April 16, 1957 V. MAUCK ET AL 2,788,840

METHOD FOR PRODUCING PIPE COVERING AND THE LIKE

Filed Jan. 15, 1954 5 Sheets-Sheet 1

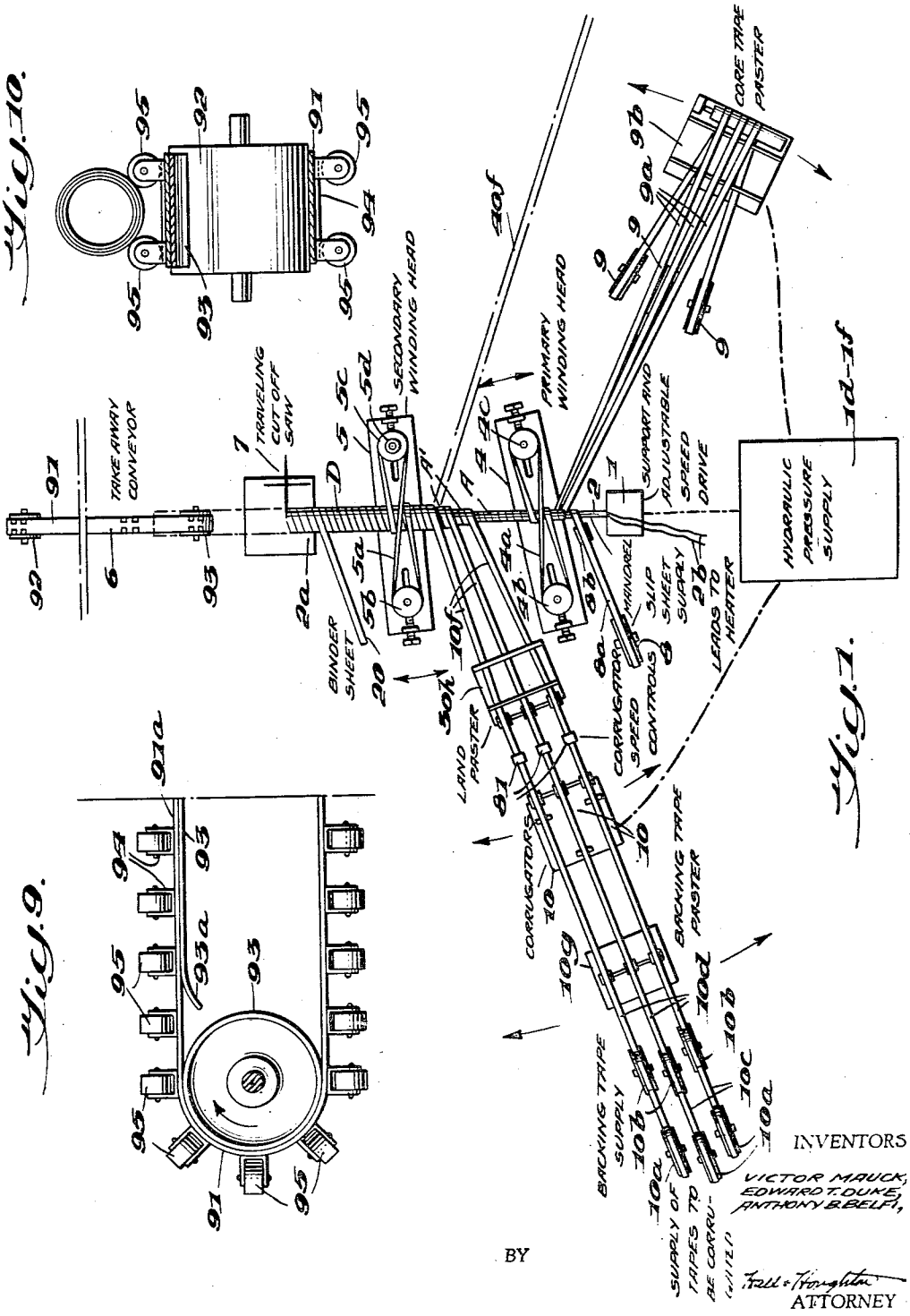


Fig. 10.

Fig. 9.

Fig. 1.

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METHOD FOR PRODUCING PIPE COVERING AND THE LIKE

Filed Jan. 15, 1954 5 Sheets-Sheet 2

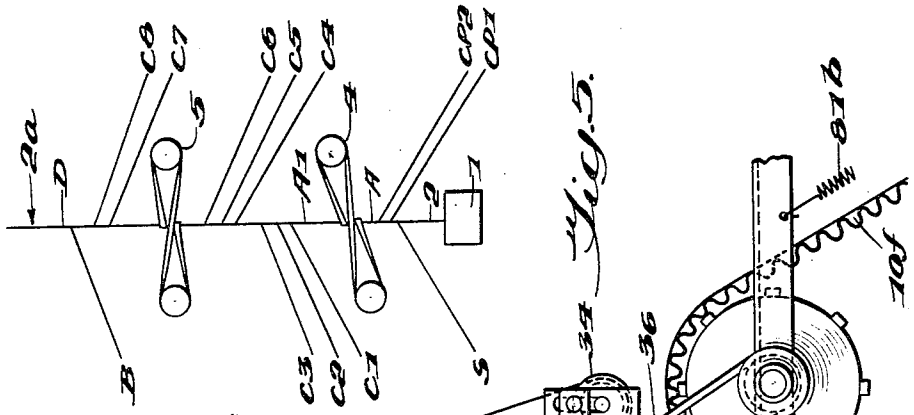


Fig. 1.

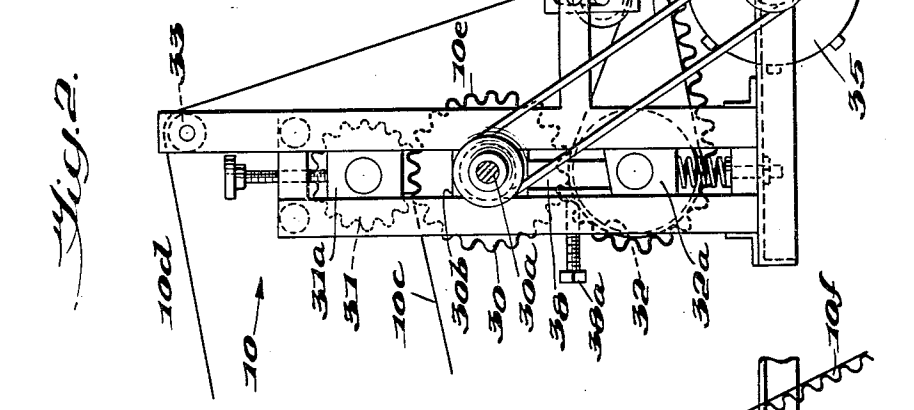


Fig. 2.

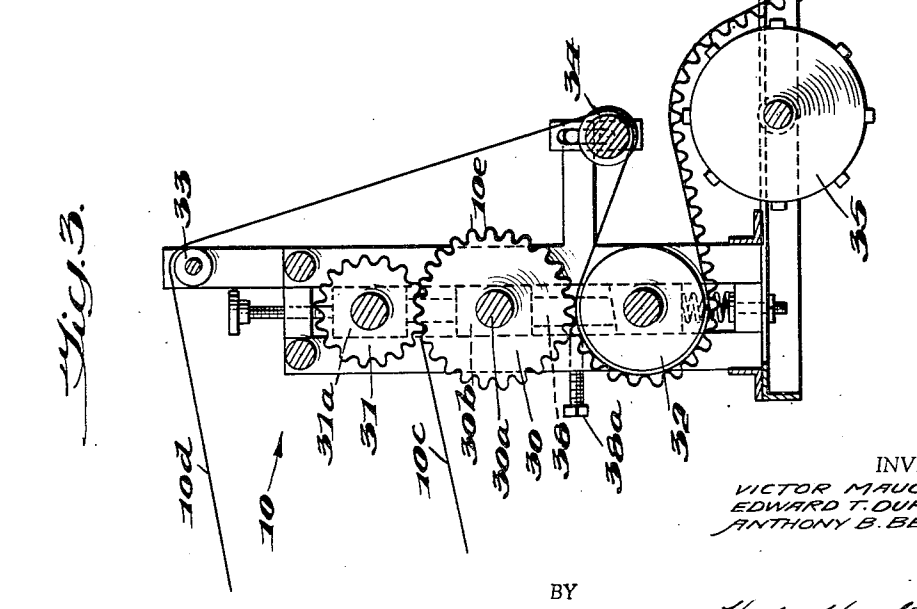


Fig. 3.

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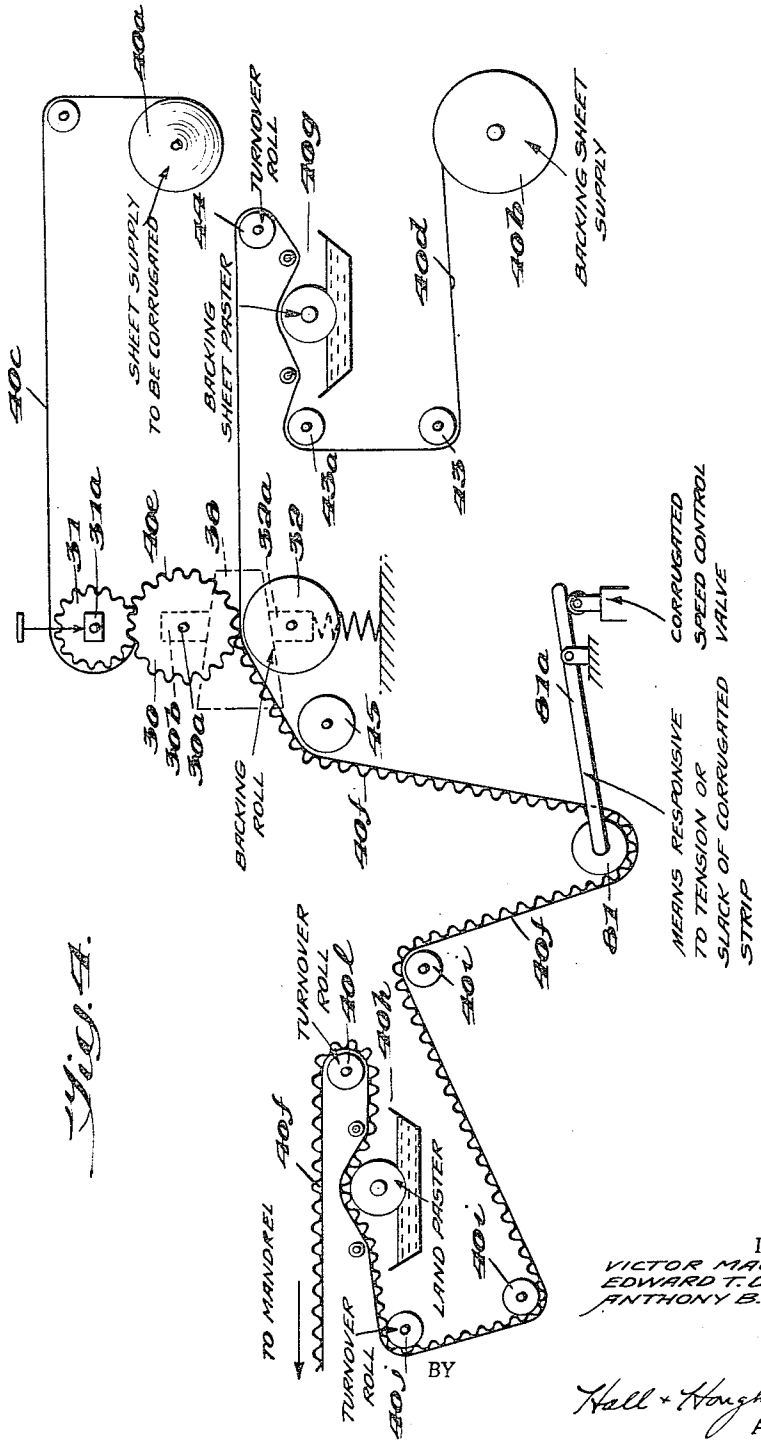


Fig. 4.

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METHOD FOR PRODUCING PIPE COVERING AND THE LIKE

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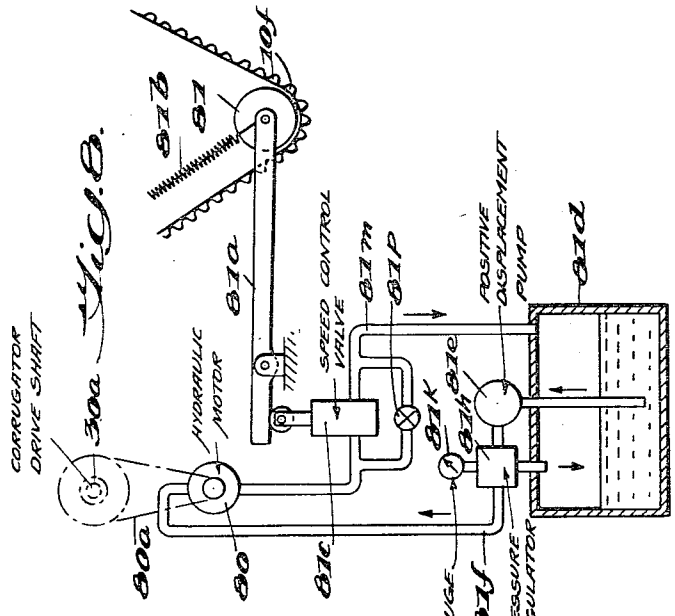


Fig. 8.

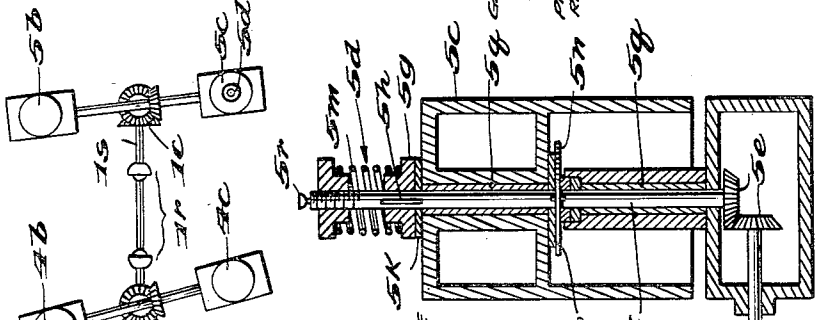


Fig. 7.

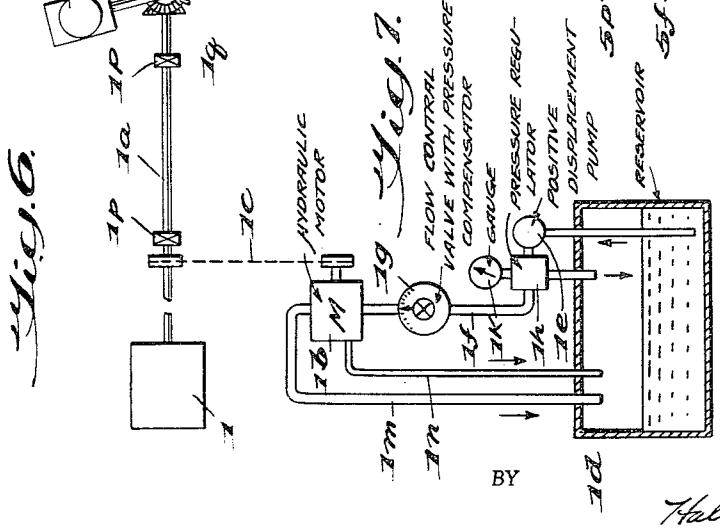


Fig. 6.

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METHOD FOR PRODUCING PIPE COVERING AND THE LIKE

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Fig. 11.

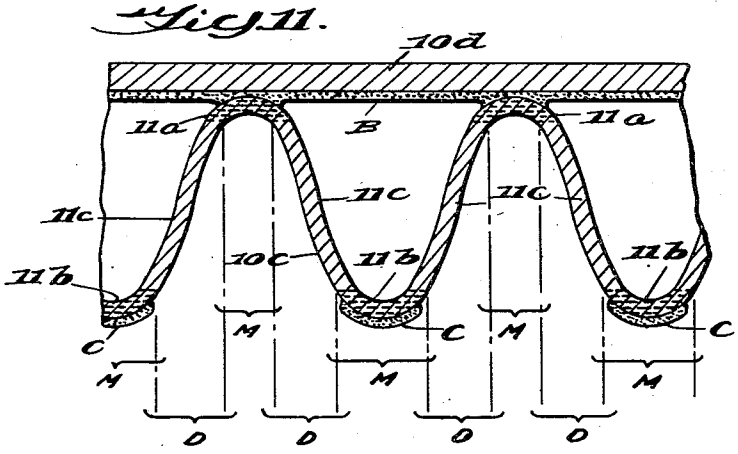


Fig. 12.

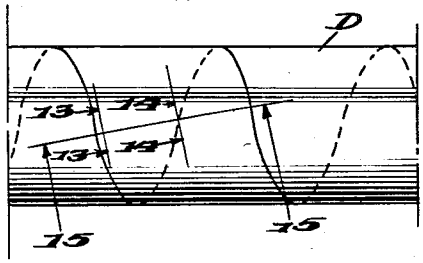


Fig. 13.

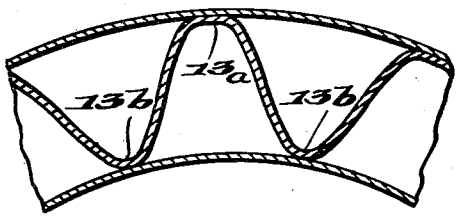


Fig. 14.

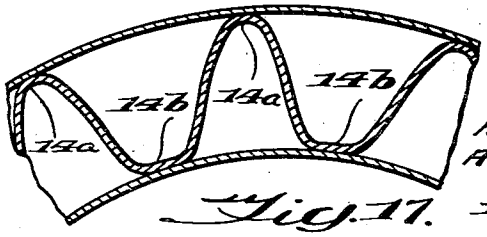


Fig. 15.

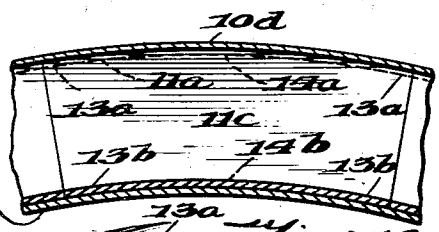


Fig. 16

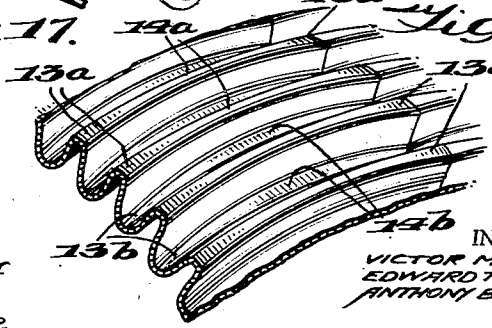
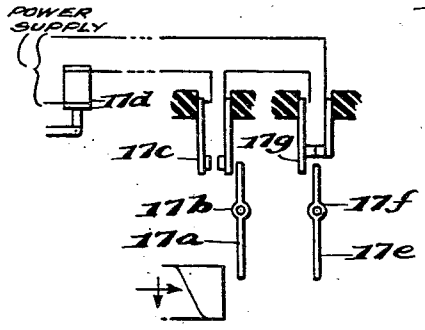


Fig. 17.



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United States Patent Office 2,788,840 Patented Apr. 16, 1957

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METHOD FOR PRODUCING PIPE COVERING AND THE LIKE

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Application January 15, 1954, Serial No. 404,322

11 Claims. (Cl. 154—28)

This invention relates to helically wound air cell pipe covering and aims to provide an improved product of this type and a novel method and apparatus particularly, but not exclusively, adapted for the production thereof. The claims herein have been restricted to the method aspects of the invention, the product and apparatus having been made the subject of a divisional application.

When an attempt is made to helically wind into a tube a strip of backed corrugated paper-board of asbestos or other material, with the corrugation thereof extending at an angle to the longitudinal axis of the tube, the inherent resistance of such corrugated material to bending in any direction other than parallel to its corrugations is met with. This resistance causes the corrugations of the strip to remain substantially straight and rigid like a lead pencil laid in contact with a cylindrical surface but at an oblique angle to the longitudinal axis thereof. Hence the edges of the corrugated strip lie at a greater radial distance from the tube axis than the central portions thereof and cause difficulty in producing a butt joint and also cause the butt joint regions to form in effect a raised rib extending helically about the tube, with the longitudinal cross-sections of the wrapped corrugated material exhibiting concave, or sway-backed, surface configurations between such ribs. This effect is not only unsightly, but it also interferes with the obtaining of good bonding between layers.

The problem presented is well known to those skilled in the art and although some patentees have overlooked it in proposing to so helically wind backed corrugated strip material, others have made certain proposals in an effort to avoid or overcome the difficulty. Some of these, e. g. Amesbury, in U. S. Patent 1,051,660 of January 28, 1913, and Muessman, in U. S. Patent 1,519,694 of December 16, 1924, have proposed arranging the corrugations diagonally of the longitudinal axis of the backed corrugated strip or tape, to position them parallel to the longitudinal axis of the tube, thus to avoid the difficulty. But such proposals present additional difficulties: for every different width of corrugated tape wound on a given radius there is a different angle of helical lead, and for every different radius of winding with the same width strip there is a different angle of helical lead; thus to take advantage of these proposals it is necessary to provide a different width of strip, or a different angularity of corrugations, for every different radius on which the strip is to be wound, if even a close approximation to longitudinal alignment of the corrugations is to be obtained. Beyond this is the difficulty of corrugating the material at an angle, or of cutting diagonal strips from sheet material corrugated at right angles to its length and splicing the same; and as a result of the several difficulties such proposals have not been commercially successful.

Another mode of procedure proposed for attempting to cope with the problem is that disclosed by Cumfer, in U. S. Patent 2,224,810. This proposal attempts to destroy

the resistance to bending of a corrugation along its length by breaking of the corrugation into short lengths as by knife or saw cuts or the like through its exposed lands and web portions in much the same manner in which carpenters kerf the back side of a stiff panel so it may be bent around a corner. But the added procedure is expensive and in addition partially destroys the strength of the corrugations, rendering the product less resistant to crushing for a given weight of material.

As a result of the shortcomings of the prior proposals for solving the problem of helical winding of corrugated strip material, the continuous production of air cell pipe covering by the helical winding of a corrugated strip has never become conventional in the art, and the conventional mode of producing air cell pipe coverings of corrugated sheet material still consists in the convolute spiral winding of short sheets of corrugated material, one at a time, typical examples of which are shown in the expired patents to Clarke 1,704,174 of March 5, 1929, and Deakin 2,051,076 of August 18, 1936, and in the patent to Fischer 2,235,630 of March 18, 1941. These methods are not only inherently slow, but they either do not produce truly cylindrical pipe coverings, or crush flat the corrugations at the end portions of the sheets in an effort to produce a more nearly cylindrical product, thereby reducing the insulating efficiency and increasing the weight and cost of the product. Moreover they do not offer any opportunity for the use of narrow edge trimmings resulting from the trimming to standard size of the asbestos or other paper sheet made by the paper-making machine, and hence do not have the economic advantage of utilizing otherwise non-salable material.

The present invention aims generally to overcome the disadvantage of present and previously proposed practices in this field, and has among its objects, severally and interdependently, the production of a better, cheaper and lighter, air cell, insulating, pipe covering than that produced by methods heretofore deemed practical by those skilled in the art; the production of a helically wound air cell tubular pipe covering from corrugated tapes or strips having their corrugations positioned at an oblique angle to the longitudinal axis of the tube and substantially intact, but nevertheless of substantially true cylindrical shape; the production of corrugated asbestos air cell pipe covering comprising less adhesive than that now produced by commercially conventional methods, and hence lighter and cheaper, but without any substantial sacrifice in strength; the provision of new method steps and combinations thereof to provide a feasible and commercially practical method for the continuous production of such tubing, some of which steps and combinations are also feasible for other purposes as well; and the provision of new elements and combinations of apparatus particularly, but not exclusively, adapted for the practice of the method and the production of the new product.

Other and more detailed objects and advantages of the invention will be evident from the following detailed description of illustrative embodiments of the several aspects of the invention.

The invention resides in the novel product, and in the novel features and combinations of the method and apparatus devised for its production, as herein described, and as more particularly defined in the appended claims.

In the accompanying drawings of illustrative embodiments of the invention,

Fig. 1 is a diagrammatic plan view showing the new arrangement of apparatus to carry out the new process and produce the new product.

Fig. 2 is a side elevation of a corrugator particularly adapted for employment in the arrangement of Fig. 1,

Fig. 3 is a vertical section through the corrugator of Fig. 2.

Fig. 4 is a diagram illustrating the arrangement for producing and feeding corrugated strip corrugated side up, to the tube winding machine of Fig. 1.

Fig. 5 is a diagram in plan illustrating a number of ways the various plys may be fed to the tube winding machine.

Fig. 6 is a diagram of the winding head drive of the winding machine coupled with a diagram of the adjustable speed hydraulic drive employed.

Fig. 7 is a vertical section through the driven roll of the secondary winding head of the winding machine, with the driving shafts and gears therefor in elevation.

Fig. 8 is a diagram of the variable speed hydraulic drive employed for each of the corrugators and of the means for automatically adjusting the corrugator speed to that of the winding machine.

Fig. 9 is a detail in longitudinal elevation of a part of the receiving and take away conveyor of Fig. 1.

Fig. 10 is a detail in longitudinal section thereof.

Fig. 11 is an exaggerated detail of the backed corrugated strip traveling from the corrugator and land paster to the winding head.

Fig. 12 is an elevation view of a portion of the new product.

Fig. 13 is a diagrammatic sectional detail taken on the line **13—13** of Fig. 12 adjacent an edge of a corrugated strip.

Fig. 14 is a similar detail taken on the line **14—14** of Fig. 12 adjacent the center line of the strip.

Fig. 15 is a similar detail taken on the line **15—15** of Fig. 12 parallel to the length of a corrugation.

Fig. 16 is a detail showing the alteration in the shapes of the adhesive moistened land portions of the corrugated strip, to the substantial exclusion of any collapse of the web portions thereof, effected by the method and apparatus exemplified in Fig. 1.

Fig. 17 is a diagram illustrating suitable controls for actuating the cut-off saw.

In the embodiment exemplified in Fig. 1, there is provided a tube winding machine comprising a support **1**, a stationary hollow cylindrical mandrel **2** extending therefrom to about the point **2***a* and tapering theretoward, and a more or less conventional or core-winding head **4** comprising a winding belt **4***a* trained about pulleys or drums **4***b* and **4***c* with one of its runs looped helically about the mandrel **2**, the drums **4***b* and **4***c* being laterally movable as shown to enable tensioning of the belt **4***a*, and one of the drums, herein the drum **4***c*, being driven by suitable gearing hereinafter described in connection with Figs. 6 and 7.

In spaced relation to the core winding head **4** the winding machine is provided with a secondary, or corrugated-ply winding head **5**, comprising a similar belt **5***a* trained on laterally movable pulleys **5***b* and **5***c*, one of which, the pulley **5***c* in the form shown, is driven by suitable gearing further described in connection with Figs. 6 and 7, through a friction clutch means **5***d*. The drive gearing and circumference of the pulley **5***c* are preferably so related to those of head **4** that during the winding of the plies wrapped on the tube by head **5** the friction clutch **5***d* is subjected to continuous slip as and for the purpose hereinafter described.

Spaced a substantial distance from the end of the mandrel at **2***a* is a take away conveyor means **6**, adapted to receive the rotating tubing as it is delivered from the mandrel. Between the end of the mandrel at **2***a* and the conveyor **6** there is located traveling cut-off means **7** shown as a cut-off saw adapted to swing through the rotating tubing and simultaneously move longitudinally therewith to cut a section of predetermined length therefrom, and to then retract out of the path of the tubing and move back toward the location **2***a* ready to cut the next measured section therefrom.

Referring to Figs. 1, 6 and 7 the drums **4***c* and **5***c* of winding heads **4** and **5** are driven from the main drive shaft **1***a* of the winding machine. This main shaft **1***a*, in the form shown in Fig. 6, is driven at adjustable speed by hydraulic motor means **1***b* that is preferably connected to drive shaft **1***a* by a chain and sprocket drive **1***c*. The hydraulic motor **1***b* is supplied with fluid drawn from a reservoir **1***d* by a suitable positive displacement pump **1***e* from which it is supplied to pressure line **1***f* that leads through a manual control valve **1***g* to the motor **1***b*. The pressure line **1***f* in the form shown is provided with a suitable relief valve **1***h* discharging back into the reservoir **1***d*, and with a suitable pressure gauge **1***k*, and the control valve **1***g* is conveniently a standard flow control valve with pressure compensator, by which the flow may be regulated to impart any desired speed to the hydraulic motor within the capacity of the pump **1***e*. The motor **1***b* discharges back to the reservoir **1***d* through return line **1***m*, and any leakage through the motor packings is returned to the reservoir through a suitable bleeder line **1***n*. By this arrangement the operator may control the speed of the motor **1***b* to impart any desired speed to the winding machine main shaft **1***a*.

The main drive shaft **1***a* is supported in suitable bearings **1***p* and carries a bevel gear **1***q* coupled for driving the drum **4***c* as hereinafter described. Beyond the gear **1***q* the drive shaft **1***a* is coupled through a universal connection **1***r* to a secondary drive shaft **1***s* for driving the drum **5***c* of the winding head **5**.

As shown in more detail in Fig. 7, the secondary drive shaft **1***s* drives the drum **5***c* through bevel gearing **1***t* coupling it to a vertical shaft, that is coupled to a splined or extensible shaft **1***u* by bevel gearing **1***v*, in turn coupled to the drum **5***c* by bevel gearing **5***e* and vertical drum shaft **5***f*, to which the driving element **5***g* of the friction clutch is splined at **5***h*. The driving element **5***g* bears on the drum **5***c* through a friction disc **5***k* of clutch lining or the like under the adjustable pressure of a spring **5***m*, and the shaft **5***f* also carries another disc **5***n* with clutch lining **5***p* bearing on the under side of the drum **5***c* thus affording an adjustable friction drive for the drum **5***c*. Suitable bearings **5***q* and lubricating provisions **5***r* are provided.

The drum **4***c* (Figs. 1 and 6) is driven from the bevel gear **1***q* through similar means except that the shaft corresponding to the shaft **5***f* is locked directly to drum **4***c* and not friction coupled thereto.

As above noted, the ratio of the driving gears, and the relative diameter of the drums **4***c* and **5***c* are such that the driving plate **5***g* of clutch **5***d* has an angular velocity that exceeds that permitted to the drum by the rate of rotation of the tubing established by the drum **4***c* and belt **4***a*, notwithstanding the increased diameter of the tubing by the addition of plies thereto between the two driving heads **4** and **5** (Fig. 1). Thus while the clutch **5***d* slips continually during the production of the tubing, it exerts a frictional traction that attempts to rotate and advance the tubing at a more rapid rate than that permitted by the drum **4***c* thus tending to tighten the helices. The portion of the tubing A between the two winding heads is thus put under circumferential and longitudinal tension regulated by the spring **5***m* (Fig.7), this tension being applied through the plies newly added through the secondary winding head, and this novel provision, and the employment of a stationary mandrel, insures against buckling of the tube between the winding heads and aids in carrying out the new method of applying the corrugated plies to the core.

As shown in Fig. 1, the hollow mandrel **2** is preferably provided with electrical heating means energized through leads **2***b* brought out through the supported end of the mandrel.

In the arrangement shown in Fig. 1, the apparatus includes a slip sheet supply reel **8** from which a slip sheet strip or tape **8***a* is drawn, passed in contact with a block of wax soap or the like **8***b*, and wrapped around the mandrel **2**, waxed side inwardly, to pass through the pri-

mary winding belt 4*a*. Also in the form shown, two or more reels 9 of core tape are provided, that deliver plain flat tapes 9*a* of asbestos or other paper to a paster 9*b* that moistens one side of each core tape with an adhesive such as sodium silicate solution. The tapes 9*a* after passing through the paster 9*b* are passed around the mandrel, with their adhesively coated faces inwardly directed, and are wrapped about the slip sheet strip 8*a* by the primary winding head to form the core tube A. The heating of the mandrel causes the wax carried by the slip sheet to act as a lubricant for the mandrel allowing the core A to rotate freely thereon, and also drives the moisture from the core strips 9*a* outwardly producing a partial set of the adhesive in the core A.

Still referring to Fig. 1, the apparatus therein shown further comprises a separate corrugator 10 for continuously supplying each strip of backed corrugated material to the winder, and preferably of the type described more fully hereinafter in connection with Fig. 2 and Fig. 3. Each corrugator 10 is fed from a reel 10*a* and a reel 10*b* with a strip or tape 10*c* of asbestos or other paper to be corrugated and with a similar strip 10*d* for backing the corrugated strip. As indicated in Fig. 1 several corrugators 10 may be carried by a single frame, but each corrugator unit 10 is separately driven by variable speed driving means hereinafter described in connection with Fig. 8, under a separate speed controller 81.

Turning now to Figs. 2 and 3, each dry strip 10*c* of asbestos paper or the like to be corrugated passes toward the winder between a main corrugating roll 30 and an auxiliary corrugating roll 31 and becomes a corrugated dry strip 10*e*, which is carried around by the corrugating roll 30 and passes between it and the smooth cylindrical backing roll 32. Each backing tape 10*d* (Fig. 1) passes through a paster 10*g* (Fig. 1) that moistens its under side with a suitable adhesive, such as sodium silicate solution. The adhesive moistened tape 10*d* then passes over turnover rolls 33 and 34 (Figs. 2 and 3) and enters between the corrugated tape 10*e* and the backing roll 32*h*, travelling away from the winder with its adhesively coated side facing the adjacent lands of the corrugated strip 10*e*, to which it adheres forming the composite backed corrugated strip 10*f*, which passes about the backing roll 32 and is delivered toward the winder over a delivering roll 35 that is driven from the corrugating roll by the driving belt 36. Each corrugator 10 is in turn driven by a separate variable speed drive, shown in Fig. 8 as a variable speed hydraulic motor 80 connected with the shaft 30*a* by a V-belt drive 80*a*.

Still referring to Figs. 2 and 3, the corrugator therein, as is preferred, embodies two other novel features contributing materially in providing a successful apparatus for the continuous process. In the first place, the bearing blocks 32*a* for the backing rolls 32 are spring-urged toward the fixed bearing blocks 30*f* of the corrugating roll 30 and the minimum clearance between these rolls is adjusted by wedge block 38 and adjusting screw 38*a*. The bearing blocks 31*a* of the auxiliary corrugating roll may be similarly mounted if desired. This provision is highly useful and automatically accommodates irregularities in the stock, and the extra thicknesses where the leading end of a new roll of tape is joined as by lapping and pasting to the trailing end of a nearly used roll to afford a continuous strip. In addition, at least the bearing blocks 30*b* for the main corrugating roll, are preferably provided, not with the usual bushing or friction bearings, but with antifriction bearings advantageously of the needle-bearing type. These provisions, which are not required in ordinary corrugators, are of peculiar utility in the present invention in which the composite tape 10*f*, while still moist, is placed under some tension and fed to the secondary winding head, as they prevent jumping of the tape apt to cause breakage thereof in its partially moistened condition.

Turning now to Figs. 2 and 8, each composite strip 10*f* delivered from the corrugator delivery roll 35 passes downwardly and then upwardly about a tension controlling means comprising a roller 81, that is carried by a power multiplying lever 81*a*, with part of its weight counterbalanced, as by the spring 81*b*. The lever 81*a* is pivoted on a suitable support, and as the roll 81 is raised, by the secondary winding head 5 (Fig. 1) drawing composite web 10*f* from the loop more rapidly than it is supplied thereto by the corrugator, the lever 81*a* increases the opening of the speed control valve 82, thus increasing the rate of driving of the corrugator shaft 30*a* by the hydraulic motor, and vice versa. The arrangement is preferably such that when the winding head 5 is stopped, a relatively short drop of the loop and roll 81 suffices to automatically stop the corrugator as well, and when the winding machine is restarted, a relatively short range of rise of the loop is sufficient to adjust the speed of the corrugator progressively to match any obtainable winder speed. As each corrugator is provided with a similar tension loop control, by this arrangement adjustment of the single control 1*g* (Fig. 6) by the operator serves to produce any desired change of speed of the tube winder and the corrugators automatically adjust their outputs to match the changed speed of the winder.

It will be noted that the corrugators 10 in Fig. 1, detailed in Figs. 2 and 3, deliver the composite backed corrugated strip 10*f* with its unbacked or open side downwardly positioned, and that in the arrangement shown in Fig. 1 these strips 10*f* are fed to the top side of the core A with the downwardly facing open lands of the first strip bearing on the core A, and with these of subsequently supplied strips each similarly bearing on the backing strip of the previously supplied strip A'.

Now ordinarily, when a corrugated strip is to be adhesively secured to sheets on each side of it, the practice is to apply adhesive, such as sodium silicate solution, to both sides of the strip to be corrugated, so that after corrugation it will adhere on both sides to the adjacent plain sheet. Such practice is avoided in the present invention, however, for several purposes that will be described more fully in connection with Figs. 11–17. Instead, as above described, it is the backing strip or tape that is pasted in forming the composite corrugated strip 10*f*, and as such strip is being passed to the winding head 5 (Fig. 1) the open lands only of the corrugated side of the strip 10*f* are moistened with adhesive, such as sodium silicate solution, by a paster herein termed a land paster 30*h* (similar to the paster 40*h* in Fig. 4) over which the strip 10*f* passes on its way from the tension loop to the winding head 5. Thus the backing strip and the lands of the corrugated strip facing the same are moistened and softened by the adhesive solution from paster 10*g*, and the open lands of the strip 10*f* are moistened and softened by the adheisve solution applied by the land paster 30*h*, and the composite tape is applied to the tube A (or A') by the winding head 5 while these conditions pertain and while the web portions of the corrugated strip 10*e* that have not been moistened by application of adhesive solution to them, remain relatively dry and stiff. A binder sheet or strip 20 of any desired surface characteristic, may be applied preferably between the winding head 5 and the end of the mandrel at 2*a*, with either flush points or lapped joints, depending on whether it is of the same or greater width than the underlying strips, such strips being supplied through a paster at either side of the machine.

The corrugator and paster arrangement 10, 30*h* thus far described delivers the backed corrugated strip 10*f* open face down, as noted, and in some instances, when not too many corrugated plies are being applied to the tube A, such arragements are all that are needed. But on occasion, as where a larger number of plies is being supplied to the winding head 5, or where other special requirements necessitate, one or more composite strips may be fed from the other side of the machine, corrugated side

up, to the under side of the tube being formed, as indicated at **40***f*, Fig. 1. In such case a different arrangement of the corrugating and pasting equipment is required that will now be described in connection with Fig. 4.

In Fig. 4, the dry sheet or strip to be corrugated, **40***c*, is supplied from a reel or roll **40***a*, and the backing strip **40***d* from a similar reel or roll **40***b*. In this case, however, the strip **40***c* is carried around the auxiliary corrugating roll **31** and travels backwardly away from the winding machine as it passes between it and the main corrugating roll **30**. The corrugated dry strip **40***e* then travels forwardly toward the winding machine as it passes between the corrugating roll **30** and the backing roll **32**, the arrangement of the corrugator otherwise being the same as in Figs. 2 and 3.

The backing sheet or strip in this instance passes, for convenience, over turnover rolls **43**, **43***a* before passing over the paster **40***g* in a direction leading away from the winder, and then over a turnover roll **44** to present its pasted side uppermost as it passes over the backing roll **32** toward the winder. The composite strip **40***f* passes over a driven delivery roll **45** (similar to roll **35**, Figs. 2 and 3) and forms a tension loop about the associated tension roller **81** as before, after which is passes over idler rolls **40***i* and turnover roll **40***j* and travels away from the winder as its open lands are moistened by the paster **40***h*. The composite strip with its backing strip and open lands pasted, is then passed over another turnover roll **40***l* from which it travels to the underside of the tube being formed, as shown in Fig. 1.

As shown in Fig. 8, each of the corrugators is driven by a separate hydraulic motor **80** under control of the speed control valve **82**. As shown in Fig. 8, the hydraulic motor **80** is supplied with pressure fluid by a positive displacement pump means **81***e* through a pressure line **81***f* provided with a by-pass valve **81***h* and a gauge, that may be similar to the corresponding parts in Fig. 7. In the form shown in Fig. 8, however, the pressure line **81***f* is connected directly to the hydraulic motor **80**, and the automatic speed control valve **81***c* is connected in the return line **81***m*, a manual valve **81***p* being provided in parallel with the valve **81***c* to facilitate running of the corrugator for threading up at the commencement of an operation, and for cleaning out at the conclusion of a work period. Bleeders, like **1***n* in Fig. 6, may also be provided.

Reference is now made to Figs. 11–17 illustrating how the present invention produces a substantially truly cylindrical pipe covering despite the fact that the corrugations therein are disposed at an oblique angle to the longitudinal axis of the tubing. As above described and shown in Fig. 11 to an enlarged scale, the adhesive solution B preferably of sodium silicate, that is applied to the backing strip **10***d* (or **41***d*) of asbestos paper or like somewhat absorbent material by the paster **10***g* (or **40***g*) moistens that sheet as indicated by the broken line convention, and when brought into contact with the adjacent land portions **11***a* of the corrugated dry somewhat absorbent strip **10***c* by the backing roll **32** also transmits moisture thereto as similarly indicated. The backing sheet **10***d* and the adjacent land portions **11***a* are thus rendered moist and somewhat softened. The subsequent application of the adhesive solution C by the paster **30***h* (or **40***h*) to the open or unbacked land portions **11***b* of the corrugated strip **10***c* similarly moistens and softens these land portions. However, the web portions **11***c* of the corrugated strip **10***c* to which no adhesive is directly or indirectly applied, remain relatively dry and stiff compared to the land portions **11***a* and **11***b*.

The composite strip or strips in the differentially moistened condition illustrated in Fig. 11 are then wound, by the winding belt **5***a* adjusted to proper tension, one on the underlying cylindrical core A (Figs. 1 and 15) and the others on the backing sheets A′ of the respective underlying ply (Fig. 15). Under these circumstances the softened open lands **11***b* (Fig. 11) are easily flattened and widened to a considerable degree near the longitudinal center line of the strip as indicated at **14***b* (Figs. 14, 15 and 17) the flattening and widening tapering off toward the edges of the strip as shown at **13***b* (Figs. 13, 15 and 17). At the same time, the softened backed lands **11***a* (Fig. 11) undergo a somewhat similar flattening, but in this case it is the portions of the lands **11***a* near the edges of the strip that flatten and widen the most, as shown at **13***a* (Figs. 13, 15 and 17) the flattening and widening tapering off toward the center line of the strip, as shown at **14***a* (Figs. 14, 15 and 17). And as the backing sheets **10***d* or A′ (Figs. 11 and 15) are also relatively moist and soft, they follow the curvature thus imparted to the covered lands **13***a*, **14***a* along line **15—15** Fig. 12 (see Fig. 15) and thus are brought into conformance with what to the eye, appears to be a substantially true cylindrical contour, as indicated at D in Fig. 12. But since the web portions **11***c* (Fig. 11) of the corrugated strip are relatively dry and stiff, they resist deformation and collapse to a greater extent than do the moistened parts of the composite strip and thus, the tension of the belt **5***a* being properly adjusted, maintain the composite strip against collapse, and impart sufficient strength to it to transmit to the core A the tractive force derived from the friction drive **5***d* (Figs. 1 and 7).

As above noted, by the time the core A reaches the secondary winding head **5** (Fig. 1) it has been substantially heated and stiffened by the heat from the mandrel **2**, the tractive force exerted on it between the two heads having also pulled its several helical tapes or strips down tightly together about the mandrel. Thus although the plies wrapped about the core are relatively soft and moist the formed tube has sufficient stiffness to support itself cantilever fashion over the intervening space between the end of the mandrel and the beginning of the conveyor **6** (Fig. 1). Furthermore, additional heat is supplied from the mandrel up to the point **2***a*, tending to drive the moisture toward the outside of the tube and further stiffens its core. Due to these factors, as the tube leaves the mandrel, it is in a state in which it can be severed into measured lengths by the traveling cut-off saw **7**, provided that saw is one capable of cutting material still wet with adhesive, and more particularly sodium silicate adhesive, without undue gumming. Such a cut-off saw that eliminates completely the problem of gumming, has been developed by Edward T. Duke, one of the co-inventors of the present improvements, and is more fully described in his copending sole application, Serial No. 426,183, filed April 28, 1954.

The cut-off saw carriage and actuating mechanism are preferably of a conventional type such as that manufactured by A. B. Belfi Co., of Philadelphia, Pa., and forms no part of the present invention.

In the Belfi cut-off saw a weight pulls the saw carriage lengthwise and a vacuum line is opened at the end of the saw travel to throw the saw back to its starting position, where it latches until released by a solenoid to again enter, and move lengthwise with, the stock being cut. To adapt such mechanism to the present process a dual switch device has been developed associated with the solenoid. In this device, as shown in Fig. 17, there is provided in the path of the leading end of the tube D advancing from the mandrel a first trip lever **17***a*, spaced from the entering plane of the saw by a distance corresponding to the length of tube to be cut. The lever **17***a* is arranged to be tilted by the tube about a pivot point **17***b* and closes a pair of contacts **17***c* when raised by the tube. The closing of the contacts **17***c* completes the circuit to the releasing solenoid **17***d* of the cut-off saw mechanism, starting the saw into the work at the proper point. As the saw completes its cut and is returned to its starting position in a distance much shorter than the tube length being cut, there is provided a short distance beyond the lever **17***a* a second lever **17***e* pivoted at **17***f* that opens a pair of nor-

mally closed contacts **17***g* connected in series with the contacts **17***c*. Thus just after the saw has been released by the circuit maker **17***a*—**17***c*, the circuit breaker **17***e*—**17***g* opens the circuit, so that the saw latch will be in condition to retain the saw against operation until the next section of tubing to be cut is measured.

Since the take-away conveyor is operated at a speed greater than the rate of advance of the tube D from the mandrel, as soon as a section is cut by the saw it begins to advance away from the remainder of the tube advancing from the mandrel, with the result that the severed portion passes out from under the lever **17***a* and opens the circuit maker contacts **17***c*, and then passes out from under the lever **17***e* and closes the circuit breaker contacts **17***g* without that section of tubing ever closing the solenoid circuit again, but leaving the elements in the relationship illustrated in Fig. 17 so that the solenoid circuit will again be closed when lever **17***a* is raised by the next measured length of tubing.

As above mentioned the take-away conveyor **6** is driven at a faster rate than that at which the tube is fed from the mandrel. In practice a rate 25% faster has been found satisfactory. Such a rate may be selected manually, or it may be maintained if desired, irrespective of variations in the speed of the winder, in any suitable way, for example, by driving the conveyor **6**, with proper gear ratio, from some convenient portion of the driving assembly connecting the motor **1***b* (Fig. 6) with the winding heads, for example, from the motor shaft, from chain **1***c*, or from the shafts **1***a* or **1***s*.

The take-away conveyor may be of any suitable form, but a particularly simple and satisfactory form is shown in Figs. 1, 9 and 10. In this form, the conveyor comprises a belt **91** trained about two pulleys **92** and **93**, one of which is power driven. The upper run of the belt **91***a* which moves away from the mandrel **2** is held level by an underlying shelf or plate **93**, preferably having down turned ends **93***a*. Attached to the belt at intervals of about every six inches or so along its lengths are transverse frames **94** supporting rollers **95** freely rotatable on longitudinally extending axles, these rollers being similar to conventional roller-skate wheels, preferably of the ball-bearing type, and preferably with rounded edges like those of conventional roller-skate wheels. The conveyor being mounted with its upper run about level with the lower surface of the tubing D being delivered from the mandrel, as the tubing advances, the rollers **95** rising about the pulley **93** contact the lower surfaces of the leading end of the tubing D and gently raise it, if it is sagging slightly, to alignment with the bed afforded by the rollers **95** on the upper run **91***a* of the belt, as illustrated in Fig. 10, the free rotation of the rollers allowing the tube D to rotate without hindrance. As more than half of the measured length of tubing to be cut is rolling in the bed thus afforded before the cut-off saw severs the section from the tube, there is no tendency of the cut section to tip backward off the conveyor. The cut sections may be removed from the conveyor manually or by any suitable mechanical means and are then preferably laid out straight on a level surface to dry and stiffen.

It has been noted that while the heated core of the tube is somewhat dried and stiffened, when inorganic adhesive such as sodium silicate solution is employed, the balance of the tube contains considerable moist adhesive, and moisture driven from the core area by the heating thereof, when it is cut into sections. This is important in the case especially of inorganic adhesives such as sodium silicate, in which too rapid a set of the adhesive produces an inferior product as regards strength, heat resistance, etc. When the severed sections of the tube are laid out to dry and stiffen, the moisture redistributes itself fairly evenly throughout the tube structure and the tubing seasons and dries slowly developing the full strength of the adhesive.

The tubes thus formed may, when desired, be split lengthwise in any suitable way, preferably with the binder strip and the adjacent backing strip left intact at one side of the tube or with other provisions to provide a hinge for the split unit. Such provisions per se are well known in connection with convolute wound pipe covering, and are described, for example, in Deakin's U. S. Patent No. 2,051,076 issued August 18, 1936, and form no part of the present invention.

Turning now to Figs. 1 and 5, it will be appreciated that many different arrangements of the equipment may be employed for feeding plies of different material and number to the winder in the making of products of different sizes and of different numbers of plies. As indicated in Fig. 5, one slip sheet ply S is generally employed, and this ply is usually made up of a single strip of appropriate width. Only a few core plies, e. g. CP1 and CP2, are usually applied ahead of the first winding head **4** and these are generally fed to the winder from the same side of the machine over a common paster appropriately oriented (compare pasters **30***h* and **40***h*, Figs. 1 and 4). When these plies pass directly through the winders without addition of other plies thereto, we still prefer to employ the secondary winding head **5** to apply tightening traction to the helically wound tube as above described.

Usually not more than six corrugated plies are added between the two winding heads. When not more than three such plies are added they are usually supplied from the same side of the machine, as exemplified at C1—C3 or C4—C6 in Fig. 5, and at **10***f* in Fig. 1. When four plies are thus added two are usually supplied from each side of the machine, etc. When more than six plies are employed, the additional plies are usually supplied between the second winding head **5** and the end of the mandrel at **2***a*, as is the binder strip B when used.

As indicated by the arrowed arcs and at **10***f* in Fig. 1, and by the divergence of the lines C1—C3, C4—C6, and C7—C8 in Fig. 5, the helical pitches of the winding belts **4***a* and **5***a* and the angles at which strips of ply-forming material are supplied to the winding machine must be adjusted generally in accordance with the widths of the strips and the diameters on which they are wound. Furthermore, the angularity of each strip relative to the longitudinal axis of the mandrel changes the effective width of a given strip, measured longitudinally of the mandrel. Hence, for each ply to form a completely butted joint, the several plies would have to be slightly increased in actual width in the order of their application to the tube. The difference is very slight in the case of thin plies such as the slip sheet and the core plies CP1 and CP2, and the strips for such plies are usually cut of equal width and wind with closely butted joints. When corrugated strips of the same width as the strips CP1 and CP2 are employed, however, after the first ply the effective width of each ply, parallel to the longitudinal axis of the tube, is slightly lessened because the strip is supplied thereto at a less oblique angle (see Fig. 1). Thus, if a number of corrugated strips of equal width are used, the helical joint in the first ply will be nearly closed, that in the second will be slightly more open, and the gap between the edges of the helically wound strips increases from ply to ply. When only a few corrugated plies are being used, this gap is inconsequential and the plies are usually all cut to the same width, and the gap in the outermost ply is covered with the binder tape sheet **20** (Fig. 1).

Where a large number of corrugated plies is being added, several of the strips, say C1—C3, may be of one width, the next group, say C4—C6, may be, say one-fourth inch wider, and the final group, say C7 and/or C8, may be of still greater width to produce substantially closed joints at the exterior of the tube D. When the binder strip **20** is employed, it is usually formed of quite thin stock, and of a width to produce a lap joint, prefer-

ably a hair-lap joint, and it thus aids and does not detract from the purely cylindrical effect obtained.

As above indicated, since the tubes according to the invention are formed from relatively narrow continuous strips, and as strips of different widths can be used, such strips can be cut from the inner margins of the selvedge trimmed from the edges of the wide paper sheets, such as asbestos paper sheets, as delivered from the paper making machine. In such machines the paper is generally made with considerable excess width, to provide for any unusual variation in selvedge contour, and hence a relatively wide selvedge trim is removed to reduce the sheet to standard width. Normally such trim has to be returned to the beaters for reprocessing through the machine, but large quantities of such selvedge trim material may be utilized for the purposes of the present invention without such reprocessing. Further economies of course are effected by the mode of pasting the backing ply, the pasters of course comprising the usual doctor blades, and by the mode of assembling the air cell tubing, which yield a product some 20% lighter than a convolute wound pipe covering of comparable size, and one which is a more efficient insulator.

While the machine, the core tensioning method, the hydraulic drive, the cut-off arrangement, the conveyor etc. are especially useful in combination with other steps and features with which they cooperate for the production of the new air cell tubing structure, particular elements and combinations of them, as noted, are also useful in other connections. For example, certain parts and features of the invention, such as the primary and secondary winding head sub-combination, are useful in the continuous formation of spiral tubing of plain asbestos tape, or of other materials of less strength than plain asbestos tape, such as creped asbestos tape, wool-felt tape, reinforced hair felt tape, glass fiber roving tape, felted glass fiber tape, polymerization setting adhesive impregnated glass fiber tape heated to initiate the set as applied or after winding, and such materials in combination with various core, intermediate, or finish plies of standard strength materials.

The hydraulic drives in combination with each other solve the very difficult problem of synchronization and other problems presented in the arrangement of Fig. 1, in a simple and efficient manner. Variable speed electrical drives can be synchronized only by expensive installations of electronic control equipment; variable speed belt drives such as the Reeves variable speed pulley type of drive, are irregular and uncertain in operation. With the hydraulic drives, all minor variations in speed requirements are met at once, and the desired power can be applied to each fluid motor as required. Further, the use of constant pressure as maintained by the relief valve, combined with flow control by valves of the metering or tapered spindle type, reduces the entire problem of synchronization to a mere matter of controlling the flow to maintain constant tension. And with the new combination it becomes a simple matter to slow down the entire operation, without stopping, to make splices of any of the several ply materials as a roll thereof becomes exhausted. This ability is of great practical utility, as it eliminates waste through the production of short ends or through the continued winding of defective tubing, and saves the time of shutting off the equipment, and clearing and restarting on a bare mandrel, and eliminates the problem of maintaining the mandrel heat in the proper range under such conditions.

While there have been described herein what are at present considered preferred embodiments of the invention, it will be obvious to those skilled in the art that many modifications and changes may be made therein without departing from the essence of the invention. It is therefore to be understood that the exemplary embodiments are illustrative and not restrictive of the invention, the scope of which is defined in the appended claims, and that all modifications that come within the meaning and range of equivalency of the claims are intended to be included therein.

We claim:

1. A continuous process for the manufacture of corrugated tubing that comprises (*a*) corrugating a dry strip of sheet material, (*b*) moistening one side of a backing strip with adhesive and applying said adhesively moistened side to the lands of the corrugations on one side of the corrugated dry strip to cover the same, (*c*) moistening the land portions only of the uncovered side of the corrugated strip with adhesive, and (*d*) winding the resulting composite strip spirally to form a tube while the backing strip and the land portions only of the corrugated strip are relatively moist and soft and while the web portions of the corrugated strip are relatively dry and stiff, whereby the moistened lands are progressively flattened between the central and edge portions of the composite strip to conform to a cylindrical contour.

2. A continuous process for the manufacture of corrugated tubing that comprises (*a*) corrugating a dry strip of sheet material, (*b*) moistening one side of a backing strip with adhesive and applying said adhesively moistened side to the lands of the corrugations on one side of the corrugated dry strip to cover and moisten the same, (*c*) moistening the land portions only of the uncovered side of the corrugated strip with adhesive, and (*d*) spirally winding the resulting composite strip while the backing strip and covered and uncovered lands of the corrugated strip are relatively moist and soft and while the web portions of the corrugated strip are relatively dry and stiff with a separate flexible strip breaking joints therewith and contacting the uncovered side thereof, whereby the moistened lands are progressively flattened between the central and edge portions of the composite strip to conform to a cylindrical contour.

3. A continuous process for the manufacture of corrugated tubing that comprises (*a*) spirally winding at least two core forming strips in partially overlapping relation with adhesive applied to one of the contacting surfaces thereof to form a tubular core, (*b*) corrugating a plurality of dry strips of sheet material, (*c*) moistening one side of a backing strip for each corrugated strip with an adhesive and applying the adhesively moistened side of the backing strip to the lands on one side of its corrugated strip to cover the same, (*d*) moistening with adhesive the land portions only of the uncovered sides of the corrugated dry strips, (*e*) and spirally winding the resultant composite strips while the backing strips and covered and uncovered lands thereof are relatively moist and soft and the web portions of the corrugated strips thereof are relatively dry and stiff, one on the tubular core with its adhesively moistened uncovered lands bearing on said core, and others in sequence each with its adhesively moistened uncovered lands bearing on the backing sheet of the preceding composite layer, whereby the moistened lands are progressively flattened between the central and edge portions of the composite strip to conform to a cylindrical contour.

4. A continuous process for the manufacture of corrugated air cell asbestos tubing that comprises (*a*) corrugating a dry strip of water absorbent asbestos paper, (*b*) moistening one side of a flat strip of water absorbent asbestos paper with sodium silicate solution and applying said moistened side to the lands of the corrugations on one side of the corrugated dry strip to adhere thereto and moisten the land portions thereof on the so covered side of the corrugated strip, (*c*) moistening the other land portions only of the corrugated strip with sodium silicate solution, (*d*) winding the resultant composite strips spirally under gentle cylinderizing pressure while the backing strip and land portions only of the corrugated strips are softened by the solution and while the web portions of the corrugated strip are relatively dry and stiff so that the backing strip and land portions only

of the corrugated strip are warped to produce a substantially smooth cylindrically shaped tube while collapse of the corrugated sheet is prevented by the relatively dry web portion thereof, and (*e*) drying the so formed tube.

5. A continuous process for the manufacture of corrugated air cell asbestos tubing according to claim 4, in which the drying of the tube is initiated by internally heating the tube during the winding and cylinderizing thereof.

6. A continuous process for the manufacture of corrugated air cell asbestos tubing that comprises (*a*) spirally winding and longitudinally advancing at a set rate at least two core forming strips of sheet material in partially overlapping relation with an adhesive solution applied to one of the contacting surfaces thereof to form a tubular core and heating the core as it is wound to stiffen the same, (*b*) simultaneously corrugating a plurality of dry strips of absorbent asbestos paper, (*c*) moistening with an adhesive solution one side of a backing strip of absorbent asbestos paper for each corrugated strip and applying the so moistened side to the lands on one side of its corrugated strip to cover the same, (*d*) moistening with adhesive solution the land portions only of the uncovered sides of the corrugated dry strips, (*e*) spirally winding the resultant composite strips, while the backing strips and covered and uncovered lands thereof are relatively moist and soft and while the web portions thereof are relatively dry and stiff, one on the tubular core with its moistened uncovered lands bearing on the core and the others in sequence thereon each with its moistened uncovered lands bearing on the backing of the underlying composite strip, under gentle tension and pressure sufficient to warp the moistened land portions and backing strips to substantially cylindrical form but insufficient to collapse the relatively stiff web portions of the corrugated strips, and (*f*) drying the resulting air cell tubing.

7. A process according to claim 6, further including the step of cutting the formed tube into sections while it is being longitudinally advanced and while it is still moist.

8. A process according to claim 6 in which a hanging loop is formed in each composite strip being fed to the core, in spaced relation to the core, and in which the rate of production of the composite strip is controlled in response to the depth of the hanging loop to maintain a substantially fixed gentle tension on the composite strip.

9. A process according to claim 6 in which the rate of production of each composite strip is continuously regulated to maintain a substantially constant tension therein as it is fed to the core.

10. A process according to claim 8, in which the tension in the composite strips being fed to the core is offset by winding the same on the core under gentle limited traction exerted in the direction tending to wind the strips on the core and feed the resulting tubing longitudinally at a rate greater than the set rate of winding and feeding of the core, and thereby tending to stretch and tighten the core.

11. In the forming of air cell tubing by the winding of strips of corrugated material spirally about a cylindrical surface with the corrugations thereof extending at an angle to the length of such surface; the method of obtaining a cylindrical conformation despite the tendency of the ends of the corrugations to stand up from the surface on which the strip is being helically wound, that comprises moistening the lands only of such corrugations to soften the same to the exclusion of the web portions of such corrugations, spirally winding and pressing the corrugated strip against the surface with the corrugations thereof extending diagonally relative to the length of such surface while such land portions are moist and soft and thus bendable at their central and end regions to conform to a cylindrical contour and while such web portions are relatively dry and stiff to prevent collapse of said corrugations, and thereafter drying the resulting curved corrugations.

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