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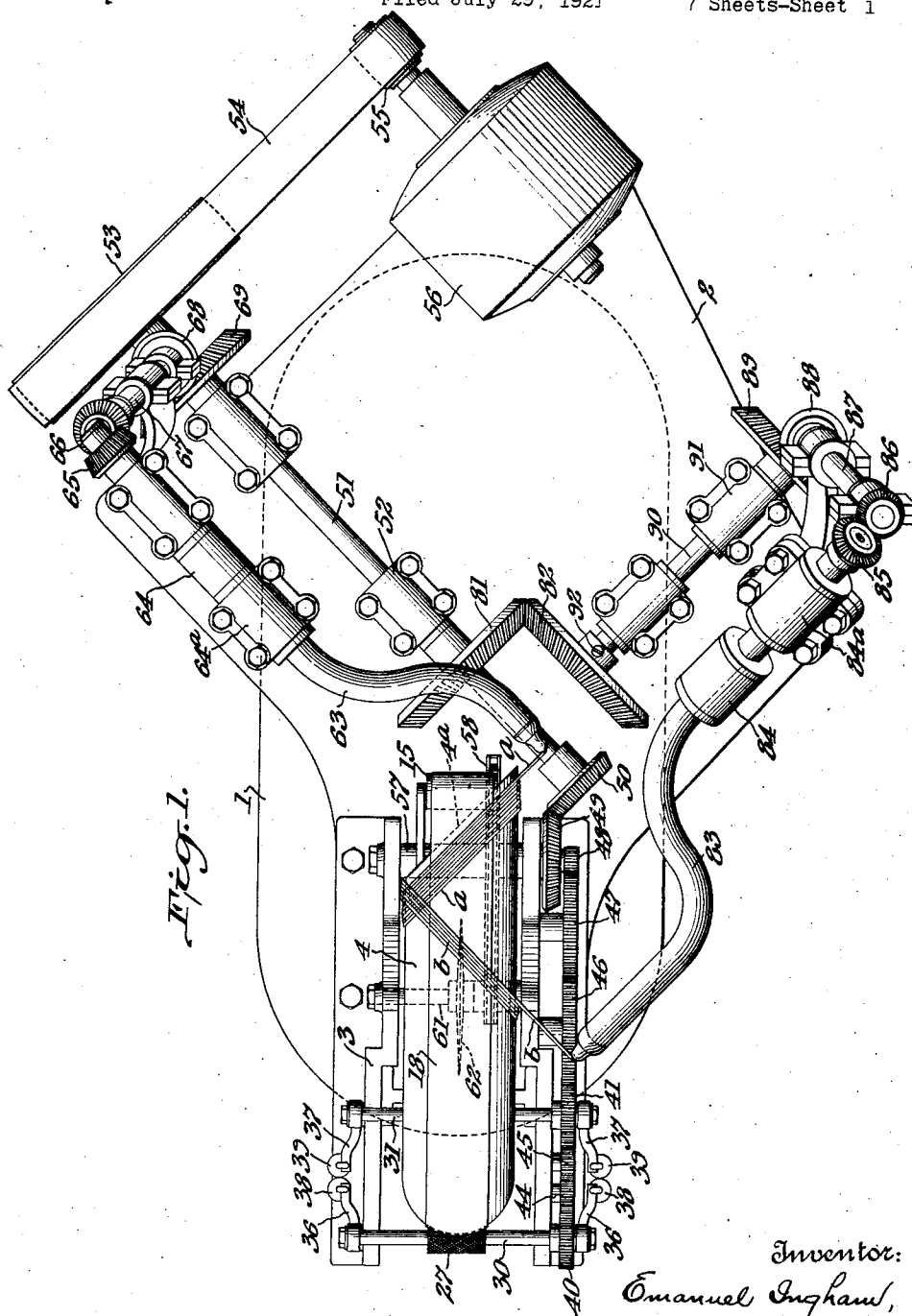
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1,595,404

METHOD OF AND MEANS FOR PRODUCING TUBULAR CORD FABRICS

Filed July 29, 1921

7 Sheets-Sheet 1



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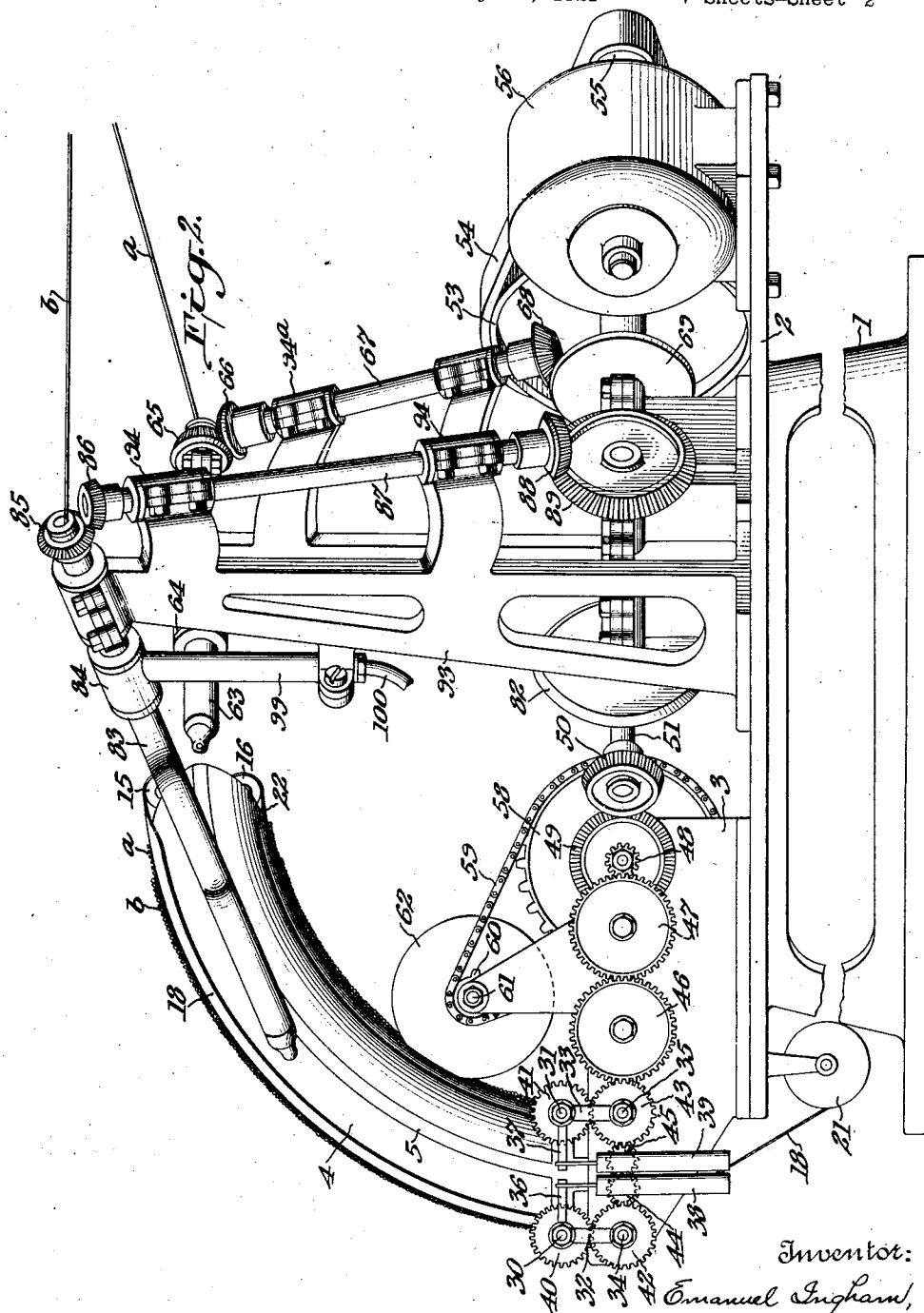
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7 Sheets-Sheet 2



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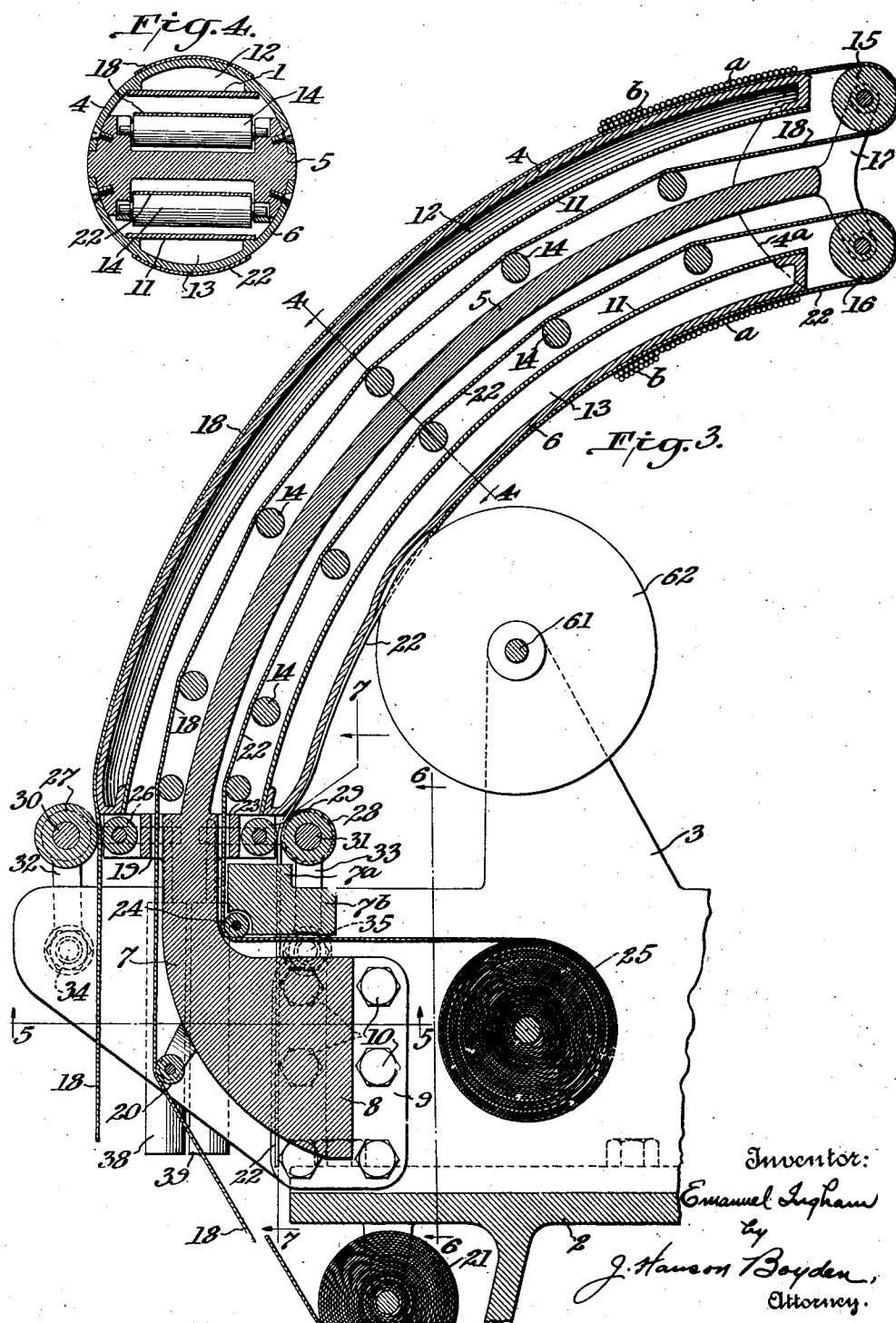
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7 Sheets-Sheet 3



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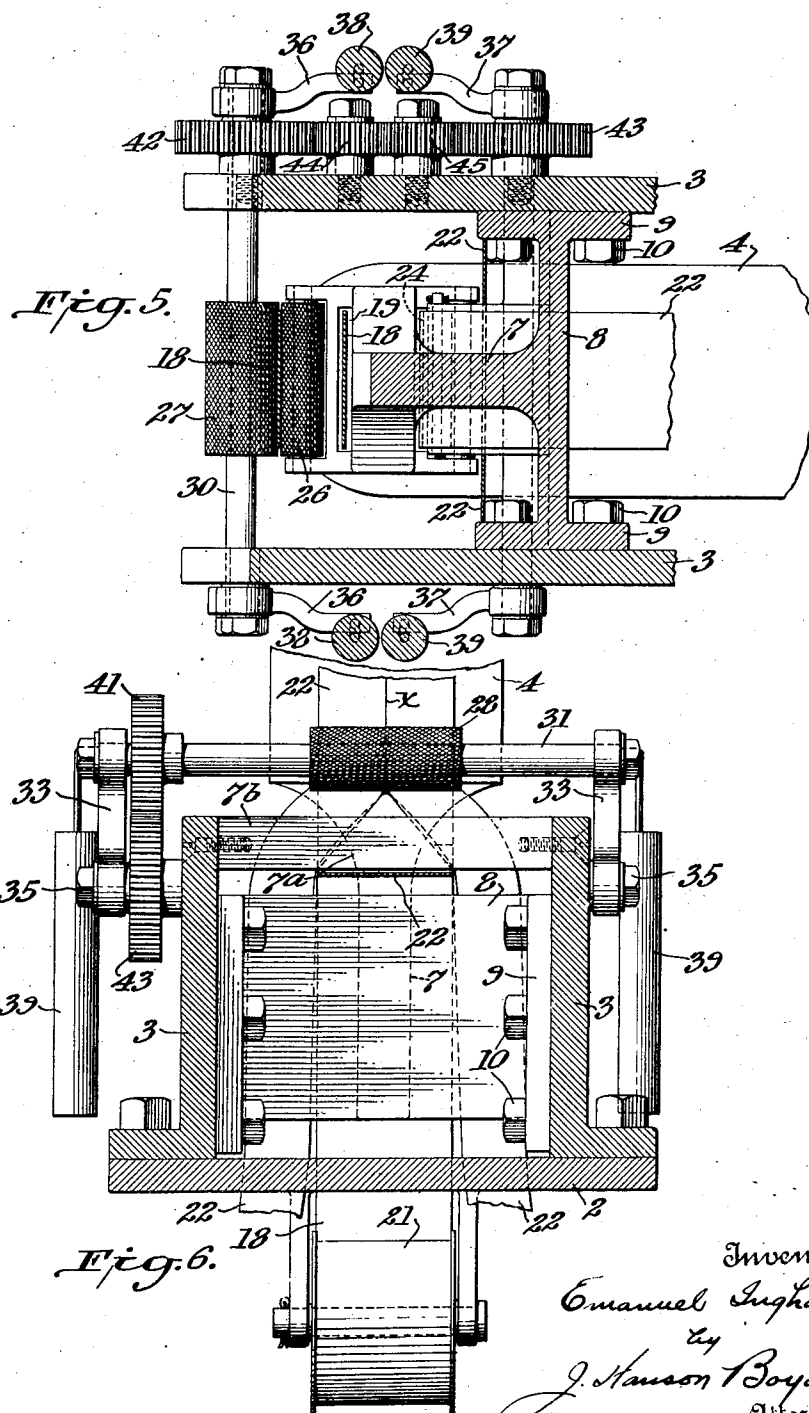
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7 Sheets-Sheet 5

Fig. 8.

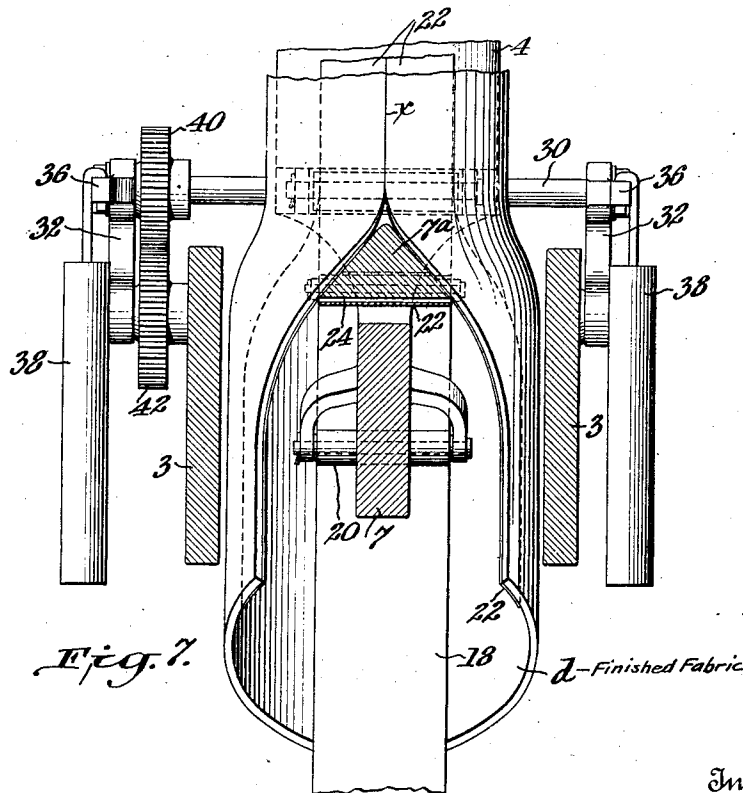
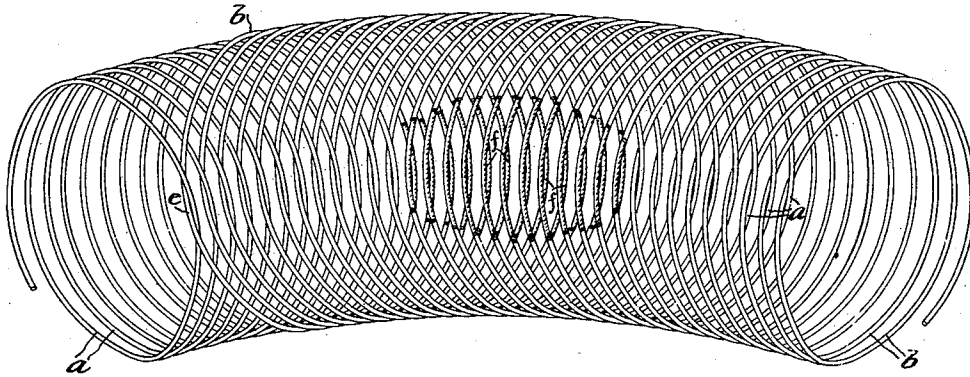


Fig. 7.

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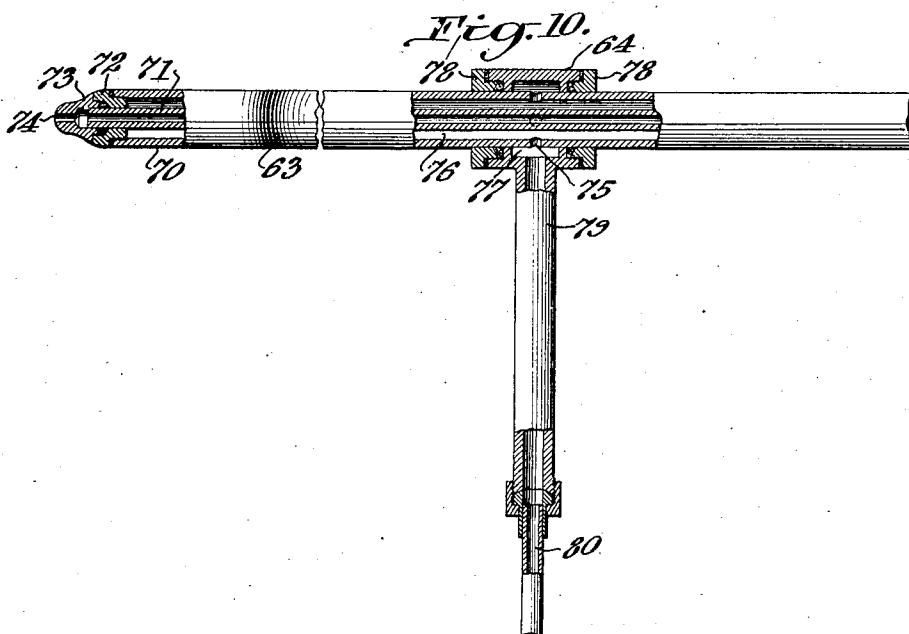
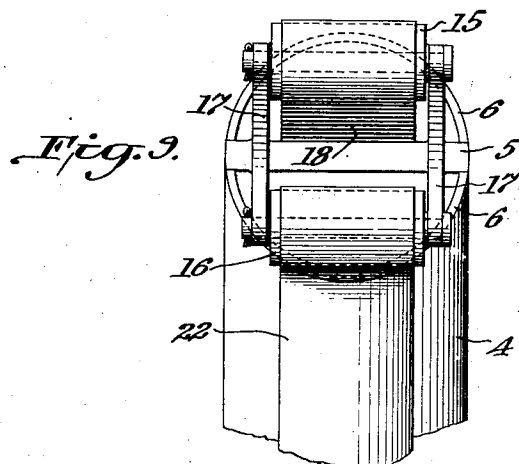
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7 Sheets-Sheet 6



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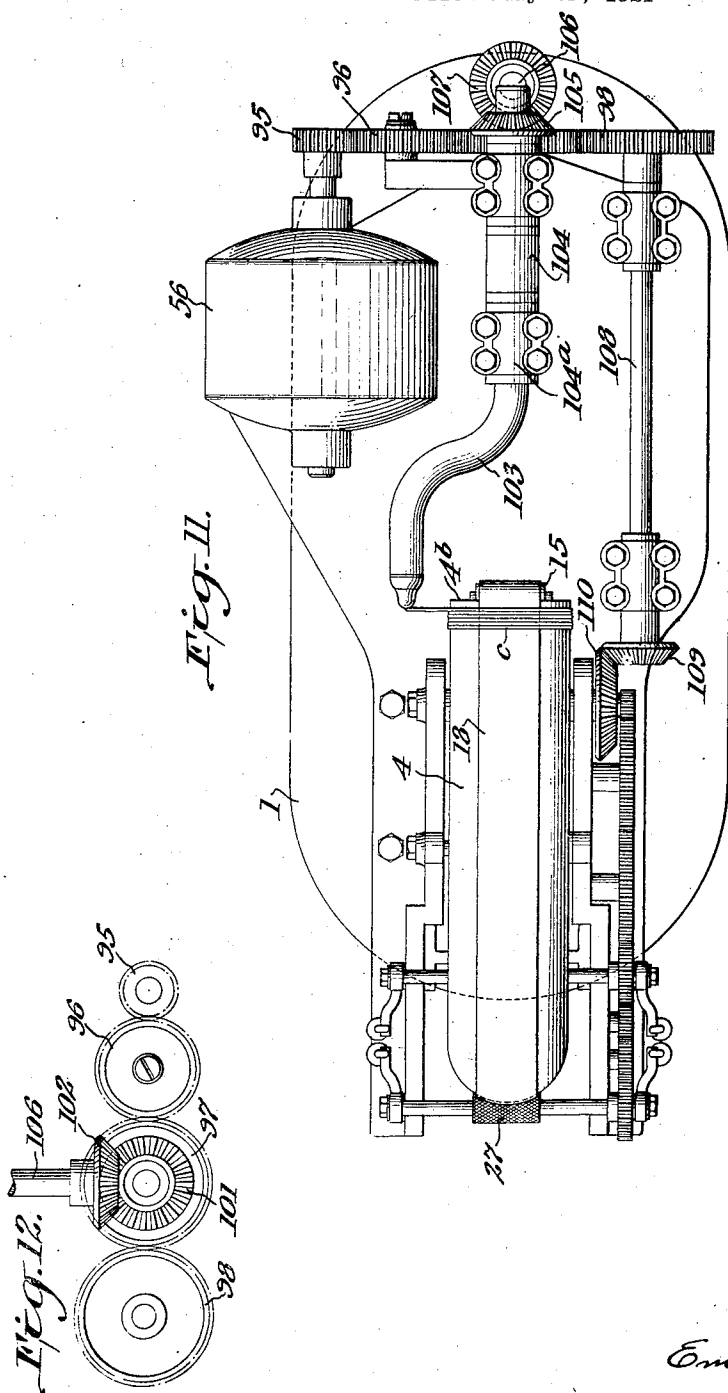
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METHOD OF AND MEANS FOR PRODUCING TUBULAR CORD FABRICS

Filed July 29, 1921

7 Sheets-Sheet 7



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UNITED STATES PATENT OFFICE.

EMANUEL INGHAM, OF WASHINGTON, DISTRICT OF COLUMBIA.

METHOD OF AND MEANS FOR PRODUCING TUBULAR CORD FABRICS.

Application filed July 29, 1921. Serial No. 488,280.

This invention relates to a method of and means for producing tubular cord fabrics or structures, and more particularly for producing such tubular fabrics which are curved longitudinally or arcuate in form so as to be adapted for use as a basis for pneumatic tire carcasses.

While my invention is of course, clearly well adapted for the production of straight tubular fabrics such as are employed in the manufacture of hose and the like, I have illustrated and described it only as applied to the production of arcuate or longitudinally curved fabrics intended for use in the manufacture of pneumatic tires.

Many attempts have heretofore been made to devise machines for automatically producing a bias or diagonal cord fabric suitable for tire carcasses, and for causing such fabric to conform to the shape of a tire. The method most widely used at present consists in producing flat sheets of cord fabric with the cords running diagonally, and in applying such flat sheets or strips around a suitable core, with which by means of heat and pressure, it is eventually caused to conform in a more or less accurate manner. It has also been proposed to provide a form in the shape of a tire and to lay diagonal cords back and forth around such form, thus building up a complete tire carcass which is subsequently removed from the form, after being completed.

In none of the attempts of which I am aware, however, has it ever been proposed to produce a cord fabric in indefinite lengths, which fabric is curved, both transversely and longitudinally as it comes from the machine on which it is formed, so that when a piece of proper length is cut off and its ends brought together, such piece automatically assumes the exact shape of a tire carcass.

It is therefore the main object of the present invention, to provide a method and means for producing a cord fabric continuously and in indefinite lengths, such cord fabric being longitudinally curved or arcuate in form and tending to curl itself into coils as it comes from the machine on which it is manufactured, such coils being of substantially the same diameter as that of the

tire to be produced. More specifically, the present invention has for its object the production of a curved tubular fabric of the kind described comprising a plurality of plies or layers, the cords in adjacent plies being disposed at an angle to each other, and the cords in at least some of the plies lying at an angle to the axis of the tire. In other words, I propose to produce in indefinite lengths a complete curved tubular cord fabric made up of superposed layers of bias or diagonally extending cords which cross each other.

In order that my invention may be readily understood, reference is had to the accompanying drawings illustrating one embodiment thereof, and forming a part of this specification, in which drawings:

Fig. 1 is a plan view of a machine designed for producing a 2-ply diagonal cord fabric.

Fig. 2 is a side elevation of such machine, a portion of the cord fabric being shown in section.

Fig. 3 is a vertical section on an enlarged scale through the arcuate form or mandrel around which the cords are laid.

Fig. 4 is a transverse section through such form on the line 4—4 of Fig. 3.

Fig. 5 is a transverse section on the line 5—5 of Fig. 3 looking in the direction of the arrows.

Fig. 6 is a section on the line 6—6 of Fig. 3 looking in the direction of the arrows.

Fig. 7 is a section on the line 7—7 of Fig. 3 looking in the direction of the arrows.

Fig. 8 is a fragmentary, diagrammatic side elevation of a portion of the 2-ply fabric produced in accordance with my invention, parts being broken away to show the rear side thereof.

Fig. 9 is an end elevation of the upper end of the form or mandrel about which the cords are laid.

Fig. 10 is a view partly in section and partly in side elevation, illustrating one of my improved winding arms and the method of supplying a heating medium thereto.

Fig. 11 is a plan view similar to Fig. 1, but showing a modified arrangement for winding a single layer of cords at right-angles to the axis of the form; and

Fig. 12 is a fragmentary end elevation of the gearing shown at the right of Fig. 11.

Referring to the drawings in detail, and more particularly to Figs. 1 to 10 thereof, it will be seen that my improved machine comprises a suitable base or standard 1 on which is supported a table or platform 2 on which the mechanism is mounted. At one end of the table 2 is a pair of spaced up-standing side plates 3, and these support the lower end of the curved arcuate form or mandrel 4 about which the cords are laid.

Referring especially to Figs. 3 and 4, it will be seen that this form or mandrel comprises a central rib or frame 5, preferably formed of cast iron, and a pair of trough shaped portions 6, which when fitted on either side of the central rib 5, produce a structure circular in cross-section as shown in Fig. 4. The lower end of the rib or frame 5 is prolonged to form a supporting bracket 7, and this is rigidly united with a cross web 8 terminating at each end in flanges 9, which are bolted to the inside of the side plates 3 by means of bolts 10. Thus the form or mandrel is rigidly supported as shown in Fig. 3.

In order to successfully operate with rubberized cords as hereinafter described, it is desirable that the form or mandrel be heated. To this end, I provide on the inside of the form, a pair of longitudinally curved plates or strips 11, forming chords of the circle shown in Fig. 4, and providing between themselves and the outer shell of the form, longitudinal chambers 12 and 13 to which steam or other heating medium may be supplied by suitable means (not shown). Thus the entire form may be maintained at any desired temperature.

Mounted at suitable intervals throughout the hollow interior of the form or mandrel, are a series of transversely extending rollers 14 spaced approximately as shown in Fig. 3.

At the upper end of the form or mandrel are a pair of transversely disposed rollers 15 and 16 journaled in a suitable bracket 17 as clearly shown in Figs. 3 and 9.

A band or tape 18 extends from a reel or spool 21 suitably supported beneath the machine, and after passing over a guide roller 20, is led through an opening 19 in the bottom of the form or mandrel. It then passes over one set of the rollers 14 and out of the upper end of the form, thence back over roller 15 and along the entire outer periphery of the arcuate form, against which it lies closely as shown in Fig. 3. This band or tape may be of any suitable width, but preferably should not be wide enough to buckle or wrinkle appreciably by reason of the double curvature which it has to assume in passing over the form.

Another band or tape 22 is fed from a second reel or spool 25 journaled between the side plates 3, and after passing over a guide

roller 24, is led up through an opening 23 and thence over another set of guide rollers 14 until it emerges from the upper end of the form. It then passes back around the roller 16 and thence along the inner periphery of the curved form 4 through-out the length thereof.

At the lower end of the form 4 are two pairs of feed rollers 26, 27 and 28, 29, the rollers 26 and 29 being idlers and being housed underneath the form, while the rollers 27 and 28 are caused to grip the tapes 18 and 22 respectively between themselves and the idlers 26 and 29. The bite between the rollers 26 and 27 and the rollers 28 and 29 is preferably substantially flush with the outer and inner surfaces respectively of the form, so that the tape 18 passes straight down between the rollers 26 and 27 and the tape 22 passes smoothly down between the rollers 28 and 29. The rollers 27 and 28 have a knurled or roughened surface as clearly shown in Figs. 1, 5 and 6, and are positively driven by suitable gearing as hereinafter described. It will be particularly noted that the roller 27 is of larger diameter than the roller 28, so that when driven at the same speed, the roller 27 will cause the tape 18 to travel faster than will the roller 28 the tape 22. This is necessary because of the difference in radius between the outer and inner peripheries of the arcuate form or mandrel, in order that any two points on the two tapes which are in radial alignment at the upper end of the form, shall remain in radial alignment as the two tapes travel along the outer and inner peripheries of the form.

The rollers 27 and 28 are secured to shafts 30 and 31 respectively, these shafts being journaled in the upper ends of pairs of arms 32 and 33 respectively, such pairs of arms being pivoted about fixed axes indicated at 34 and 35. The arms 32 and 33 have rigidly secured thereto horizontally extending levers 36 and 37 respectively, such levers carrying at their ends suitable weights 38 and 39. From an inspection of the drawings, it will be apparent that these weights tend to rotate the arms 32 and 33 about their pivots 34 and 35, so as to cause the rollers 27 and 28 to bite or grip the tape. Gears 40 and 41 are rigidly secured to the shafts 30 and 31, and mesh with similar gears 42 and 43 journaled about the pivots 34 and 35, and the gears 42 and 43 are constrained to rotate together by means of intermeshing connecting gearing 44 and 45. Thus when the gear 43 is rotated, the rollers 27 and 28 will be caused to rotate at the same speed and thus feed the tapes along the form, rocking of the levers 32 and 33 on their pivots having no effect on the gearing since the gears 42 and 43 are mounted concentrically therewith.

The gear 43 meshes with a train of gearing 46, 47 and 48, the last element of which is

fixed to a shaft 57 on which is rigidly secured a bevel gear 49. This gear meshes with another bevel gear 50 fast on a shaft 51, journaled in bearings 52 and carrying at its other end a belt wheel or pulley 53. A belt passes over the wheel 53 and a pulley 55 fast on the shaft of an electric or other motor 56.

Also on the shaft 57 is rigidly secured a sprocket wheel 58, and a sprocket chain 59 passes around the wheel 58 and a sprocket wheel 60 fast on a shaft 61. On the shaft 61 is mounted a cutter disc 62, the periphery of which is disposed in close proximity to the inner periphery of the curved form 4 as clearly shown in Fig. 3, and this cutter serves to slit the tubular fabric on the inside of the curvature thereof as it is drawn along the form. It also slits the tape 22 as shown in Fig. 3, which tape in passing downwardly is divided by a wedge shaped spreader 7^a (see Figs. 6 and 7), which spreader is disposed immediately below the feed roller 28 and is supported on a cross bar 7^b secured between the side plates 3 as clearly shown in Fig. 6.

In order to wind or lay the cords around the form 4, I employ one or more winding arms which are preferably crank-shaped. In Figs. 1 and 2, I have shown a pair of winding arms disposed at an angle of 90° to each other and substantially 45° to the axis of the form. We will consider first the single winding arm which I have designated by the reference numeral 63, and which is adapted to lay cord *a*. This arm is substantially horizontal and is journaled in bearings 64^a. The body of the arm also passes through a stuffing box 64, as will be hereinafter more fully described. The rear end of the arm carries a bevel gear 65 which meshes with a similar gear 66 on the upper end of a shaft 67, mounted in suitable bearings 94^a supported by a frame 93, and carrying at its lower end, bevel gear 68 meshing with a bevel gear 69 rigidly secured to the shaft 61. Thus as the motor shaft runs, the arm 63 is made to revolve, thus causing its free or delivery end to gyrate around the upper end of the form 4. By reference to Fig. 1, it will be noted that this upper end of the form is preferably beveled off as indicated at 4^b on a plane at right angles to the axis of the arm 63.

Referring to Fig. 10, it will be seen that the arm 63 is of hollow construction and consists of outer and inner tubes 70 and 71 spaced apart as shown, to form an annular chamber 76. This chamber is closed at its end by means of a bushing 72 and a packing gland 73 surrounds the projecting end of the inner tube 71 and is itself provided with a delivery opening 74 through which the cord passes from the inner tube.

As before stated, a stuffing box 64 surrounds the outer tube 70 and has its ends

closed by suitable packing glands 78, it being understood that the winding arm is free to turn in this stuffing box. Within the box there is formed an annular chamber 77, and the tube 70 is provided with openings 75 establishing communication between the chamber 77 and the annular space 76. In communication with the chamber 77 is a tubular support 79 which is mounted in a suitable clamp carried by the frame 93, and is connected at its lower end with a pipe 80. From the above described construction, it will be understood that steam or other heating medium supplied through the pipe 80 will pass up and into the annular space 76, thus forming a jacket around the inner tube 71, which may be thereby heated to any desired degree.

In the manufacture of my improved cord fabric, I propose to use what is known as rubberized cord. This rubberizing may be accomplished in any way well known in the art, and the rubber coating may be made of any suitable or desired consistency. The cord may be rubberized and partially dried before being supplied to my machine or I may interpose a suitable rubberizing die or device between the reel or spool on which the cord is wound and the end of the winding arm where the cord enters. In any event, it will be understood that cord, suitably rubberized, is led into the rear open end of the winding arm 63 as indicated at *a* in Fig. 2.

With the construction so far described, it is obvious that as the delivery end of the arm 63 is gyrated around the form 4, the cord *a* will be laid or wound around the upper end of such form and also around the two tapes 18 and 22, supported by the form. As the winding arm gyrates, the train of gearing 48, 47, 46, 43, etc. will be actuated, thus causing the feed rollers 27 and 28 to revolve, and causing the tapes 18 and 22 to be drawn along the form 4 at speeds proportional to the respective radii of the inner and outer peripheries of the form. The exact speed of travel of these tapes will depend upon the size and character of the cord being employed; as evidently, the larger the cord, the faster must be the feed. It will therefore be understood that the speed of the tapes should be so adjusted as to be properly proportioned to the speed at which the cord fabric is built up, so that the tapes will travel approximately a distance equal to the diameter of the cord during the time in which each consecutive convolution of cord is laid. It will be apparent that in this way the consecutive or successive convolutions of the cord will be caused to lie closely adjacent to each other, although it is of course obvious that adjacent convolutions will be separated slightly further on the outer periphery of the form than at the inner periphery thereof.

It is my intention that the successive adjacent convolutions of rubberized cord will be of such consistency as to adhere to each other and also to the tapes, and to this end it may also be desirable in some cases to rubberize the tapes as well. The object of heating the form 4 and the hollow winding arm is to prevent the rubberized material from sticking thereto and cause the finished cord fabric to slide freely along the form 4. The tapes or bands also assist in preventing sticking.

Further considering the operation of the winding arm 63, as best shown in Fig. 1, it will be observed that the successive convolutions of cord are wound or laid always in substantially the same plane, that is to say, the plane defined by the path of the delivery end of the arm. In the arrangement above described, this plane intersects the axis of the form at an acute angle, shown as approximately 45°. Thus the finished fabric, consisting of the adjacent convolutions of cord, adhering to each other and to the tapes, is fed along the form at a rate exactly equal to that at which it is built up by the addition of successive convolutions, it being understood that the cord is continuously wound in a fixed plane and the finished fabric continuously fed along so as to make room for the successively added turns.

When the tubular fabric has been drawn along the form to the point where the cutter disk 62 is reached, the fabric comprising the cords and tape is slit by the cutter, as indicated by the line *x* in Fig. 7, and thereafter becomes C-shaped instead of a complete tube. This C-shaped fabric then passes down over the spreader 7^a, as shown more particularly in Fig. 7, and its edges are thus spread apart so that the fabric can be removed from the form as indicated at *d*. It is only necessary that the edges be spread far enough apart to clear the supporting bracket 7.

Referring again to Fig. 1, it will be seen that I have shown a second winding arm 83 disposed at substantially right-angles to the arm 63 and adapted to lay cords in a plane at substantially right-angles to the cords *a*. This arm 83 is in all respects similar to the arm 63, except that the radius of gyration is preferably greater in order to enable it to properly clear the form. The arm 83 passes through a stuffing box 84, similar to 64, and is journaled in bearings 84^a. It carries at its rear end a bevel gear 85 meshing with a bevel gear 86 carried on an inclined shaft 87, journaled in bearings 94, supported by the frame 93 and carrying at its lower end a bevel gear 88. This meshes with a bevel gear 89 mounted on a shaft 90, journaled in bearings 91 and carrying at its inner end a bevel gear 82 meshing with a bevel gear 81 on the shaft 51. In this way mo-

tion is transmitted from the shaft 51 to the winding arm 83.

It may be here noted that the gear 82 is preferably secured to the shaft 90 by means of a set screw 92 or the like in such a manner that it may be loosened and shifted out of mesh with the gear 81. In this way either one or both of the winding arms may be employed as desired.

Assuming that both winding arms are employed, and that a cord *a* is fed to the winding arm 63, and a cord *b* to the winding arm 83, it will be seen that two layers of cords will be simultaneously and continuously wound upon the form 4, the convolutions of the two cords lying at an angle to each other, so that they cross. In this way a 2-ply diagonal cord fabric is built up, and the cords having been previously rubberized, will adhere to each other, thus forming a substantial tire carcass.

In Fig. 8, I have endeavored to show the nature of this 2-ply fabric. In this figure, the adjacent convolutions are shown separate for the sake of clearness, although it will be understood that in practice the adjacent convolutions are substantially in contact. An examination of Fig. 8 clearly shows an inner layer formed of the continuously wound cord *a*, and another and outer layer formed of the continuously wound cord *b*, the convolutions of the two cords crossing each other at an angle at both the inner and outer periphery of the fabric. At one side of the fabric however, (the side next to the observer in Fig. 8 and the side opposite to the position of the winding arms in Fig. 1), the corresponding convolutions of the two windings are interlinked as shown at *e* in Fig. 8, while at the opposite side (the back, as viewed in Fig. 8), these convolutions are not interlinked but are simply superposed as shown at *f*. In other words, the two cord layers are entirely superposed except at the point *e*, where they are interlinked. This interlinking serves to knit the two layers together and to prevent relative displacement. It will be observed that since the cords are under tension and the convolutions are inclined away from the interlinking point, there might be a tendency for the outer turns to slip, but this interlinkage securely anchors the respective convolutions of the cords and prevents slippage. On the opposite side, adhesion of the rubberized cords will be sufficient to hold the convolutions in place.

Referring now to Fig. 11, I have shown how the same principle can be applied to producing a tubular cord structure consisting of convolutions wound in a plane at right-angles to the axis of the form. In this modification, the end of the form 4, instead of being beveled, is shown as square as indicated at 4^b. The winding arm 103 is

set with its axis in the same vertical plane as that of the form. The winding arm is mounted in bearings 104^a and passes through a stuffing box 104 similar to 64 above described. The rear end of the arm carries a bevel gear 105 which meshes with a bevel gear 107 carried at the upper end of a vertical shaft 106, (see Fig. 12). Power is transmitted to this shaft 106 by means of a pinion 95 on the shaft of the motor 56, through the transmission gears 96 and 97, the latter of which is rigid with a bevel gear 101 meshing with a similar gear 102 fast on the shaft 106.

The cutting and feeding mechanism is driven through a gear 98 meshing with gear 97 and mounted on a shaft 108. This shaft carries a bevel gear 109 meshing with a bevel gear 110 on a shaft corresponding with the shaft 57 in Fig. 1.

The operation of this modification is exactly the same as described in connection with the other figures, except that the cord is laid in a plane at right-angles to the axis of the form. This may be desirable in some cases.

Moreover, I contemplate superposing a fabric similar to that shown in Fig. 8 upon a fabric such as shown in Fig. 11, so as to produce a 3-ply cord fabric, all of the layers of which are at an angle to each other. Moreover any desired number of layers can be superposed so as to form structures of 4-ply, 6-ply, 8-ply, etc., as desired. Thus a tire carcass of any desired strength can be built up.

Moreover, I contemplate combining the three arms 63, 83, and 103 in a single machine, so that the three layers may be applied simultaneously and continuously. Thus the transverse layer will act as a binder for the two diagonal layers. This may be accomplished by mounting the single arm shown in Figure 11 on the same base as that carrying the other two arms, shown in Figure 1, and driving all three arms in synchronism by means of interconnected gearing.

It will of course be understood that in forming a tire carcass of my improved fabric, a piece of fabric of the desired length is cut off and its ends spliced to form a complete tire. The piece may be of such length as to extend only once around the wheel or it may be long enough to extend two or three times around the wheel, in the latter case the fabric being wound spirally, and the successive layers superposed. After the carcass has thus been formed from the rubberized fabric, it will be assembled in a suitable mold and vulcanized in a manner well known in the art.

While of course the cord structure resulting from my improved method of manufacture is not, strictly speaking, a "fabric", still

I have used the words "cord fabric" throughout the specification and claims as means a tube or sheet formed from assembled strands of cords extending transversely of the sheet or tube and lying either at right-angles or at an acute angle to the axis thereof.

What I claim is:—

1. The method of producing a cord fabric which consists in winding a single rubberized cord continuously around a stationary form, with successive convolutions of said cord in substantial contact throughout their length, causing the adjacent convolutions to adhere to constitute a fabric, feeding the accumulated cord along the form as successive turns are laid, and slitting the resulting tubular cord structure longitudinally.

2. The method of producing a cord fabric which consists in continuously winding a single cord around a fixed form or mandrel, with successive convolutions of said cord in substantial contact, feeding the accumulated turns along the form a distance approximately equal to the thickness of the cord as each convolution is added, and slitting the resulting tubular cord structure.

3. The method of producing a diagonal cord fabric which comprises winding cord continuously around an elongated stationary form in a fixed plane intersecting the axis of the form at an acute angle, and feeding the accumulated turns along the form as successive convolutions are laid.

4. The method of producing a diagonal cord fabric which comprises winding a single cord in a fixed plane continuously around an elongated, stationary form, with successive convolutions of said cord in substantial contact throughout their length, the said plane of winding intersecting the axis of the form at an acute angle, causing adjacent convolutions to adhere to constitute a fabric, and feeding the finished fabric along the form as the cord is wound.

5. The method of producing a diagonal cord fabric which comprises winding a single cord in a fixed plane continuously around an elongated, stationary form, with successive convolutions of said cord in substantial contact throughout their length, the said plane of winding intersecting the axis of the form at an acute angle, whereby the cord is laid in a distorted helix, causing adjacent convolutions to adhere to constitute a fabric, and feeding the finished fabric along the form as the cord is wound.

6. The method of producing a cord fabric which consists in winding a cord continuously around a stationary form and over a tape supported on said form, causing the successive convolutions to lie substantially in contact throughout their length and to adhere to said tape, and to each other, to constitute a tubular fabric, with the tape inside, feeding such fabric along the form as the

cord is laid, and finally slitting said tubular cord fabric.

7. The method of producing a cord fabric which consists in winding an adhesive cord continuously around a form, with successive convolutions substantially in contact and adhering to each other throughout their length, preventing the cord convolutions from sticking to the form by interposing between the cord and the form a tape or band, and causing said tape or band, together with the accumulated adhering turns of cord supported thereon to travel along the form as successive convolutions of cord are added.

8. The method of producing a tubular cord fabric which consists in simultaneously winding two cords around a form, each convolution of each cord lying substantially in a single plane, which planes intersect.

9. The method of producing a tubular cord fabric which consists in simultaneously winding two cords around a form at an angle to each other, and interlinking the convolutions of the cords at one point.

10. The method of producing a tubular cord fabric which consists in simultaneously winding two cords around a form at an angle to each other, in such manner that each convolution of one cord is interlinked with the corresponding convolution of the other.

11. The method of producing a tubular cord fabric which consists in simultaneously winding two cords around a form, the successive convolutions of each cord lying substantially in contact, and each convolution of one cord crossing each adjacent convolution of the other cord at two points.

12. The method of producing a tubular cord fabric which consists in simultaneously winding two rubberized cords continuously around a form so as to cause successive convolutions of each cord to adhere to each other and the convolutions of one cord to be superposed upon and adhere to those of the other.

13. The method of producing a tubular cord fabric which consists in simultaneously winding two cords continuously around a form at an angle to each other, so that the convolutions of the two cords are interlinked to constitute a fabric, and feeding such fabric along the form as the cords are laid.

14. The method of producing a tubular cord fabric which consists in simultaneously and continuously winding two cords diagonally around a form at an angle to each other, so that the convolutions of the two cords are interlinked to constitute a fabric, and feeding such fabric along the form as the cords are laid.

15. The method of producing a tubular cord fabric which consists in simultaneous-

ly and continuously winding two cords around a form at an angle to each other so that the convolutions of one cord are interlinked with those of the other to constitute a fabric, and feeding such fabric along the form as the cords are laid.

16. The method of producing a tubular cord fabric which consists in simultaneously and continuously winding two cords around a form at an angle to each other so that the convolutions of the two cords are interlinked at one point, and superposed at all other points, causing said superposed convolutions to adhere to constitute a fabric, and feeding such fabric along the form as the cords are laid.

17. Means for producing a cord fabric suitable for use as the basis for a pneumatic tire carcass, comprising a fixed arcuate form having a radius of curvature approximately equal to that of the tire to be produced, mechanism for winding a cord continuously around said form with the successive convolutions of the cord lying close together, means for causing adjacent convolutions to be held together to constitute a fabric, and means for feeding such fabric along the arcuate form as the cord is laid.

18. The combination with a fixed form or mandrel, of mechanism for continuously winding a single cord therearound in such manner that successive convolutions of said cord remain in substantial contact throughout their length, means for feeding the accumulated turns of cord along the form as successive convolutions are added, and means for longitudinally slitting the resulting tubular cord structure.

19. The combination with a fixed form or mandrel, of mechanism for continuously winding a cord diagonally around the same in such manner that successive convolutions of the cord remain close together in substantial contact, all parts of each convolution lying substantially in a single plane and varying from such plane only by an amount equal to the diameter of the cord.

20. The combination with a fixed form or mandrel, of mechanism for continuously winding a single cord diagonally around the same, to produce a layer, with successive convolutions of said cord substantially in contact, and means for feeding the accumulated turns along the form as fast as successive convolutions are added.

21. The combination with a fixed form or mandrel, of mechanism for continuously and simultaneously winding a plurality of cords around the same at angles to each other, and means for feeding the accumulated cords along the form a distance substantially equal to the thickness of the cord as successive convolutions are added.

22. The combination with a fixed form, means rotatable about different axes for si-

multaneously winding a plurality of adhesive cords around the same to produce a cord fabric, and means for feeding such fabric along the form as the cords are wound.

23. The combination with a fixed form having a passageway extending there-through, longitudinally thereof, of means for causing a band or tape to travel from one end of the form through said passageway to the other end thereof, and thence back along and over the outer surface of said form, and means for continuously winding successive convolutions of cord around said form and onto said band as the latter travels along.

24. The combination with an elongated hollow form in the nature of a cantilever, fixed at one end and free at the other, of means for causing a band or tape to enter the fixed end of said hollow form, pass through the same to the free end, and then travel back along and over the outer surface thereof, and means for continuously winding cord around the free end of said form and the band supported on the surface thereof, as the latter moves along, the successive convolutions of cord traveling with such band toward the fixed end of the form.

25. The combination with a fixed, longitudinally curved form having one free end, of means for continuously winding a cord around said free end thereof, means for feeding the winding along the form toward the other end as successive convolutions are added, and means for cutting each convolution to effect its removal from the form.

26. The combination with an arcuate form, of means for producing a tubular flexible structure around the same, and means for causing such structure to travel along the form, such means comprising feeding devices at both the inner and outer peripheries of said form, means whereby such feeding devices tend to propel the adjacent parts of said structure at speeds proportional to the radii of curvature of the inner and outer peripheries of the form.

27. The combination with a fixed, longitudinally arcuate form, of means for producing a tubular flexible structure around the same, means for feeding such structure along the form, such means comprising feed rollers for engaging the structure at both

the inner and outer peripheries of said form, said rollers being of different diameters.

28. The combination with an arcuate form, of means for producing a tubular flexible structure around the same, means for feeding such structure along the form, such means comprising feed rollers for engaging the structure at both the inner and outer peripheries of said form, the diameters of said rollers being proportional to the radii of curvature of the inner and outer peripheries of the form, respectively.

29. The combination with an elongated form or mandrel, of means for continuously winding cord around the same, comprising a rotary winding device having a cord delivery guide spaced radially from its axis of rotation, and means for causing said cord delivery guide to travel around said form in a fixed plane intersecting the axis of the form at an acute angle.

30. The combination with a form or mandrel, of means for continuously winding cord around the same comprising a pair of gyratory winding devices, and means for revolving said devices at the same speed about axes disposed at an angle to each other.

31. The combination with an arcuate form, of means for continuously winding cord around one end thereof comprising a pair of gyratory winding arms, and means for rotating said arms about axes inclined to each other and to the plane of said form.

32. The combination with a rigid, fixed form or mandrel, of means for continuously winding cord around the same, said means comprising a crank arm rotatable about an axis disposed at an angle to that of the form, and having cord delivery means at its free end, means for rotating said arm, and means for feeding the accumulated turns progressively along the form.

33. The combination with a transversely curved, longitudinally arcuate form, of independent means for continuously laying two threads diagonally around the same at an angle to each other to produce a tubular fabric of indefinite length, one of said threads being laid in a fixed plane, and means for removing said fabric continuously from said form as it is produced.

In testimony whereof I affix my signature.
EMANUEL INGHAM.