exit therefrom, the barrel can also be protected by being shortened as much as is necessary and an ejector placed thereover. The propulsion of an annular column of higher pressure fluid through the ejector barrel will prevent adherence of filaments or pellets to either barrel, even without the above lining. Obviously, the length of the barrels will vary within wide limits depending mostly upon their diameters which will be determined from the volume of pellets to be shot simultaneously therethrough.

If the filaments are cold-drawn by propulsion pellets of lower softening temperature than the filaments, both are then calendered at a temperature and pressure at which the pellets are fluid and adhesive but below the softening point of the filaments, i.e., point at which they begin to lose their stretch-orientation. The pellets should be of uniform size and carefully proportioned to the weight of the fibre-forming material, and may be almost anything up to 100 percent of the weight of the filaments, or they may weigh many times the latter, depending upon the material used and the purpose for which the pipe is required. The filaments will usually vary between 10 microns and one mil in diameter, but may be even finer or coarser than these figures indicate.

In accordance with another aspect of my invention, if an inorganic material, such as glass, is to be used for reinforcing purposes, it can be deposited in fibre-forming fluid and adhesive portions on the peripheral surface of a primary member moving through an endless circuit. Simultaneously discrete pulling solids are deposited on an adjacent peripheral surface of a secondary member, also moving through an endless circuit. The converging and diverging paths of the two surfaces result in contact being made between the glass portions and the pulling solids, and the glass portions being attenuated into filaments of predetermined length. The solids are then propelled by force of a fluid stream to increase the attenuation of the filaments.

Sometimes, however, it is desirable to deposit the glass or other fibre-forming material on a primary member in discrete solid portions, and reduce the solid portions to fibre-forming fluid and adhesive portions before contact with the pulling solids, or by contact with heated pulling solids. The filaments then produced by propulsion of the solids can be deposited in an adhesive condition on a rapidly revolving mandrel and the solids will be bonded by the filaments. If the filaments are stretched and deposited at a temperature below that at which they are adhesive, they and the solids can be bonded by a vinyl, phenol-formaldehyde, polyester, or other resin. In any event, such a resin can be used to coat and impregnate the cylindrical web of solids and filaments, and the web then subjected to calendering and quenching to cure a thermoplastic resin, or calendering and heating to set a thermosetting resin.

The rotation of the mandrel with the relative axial movement of the windings thereover result in the windings being built up that intersect or cross at an acute angle with one another in both spiral and helical directions, but not in regular parallel lines unless the filaments retain their continuity between the feeding device for the fibre-forming material and the mandrel. The relative axial movement may result simply from the movement of the windings along their mandrel as the pipe is formed, or in addition to the said movement there may be a simultaneous reciprocating relative movement of the mandrel and the spinning gun. Of course, when a conical structure is being built, such as sometimes required for standards to support street lighting fixtures, there will, as a rule, be no relative axial movement of the deposited windings over their conical supporting structure.

The invention is exemplified in the following description and preferred arrangements are illustrated by way of examples in the accompanying drawings, in which:

Fig. 1 is a vertical section of a spinning apparatus with cross section of a pipe forming device taken on line 1—1 of Fig. 2.

Fig. 2 is a longitudinal section of the pipe forming device shown in Fig. 1.

Fig. 3 is a modification of the pipe forming device shown in Fig. 1.

Fig. 4 is a cross section of the filament stretching barrel taken on line 4—4 of Fig. 1.

Fig. 5 is a vertical section of a modified form of spinning apparatus with cross section of the pipe forming device taken on line 5—5 of Fig. 6.

Fig. 6 is a longitudinal section of the pipe forming device shown in Fig. 5.

Fig. 7 is a cross section of the grooved collar taken on line 7—7 of Fig. 6.

Fig. 8 is an elevation view of the cylinder used to reciprocate either the spinning apparatus or pipe device.

In these drawings, the usual steam-packing, also ball bearings for weight and thrust, have been omitted as they form no part of my invention. Referring now to the drawings more specifically by reference characters:

As shown in Fig. 1, the rotor consists of an outer annular ring or liner **1** enclosing an inner annular ring **2**, both being held in fixed relative relation. The rotor rotates about a shaft **3** which is maintained in a stationary position by the side walls of the casing **4**. The outer ring is equipped with pockets **5** and passages **6** which connect with radial openings **7** in the inner ring, and the said openings connect through suction and pressure ports **8** and **9** respectively, with suction and pressure pipe connections **10** and **11**, respectively.

The lower part of the casing forms a hopper **12** for the pulling pellets **13**; and the former is equipped with an air inlet **14**, check valve **15**, check valve cage **16**, and flexible strips **17** to prevent removal of air from the upper part of the casing. The top of the latter forms a gun barrel **18** whose longitudinal axis is tangential with the periphery of the rotor. The inner end of the barrel encloses the outer end of an extruding device **19**, described in my U.S. Patent No. 2,437,263, through which the fibre-forming material **20** is extruded in finely divided streams by pistons **21** as the material is brought to fluidity by heating coils **22**, and these extruded streams are attenuated into filaments **23** by pull of the pellets. Brackets **24** and pins **25**, attached to the casing, take the rollers **26** which ride on rails **27**; and also attached to the casing is a bracket **28** to be connected to the operating cylinder described below. Hub **29** of the rotor extends through the side wall of the casing and is driven by a belt from a source of power not shown.

Fig. 2 shows a pipe forming device which is particularly suitable for producing flexible pipe. A bed or baseplate **30** supports a winding shaft **31** which is annular for the greater part of its length, and to its open end is attached a swing joint **32** and pipe connection **33** to a source of suction for introduction of a treating fluid which finally escapes through openings **34**. Axially grooved collar **35** and circumferentially beaded collar **36** are rigidly attached to the inner end of the shaft, and to the beaded collar is attached the supporting pipe **37**, the shaft being rotated by gear **38**. Enclosing the shaft and driven by gear **39** is a perforated feeding sleeve **40** whose exterior threads **41** cooperate with the interior threads **42** of the gear **43** to helically groove the plastic pipe **44** and move it along the perforated supporting sleeve **45**, driven by gear **46**, as the pipe is formed thereon. The calender roll **47** is equipped with helical rings **48**, rotates in bearings **49** and **50**, is enclosed in casing **51**, and driven by gear **52**. The pipe, after being helically grooved and the grooves shoved together, is subjected to heat in casing **53** from lamps **54**, or to a temperature regulating fluid that enters and leaves through connections **55** and **56**, respectively. During the curing period the pipe is supported by the stuffing-box **57** and gland **58**, which may also aid the feeding threads (**41** and **42**) in shoving the helical grooves together.

Figs. 3 and 4 show a modified arrangement of the pipe forming apparatus in which the mandrel, calender roll, and suction outlet **59** are all in axial alignment with the filament stretching barrel. Angle iron ring **60** and cover plate **61** attached to the barrel prevent ingress of air around the barrel while the conveying fluids from the barrel are being exhausted through the outlet.

Fig. 5 shows a modified form of a spinning gun particularly suitable for the spinning of glass fibres. In this arrangement discrete fibres **70** are conveyed by an endless belt **71** over a roll **72** and deposited in a uniformly distributed condition on the periphery of a foraminous drum or rotor **73**. This drum, which is in rolling contact with the lower rotor, rotates about the stationary arms **74**, **75**, **76**, and **77**, held in fixed position between the sidewalls of the housing, thereby forming a neutral chamber **78** having no connections; suction chambers **79** and **80**, the former having a connection **81** to a source of suction, and the two being connected by an opening **82** in the arm **75**; and a blowing chamber **83** having a connection **84** to a source of fluid pressure.

The lower rotor **85** is driven by shaft **86** from a source of power not shown, and is equipped on its peripheral surface with uniformly spaced pockets or reservoirs for the filament forming material **87**. This latter is first introduced into hopper **88** in discrete and finely divided portions, as from 50 to 200 mesh. The rate of feed of this material is regulated by rotary valve **89** at the entrance to the feed pipe **90**, and the material is then dispersed and delivered in fibre-forming fluidity against the periphery of the rotor by a blast from the burner **91**, which is supplied by fuel and air under pressure through pipe **92** from a source of supply not shown. A scraper **93**, pressured by a spring **94**, removes excess from the surface of the rotor and the drip escapes through the drain **95** in the refractory wall **96** and steel casing **97**. When the peripheries of the rotors enter diverging paths, short discontinuous filaments **98** are formed which are attenuated into long discontinuous filaments **99** when the fibres connected at its outer end are blasted from that portion of the foraminous drum passing over the pressure chamber **83**. A jet flame **100** may be used to sever the inner ends of the filaments, if the pull on the latter does not completely empty the pockets of their fibre-forming material.

Figs. 6 and 7 show the modified pipe forming device indicated by cross section in Fig. 5. The bed or baseplate **101** supports the winding mandrel which consists of an annular shaft **102** equipped with peripheral openings **103**. The shaft is driven by gear **104** and enclosed by a perforated supporting sleeve **105**, the latter being driven by gear **106**. Rigidly attached to the inner end of the shaft are the helically grooved collar **107** (Fig. 7) and the circumferentially beaded collar **108**, and into the open end of the shaft is screwed a plug **109** to which is connected swing joint **110** and pipe line **111** for entrance of steam or other treating fluid.

The reinformed plastic pipe **112** is moved along the mandrel sleeve as formed by means of a helical thread **113** on the primary calender roll **114**, the latter being driven by gear **115**; and cooperating with the calender thread is the internal thread **116** of the gear **117**. The primary calender roll is supported by bearings **118** and **119**, and secondary calender roll **120** by bearings **121** and **122**. After passing between the secondary roll and the beaded collar, the plastic pipe is supported internally by the sleeve **123** attached to the annular shaft, and externally by stuffing-box **124** and gland **125**. Casing **126** encloses the forward end of the plastic pipe, and its temperature is regulated by infra-red ray lamps **127**, or a treating fluid that enters and leaves the casing through pipe connections **128** and **129**, respectively. Wheels **130** are attached to shafts **131** which pass through front and rear bearings **132** and **133**, respectively, in the baseplate, and travel on rails **134**. A lug **135** is suitably connected to the bed for connection to a piston rod.

Fig. 8 shows a hydraulic cylinder **136** which is bolted to the flooring in fixed position. It is equipped with a two-way rotary valve **137** having pipe connections **138**, **139**, **140**, and **141**, to pump, reservoir, and to opposite ends of the cylinder, respectively; and a lever **142**. The piston rod **143** is connected to the baseplate lug by nut **144**; and pins **145**, suitably positioned in the baseplate, reverse the valve lever whenever the piston rod has reached the end of its travel.

The operation of the apparatus described above has been indicated in part in connection with the foregoing description. The following examples will more completely illustrate the methods that can be used in the practice of my invention.

Example I

Flexible 6 inch diameter pipe is produced from wholly organic materials, such as polyamide filaments and polyethylene pellets, as indicated in Figs. 1 and 2.

Passage of air through hopper **12**, pockets **5**, air passages **6** and **7**, port **8**, and suction outlet **10**, results in one or more polyethylene pellets about ⅛ inch in diameter filling each pocket as the periphery of the rotor passes over hopper **12**. The passages **6** are smaller than the pellets, and consequently the latter are held in the pockets under a differential pressure as long as the passages are connected to the suction port **8**. Polyamide material having a molecular weight of about 20,000 is brought to fibre-forming fluidity at 300° F. by coils **22** and extruded in finely divided adhesive streams **20** by the pistons **21**. Extrusion is tangential to the movement of the periphery of a rotor 18 inches in diameter, rotating at 5 to 10 r.p.m., and rotation of the latter results in contact being made at a temperature of about 300° F. between a fluid stream and a pellet, or a plurality of streams and an axial row of pellets. Adherence between a stream and a pellet and a lesser adherence between the stream and the polytetrafluoroethylene liner **1**, results in a positive pulling or stretching of a stream **20** into a filament **23**.

The attenuation of a fluid stream **20** into a filament by positive pull of a pellet, with or without adherence of the stream to the periphery of the pocket liner, is continued until a pellet pocket passage opens to port **9** and pressure connection **11**, whereupon the pellet is propelled from its pocket by a blast of air at room temperature and 10 lbs. pressure. This cold-draws the filament and strips it from the periphery arc of the liner back to the next pellet at which point the elastic limit of the filament will have been reached and it will break, providing the pellet has been shot a reasonable distance, as for instance, ten to twenty feet for a filament $\frac{1}{32}$ inch diameter at its point of contact with a pellet conveyed in a pocket spaced about 4.5 inches from a succeeding pocket. Or if a filament has not reached its elastic limit, or at least a portion of it has been maintained in an adhesive condition by using steam or other propulsion fluid at a temperature of 300° F., a string of pellets can be propelled through the gun barrel in a continuous succession, uniformly spaced on unbroken filaments, the conveying fluid escaping through suction outlet **59**. Size of fibre stream, temperature and pressure of propulsion fluid, and distance the pellets are propelled may all vary within wide limits to give continuous or discontinuous filaments.

Propulsion of the pellets through the gun barrel results in the former being deposited on the foraminous supporting sleeve **45** which has a rotative speed of about 20 r.p.m. and is maintained at a temperature of 200° F. by steam entering shaft **31** through the swing joint **32** from pipe connection **33** and passing through the perforations of the shaft, pulling sleeve, and supporting sleeve. At this temperature the polyamide filaments lose none of their stretch-orientation, and the rapid rotation of their supporting sleeve with back and forth movement of gun on rails **27** results in the filaments being deposited uniformly and in both spiral and helical coils about the sleeve with the filaments crossing one another at an acute angle. But the temperature of 200° softens the pellets, and rotation of the calender roll **47** results in a uniform spread of the pellets over and in the interstices of the filamentary web to form a smooth surface pipe which is nonadherent to either roll or sleeve due to their coating with an antiadhesive, such as polytetrafluoroethylene. The left hand or rear portion of the supporting sleeve where the first thin shell of pipe is formed is imperforated, and there will be no tendency for the fluid pellets under calender pressure to enter the forward perforations.

The to-and-fro movement of the spinning gun across the length of the calender roll can be obtained by any ordinary fluid (steam, air, water, etc.) operated cylinder actuated by a rotary valve, all of which is well known to those versed in the art. In the present case, the cylinder **136** (Fig. 8) is bolted to the floor and its piston rod is attached by nut **144** to the bracket **28** of the rotor casing. Fluid from a pump connnection **138** enters valve **137** and is forced to opposed ends of the cylinder alternately through pipe connections **140** and **141**. The return of the fluid, if liquid, to its reservoir is through connection **139**, otherwise the exhaust can escape to the atmosphere. Trip members **145** suitably attached to the underside of the rotor casing and extending to the valve lever **142** reverses the latter and the fluid pressure flow whenever the piston rod has reached the end of its stroke.

The travel of the plastic pipe along its supporting sleeve as the former is built thereupon is accomplished by the pull of the internal thread **42** of the gear **43** and the external thread **41** of the feeding sleeve **40**, the two threads or helices being displaced in respect to each other to the extent of one-half their pitch, and decrease in this pitch and tightening of the packing in stuffing-box will aid in shoving the grooved helices of the plastic pipe closer together. The forward movement of the plastic pipe may also be aided by the helical thread **113** of the calender roll and steam pressure passing through the perforations of the shaft, pulling sleeve, and supporting sleeve. Axially grooved collar **35** (somewhat similar to **107** in Fig. 7) prevents turning of the plastic pipe on its supporting sleeve, and the collars circumferential beaded portions removes any ridges made by the axial grooves. Curing of the plastic pipe is accomplished by passing air at zero temperature through the casing **53** from inlet connection **55** to the outlet connection **56**.

Obviously, the pulling sleeve **40** with exterior thread **41** must turn at the same speed as the interior thread **42** of the gear **43**, and the speed of these threads must be greater than the speed of the supporting sleeve, if both rotate in the same direction, in order to pull the plastic pipe along the latter; and the speed of the axial grooved collar **35**, and annular shaft **31** to which it is affixed, should be the same as the supporting sleeve **45** if the plastic pipe is to move forward without turning on the said sleeve.

Example II

Organic filaments and inorganic pulling solids can be utilized in much the same way to produce flexible pipe. In this example, polyamide filaments are pulled by chopped glass strands from one-half inch to two inches in length in the same manner as described above for polyethylene pulling solids.

Upon deposition over the mandrel, the glass fibres and polyamide filaments are impregnated and coated by a polyester resin from spray **146** (Fig. 5) at a temperature below the softening point of the filaments, the weight of the resin usually varying between 25 and 40 percent of the weight of the pipe. The impregnated pipe is calendered as it is moved along the mandrel, and radiant heat at a temperature of about 200° F. from the lamps **54** sets the resin as the pipe moves through casing **53**.

Obviously, asbestos, micaceous mineral, and the like can also be used as pulling solids; also other resins, such as vinyl-chloride-acetate can be used for coating purposes, and cooling fluids used for setting purposes.

Example III

Wholly inorganic materials, such as glass and asbestos, can be used in somewhat similar manner to produce rigid pipe, as indicated in Figs. 5 and 6. The arrangement for spinning glass is similar to that described in the above mentioned Patent No. 2,750,317.

Asbestos fibres **70** are conveyed on a belt **71** and uniformly distributed over a rotor consisting of a foraminous drum **73** of 100 mesh, which rotates about stationary arms **74, 75, 76,** and **77**. These arms enclose suction chambers **79** and **80**, and thereby maintain the fibres on the periphery of the drum until blasted therefrom by heated air or steam pressure from chamber **83**.

Small, discrete particles of fibre-forming glass **87**, such as from 100 to 200 mesh, are charged into the hopper **88** and fed as required by rotary valve **89** through pipe **90** to the burner **91**, which is supplied by fuel under pressure by pipe **92** from a source not shown. The blast of burning fuel reduces the discrete particles of glass to a fibre-forming fluidity at a temperature of about 1900° F., and in that condition they are deposited on the peripheral surface and in the pockets of rotor **85**; or the particles, if deposited in a solid condition, will adhere to and be reduced to fibre-forming fluidity by the rotor heated to about 2100° F. from a jet flame **100** or other suitable means. The molten glass in either case is scraped by a spring pressured blade **93** into the pockets and the excess is removed entirely from the rotor and drained through outlet **95**.

Converging paths of the two rotors bring the discrete asbestos fibres and the pockets filled with fibre-forming glass material into adhesive contact, and their diverging paths cause the glass in their respective reservoirs to neck down into positively stretched filaments **98** until finally the fibres are cut off from their suction contact with the peripheral surface of the primary rotor and blasted therefrom by heated air or steam pressure within the pressure chamber **83**. The blast gives the fibres a theoretical initial velocity of at least 10,000 feet per minute and the pull exerted by the fibres to which the filaments **98** are adhesively connected, produce filaments **99** from 2 to 20 feet in length.

The operation of the pipe production apparatus is much the same as that described in Example 1, with the following exceptions: the plastic pipe is moved along its supporting sleeve **105** by means of the exterior helical thread **113** on calender roll **114** aided by interior helical thread **116** of the gear **117** and interior steam pressure from shaft **102**; and the peripheral travel of these threaded surfaces will ordinarily be greater than that of the supporting sleeve, if they rotate in the same direction, to move the plastic pipe forward. Helically grooved collar **107** permits a limited amount of turning of the plastic pipe during such movement, and this also aids the forward movement. The markings or ridges left by the feeding threads and grooves are removed by the secondary calender roll **120** and the circumferentially beaded collar **108**. The glass filaments and asbestos fibres are impregnated and bonded by a polyester resin from a series of sprays **146** within the casing **51**, similar to that in Fig. 2, and the pipe is cured by radiant heat from lamps **127** within casing **126**.

In the above examples the blast from the spinning rotor is exhausted from casing **51** by suction outlet **59**, and entrance of air to the casing from other sources is prevented by closure plate **61**. This plate moves in close contact with the entrance of the casing and extends sufficiently therebeyond to form a closure during the relative axial movement of the gun and pipe-forming device. The arrangement shown in Figs. 3 and 4 for equal distribution of the conveying fluid around the pipe-forming device will usually result in the filaments being deposited more uniformly about the mandrel.

It is obvious from the above examples that a fibre-forming material can be deposited on a retaining wall in discrete portions, or as a film or threads connected to a source of supply, and the wall moved to bring the material and discrete pulling solids into adherent contact. Convers-ely, the solids can be deposited on a retaining wall in spaced portions or uniformly distributed condition, and the wall moved to bring the solids and fibre-forming material into adherent contact. In any event the fibre-forming material must be sufficiently adhesive to adhere to the fibre-forming material, during propulsion of the solids.

It will furthermore be evident that pulling solids can be so regulated as to size and spacing on a retaining wall, and the distances and directions they are to be propelled from the wall so controlled, that they can be deposited with great uniformity and spacing, and the filaments will have a predetermined stretch; and when thermoplastic pellets are subjected to heat and pressure to bond a filamentary web to a cylindrical web to be reinforced, the pellets can be calendered and thinned out to produce an impervious coating over, and/or fill the interstices of, the reinforcing web.

It will also be evident that filaments and pulling solids can be deposited over the periphery of a mandrel without one being used to bond the other, and suction through the mandrel and swivel joint connections used to aid the said deposition to form a pervious cylindrical wall for a pipe or other structure. The wall can then be impregnated and coated with a polyester or other suitable resin and calendered to make it impervious. And by siutable regulation of temperatures and materials, the filaments can be bonded by pulling solids without loss of stretch-orientation to the filaments; or the solids can be bonded by the filaments without loss of stretch-orientation to the latter, if either or both are coated with a non-solvent adhesive by ejector in the stretching barrel or spray after deposition.

It will again be evident that the inorganic materials of Example III can be used to produce the flexible pipe of Examples I and II; also, the organic materials of Example I, or organic and inorganic materials of Example II, can be used to produce the rigid type of Example III. In similar manner, other fibre-forming materials in molten, solution, or other condition, can be used to produce either rigid or flexible pipe. If solvents are used to reduce fibre-forming materials to fluidity, a portion will evaporate under heat from the mandrel in the pipe deposition chamber and be carried off through outlet **59**, and the balance will be evaporated in the setting chamber and carried off through outlet **56** in Fig. 2, or outlet **129** in Fig. 6.

It will be understood throughout the specification and appended claims that a "spiral" is one whose successive coils circle around a center and gradually recede therefrom, or approach thereto; a "helix" is one whose successive coils extend axially, as in an ordinary screw thread; and "glass" is used in a generic sense to include glass and mineral wool compositions, and the like.

I claim as my invention:

1. In a method for making pipe, the steps comprising: dispersing a fibre-forming material in a heated gaseous atmosphere to produce discrete fluid particles; depositing the said particles on a primary rotating member to form a coating thereover of fibre-forming fluidity; adhesively contacting predetermined portions of the said coating with discrete solids; propelling the said solids by force of a fluid stream moving in a controlled path to attenuate the said portions into solids-entrained, stretch-oriented filaments; depositing the said filaments in a successive series of superposed windings about a secondary rotating member by relative movements of the windings in said controlled path and the said secondary member; and bonding the said solids and windings together to form the wall of the said pipe.

2. The method of claim 1 for making pipe, including the step of calendering the said wall during the said relative movements to consolidate the said filaments and solids and extend the said bonding throughout the said wall.

3. The method of claim 1 for making pipe in which the said filaments are built up in spiral and helical windings with the said solids uniformly distributed therethrough.

4. The method of claim 1 for making pipe, including the step of applying tractive force to the said wall to move the wall axially along the said secondary member as the said windings are built in superposed layers thereupon.

5. The method of claim 4 for making flexible pipe, and including the steps: helically grooving the said pipe; compressing the helical grooves axially; and applying heat to set the said grooves during the movement of said wall.

6. The method of claim 5 for making flexible pipe in which all the said steps are successive and continuous.

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