Nov. 13, 1962 D. LABINO 3,063,887

METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

Filed March 3, 1958 12 Sheets-Sheet 1

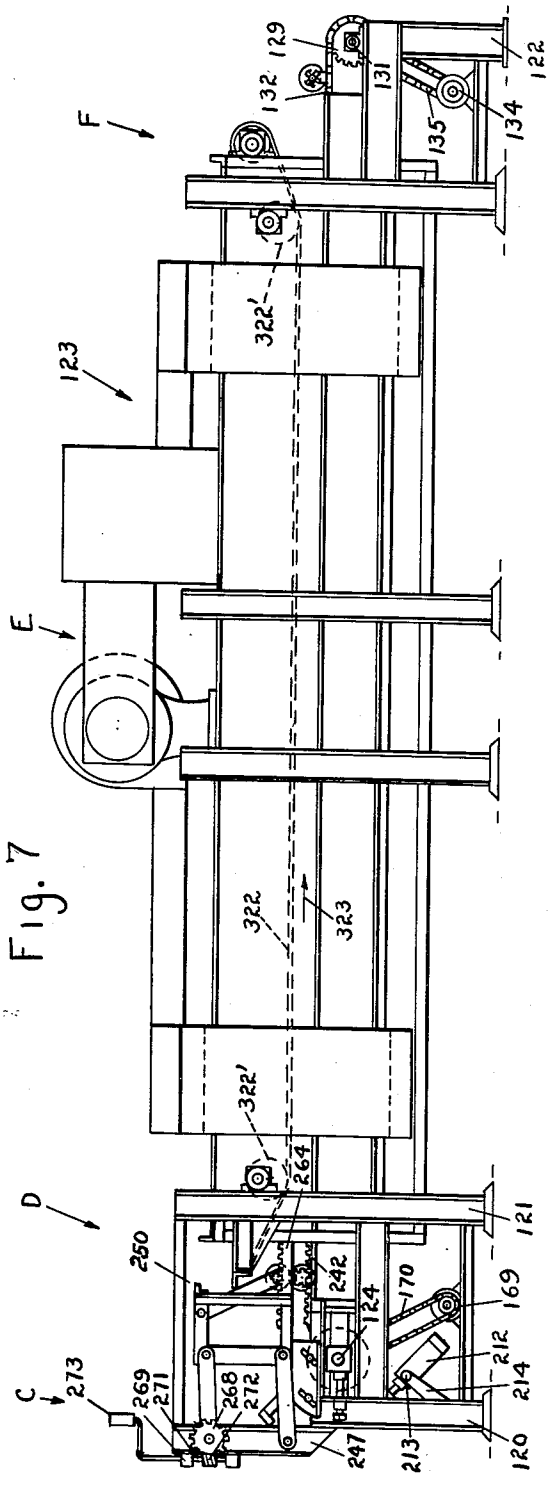


Fig. 7

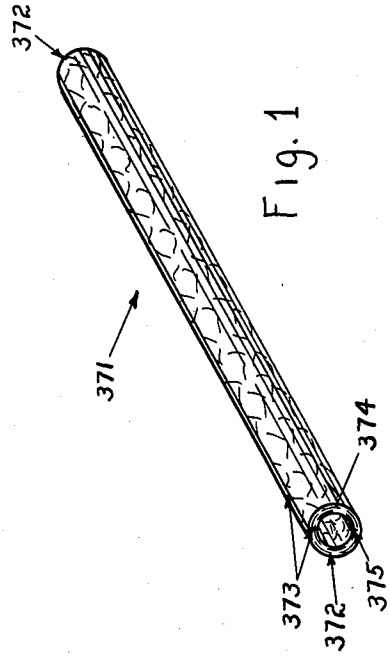


Fig. 1

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

Filed March 3, 1958 12 Sheets-Sheet 2

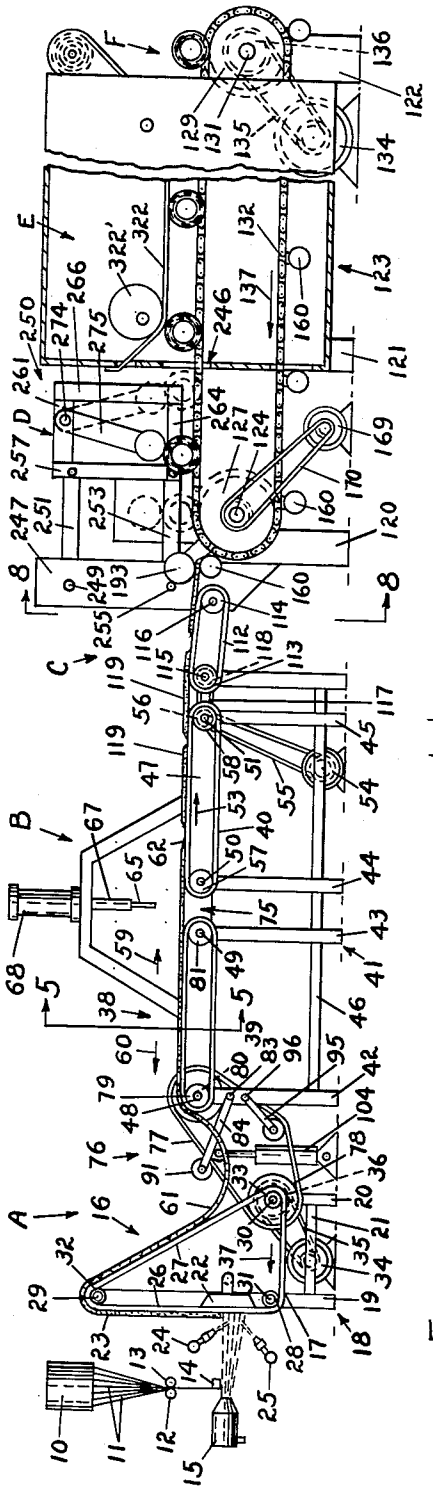


Fig. 2

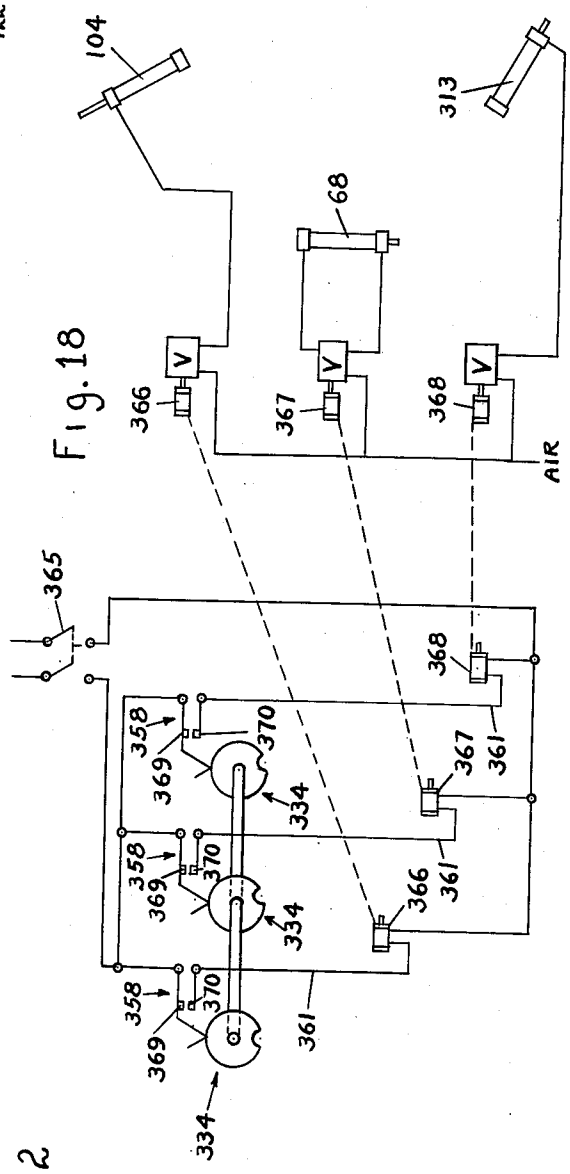


Fig. 18

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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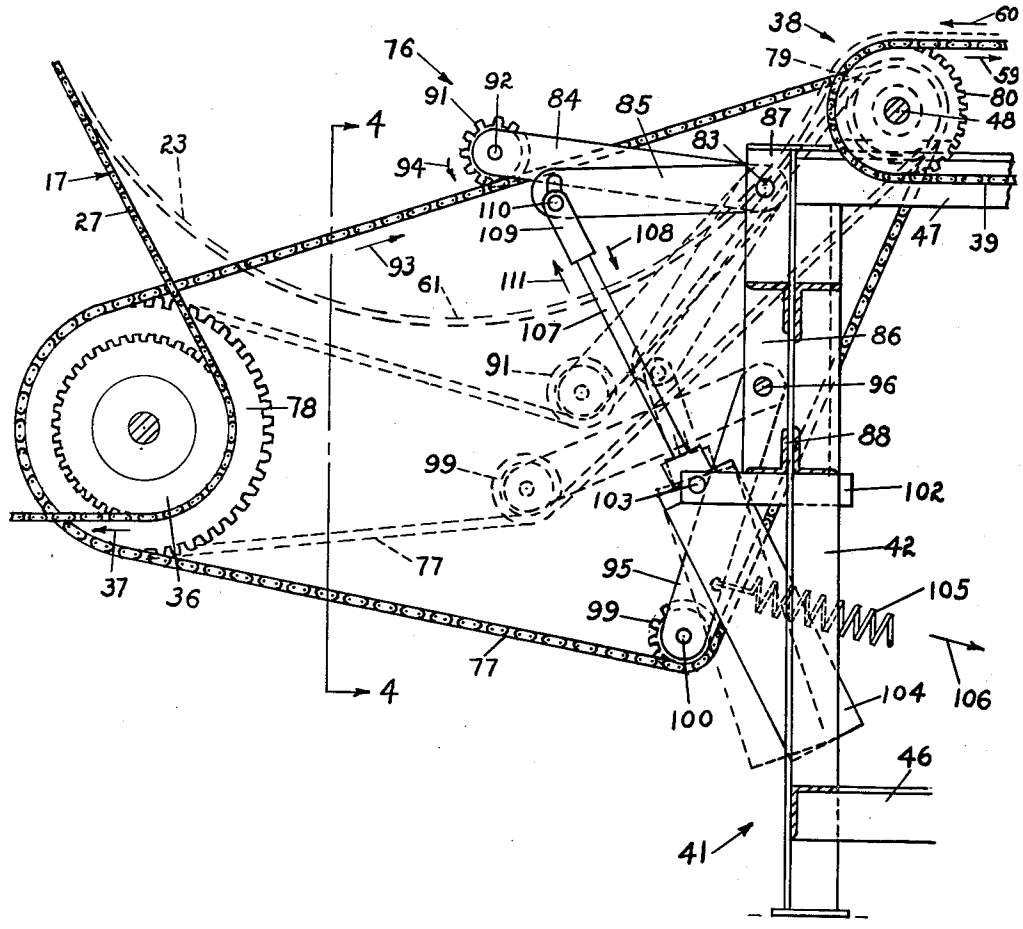


Fig. 3

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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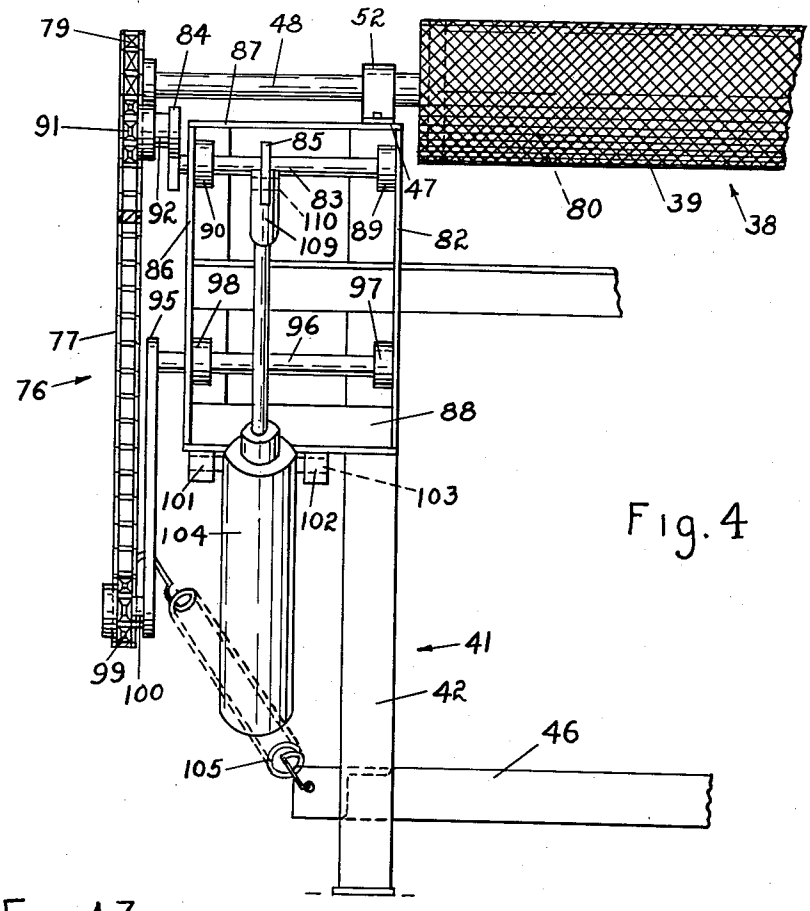


Fig. 4

Fig. 17

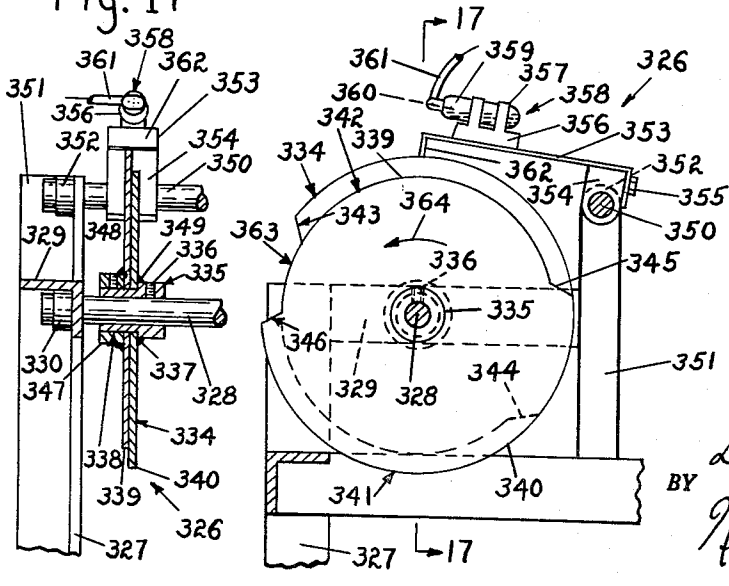


Fig. 16

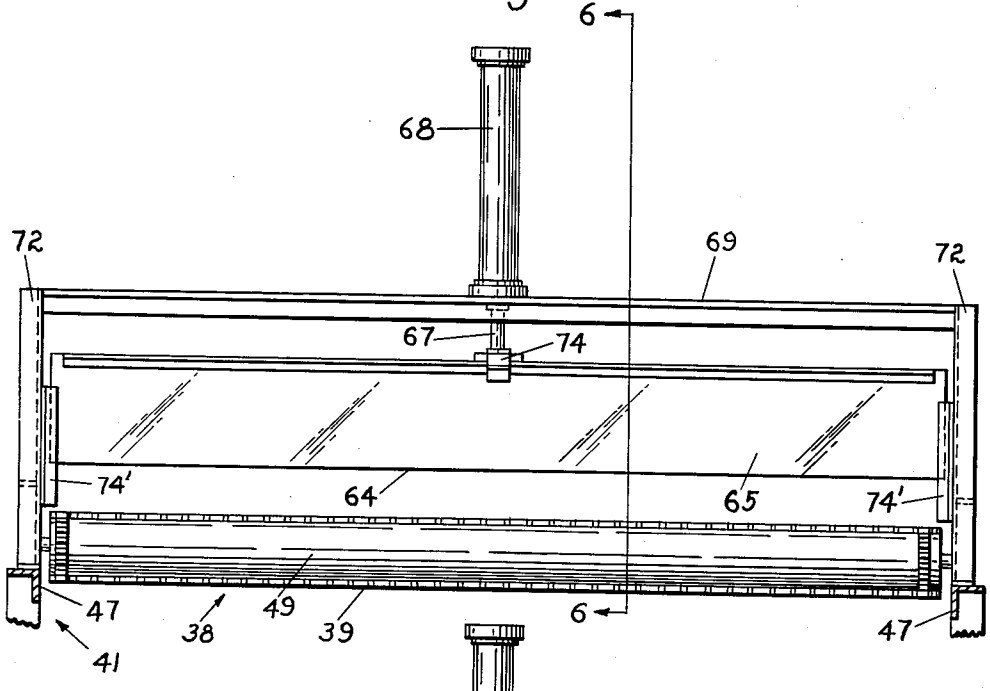
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Nov. 13, 1962 D. LABINO 3,063,887

METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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Fig. 5



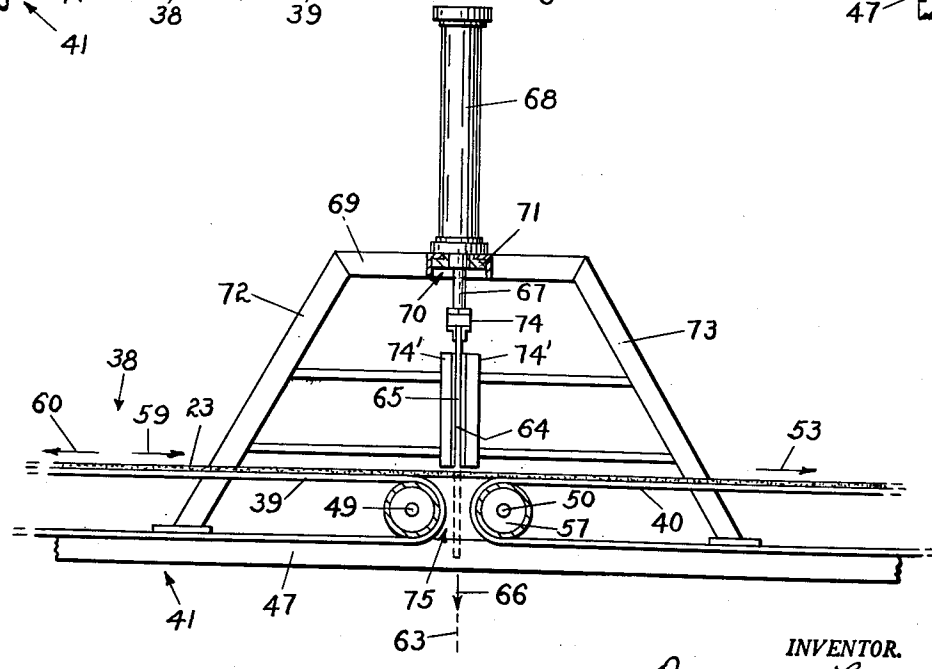


Fig. 6

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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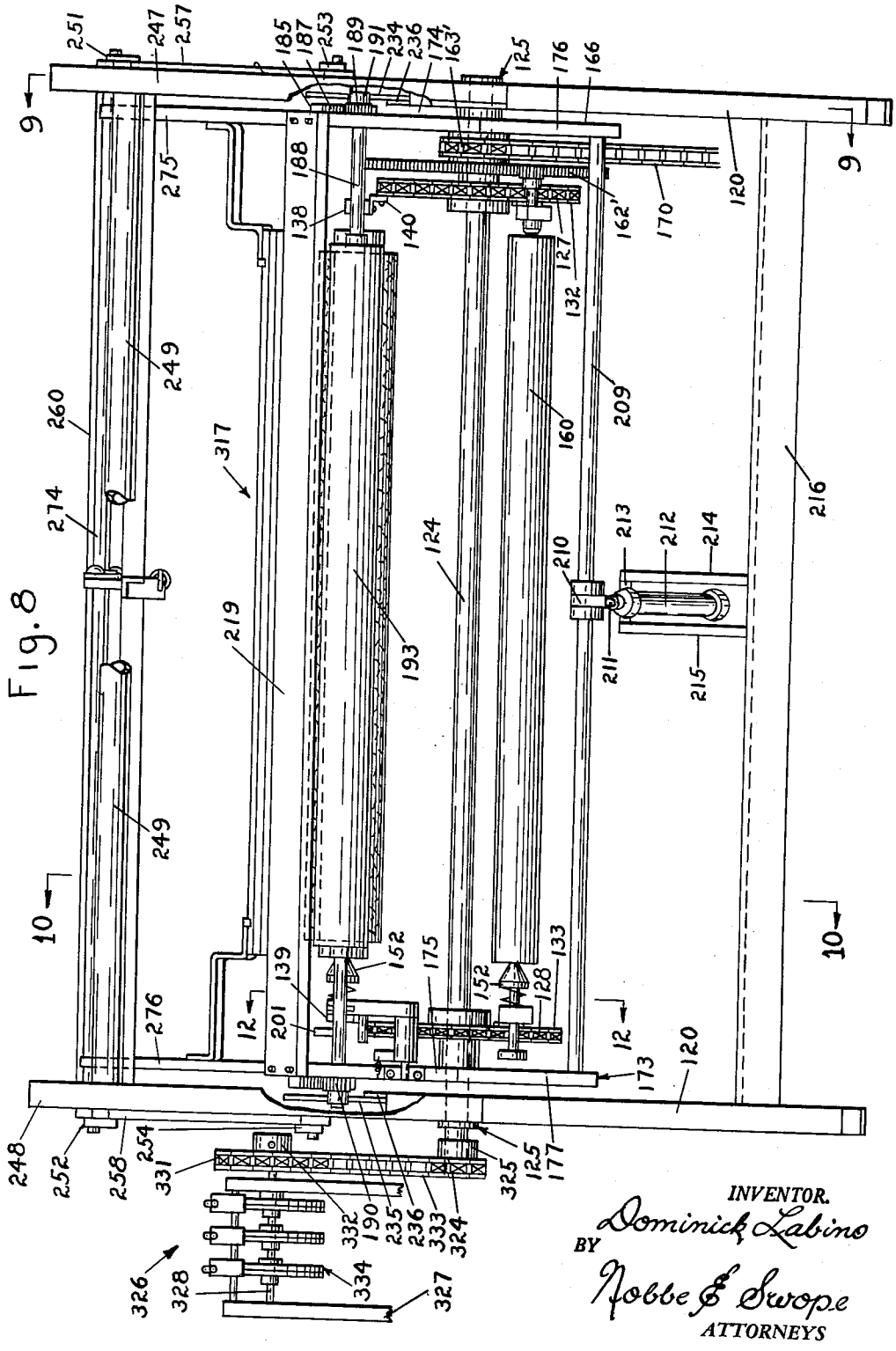


Fig. 8

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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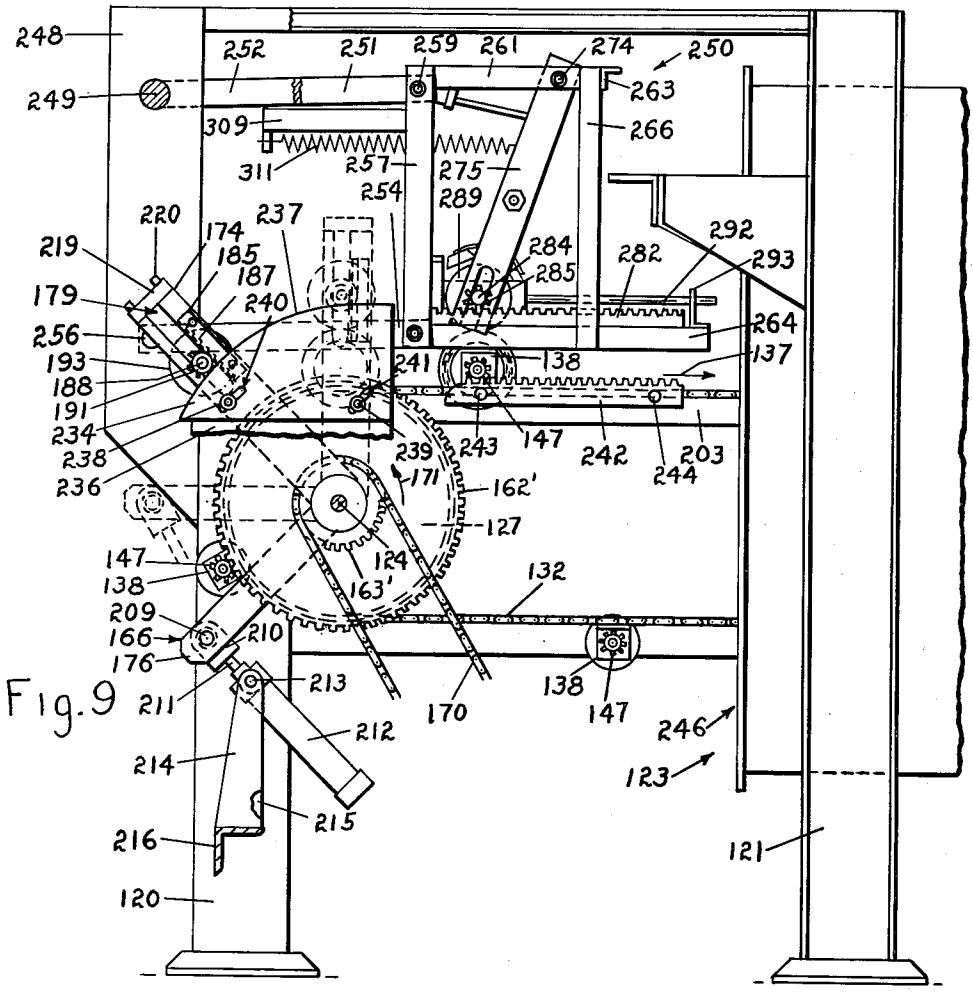


Fig. 9

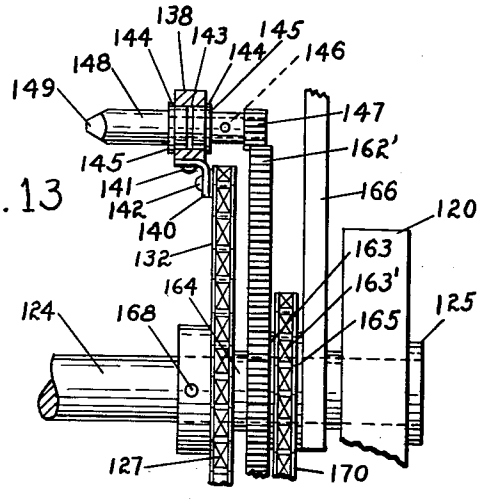


Fig. 13

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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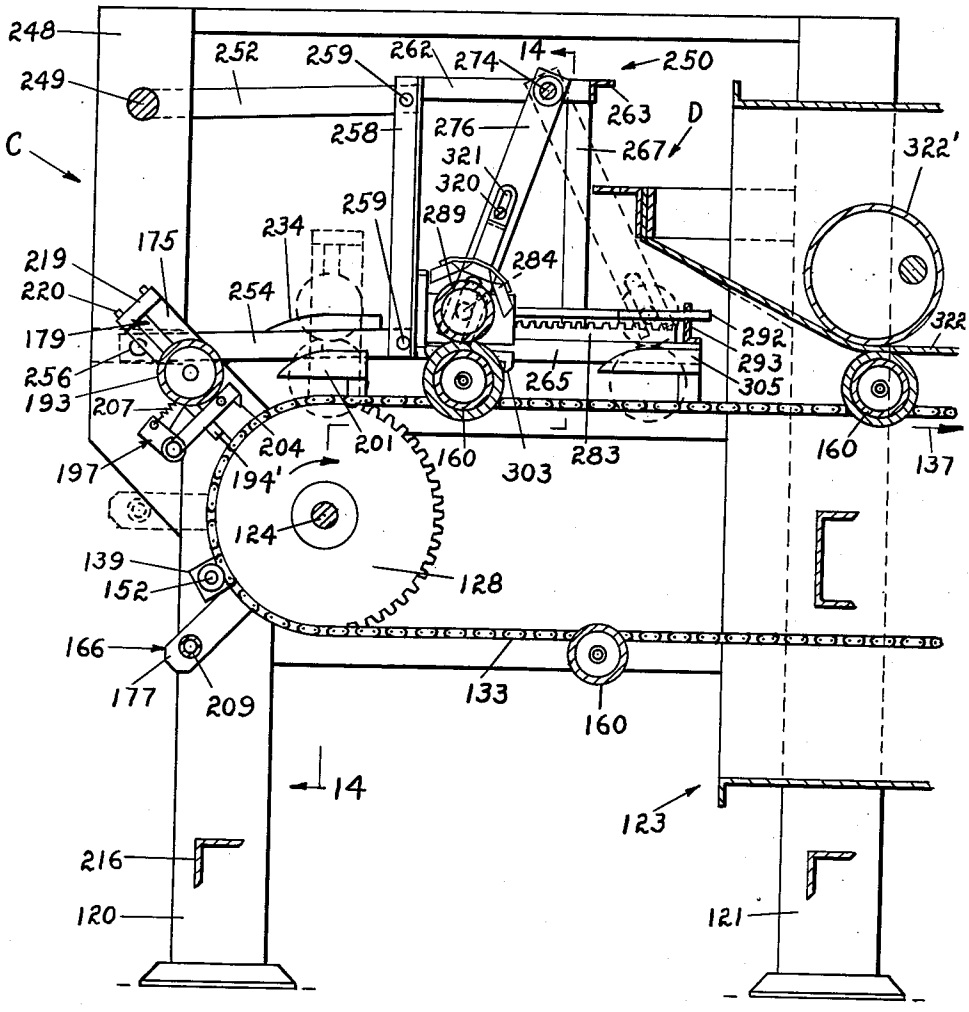


Fig. 10

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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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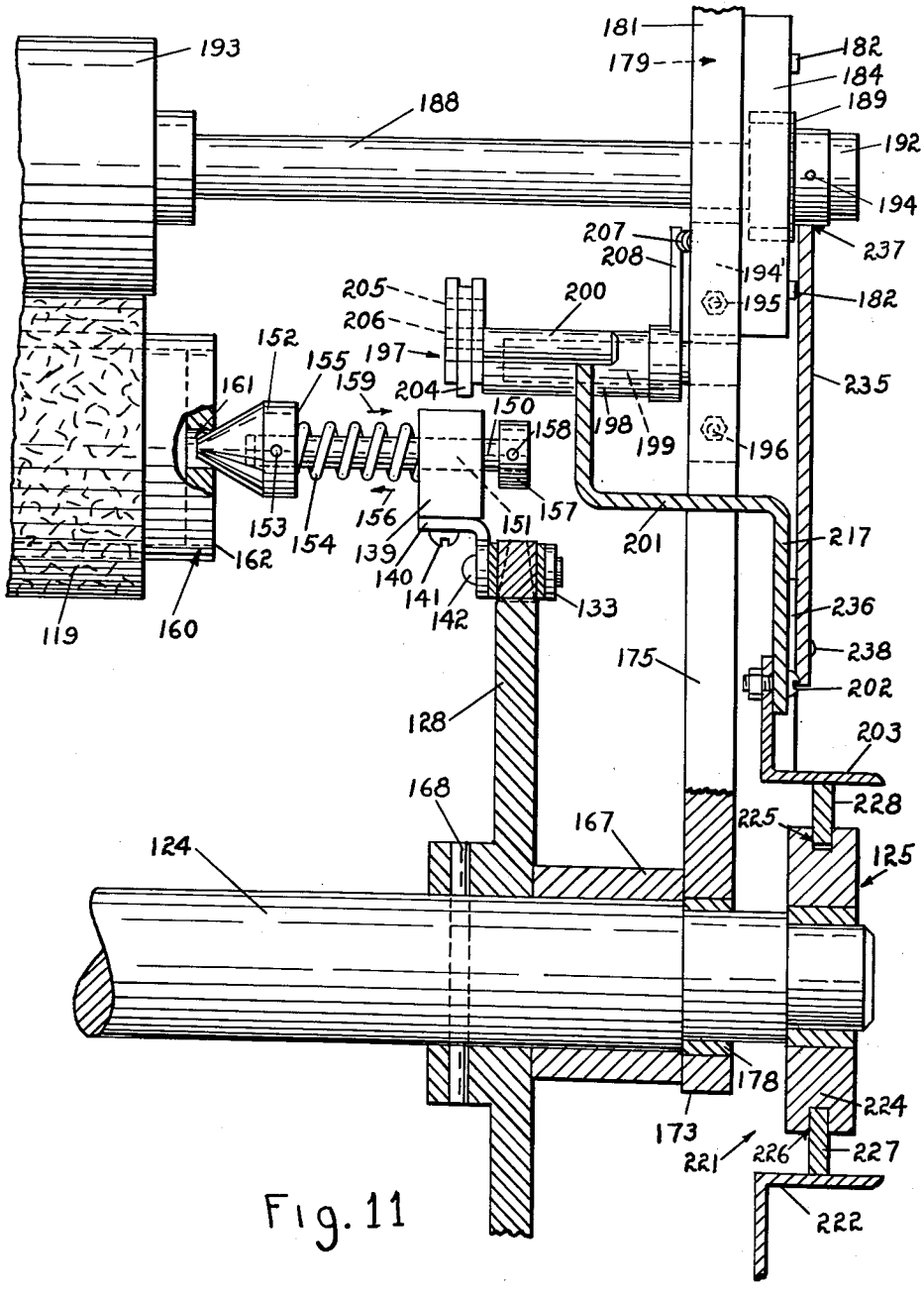


Fig. 11

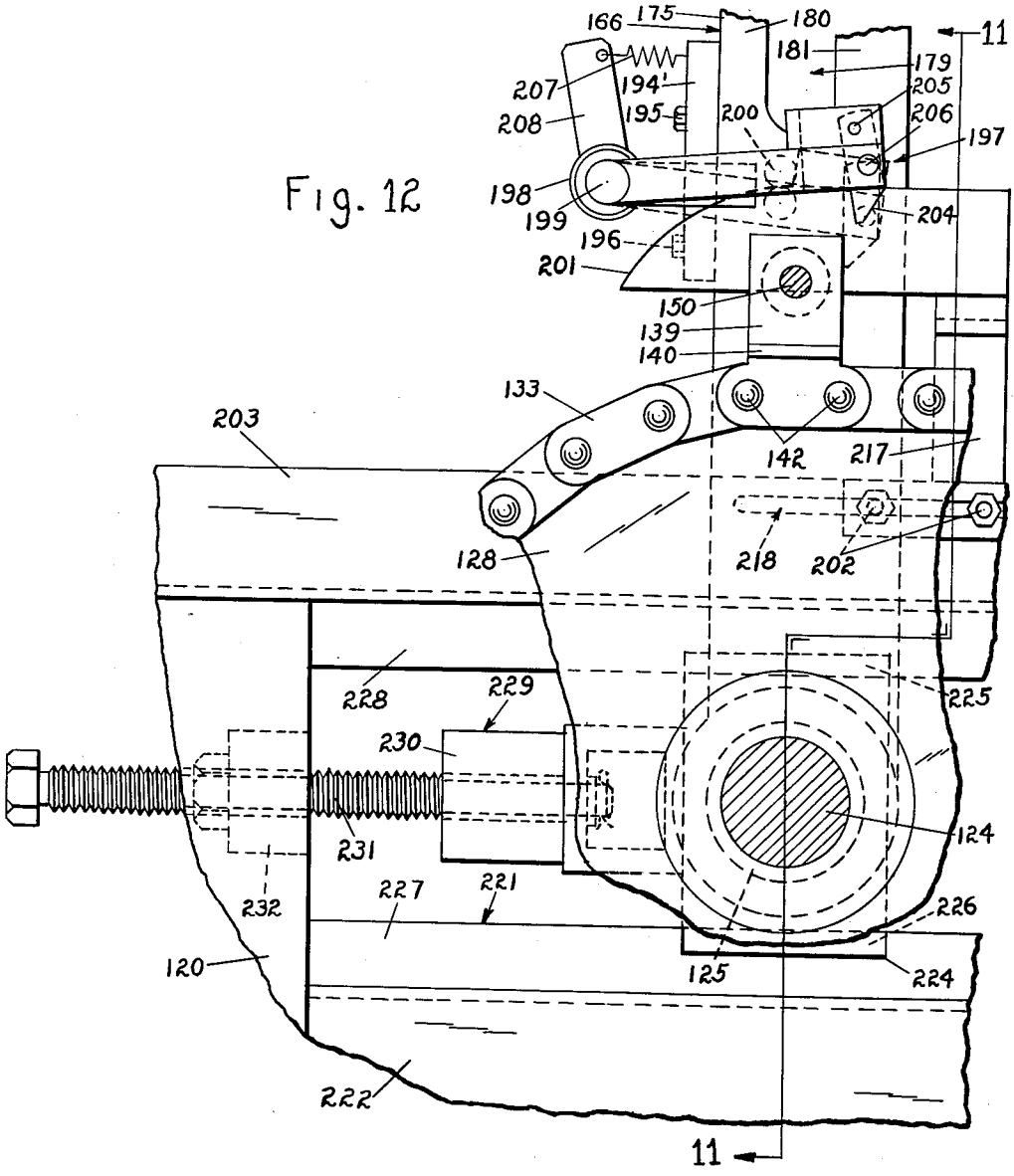
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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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Fig. 12



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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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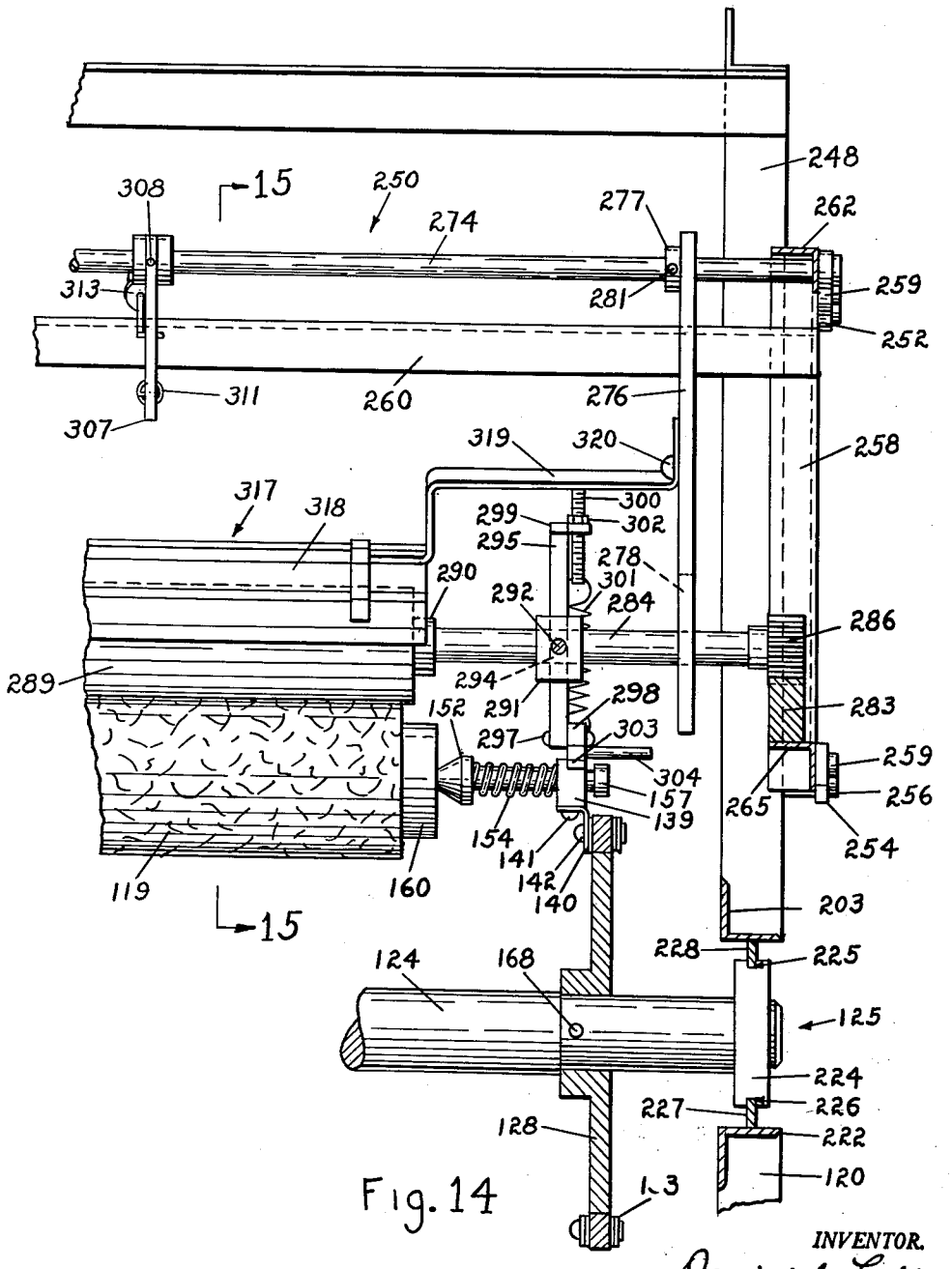


Fig. 14

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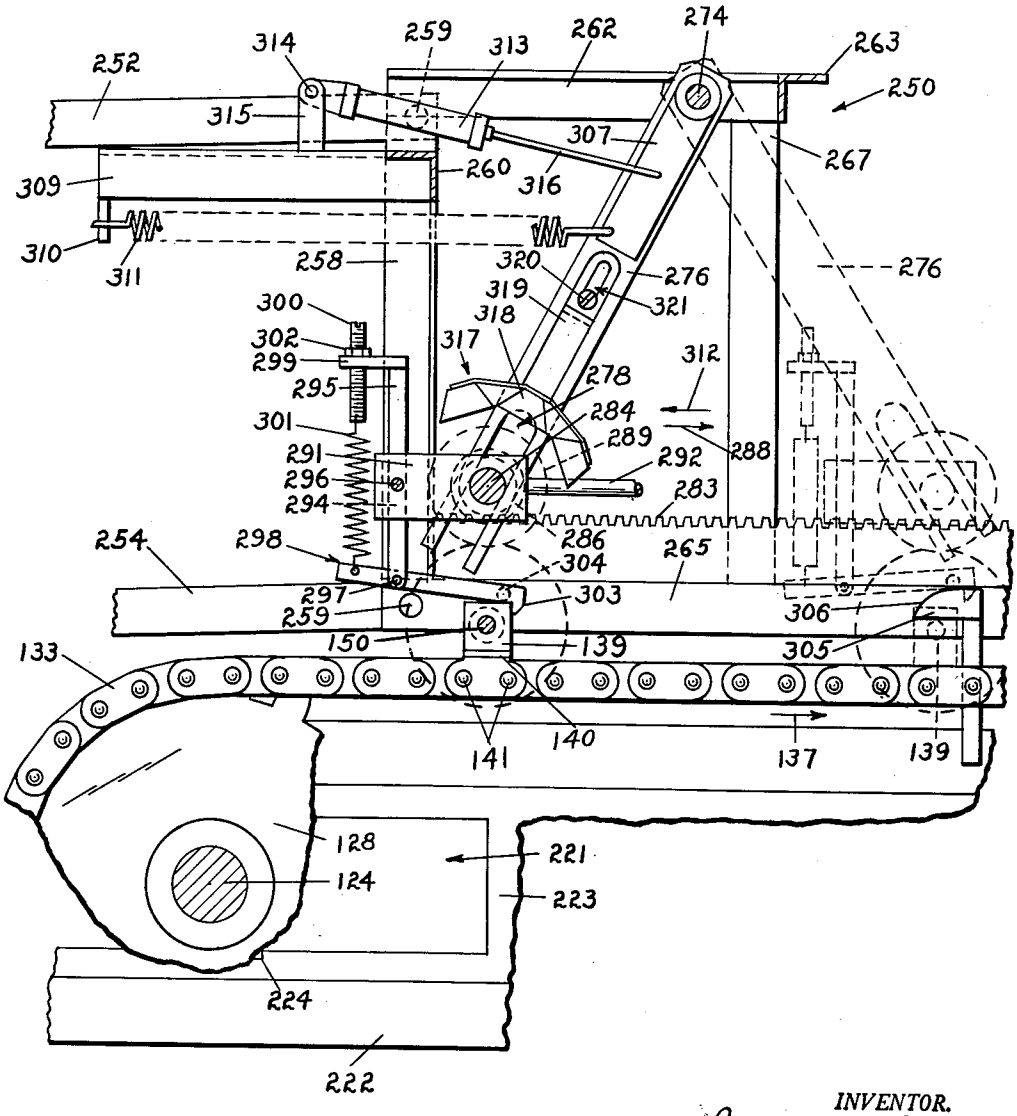
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METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

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Fig. 15



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United States Patent Office

3,063,887

Patented Nov. 13, 1962

3,063,887

METHOD AND APPARATUS FOR FORMING AND COLLECTING FIBERS INTO AN IMPROVED PIPE COVERING

Dominick Labino, Grand Rapids, Ohio, assignor, by mesne assignments, to Johns-Manville Fiber Glass Inc., Cleveland, Ohio, a corporation of Delaware

Filed Mar. 3, 1958, Ser. No. 718,636
6 Claims. (Cl. 156—37)

This invention relates to an improved pipe covering or fibrous casing which is to be utilized for thermal insulation and to a method and apparatus for making the same.

The pipe coverings of the prior art which heretofore have been used as thermal insulators may be said to fall into basically two general classes.

The first class is composed of the type of pipe coverings in which the insulating material is composed either of bulk substances, comprising loosely integrated fibrous or granular material, or flexible mats. These loosely packed or flexible forms are normally held in place by suitable retention means since they themselves do not possess the capability of shape retention. In practice, these flexible forms are either wrapped about or helically wound about a pipe and encased either by sheet metal, metal mesh, plastic or paperboard envelopes or sleeves placed around the material and brought into covering position about the pipe. The second class of materials comprises those which are slightly more rigid and consists both of the fabricated forms and the molded forms. The coverings in this latter class are conventionally made and placed about the pipe in two circumferential halves or semicircular portions. Again, it is conventional to supply an envelope, jacket, or other suitable retention device to secure these molded or fabricated forms into their position covering the pipe.

All of the pipe coverings as discussed are relatively heavy and in addition, these fabricated and molded forms are particularly limited in use by reason of the fact that their inside diameter dimension, which fixedly determines the size and shape of the pipe which may be insulated, is not easily changed. These and other basic limitations of the molded type of pipe covering are discussed in detail in the patent to Stephens, No. 2,778,759, dated January 22, 1957, wherein to overcome these limitations an improved pipe covering is described which is illustrated in FIG. 1 herein. It was found that by controlling the diameter and length of the glass fibers forming the fibrous casing within predetermined limits, by controlling the weight of the binder with respect to the weight of the finished product within predetermined limits and by controlling the density to which the product is compressed during the molding thereof, an improved thermal pipe insulation was obtainable.

However, the demands of present commercial practice presents many additional factors which cannot be met either by the apparatus or the methods of the presently known art.

When using an apparatus which depends upon molds to form the pipe covering, it is necessary to roll the fibrous mat about a mandrel and insert the mandrel within a mold formed of two halves. The mold is then closed about this mat on the mandrel and one end of the mold is sealed off while gases, from a suitable source such as a gas fired oven, are fed into the interior of the mandrel. These hot gases set the resin, drive off moisture and cure the covering. Whether or not the formed uncured cylindrical mat is cured by means of a perforated mandrel or is inserted into an appropriate oven would be a matter of choice. However, by the use of a mold to form the configuration of the cylindrical pipe covering, a number of important limitations both as to manufacturing tolerances and manufacturing flexibility are introduced.

In using a mold there is no way in which the critical dimensions of the thermal insulation may be varied without the substitution of a complete new set of molds for a selected size of pipe. This would mean that should there be desired a variation in either the inside diameter of the pipe covering, in the wall thickness of the covering or in the outside diameter of the pipe covering, there would have to be a complete substitution of at least a new size mold and in some instances both a new mold and a new mandrel. In present commercial practices in the manufacture of pipe coverings, there is an ever increasing demand for variations of all the three dimensions of the pipe covering, both its inside dimension, its wall thickness and its outside dimension. Accordingly, the mold method of manufacturing thermal pipe coverings by reason of necessity of replacement of molds and a requirement of keeping an extensive supply of mold sizes available, in combination with varying sized mandrels, has presented a most cumbersome and even burdensome storage problem that necessarily has had a detrimental effect on the flexible quantity and quality of the resultant product.

Additionally, a mold when clamped upon a fibrous mat or wrapped about a mandrel, at the mating point of the two cylindrical halves, will form in the fibrous mat a longitudinal ridge, particularly since the fitting tolerances of the two portions or halves of the mold would be almost impossible to maintain in perfect fit over a prolonged period of time with extensive use. These irregularities in the outer surface of the mat would have to be subsequently removed by either grinding or other treatment in order to present a smooth outer peripheral surface.

When using a mold and mandrel combination, it has been found extremely difficult to maintain proper alignment between the absolute center of the mandrel and the absolute center of the molds along the entire longitudinal center line of the mandrel. This centering between the mold and the mandrel is extremely important as it is essential that the pipe covering, when formed, present equal insulating resistance to a loss of heat of its enclosed pipe in all directions. It is well understood that a pipe covering, for example, which had a variable wall thickness, would present a greater resistance to the loss of heat through those portions of the covering having the greatest wall thickness. These relatively thicker wall portions would be formed when the material contained within the mold was subjected to unequal pressures either through the medium of a mold forming device or by reason of the fact that the mold was not centered with respect to the longitudinal center line of the mandrel. No matter what the cause of the formation of the thicker portions, it would naturally follow that the presence of areas of greater wall thickness would mean the introduction of walled areas of a reduced thickness in another portion of the covering.

By having walled areas of varying thicknesses it would be imposisble to secure equal insulaing resistance about all portions of the pipe covering and the resulting imperfections would prove a serious limitation in the commercial application of the product. Further, if the longitudinal center lines of the mold and the mandrel were not coincident, variations in the shape and size of the inside diameter of the opening through the pipe covering would occur throughout the length of the covering resulting in something less than a perfect fit for the covering about a pipe. This would be true although the covering is to some extent flexible, because the covering must neces-

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sarily have certain properties of substantially rigid form. These variations in the inner diameter, particularly in the treament of the smaller pipe sizes, have proven to be an important limitation in the pipe coverings of the prior art.

It is highly desirable, therefore, in the manufacture of the pipe coverings to secure, as closely as possible, uniformity in the wall thickness of the pipe and uniformity of the inside diameter of the pipe covering as well as the hereinbefore discussed uniformity of the outside dimension and constant density. By controlling all these factors a pipe covering will result that is perfectly even in its dimensional form. All of the dimensions will be symmetrically formed about the center axis of the pipe covering and the wall thickness will be constant thereby forming a concentric ring, of equal thickness throughout, about a longitudinal line through the center of the opening in the covering. Therefore, constant pipe covering characteristics may be selected that will remain substantially the same over a considerable period of prolonged operations but yet are alterable if desired.

It is an important object of the present invention to form a fibrous casing under controlled conditions of temperature and pressure.

Another object of this invention is to form a fibrous covering from a fibrous mat impregnated with an unactivated binder and to activate the binder incrementally.

Another object of the invention is to form a fibrous casing from a fibrous mat impregnated with an unactivated binder and to incrementally activate the binder by initially activating the binder in the peripheral surface area of the casing to form an outer shell about the casing and subsequently to activate the remaining binder in the casing.

Another object of the invention is to direct pressure against the peripheral surface area simultaneously when activating the binder.

Another object of the invention is to direct pressure against the peripheral surface area of the casing while activating the remaining binder in the casing.

Another object of the invention is to direct pressure to the fibrous mat while wrapping the mat about a rotating mandrel to initially blend the fibrous mat throughout the length of the casing.

It is yet another object of the present invention to direct pressure to the peripheral surface of the casing after it is wrapped before activating the binder to smooth the peripheral surface of the casing.

It is still another object of the present invention to rotate the fibrous casing wrapped about the mandrel by rotating the mandrel while activating the binder on the peripheral surface area of the casing.

It is further another object of the present invention to rotate the fibrous casing by rotating the mandrel while activating the binder throughout the fibrous mat.

It is accordingly an object of the present invention to provide an improved apparatus to form a fibrous casing or pipe covering wherein all the thickness dimensions of the pipe coverings are selectively adjustable with a minimum of operational delay.

It is another object of the present invention to provide a pipe covering machine wherein the operation between all elements is timed so that the machine is continuous and automatic whereby the production of the pipe coverings is uninterrupted.

It is yet another object of the present invention to provide a method of producing a pipe covering wherein the percentage of binder material is maintained at a minimum within the fibrous mat.

It is yet another object of the invention to provide a pipe covering wherein the density of the homogeneous fibers of the mat will be maintained uniform despite any change in either inside diameter, outside diameter or wall thickness of the resilient covering.

Other objects and advantages of the invention will

become more apparent during the course of the following description when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

FIG. 1 is a perspective view of a fibrous casing made according to the method and apparatus of the present invention;

FIG. 2 is a side elevation of the interconnected element forming the complete apparatus;

FIG. 3 is an enlarged side elevation partly in section and with parts broken away of the conveyor reversing mechanism as illustrated in FIG. 2;

FIG. 4 is a sectional view with parts broken away taken along the line 4—4 of FIG. 3;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 2;

FIG. 6 is a sectional view taken along the line 6—6 of FIG. 5;

FIG. 7 is a side elevation of the wrapping, ironing and binder activating portions of the apparatus as illustrated in FIG. 2;

FIG. 8 is a sectional view with parts broken away taken along the line 8—8 of FIG. 2;

FIG. 9 is a sectional view taken along the line 9—9 of FIG. 8;

FIG. 10 is a sectional view taken along the line 10—10 of FIG. 8;

FIG. 11 is a sectional view taken along the line 11—11 of FIG. 12;

FIG. 12 is a sectional view with parts broken away taken along the line 12—12 of FIG. 8;

FIG. 13 is an enlarged fragmentary detail view with parts broken away and parts shown in section of the gear arrangement on a drive shaft operating the mandrel rotating shaft;

FIG. 14 is a sectional view taken along the line 14—14 of FIG. 10 with parts broken away;

FIG. 15 is an enlarged fragmentary sectional view with parts broken away taken along the line 15—15 of FIG. 14;

FIG. 16 is an enlarged elevation view of the timing mechanism as illustrated in the lefthand portion of FIG. 8;

FIG. 17 is an enlarged sectional view taken along the line 17—17 of FIG. 16; and

FIG. 18 is a schematic wiring diagram of the electrical circuit of the timing mechanism.

In general, this invention contemplates forming a thermal pipe insulation fibrous casing or conduit from a mat of glass fibers, bonded with a binder, which may be used for thermal pipe insulation and wherein the binder is activated to fixedly form the casing after the mat is first formed into a desired shape. The pipe insulations which are formed from this invention are normally cylindrical and are easily controlled as to quality standards by reason of the interdependence of the apparatus employed with the method of production to allow full maximum control of these quality standards and at the same time provide maximum selection of desired variations in production tolerances. Thus, important maximum flexibility of these tolerances is secured so that the product may be produced to meet the ever changing quantity demands for different sizes and shapes of covering without losing the desirable product quality standards or production time. In the description which will hereinafter follow, the apparatus providing the objects of this invention will be presented in accordance with a number of the stations or stages which are indicated by portions of the machine as enumerated in FIG. 2. Generally and without, at this point, presenting a detailed description of either the apparatus of the process, these stages comprise the following: Station A, where primary fibers are blasted to produce secondary fibers which fall upon an endless belt and are simultaneously sprayed with a binding material to form

a continuous and endless fiber mat; station B, where the endless mat formed of secondary fibers, in combination with the thermosetting binder or resin, is sheared into the desired lengths to be later employed to form the pipe covering of desired dimensions; station C, where these lengths of the fibrous mats are wrapped about a mandrel to form the uncured cylindrical casing of the desired dimensions; station D, where the uncured mat, in cylindrical form, wound about the mandrel passes through a first or initial stage of incremental binder activation, to activate the binder in at least the peripheral surface area of the casing; station E, where the casing having a portion in which the binder has been activated to bond the fibers in that portion to one another passes through a second stage of incremental binder activation to activate the remaining binder in the casing; station F, where the casing is positioned for unloading and conveying for further processing.

The pipe covering, as it is formed moving from stations A to F inclusive of the apparatus, undergoes a change from the primary strands of glass fibers at station A to the thermal insulation pipe covering, cylindrical in form, wherein all the fibers are bonded to one another which is delivered at station F. This apparatus is continuous and uninterrupted in its operation so that if the process of the present invention is practiced on a never ending continuous operating belt of materials, the production of the pipe coverings will likewise be continuous.

Turning now to a description of the apparatus comprising station A where the primary fibers are blasted to produce secondary fibers and sprayed with the binder to form a fiber mat and referring particularly to FIG. 2, there is shown a glass melting pot **10** of clay, platinum or any suitable alloy for the heating and melting of glass marbles. The pot is circular and has a conventional aperture plate at its lower extremity provided with a plurality of concentrically arranged apertures adjacent the periphery thereof.

A plurality of streams of molten glass are attenuated from pot **10** into primary filaments **11** passing between and drawn by the coacting rollers **12, 13**, it being understood that suitable drive means are provided for these rollers **12, 13**. The rollers **12** and **13** draw the streams or primary strands **11** of glass fiber to the desired size and advance them at the desired rate, through suitable guide means **14**, the extremities of the filaments **11** being directed by the guide means into the blast emanating from the burner **15**. A combustible gas mixture is fed through the burner **15** to create a high speed blast of intense heat capable of melting and attenuating the primary filaments **11** to very fine fibers at a high rate. As the filaments **11** are fed into the blast, they are rendered fluid and drawn out by the force of the blast into very fine glass fibers.

It is well understood that the method and apparatus for making these glass fibers is shown in United States Patents No. 2,663,906, issued on December 29, 1953, to Dominick Labino, and No. 2,814,657, issued on November 26, 1957, to Dominick Labino. The indicated sizes of the fibers, attenuated by the gaseous blast, may be varied in many ways. The fibers in the instant case may be in the diameter range of between 1½ microns to 4 microns and preferably between 2½ and 3 microns.

The fibers are directed by the blast to a suitable collecting means **16**. These latter means include a continuous belt **17** or conveyor of wire mesh or other foraminous material capable of collecting and transporting the fibers directed thereon by the gaseous blast emitted from burner **15**. The belt is supported along its pathway by a supporting framework indicated generally by **18**. This framework **18** consists of a plurality of pairs of upright angle irons **19** and **20**. Only one angle iron from each pair appears at one side of the conveyor as shown in FIG. 2, it being understood that identical uprights appear on both sides of the conveyor path. These uprights may be innterconnected by suitable pairs of interconnecting cross angle irons **21** (only one shown) as desired for structural support.

The continuous belt **17** travels over a suction box **22** suitably mounted to angle iron **19** to cause a flow of air through the conveyor to aid in the deposition of the fibers, in the form of a mat **23**, onto the conveyor **17**. A series of binder applicators or nozzles **24**, only one shown, may be disposed in the position as shown in FIG. 2 running transversely of the blast stream in order to coat the blasted fibers with a binder as they are being deposited or collected upon the endless conveyor **17**. The binder or resin content as broadly recited is 5% to 14% of the mat weight as determined by ignition loss and is preferably about 10% or slightly below 10%. Additional nozzles **25** directing a fine spray of water are positioned as shown in FIG. 2 and when the conditions of humidity make it desirable may further introduce a fine spray of water or other liquid to the glass fibers as they are being collected to form the mat **23**.

The source of the compression for the nozzles **24, 25** is not shown, it being understood that both the binder through nozzles **24** and water through nozzle **25** would be introduced under an air jet, or stream, provided with suitable regulating valves or other controls. As seen in FIG. 2, the conveyor belt **17** follows substantially a triangular path so that the mat **23** formed upon the long side **26** of the belt triangle thus formed, is carried up and over the high point of the conveyor and down the hypotenuse side **27** of the belt triangle. Although the conveyor is formed as a triangle it is not intended to limit the invention in any way by this showing as other forms and configurations could be used. It has been found desirable, however, that when the mat is carried towards a subsequent station, in this case station B, that the conveyor side in proximity to the next processing station be sloping as is side **27** of the instant case.

The conveyor belt **17**, in the embodiment shown, is mounted to freely rotatable shafts **28, 29, 30** which are conventionally mounted in journals or brackets affixed to the angle iron bars **19, 20**, hereinbefore described, comprising the framework **18** supporting the belt **17**. A plurality of rollers **31, 32, 33** respectively are keyed or otherwise fixedly mounted to the shafts **28, 29, 30** to support and to drive the belt **17**. Other driving connections such as a gear and chain arrangement could be used instead of the friction rollers **31, 32** and **33** to support and to cause movement of this belt **17** without departing from the spirit of the invention.

A drive motor **34**, resting on the floor of the structure housing the apparatus, is connected by means of a link chain **35** to a sprocket **36** which in the embodiment shown in FIG. 2 is fixed or keyed to shaft **30**. This motor **34** through the chain **35** causes a rotation of shaft **30** and this rotation of shaft **30** through the medium of roller **33** is transmitted to the belt **17** so that belt **17** is driven at a consistent rate of speed in the direction of arrow **37**. The rollers **31** and **32** about shafts **28** and **29**, serve as suitable guide means to maintain the belt in proper alignment relative to the blast burner **15**. The timing of the motor **34** which determines the speed of belt **17** is synchronized with the delivery of the stream of fibrous material from the blast burner **15** so that a continuous fibrous mat **23** is formed and carried by the belt **17** as it moves.

The fibrous mat **23**, formed at station A, is led from the sloping side **27** of the triangle formed by belt **17** up and onto a table conveyor means generally indicated at **38** where it is led into station B. The conveyor means **38** includes two independent conveyor belts **39** and **40** each being formed of a suitable wire mesh or foraminous material which develops friction against the fibrous mat **23** so as to grip the mat and to pull and direct it along its path. At station B, this mat **23** is sheared, by means

to be hereinafter described, into segments of a predetermined length preparatory to its being further conveyed to station C where it is formed upon a mandrel into a cylindrical tube as will later be described.

The shearing at station B in the present invention is performed by a suitable knife edge. As will be hereinafter described, the action of the knife does not sever the mat but rather in cooperation with a reversing conveyor movement tears or rips the material to form a feathered or tapered edge of the segments of the mat as they are separated from the continuous belt of material. At station B, the fibrous mat is placed in tension by two independently driven conveyor belts, which at the moment of the severance of each section, are moving in opposite directions. This conveyor action, creating a tension in the material, in combination with the simultaneous movement of the severing knife, which under positive pressure is directed downwardly, causes a ripping or tearing severance of the material. In this manner, the ends of the segments separated from the continuous belt are not cut along a distinct vertical plane or line forming a smooth slice in the material, but rather the fibrous mat edges are feathered. This novel result is caused by the hereinabove discussed reversible action of the conveyor belts **39** and **40** with respect to each other acting in timed relationship with the cutting tool.

Referring now to FIGS. 2, 3 and 4, the framework **41** for conveyor means **38** includes a plurality of pairs of upright angle iron bars **42** and **43** only one bar from each pair being shown, which supports the conveyor **39** and similar bars **44** and **45** supporting conveyor **40**. These upright pieces are interjoined by a first cross bar **46** connecting them at their lower portions and by a second cross bar **47** extending substantially longitudinally and parallel with respect to the line of conveyor movement but disposed outside of the belts **39**, **40** forming the conveyor path. The belts **39** and **40** are mounted in normal tension by means of freely rotating shafts **48**, **49**, **50** and **51**, two of said shafts supporting each belt. Suitable journal bearings such as that shown at **52**, FIGS. 3 and 4, are mounted to the cross bar **47**, of the conveyor supporting framework, to provide support for the shafts at a point outside of the line of conveyor movement.

The conveyor belt **40** travels constantly in the direction of arrow **53** under the action of a constant speed drive motor **54** which through a suitable chain **55** causes rotation of shaft **51** by driving the shaft **51** through the medium of suitable sprocket **56** fixed to the shaft. Rollers **57** and **58** mounted on the shafts **50**, **51** respectively hold belt **40** in tension and the driving action of motor **54** is transmitted to the conveyor **40** by roller **58**. It is understood that the means of transmitting the drive from the various shafts to the belts is conventional in all respects and since it does not form a part of the present invention, only those portions of the drive believed necessary for a clear understanding of the invention have been and will be herein discussed.

The belt **39** as seen in FIG. 2, independent of the belt **40**, is driven by independent drive means. As will be later described, belt **39** normally moving the direction of arrow **59**, accelerates in the direction of arrow **59** and also reverses to move in the direction of arrow **60**, all in timed relationship to the action of the knife shearing means also to be later described.

The mat **23**, as it is delivered from the downward sloping side **27** of the belt **17**, forms a loop at **61** and is carried upwardly to come to rest upon the surface of conveyor belt **39** moving initially in the direction of arrow **59**. At this time, both the belts **39** and **40** are moving in the same direction, that is in the direction of arrows **59** and **53** respectively. When the lead edge **62** of mat **23** has moved under and beyond the vertical line **63**, appearing in dot-dash (FIG. 6), that extends directly downwardly from the lower edge **64** of the knife blade **65**, the knife blade **65** will be caused to be directed downward in the direction of arrow **66** (FIG. 6) along the line **63** at the proper moment by adjustment of suitable timing means that will be later described.

Referring now to FIGS. 2, 5 and 6, the knife blade **65** is mounted at the lower extremity of an air piston rod **67** and receives its downward force from the double acting air cylinder **68** when compressed air is allowed to enter the cylinder **68**. When the timing means directs air into cylinder **68**, piston **67** is forced downward in the direction of the arrow **66** forcing the lower edge of knife **64** to extend below the substantially horizontal plane of mat **23**. Referring to FIGS. 5 and 6, it is seen that the knife blade **65** extends transversely of the mat **23** and is supported so as to be substantially perpendicular to the path of the belts **39**, **40** for the full width of the mat **23**. Air cylinder **68** is affixed to cross plate **69** by welding or other suitable means and an opening **70** is provided substantially central of plate **69** to coincide with the axis of movement of piston rod **67** to allow freedom of travel for the piston rod **67** both upwardly and downwardly. A shoulder bearing **71** surrounds the opening and may be conventionally fitted into opening **70** either by friction fit, a flange arrangement or welding It being well understood that any suitable means for mounting the cylinder **68**, with its piston rod **67**, on plate **69** may be used without departing from the spirit of this invention. Plate **69**, be means of conventional angle irons **72** and **73**, is supported above the plane of the conveyors and angle irons **72** and **73** are conventionally welded, one end to the plate **69** and the other end to the upper cross bar **47** of the supporting framework **41**. As seen in FIG. 5, when the piston rod **67** is drawn into air cylinder **68**, the lower edge **64** of the knife blade **65** is supported above and out of contact from the fibrous mat **23** passing across conveyors **39** and **40**. Any conventional brackets **74** or welding may be used to fixedly mount the piston rod **67** to the knife **65** and if desired, guide means **74'** laying closely adjacent the terminal face portions of the knife may be utilized to maintain the knife blade in its proper position perpendicular to the plane of the conveyors.

Referring again to FIGS. 2 and 6, it is seen that the belts **39** and **40** do not come into flush contact with each other but since shafts **49** and **50** are spread apart, an opening **75** directly below the downward acting knife **65** is formed. It is therefore seen that when the lower edge **64** of the knife **65** is forced downwardly in the direction of arrow **66**, the knife **65** passes between the belts **39**, **40** and through opening **75** and does not contact either the belt **39** or the belt **40**.

When air cylinder **68** is activated through timing means to be later described to open the air cylinder valve (not shown) to direct compressed air into cylinder **68**, the knife **65** will be forced downward to pass through the horizontal plane of the fibrous mat **23** between the two belts **39**, **40** of the conveyor **38** at station B. At the time that the knife blade **65** is being forced downward, another portion of the timing means causes a reversal of direction of movement of the conveyor belt **39**.

As was hereinabove described, conveyor **39** initially moves in the direction of arrow **59** forcing the fibrous mat **23** under and past the vertical plane determined by the line **63** extending below knife **65**. When the knife descends under action of the air cylinder **68** at that same instant, the timing means will cause the conveyor **39** to reverse direction so that it will then move in the direction of arrow **60** FIGS. 2 and 6. This places the mat in tension before the blade **65** engages the mat **23** since one portion of the mat **23** is now acted upon by the conveyor belt **40** moving in the direction of arrow **53** while the other portion of the mat is acted upon by the belt **39** moving in the opposite direction as indicated by arrow **60**. Therefore, when the knife **65** is forced downwards to sever or tear the mat **23** the mat **23** will be stretched in tension by this counterdirectional tractive force. The

knife 65 as it passes through the fiber mat 23 is thereby assisted in severing the mat 23 since the cutting action of the knife 65 will be augmented by the tearing or pulling action of the two belts 39, 40. This combination of downward force by the knife 65 and counterdirectional pulling action of the belts 39, 40 results in the hereinbefore mentioned tapered or feathered lead and trail ends of the severed mat.

When the fiber mat 23 has been severed and the knife 65 raised by positive action of the double acting air cylinder conveyor section 39 will be caused to reverse its direction and will move again in the direction of arrow 59. This allows the subsequent or succeeding portion of the mat 23 to be severed, to be led under the knife blade where it continues its movement in the direction of arrow 53 under the pull of conveyor 40. It is understood that each severed length of the mat 23, as shown in FIG. 2, continus to move in the direction of arrow 53 for further processing at station C under the action of the conveyor section 40 driven at a constant speed by motor 54. In addition to providing for the tapering of the ends, which will be hereinafter described as an advantage of this reversing action, this reversing of the conveyor 39 provides for a separation of the sections of the mat and is also timed, through suitable means to be hereinafter described, with the processing to be accomplished at station C so that the individual mat sections will arrive in proper timed relationship with respect to each other and with respect to the other operating portions of the apparatus so that continued and uninterrupted operation will result. The reversing of conveyor section 39 is likewise timed to the downward stroke of the knife 65 and timed in cycle with the operations of other stations in the apparatus so that each one performs its operation on the mat in timed relationship with all the other sections or stations of the apparatus.

Referring now to FIGS. 2, 3 and 4, there is shown the reversing means 76 which provide for the hereinabove described reversing and accelerating action of conveyor belt 39. A link chain 77 positioned initially as shown in heavy lines, FIG. 3, extends from a sprocket 78 which is fixedly mounted to shaft 30, which is the lower shaft at the right end of the collection means 16. This chain 77 extends up to engage a sprocket 79 which is fixed to the shaft 48. The conveyor 39 is held in tension and travels along a path determined by rollers or sprockets 80, 81, as seen in FIGS. 2 and 3 and is keyed or suitably fixed to shafts 48, 49 respectively. Therefore as the drive motor 34, through the means of shaft 30 hereinbefore described, causes the belt 17 to move in the direction of arrow 37, FIGS. 2 and 3, this drive is transmitted by shaft 30 to the sprocket 78 to belt 77 and through sprocket 79 to rotate the shaft 48 and sprocket 80 to initially move the conveyor 39 in the direction of arrow 59. Referring now to FIGS. 3 and 4, from angle bar 42 of the supporting framework 41 of the conveyor means 38 or from a link extension 82 connected to bar 42 if desired, arms 84, 85 are pivotally mounted by means of a shaft 83. The arms, 84, 85 pivot as a unit being fixed in position relative to shaft 83. A vertical angle brace 86 is mounted by means of two cross braces 87, 88 welded or suitably fastened to upright angle extension iron 82, to position journals 89, 90 (FIG. 4) that hold shaft 83 for rotation. At the outer extremity of the arm 84 is a gear 91 mounted by means of a pin or stud 92 so as to be freely rotatable. The teeth of gear 91 engage the links of chain 77 on the outer surface of the periphery so that as the chain 77 moves in the direction of arrow 93 (FIG. 3), the gear 91 rotates in a counterclockwise direction as viewed in FIG. 3, i.e. in the direction of arrow 94. At another portion of the frame bar extension 82 is mounted an arm 95 by means of a shaft 96. This shaft 96 is supported from journals 97, 98 in the same manner as shaft 83 is supported by journals 89, 90. Arm 95 extends downwardly and at its extremity has a gear 99 similar to the aforementioned gear 91, mounted for rotation about pin 100. The teeth of gear 99 engage the belt or chain 77 on the inside at its periphery. A pair of bars 101, 102 welded to the angle iron 88 are provided to receive a shaft 103 which pivotably supports a double acting air cylinder 104. A spring 105 is fastened between the extremity of arm 95 and a cross brace 46 of the framework as shown in FIG. 4, so that a constant pressure in the direction of arrow 106 (FIG. 3) is applied. This pressure causes or holds the arm 95 in the heavy line position as shown in FIG. 3 and in the absence of any other force being applied will hold the belt 77 essentially in its heavy line position so that the arms 84, 85 will be held in heavy line position as shown in FIG. 3. In this position the air cylinder 104 has been activated so that the piston rod 107 is fully extended. When the knife blade 65 as hereinbefore described is forced downward, the timing means will activate air cylinder 104 to sharply force the plunger 107 to move downward in the direction of arrow 108. Piston rod 107 having a bifurcated end 109 is fixedly connected by stud 110 to the extremity of arm 85 and forces arm 85 to suddenly move from its heavy line position of FIG. 3 to the dotted lin position of FIG. 3. Since arm 85 is operably engaged to arm 84, by common shaft 83, the arm 84 will likewise be drawn downward to its dotted line position as shown in FIG. 3. When this downward force is applied to the arm 84 it causes chain 77 to be moved from its heavy line position to the dotted line position of FIG. 3. Since the chain is of a predetermined length when this upper portion of the chain is pulled down by arm 84 the lower portion of the chain 77 will be pulled upwards to move from its heavy line position to the dotted line position as shown in FIG. 3. The resultant force of the action hereinabove described is sufficient to overcome the tension in spring 105 and the arm 95 pivoting about the shaft 96 will be raised to its dotted position as chain 77 is raised. At this time the cylinder 104 pivots slightly from its full line position to its dotted line position and also at this moment since the chain 77 is moving at a constant speed in the direction of arrow 93, this change in the position of the chain 77 means that the chain 77 will travel a longer distance from the sprocket 78 to the sprocket 79 and a shorter return distance. This radical change in the distance travelled by chain 77 as it moves from sprocket 78 to sprocket 79 increasing the distance of the upper portion of travel while correspondingly reducing the distance of the lower portion of travel, causes a reversal of conveyor 39. This results as sprocket 79 will not turn clockwise to force conveyor 39 to move in the direction of arrow 59 but sprocket 79 will turn briefly counterclockwise and hence will cause the conveyor 39 to move in the direction of arrow 60. When the chain 77 has finished its movement and has reached the dotted position of FIG. 3, the chain 77 will reverse the above action and conveyor 39 will again be driven in the direction of arrow 59.

When the knife blade 65 has severed the mat the timing means to be hereinafter described causes activation of air cylinder 68 to raise the lower edge 64 of blade 65 from a position below the horizontal plane of mat 23 to its horizontal position as shown in heavy lines in FIGS. 2, 5 and 6. When the knife is raised, the conveyor section 39 as hereinbefore described will have been reversed so that the mat on the left side of the blade as viewed in FIG. 6 will have been pulled away from the knife blade 65. Since the conveyor 40 has constantly moved in the direction of arrow 53 the mat 23 will have pulled away from both sides of the knife and the knife will be free to raise without carrying with it the ends of the severed mat that, being impregnated with a binder, is tacky. This has been found to be most important as

the damp, uncured fibrous mat has a tendency to adhere to a metallic surface and if it were not pulled away from from the knife blade, it would tend to follow the blade as it was lifted upward.

The timing of the reversing means **76** is such that a return of the direction of movement of conveyor **39** to its original direction as shown by arrow **59** will take place just after the timing means has elevated knife blade **65**. When a sufficient period of time has elapsed so that knife **65** has cleared above mat **23**, the timing means will cause a second activation of the cylinder **104**. When this occurs, chain **77** is returned to its full line position as the downward force exerted by the piston **107** in the direction of arrow **108** is released. Piston **107** will actually be raised or thrust in the direction of arrow **111** so that all parts slowly return from their dotted line position in FIG. 3 to their full line position in FIG. 3. The spring **105** which was extended or stretched when the arm **95** moved from its heavy line position to its dotted position, now pulls downwardly on arm **95** to supply the positive action on chain **77** to return it and all connected parts to their original heavy line position as shown in FIG. 3. When the above action takes place, it is seen that an effect opposite to the aforementioned action, which caused the reversal of sprocket **79**, will be exerted on sprocket **79** as the distance of travel of the lower section of chain **77** is now increased while the distance of travel of the upper section of chain **77** is being diminished. Therefore, sprocket **79** will rotate at a slightly greater speed, than normally developed by chain **77**, as the chain is moving to return to its full line position and this acceleration of sprocket **79** will continue until the chain **77** returns to its extended full line position. The result of this acceleration means that the conveyor section **39** will be travelling at a slightly greater speed in the direction of arrow **59** than will the conveyor section **40** by travelling in the direction of arrow **53** and this causes a bunching or slight overlapping of the material on the conveyor **40** onto itself. However, this bunching or overlapping quickly ceases and the mat returns to an even and normally horizontal flow across conveyors **39**, **40** when the chain **77** returns to its normal full line position. This overlapping of mat **23** onto itself is a natural consequence and balances out for the slight reversal of the movement of conveyor belt **39** so that the total volume movement of the fibrous mat **23** will remain constant from the forming station A to the shearing station B over a given operating period. If this acceleration and overlapping were not present then by constantly reversing the direction of the conveyor section **39** the size of loop **61** would continue to grow and eventually the size of loop **61** would become undesirably excessive.

Therefore by the compensating reversing and accelerating action of the conveyor section **39**, the lost volume flow of the mat **23** caused by constant cyclic reversal of conveyor **39** is regained by brief subsequent acceleration of belt **39** to balance the reversal and the mat **23** therefore will move continuously and evenly from the forming section A through the shearing section B.

As the fiber mat **23** passes from the shearing station B, the conveyor **40** moves the severed sections to station C. Referring to FIG. 2 it is seen that an additional conveyor belt **112**, supported between rollers **113** and **114** keyed on shafts **115**, **116** respectively is driven by a belt or chain **117** extending from a sprocket **118** on shaft **115** to sprocket **56** on shaft **51** and carries segment **119** to station C. If desired, rather than using an additional conveyor, the conveyor **40** could be extended towards station C so as to include that portion of the conveying system supplied in FIG. 2 by the additional conveyor **112**.

At station C the individual segments **119** having been sheared from the continuous fiber mat **23** are wrapped about a mandrel. Each segments movement is timed so

as to arrive at station C synchronized in cycle with the means to be now described by which each segment of the mat is wrapped about a mandrel. Referring now to FIGS. 7 through 15 inclusive, there is supported upon upright angle irons **120**, **121** and **122** the apparatus for wrapping the fibers and also the baking oven **123** where activation of the binder occurs. As was the case in stations A and B only one of each pair of supporting uprights has been shown, it being understood that a complimentary identical upright of each pair is positioned on each side of the conveyor path. This is shown in FIG. 8 where both supports **120** are visible. A shaft **124** is supported in journal bearings **125** to extend between the opposed uprights **120**. Mounted to this shaft **124** and keyed thereto at opposite ends, outside the path of the fiber material by suitable means, is a pair of sprockets **127**, **128**. Referring to FIG. 2, a second pair of opposed sprockets **129**, **130** are mounted at station F on a shaft **131**. A pair of link chains **132**, **133** respectively, are supported in tension by means to be hereinafter described, to travel in a path defined by sprockets **127**, **128** and **129**, **130**. The sprockets **129**, **130** at station F are mounted on shaft **131** in a manner similar to sprockets at **127**, **128** of station C, i.e. between opposed bars **122** of the framework of the apparatus. Drive motor **134** (FIG. 2) through the medium of a chain **135** engages sprocket **136**, also fixed to shaft **131**, to supply the power drive to the apparatus causing a rotation of the link chains **132**, **133** and sprockets **127**, **128**, **129**, **130**, generally in the direction of arrow **137** of FIG. 2. Referring to FIGS. 8 and 12 at equi-spaced points along the chains **132**, **133** and mounted to the chains by suitable links are a plurality of blocks **138**, **139** projecting inwardly relative to the chains. The blocks are located and disposed opposits to each other on their respective chains.

Referring to FIG. 13, the block **138** is mounted to bracket **140** by screws **141** and bracket **140** is mounted to chain **133** by link pins **142**. The block **138** has a center opening **143** to receive a pair of bushings **144** held by flanges **145** against lateral shifting. A shaft **146** extends through the bushings **144** and a gear **147** is fastened concentrically to the outer end thereof. The section **148** of the shaft **146** extending inwardly of the block **138** is tapered as a pyramid at its end **149** for a purpose to be later described. The block **139** FIG. 11 is mounted similarly to chain **133** by bracket **140**, screws **141** and link pins **142**. A shaft **150** extends through opening **151** in bearing block **139** and has a conically tapered tip section **152** mounted to shaft **150** by a pin **153**. A coil spring **154** is compressed between a face of the block **139** and the opposite inner face **155** of the base of tip **152** to normally force the tip in the direction of arrow **156**. A knob **157** is mounted at the other end of shaft **150**, by a pin **158**. If the knob **157** is moved in the direction of arrow **159**, it causes the tip section **152** to be withdrawn in the direction of arrow **159**.

Referring particularly to FIGS. 8, 11 and 14, suspended between each pair of blocks **138**, **139** is a mandrel **160** which in the embodiment shown is hollow. Each mandrel has openings **161** in its ends **162** adapted to respectively engage the conical end **152** of shaft **150** and the pyramidal end **149** of shaft **146**.

To position the mandrel the operator inserts the tip **152** into one of the openings **161** in the end of a mandrel **160** and exerts a longitudinal pressure on the mandrel to compress spring **154**. The other end of the mandrel is aligned with the mating shaft **146** and upon release of the pressure the mandrel is moved endwise by spring **154** so that the pyramid end **149** engages the opening **161** in that end of the mandrel. The pyramid end **149** forms a driving connection with the mandrel for a purpose which will be disclosed hereinafter.

Removal of the mandrels at station F is likewise accomplished in much the same manner in order to facilitate

the slipping of the final form of the fibrous casing from the mandrel, it has been found desirable to keep a thin coating of wax on the mandrel. This wax film both assists the pickup of the mat section 119 during wrapping and also prevents the tacky fiber from sticking to the mandrel.

Referring now to FIG. 10, a plurality of mandrels 160 are positioned as indicated at equi-spaced points along the entire length of chains 132, 133 and suspended therebetween in opposed equi-spaced blocks 138, 139. Referring to FIGS. 8, 9 and 13 mounted to shaft 124 is a gear 162'. This gear 162' is spaced by a shoulder bearing 163 from a sprocket 163'. Both the sprocket 163' and the gear 162' are free to rotate independent of the direction of rotation of shaft 124 by reason of their mutual connection to shoulder bearing 163. Referring to FIG. 13, there is shown further that a shoulder bearing 164 separates sprocket 127 from gear 162' and a shoulder 165 separates a bell crank arm 166 from the framework 120, being kept in position by pin 168 extending through the hub of sprocket 127 and shaft 124 and by collar 167 (FIG. 11) separating bell crank arm 173 from sprocket 128. As seen in FIGS. 2 and 7, the drive motor 169 is connected by a drive chain 170 to sprocket 163' and causes sprocket 163' and gear 162' to rotate in the direction of arrow 171 (FIG. 9).

Referring again to FIGS. 8 and 13, it is seen that the gear 147 mounted on each mandrel supporting shaft 146 will engage the teeth of the sprocket 162' at a specified time. As was hereinbefore pointed out the blocks 138, 139, equi-spaced opposite each other along chains 132, 133 support mandrels 160 therebetween held by the inwardly directed tapered end points 149, 152 of rotatable shafts 150, 146. Referring to FIG. 9, it is shown that as these mandrels 160 move with chains 132, 133 the gear 147 will be engaged to gear 162' for about 180° of its periphery and the counterclockwise rotating gear 163' will cause gear 147 to rotate clockwise while so engaged. This will in turn mean that each mandrel 160, as its gear 147 engages gear 162' will be rotated in a clockwise direction. Each mandrel 160 is therefore rotated about its longitudinal axis maintained in correct longitudinal position by tapered points 149, 152 resting in the center openings 161 of the ends 162 of the mandrel. As seen in FIGS. 8 and 9, a pair of bell cranks 166, 173 each consisting of upper arms 174, 175 and lower arms 176, 177 yoked together to rotate in unison on bearings 178 (FIG. 11) mounted on shaft 124. Since the two bell cranks are identical only one will be described in detail, it being understood similar construction is present in its companion. Referring to FIGS. 8, 9, 10, 11 and 12, the bell crank upper arms 174, 175 are bifurcated to form an opening 179 between secondary arms 180, 181. Mounted to secondary arm 181 of both cranks by mounting screws 182, 183 are plates 184, 185 having toothed racks 186, 187 the teeth of which extend into the openings 179 of the bell crank arms. A shaft 188 pushing through the openings 179 has gears 189 and 190 mounted at its ends and the gears are held against lateral shifting by collars 191, 192 as they engage the racks 186, 187. This shaft supports a forming roller 193 that extends transversely of the direction of movement of the mandrels and which is slightly shorter in length than the mandrels 160. This forming roller 193 being fixed to the shaft will rotate with the freely rotatable shaft 188 when a force is imparted to it. The gears 189, 190 as seen in FIGS. 9 and 11 are secured to the shaft 188 by pins 194 so that the gears 189, 190, the shaft 188 and the forming roll 193 form a unitary structure.

It is seen in FIG. 9 that the bell cranks 166, 173 hold the forming roller 193 in the path of the mandrel 160 as the mandrel follows that path defined by the chains 132, 133 and the mandrel periphery comes into close promixity to the forming roller periphery as is best shown in FIG. 2. At the same moment the conveyor 112 has delivered into the nip formed between the periphery of mandrel 160 and the periphery of forming roller 193 the lead edge of a segment 119 of the severed mat. As was hereinbefore described each mandrel 160 is moving along the path of the chain in the direction of arrow 137 and through the engagement of gears 147 with gear 162' the mandrels will rotate about their longitudinal axis in a clockwise direction. When the mat segment 119 is acted upon by the rotating mandrel in the nip between forming roller 193 and mandrel 160 the segment is drawn or wound about the mandrel and the forming roller 193 rotates as a backup roller in a counterclockwise direction. The mat segment 119 is therefore subject to pressure while being wrapped around mandrel 160 through the weight of roller 193. This pressure applied the full length of the mat segment blends the fibers intimately as the pipe covering is formed to prevent the formation of layers during the wrapping. By replacing the roller 193 if desired with either a heavier or lighter roller the amount of the pressure may be varied according to the conditions of pressure as determined by manufacturing requirements. In addition this pressure continues for a period of time during which the forming roller 193 and mandrel 160 are locked to one another, after the mat is wrapped about the mandrel and carried together along the path of the mandrels defined by chains 132, 133. Therefore, when the wrap of segment 119 about mandrel 160 is completed, roller 193 bears against the peripheral surface area of the formed pipe covering to smooth the peripheral surface and to cause the trial edge of the segment which is tapered, to be blended intimately into the peripheral surface.

In order that the wrap of material about the mandrel is made under constant pressure it is necessary to provide a means whereby the forming roller will remain flush to the mandrel and fiber material being wrapped thereabouts until the wrap is completed as the diameter of the casing being wrapped increases. Also means are required to reposition the forming roller so that it will be in position to repeat the process with each succeeding mandrel moving along between constantly moving chains 132, 133 as seen in FIGS. 2, 9 and 10.

Mounted to the upper arm 175 of the crank 173 is a bracket 194' (FIGS. 10, 11 and 12) fastened by screws 195, 196 which supports the means which serves as a temporary connection to synchronize movement of the roller 193 and the mandrel 160 to carry both along together while the bell crank 166 moves from its heavy line position of FIG. 10 to the dotted line position of FIG. 10. An arm 197 extending substantially tangentially to the periphery of the sprocket is attached to a sheath or sleeve 198 which is about a shaft 199. The shaft extends from the bracket 194' inwardly over the path of chain 133. At the extremity of the arm 197 is a camming pin 200 which extends over the path of chain 133 in a position to engage the surface of a cam 201 that is suitably mounted by screws 202 to a cross angle iron bar 203 which forms part of the framework of the apparatus. The extremity of the arm 197 is bifurcated to receive a downwardly extended dog hook 204 held in place by pins 205, 206. A tension spring 207 connected between the arm 174 and an upwardly extended bar 208 joined to sheath 198 normally holds the hook in its solid line position as seen in FIG. 10 and in its dashed line position as shown in FIG. 12. As the mandrel 160 is carried along its path each block 139, in turn, will engage the dog hook 204 so that the bell cranks 166, 173 move with the mandrel 160. This engagement takes place at the same time the mandrel 160 is rotating, as hereinbefore described, so that the mandrel engages the roller 193 forming a nip therebetween to draw the individual and successively delivered fiber mat sections 119 about the mandrel. When the block 139-hook 204 engagement has raised the bell cranks from the full line

position to the dotted position (FIGS. 9 and 10) the pin 200 will be cammed upwardly by the action of the camming plate 201. As this occurs the hook 204 will be released from the block 139 so that the bell cranks are released whereby arms 166, 173, and forming roller 193 therebetween, will both by reason of their own weight return to the solid line position of FIGS. 9 and 10. As the rotation of the mandrel 160 causes the mat to be wrapped around the mandrel, it obviously follows the wrapped casing will increase in diameter progressively as the fiber mat is wrapped. As this diameter increases, the forming roller 193 is caused to walk upwardly by cams to be hereinafter described and gears 189, 190 engage the racks 186, 187 of plates 184, 185. The roller 193 bearing against the rotating mandrel is mounted so that it is free to move upwardly with respect to the mandrel 160 as the material is wrapped about the mandrel. When the mandrel 160 reaches the fully raised position indicated in dotted outline in FIGS. 9 and 10 the wrap will have been completed and after it rolls the outside periphery to smooth the casing the forming roller 193 may be released to return to its rest or mandrel aligned position where it will be positioned to engage a subsequent mandrel carried by the chains 132, 133.

In this manner a continuous recycling of the apparatus is secured so that each mandrel as it moves to receive the section 119 of fibrous mat engages and lifts the forming roller 193 with the mandrel for a prescribed period of time. Then by the camming action above described the bell cranks 166, 173 supporting this roller will be released to reposition roller 193 for the subsequent mandrel. Connecting the lower bell crank arms 176, 177 is a shaft 209 (FIGS. 8, 9 and 10) having a yoke 210 mounted intermediate its length connected to the piston rod 211 of air cylinder 212. The air cylinder is fixed by means of a shaft 213 between two upstanding brackets 214, 215 so as to be pivotable relative to itself. The brackets 214, 215 are welded or otherwise suitably mounted to a cross bar 216 which interconnect the angle irons 120. The mounting of cam 201 is accomplished through a connecting arm 217 by means of screws and bolts 202. The cam 201 is longitudinally shiftable for adjustment as the screw shafts extend through the longitudinal slot 218 (FIG. 12) and this adjustment controls the moment that forming roller 193 will be released from dog 204.

In order to maintain the shaft 188 about which the forming roller freely rotates from being ejected from the bifurcated ends at bell cranks 166, 173, a safety or holding plate 219 is mounted to the upper ends of bell arms 174, 175 by means of screws 220. This also forms an upper limiting stop for the hereinabove discussed walking action of roller 193. Air cylinder 212 provides a cushioning action to counteract the falling forming roller 193 suspended between bell cranks 166, 173 which falls under its own weight. Also after the bell cranks 166, 173 have fallen almost all the way the cylinder 212 provides positive pressure to position the bell cranks 166, 173 and forming roller 193 to align them relative to the succeeding mandrels so that the subsequent sections of the fibrous mat will be drawn into the nip between roller 193 and mandrel 160 and onto the mandrel 160. It is important that this relationship between the forming roller and mandrel be maintained to be sure that the proper and constant wrap of a fiber mat section 119 will be made about the mandrels. From the description hereinabove set forth, it is therefore seen that the forming roller 193 moving with the rotating mandrel 160 directs pressure downwardly on the mat section 119 by reason of its weight as the mat is wrapped about the mandrel. This results in a constant wall thickness of the pipe covering as it is formed about the mandrel and prevents variations in wall thickness or insures peripheral evenness.

In order to maintain the chains 132, 133 in tension, means for tightening the tension are provided on each side of shaft 124. Since the same structure appears on both sides only that present on one side has been shown in detail. Referring to FIGS. 11, 12 and 15, an opening 221 is formed in the framework by cross bars 203 and 222 which are joined by vertical angle irons 223 and frame upright 120. The journal 125 is surrounded and integrally attached to a slidable plate 224 which has longitudinal key slots 225, 226 which ride in vertical tracks 227, 228 welded to the angle irons 222, 203 respectively. A hollow lug 229 (FIG. 12) integrally joined to plate 224 has an internally threaded sleeve 230. A hexagonal headed screw 231 extends through a nut 232 welded to the side of the frame support 120 and continues through the sleeve 230 to terminate at the hollow center of the lug 229 where the end is secured by a washer and a cotter pin. By adjustment of screw 231 the plate 224 will move journal 125 longitudinally with respect to the frame to properly tension the chains 132, 133. The journal construction on opposed sides of the frame is identical. Other conventional means can be used such as weights instead of screws 231 to achieve tension in chains 132, 133 without departing from the scope of the invention.

As the sections 119 are wrapped about the mandrel 160 the pressure of the forming roller 193 causes the feathered edges to be pressed flat against the body of the pipe covering as hereinbefore described so that it becomes almost impossible to visually determine where the section starts or stops in the cylindrical form. This insures an even wall thickness around the entire circumference of the pipe covering. To assist in the control of this pressure exerted by the forming roller 193 against the mandrel 160 as it receives the fiber mat section 119, the gear 189, 190 and rack 186, 187 arrangement allows the roller shaft 188 to walk-up between bifurcated arms 174, 175 has been hereinbefore described. However, to provide even pressure on the mat so that the weight of the forming roller is sufficient only to smooth form the pipe covering and is not excessive to a degree sufficient to compress the fibers, a pair of cam plates 234, 235 (FIGS. 8, 9 and 11) are adjustably mounted from a pair of blocks 236 which in turn are welded to the framework cross bars such as 203. Forming roller cam plates are adjustable for a purpose to be later described and the hubs of gears 189, 190 ride on the cam edge 237 of these plates. This adjustability is secured through suitable retaining screws 238, 239 which engage the plates 234 to block 236 through slots 240, 241. Similar screws (not shown) are provided to adjust the plate 235 so that plates 234 and 235 may be aligned with respect to each other. In this way the shaft 188 is positively raised and the distance between the circumferential surface of roller 193 and the circumferential surface of mandrel 160 is gradually increased as the fiber increases the all over diameter of the wrapped casing.

The roller 193 therefore bears downwardly against the fibrous material as it is being wrapped about the mandrel 160. The portion of the weight of this roller 193 which presses against the tacky fiber mat is sufficient to provide a pipe covering, in normal operation which has a density of three pounds per cubic foot or less. The cams 234, 235 are shaped, in the embodiment shown, to lift the roller gradually with relation to the rotational axis of mandrel 160 to maintain a constant weight on the wrapped material and at the same time to compensate for the progressively increasing thickness of the material. It follows that forming roller 193 by adjustment of cams 234, 235, or by varying the shape of the cams, may be caused to exert greater pressure at any selected moment of the wrapping period so as to compress the fibers more fully at any selected portion of the casing, i.e. at the middle of the pipe covering or at the outer shell. The forming roller 193 does not freely rest on the material although it contacts the material and is so rotated through this contact, but strictly speaking, the roller 193 rests against the material and exerts through its own weight pressure against

the material only to a proportion or degree as determined by the cams 234, 235.

Referring more specifically to FIG. 2 it is noted that the material segment 119 is directed into the nip formed between mandrel 160 and the forming roller 193 and is wrapped about the mandrel at this point. It is well understood that when a material is being drawn about a mandrel type surface it forms a succession of layers of material. The innermost layers, by reason of the tension in the material against which mandrel is drawing are caused to have a greater density or tighter wrap than the outermost layers. By forcing the forming roller 193 against the material being wrapped so as to compress the material, the density is increased since the additional pressure of the forming roller serves to further compress the material against the mandrel. It has been found desirable in certain instances to slightly raise the cam plates 234, 235 so that some of the initial wrapping of segment 119 will be made about mandrel 160 without additional pressure of forming roller 193. The forming roller will then engage the material, after the initial wrapping, so that the pressure on the material at the innermost layers will be slightly lessened. Referring to FIG. 2, the mandrel 160, through the medium of the gears 162', 147 which are rotated in a counterclockwise direction, is normally rotated in a clockwise direction. However, if shaft 116 was lowered so that the segment 119 rather then entering into the nip between a mandrel 160 and forming roller 193 was delivered for pickup to the lowermost portion of the mandrel and the mandrel caused to rotate in a counterclockwise direction, the pickup of the material would take place so that the material would proceed halfway around the periphery of the mandrel before reaching a point where the roller 193 would be operative. Such a reversal of the direction of rotation of mandrel 160 could be achieved for example by reversing the drive of the gear 162' hereinbefore discussed. In such a manner it would be possible if desired to reduce the density of the pipe wrapping by approximately 50% so that rather than a wrapping of three pounds per cubic foot, a density of one and a half pounds per cubic foot will result. This adjustability of density in the casing is achieved usually by adjustment of cams 234, 235 so as to vary the weight transferred from roller 193 to the material but density variation can also be secured by an alteration of the point of delivery of the segment 119 with respect to the nip between mandrel 160 and roller 193, as hereinbefore described or by varying the length of the mat. Broadly the density of the casing is between one and a half pounds to six pounds per cubic foot and normally between three pounds and five pounds per cubic foot.

As mandrels 160 advance along the path of the conveyor on its upper turn, generally in the direction of arrow 137, a section of fiber mat material 119 having been wrapped about the mandrel by the hereinbefore described action of forming roller 193, the gear 147 on the shaft 146 supporting one end of the mandrel, contacts the gear rack 242. As seen in FIG. 9, this rack 242 is mounted to the angle iron cross bar 203 of the framework of the device by suitable screws 243, 244, this rack being mounted inside the framework in the same plane substantially as the gear 162'. As the mandrel continues in the direction of arrow 137 toward the opening 246 in the oven 123, the mandrel 160 with the fiber wrapped about it will be rotated substantially in a clockwise direction while the gear 147 engages the rack 242 as seen in FIG. 9.

In order to insure that the smooth outside peripheral surface of the pipe covering determined by the rolling action of the roller 193 will be permanently fixed it has been found desirable to incrementally activate the binder in the wrapped mat by initially ironing the outer periphery or circumference of the fiber covering before it enters into the oven 123 where all the remaining binder will be activated. This preliminary treating or ironing of the fiber mat is accomplished by an ironing roller device to be now described which as indicated diagrammatically in FIG. 2 constituting station D.

Referring to FIGS. 2, 7, 8, 9, 10, 14 and 15, a pair of vertically angle irons 247, 248 are welded or otherwise suitably mounted to the base uprights 120 which form the supporting stations for station C. As seen in FIG. 8 shaft 249 extends between the uprights 247, 248 and upon this shaft is mounted the adjustable ironing roller supporting means generally indicated by the numeral 250 FIG. 9. The general supporting structure is duplicated on both sides of the device, in identical form, and cooperation between the opposite pieces of the adjustable framework is provided. When adjustment, vertically of the conveyor pathway is desired, a parallelogram movement of certain portions of the framework is achieved through a double pivoting arrangement.

Referring now to FIGS. 9 and 10 extending laterally from the shaft 249 and fixed relative thereto so as to be pivotable therewith, are two arms 251, 252. At a point below the arms 251, 252 are similar inwardly extending arms 253, 254 mounted to uprights 247, 248 by means of studs 255, 256 respectively and pivotable thereabout. Connecting the inner extremities of arms 252 and 254 and likewise the inner ends of arms 251 and 253 are vertical angle iron braces 257, 258. These vertical irons being mounted to the respective bars 251, 252, 253, and 254 by means of studs or bearings 259 each forming a pivotable joint. The vertical supports 257, 258 are further interconnected by a cross-piece or support 260, FIGS. 14 and 15. Welded or otherwise suitably mounted to the upper extremity of braces 257, 258 are bars 261, 262, perpendicular thereto, and substantially horizontally disposed with respect to the conveyor path as determined by the chains 132, 133. These substantially horizontal angle iron braces 261, 262 are also rigidly connected to each other by another cross brace 263 at their free ends. Extending from the lower extremity of the vertical braces 257, 258 and parallel to the bars 261, 262 are further horizontal supports 264, 265 at one end freely mounted to the braces 257, 258, about the studs 259, and held substantially horizontal by vertical bars 266, 267 that are welded to the free ends of the upper horizontal braces 261, 262. The joining of braces 266, 267, with the lower horizontal braces 264, 265 is accomplished through conventional welding. Referring now to FIG. 7 fixedly mounted to the shaft 249, as it extends through the supporting brace 247, is a worm wheel 268. Mounted to the vertical brace member 247 are two bearings 269, supporting therebetween a shaft 271 having a worm gear 272, fixedly mounted thereto and in engagement with the teeth of the worm wheel 268. Attached to the shaft is a handle 273 which when turned will impart a rotation, through the medium of the shaft 271, worm gear 272 and worm wheel 268, to the shaft 249. As this is done a parallelogram movement is gained wherein the horizontal brace members 261, 262, 264, 265 remain substantially horizontal, however being displaced substantially perpendicular to the line of the conveyor movement. This follows since the first mentioned horizontally inclined arms 251, 252 are fixed, relative to shaft 249, and accordingly raise and lower the framework, however, maintaining it substantially horizontal. This parallelogram movement is well known and only the parts of the framework which it is believed necessary for an understanding of the movement have been hereinabove described.

Referring now to FIGS. 9, 10, 14 and 15, a shaft 274 extends between the upper horizontal brace members 261, 262 and downwardly extending from shaft 274 are a pair of ironing roller supporting arms 275, 276 secured to the shaft 274 by attached bosses 277. The lower extremities of arms 275, 276 are bifurcated, forming openings 278 and the bosses 277 are held rigid relative to shaft 274 by a pin 281 (FIG. 14) so that the two arms are maintained in the same plane relative to each other. Mounted by welding or any suitable or conventional means to the horizon-

tally extending cross braces **265, 264,** are gear racks **282, 283,** FIGS. 9, 14 and 15. These racks are similar to the rack hereinbefore described. Positioned in the openings **278** of the respective bifurcated ends of arms **275, 276** is a shaft **284** and at each end of the shaft are gears **285, 286** engaging the racks **282, 283** respectively. Shaft **284** rotates with the gears **285, 286** and as seen in FIGS. 9, 10 and 15 the arms **275, 276** move in the direction of arrow **288** (FIG. 15) as actuated by means to be hereinafter described to carry shaft **284** along between the bifurcated ends of the arms. The shaft **284** will be rotated substantially in a clockwise direction, as the teeth of the gears **285, 286** are drawn across the toothed racks **282, 283,** by reason of the clockwise rotation of the gears **285, 286.** Despite the clockwise movement of shaft **284,** ironing roller **289,** FIG. 14, being freely rotatable about the shaft **284** through the medium of bearings **290,** is free to rotate in response to mandrel **160** in a counterclockwise direction independent of shaft **284.** This counterclockwise or back-up roller motion is induced into the ironing roller **289** through the medium of the frictional contact of roller **289** with the material **119** wrapped about the mandrel **160.**

Referring now to FIGS. 14 and 15, a dog engagement device similar to the aforementioned arm **197** and hook **204,** hereinbefore described, engages the ironing roller **289** to the mandrel **160** to provide synchronized movement of the ironing roller **289** and the mandrel **160** as they pass through ironing station D for a predetermined time period and predetermined distance.

A bearing block **291** is mounted about shaft **284** and the shaft is freely rotatable through the block. The block **291** is maintained substantially horizontal by means of a guide rod **292,** FIGS. 14 and 15 which extends from the block and as seen in FIGS. 8 and 9 is received into an upstanding bracket **293** (FIGS. 9 and 10) welded or otherwise suitably affixed to span bars **264** and **265.** At the inner end of the block **291** is vertically extending opening **294** through which is slidably mounted a rod **295** vertically positioned relative to block **291** by means of a set screw **296.** At the lower end of the rod **295** is pivotally mounted, by means of pin **297,** a substantially horizontal rod **298.** At the upper end of rod **295** is a support bar **299** having a threaded opening therein to receive a screw **300** and a spring **301** is connected between the lower extremity of the screw **300** and the aligned end of bar **298** so that the opposite end of bar **298** is normally held downward. Variations in the amount of pressure exerted on the downward end of bar **298** by spring **301** is adjusted by means of the threads in the support bar **299** and maintained by a lock nut **302.** The arm has at its downward projecting inner end a dog hook **303** and a camming pin **304.** Mounted at a point short of oven entrance **246** at approximately the inner end of the racks **282, 283** is a cam plate **305** (FIGS. 10 and 15) similar to the aforementioned described cam **201.** This cam is suitably mounted by conventional adjustable means, such as screws, to the angle bar **203** so as to be both vertically and laterally adjustable. It is therefore seen that as the shaft **284** is carried in the direction of arrow **288,** the cam pin **304** will ride upwards on the cam surface **306** of cam **305** in the same manner as the camming surface of cam **201** raised upwards on the cam pin **200.**

Referring now to FIG. 15 as the chains **132, 133** continue their path around their respective sprockets, the chains move substantially in the direction of arrow **137.** Block **139** attached to chain **133,** upwardly projecting relative to the chain, engages the hook **303** of the ironing roller arm **298** as shown in FIG. 15. As the chain continues to drive the shaft **284** through this dog connection, it will cause the ironing roller **289** to move in the direction of arrow **288.** As the shaft so moves the gears **285, 286** walk across the racks **282, 283** as hereinbefore described while the ironing roller **289** engages the surface of the fiber wrapped about the mandrel **160.**

As the shaft **284** advances in the direction of arrow **288** it carries with it the bifurcated arms **275, 276** pivoting about their shaft **274.** As the ironing roller **289** is caused to move in the direction of arrow **288,** FIG. 15, it moves along a horizontal line substantially parallel to the line of movement of mandrels **160** and chains **132, 133.** By means of the crank **273** (FIG. 7) the relative height of the framework **250** supporting the aforementioned parts and in particular the height of racks **283, 282,** which set the height of ironing roller **289,** will be determined. The ironing roller **289** will be set in a vertical height so as to, by reason of its own weight, bear slightly against the fiber mat **119** wrapped about the mandrel **160.** The setting of the ironing roller with respect to the final outside diameter of the impregnated fiber material desired is slightly less than this final outside diameter by approximately ⅛ to ¼ of an inch. This is possible since there is a tendency in the material to snap back or spring back after rolling and therefore placing the periphery of the ironing roller **289** so that it rides within the diameter of the pipe covering as measured from the center of the mandrel to slightly compress the material, it will not materially effect the final outside diameter. Therefore, the ironing roller **289** will direct pressure on the peripheral surface of the fibrous casing by its own weight to insure a smooth finish of the pipe material wrapped about the mandrel. This follows since by reason of its frictional contact with the mandrel, it rotates substantially as a back-up roller in the same manner as did the forming roller **193,** and will act uniformly on all parts of the material. The incremental activation of the binder hereinbefore discussed by initially activating the binder in the peripheral surface area causes the formation of a relatively hard shell of fibrous material bonded by an activated binder in proximity to the peripheral surface. This shell formed under controlled heat and pressure conditions within predetermined limits as determined by the relative dimensions and properties of the casing being processed is sufficient to activate only the binder in the immediate peripheral surface. The discussed pressure is desirable in order to insure positive retention of the outside dimension of the wrapped mat as it proceeds through the apparatus. By adjustment of the relative height of the aforementioned racks by adjustment of the elevation of its supporting structure, this pressure that the ironing roller will exert against the material on the mandrel may be effectively controlled to achieve the best results. As the arms **275, 276** approach the dotted line position as shown in FIG. 15, disengagement of the ironing roller **289** from the mandrel is gained by reason of the upward camming action of arm **298** through the camming pin **304** engaging the cam **305.**

Although with regard to the binder activation as hereinabove discussed, it is incremental with respect to its depth or penetration into the fibrous casing, the initial binder activation by ironing roller **289** is also segmental with respect to its treatment of the peripheral surface area of the casing. This follows since the free rolling action of the ironing roller, which acts as a pickup roller, causes the ironing roller heated surface to contact the surface of the casing progressively as the casing and the ironing roller rotate in frictional engagement. The peripheral surface of the casing therefore is progressively or segmentally contacted by the heated surface of the ironing roller and the temperature of the surface is sufficient only to activate the binder in that portion of the casing surface progressively and successively contacted as the casing is rotated.

In order to reset the ironing roller in its original position, suitable means to be now described are provided.

An arm **307,** FIGS. 14 and 15 is fixedly mounted by a screw **308** so as to be pivotable along with the shaft **274** as the shaft pivots under the action of the arms **275, 276.** Supported from the cross brace **260** and extending substantially to the rear of the apparatus is a further cross iron **309** having a downwardly extending tab **310.** A spring

311 is connected from this tab 310 to the plate 307 and is drawn into tension as the pivoting arm 275 moves from its full line position to the dotted line position indicated in FIG. 15. When arms 275, 276, moving with shaft 284, are disengaged from the movement of the chains 132, 133 as hereinbefore described, the spring 311, in its extended condition, will tend to draw the arms 275, 276 in the direction of arrow 312 (FIG. 15) and to return them to the full line position as indicated in FIG. 15. In order to insure that the arms 275, 276 are positively returned, so as to be correctly aligned with the next mandrel rotated by the chains 132, 133, an air cylinder 313 is pivotably mounted by pin 314 to a bracket 315 rising from the support 309. The piston rod 316 of air cylinder 313 is engaged to the plate 307 as seen in FIG. 15. By suitable timing means to be hereinafter described, the air cylinder 313 is caused to operate to pull on the plate 307 in the direction of arrow 312 to cause positive return of the arms 275, 276 and the elements connected thereto to the full line position as indicated in FIG. 15, while shaft 274 rotates clockwise. When this occurs, arm 298 through the medium of spring 301, will again be held in a downward direction or position so that its hook 303 will be positioned to engage the next succeeding block 139 on the chain 133 as it is pulled upwardly and around sprocket 128 along the path of the conveyor chains 132, 133. It is understood that at this time, on the mandrel 160 supported between the block 138 and block 139, will be another fibrous casing previously wrapped about the mandrel by the hereinbefore described action of the forming roller 193. This recycling will continue as the chains 132, 133 will continuously cause mandrels 160 to pick up fiber at station C and pass it through station D.

The ironing roller 289 is formed of a heat transfer material and is heated through conventional radiant heating elements generally indicated at 317, FIGS. 14 and 15. These heating elements are mounted beneath a substantially half-moon hood 318 and extend transversely of the conveyor path and longitudinally of roller 289 substantially the full width of the roller 289. A pair of mounting brackets 319, FIGS. 14 and 15, support the hood between the arms 275, 276. These brackets are welded or suitably attached to the hood 318 at one end and at their other end through screws 320 affixed to the arms 275, 276. The screws 320 extend through key slots 321 in the brackets 319 so that the hood may be raised or lowered relative to the ironing roller 289 whereby the position of the heat radiating elements 317 is adjustable. In this way, the amount of heat transferred to the roller may be controlled and also the position of the hood, relative to the roller, may be adjusted to locate the roller 289 when changes of either mandrels or pipe wrappings sizes are made. In place of radiant heating elements 317, the same effect could be achieved by applying gas flame heat directly to the surface of the ironing roller 289. The use of a flame heater will heat the roll so that its periphery is substantially within the ranges of 700 to 900° F. Heat within these ranges, has been found satisfactory for preheating to form a shell in the peripheral surface area of the wrapped material. However, in general it is desirable to have sufficient heat passed from the roll to the binder to impregnated fibrous material wrapped about the mandrel to activate only the binder in the area of that portion of the wrapped casing contacted by the heated surface to accomplish the initial stage of incremental binder activation as hereinbefore discussed.

It is therefore seen referring to FIG. 2, that the matted fibers are deposited on a conveyor 16, are collected into a fibrous mat 18 at the collection station A, transported by conveyor means 38 through station B where the mat 18 is sheared into individual segments 119, further carried by conveyor 112 into station C where the fiber sections 119 are wrapped about a mandrel 160 through cooperation of the mandrel and a forming roller 193, further transported after wrapping about the mandrel to a station D where the fibrous mat so wrapped about the mandrel is subjected to initial binder activation to bond the fibers about the periphery to one another and then conveyed to station E where it enters into oven 123 in which the remaining resin or binder in the mat is activated to bond all of the fibers to one another after this initial activation hereinbefore discussed occurring under ironing roller 289.

Referring now to FIGS. 7 and 10, as the mandrel 160 is transported through oven 123, a press chain 322 is suitably positioned so as to engage the upper surface of the cylindrically formed mat wrapped about the mandrel.

Since as hereinbefore described, mandrel 160 is supported between bearing blocks 138, 139, mounted to chains 132, 133, and is freely rotatably therebetween on shafts 146, 150 as press chain 322 engages the upper surface of the cylindrical mat wrapped about formed mandrel 160, the chain causes the mandrel to rotate. The mandrel moving laterally in the direction of arrow 323 (FIG. 7) is thereby simultaneously rotated counterclockwise about a longitudinal axis as determined by the shafts 146, 150 while being subjected to heat. It is essential in this stage of binder activation of the binder in the fibrous mat in order to form an evenly treated insulated pipe covering that the mandrel and covering thereon are rotated as they pass through the oven so that heat will be evenly applied about all sections of the mat. In addition the press chain 322 which by suitable means, conventional in the art, may be raised or lowered to exert desired pressure upon the outer peripheral surface of the circumference of the fiber mat wrapped about the mandrel to assist in maintaining a constant outside dimension as the mandrel is conveyed, along the longitudinal conveyor plane in the direction of arrow 323 as determined by the chains 132, 133. This pressure may be varied as determined by the properties and dimensions of the casing being processed.

It has also been found that under certain conditions incremental activation of the binder may be replaced by complete binder activation in the oven 123. Under certain conditions the formation of an outer shell is not necessary and a smooth constant dimension covering or casing will result from the normal action of the forming roller 193 and the oven 123 with its press chain 322. This elimination of initial binder activation will be determined by the dimensions and properties that are to be expected from the final produced casing.

As was hereinbefore described, the main drive for conveyor chains 132, 133 is supplied through a constant speed motor 134 which drives shaft 131, FIGS. 2 and 7, about which are mounted the drive sprockets 129, 130.

Referring now to FIGS. 8, 16 and 17, the timing means discussed hereinbefore will now be described in detail. Since the shaft 124 is directly driven through the chains 132, 133 it rotates in the same direction and at the same speed as does the drive shaft 131. The shaft 124, extending beyond its lefthand journal 125 (FIG. 8) mounted to the upright 120, has a sprocket 324 fixedly mounted thereto, through the medium of the sprocket collar 325. Positioned at a point offset from the upright 120 is timing means 326 supported upon uprights 327. These timing means 326 include shaft 328 suspended between suitable cross braces 329 interconnecting uprights 327 and 351 in journal bearings 330. On the extremity of shaft 328, projecting towards the upright 120, FIG. 8, is mounted a sprocket 331 fixed relative to the shaft by means of its collar 332. A link chain 333 or other suitable connecting belt interconnects the sprockets 324 and 331 so that the drive of shaft 124 is transmitted directly to the shaft 328. The arrangement of the gears 324 and 331 and chain 333 is such that shaft 328 rotates in the same direction and in timed relation to shaft 124. A plurality of timing cam means 334 FIGS. 16 and 17 are suitably mounted to the shaft 328. Since all of the cam means are identical, only one of them FIG. 16, has been shown in detail, and that one will now be described in detail.

A first collar 335 is fixedly mounted by means of a set screw 336 to the rotating shaft 328. As seen in FIG. 17, this collar 335 has a shoulder 337 so that collar 335

has a reduced diameter generally formed as indicated at **338**. Each cam means **334** consists of two camming plates **339** and **340**. Each of the plates has two separate radii so that the peripheral edge **341** is disposed at a greater distance from the center of the shaft **328** than is the peripheral edge **342**. Each of the plates is formed in such a way that the peripheral portions **341** of greater radius is slightly greater than 180° of the total cam circumference. When two plates are placed adjacent and flush to each other, the peripheral portions of greater radius of each overlap and form a continuous peripheral edge the radius of which is constant through 360°. Joining the edges **340** and **341** on each plate **339**, **340** are cam surfaces **343**, **344** and **345**, **346** respectively, tapered towards each other for a purpose to be hereinafter described. Referring to FIG. 17, two plates **339** and **340** are seated adjacent shoulder **337** in the reduced diameter **338** of collar **335**. A second collar **347** is fixedly positioned relative to the first collar **335** by means of set screw **348** and bears against the cam plates **339** and **340** so as to fixedly seat them relative to the first collar **335** and to each other when the second collar **347** pinches them against shoulder **337**. By releasing the screw **348** the plates **339**, **340** may be rotated about the collar **335** so that any desired linear portion of the peripheral surfaces **342**, i.e. that having the lesser radius, may be exposed. If desired, the plates **339**, **340** may be welded, as shown at **349**, FIG. 17, each to a collar **335**, **347** so that the plates may be rotated into position, relative to each other, by setting the collars with respect to shaft **328**.

Fixedly mounted between the uprights **351**, is a second shaft **350** FIGS. 16 and 17 substantially parallel to and in the same vertical plane as the shaft **328**. This shaft **350** is secured to uprights **351** in bearing collars **352** for rotation therein. A support arm **353** is suspended from a block **354** by screw **355** and extends over the rotating cam means **334**, and block **354** is free to pivot on the shaft **350**. A weighted base member **356** is positioned toward the inwardly extending end of the arm **353** and by suitable clamping means **357** has mounted thereon a mercury switch **358**. The mercury switch includes a vial **359**, which when held tilted as shown in FIG. 16, holds its contained mercury to its rear out of contact from the electrode contact **360**. However, when the arm **353** rocks downward under action to be later described, the mercury in the vial would slide forward so as to contact electrode **360** and cause a circuit through lead **361** to be closed. At the inner end, and downwardly extending from the arm **353**, is a hook tab **362** adapted to ride against the periphery of the cams **339**, **340**. It follows that as the cam plates **339**, **340** are adjusted to expose a part of a lesser periphery **342** of one cam, the hook tab **362**, riding along the periphery **341** of the cam of greater radius, will slide down, for example, cam surface **346** on cam **340**, FIG. 16, and ride across that portion indicated at **363** of the periphery **342** having a reduced radius. At this time, arm **353** will pivot downwardly under the weight of base member **356** and the mercury in vial **359** will come into engagement with the contact **360** closing the circuit through lead **361**. As the cams **339**, **340** continue to rotate in the direction of arrow **364** and the tab hook **362** rides upward on cam surface **343** of cam **339**, arm **353** will return to the position as shown in FIG. 16 and the mercury will be withdrawn from engagement with contact **360** and the circuit will thus be broken. Since the cams **339**, **340** may be placed in any suitable position relative to the shaft **328**, the operation of a particular circuit may be timed both as to its instant of operation and relative to all other operations similarly activated. Likewise since the cams **339**, **340** may be adjusted relative to each other to control the distance between the cam surfaces **343**, **346** the length of time that a particular circuit will be closed is thereby controllable as each circuit is closed while the depending tab **362** rides along that portion **363** of the lesser periphery **342**. In this way, since the shaft **328** rotates in time with shaft **124**, the instant when a particular operation of the apparatus at any particular station is to be initiated may be timed with relationship to the moment a mandrel would come into position to receive the segment **119** being delivered by conveyor **112**. As shown in FIG. 8, there are in the embodiment illustrated three of these cam means **334**, each operable, as hereinabove discussed, by independent adjustment of each of the cam means. Through connection of leads **361** from each cam as shown in the schematic wire diagram of FIG. 18, the actuation of various elements may be timed in relation to the rotation of the drive chains **132**, **133** which carry the mandrels **160**.

Referring now to FIG. 18, when the switch **365** is engaged, to close the circuit from a suitable power source, one side of the line to each of the solenoids **366**, **367**, **368** will be closed by suitable leads and the other side of the line normally open by reason of the fact that the mercury switch maintains a gap between the contacts **369**, **370** of each. When as hereinbefore described, cam means **334** are rotated and at a specific moment arm **353** slides downward to actuate the mercury switches and close contacts **369**, **370**, current will be passed to energize a selected solenoid through leads **361** and to operate the solenoids.

As seen in FIG. 18, solenoid **366** is connected to the reversing air cylinder, **104** solenoid **367** is connected to the knife cylinder **68** and the third solenoid **368** is connected to the positive ironing roller repositioning air cylinder **313**. It therefore follows that by selecting relative to a 360° cycle, the moment at which a selected depending tab **362** will slide down inclined cam surface **346** to cause the pivoting action of arm **353**, the moment at which a particular solenoid will be activated is determined. This operating cycle is easily, by mechanical adjustment, of cams **339**, **340** controllable relative to the instant at which a mandrel **160** comes up about the sprockets **127**, **128** so as to properly cause the separate elements to cooperate one with another in timed relationship.

Therefore, the reversing of the conveyor is timed to the operation of the shear knife by mechanical adjustments of these solenoids **366**, **367** and both timed to the speed of the chains **132**, **133**. In addition, the positive repositioning of the ironing roller **289** is likewise timed so as to occur at just the proper moment. By so timing the above mentioned solenoids, and by conventionally timing the rotation of the drive motors **34**, **54**, **169** and **134**, it is possible to tie in together the longitudinal speed of movement of all the various conveyor belts with the chains **132**, **133** so that an uninterrupted flow of material is achieved. The timing of the shearing action of individual segments **119** from the mat **18** at station B may likewise be timed with the speed of chains **132**, **131** so that as a mandrel **160** moves into position to form a nip between itself and the forming roller **193**, an individual section **119** will be delivered into the nip. This recycling is continuously repeated so that as each successive mandrel **160** is rotated up into position, a mat section **119** is simultaneously being delivered by the timed relationship of the conveyor belts **40** and **112**.

Heretofore has been discussed, in detail, various mechanical means by which the apparatus maintains a continuously operating endless path of fibrous material wherein finely divided filaments of flame blown fibers are introduced at the entrance end of the apparatus and are removed at the discharge end of an oven as a cylindrical pipe covering. The preformed resilient thermal pipe insulation or coverings **371** are further transported from the discharge end of the apparatus for finishing, inspection and othtr conventional operations such as trimming of the edges **372**, gauging, and the forming of a longitudinal slit **373** through the cylindrical wall **374**, lengthwise of the pipe covering, to make it adaptable to form around a pipe.

The mechanical steps making this possible have been

described in some detail; however, for a better understanding of the step by step method of operation of brief summary will be now presented.

The fibrous mat 18 is formed in the usual manner and transferred from its collecting means 16 at station A to a horizontal conveying means 38 at station B composed of two endless belts 39 and 40. The belt 39 and the collection belt are connected to a common power source and suitable means are provided to periodically reverse the direction of movement of the belt 39.

Positioned at station B at a point between the two belts 39 and 40 is a shearing knife 65 which severs the fibrous mat 18 into individual segments 119. However, before severing the mat the conveyor belt 39 is reversed through the medium of solenoid 366 operable through its cam means 334. When the belt 39 is reversed, the belt 40 continues to travel at a constant rate in the opposite direction, and the belts each grip the mat through frictional engagement to bring the mat into tension between the two conveyors. While the mat is held in tension, a second solenoid 367 causes the knife blade to be driven downwardly to sever a segment 119 from the belt 18.

The cooperation between the knife blade, and the mat held in tension, serves to actually tear or shread the edge of the segment severed from the mat so that it is formed as a tapered or feathered edge. This feathered edge is desirable for when the mat is subsequently fed into the nip between forming roller 193 and the positively driven rotating mandrel 160 so as to be wrapped around the mandrel, the feathered edge eliminates any ridge portions being formed upon the outer surface or the inner of the material as it is wrapped when acted upon by the pressure of forming roller 193.

After a preselected time, the knife blade 65 is raised upwardly to withdraw the knife above the plane of the conveyor belts 39, 40, as the solenoid 367 again operates the double acting air cylinder 68. At this time, and in timed relationship thereto, belt 39 is again reversed and caused to lead further portions of the mat 18 under the knife 65 so that it will be subsequently severed.

The conveyor 40, along with conveyor 112, moves the mat segment 119 along to station C where the mat segment 119 is wrapped about a mandrel 160 under pressure and action of forming roller 193. The conveyors 112 and 40 are driven by motor 54, the speed of which is subjected to adjustable control means whereby the rate of speed of these conveyors is selectively adjustable.

Stations C, D, E and F generally determine the actual pipe covering forming section of the apparatus. Suspended within and extending through an oven is a pair of parallel chains 132, 133 driven by a conventional motor 134. Suspended between chains 132, 133 in block mountings 138, 139 are freely rotatable mandrels 160, located at spaced intervals along the chains equi-distant from each other. The conveyor chains 132, 133 cause the mandrels to follow a continuous path along an upper and lower sweep. A mandrel 160 after having a segment 119 wrapped thereabout will follow the upper pathway where the material, wrapped about the mandrel is incrementally treated to activate the binder to bond the fibers to ane another. After this binder activation and after the fibrous casing is removed from the mandrel at station F, the mandrel 160 continues its continuous pathway through the lower sweep of the oven eventually coming around to be repositioned to receive additional segments.

To further explain the wrapping action at station C, a mandrel 160 moves up to a position where it is in nip engagement with forming roller 193 so that at this precise moment, the conveyor 112 will deliver into the nip formed between these two elements, the lead or front edge of a segment 119 of the mat. A gear 162', engaged to a gear knob 147 on one shaft supporting a mandrel, is driven by a variable speed motor 169 so that the mandrel is caused to rotate. This independent rotation causes a segment 119 of the mat to be drawn about the rotating periphery of mandrel 160 as the forming roller 193 rotates in an opposite direction as a back-up roller.

This forming roller 193 travels a short distance with the rotating mandrel 160 as the mandrel rotates under the action of gear 162', the mandrel 160 at the same time being carried along the path of the conveyor chains 132, 133. By suitable mechanical means, the forming roller 193 is dogged and engaged to the mandrel 160 as the mandrel moves so that both follow the same pathway substantially together and the forming roller by its pressure smooths the peripheral surface of the wrapped mat.

When a mat section 119 has been fully wrapped about the periphery of mandrel 160 and smoothed, the forming roller 193 is acted upon by camming means to be disengaged from the mandrel 160. This occurs when mandrel 160 has substantially reached the position where it is in line with the upper sweep of the conveyor path determined by the chains 132, 133. When the roller 193 is released it will fall back to its original position under its own weight where it will form a nip with a subsequently arriving mandrel to assist the mandrel in rotating an additional segment around its periphery. This return is cushioned by an air cylinder 212.

The forming roller 193 is constructed so that it will not be effected by the increase in the diameter of the casing periphery when the diameter increases as segment 119 is wrapped thereabout. The roller is supported so that it is free to walk up in an opening in a pair of bifurcated arms and will at all times maintain the desired pressure against the mandrel to form a firmly wrapped smooth covering.

When the pipe covering has reached its upper run and starts towards the oven 123, it is contacted at station D by preliminary heat treating means or ironing means where the first stage of the incremental binder activation occurs. This means consists of an ironing roller 289 adapted to ride against the outer periphery of the segment of the mat wrapped around the mandrel. This roller preliminarily heat treats or bakes the exposed periphery to activate the binder only in the peripheral surface area before the wrapped mat is subjected to full heat treating in the oven to activate the remaining binder. The mandrel 160 through suitable racks 282, 283 is rotated so that this preliminary heat treating occurs over the complete peripheral area. A dog engagement is provided to keep the ironing roller in engagement with the rotating mandrel for a predescribed length of time and distance where both move as a single unit and at the end of this time, the ironing roller 289 is released from engagement with the rotating mandrel. The air cylinder 313 is caused to operate at this moment by cam means 334, which it is noted is timed with relationship to the other solenoids 366, 367, so that the ironing roller 289 is positively returned to be positioned to engage the next mandrel carried along by chains 132, 133.

Suitable means are present on this ironing roller 289 so that its position relative to the segment of the mat wrapped about the mandrel is adjustable to control the rolling pressure it directs on the peripheral surface. This is important in the case of a change either in the wall thickness of the pipe covering or in a change of the diameter of the mandrel itself. The ironing roller 289 may be raised or lowered so that it will always substantially occupy a position slightly less than the desired outside dimension of the wrapped pipe covering.

After the preliminary heat treating at station D each mandrel 160, having a pipe covering formed thereabout is carried through the oven of station E where the second stage of incremental binder activation occurs. However, as mandrel 160 so moves, it is rotated about its longitudinal axis under the frictional engagement of the periphery of the covering with a press chain 322 supported in the oven. This stationary press chain or web exerts a pre-

determined pressure over the entire outside area of the pipe covering and as it passes through the oven to maintain the pipe covering within the tolerances of the resultant desired outside diameter or wall thickness of the covering. If desired, the pressed chain **322** might be eliminated from the oven and the tooth racks **282, 283** might be extended through the oven so that the mandrels would be rotated without the use of pressure on their outer surface. The pressure wihin the oven assists in maintaining the outside diameter of the pipe covering, however, it is not essential under certain conditions when incremental binder activation or preliminary ironing is used. The outside diameter, affixed by formation of a shell during the initial stage of binder activation, does not materially change during the second stage where the remaining binder is activated whether or not a press chain is used. It is essential, however, for even baking and for a more perfect pipe covering that the mandrel **160** with its pipe covering wrapped thereabout positively rotates as it goes through the oven so that all portions of the outer periphery of the mandrel receive the same baking whereby all the binder remaining after initial binder activation will be activated so that all the fibers in the mat are bonded to one another.

It is important that a mandrel **160** be capable both of picking up a segment **119** of the mat during rotation and also when the mat arrives at the station F of the oven allowing the pipe covering to be easily removed from the mandrel. In order that this operation can be accomplished smoothly, the mandrels are normally kept waxed so that adherence between the fibrous covering and the mandrel is avoided. It is noted that each mandrel **160** is suspended between the pointed ends **152** and **149**, of the mandrel support shafts and under compression of spring **154**. It naturally follows that a mandrel may be removed from between these shafts by compressing the spring while the chains **132, 133** are still rotating. Thereafter the pipe covering is stripped from the mandrel and the mandrel returned to its position. This is possible since the rate of speed of the chains **132, 133** carrying the mandrels is relatively slow so that sufficient time is available for the operator to strip the covering from the mandrel and to rewax the periphery thereof.

An important advantage of this apparatus is that it has eliminated necessity of keeping an extensive supply of molds for various size mandrels by using a common binder activating means operable on each independent casing. The binder activating means have adjustable pressure means and all the conveyors and apparatus elements are adjustable to accommodate various size mandrels for different size pipe coverings. In addition, other elements of the device, as hereinbefore described, are capable of individual timing and adjustment with respect to themselves and also with respect to other elements so that all may be mutually intertimed to coordinate movement. It is therefore necessary for any given diameter size of pipe coverings, with regard to the inside diameter, that there need only be a sufficient number of mandrels so that they may be properly interspaced on the blocks **138, 139** attached to the chains **132, 133**. This means that only a definite number of mandrels need be kept on hand since the mandrels will be constantly reused during the recycling while they follow the continuous pathway along the upper and lower turn of the conveyor chains **132, 133** in the direction of arrow **137**. The inside diameter may easily be adjusted by taking off one set of mandrels and placing on new mandrels of a different diameter and the machine need not be stopped during these size changes but merely retimed.

With regard to the outside diameter, or wall thickness, it is necessary to adjust certain of the mechanical means in order to coordinate their movement and to adjust the entire device along its length to control this outside diameter. For example, if it should be desired to increase the outside diameter, the interval between strokes of the knife at station B be lengthened so as to cut a greater length of material, the assumption being that the same sized mandrel is used. When this increase of material is used to increase the wall thickness, the forming roller **193** is lifted so as to assume a new position relative to the mandrel that is slightly greater than the outside periphery, by adjustment of cams **234, 235**; the ironing roller is raised by crank **273** so that it is still slightly greater than the desired final outside diameter; the temperature of the oven is lowered to a temperature sufficient to actuate the binder; the press mat **23** raised by adjustment of eccentric cams **322'** there being two, one at each end of the chain and the conveyors generally slowed up so that the same action of all the forces will result in an evenly baked and cylindrical pipe covering being transported for discharge to station F of the oven.

It is therefore seen that a continuous never-ending cycle of fibrous casing production is achieved where the individual steps are repeated in timed relationship with each other. All of the elements have been provided with suitable adjustable means novel in relationship, so that when either the inside diameter or the outside diameter are singularly or in combination increased or decreased, the operator, by experience, will use the various adjustments, set the proper position for each so that an even, all around article will be formed. At station F, through the spring release means described in the specification, by which the end **152** of the holding shaft **157** mounted on block **139** is inwardly biased against the mandrel **160**, the mandrels themselves are easily replaced when different sizes are desired to be used.

The apparatus for producing a cylindrical pipe covering or fibrous casing from an unending stream of flame blown filaments is as described a continuous and uninterrupted process whereby constant recycling of all the parts occurs so that there is no handling of the material throughout its path until it has arrived at the discharge station F of the device. The subsequent steps of sawing off the ends so as to smoothly form each end of the pipe covering, of gauging the tolerances of the outside diameter and conventional slitting may be performed by any suitable combination of elements either separate or by suitable conveyors connected to each other.

As previously brought out, when the fibrous conduit has passed through the forming oven **123** it is removed from the mandrel **160**, the ends are trimmed, and a longitudinal slot **373**, parallel to the longitudinal axis of the conduit, is formed completely through one wall. In order to facilitate spreading apart the conduit section a similar, aligned longitudinal slot **375** may be formed partially through the opposite wall of the conduit so that excessive effort will not be required to open the conduit section. Preferably, this second slot extends approximately three-quarters of the way through the thickness of the wall.

It has been found that when the fiber diameter is maintained between about 2½ to 3 microns, the resin content as measured by ignition loss between about 8 to 9%, and the density between about three to five pounds per cubic foot, the fibrous conduit has sufficient resiliency so that when opened, to surround a section of pipe to be insulated, the material will spring back to its original shape around the pipe. The exact reason as to why this occurs is not fully understood particularly having in mind the relatively low resin content of the conduit. However, it is believed to be due to a joint action of density, fiber diameter, and resin content which action in turn may be aided by the fact that in the preferred form of carrying out the method of the invention only an outermost skin or shell of the conduit is first cured by means of contact with the heated member **289**.

It should be additionally pointed out that by varying the speed of motor **169**, the speed at which the segment **119** is wrapped about mandrel **160** may be changed. The faster that the mandrel is rotated by this motor, the thinner a wall thickness is achieved and the tighter a wrap secured, the density of the mat being normally determined by the speed at which the fiber mat **18** is originally formed at station A. The forming unit therefore determines the weight of the mat and the density per cubic foot of the mat will remain substantially the same throughout the mat.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment of the same, but that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. In the formation of a generally cylindrical fibrous casing having substantially uniform thickness wherein said generally cylindrical fibrous casing is not confined within molds during the curing of the binder therein, the method comprising:

(*a*) forming on a mandrel a generally cylindrical fibrous casing of substantially uniform thickness imgregnated throughout with uncured heat-curable binder,

(*b*) applying sufficient heat to the peripheral surface of said fibrous casing by contacting said peripheral surface with a hot body to contact cure the binder immediately adjacent said peripheral surface to form a substantially rigid shell on said fibrous casing producing a fibrous casing of substantially uniform thickness on which said rigid shell provides a substantially cylindrical external periphery,

(*c*) separating said fibrous casing and said hot body,

(*d*) curing the binder in the remaining portions of said fibrous casing without confining the fibrous casing in a mold and while maintaining at least portions of the shell freely exposed, and

(*e*) relying upon said substantially rigid shell to maintain the external shape and the substantially uniform thickness of said fibrous casing during said curing of the binder in said remaining portions of said fibrous casing.

2. A method as defined in claim 1 wherein said contact curing comprises:

(*a*) compressing a longitudinal segment of the fibrous casing while simultaneously applying sufficient heat with said hot body to contact cure the binder immediately adjacent the peripheral surface of compressed segment, and

(*b*) progressively advancing said compression and heat application about the periphery of the fibrous casing to produce a fibrous casing of substantially uniform thickness having a substantially continuous rigid shell defining a generally cylindrical external periphery thereof.

3. A method as defined in claim 1 wherein said contact curing comprises:

(*a*) compressing said fibrous casing while effecting relative rolling movement between said fibrous casing and said hot body and producing a fibrous casing of substantially uniform thickness, and

(*b*) applying sufficient heat with said hot body to the peripheral surface of said fibrous casing during said relative rolling movement to contact cure the binder immediately adjacent said peripheral surface to form a substantially continuous rigid shell on said fibrous casing, defining the desired generally cylindrical periphery thereof.

4. Apparatus for use in the formation of a tubular fibrous casing from a segment of fibrous material impregnated throughout with a heat curable binder, comprising:

(*a*) A mandrel,

(*b*) means for wrapping said segment around said mandrel to form a tubular fibrous casing of substantially uniform thickness impregnated throughout with uncured heat-curable binder,

(*c*) means for contacting said tubular fibrous casing with a hot surface at a temperature sufficient to contact cure the binder immediately adjacent the external peripheral surface of said fibrous casing to form a tubular shape-retaining shell on said fibrous casing confining the remaining portions of said fibrous casing at its external periphery,

(*d*) means for disengaging said fibrous casing and said hot surface from contact with each other after effecting said contact cure, and

(*e*) means for curing the remaining binder in said fibrous casing while maintaining substantial portions of said peripheral surface freely exposed and relying primarily upon said shell to maintain the desired contour of the external periphery of said tubular fibrous casing.

5. Apparatus for use in the formation of a tubular fibrous casing from a segment of fibrous material impregnated throughout with a heat-curable binder, comprising:

(*a*) a mandrel,

(*b*) means for wrapping said segment around said mandrel to form a tubular fibrous casing of substantially uniform thickness impregnated throughout with uncured heat-curable binder,

(*c*) means for contacting said fibrous casing with a hot surface at a temperature sufficient to contact cure the binder immediately adjacent the external peripheral surface of said fibrous casing to form a tubular shape-retaining shell on said fibrous casing confining the remaining portions of said fibrous casing at its external periphery,

(*d*) means for establishing relative rotational movement between said peripheral surface of said fibrous casing and said hot surface,

(*e*) means for disengaging said fibrous casing and said hot surface from contact with each other after effecting said contact cure, and

(*f*) means for curing the remaining binder in said fibrous casing while maintaining substantial portions of said peripheral surface freely exposed and relying primarily upon said shell to maintain the desired contour of the external periphery of said tubular fibrous casing.

6. Apparatus for use in the formation of a tubular fibrous casing from a segment of fibrous material impregnated throughout with a heat-curable binder, comprising:

(*a*) a mandrel having a generally solid external peripheral surface,

(*b*) means for wrapping said segment around said mandrel to form a substantially cylindrical fibrous casing of substantially uniform thickness impregnated throughout with uncured heat-curable binder,

(*c*) means for contacting said fibrous casing with a hot surface at a temperature sufficient to contact cure the binder immediately adjacent the external peripheral surface of said fibrous casing to form a tubular shape-retaining shell on said fibrous casing confining the remaining portions of said fibrous casing at its external periphery and for applying pressure to said fibrous casing during the formation of said tubular shape-retaining shell,

(*d*) means for disengaging said fibrous casing and said hot surface from contact with each other after effecting said contact cure, and

(e) means for curing the remaining binder in said fibrous casing while maintaining substantial portions of said peripheral surface freely exposed and relying primarily upon said shell to maintain the desired contour of the external periphery of said tubular fibrous casing.

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