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METHOD AND APPARATUS FOR WINDING COLLAPSIBLE TUBING

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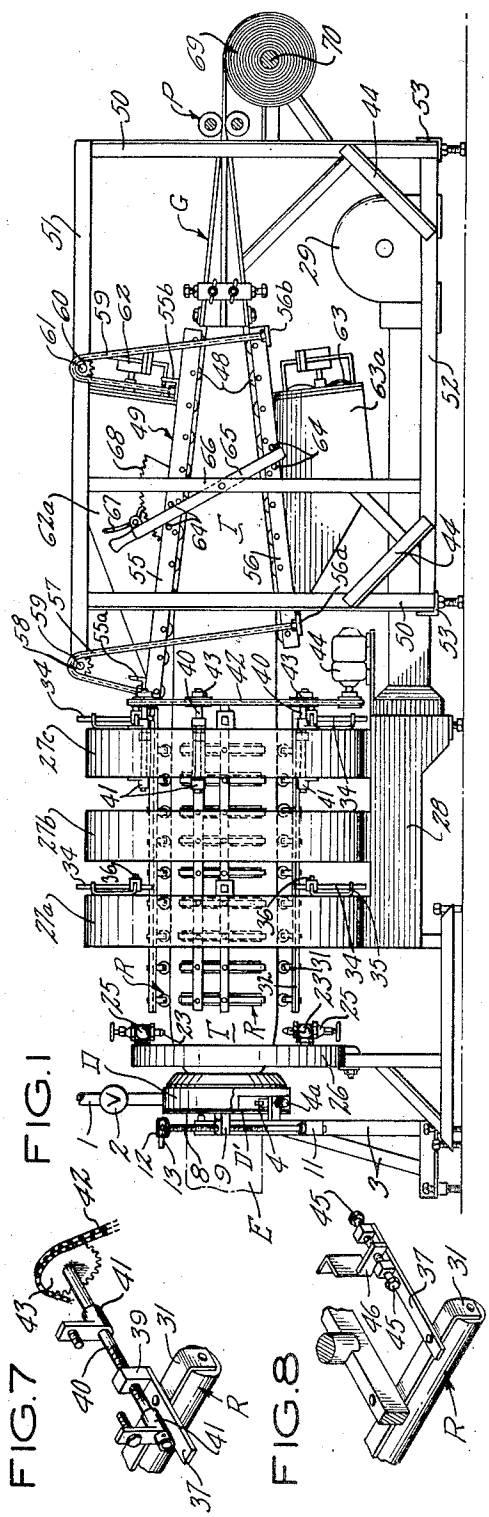


FIG. 1

FIG. 7

FIG. 8

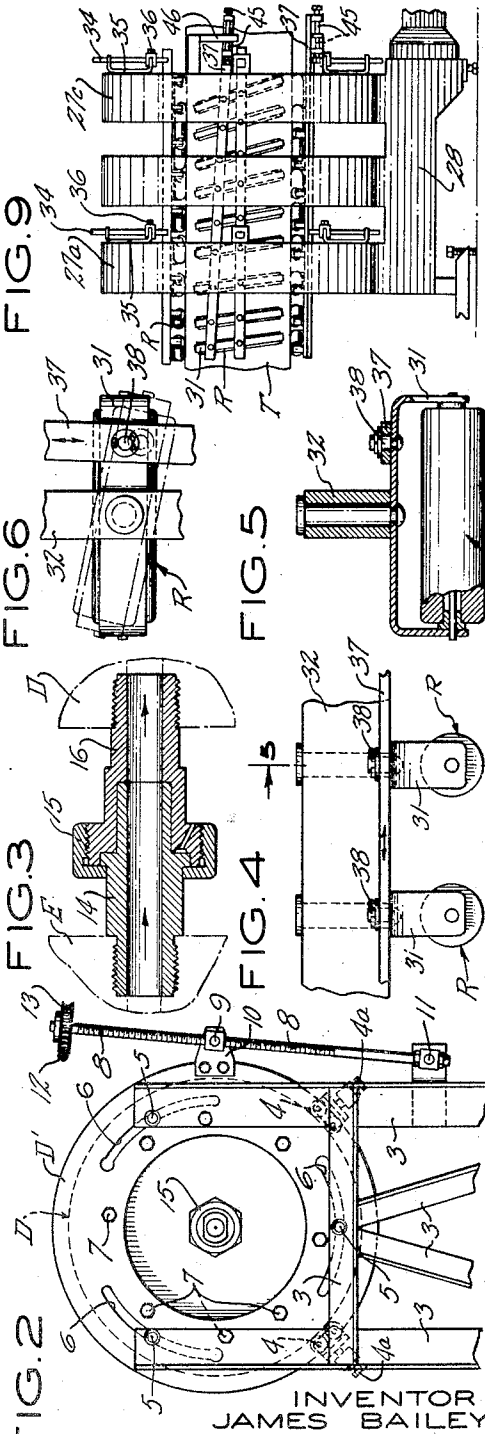


FIG. 2

FIG. 9

FIG. 6

FIG. 5

FIG. 3

FIG. 4

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METHOD AND APPARATUS FOR WINDING COLLAPSIBLE TUBING

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The present invention relates to the manufacture of thin wall tubing from resinous materials and provides improvements in the methods and apparatus disclosed in U. S. Patent 2,559,386, issued July 3, 1951, to the present inventor.

There is a large demand in the packaging and related fields for flexible plastic tubing having a wall thickness of a few thousandths of an inch and in widths, when collapsed, ranging from a few inches to several feet. Considerable difficulty has been experienced in the past in supplying this demand and, in particular, in satisfying the close tolerance requirements which includes holding to uniform thickness and to uniform collapsed or layflat width. The above-mentioned patent discloses satisfactory practices for manufacturing such tubing.

The process of the invention there disclosed generally comprises extruding a hot, thin-wall plastic tubing, controlling the temperature of the tubing, expanding the tubing into contact with sizing rolls tangentially disposed in a series of spaced circles concentric with the tubing and cooling, setting and collapsing the sized tubing in a continuous operation. The sizing rolls are freely rotatable so that as they receive the tubing in a plastic condition and under a slight inflating pressure from the extrusion nozzle, there is no sliding action between the rolls and the tubing and a substantially frictionless sizing contact is maintained.

The rolls are located at spaced intervals in a circle about the tubing, the position of the rolls being adjustable so as to vary the size and shape to which the tube is inflated. A series of such rings or circles of rolls are provided at spaced intervals so as to provide frictionless sizing and shaping restraint for the tubing until it has cooled and set against further plastic deformation by the inflating pressure.

Each ring of rolls may define the same shaping passageway for the tubing, or the several rings may define successively larger or smaller openings so as to provide for a gradual increase or decrease in the size of the tubing to a final size and shape.

Thereafter the tubing is collapsed by converging boards or series of rollers, or a combination of the two, and the collapsed tubing wound on rolls for subsequent use.

It has been found that if tubing is manufactured in the described manner and with the apparatus mentioned, any variations in thickness generally occur along the same longitudinal elements of the tubing and build up in ridges and valleys on the stock roll. This may produce undesired stretching and deformation of the tubing as well as making for irregularity which is unsightly in the roll of finished tubing.

It is an object of the present invention to provide smoothly regular rolls of tubing in which undesirable ridges and valleys are avoided.

More specifically, it is an object to provide improved method and apparatus of the type indicated with which such thick and thin streaks as may be formed in the tubing are distributed along the roll rather than permitting them to wind on top of each other in successive layers.

In accordance with the invention, the tubing is rotated or oscillated slight amounts about its axis during formation so that thick and thin elements of the tubing are not always collapsed and wound in the same positions relative to each other and to the roll on which the collapsed tubing is wound. The oscillation or rotation may be effected intermittently or continuously and in a variety of

ways and by various means such as oscillating the extrusion die about its axis and by slightly skewing the sizing rolls or the collapsing rolls from perpendicular to the axis of the tubing so as to give the tubing a slight rotation about its axis and cause it to collapse along different elements relative to the die or nozzle.

Other and more detailed objects and advantages of the invention will be apparent to those skilled in the art from the following description of the several embodiments of the invention shown in the accompanying drawings in which:

Figure 1 is a side elevation of apparatus for producing layflat tubing in accordance with the invention;

Fig. 2 is an enlarged view, taken from the left of Fig. 1, of an extrusion nozzle and adjustment means embodying features of the invention;

Fig. 3 is an enlarged view in longitudinal cross-section of a portion of Fig. 1 showing the rotary connection between the extruder and nozzle;

Fig. 4 is an enlarged view of a portion of one of the roller assemblies shown in Fig. 1 illustrating an adjustment feature;

Fig. 5 is a cross-sectional view taken on line 5—5 of Fig. 4;

Fig. 6 is a plan view of the roller shown in Fig. 5, an adjusted position of the roller being shown in phantom;

Fig. 7 is an enlarged perspective view of a portion of adjustment mechanism shown in Fig. 1;

Fig. 8 is a perspective view of a modification of the mechanism shown in Fig. 7; and

Fig. 9 is a view of another embodiment of the sizing roll assembly of Fig. 1.

Referring to Fig. 1 of the drawing, the illustrated embodiment of the present invention generally includes a tubing die D from which a thin wall tubing T may be continuously extruded. A suitable extruder mechanism, which is fragmentarily shown in phantom at E, and which may include heating, homogenizing, and pressure producing parts or components, is provided for forcing a plastic material, such as polyethylene, through the die D under proper extrusion conditions of temperature, pressure and homogeneity.

Extending into the die D is a pressure line 1 controlled by a valve 2 through which a suitable fluid as, for example, air is introduced to maintain a desired pressure within the tubing T and expand it to a desired diameter.

In accordance with the present invention, provision is made for rotating or oscillating the die D about its axis through an arc and relative to the extruder E and tube sizing and collapsing mechanism, which will be hereinafter described. Fig. 2 illustrates an embodiment of a suitable mounting for the oscillatable die. There are provided suitable die supporting frame members 3 to which are secured spaced roller bearings 4 on which the periphery of the die D is rotatably supported.

In order to effect alignment of the die D with the bore of the extruder E, the die supporting bearings 4 are provided with adjustment screws 4*a*.

The die D is further supported by bolts 5 which extend through arcuate slots 6 in a die plate D' which is fastened to the die D by bolts 7. The bolts 5 may be tightened in any desired position of adjustment of the die and may be eased so that the die may be continually or intermittently oscillated during the production of the tubing T. It will be apparent that antifriction bearings may be placed between the frame members 3 and the die plate D' to facilitate easy periodic oscillatory adjustment of the die, as well as continuous oscillation thereof, if the latter is desired. The oscillation of the die D is readily effected by means of a threaded rod 8 which carries a traveling nut 9 swivel-mounted to a bracket 10 fastened on the die plate D'. One end of the rod 8 is rotatably journaled in another swivel bearing 11 secured to the frame 3 and is rotated to adjust or oscillate the die D by a worm 12 and worm gear 13 fastened to its other end. The worm may, of course, be hand driven to effect manual adjustment or may be driven by a reversing motor so that a preselected desirable intermittent or continuous repetitive oscillation is imparted to the lie D.

As shown in Fig. 3, the connection between the ex-

truder E and the die D provides for relative rotary or oscillatory movement therebetween about their common axis. The connection includes a flanged nipple 14 which is fastened to the extruder E and rotatably secured by a threaded and flanged coupling sleeve 15 in a conforming bore of a nipple 16 which is fastened to the die so that plastic flows, as shown by the direction of the arrows, without interruption or leakage from the extruder E, through the connecting nipples 14 and 16, into the tubing die D while the die is being oscillated.

The tubing T issuing from the die D is air cooled as it passes through a ring or circle of fishtail, gas-burner type jet nozzles 23 which are mounted on a circular manifold 26. Manually operable needle valves 25 individually control the cooling air supplied to the nozzles 23 from the manifolds 26 which are connected to a compressed air supply (not shown).

While for simplicity of illustration only two of the nozzles are shown in the drawings, in actual practice a much larger number, as for example twenty, are provided at equally spaced intervals about the manifold ring 26. The air from the nozzles 23 reduces the temperature and, consequently, the plasticity of the extruded tubing. Differential regulation of the several jet nozzles serves to control uniformity of thickness of the blown tubing. Thus, when the tubing is blowing up unevenly and a thin streak develops, a little more air from the jet nozzles 23 overlying this particular streak gives additional chilling to that portion of the tubing. The additional chilling reduces expansion and thinning of the underlying portion and greater uniformity of thickness is obtained.

The tubing T next passes through a series of three annular wind boxes 27*a*, 27*b*, 27*c* which direct cooling air against the tubing. The several wind boxes 27*a*, 27*b*, 27*c* are supplied with air under pressure of a few inches of water from a common manifold 28 and blower 29. The air thus supplied to the wind boxes is discharged into contact with the tubing T through a series of openings (not shown) which are located at spaced intervals in the inner peripheral wall of each wind box.

A series of freely rotatable rollers R are provided to support and control the size of the tubing. The rollers R are arranged transversely of and tangentially to the periphery of the tubing so as to be tangent thereto at spaced intervals and limit the diameter to which the tubing is blown.

The rollers R are rotatably mounted at their ends in individual U-shaped bearing brackets or yokes 31 which are secured at their centers to mounting bars 32. Each of the mounting bars 32 is adjustably secured at spaced points to the inner end of its own pair of supporting rods 34 which extend radially from the tubing T. The rods 34 are slidably supported in individual bearing brackets 35 which as shown in the drawings are secured to the wind boxes 27*a* and 27*c*. As thus supported, the rods 34 may be moved radially inward or outward to enlarge or decrease the shape of the passageway defined by each of the several rings of rollers R. Each of the rods 34 is provided with an adjustable fastener 36 for locking the rod in a desired position of adjustment.

Provision may also be made for longitudinally adjusting each of the mounting bars 32 relative to its supporting rods 34, as by means of a slot and bolt connection (not shown) between the inner end of each rod 34 and its mounting bar 32.

In accordance with the invention, means are provided for skewing the rollers R slightly from their normal positions at right angles to the axis of the tubing T so as to impart a slight rotary movement or twist to the tubing about its axis as it passes through the sizing roller assembly. As shown in Figs. 1, 4, 5 and 6, the roller yokes 31 are swivel mounted to their supporting bars 32. Spaced from each of the bars 32 is an adjustment bar 37 which is pivotally secured by pins 38 to each roller yoke 31 carried by the associated bar 32. It will be seen that longitudinal movement of the adjustment bars 37 skews the rollers R relative to their normal positions which is at right angles to the axis of the tubing T.

The longitudinal adjustment movement of the rods 37 may be continuously or intermittently effected. Fig. 7 shows rod reciprocating mechanism which includes a traveling nut 39 that is fastened to the rod 37 and that is carried on a threaded shaft 40 journaled in fixed bearings 41 and rotated by a chain 42 which engages a sprocket 43 pinned or otherwise secured to the shaft 40. As shown in Fig. 1, the chain 42 engages all of the sprocket 43 on four threaded adjustment shafts 40 and is driven by a reversing motor drive 44 so that all four adjustment bars 37 are simultaneously reciprocated equal amounts in the same direction. However, the front bar 37 of Fig. 1 is above its associated bar 32 whereas the diametrically opposite one to the rear of the view is below its associated bar 32 and the upper and lower bars 37 are similarly disposed relative to their associated bars 32 so that diametrically opposite rollers R are skewed in opposite directions and their twisting effect on the tubing T about its axis is additive rather than offsetting or counter to each other.

Fig. 8 illustrates a manually operative modification of the roll skewing adjustment mechanism wherein the rod 37 has a pair of opposing adjustment screws 45 engageable with opposite sides of a fixed stop 46 for moving the rod 37 longitudinally in either direction. Like manual adjustment means may be provided for each of the rods 37 and thus provide means for varying the adjustment of each row of rollers R.

Each rod 37 shown in Fig. 1 is parallel with its associated roller supporting bar 32 so that all of the rollers supported by a particular rod are skewed like amounts and remain parallel in every position of adjustment. However, it should be understood that the present invention contemplates skewing successive rings of rollers R differing amounts. Fig. 9 shows an embodiment wherein the adjustment bars 37 are angularly disposed to their associated bars 32 so that the amount of skewing is progressively greater for each successive ring of rollers R in the direction of travel of the tubing T. The invention also contemplates imparting a twisting motion to the tubing by other means as, for example, arcuately rotating the wind boxes 27*a* and 27*c* on which the rollers R are mounted so that the tubing T rotates with the rollers R about its axis. It will be understood that the rings of rollers R may be individually rotated rather than as an entire assembly by mounting each ring of rollers R on its own individually rotatable mounting ring.

After passing through the wind boxes 27*a*, 27*b*, 27*c* and the frictionless restraining passageway defined by the rollers R, the tubing T is partially collapsed by a roller assembly, which includes a series of rollers 48 located transversely of the tubing along two converging lines above and below the tubing.

The tube collapsing roller assembly includes a frame, generally designated 49, having vertical corner posts 50 secured in spaced relationship by upper and lower longitudinal frame members 51 and 52 and by transverse spacing members 53. Corner braces 44 give the frame necessary rigidity. The rollers 48 are journaled at their ends in pairs of upper and lower longitudinal frame members 55 and 56, respectively, the upper pair of frame members 55 being secured in proper spaced relation by fore and aft transverse members 55*a* and 55*b* and the lower pair of frame members 56 being similarly secured by fore and aft transverse members 56*a* and 56*b*. The forward end of the roller frames 55 and 56 are supported by the ends of chains 57, the latter being supported by sprockets 58 secured at ends of a shaft 59 rotatably mounted in the forward ends of the members 51. Clockwise rotation (Fig. 1) of the sprockets 58 operates chains 57, so as to raise the forward end of the upper roller frame 55 and simultaneously lower the forward end of the lower roller frame 56 so as to enlarge the distance of the frame members 55 and 56 from the center line of the tubing T a like amount. As is apparent from the drawings, counter-clockwise rotation of the sprocket 58 reduces the distance between the upper and lower roller frame members 55 and 56 a like amount above and below the center line of the tubing T.

The aft ends of the frame members 55 and 56 are similarly supported and their positions adjusted by chains 59 which engage sprockets 60 secured to the ends of a transverse shaft 61 rotatably journaled in the longitudinal frame members 51.

In order to assure sufficient cooling of the tubing and thus prevent sticking to the rollers 48, additional cooling is provided by like upper and lower blowers 62 and 63 which, respectively, are mounted on the upper and lower frames 55 and 56 and the air from which is directed by suitable ducts 62*a* and 63*a* towards both upstream banks

of upper and lower rollers **48** and the portion of the tubing engaged thereby.

In accordance with the invention, the rollers **48** also may be skewed relative to their normal position at right angles to the center line or axis of the tubing T. More particularly, the near frame members **55** and **56** as viewed in Fig. 1 are each provided with a pair of pins **64** which straddle a hand lever **65** that is pivoted to a vertical frame member **66** in the horizontal mid-plane of the collapsing tubing T. The corresponding frame members supporting the far ends of the rollers **48**, as viewed in Fig. 1, are vertically adjustable by means of the chains **57** and **59** but are restrained against longitudinal movement by pins (not shown) which are similar to the pin **64** and straddle a vertical frame member (not shown) directly behind and similar to frame member **66** as viewed in Fig. 1.

Thus, when the hand lever **65** is pivoted it moves the upper frame members **55** longitudinally relative to each other and the lower frame members **56** equal amounts in the opposite direction relative to each other thereby skewing the upper and lower rollers **48** in opposite directions. The lever **65** may be provided with a pawl **67** engageable with a fixed ratchet **68** for holding the frame members **55** and **56** in a selected position of roller skewing adjustment. The rigidity afforded by the cross-members **55***a*, **55***b* and **56***a*, **56***b*, and by the blower **62***a*, may be sufficiently small to permit the necessary limited longitudinal movement of the roller supporting frame members **55** and **56** required for skewing adjustment of the rollers **48**, or the near member of each pair of side members **55** and **56** as viewed in Fig. 1 may have a suitable connection, such as pin and slot (not shown) with its associated cross members and with the blower housing **62***a* which permits necessary longitudinal movement relative thereto without straining the members. In either case, the far side frame members **55** and **56** are, of course, restrained against longitudinal movement and are permitted only vertical adjustment movement by the cooperation of the pins (similar to **64**) which straddle the vertical frame member directly in back of member **66** (Fig. 1).

From the rollers **48**, the tubing T is drawn by a pair of driven pulling rolls P between a pair of converging boards to complete the collapse of the tubing. If gusseted tubing is desired, the board may be parts of a gusseting mechanism, generally designated G, which acts to further collapse the tubing and, at the same time, in cooperation with the internal fluid pressure introduced and maintained through the pressure line **1**, forms tucks, pleats or gussets in the sides of the collapsing tube. For further details of the gusseting mechanism G, reference may be made to U. S. Patent No. 2,544,044, issued March 6, 1951, to Reber and Dalzell. From the pulling rolls P, the fully collapsed and gusseted tube is fed to and wound in a roll **69** upon a driven arbor **70** of a conventional winding mechanism (not shown).

During operation of the apparatus heretofore described, hills and valleys may form circumferentially in the roll **69** due to slight differences in wall thickness of the tubing T. In accordance with the present invention, the hills and valleys may be avoided by periodically or constantly shifting the positions of the elements of the tubing relative to its fold or collapse lines. This may be done by oscillating the die D, or by skewing the rollers R or **48** or any desired combination of those adjustments. The effect of such adjustment is to rotate the tubing about its axis and vary the position of the elements of the tube relative to the collapsing or fold lines.

In the case of gusseted tubing, it is preferred for the pleats to meet along the center line of the collapsed tubing so that four, and only four, thickness of tubing wall extend from side to side of the collapsed tubing.

It will be understood that each of the several circles of rollers R may define the same size opening for the tubing. It also will be understood, however, that alternatively the several rings may define successively larger or smaller sizing openings so as to provide for a gradual increase or decrease in the size of the tubing T to a desired final shape and size. In either event, the rollers R provide frictionless shaping restraint to a point where the tubing has cooled and set against further plastic deformation.

In the case of each circle or ring of rollers R, the axes of the rollers comprising the ring preferably are located in the same plane disposed at right angles to the axis of the tubing T. However, in the case of small diameter tubing where the length of the rollers R make it impossible to adjust them in the same plane tangentially to the required small diameter, the rollers R may be spaced so as to overlap one another.

It will be appreciated that the number of rollers R arranged in each circle or ring and the number of such rings employed in a particular installation will be dependent upon the amount of sizing restraint necessary to prevent overinflation of the tubing at any point.

Small variations in the internal or inflating pressure within the tubing have little or no effect on the size of the tubing where the frictionless sizing restraint of the rollers R is employed and any tendency for wrinkles to occur in rolling the tubing is substantially eliminated.

Embodiments other than those illustrated for obtaining the advantages of the invention will occur to those skilled in the art and it, therefore, is to be understood that the described embodiments are merely illustrative and that the scope of the invention is defined by the following claims.

I claim:

1. The process of forming and handling thin-wall tubing of thermoplastic material which includes continuously extruding said material in a heated and plastic condition through an annular die in the form of tubing elements of which differ in thickness, expanding the extruded tubular material, cooling said expanding material below its temperature of plasticity and thereby setting said tubing, collapsing said tubing along longitudinal fold lines occurring on successively different longitudinal elements of said tubing and progressively gathering the collapsed tubing on a roll so that successive convolutes of an element of the tubing are laterally offset from each other on said roll.

2. Apparatus for collapsing and gathering tubing of thermoplastic material elements of which differ in thickness, said apparatus including a roll on which to wind collapsed tubing, means for collapsing said tubing and means for rotating the uncollapsed portion relative to the collapsed portion so as to vary the longitudinal elements of the tubing on which the tubing is collapsed and space successive convolutes of an element of the tubing laterally of said roll.

3. Apparatus for forming, collapsing and winding on a roll tubing of thermoplastic material elements of which differ in thickness and wherein said apparatus includes means for continuously extruding thermoplastic material through an annular die in the form of tubing, means for inflating and expanding said tubing, a roller assembly for limiting expansion of said tubing, means for skewing the rollers of said assembly from perpendicular positions relative to the direction of travel of the tubing, means for continuously varying the askew angularity of the rollers relative to said line of travel, means for continuously collapsing successive portions of the tubing along spaced longitudinal elements of the tubing, and means for rotating portions of said tubing relative to each other so that collapse is effected along different elements of said tubing and successive convolutes of an element of the tubing are spaced laterally on said roll.

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