Aug. 23, 1966 L. J. GUICHON ET AL 3,268,380

VARIABLE SPEED RIBBON WINDING MACHINE

Filed Jan. 30, 1963 19 Sheets-Sheet 1

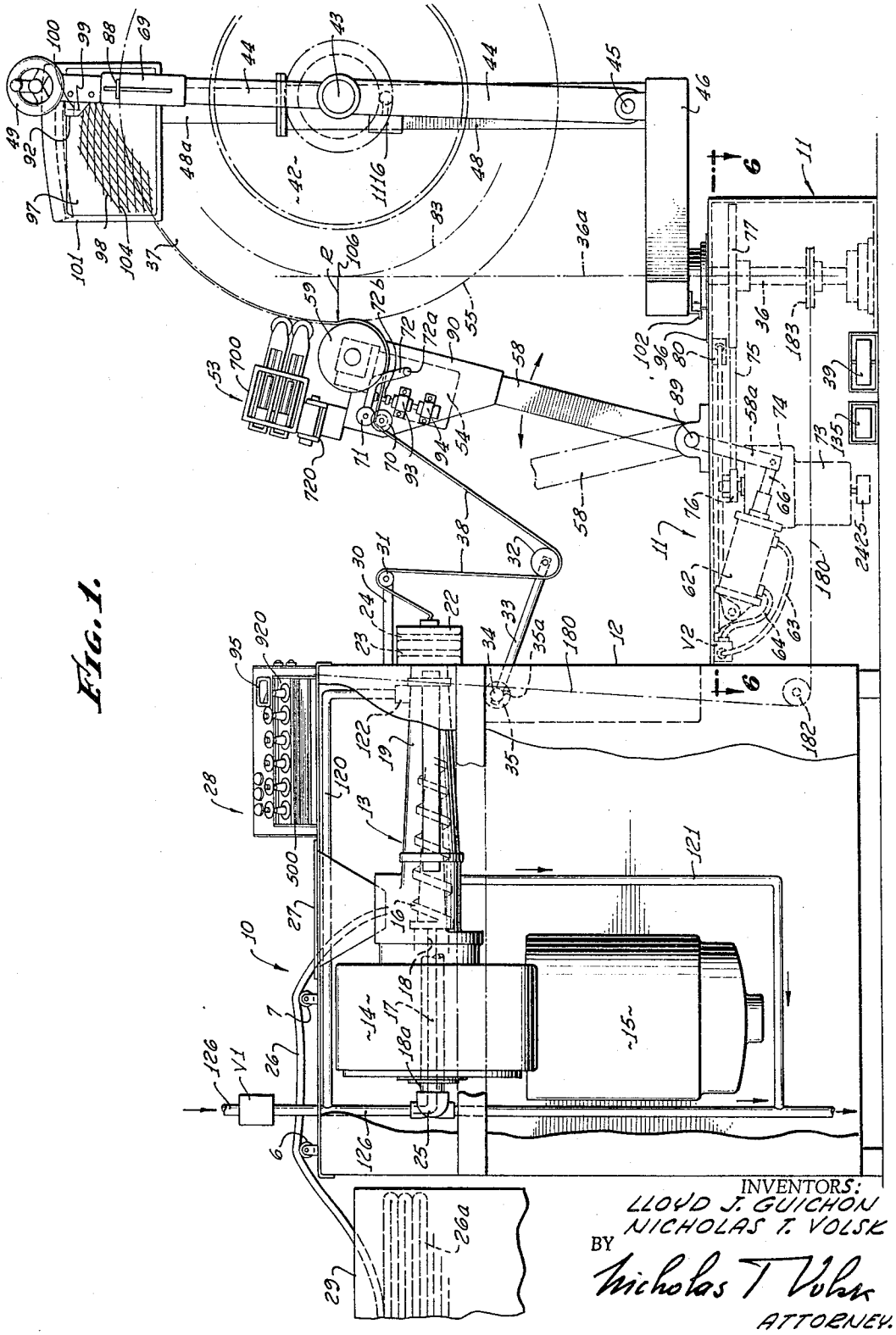


FIG. 1.

INVENTORS:
LLOYD J. GUICHON
NICHOLAS T. VOLSK
BY
Nicholas T Volsk
ATTORNEY.

Aug. 23, 1966 L. J. GUICHON ET AL 3,268,380

VARIABLE SPEED RIBBON WINDING MACHINE

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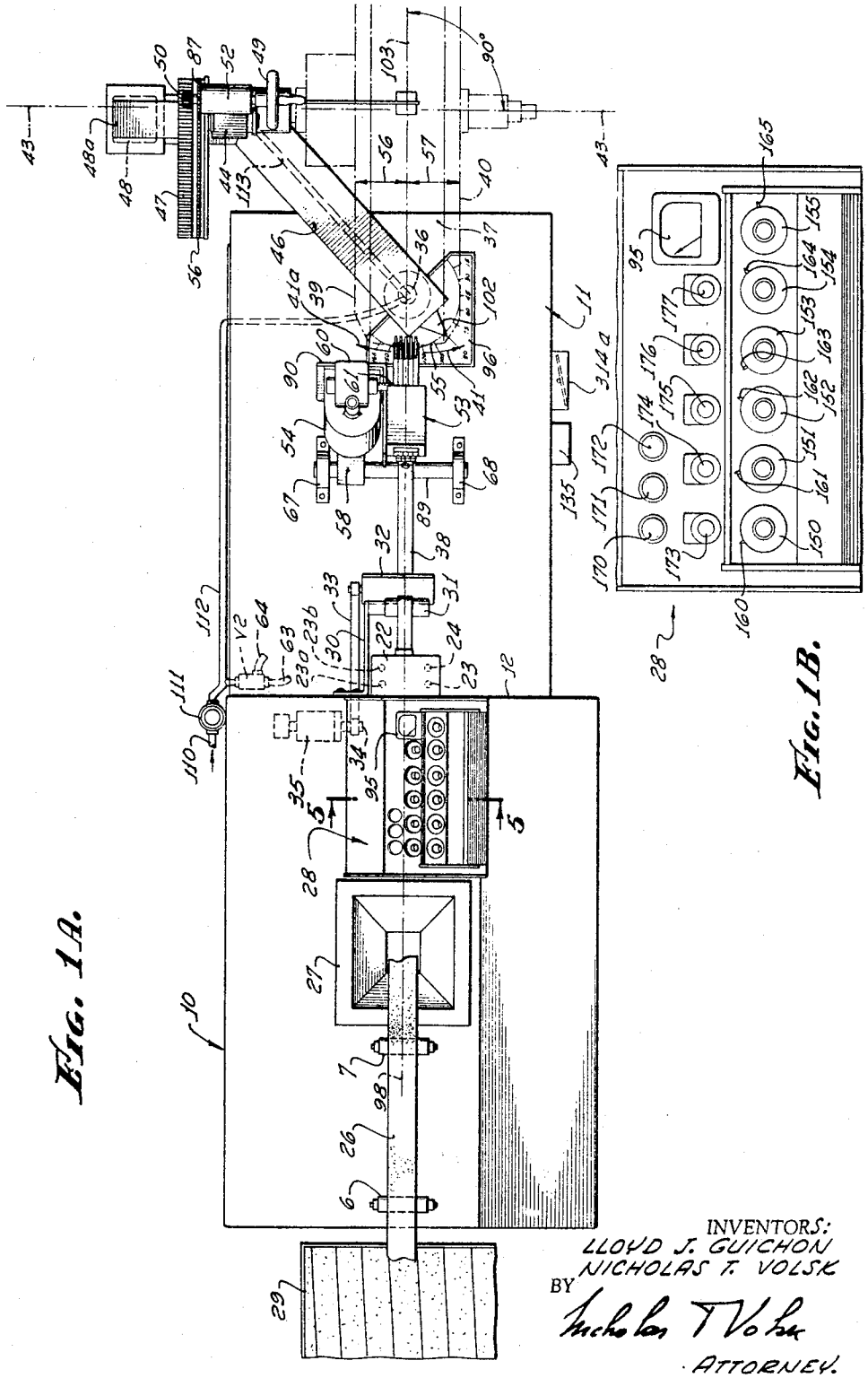


FIG. 1A.

FIG. 1B.

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Nicholas T Volsk
ATTORNEY.

Aug. 23, 1966 L. J. GUICHON ET AL 3,268,380

VARIABLE SPEED RIBBON WINDING MACHINE

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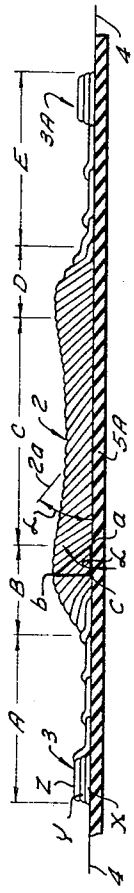


Fig. 3.

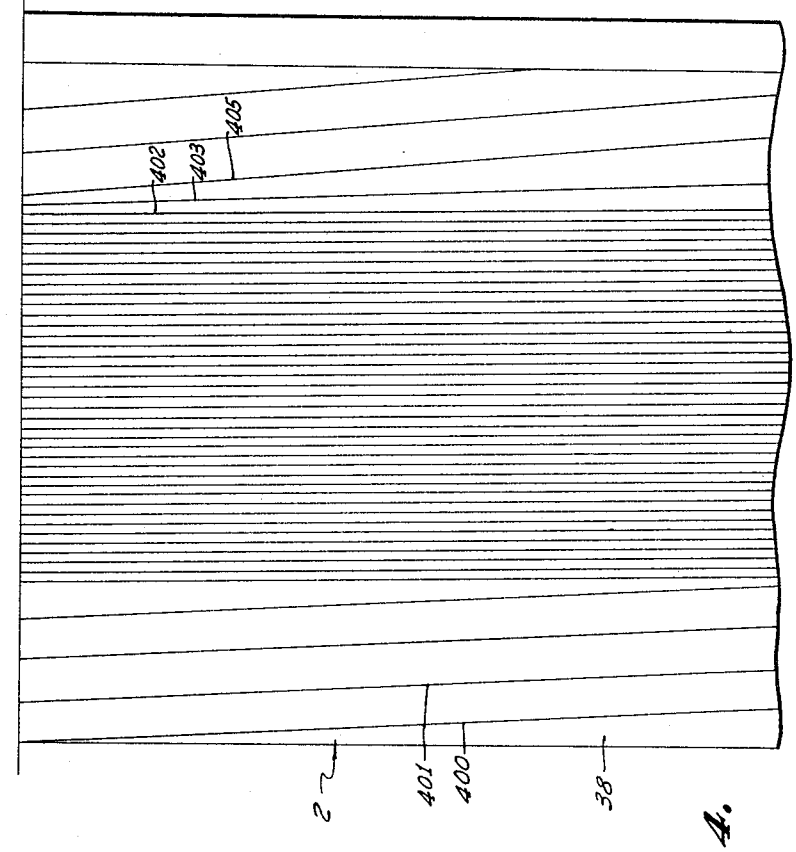


Fig. 4.

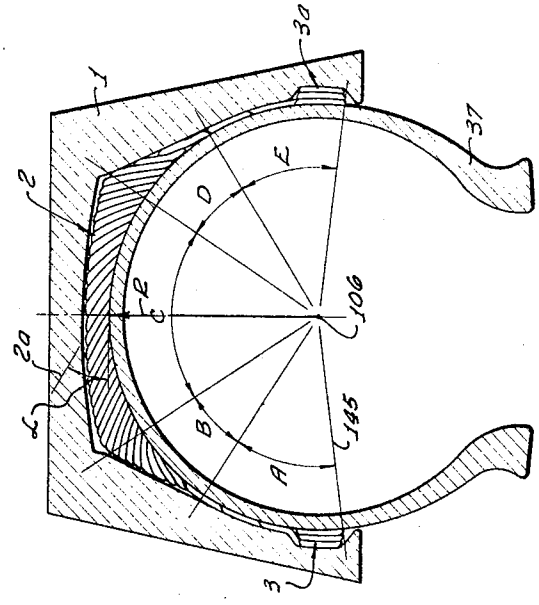


Fig. 2.

INVENTORS:
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Nicholas T. Volsk
ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 27.

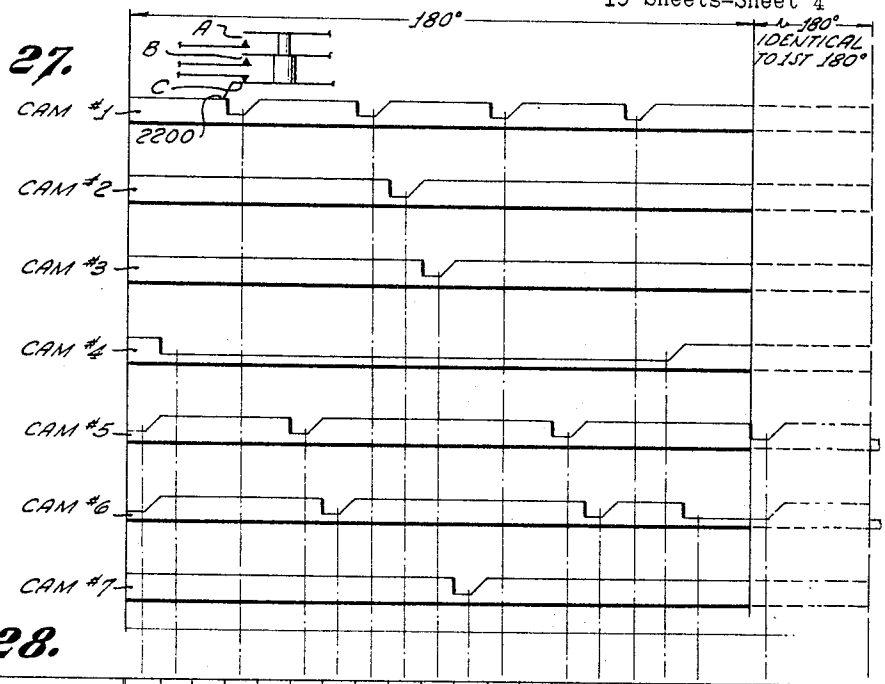


FIG. 28.

POSITION	0	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	190°	360°
CAM SW. #1				×				×				×				×					
CAM SW. #2									×												
CAM SW. #3										×											
CAM SW. #4		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×				
CAM SW. #5	×					×								×						×	
CAM SW. #6	×						×								×			×	×	×	
CAM SW. #7											×										
HOME POSITION					#1	#2	#3						#1	#2	#3						
END OF 1ST TURN				A				A1	B	C	D	E				E1					

BEAUTY RINGS — BEAUTY RINGS COMPLETES LAST TURN OF E1 — HOME POSITION

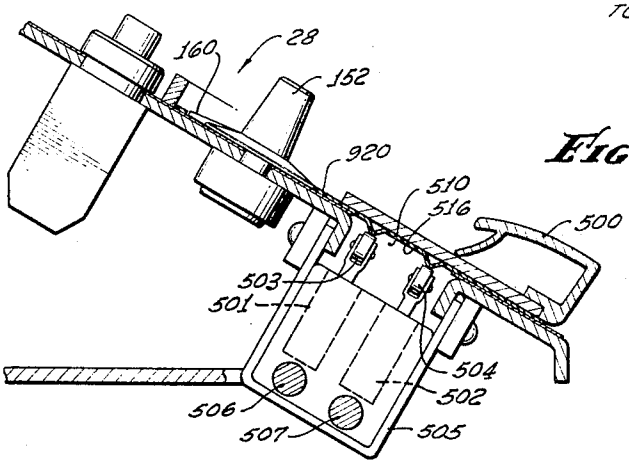


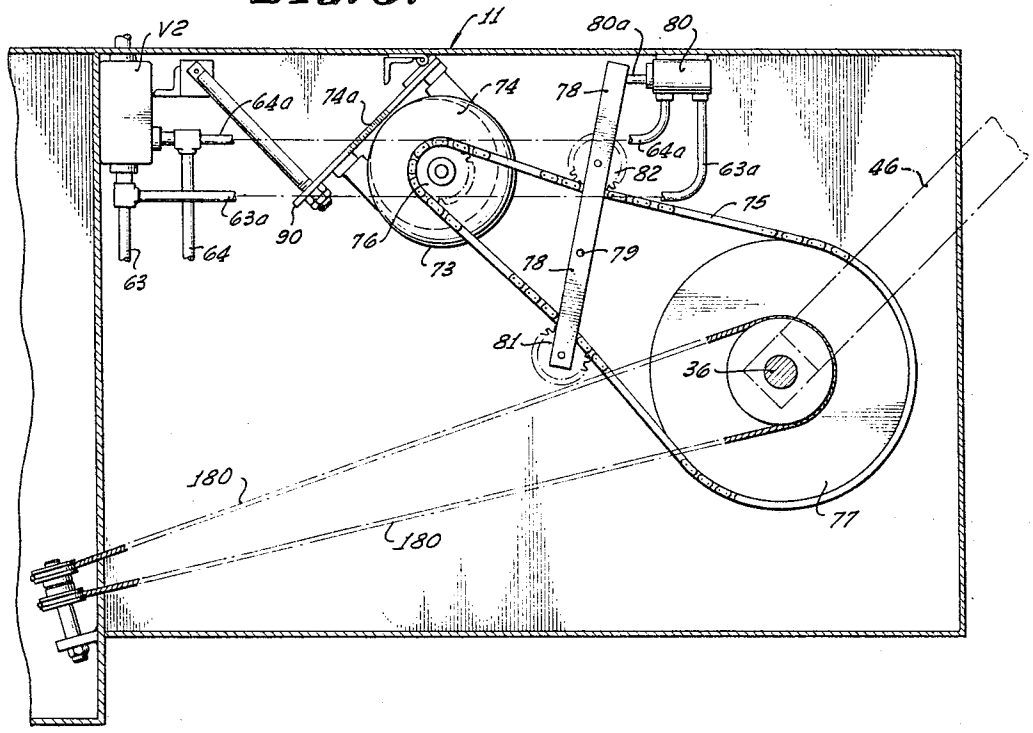
FIG. 5.

INVENTORS:
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BY Nicholas T Volsk
ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 6.



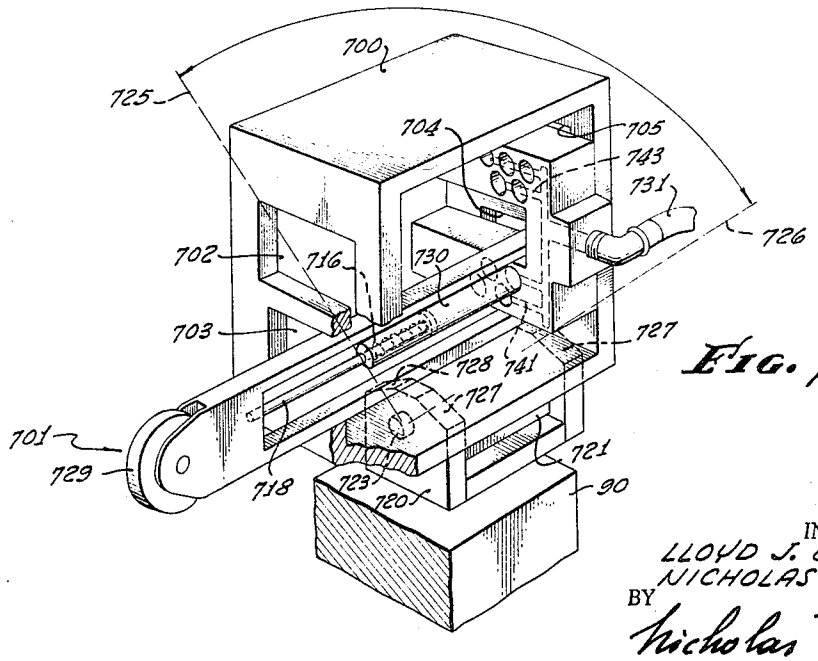


FIG. 7.

INVENTORS:
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BY
Nicholas T Volsk
ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 8.

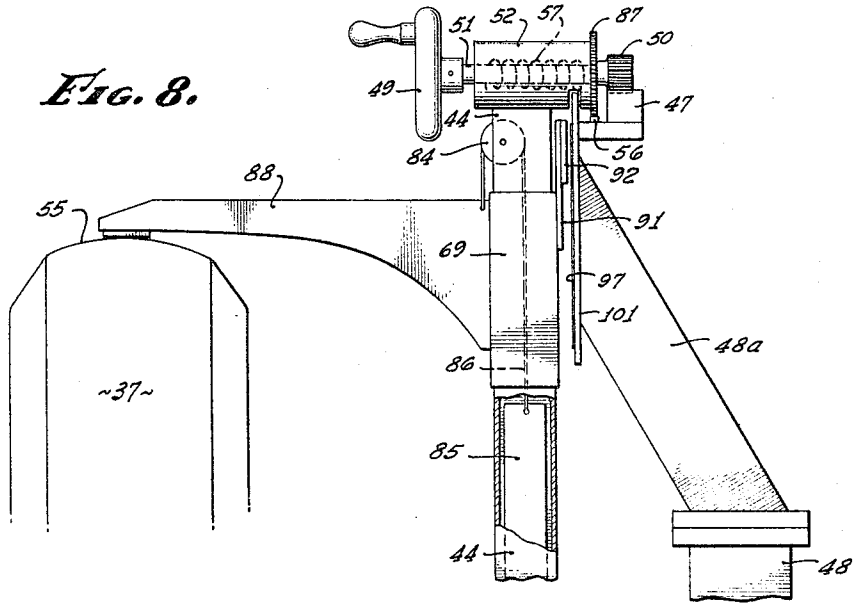


FIG. 16.

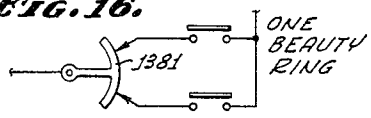


FIG. 17.

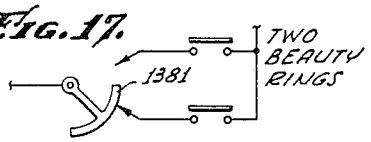


FIG. 18.

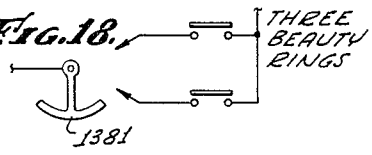
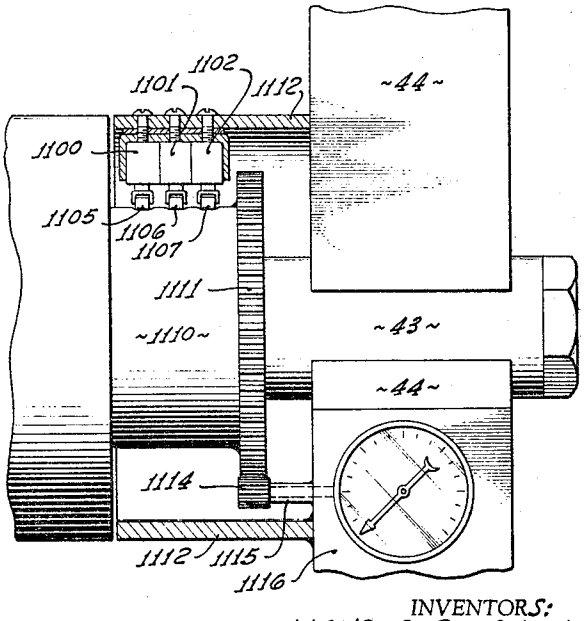


FIG. 11.



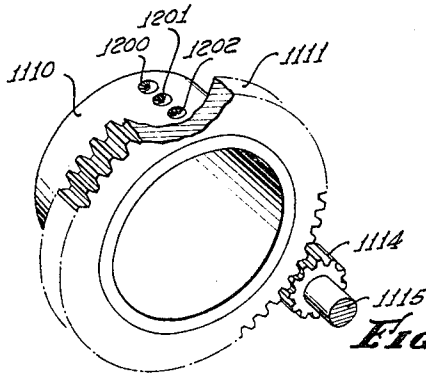


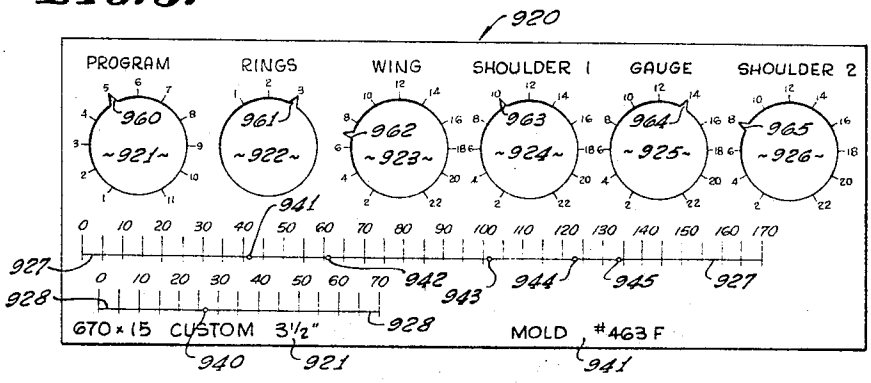
FIG. 12.

INVENTORS:
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NICHOLAS T. VOLSK
BY
Nicholas T. Volsk
ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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Fig. 9.



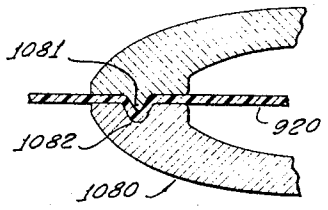
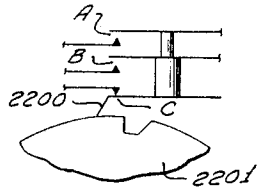
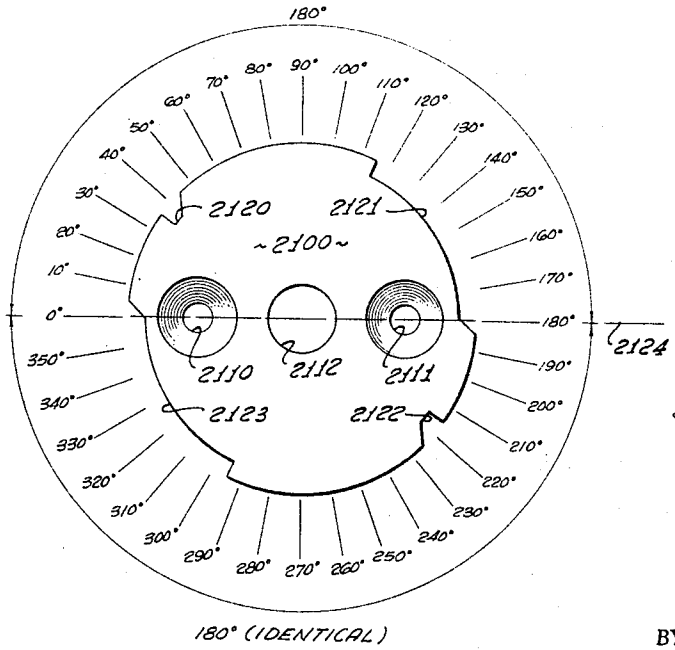


Fig. 10.

Fig. 22.

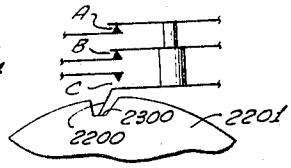




180° (IDENTICAL)

Fig. 21.

Fig. 23.



INVENTORS:
LLOYD J. GUICHON
NICHOLAS T. VOLSK

BY

Nicholas T Volsk

VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 13.

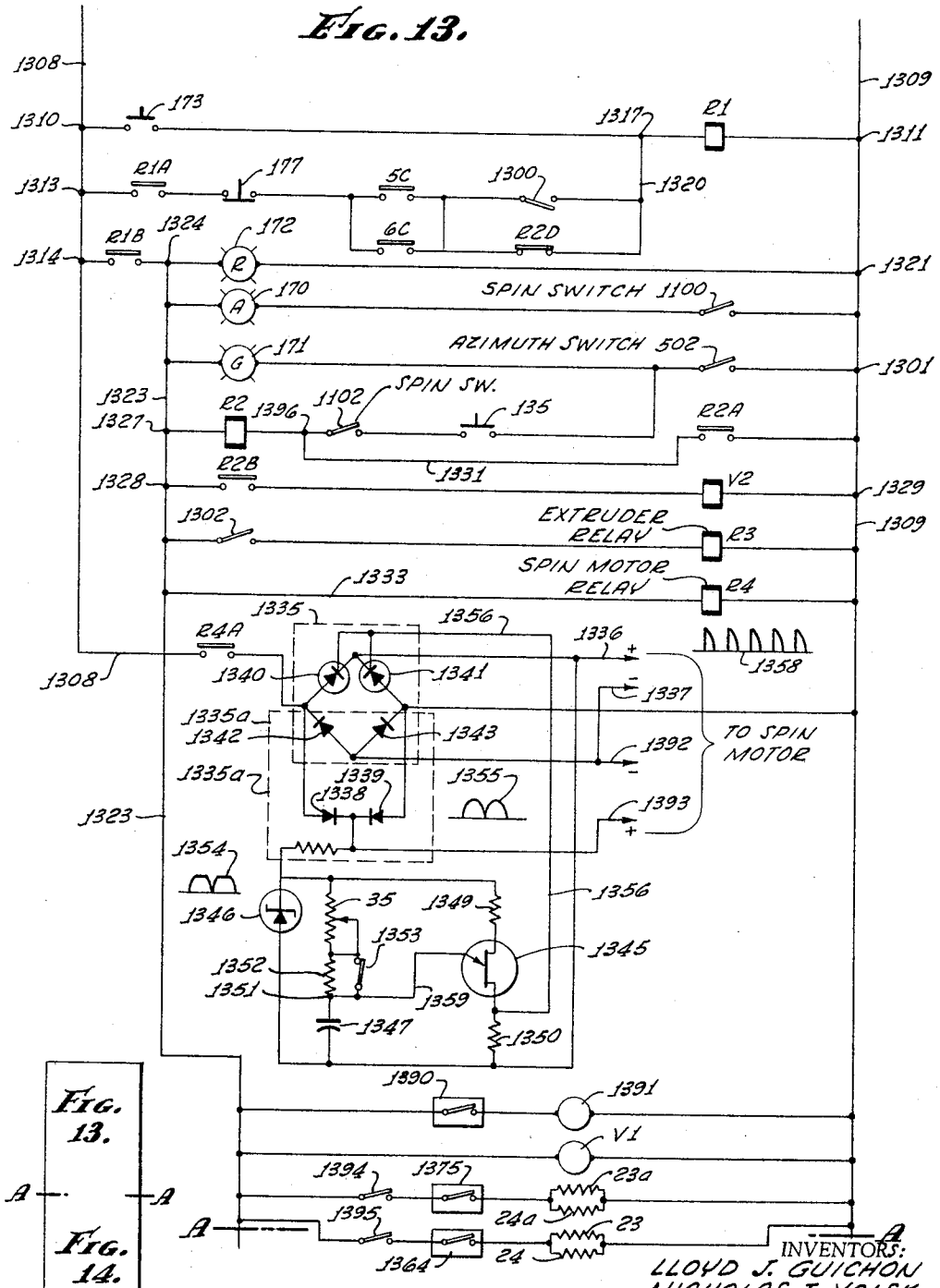


FIG. 13.

A — A

FIG. 14.

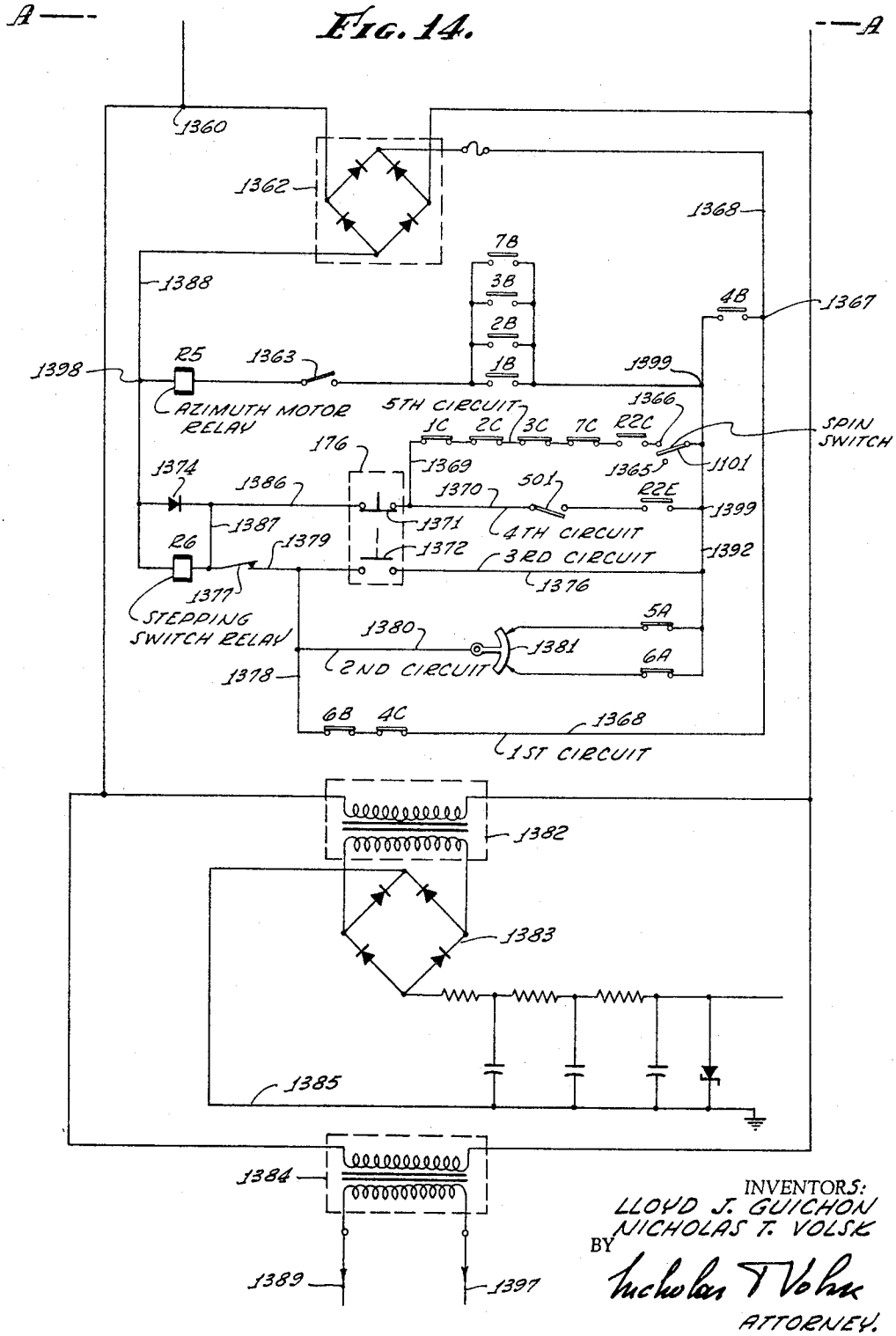
FIG. 15.

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VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 14.



INVENTORS:
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ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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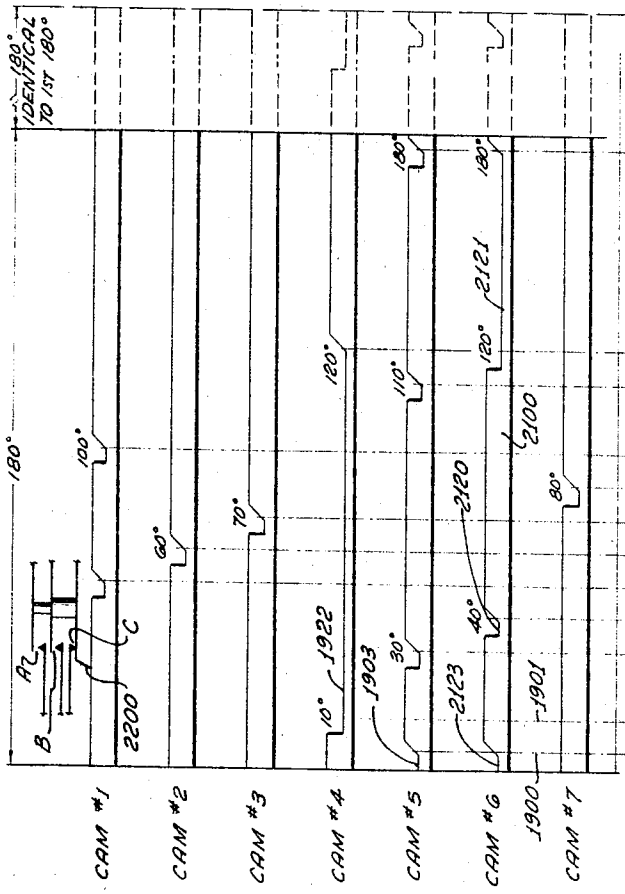


FIG. 19.

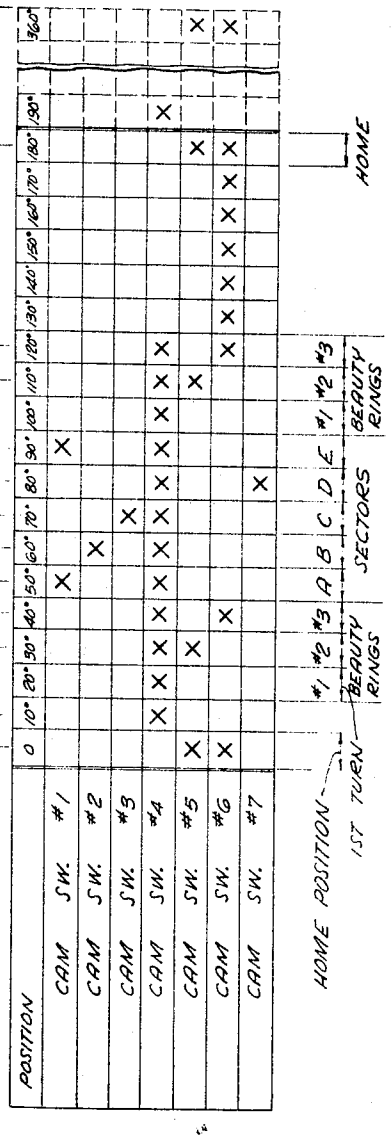


FIG. 20.

INVENTORS:
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VARIABLE SPEED RIBBON WINDING MACHINE

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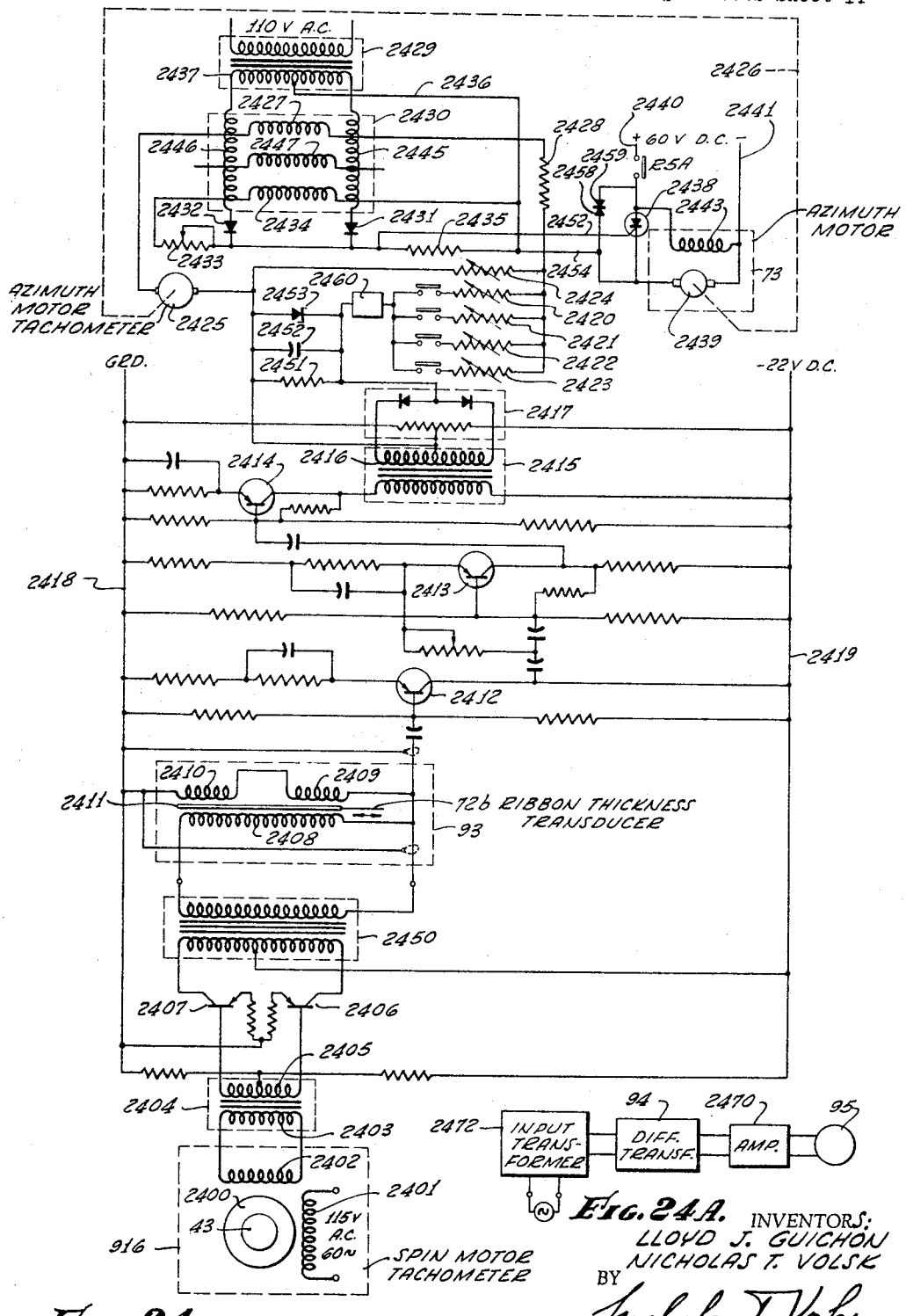


FIG. 24.

FIG. 24A.

INVENTORS:
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Aug. 23, 1966 L. J. GUICHON ET AL 3,268,380

VARIABLE SPEED RIBBON WINDING MACHINE

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Fig. 25.

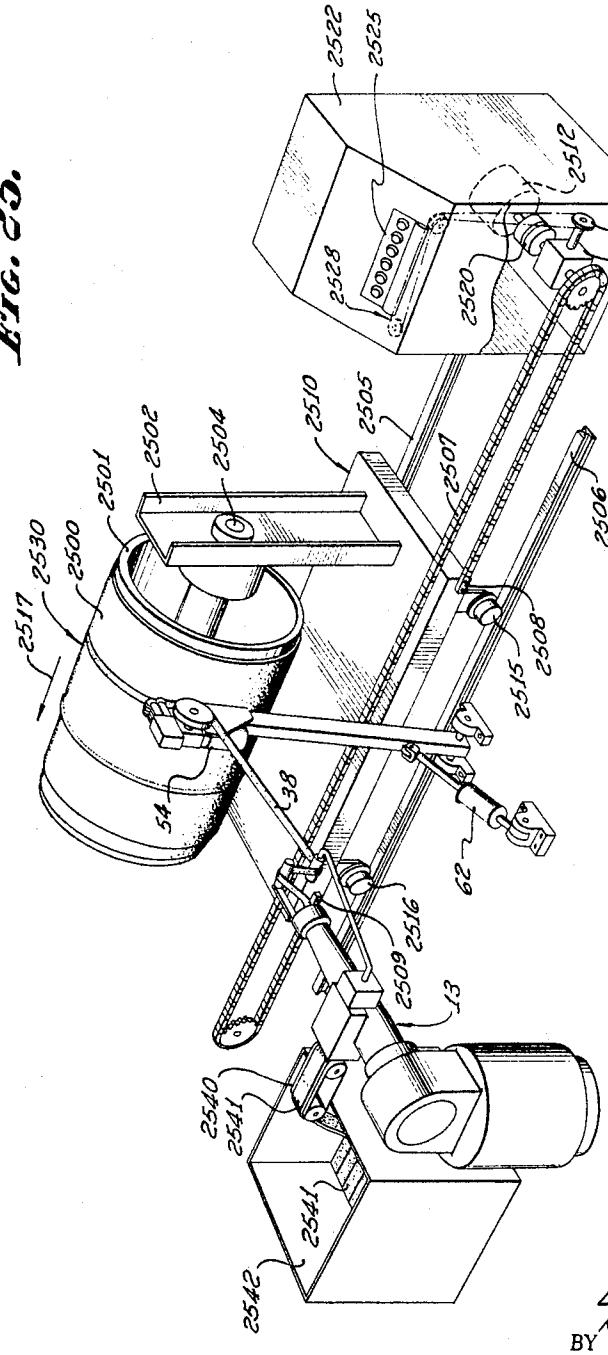
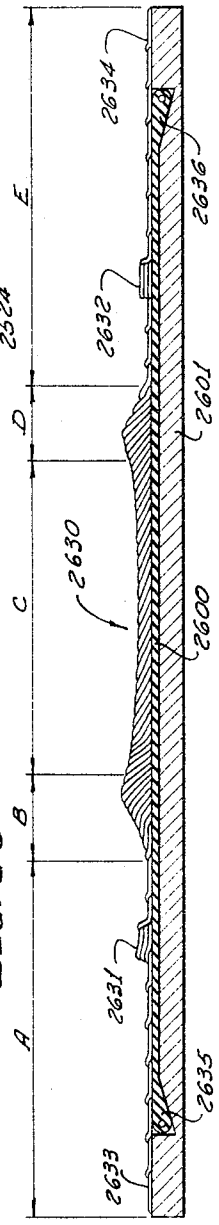


Fig. 26



INVENTORS:
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VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 29.

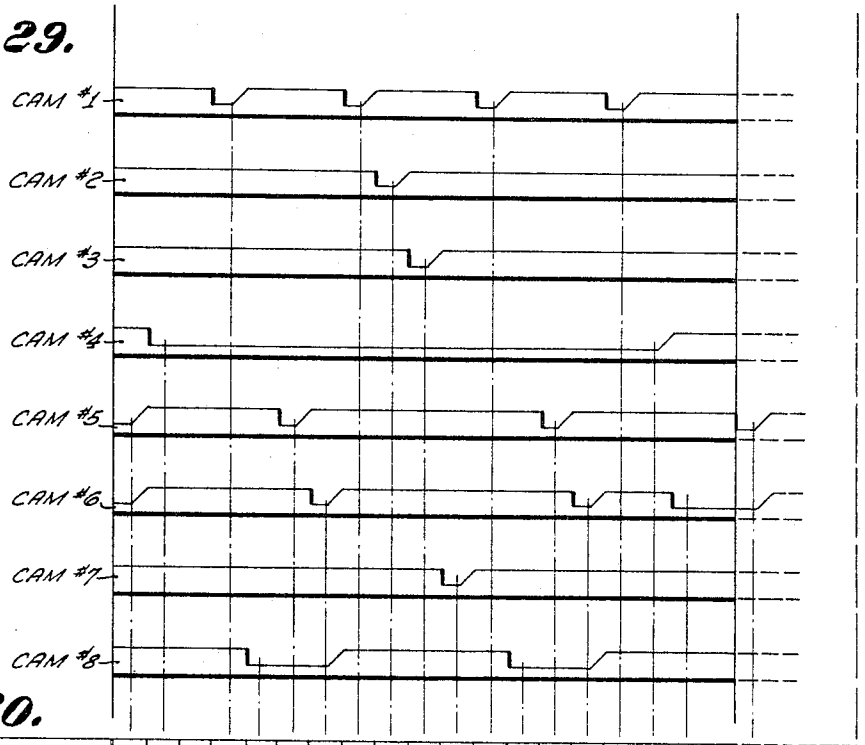


FIG. 30.

POSITION	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	360
CAM SW. #1				×				×				×				×					
CAM SW. #2									×												
CAM SW. #3										×											
CAM SW. #4		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×				
CAM SW. #5	×					×								×						×	
CAM SW. #6	×						×								×			×	×	×	
CAM SW. #7											×										
CAM SW. #8					×	×	×						×	×	×						

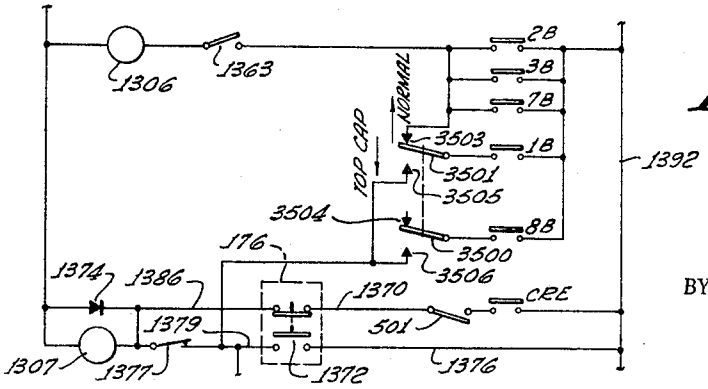


FIG. 35.

INVENTORS:
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VARIABLE SPEED RIBBON WINDING MACHINE

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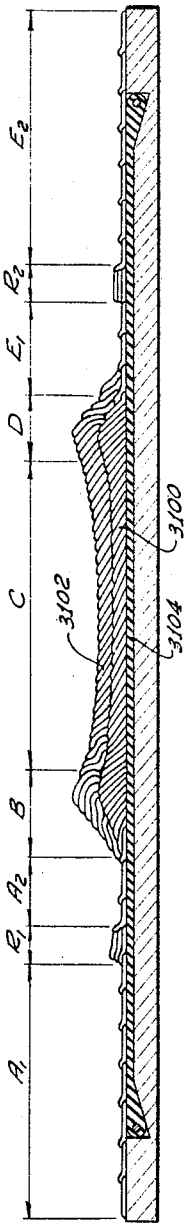


Fig. 31.

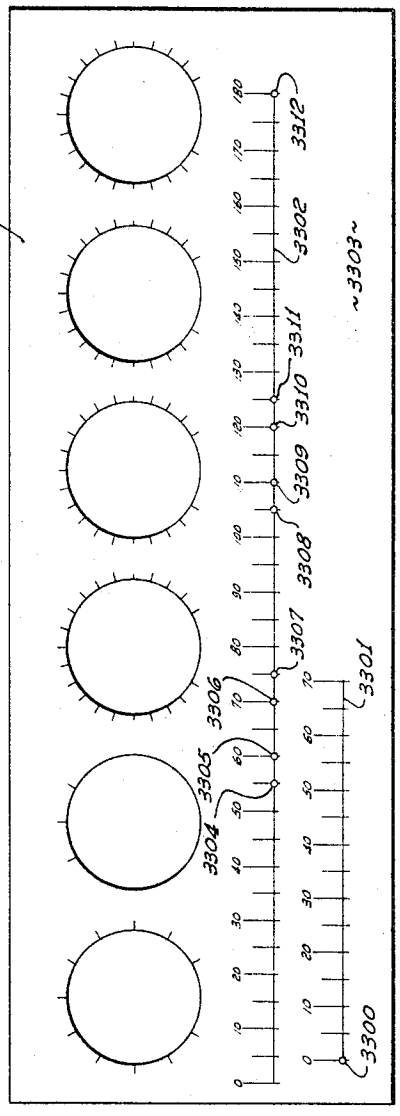


Fig. 33.

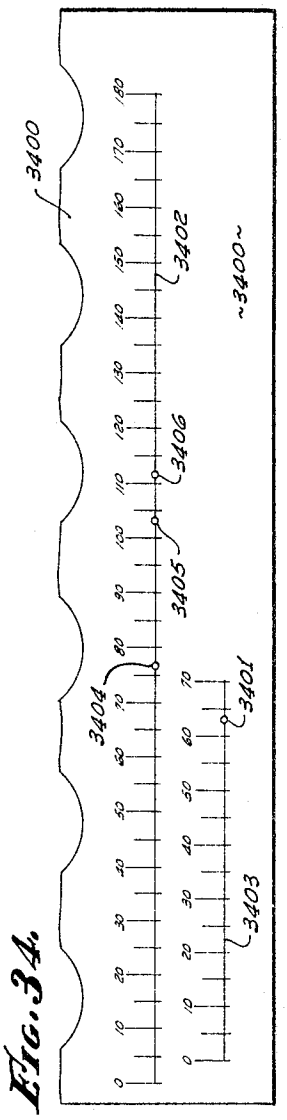


Fig. 34.

INVENTORS:
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VARIABLE SPEED RIBBON WINDING MACHINE

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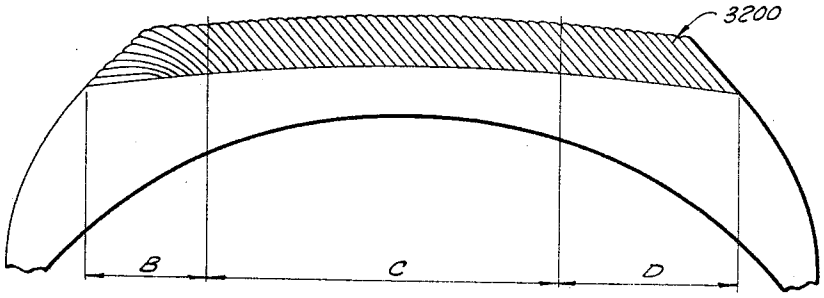
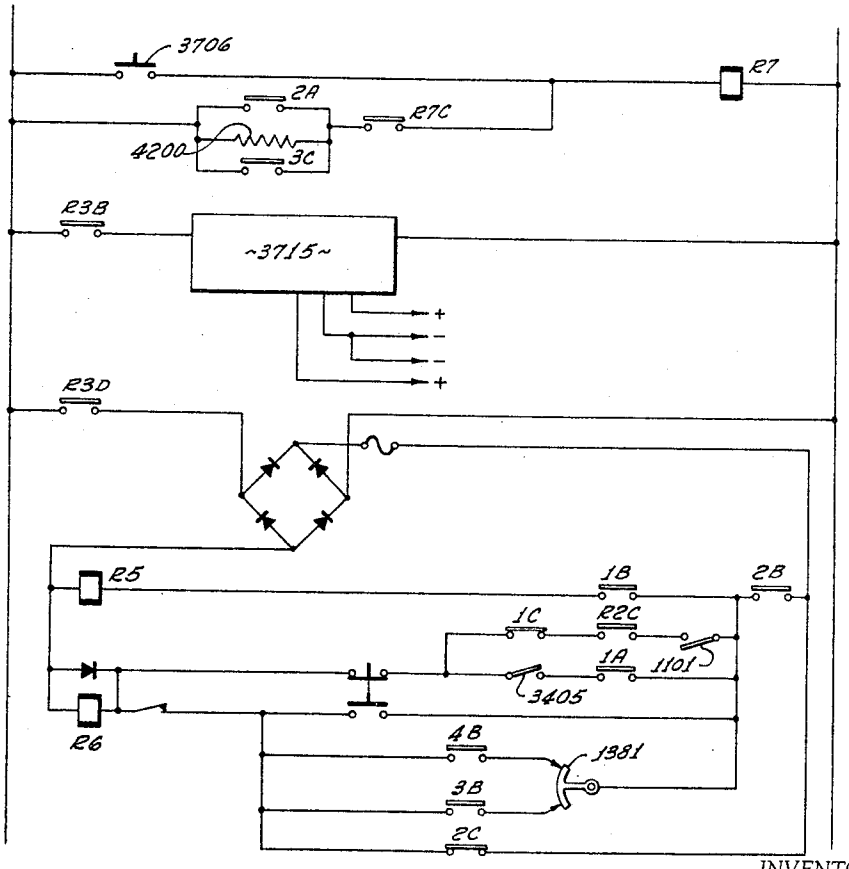


FIG. 32.

FIG. 42.



INVENTORS:
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VARIABLE SPEED RIBBON WINDING MACHINE

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Fig. 36.

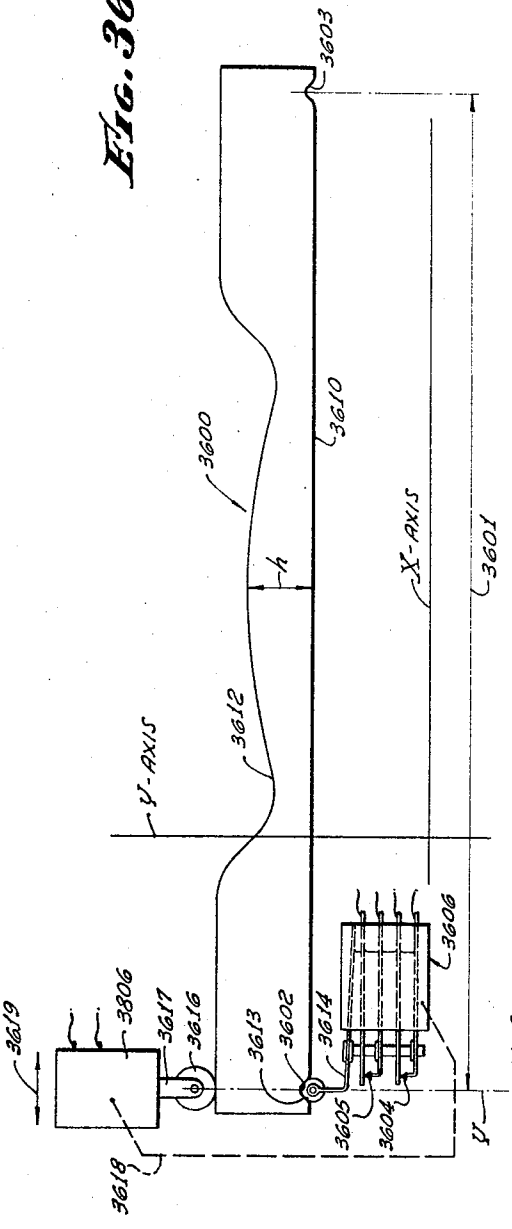
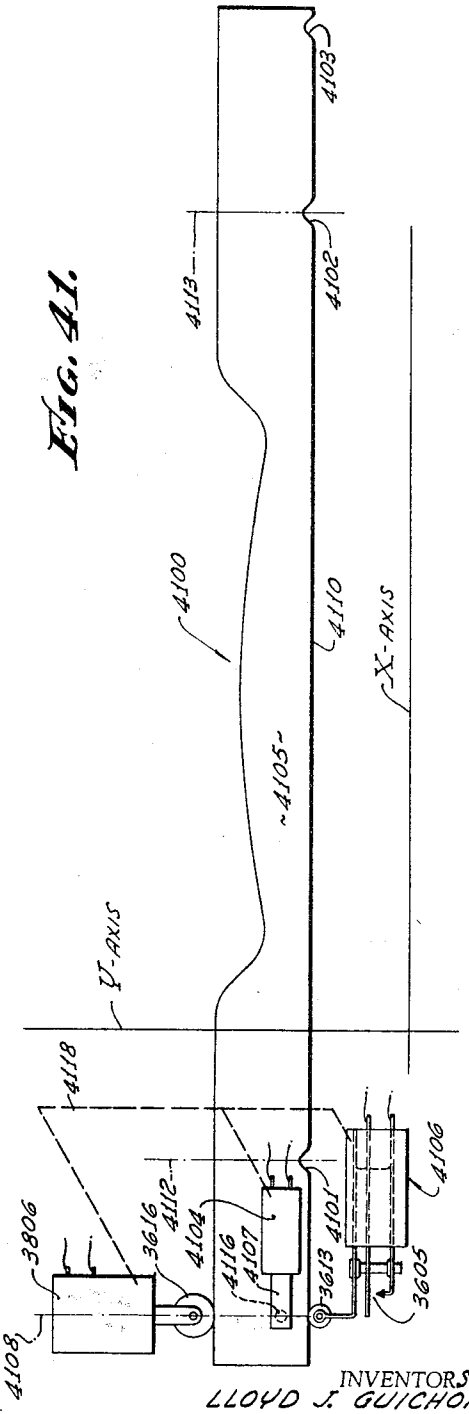


Fig. 41.



INVENTORS:
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NICHOLAS T. VOLSK

BY Nicholas T Volsk

ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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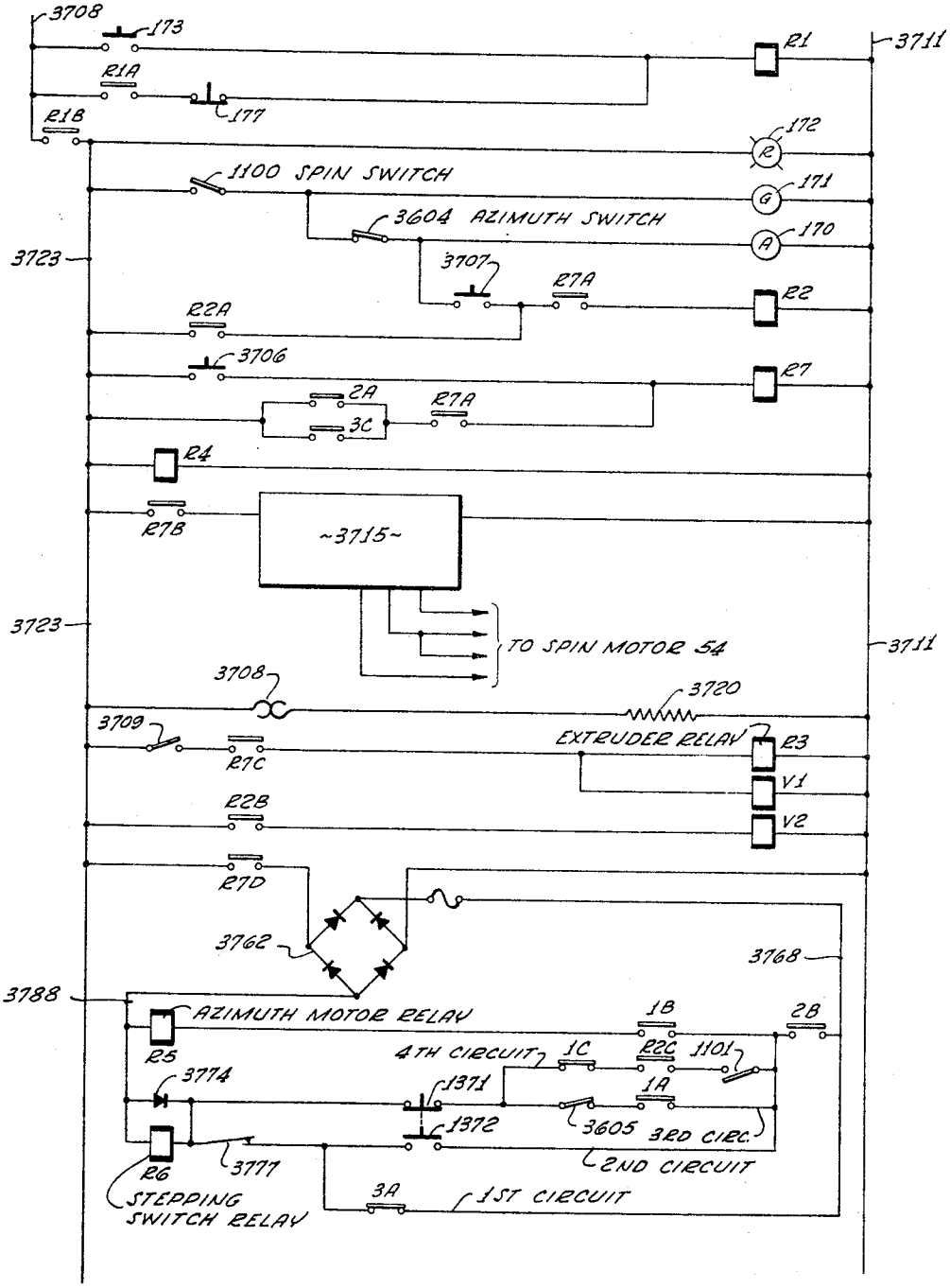


FIG. 37.

INVENTORS:
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BY
Nicholas T Volsk
ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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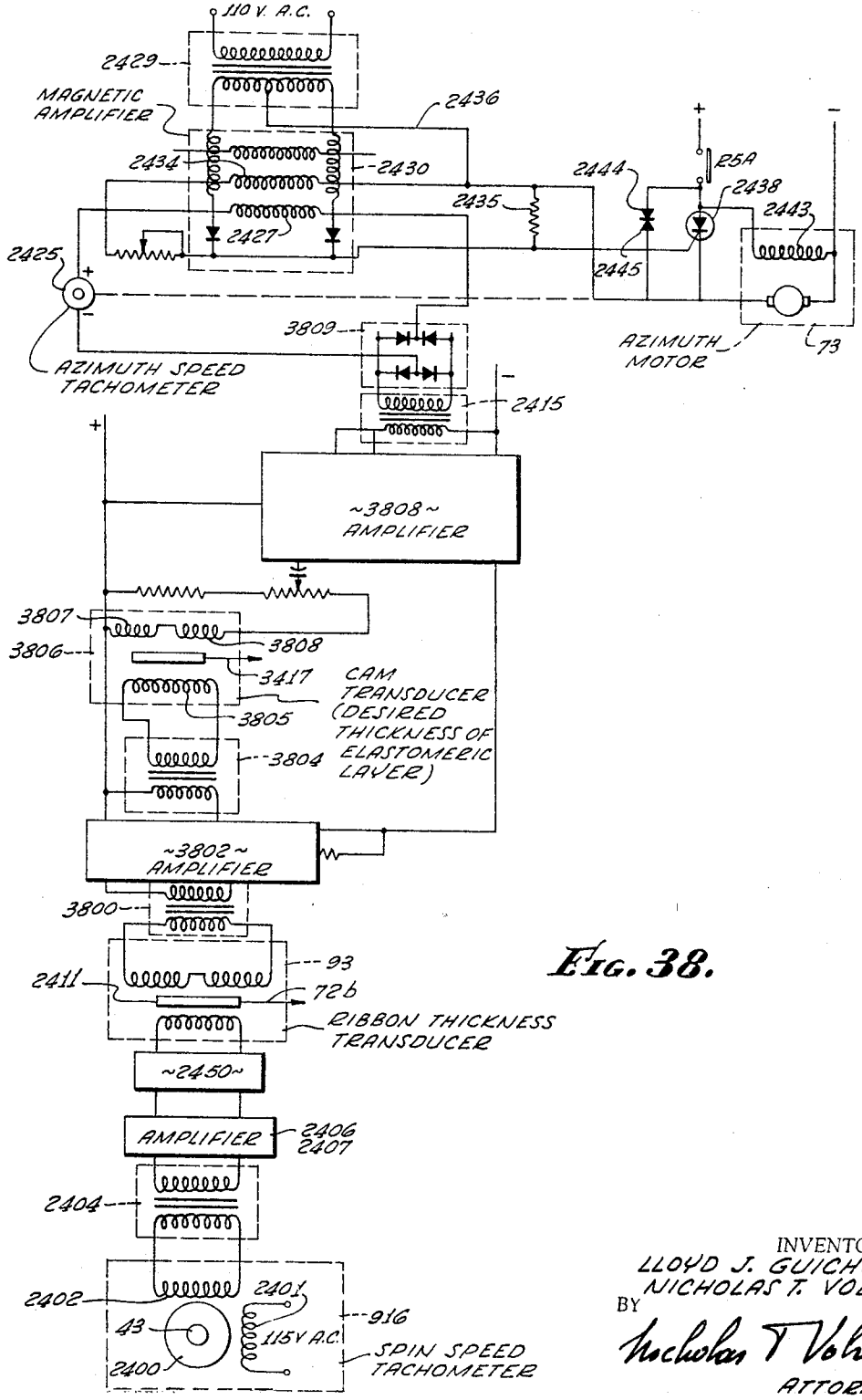


Fig. 38.

INVENTORS:
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BY
Nicholas T Volsk
ATTORNEY.

VARIABLE SPEED RIBBON WINDING MACHINE

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FIG. 39.

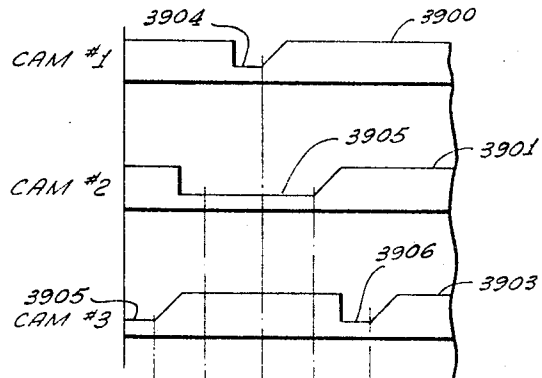


FIG. 40.

	0°	10°	20°	30°	40°	
CAM #1			×			
CAM #2		×	×	×		
CAM #3	×				×	

HOME 1ST TURN — HOME LAST TURN — COMPLETE WINDING EXCEPT 1ST AND LAST TURNS

FIG. 43.

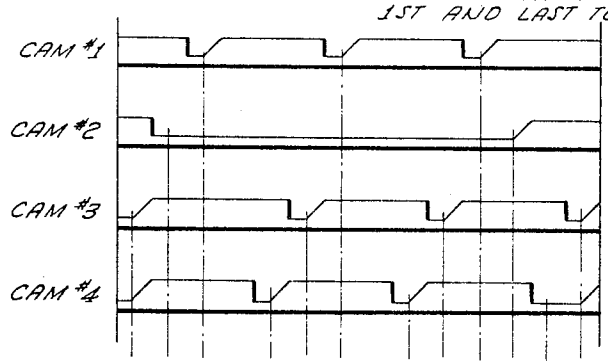


FIG. 44.

	0	10	20	30	40	50	60	70	80	90	100	110	120	130
CAM #1			×				×				×			
CAM #2		×	×	×	×	×	×	×	×	×	×	×		
CAM #3	×					×				×				×
CAM #4	×				×				×				×	×

HOME HOME

INVENTORS:
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NICHOLAS T. VOLSK
BY Nicholas T Volsk
ATTORNEY.

United States Patent Office 3,268,380 Patented August 23, 1966

3,268,380

VARIABLE SPEED RIBBON WINDING MACHINE

Lloyd J. Guichon and Nicholas T. Volsk, Costa Mesa, Calif., assignors to W. J. Voit Rubber Corp., a corporation of California

Filed Jan. 30, 1963, Ser. No. 254,958
18 Claims. (Cl. 156—130)

This invention relates to machines and methods for winding an elastomeric material on a casing of a pneumatic vehicular tire in the course of its original manufacture or for retreading used pneumatic tires.

The invention will be described in connection with the retreading of used tires first, and it then will be followed with the description of applying elastomeric material to a casing of a new tire in the course of its original manufacture.

According to this invention, a relatively thin ribbon of natural or synthetic rubber, or a combination of the two, or other elastomeric material, extruded by a local extruder, which constitutes a part of the machine, is wound at a predetermined and controllable rate of azimuth movement on the pneumatic tire casing which has been previously properly buffed and coated with cement. At the beginning of the automatic winding process, the free end of the locally extruded, hot, tacky and very pliable ribbon, which has a temperature between 150° F. and 250° F., depending on the composition, upon its extrusion, is manually secured by adhesion to a sidewall of the casing at a point located along one edge of the layer to be deposited on the casing. This is the only manual step in the process. From then on the winding is continued under the control of an electronic programmer until a predictable and the desired variable thickness layer of uncured elastomer has been automatically applied to the buffed surface of the tire. The variable thickness layer is obtained by winding, as it will be called here, a "variable pitch continuous spiral" on the casing. The nature of this variable pitch continuous spiral will become more apparent from a later, more detailed description of the two types of spirals which may be produced with two distinct methods of winding the ribbon on tire casings disclosed here.

According to the first method, the continuous spiral consists of several sets of constant pitch spirals which are obtained by subdividing the casing or the width of the contemplated variable thickness layer to be deposited on the casing into a plurality of sectors and making the pitch of the spiral constant within each sector, thus producing a single, continuous variable pitch spiral composed of a plurality of constant pitch spirals within each sector. The magnitude of each pitch within each individual sector is adjusted so as to produce or deposit the desired thickness of the elastomer within each sector. Even in the above method, the pitch remains constant within a given sector only as long as the thickness of the extruded ribbon remains constant.

According to the second method, the pitch of the spiral remains constant only as long as the desired thickness of the layer remains constant and the thickness of the extruded ribbon remains constant. There is no subdivision of the width of the layer into a plurality of sectors since the programmer of the machine is controlled by a variable amplitude, or height, cam, which may have very many variations in its amplitude. This cam corresponds to the desired thickness of the layer.

The above two distinct methods are applicable to the new and used tires and to variable thickness layers with or without beauty rings. Moreover, the beauty rings may be desired along or at the two edges of the layer in retreading old or used casings, and it may be desired approximately in the middle of each sidewall sector or portion of the layer when making new tires.

The disclosed variations in the programmers, which make all of the above methods possible, include all of the above alternatives.

Let us describe more in detail the first method, using several sectors, as it applies to a used tire with two beauty rings at the two edges of the layer. Such spiral begins with one to three turns having a zero pitch at which time either one, two or three complete turns of ribbon are superimposed 100% on top of each other for producing the so-called "beauty ring," and then it is followed by a spiral, the pitch of the spiral being automatically changed several times by decreasing and increasing the pitch several times and, in this manner, by varying the percentage of overlap between 100% at the beauty rings and a minimum overlap of 5% at the sidewalls, in the course of the winding cycle at predetermined positions of the ribbon on the casing. Such changes in the pitch of the spiral and the percentage of overlap, and the angle of inclination of the ribbon's face to the surface of the casing are obtained automatically with the aid of the electronic programmer, the machine, in this manner, depositing a variable thickness layer of the elastomer on top of the casing. The winding cycle is then completed, just prior to its termination, by winding again one, two or three turns having zero pitch, i.e., one, two or three complete turns which are 100% superimposed on top of each other in order to produce the second beauty ring at the second sidewall of the casing. Thus, the entire ribbon winding cycle is completed during a single transverse path, or pass, of the ribbon across a casing as differentiated from a plurality of paths and a plurality of passes and a plurality of superimposed layers of the ribbon known to the prior art. The wound pattern, therefore, begins and ends with a desired number of turns, from one to three turns, which has or have zero pitch. These zero pitch turns are used for obtaining the so-called two beauty rings which project beyond their respective sidewalls and protect these sidewalls from scuffing, usually against curbstones, when parking. Between the two beauty rings there is a plurality of sets of constant pitch spirals, the first set followed by the second set, etc. As will be pointed out more in detail later, there are five sets of essentially constant pitch spirals in the illustrated example: two sets for two sidewalls, two sets for two shoulders and one set for the crown. These five sets were found to be sufficient to obtain the type of variable thickness layer desired for retreading used tires and, with some modifications, for making new tires. In this manner, a variable thickness single elastomeric layer of uncured elastomeric ribbon is deposited along the outer surface and periphery of the casing. This layer fills completely and exactly the space, or gap, between the inner surface of the matrix and the outer buffed surface of the casing. It is well known in the art of retreading and also in making of new tires, that the casing and the external elastomeric layer must engage the matrix in the mold for obtaining proper adhesion of the elastomer and elimination of any air pockets in the subsequent compression molding.

Upon completing of the winding cycle, the casing is compression molded in conventional manner to produce a tread of proper depth, resurfaced sidewalls, and beauty rings, when such are desired, all positively bonded to the casing.

The locally extruded ribbon thus not only eliminates the necessity of having large stocks of composite tread rubber, having a natural rubber adhesion underlayer of different sizes and different compositions required by the present methods, but it also drastically reduces the initial cost of the elastomer because of the elimination of all prior special size extrusions, elimination of the natural rubber adhesion underlayer, expensive polyethylene backing, special packing in individual boxes, enormous amounts of clerical paper work, writing and sorting of

orders, special shipping, etc., all of which are indispensable when tread rubber is ordered specially for each set of tires as special size camelback. Because of the simultaneous local extrusion of the ribbon and its immediate winding on a casing, the elastomer has a temperature from 150° F. to 250° F. and, at this temperature, it has optimum viscosity and tackiness for positive stitching and adhesion to a compoundly curved surface of the tire casing. The end product, therefore, is a product of the highest quality, without any air pockets, and very positively bonded to the casing, which is indispensable not only from the point of view of long wear, but also the very safety of high speed tires.

It is, therefore, an object of this invention to provide an automatic machine for depositing a variable thickness layer of exact predictable dimensions on a tire casing by winding a locally extruded ribbon along a path including variable pitch spiral, which, in one method, is composed of a plurality of sets of constant pitch spirals, one constant pitch set merging into the next constant pitch set, the pitch of the first set differing from the second set, etc.

It is also an object of this invention to provide a method and a machine for winding an elastomeric ribbon on a tire casing along a path of a continuously varying pitch spiral, the pitch of the spiral remaining constant only when the thickness of the desired elastomeric layer is constant and the thickness of the extruded ribbon is also constant.

It is an additional object of this invention to provide electronic programmers for the machines of the above type which automatically control the operation of the machines by means of a program card in one instance and a variable amplitude cam in the other instance specifically programmed for a casing and a matrix of given sizes and for the desired and fully predictable shape and variable thickness of the layer of elastomer to be deposited on the casing.

Still another object of this invention is to provide a machine for automatically applying a variable thickness layer of uncured elastomeric material on a pneumatic casing in the course of its original manufacture by winding either a true variable pitch continuous spiral, according to one method, and a variable pitch spiral, according to the second method, in which the variable pitch spiral is composed of a plurality of constant pitch spirals, the thickness of the deposited layer being automatically controlled in each method by an electronic programmer which controls the rate of transverse travel of the drum or wheel supporting the casing.

Still another object of this invention is to provide a method of automatically winding a ribbon having a thickness T and a width W, width W being several times greater than the thickness T, in which a variable thickness layer is deposited on a casing during a single continuous, uninterrupted transverse travel, called here an azimuth travel, of the ribbon across the casing by varying the percentage of overlap between the respective succeeding and preceding turns from 100% overlap to 5% overlap.

It is an additional object of this invention to provide the methods and the machines of the above type in which the azimuth movement is a continuous, controllable speed movement, taking place during each spin revolution of a casing except during the winding of the beauty rings, the programmer determining the speed of the azimuth movement during each spin revolution and altering this speed at predetermined relative positions of the ribbon and the casing with respect to each other.

The novel features which are believed to be characteristic of this invention, together with the further objects and advantages thereof, will be better understood from the accompanying drawings, in which several embodiments of the invention are illustrated by way of several examples.

Referring to the drawings:

FIG. 1 is a side view of the machine suitable for retreading used tires;

FIG. 1A is a plan view of the machine illustrated in FIG. 1;

FIG. 1B is a front view of the control panel for the machine illustrated in FIG. 1;

FIG. 2 is a transverse section of a casing and of a matrix surrounding the casing; a variable thickness elastomeric layer prior to its curing is illustrated which is deposited on the casing by winding the elastomeric ribbon around the periphery of the casing;

FIG. 3 is a transverse section of the elastomeric layer applied to a casing but developed along a straight line;

FIG. 4 is a plan view of a small portion, or sector, of the elastomeric layer;

FIG. 5 is a side view, partly in section, of the control panel;

FIG. 6 is a top plan view, taken along line 6—6, FIG. 1, of the azimuth motor and of the mechanisms actuated by the azimuth motor;

FIG. 7 is a perspective view of a pneumatic stitcher;

FIG. 8 is a side view of two interconnected columns used for adjusting the azimuth radius of a casing;

FIG. 9 is a plan view of a control card used for controlling the operation of the machine in accordance with the first method of winding the ribbon;

FIG. 10 is a sectional view of pliers used for making detents on the card of FIG. 9;

FIG. 11 is a side view, partly in section, of the spin axle, "spin" switches and a spin tachometer;

FIG. 12 is a perspective view of the spin switch cam of the spin tachometer gears and of the spin tachometer shaft;

FIGS. 13 and 14 are those two portions of the schematic diagram of the programmer which control the operation of the spin and azimuth motors and of the stepping switch, this programmer being made to operate the machine in accordance with the first ribbon-winding method;

FIG. 15 is a diagram illustrating the manner in which FIGS. 13 and 14 should be matched with respect to each other along line A—A for obtaining the above portion of the programmer;

FIGS. 16, 17 and 18 are plan views of three different positions of a beauty ring selector switch used in the programmer of FIGS. 13, 14 and 24;

FIG. 19 is a development of the seven circular cams used in connection with a seven-cam rotary stepping switch used in the programmer of FIGS. 13 and 14, the seven circular cams having been developed along their respective seven, spaced and parallel straight lines for a better understanding of the functioning of these cams;

FIG. 20 is a table illustrating the sequence of operation of the rotary cam stepping switch for winding the ribbon in accordance with the pattern illustrated in FIGS. 2, 3 and 4.

FIG. 21 is a side view of one cam used in the rotary cam stepping switch;

FIGS. 22 and 23 are two side views of three cam-operated contacts of the stepping switch;

FIG. 24 is the remaining portion of the schematic diagram of the programmer for winding the ribbon in accordance with method #1;

FIG. 24A is a schematic diagram of the circuit for a meter indicating the thickness of the ribbon;

FIG. 25 is a perspective view of a machine suitable for making new tires in accordance with the disclosed methods #1 and #2;

FIG. 26 is a cross-section of the pattern wound on a new tire casing in the course of making new tires;

FIG. 27 is a side view of the stepping switch cams and FIG. 28 is a sequence of operation table for the stepping switch for winding the ribbon on new tire

casings in accordance with method #1 and the pattern illustrated in FIG. 26;

FIG. 29 is a side view of the stepping switch cams and FIG. 30 is a sequence of operation for the stepping switch for winding the ribbon on a new or used casing in accordance with the pattern illustrated in FIGS. 31 and 32 by using method #1;

FIG. 31 is a sectional view of a new tire casing with two variable thickness layers deposited on the casing;

FIG. 32 is a sectional view of a new or used tire casing with a single variable thickness layer deposited on top of the casing, the layer including only sectors B, C and D according to method #1, or the central portion of the casing according to method #2;

FIGS. 33 and 34 are two cards used for depositing two layers illustrated in FIG. 31 by using method #1;

FIG. 35 is a part of the schematic diagram of a programmer for winding ribbon on new or used tire casings in accordance with method #1 and for producing the patterns shown in FIGS. 31 and 32;

FIG. 36 is a side view of a variable amplitude cam, of a transducer for scanning the upper part of the cam, and of a switch for scanning the lower part of the cam, the cam being used for operating the machine in accordance with method #2;

FIGS. 37 and 38 are schematic diagrams of a programmer to be used in connection with a variable amplitude cam illustrated in FIG. 36 and for operating the machine in accordance with method #2;

FIG. 39 is a side view of three cams and FIG. 40 is a table of operation of the stepping switch used in FIG. 37;

FIG. 41 is a side view of a variable amplitude cam for winding a pattern on a new tire casing, such as that illustrated in FIG. 26, by using method #2;

FIG. 42 is a modified schematic diagram of FIG. 37 for winding a pattern of the type illustrated in FIG. 26 by using method #2;

FIG. 43 is a side view of the stepping switch cams and FIG. 44 is a sequence of operation table for the stepping switch for winding the ribbon pattern of the type illustrated in FIG. 26 by using method #2.

A variable pitch continuous spiral

Before proceeding with a more detailed description of the first winding method disclosed here, it would be helpful to define some of the terms which will be used in describing the first method. The word "pitch" in mechanical engineering and machine engineering, means a distance from any point on the thread of a screw to the corresponding point on an adjacent thread measured parallel to the longitudinal axis of the screw. Thus, the pitch of a screw is also the distance advanced on a screw in one revolution of the screw. Screws may have a constant pitch or a variable pitch. When an extruded ribbon is wound on a casing which is rotated at a constant rate around its spin axis, which is its normal axis of rotation, and is simultaneously moved at a constant rate in "azimuth," which is the lateral, or transverse, movement of the casing along the spin axis, and with respect to the ribbon, the path followed by the ribbon is a continuous constant pitch spiral. When the rate of spin is constant and the rate of the azimuth motion is variable, then the ribbon follows a continuous variable pitch spiral. In all of the above examples, it was assumed that the spin rotation and the azimuth motion are continuous motions, and, therefore, to change the constant pitch spiral to the variable pitch spiral, all one had to do was to make either of the two motions, or, in one private case, both motions, variable speed motions in order to obtain a variable pitch spiral.

Three methods are possible for obtaining and controlling a variable pitch spiral. In the first method, which is the first system disclosed here, the azimuth rotation is continuous, but the rate of the azimuth rotation is changed, and is made either smaller or larger, as the casing leaves one sector and enters the next sector, such as the previously mentioned five sectors A through E. In the second method, also disclosed here, a continuously varying azimuth motion is used as long as the thickness of the layer varies. In the third method a start-stop azimuth motion is used in which the azimuth motion has a constant rate, or speed, but lasts for a variable interval of time which is shorter than the time required for one complete spin revolution of the casing around the horizontal spin axis 43, FIG. 1. The third method is disclosed in the copending application of R. G. Holman, Serial No. 196,542, filed May 1, 1962.

The simplest, practical, automatic ribbon-winding machine, capable of depositing a variable thickness layer by varying the pitch of a spiral, is the one in which the rate of spin is made constant and then only the rate of the azimuth movement is varied. That this is true, follows from the fact that in such machine and its control system, the number of variables is reduced to an irreducible single variable, i.e., the azimuth movement. In a practical, and most economic machine, it is more feasible to spin the casing at a speed which makes the peripheral speed of the casing continuously equal to the speed of extrusion of the ribbon. Since the ribbon is not necessarily extruded at exactly a constant speed, the spin speed is not exactly constant but is a function of the speed of ribbon extrusion. The next alternative is to make the azimuth movement substantially constant as long as the speed of the ribbon extrusion is substantially constant, and then change the azimuth movement at predetermined positions of the ribbon on the casing. When a thicker layer is desired, the azimuth movement is made slower, and vice versa. This is the first system disclosed in this specification. Therefore, in the first disclosed system, the casing is subdivided into a plurality of sectors and then the rate of the azimuth movement is made constant in a given sector as long as the spin speed and the thickness of the ribbon remain constant. The rates of the azimuth movement are then changed from sector to sector depending on the thickness of the desired elastomeric layer on any given portion, or sector, of the carcass. It becomes necessary to control and vary this azimuth speed as a function of the speed of extrusion of the ribbon and also as a function of the thickness of the ribbon because both of these parameters have a direct and immediate influence on the thickness of the deposited layer. In the light of the above, if we are to disregard the minor variations, and they are minor, in the thickness of the ribbon and the spin speed, then the azimuth speed in the first disclosed system would remain constant during the azimuth traverse of any particular sector, and it is then changed from sector to sector. The resulting continuous spiral may then be regarded as a continuous spiral composed of a plurality of constant pitch spirals, as long as the ribbon thickness is constant, merging into each other at the end of a preceding sector and the beginning of the next, succeeding sector, the pitch varying from sector to sector. Accordingly, in the first method disclosed here, the overall spiral is, indeed, a continuous, variable pitch spiral, but this spiral is composed of a plurality of constant pitch spirals with different pitches in the components of this overall spiral. However, if the variation in the thickness of the ribbon is taken into consideration, then even the "constant pitch" components of the overall spiral are not truly constant pitch segments of the overall spiral but vary slightly as the thickness of the ribbon varies. In this light, the overall spiral then becomes, indeed, a truly classical continuous variable pitch spiral but of that type in which the most important changes in the pitch of this spiral take place when the ribbon leaves one sector and enters the succeeding sector.

As mentioned previously, this invention also discloses the second method of winding the ribbon in which the variable thickness elastomeric layer is not divided into

a plurality of constant pitch spiral sectors. Instead, a variable height or a variable amplitude continuous cam is used for controlling the electronic programmer and the speed of the rotation of the azimuth motor, and the amplitude of the cam is made to vary in accordance with the desired variations in the thickness of the layer to be deposited on the casing. Since the height or amplitude of the cam need not necessarily be constant in any particular portion, the pitch of the spiral wound on the casing may, indeed, vary continuously from one edge to the other edge of the layer. However, since the crown and the sidewalls, as a rule, do have portions which have a reasonably constant thickness of elastomer, it is also possible to make some portions of the cam to have a constant height, in which case the resultant spiral will also have a constant pitch portion or portions. The advantage of the second method as compared to the first method resides in the fact that with the variable amplitude cam it becomes possible to have a much greater number of variations in the thickness of the layer since the amplitude of the cam can have very gradual and continuous changes in its amplitude. The second method also produces a simpler programmer and a better end product in that the thickness of the layer can be controlled with a greater precision.

The "continuous variable pitch spiral," will relate to the spiral composed of a plurality of spiral sectors, or portions, having different pitch from sector to sector and either a constant or a substantially constant or a slightly variable pitch, the latter depending on the method, i.e., the first or the second method used, and, in the main, the thickness of the ribbon. When there is a variation in the thickness of the ribbon there is also a corresponding variation in its width. However, the change in width is much smaller than in thickness, and, therefore, can either be disregarded, or the control system and the feed-back circuit can be adjusted so as to take into consideration both changes in thickness and in width, at the same time.

The first method

Proceeding now with a more detailed description of the variable pitch continuous spiral path followed by the ribbon in the first method, FIG. 2 illustrates, diagrammatically, a transverse section of a pneumatic tire casing **37** with a variable thickness layer **2** of elastomeric ribbon wound on its outer surface and surrounded by a matrix **1**. The deposited variable thickness layer **2** fills completely the gap between the casing **37** and the matrix **1**. The variable thickness layer **2** is deposited by winding a plurality of turns of the ribbon around the casing during a complete winding cycle, including a single azimuth pass and many simultaneous spin revolutions of the casing. A continuous, variable pitch spiral is wound which may have variations in the percentage of overlap from 5% to 100% between adjacent turns and the concomitant variation in an angle of inclination α between the transverse dimension of the ribbon and the casing. The above is obtained, as stated previously, by changing the speed, or rate, of the azimuth travel at predetermined azimuth positions of the casing as the azimuth travel progresses from sector to sector along the outer periphery of the casing. The programmer, electrically, subdivides the casing into a plurality of sectors, five sectors A through E having been found adequate for obtaining the desired layer on conventional passenger and truck tires. There are vectors defined by the radial lines emanating from the geometric center **106** of the carcass in FIG. 2. The five sectors are: the two sidewall sectors A and E, the two shoulder sectors B and D, and the crown sector C. The two sidewall sectors A and E may include scuff-preventing beauty rings **3** and **3A**, which may have one, two or three layers of ribbon deposited on top of each other. The thickest part of the deposited layer is at the two shoulder sectors B and D, an intermediate thickness is deposited at the crown sector C, and the sidewall sectors A and E, beyond the beauty rings **3** and **3A**, have the thinnest layers. Thus, by varying the percentage of overlap, and therefore, angle between the surface of the casing and the transverse line corresponding to the width of the ribbon passing through the point of contact of the ribbon's edge with the casing (this line is line *2a* in FIG. 3), it becomes possible to obtain a variable thickness layer with the ribbon having constant dimensions during one, or a single, transverse azimuth pass across the entire casing.

The thickness of the extruded ribbon **38**, FIG. 1, may vary slightly if there is any variation in the temperature, composition and uniformity of prior mastication of the strips of stock fed into the extruder. The machine is provided with two adjustments for this purpose. The first ribbon thickness adjustment and measurement is an electrical measurement of the thickness of the extruded ribbon and adjustment of the amplitude of the control signal produced by this measurement. The second ribbon thickness adjustment is in the extrusion die **22**, FIG. 1. The programmer is provided with a transducer actuated by the ribbon and connected to a compensating circuit for regulating the operation of the machine (by adjusting the speed of the azimuth motor) so as to take into consideration and automatically and continuously correct for relatively minor variations in the thickness of the ribbon that may take place in the course of its extrusion. For larger initial adjustments and settings of the die for the desired thickness of the ribbon, the die is provided with a manually adjustable gate.

Examination of the pattern illustrated in FIGS. 2 and 3 indicates that the disclosed method cannot be practiced successfully unless the ribbon has sufficiently large W/T ratio, where W is the width of the ribbon and T is its thickness. This at once follows from the solution of the right triangle *a-b-c* illustrated in FIG. 3. If the maximum thickness *b-c* is in the order of ¾", and angle α, at this instance, is in the order of 45°, then the width should be in the order of 1.62". Another relationship which follows is

$$WT=pt \tag{1}$$

and

$$t=WT/p \tag{2}$$

where

W is the width of the ribbon
T is the thickness of the ribbon
p is the pitch of the spiral or adjacent turns, and
t is the thickness of the deposited layer.

This follows from the fact that the thickness t of the deposited layer multiplied by the pitch p must be equal to the cross-sectional area of the ribbon since it is the latter that produces the former. Experience indicates that all passenger car tires can be retreaded successfully with the ribbon being 1" wide and 0.1" thick. Thus, the W/T ratio is 10:1 ratio in the above example. It would be possible to practice the method with the above ratio having the limits from 6:1 to 15:1 with the optimum being in the order of 10:1. Angle α also cannot be equal to 90° since then the ribbon would "stand" on its edge and would be perpendicular to the surface of the casing. It then would be impractical to "stitch" the ribbon with the stitcher to the surface of the casing since the stitcher would then be exerting a large pressure directly on the edge of the ribbon and would merely collapse and deform the ribbon. The maximum value of angle α however, may be as large as 75°; it is preferable, however, that the maximum value of α be in the order of 60°.

Referring now to FIGS. 3 and 4, FIG. 3 illustrates the transverse section of a layer **2** of elastomer deposited in accordance with the first disclosed method on a casing **5A**, but developed along a straight line **4**, for a more convenient presentation of what is illustrated in FIG. 4, FIG. 4 being the plan view of a small portion of the winding applied to the outer surface of casing **5A**. Since

in making new tires, a casing **2600**, FIGS. 25 and 26, has the shape of a hollow, right cylinder with two open ends, prior to its compression molding, as illustrated in FIG. 25, FIG. 3 also corresponds, in part, to a transverse sectional view of the upper portion of the cylindrical casing **2600**, FIG. 26, of a new tire in the course of its manufacture with a variable thickness elastomeric layer **2**, FIG. 3, deposited on the outer surface of such casing. For a more accurate view of this portion of the new tire casing, with a deposited thickness layer **2630**, one is referred to FIG. 26 which, together with FIG. 25, illustrates the application of the disclosed new methods to the making of new tires. The only difference resides in the fact that the two sidewall sectors are much wider in FIG. 26 and, also, the beauty rings **2631** and **2632** are within the sidewall sectors "A" and "E," in FIG. 26, while the beauty rings **3** and **3A** are at the edges of sectors A and E in FIG. 3. In other respects, the two layers in FIGS. 3 and 26 are, for all practical purposes, identical. It is to be noted here that beauty rings are omitted in many instances in retreading as well as in making new tires.

In FIG. 3, which corresponds to retreading rather than to the making of new tires, the winding process, therefore, begins with the winding of the left beauty ring **3**, which includes, in this example, three layers X, Y and Z of the ribbon deposited on top of each other. As in FIG. 2, the entire deposited layer also includes five sectors which are the first sidewall sector A, the first shoulder sector B, the crown sector C, the second shoulder sector D and the second sidewall sector E, the beauty rings, having been included in the above adopted nomenclature, within the sidewall sectors solely because of the fact that they are located directly at the midportions of their respective sidewalls. Operationally, however, they are produced by those portions of the programmer which is provided specifically for winding the desired number of complete 360° turns on top of each other, with 100% overlap, as shown in FIGS. 2 and 3.

FIG. 4 illustrates the plan view of the pattern which is produced when there are simultaneous spin and azimuth rotations. Since the azimuth rotation is very small, the pattern appearing in FIG. 4 is a series of substantially parallel lines. These lines are, indeed, parallel to each other in each sector because the rate of the azimuth rotation remains constant within each sector (except for the variations in the thickness of the ribbon), but it differs from sector to sector with this limitation: the rates are the same for the two sidewall sectors A and E.

In light of the above description, the pattern followed by the ribbon is that of a variable pitch continuous spiral as represented by lines **400**, **401**, **402**, **403**, **404**, **405**, . . ., with the spiral following a path of uniformly and equally displaced from each other parallel lines during each sector, with the pitch of the spiral being equal to zero at the beginning and the end of the spiral when beauty rings are wound and having a uniform pitch during the winding of the ribbon in each sector. The above, again, should be qualified by stating that the pitch in each sector remains, for all practical purposes, constant as long as T is constant, where T is the thicknes of the ribbon. Thus, if t is the thickness of the layer in any given sector,

$$P_{A-E}=(T)(t) \tag{3}$$

where P_{A-E} is the pitch in any sector A through E.

Also,

$$P_A\ P_B\ P_C\ P_D\ P_E \tag{4}$$

Ribbon winding machine for the first method

Referring now to FIG. 1, the machine is mounted in two box-like members **10** and **11**, which are joined together along a vertical wall **12** of box **10**. Box **10** is used for mounting an extruder **13**, and extruder motor **15**, a gear box **14**, an electronic programmer, an electric power panel with its switches and fuses, compressed air piping and valves, and cooling water piping and valves. The extruder is provided with a screw **16**. Screw **16** preferably is a hollow screw and, when this is the case, it is provided with a centrally located stationary pipe **17** mounted in the central bore **18** of screw **16**. Pipe **17** is connected to a source of cooling water through a stationary coupling **25**. Pipe **17** conveys water to the tip of the screw and then the cooling water is returned through the screw bore **18** and rotatable pipe **18***a* which is connected at one end to the extruder screw **16** and at the other to a rotatable coupling in the pipe joint **25**. In this manner, the cooling water enters pipe **17** and is discharged at the tip of the screw into the screw bore **18**; it is then returned through a concentric duct which is formed between pipe **17** and the central bore **18**, pipe **18***a* and coupling **25**.

The extruder barrel **19** is also provided with a water jacket for cooling the barrel after the extruder is put into operation. Experience has shown that the smoothness of the extruded ribbon is quite sensitive to the viscosity of the material and this viscosity can be controlled by maintaining the temperature of the extruder at that level which produces a smooth ribbon. Controlled water cooling accomplishes the above. Water enters jacket **19** through a flexible hose **120** connected to an incoming cooling water pipe **126** and leaves through a hose **121**. A thermostat **122** is in series with pipe **120** and is partially imbedded in jacket **19** so as to be kept at the temperature of the jacket. A solenoid-operated valve **V1** is connected in series with pipe **126**. Valve **V1** is automatically opened when the machine is started and is automatically shut off when the machine is stopped. Thermostat **122** controls the rate of cooling by regulating the amount of the cooling water flowing through the jacket circuit.

The extruder terminates in a die member **22**, which is also provided with a plurality of cartridge type electric heaters such as heaters **23**, **23***a*, **23***b* and **24**. All electric heaters are controlled by means of thermostats.

The temperature of all the component parts of the extruder thus are maintained substantially constant to maintain the temperature of the extruded ribbon in the range of 150° F. to 250° F.

Box **10** is also provided with a funnel-shaped member **27**, which is used for feeding the elastomer ribbon **26** into the extruder **13** with the aid of rollers **6** and **7** from a container **29**. Ribbon **26** is produced by mixing the materials in a Banbury mixer and then transferring the mix onto sheeting machines; the elastomer sheets are cut into continuous ribbons **26***a* which are between 3"–5" wide and from ¼" to ½" thick, and then such ribbon is fed into the extruder at the rate controlled by the extruder. In order to prevent adhesion between convolute turns of continuous ribbons **26***a* in box **29**, ribbon **26** is dusted and covered with such anti-adhesive agents as zinc sterate slurry, soap solution, or dusting talc.

Box **10** is also provided with a control panel **28** of the programmer, which is used for mounting push button switches for starting and emergency stopping the machine, the potentiometer control dials, indicating lights, ribbon thickness meter, a program card for controlling the programmer and card-scanning switches on the back portion of the panel. Panel **28** is also provided with a hinged member **500**, FIG. 5, which is used for holding a card **920** with the aid of springs, not visible in any of the figures, which hold the card under proper pressure against the front plate **28** of the panel. This pressure should be sufficiently high so as to resist effectively the counter-pressure exerted on the card by the two card-scanning, or card-reading, microswitches **501** and **502** and their rollers **503** and **504** which are also spring-biased for positive reading of the card. Panel **28** is provided with an opening **510** to permit the two microswitch rollers **503** and **504** to have a direct pressure contact

with the bottom surface 516 of the card for "reading" the card.

Box 10 is also provided with an idler roller arm 30 supporting an idler roller 31. A dancer roller 32 is also mounted on dancer roller arm 33 and arm 33 is connected to a shaft 34, and a potentiometer arm 35a mounted on shaft 34. The potentiometer arm 35a and its potentiometer 35 are used to control the speed of a direct current spin motor 54. Arm 35a also connects a high resistance in series with the armature of the spin motor 54 so as to stop spin motor 54 in case of an accidental breaking of ribbon 38. This will be described more in detail later in connection with the description of FIG. 13.

Azimuth radius mechanism

Proceeding now with the description of that portion of the machine which relates to a rotational support for a casing 37 and its wheel 42, it is necessary to spin wheel 42 around its horizontal axle 43 and it is also neccessary simultaneously to rotate casing 37 in azimuth around a vertical azimuth axis 36a. It is also necessary, before such simultaneous spin and azimuth rotations are started, to place the wheel and the casing in such a position with respect to the azimuth axis 36a and stitcher 53 and spin wheel 59 that the outer circumference 55 of the casing would be rotated around its approximate geometric center 106, FIG. 2, with a proper radius during its azimuth rotation. The geometric center 106 should lie on the azimuth axis 36a and after the geometric center 106 is aligned with the azimuth axis 36a, the casing will have the desired azimuth radius R. The radius R should be equal to the circumferential radius of casing 37 and especially to the radius of that portion of its external surface 55 which includes the five sectors A through E, FIG. 2. Since this portion of the casing is not a perfect circle, the actual magnitude of radius R should be equal to the average valve of the radii of the five sectors. This azimuth radius is also illustrated in FIG. 2. As will be explained later, the magnitude of this radius is given to the operator of the machine on the program card 920 at 921 in FIG. 9. Therefore, the position of the geometric center 106, and the position of the circular axis of casing 37 should be adjusted with respect to the azimuth axis 36a so that center 106 is lying directly on axis 36a and axis 36a is then also tagent to the circular axis 83 of the toroidal casing at the geometric center 106. In this case, the casing may be considered to be a substantially circular tube, or a toroid, with the circular axis 94, FIG. 1, passing through the centers 106 of such tubes. The outer surface 55 of the casing is then spaced from the vertical axis 36a by a distance equal to the radius R. Such proper spacing of the outer surface 55 from the azimuth axis 36a is necessary so as to produce proper, strictly bi-symmetrical, distortion-free ribbon pattern on the casing and also the desired thickness of the layer. This portion of the machine is described below.

The pneumatic, toroidally shaped casing 37 is mounted on an expandable wheel 42, such as that disclosed in the U.S. Patent 2,960,130 to J. A. Smyser, issued November 15, 1960, and wheel 42 is mounted on a horizontal axle 43 supported by means of a pivoted azimuth arm 44, pivoted on a pivot 45. Pivot 45 is mounted on the horizontal leg portion 46 of an L-shaped azimuth arm 46–48, which is fixedly mounted on the vertical azimuth shaft 36. The pivoted arm 44 can be rotated by means of a stationary rack 47, FIG. 8, a pinion 50 and a hand wheel 49, either toward or away from the vertical axis 36a and in this manner the position of casing 37 is adjusted until this circular axis 83 is tangent to the vertical axis 36a. Rack 47 is mounted on top of the upright column 48 which has a slanted upper portion 48a. Column 48 is welded to the horizontal leg 46 of the arm. Pinion 50 is connected to a hand wheel 49 which is used for rotating arm 44 either toward or away from axis 36a. Wheel 49 is mounted on a rotatable shaft 51, and shaft 51 is mounted in a hub 52. Hub 52 is welded to the top of the pivoted arm 44. Shaft 51 is surrounded by a coil spring 57 which normally keeps shaft 51 in the position illustrated in FIG. 8, i.e., shifted to the left. Two pinions, 50 and 87, are affixed to shaft 51 and rotate with shaft 51. Pinion 50 always engages rack 47 and pinion 87 engages rack 56 only when wheel 49 is shifted by spring 57 to the position shown in FIG. 8, at which time pinion 87 abuts against hub 52 and also is in mesh with rack 56. When pinion 87 is in mesh with rack 56, it interlocks the pivoted arm 44, with the vertical column 48 and then arm 44 cannot rotate, nor be rotated, around pivot 45. This is the position of the elements when it is desired to hold casing 37 and the casing wheel 42 in a fixed position with respect to the frame of the machine, for instance, when the machine is in operation. When wheel 49 is pushed in by the operator against the pressure of spring 57, pinion 87 disengages rack 56 and arm 44 can then be rotated around pivot 45, FIG. 1, in either direction for adjusting the position of the circular axis 83 so that it is tangent to the azimuth axis 36a for obtaining the desired azimuth radius.

This is accomplished by making the vertical azimuth axis 36a pass substantially through the center 106, FIG. 1, of casing 37. To obtain the latter, the operator first measures the outside diameter of the buffed casing 37 by placing an arm 88 over casing 37 and its outer surface 55 in the manner illustrated in FIG. 8. Arm 88 is slidably mounted on the pivoted arm 44 by means of a slidable sleeve 69. The arm and the sleeve are counterbalanced by means of a pulley 84, FIG. 8, weight 85 and a cable 86. Also mounted on sleeve 69 is a plate 91, FIG. 8, and a transparent indicator 92, FIGS. 1 and 8, provided with two cross-hair lines 99 and 100. The slanted portion 48a, FIG. 8, of column 48 is provided with a plate 101, and on the front of plate 101 is mounted a scale 97. Scale 97 has two sets of intersecting lines. The first set 98 indicates the outside diameter of the carcass as measured by arm 88, FIG. 8, and the second set of lines 104 indicates the azimuth radius which is given to the operator on the face of a card 920, FIG. 9. This card will be described more in detail later. For example, card 920 indicates that the azimuth radius for a 670 x 15 casing which is to be molded in a special 670 x 15 custom design mold #463F (these mold numbers are private serial numbers of various mold manufacturers, such as Lodi of California, etc.), the number of the mold being also specified on the card at 941, which produces a tread suitable for that particular use. Accordingly, the azimuth radius, in the main, is obtained by making it substantially equal to the radius of a circle which best approaches the cross-sectional locus of the outer surface of the casing and especially its sectors A–E.

Once the length of the azimuth radius has been obtained from the cards, the azimuth radius wheel 49 is turned until the point of intersection of the cross-hair lines 99 and 100 on indicator 92 coincides with the desired intersection of the two sets of lines. Wheel 49 is then released and its locks the pivoted arm 44 to the fixed vertical column 48 in the right position by means of pinions 87 and 50, and racks 47 and 56 in the manner illustrated in FIG. 8. The casing 37 then has the proper azimuth radius with respect to the azimuth axis 36a.

Program card for the first method

It is necessary to digress here from the description of the machine to describe the program card 920 which is used for timing the operation of the electronic programmer. The card and the programmer control the operation of the entire machine.

Card 920 has six knob openings 921–926 placed in a single row, along one straight line. These openings are used for mounting the card over the corresponding knobs

150–155 on panel 28. Card 920 is provided with appropriate scales 927 and 928 of protractor 96, and also with the scales around each opening 921–926 for proper setting of knobs 150–155. The scales 928 and 927 correspond to the angular scale on a protractor 96 which is read with the aid of a protractor pointer 102 mounted on the azimuth arm 46.

FIG. 10 is a sectional view of the tip, or jaws, portion of pliers 1080 with proper indentations 1081 and 1082 for deforming the card and thus produce five indentations 941–945 along scale 927 and one indentation 940 along scale 928. These indentations are then used for actuating the microswitches 501 and 502. The microswitches 501 and 502 scan, or "read" the card and in this manner, deliver electrical pulses for controlling, or, in this case, sequentially timing, the operation of the programmer in the manner described later.

Potentiometer, beauty ring and resistance network knobs

Once the azimuth radius and the matrix have been chosen, it is then necessary to set the five potentiometer knobs 150, 152–155 and a "ring" knob 151 to their proper positions so that an elastomeric layer of the desired thickness and a desired number of turns of the ribbon is wound on each sidewall for each beauty ring. The information for setting the knobs 150, 152–155 is obtained from the charts which indicate the thickness of the layers obtained in different sectors along the transverse dimension of the casing, with different settings of the potentiometer knobs 150–153, for any given radius. These charts are obtained in a purely experimental manner by calibrating four potentiometers 2420–2423 and the resistance network 2424, FIG. 24, in the programmer, which is achieved by operating the machine at a fixed radius and different potentiometer settings for successive runs of the machine, and then measuring the thicknesses of the deposited layers obtained with these runs. Such calibration runs are then repeated for different azimuth radius settings.

Potentiometer knobs 150, 152–155 are provided with protruding pointers such as a pointer 160 on knob 152 in FIG. 5, and card 920 is provided with corresponding indentations 960–965. Since the card cannot be properly "seated" on the panel until the six knob pointers, such as pointer 160 on knob 152, and indentations 960–965 coincide, these identations 960–965 on the card insure the fact that the knobs 150, 152–155 and their potentiometers are set to the proper positions prior to the operation of the machine. The setting of knobs 150, 152–155 direcly determines the thickness of the elastomeric layer deposited in any given sector A through E. Each sector, except the two sidewall sectors, which have one common knob 152, has its own knob for the adjustment of its potentiometer to control its individual thickness. The two sidewall sectors have a common knob 152 because of the identity of the thicknesses and patterns produced at these two sidewall sectors. Therefore, the desired layer, filling the desired matrix in the manner illustrated in FIG. 2, is obtained by using the proper azimuth radius matched with the corresponding proper settings for the potentiometer knobs 150, 152–155.

The ring knob 151 can be set into three different positions, No. 1, No. 2 and No. 3, which indicate the number of beauty rings wound at the beginning of the cycle, these rings being indicated at 3A in FIG. 2. As will be explained later, this knob is connected to the so-called selector switch 1381 in FIG. 14, which is also illustrated in FIGS. 16, 17, and 18 in its three different possible positions for winding either one, two or three complete turns for producing the beauty rings.

Starting azimuth position and card calibration

After the pivoted arm 44 is placed in proper position so that there is a proper azimuth radius and the potentiometer knobs 150, 152–155 are properly set, it is then necessary to place the wheel in proper starting azimuth position. The top cover of box 11 is provided with a protractor 96 and the horizontal leg 46 of the azimuth arm is provided with a pointer 102. Pointer 102 points at 90° when the wheel axis 43 is at right angle with respect to the longitudinal axis 103, FIG. 1A, of the machine. This protractor is used for obtaining readings, in degrees, when they are used for punching, or indenting, in proper positions, the programming card 920, the two scales 927 and 928 on card 920 being also calibrated in degrees. This card calibration is achieved by taking the angles A through E, FIG. 2, from the desired matrix and then making the indentations 941 through 945 by measuring off these angles on scale 927 which is calibrated in degrees. Identation 940 on scale 928 corresponds to the desired initial position of the casing, at which point the winding cycle is to begin. The position of this indentation corresponds to the position of line 145 in FIG. 2. The correlation between the angles A–E and line 145 on one hand and the casing on the other hand is established by means of the protractor 96 and its pointer 102. The linear travel of card-scanning microswitches 501 and 502, described below, is also properly correlated with respect to the angular travel of the azimuth shaft 36; thus, 1° of rotation of shaft 36 produces 1° of linear travel of the scanning switches 501 and 502 along their linear scales 927 and 928, these two scales being also calibrated in degrees.

From the description given above, it follows that the card calibration, or placing of identations along the two angular scales 927 and 928, is obtained with the aid of the angles data obtained from the matrices and transfer of this matrix data onto the cards.

After the card has been properly marked, it is the card, its six indentations 940–945, FIG. 9, the proper settings, of the knobs 150–155, and the programmer that control the entire operation of the machine.

Panel 28 is also provided with three lights 170, 171 and 172 and five push-button switches 173–177 which will be described later.

Card scanning microswitches

Two microswitches 501 and 502, FIG. 5, are provided with two sensing rollers 503 and 504, which are used for sensing indentations 940–945 on card 920. Card 920 may be made of any suitable material, such as aluminum or a plastic, such as polyvinyl chloride.

In order to move the microswitches 501 and 502 from one end of card 920 to another in response to the azimuth rotation of the casing, the microswitches are mounted on a carriage 505 which is made to slide along two guide rods 506 and 507 where an azimuth motor 73 becomes energized. Carriage 505 is connected to the azimuth motor by means of a flexible steel cable 180 and a plurality of pulleys 182, 183 and 77, a chain 75 and a sprocket wheel 76 (see FIG. 6) and additional pulleys which are not visible in any of the figures. Appropriate means are also provided to keep the two card-reading rollers 503 and 504 in proper pressure contact with the bottom surface of card 920. In this manner, proper scanning of the perforations 940–945, and actuation of the microswitches 501 and 502 is obtained by means of the information contained on the cards. 1° of rotation of shaft 36 produces 1° movement of the microswitches 501 and 502 along their linear scales 927 and 928. These switches scan card 920 in the manner described previously and actuate the programmer which, in turn, controls the speed of the azimuth motor 73.

Azimuth motor

Energization of the azimuth motor 73 and its speed are controlled by the programmer which will be described later. The azimuth motor 73 rotates the azimuth shaft 36 only in one direction, i.e., in the direction to produce the travel of the switches 501 and 502 from left to right on card 920. The rotation of shaft 36 in the opposite direction for returning the machine to its start

position is obtained manually by releasing the chain drive **75** between the azimuth motor **73** and the smooth face pulley **77** (see FIG. 6) which is obtained by de-energizing a solenoid valve V2, and releasing air pressure in an actuator **80**. Actuator **80** is connected to the solenoid operated air valve V2 by means of two pipes **64***a* and **63***a*. When solenoid of valve V2 is de-energized, the valve connects pipes **63** and **63***a* to an atmospheric pressure and pipes **64** and **64***a* to a high pressure, with the result that the piston in actuator **80** and the piston rod **80***a* are shifted to the right as viewed in FIG. 6. The pivoted arm **78** rotates in a clockwise direction around a pivot **79**, with the result that the pressure exerted on chain **75** by two sprocket wheels **81** and **82** is released and chain **75** then makes only a sliding contact with pulley **77**. In this manner, shaft **36** becomes disconnected from the azimuth motor **73** and especially its gear box **74**, which would otherwise prevent manual turning of shaft **36**. This manual rotation returns wheel **42** to its original position. Since the solenoid valve V2 is energized by closing a pushbutton switch **174** at the beginning of the winding cycle and is automatically de-energized by the programmer at the end of the cycle, the azimuth motor **73** remains mechanically connected to the azimuth shaft **36** throughout the entire duration of the winding cycle, and its speed of rotation is controlled by the programmer. Accordingly, the controlled azimuth rotation of the carcass is produced by continuously monitoring the speed of the azimuth rotation as a function of the thickness of the extruded ribbon **38** and the speed of the spin rotation of the carcass, and in addition to the above monitoring, the speed of the azimuth motor is altered from sector to sector to deposit the variable thickness layer of the elastomer. At the end of the ribbon-winding cycle, the azimuth motor is disconnected mechanically from shaft **36** and electrically from its source of electric current, and wheel **42** is then manually returned to its original position. Therefore, in the disclosed system, the azimuth rotation is a variable speed rotation.

The azimuth motor **73** and its gear box **74** are mounted by means of a bracket **90**, FIG. 6, within box **11**.

Stitcher arm

Referring now to a stitcher **53**, which stitches ribbon **38** onto surface **55** of carcass **37**, the stitcher is mounted on a bracket **90** of an arm **58**. Arm **58** is pivoted around a shaft **89** mounted in two hubs **67** and **68**. Arm **58** is non-rotatively mounted on a shaft **89** and shaft **89** is rotatively mounted in hubs **67** and **68**. The lower part of **58***a* of arm **58** is connected to a push rod **66**. An actuator **62** is connected to a source of compressed air through high pressure flexible hoses **63** and **64**, which, in turn, are connected to a three-way solenoid-operated valve V2. The piston in actuator **62**, when valve V2 is opened, rotates arm **58** in a clockwise direction, as viewed in FIG. 1, at the beginning of the ribbon-winding cycle for engaging the outer surface **55** of tire **37** with the stitcher **53**. When the ribbon-winding cycle is completed, the programmer automatically closes the three-way solenoid valve V2 which reverses the compressed air connections to actuator **62**, thus rotating arm **58** at the end of the winding period in the counter-clockwise direction away from the carcass. The operation of the solenoid valve V2 by the programmer will be described later with the description of the programmer. Thus, arm **58** and the stitcher are swung into the ribbon-stitching position by the actuator when the operator closes a "kick-in" switch **135** at the beginning of the winding cycle and is automatically retracted to an idle position at the end of the winding cycle. The "kick-in" switch also closes the circuit of a power relay, which closes the circuit of the spin motor **54**. The spin motor **54**, therefore, begins its operation upon closing of switch **135**. Manual actuation of switch **135** is desirable in order to start the actual winding cycle when the operator is ready and finds that the machine is also ready for properly starting the cycle. Accordingly, the actual moment when the winding cycle begins is controlled by the operator and not by the programmer. This is necessary because the cycle can be started, firstly, only when the extruder begins to extrude a smooth, even, uncurled and undistorted ribbon, and secondly, only after such ribbon is properly threaded manually through the machine by the operator. The very moment the operator threads the machine, he places it under stitcher **53** and at this moment, while still pulling on and collecting in his hands the free end of the rapidly extruded ribbon by extruder **13**, he kicks the foot kick-switch **135**, which actuates valve V2.

Ribbon thickness transducers

Arm **58** is also provided with an idler roller **70** and ribbon thickness gauging roller **71** which is supported by roller **70**, and a ribbon **38** passing between the two rollers. Rollers **71** is provided with an arm **72** pivoted on a pivot **72***a* and a plunger **72***b* terminating in a magnetic rod which operates two transducers **93** and **94**. Transducers **93** and **94** both furnish two alternating current information signals which are used for continuous measurement of the thickness of the ribbon. One of these two transducer signals is used in the compensating circuit which, in turn, controls the operation of the speed control circuit for controlling the speed of the azimuth motor **73** so that the programmer takes into consideration and continuously compensates for any minor variations in the thickness of ribbon **38**. This compensating circuit will be described more in detail later in connection with the description of FIG. 14. The second transducer **94** supplies voltage to energize a voltmeter **95** on panel **28**, which is calibrated to indicate the thickness of the ribbon. This voltmeter is used for the initial adjustment and setting of the adjustable die **22**.

Pneumatic stitcher

The stitcher is illustrated more in detail in FIG. 7, which is a perspective view of the stitcher. The stitcher is mounted on a bracket **720** which is welded to box-like member **90** and the box-like member **90** is welded to column **58**. Member **90** is used for mounting two transducers **93** and **94**, rollers **70–71** and bracket **720** of stitcher **53**, a spin motor **54** and a spin wheel **59** which engages casing **37** and spins it at a speed equal to the speed of extrusion of ribbon **38**. Bracket **702** and the stitcher frame **700** of the stitcher are provided with a hub member **721** which accommodates a pin **723** passing through two holes in member **720** and through hub **721**. The entire frame **700** of the stitcher can swing freely around pin **723** in the manner indicated by dotted lines **725** and **726**. Two stop shoulders **727** and **728** are provided on member **720** to limit the swing of the stitcher in either direction. Because of such mounting, the stitcher aligns itself automatically with respect to the adjacent portion of the casing and of the ribbon deposited on the casing, as the winding operation proceeds.

The frame member **700** of the stitcher is an open rectangular box, which is provided with four broached openings, **702**, **703**, **704** and **705**, which are used for accommodating, in a sliding engagement, nine slidable stitching arms, such as an arm **701**, five arms being mounted in the upper rectangular opening **702**, and four arms being mounted in two lower rectangular openings **703** and **705** in the stitcher frame member **700**. Each slidable stitcher arm is provided with a stitching wheel, such as wheel **729**, the stitching wheels nearest to the ribbon being serrated for obtaining a positive stitching of the ribbon. The width of the five stitching rollers on top, as well as of the four stitching rollers on the bottom of the stitcher, is wider than the width of ribbon **38** and, therefore, the first four bottom stitcher wheels apply pressure to the surface which is wider than the width of the ribbon. The same is also true of the five upper stitching rollers which apply the pressure over an even wider sur-

face than the bottom stitching wheels. The bottom stitching wheels are in a staggered position with respect to the upper stitching wheels, so that the entire combined width engaged by the bottom and top stitching wheels is stitched to the casing in a positive manner several times. It is also desirable to have the combined width of all the stitchers to be wider than the ribbon to insure the fact that proper and positive stitching is obtained over the entire ribbon, and especially its leading and lagging side edges, irrespective of the angular position of the stitcher and of the ribbon.

Each slidable stitching arm can slide either forward or backward individually and independent of the position of the adjoining or any other stitching arm, and, therefore, the entire stitcher with its slidable arms and rotatable stitching wheels, can adapt itself and conform to the irregular surface, as viewed in a transverse direction, which is produced when the ribbon is wound at an angle to the surface of the carcass.

All stitching arms are provided with individual pneumatic actuators **730**, which actuate the stitching arms by means of compressed air introduced to the stitcher through a flexible hose **731**. Actuators **730** are spring-biased by means of coil springs **716** which return the actuators to their retracted position when pressure is reduced on the pistons connected to the push rods **718**. The piston-returning springs are so weak that their counter-pressure may be disregarded altogether here. Therefore, the pressure exerted on the casing and the ribbon is that due to a constant air pressure, irrespective of the position of the stitching arms and the degree of their forward travel when air pressure is introduced into the actuators. The stitcher is connected to a source of compressed air through high pressure flexible hose **112** and **113**, FIG. 1A, which also supplies compressed air to wheel **42** for expanding the wheel and for simultaneously inflating the casing through a foot-actuated compressed air valve **39**. High pressure hose **112** is connected to pressure regulator **111** and the pressure regulator **111** is connected to a high pressure hose **110** which, in turn is connected to a source of compressed air.

Spin switches

The pivoted azimuth arm **44**, which supports the horizontal spin axle **43** of the wheel, illustrated on an enlarged scale in FIG. 11, is provided with a stationary collar **1112** and a rotatable spin switch cam **1110** and a gear **1111**. The perspective view of cam **1110** and gear **1111**, pinion **1114** and a tachometer shaft **1115** are illustrated in FIG. 11. Cam **1110** and gear **1111** are mounted on shaft **43** and rotate with shaft **43**. The cam is provided with three depressions **1200**, **1201** and **1202**, FIG. 12. Three microswitches **1100**, **1101** and **1102** are mounted on collar **1112**. Collar **1112** is welded to arm **44**, and, therefore, is stationary. Three switch actuating rollers **1105–1107** are positioned in line with the respective depressions **1200**, **1201** and **1202** in the cam member **1110**. Accordingly, the three spin switches become actuated simultaneously with each revolution of shaft **43**.

The functions performed by these three spin switches are as follows: microswitch **1100** is called the start spin position switch because it is connected in series with the power circuit of the programmer and, therefore, it permits the programmer to operate only after casing **37** and wheel **42** are placed into one, specific angular start spin position at the beginning of the ribbon-winding cycle. This specific start spin position is obtained by rotating casing **37** and wheel **42** around the spin axis **43** until the start spin position switch **1100** becomes closed, which is indicated on panel **156** by lighting an amber "spin position" light **170**. Spin switch **1101** steps the stepping switch by energizing the stepping switch relay **R6**, FIG. 14, during the beauty ring counts; therefore, the spin switch **1101** is a revolution counter which is used for counting the number of beauty rings wound on the casing and is called, therefore, as the beauty ring counter. Switch **1102** is in seires with a relay **R2**, FIG. 13; relay **R2** allows actuation of the entire programmer only after the azimuth arm **46–48** and the azimuth shaft **36** are placed in the starting azimuth position. Therefore, switch **1102** is the azimuth starting position switch.

Programmer for the first method

Proceeding now with the description of the programming system, FIGS. 13–18 illustrate the schematic diagrams of the electronic programmer and its components which are used for programming the operation of the entire machine from manual starting to automatic stopping. The programmer controls two speeds of rotation: the speed of the spin rotation around the horizontal axis **43** produced by direct current spin motor **54**, which is always made equal to the rate of extrusion of the ribbon, and secondly, the speed of the azimuth rotation. The speed of the azimuth rotation is controlled by the programmer and it depends on the rate of ribbon extrusion, thickness of the extruded ribbon, and the angular or the transverse position of the casing with respect to ribbon **38**. Thus, the azimuth speed differs from sector to sector, except that the azimuth speed in sector A, FIGS. 2 and 3, is equal to the azimuth speed in sector E, both sectors being sidewall sectors.

Stepping switch

Before proceeding with the description of FIGS. 13 and 14, it is necessary to describe a stepping switch used in the programmer because the twenty-one contacts of this switch are used in many parts of the programmer and the description of their mode of operation is essential for understanding the connections and the operation of the programmer. This switch is not illustrated as a unit, in an assembled form in the drawings, because such switches are known to the art, but its essential parts, such as the seven cams and the cam-actuated contacts, are illustrated in FIGS. 16–19 and its stepping relay **R6** is shown in FIG. 14.

The rotary stepping switch is of the type described and fully illustrated on pages 36–41 of Technical Bulletin 473 of the Automatic Electric Company of Chicago, entitled "Rotary Stepping Switches," and designated by Automatic Electric as the "OCS Relay." It is a unidirectional rotary stepping switch operated by a single relay, which is relay **R6** in FIG. 14. The switch, as manufactured by Automatic Electric may have any number of cams up to eight cams. The seven cams used here comprise seven discs, such as disc **2100** in FIG. 21, bolted together through two bolt holes **2110** and **2111**, to make up a single cylindrical barrel which is rotated through a 10° step for each energization and de-energization of relay **R6**. A central hole **2112** is used for mounting all cams on a common axis.

The side view of cam **#6** is illustrated in FIG. 21 and the side view of the notched portions of all seven cams is also illustrated in FIG. 19, where they are unfolded, or developed, along straight lines. All cams in the stepping switch are circular cams of the type illustrated in FIG. 21 and each cam has its own notches spanning different degrees at the desired angular positions along the periphery of the cam. Cam **#6** has notches **2120**, **2121**, **2122** and **2123**. The cam can be divided into two identical halves along line **2124** bisecting the cam, with the notches on the upper side and on the lower side of the cam being identical to each other. This is due to the fact that the operation of the machine and programmer is completed during 180° rotation of the cams, and, therefore, the succeeding 180° constitute merely a repetition of the same preceding cycle that has been obtained during the first 180°. The seven cams **#1** through **#7**, are developed along their individual straight lines in FIG. 19 and under each other in proper phase relationship. Since the first 180° of each cam are identical to the succeeding 180° (i.e.,

from 180° to 360°), only the first 180° of the cams are illustrated in full in FIG. 19, and the remaining 180° are omitted except for the 190° and the 360° portions. Accordingly, in giving the description of the programmer and of the stepping switch, it will be necessary to describe only the first 180°. FIG. 19 indicates that the notches in one cam differ in shape and phase when compared with the remaining cams so that there are no identical cams among the seven cams.

In order to explain the operation of the programmer and of the stepping switch, which is an integral part of the programmer, it becomes necessary at this time to explain the nomenclature that will be used in connection with the stepping switch and the programmer. Each cam operates three contacts in the manner illustrated in FIGS. 19, 22 and 23. As illustrated in three figures, when a metallic cam follower element **2200** is on the high portion of cam **2201**, or cam #1, in FIG. 19, contacts C are closed and contacts A and B are open. As illustrated in FIG. 23, when the cam follower **2200** is in a notch **2300**, then contacts C are open and contacts A and B are closed. The three pairs of contacts A, B and C are electrically independent of each other, and, therefore, each pair is capable of making and breaking their independent circuit. These contacts will be referred to in the schematic diagram and FIGS. 13 and 14 in the following manner: the cam will be referred to in accordance with its numerical order indicated in FIG. 19 as cams #1, #2, #3, #4, #5, #6 and #7. The cam will be mentioned first and the contact second. Therefore, for example, if one considers cam #1 and contacts A, B and C, the nomenclature of these pairs of contacts will be as follows: 1A, 1B, 1C, numeral 1 referring to "Cam #1" and the letters A, B and C referring to the respective pairs of the switch contacts A, B and C illustrated in FIGS. 19, 22 and 23. For cam #2, then, the nomenclature for the switch contacts will be 2A, 2B, 2C, etc.

Directly below FIG. 19, and in proper alignment with FIG. 19, is FIG. 20, which is an explanatory table indicating the various operating positions of the cam switches as they are operated by the six cams. The upper horizontal column indicates the angular position of all the cams and is numbered 0° through 360°. These 10° steps correspond to the division of the 360° periphery of each cam into 10° sectors, also illustrated in FIG. 21. Vertical center lines **1900** and **1901** in FIG. 19, indicate the midportions, or the center lines, of the respective 10° steps. The left side of the table has a table indicating the numbers of the cam switches, as cam switches #1 through #7. These are the cam switches which have three pairs of contacts operated by their respective cams #1–#7, such as the cam switches illustrated in FIGS. 22 and 23. The term "cam switch #1," or "cam switch #2," etc., refers to all three contacts collectively as a single unit. The meaning of the crosses appearing in the table of FIG. 20 is as follows: in the first vertical column for 0°, there are two crosses which indicate that the cam followers **2200** of the cam switches #5 and #6 are in the notches **1903** and **2123**, and, therefore, contacts 5C and 6C are open and contacts 5A, 5B, 6A, 6B are closed. The same designations are used throughout all of the 360° of the seven cams. The crosses, therefore, indicate when the cam followers **2200** are in their respective notches. The absence of the crosses indicates that the cam followers **2200** are on the high portions of their respective cams. Since the cams and their notches and the high portions are properly aligned with the table (cophased), all one has to do is to follow the vertical center lines **1900** or **1901** from the cams into the table and thus obtain the state of the respective switches, i.e., whether they are in a closed or open position at any given 10° step.

Programmer relays and switches

Referring to FIGS. 13 and 14, they should be read here, with the description given below, as a single figure by matching them along line A—A shown at the bottom of FIG. 13 and top of FIG. 14 in the manner illustrated in FIG. 15. The programmer includes seven relays, which are relays R1, R2, V2 (relay V2 is also shown in FIG. 1), R3, R4, R5 and R6.

Relay R1 and a manually operated starting pushbutton switch **173** are connected across alternating current buss bars **1308** and **1309** between points **1310** and **1311**. Pushbutton **173** is shunted by a circuit connected between points **1313** and **1317** which includes normally open contacts R1A of relay R1, a manually operated push-button stop switch **177**, parallelly-connected open contacts 5C and 6C of the stepping switch, contacts R2D of relay R2, a "broken tape" switch **1300**, and a conductor **1320** which connects this circuit to a junction point **1317**. The push-button stop switch **177** is a safety switch which is opened by the operator in case of any emergency or mulfunctioning of the machine when it becomes necessary manually to stop the entire machine at once. Otherwise, when the machine and the programmer function properly, the entire machine is stopped automatically at the end of the operating cycle by opening the holding circuit of relay R1 through the two circuits between points **1313** and **1317**, which include contacts 5C and 6C of the stepping switch cams #5 and #6.

The next circuit is the circuit which is connected between points **1314** and **1321**. It includes the normally open contacts R1B of relay R1 and a red pilot light **172**. Light **172** indicates that the power is connected to the programmer. All of the succeeding circuits are connected between a common conductor **1323** and buss **1309**, conductor **1323** being connected to a junction point **1324**.

The circuits connected between busses **1323** and **1309**, in the order in which they appear in FIG. 13, include the first circuit for the amber light **170** and the starting spin position switch **1100** used for indicating the proper spin position of the tire casing **37** on axle **43** at the beginning of the winding cycle. The proper "spin position" is the position of wheel **42** when all the spin switches **1100–1102** of FIG. 11 are closed and the amber light **170** is lit.

The next circuit includes the green light **171** which indicates the proper azimuth position of casing **37** at the beginning of the winding cycle. This light is connected in series with the azimuth switch **502**, FIG. 5, which becomes closed when the azimuth arms **44–48–26** and wheel **42** are manually rotated around the azimuth axis **36***a* to the proper starting azimuth position. This proper azimuth position is indicated to the operator when the azimuth switch **502** and its card sensing roller **504** sense indentation **940** on card **920**.

The next circuit, beginning at the junction point **1327**, includes an R2 relay, spin switch **1102**, a program starting kick-in switch **135** and the azimuth position switch **502**. Spin switch **1102** becomes closed at the same time all three spin switches **1100–1102** become closed.

R2 relay and three switches **1102**, **135** and **502** are connected in series between points **1327** and **1301**. A conductor **1331** connected between a junction point **1396** and buss **1309** and the normally open R2A contacts of R2 relay, shunt all of the above three switches. Switch **135** is the "kick" switch of FIG. 1, which is actuated by the operator by kicking it into a closed position with his foot.

The next circuit is connected between points **1328** and **1329**, and includes the normally open contacts R2B of relay R2 and relay V2, which is also shown in FIG. 1. Relay V2 is used for actuating the three-way air valve, which admits air to the two actuators **62**, FIG. 1, and **80**, FIG. 6. Therefore, relay V2 and actuator **62** are used for swinging arm **58**, FIG. 1, into engagement with casing **37** at the beginning of the cycle and out of engagement at the end of the cycle, while actuator **80** connects the azimuth motor **73** to pulley **77** at the beginning of the cycle and disconnects it from pulley **77** at the end of the cycle.

The next circuit includes switch **1302** and a relay R3. Switch **1302** is manually operated toggle switch used for manually energizing and de-energizing a power relay R3 which, in turn, connects the extruder motor **15** to its source of three-phase power. Switch **1302** is provided to enable one to disconnect extruder **13** and then operate the entire programmer with the extruder being idle. It is also possible to run the extruder alone, in which case the kick switch **135** remains open. This is desirable for warm-up periods to obtain a ribbon having a smooth texture and high temperature.

Spin motor circuit

The circuit connected to a conductor **1333** includes only the spin motor relay R4. Relay R4 closes the only set of contacts R4A of this relay, which connect two full wave rectifiers **1335** and **1335***a* to the armature and the field of the spin motor **54**, FIG. 1, over conductors **1336**, **1337**, **1392** and **1393**. The two full wave rectifier connections are such that diodes **1342** and **1343** are used as common diodes for the two full wave rectifier bridges **1335** and **1335***a*. The first full wave rectifier bridge includes diodes **1342** and **1343** and the silicon controlled rectifiers **1340** and **1341**. Rectifier **1335** supplies a controlled direct current to the spin motor armature over conductors **1336** and **1337**. The second rectifier **1335***a* includes diodes **1342**, **1343**, **1338** and **1339** which supply field current to the spin motor **54** over conductors **1392** and **1393**, and it also supplies current to the dancer roller control circuit of dancer roller **32**, FIG. 1.

The dancer roller circuit comprises a unijunction relaxation oscillator **1345** synchronized with the rectified wave impressed on this circuit by rectifier **1335***a*. The circuit includes three parallelly-connected circuits: the first circuit includes a PN uniqunction transistor **1345** connected in series with resistors **1349** and **1350**; the second circuit includes a zener diode **1346**, and the third circuit includes a dancer roller potentiometer **35**, a high value resistor **1352**, capacitor **1347** and a normally closed switch **1363**. Also, the emitter electrode of transistor **1345** is connected to the junction point **1351** over a conductor **1359**. The voltage output of the dancer roller relaxation oscillator circuit is used for controlling the voltage bias on the gate electrodes of the silicon controlled rectifiers **1340** and **1341** and these, in turn, control the speed of the spin motor by controlling the armature voltage through this motor. In this manner, the direct current spin motor **54** spins casing **37** at the same peripheral speed as the speed of extrusion of ribbon **38** by extruder **13**. A ballast resistor **1348** is connected in series with the charging circuit, the zener diode **1346** and transistor **1345**. Switch **1353** is the switch which is also controlled by the dancer roller **32**, and is opened by the dancer roller **32** when it is in its extreme low position, which it assumes when it is not supported by ribbon **38**, i.e., when ribbon **38** accidentally breaks. If ribbon **38** breaks, dancer roller **32** opens switch **1353** and high value resistor **1352** becomes connected in series with capacitor **1347**. This removes the potential impressed on the gate electrodes of the rectifiers **1340** and **1341** and they become non-conductive, which opens, in effect, the armature circuit of spin motor **54** and stops it. A voltage wave-form **1354** is impressed on the potentiometer **35**-capacitor **1347** circuit and base one and base two of transistor **1345**. This wave-form is the rectified sinusoidal wave **1355** with its upper portion clipped by zener diode **1346**. Diode **1346** becomes conductive at a predetermined point on wave form **1355**. When the positive potential reached on capacitor **1347** exceeds the potential at the junction point between the emitter and base two of transistor **1345**, capacitor **1347** discharges through transistor **1345** and resistor **1350**. At the end of each half cycle, the voltage at base two of transistor **1345** will drop to zero, causing transistor **1345** to fire. Capacitor **1347** thus is discharged at the beginning of each half cycle and the firing circuit is thus synchronized with the source **1335***a*. The potential drop produced across resistor **1350**, when capacitor **1347** discharges across transistor **1345**, is impressed on the gate electrodes of the silicon-controlled rectifiers **1340** and **1341** over a conductor **1356**. When the potential impressed on the gate electrodes is positive with respect to the common cathode connection **1357**, either one or the other rectifier is fired, with the result that a wave form **1358** is impressed on conductors **1336** and **1337**. Only a controllable portion of each rectified half-wave, therefore, is impressed on the armature of spin motor **54**, and the magnitude of this portion is controlled by the CR network, including the dancer roller potentiometer **35**. In this manner, the spin motor rotates casing **37** at the same peripheral speed as the speed of extrusion of ribbon **38** by extruder **13**.

The next circuit in FIG. 13 is that for controlling the temperature of the extruder barrel **19**, FIG. 1. It includes a thermostat **1390** and a solenoid-operated valve **1391** which opens upon closing of contacts R1A by relay R1, which is also true of a solenoid-operated valve V1 in the circuit for supplying cooling water to screw **16** and the jacket **19** of extruder **13** through pipes **126**, **120**, **121**, **127** and bore **18**.

The last circuit for controlling the temperature of the extruder includes four heaters **23**, **24**, **23***a* and **23***b*, thermostats **1375** and **1364** and switches **1394** and **1395** for controlling the temperature of the extruder die.

Azimuth motor relay R5 and stepping switch relay R6

Referring now to FIG. 14, the top portion of this figure illustrates the next circuit connected between points **1360** and **1361** which includes a full wave rectifier **1362** supplying direct current to azimuth relay R5 and the stepping switch relay R6 for positive operation of these relays.

The azimuth motor relay R5 is connected in series with a limit switch **1363**, four parallelly-connected contacts **1B**, **2B**, **3B** and **7B** and serially connected contacts **4B** of the stepping switch. Spin switch **1101** has contacts **1365** and **1366**. When it is on contact **1365**, it opens the circuit of relay R6, and when it is on contact **1366**, it is in series with the following circuit which begins at the junction point **1367** on buss **1368**: contacts **4B**, spin switch **1101** on contact **1366**, five serially connected contacts R2C, 7C, 3C, 2C, 1C, conductor **1369**, normally closed switch **1371** of the reset pushbutton switch **176**, conductor **1386**, conductor **1387**, stepping switch relay R6, and conductor **1388**, which completes this circuit. Reset switch **176** has two switches **1371** and **1372**, switch **1371** being normally closed and switch **1372** being normally open. An arc suppressing diode **1374** is connected in series with switch **1371** and in shunt with relay R6, which prevents false operation of relay R6 by any transients.

Card scanning circuit.—The card scanning circuit begins with conductor **1368** and then contacts **4B**, R2E, card scanning switch **501**, conductor **1370**, switch **1371**, conductors **1386** and **1387**, the stepping switch relay R6 and conductor **1388**. Switch **501** scans indentations **941**–**945** on card **920**, FIG. 9, corresponding to the sectors A–E in FIGS. 2 and 3. As will be discussed more in detail later in connection with the description of the operating cycle of the programmer, it is this circuit that connects in succession, with the aid of the stepping switch and its relay R6, one of the four variable resistors **2420**–**2423** in FIG. 24 at a time in series with the output circuit of a magnetic amplifier **2430**, and in this manner controls the speed of the azimuth rotation. This, in turn, controls the thickness of the deposited elastomeric layer in the five sectors A through E, FIG. 2.

The normally open switch **1372** of the reset button **176** is connected to a conductor **1376** on one side and to a self-interrupting contact **1377** of the stepping switch. This circuit is used for manually resetting the stepping switch.

The beauty ring selector switch **1381** is connected to

relay R6 over contacts 5A and 6A of the stepping switch and self-interrupting contacts 1377. Contacts 5A and 6A are closed when the stepping switch is in the "home" position, which corresponds to the 0° position in FIG. 20. Conductor 1378 is also connected to conductor 1368 through contacts 6B and 4C, which are used for the initial stepping of the stepping switch from 0° to 10° position.

The remaining portion of FIG. 14 includes a step-down transformer 1384 which supplies low voltage power to transducers in FIG. 24 over conductors 1389, 1397 and a rectifier 1383 connected to transformer 1382 which supplies direct current to busses 2418 and 2419 in FIG. 24.

Azimuth motor speed control circuit

FIG. 24 illustrates the schematic diagram of that portion of the programmer which includes the speed control circuit for the azimuth motor. This circuit includes the ribbon thickness compensating circuit, the speed of the spin compensating circuit, the desired instantaneous thickness of the elastomeric layer circuit, and the instantaneous azimuth motor load circuit, i.e., four circuits, all of which combine to generate a single resultant control signal which controls the magnitude of current flowing through the armature 2439 of the azimuth motor 73. The two speeds of rotation, spin and azimuth, must be correlated because the thickness of the deposited layer depends on the magnitude of these two speeds. The azimuth motor speed control system, therefore, first of all, changes the speed of the azimuth motor from sector to sector in accordance with the desired thickness of the layer. It then also makes the azimuth speed bear a fixed ratio with respect to the variable spin speed and the thickness of the extruded ribbon. Thus, there are two speed compensating circuits, one for the speed of the spin rotation and the second for the thickness of the ribbon; the third azimuth speed circuit is the one which changes the azimuth speed when the ribbon being wound on the casing leaves one sector and enters the next sector, i.e., it changes the azimuth speed from sector to sector. The last compensating circuit makes the magnitude of the current correspond to the load connected to the azimuth motor. This load is the load imposed by the azimuth shaft 36 and the card scanning mechanism. Generally this load is quite constant and, therefore, the load compensating circuit is provided primarily to produce a large starting current when the azimuth motor 73 becomes initially connected to the source of its power.

In order to control the speed of the azimuth motor so that it constantly corresponds to the spin speed and, through this spin speed, to the rate of the ribbon extrusion, the spin shaft 43 is connected to a rotor 2400 of the two-phase tachometer 916 which is similar to a two-phase induction motor with a rotor 2400 and two stator windings 2401 and 2402, winding 2401 being the excitation winding connected to a 115 volt, 60 cycle source of alternating current. A voltage having a frequency of 60 cycles and proportional to the speed of rotation of rotor 2400 is generated in the output winding 2402. The output voltage appearing across winding 2402 is proportional to the input voltage and is used to control the speed of rotation of the azimuth after it is combined with a plurality, i.e., additional three voltages, also used for simultaneously controlling the speed of the azimuth motor.

For this purpose, the tachometer output voltage is impressed on the primary 2403 of a step-up input transformer 2404. The center-tapped secondary 2405 of transformer 2404 is connected to a transistor push-pull amplifier 2406 and 2407 which impresses its output by means of an output transformer 2450 on transducer 93. From the description of FIG. 1, it is already known that transducer 93 constantly monitors, or measures, the thickness of ribbon 38. Transducer 93 includes a primary 2408, two opposing secondaries 2409 and 2410 and a magnetic plunger core 2411 actuated by rod 72*b* which is connected to the pivoted arm 72, FIG. 1. Arm 72 supports the upper roller 71 which rides on top of ribbon 38, and, therefore, the position of plunger 2411 depends on the thickness of ribbon 38. Transducer 93, therefore, combines two intelligence signals: the first signal corresponds to the speed of the spin rotation around shaft 43, and, in this manner, the speed of extrusion of ribbon 38, and the second signal corresponds to the thickness of the ribbon. The product of these two signals is impressed on three transistor voltage amplifiers 2412, 2413 and 2414 connected to busses 2418 and 2419. Transistor amplifier 2414 impresses its output on a step-up output transformer 2415 with a center-tapped secondary 2416. The secondary of transformer 2415 is connected to a full wave rectifier 2417 which impresses its output on four variable resistors 2420, 2421, 2422, 2423 and an impedance adjusting resistor 2424 connected in series with the variable resistors. Resistor 2424 is also connected in series with an azimuth motor tachometer 2425 which is driven through a shaft 2426 by the azimuth motor 73. The circuit of the azimuth motor tachometer 2425 includes resistors 2420–2423, 2451, 2424 and 2428 and a signal winding 2427 of a magnetic amplifier 2430. The magnetic amplifier 2430 includes the following windings: the signal winding 2427, the biasing winding 2447, a gain control winding 2434, and two excitation windings 2446 and 2445. Resistor 2428 is used to adjust the impedance of the azimuth motor tachometer circuit, and in this manner, in combination with the signal winding 2427, it adjusts the opposing voltage which is impressed by tachometer 2425 on the signal winding 2427 and the resultant error voltage produced in this circuit. The final control signal impressed on the silicon-controlled rectifier 2438 is the difference between all other signals impressed on the magnetic amplifier 2430 minus the signal voltage impressed on the magnetic amplifier 2430 by tachometer 2425. In this manner, the silicon-controlled rectifier 2438 is also responsive to the error voltage. The magnetic amplifier biasing winding 2447 is connected to a source of direct current, and the two excitation windings 2445 and 2446 are connected to a source of alternating current which is transformer 2429 with its secondary 2437 connected to the windings and the primary connected to a source of alternating current. The excitation windings 2446 and 2445 are connected in series with diodes 2432 and 2431 and an output resistor 2435. The voltage appearing across the output resistor 2435 is used to control the conductivity of the silicon-controlled rectifier 2438 which, in turn, controls the current flowing through the armature 2439 of the azimuth motor 73. The output resistor 2435 is also connected in series with the secondary signal winding 2434 of the magnetic amplifier, which is coupled to the signal winding 2427 through the magnetic amplifier, and, therefore, the voltage appearing across resistor 2435 also includes the control signal from the magnetic amplifier. The output resistor 2435 is connected across a silicon-controlled rectifier 2438 over conductors 2452 and 2454. Silicon-controlled rectifier 2438 is also connected in series with the armature 2439 of the azimuth motor 73, a source of direct current connected to conductors 2440 and 2441 and contacts R5A of the azimuth motor relay R5, FIG. 35, which connects the azimuth motor after the first 360° spin revolution and disconnects the azimuth motor before the last 360° spin revolution of the ribbon winding cycle. Stated differently, and as described more in detail earlier, the azimuth motor 73 remains connected throughout the entire cycle except for the first and last spin revolutions. A field winding 2443 of the azimuth motor 73 is connected across the conductors 2440 and 2441 and in series with contacts R5A of the azimuth motor relay R5. A surge suppressor, or transient shorting circuit, including diodes 2458 and 2459, is also connected across rectifier 2438.

A filtering circuit 2451–2452 and a voltage limiting zener diode 2453 are connected across the rectified output of transformer 2416 and amplifier 2460.

FIG. 24A is a schematic diagram for the ribbon thickness meter **95**, which is a calibrated voltmeter connected to an amplifier **2470**, which is connnected to the second transducer **94**, which, in turn, is connected to a coupled input transformer and a source of power **2472**. This meter continuously measures the thickness of the ribbon by means of two rollers **70** and **71**, roller **71** being connected to the pivoted lever arm **72** which actuates plunger **72***b* connected to the movable cores of the two transducers **93** and **94**, all of the above being illustrated in FIG. 1 and, in part, in FIG. 1A.

Operation of the programmer

The operation of the programmer illustrated in FIGS. 13 through 24 is as follows:

The manually-operated starting push button **173** is depressed, which energizes relay R1 and closes its two contacts R1B and R1A. Closing of contacts R1B energizes buss **1323**, with the result that the full wave rectifiers **1335**, **1335***a*, **1362** and **1383** become also energized. Rectifiers **1335** and **1335***a* energize spin motor **54**, and rectifier **1362** impresses direct current voltage on the stepping switch relay **R6**, which at once steps the stepping switch one 10° step from 0° position, or from the "home" position, to the 10° position, both illustrated in FIGS. 19 and 20. The circuit of the stepping switch relay R6 is completed at this portion of the cycle through the self-interrupting contact **1377**, conductors **1378**, **1368** and the closed contacts 6B and 4C. Contact 4C is closed because follower **2200** is on the high portion of cam #4. The self-interrupting contacts **1377** become open upon energization of relay R6 and in the course of the stepping operation of the switch from 0° to 10°, contacts 6A, 6B and 4C open and 4A, 4B and 6C close.

The spin switch **1101** is transferred to contact **1365**, and, therefore, the fifth parallel circuit 4B–1101–R2C–7C–3C . . . R6 remains open. The fourth circuit 4B–R2E–501–R6 is also open because switch **501** is open. The same is true of the remaining three parallel circuits. At the beginning of the first spin revolution, the azimuth relay R5 remains deenergized because contacts 1B, 2B, 3B and 7B at this time are all open, and, therefore, there is no azimuth rotation. Therefore, the machine winds the first beauty ring, which is always present irrespective of the position of the beauty ring selector switch **1381**.

It should be noted here that relay R6 first must be energized and then de-energized to rotate the stepping switch through a single 10° step. Energization of relay R6 merely moves the ratchet stepping arm and engages it to the cam barrel but does not produce any actual rotation of the cams. De-energization of relay R6 releases the stepping arm and it then rotates the ratchet, the cam barrel and the cams.

Stepping of the stepping switch one 10° step from 0° position to 10° position, according to the table of FIG. 20 also closes contacts 5C and 6C and opens contacts 5A, 5B, 6A and 6B, with the result that the circuit between points 1313–1317–1311 become energized through the normally closed contacts R2D and now closed contacts 6C. This circuit is the relay locking circuit for relay R1, and, therefore, this relay becomes locked for the duration of the entire winding cycle of the machine, until 190° is reached in FIGS. 19 and 20, at which time the cam follower of the cam switches #5 and #6 will again slip into the grooves of their respective cams, with the result that contacts 5C and 6C become open, thus unlocking relay R1.

Closing of the circuit of relay R1 and closing of its contacts R1B energizes red light **172** which indicates that power is connected across busses **1323** and **1309**. It also energizes the amber and green lights **170** and **171** if the spin switch **1100** and the azimuth switch **502** are in the closed position, as they should be at this time if the operator has placed casing **37** in the proper azimuth and spin start positions.

As mentioned earlier, toggle switch **1302** is normally closed, which connects power to extruder relay R3 and it becomes energized, connecting power to extruder motor **15**. Therefore, the extruder becomes energized and begins to extrude ribbon **38**.

After a hot and smooth ribbon **38** begins to be extruded by extruder **13**, the ribbon is threaded through the machine by placing it over roller **31**, under dancer roller **32**, between rollers **70** and **71** and under stitcher **53**. Immediately after placing the ribbon under stitcher **53**, the program starting "kick-in" switch **135** is kicked into the closed position by the foot of the operator, which at once energizes relay R2 through the spin switch **1102**, which is now closed, and the azimuth switch **502**, which is also now closed. Switch **502** is closed because the operator must place wheel **42** in the right angular azimuth start position before the programmer is started, and this proper start azimuth position is indicated by the green light **171** which must light before switch **135** can be kicked into the closed position. Closing of the circuit of relay R2 closes the three sets of contacts of this relay, which are contacts R2A, R2B and R2C. Closing of contacts R2C completes the self-locking circuit of relay R2; closing of contacts R2B energizes the solenoid-operated valve V2, which admits compressed air to the actuators **62**, FIG. 1, and **80**, FIG. 9. Piston **62** at once moves the piston arm **66** to the left as viewed in FIG. 1, with the result that arm **58** is swung toward casing **37** which makes stitcher **53** to engage the outer surface **55** of casing **37**. The stitcher, therefore, automatically attaches the free end of the ribbon to the outer edge of the sidewall and stitches it to this sidewall. Proper stitching of the ribbon to the surface of the tire is established as follows: the operator has a free end of the ribbon in his hand at the time he is ready to kick switch **135** into the closed position; he then kicks switch **135**, the stitcher swings toward the casing, stitches the free end to the carcass, and the excess of this free end is torn off after it has been stitched, and returned to the hopper of extruder **13**. In this manner, starting of the winding cycle is established.

Returning once more to the circuit connected between points **1313** and **1317**, it should be noted that it also includes switch **1300**, which is now closed because the dancer arm **33** now is in a proper raised position, and is held in this raised position by ribbon **38**. Therefore, the holding circuit of relay R1 is now established through the now closed ribbon switch **1300**, and this takes place at the time of threading of ribbon **38** into the machine. Normally closed contacts R2D become open upon energization of relay R2, which takes place upon closing of the program starting kick switch **135**. Accordingly, if through some accident, tape **38** breaks, it opens the tape-operated switch **1300**, which de-energizes relay R1, and de-energization of this relay opens its two contacts R1A and R1B, which de-energizes the entire machine.

Reverting again to the description of the operation of the stepping switch, when the stepping switch is in its 10° position illustrated in FIGS. 19 and 20, only cam switch #4 is in its notch **1922** in FIG. 19, and all of the remaining cams are in the high cam positions. Therefore, all of their contacts are in the position shown in FIG. 22, with all contacts C closed, and all contacts A and B open. At the same time, switch #4 has its three contacts in the position illustrated in FIG. 23, and, therefore, contacts 4A and 4B are closed and contact 4C is open. Accordingly, contact 4B, which is now closed, completes the fifth parallel circuit through the stepping switch relay R6, which circuit includes contact 4B, spin switch **1101** on contact **1366**, and closed contacts R2C, 7C, 3C, 2C, 1C.

It is necessary to digress for a moment at this time and explain more in detail as to why contacts R2C and the spin switch **1101** are connected in series with each other in the above circuit. When casing **37** is manually turned so as to place it in the proper spin position, which

is the position when all three spin switches **1100–1102** are closed, such turning of the casing may produce more than one closing and opening of the spin switches, because of back and forth rocking of casing **37** by the operator in the course of its initial turning of the casing into proper spin position. The spin switches, in such case, may produce a number of pulses and to prevent false operation of the stepping switch by the pulse generated in this manner by the spin switch **1101**, contacts R2C of relay R2 are placed in series with spin switch **1101**. Since contacts R2C remain open until relay R2 is energized, false operation of the stepping relay R6 is prevented. Also, improper operation of the entire programmer is prevented since this circuit will remain open as long as the casing is in a position which is other than the proper starting spin position.

Immediately after the kick-in switch **135** is closed, relay R2 becomes energized, and it closes the five contacts R2A, R2B, R2C, R2D and R2E. Closing of contacts R2D closes the circuit of the spin motor relay R4 and spin motor **54** becomes energized. Casing **37** begins its spinning, and three spin switches **1100–1102** are transferred to their second set of contacts. Spin switch **1101** now is on contact **1365** which opens the fifth parallel circuit of the stepping relay R6. De-energization of relay R6 turns the stepping switch from the 10° position to the 20° position. At this time, i.e., at the 20° position of the stepping switch, the operating circuit of the azimuth motor relay R5 is open because contacts 1B, 2B, 3B, and 7B are all open. Therefore, the azmiuth motor **73** remains de-energized. This circuit is between point **1399** on conductor **1392** and point **1398** on bus **1388**. It includes the azmiuth relay R5, the limit switch **1363** and contacts 1B, 2B, 3B and 7B which are all open at this instant. Therefore, at least one "beauty ring," i.e., a complete 360° turn without any azimuth motion, is wound around the periphery of casing **37** at the beginning of the cycle. The programmer is arranged so that either one, two or three beauty rings can be wound at the beginning of the cycle, the number of the rings actually wound depending upon the setting of the beauty ring selector switch **1381**. The three possible positions of this switch are illustrated in FIGS. 16, 17 and 18 where it is also indicated that when this switch is in the position illustrated in FIG. 16, then only one beauty ring is wound, and two beauty rings are wound when it is the position illustrated in FIG. 17, and finally, three beauty rings are wound when it is in the position illustrated in FIG. 18. Three rings X, Y, Z, of this type, with 100% superimposition, or overlap, are illustrated in FIG. 3.

Five circuits for relay R6.—The operation of the programmer at this phase is predicated on the fact that the circuit of the stepping relay R6 may be completed over five parallel circuits.

The first circuit is over conductors **1368**, contacts 4C, 6B, conductor **1378**, self-interrupting contacts **1377**, relay R6 and conductor **1388**.

The second circuit is over conductor **1368**, contacts 4B, conductor **1392**, contacts 5A or 6A, beauty ring switch **1381**, conductors **1380**, **1378**, switch **1377** and conductor **1388**.

The third circuit is over contacts 4B, conductors **1392**, **1376**, switch **1372**, conductor **1379**, and self-interrupting contacts **1377**.

The fourth circuit is over contacts 4B, conductor **1392**, contacts R2E, azimuth card scanning switch **501**, switch **1371** and conductors **1386** and **1387**.

The fifth circuit is over contacts 4B, spin switch **1101** on contact **1366**, contacts R2C, 7C, 3C, 2C, 1C, conductor **1369**, switch **1371** and conductors **1386** and **1387**.

The functions performed by the above five circuits are as follows:

The first circuit, over conductor **1385** and contacts 4C and 6B, merely steps the stepping switch from its 0°, or "home" position to the 10° position at the very beginning of the cycle.

The second circuit, having the beauty ring selecting switch **1381**, determines the number of beauty rings desired, depending on the setting of switch **1381** by the operator.

The third circuit, including conductor **1376**, is used for manual resetting of the stepping switch to its original position in case one wishes to do so because of some unexpected malfunctioning of the machine. By depressing push button **176**, switch **1372** closes, switch **1371** opens, and, therefore, relay R6 can then be operated only through the reset circuit **1376–1372–1377**. After the stepping switch reaches the 130° position, contacts 4B open but contacts 4C and 6B close. The reset circuit becomes automatically disconnected, but the first circuit becomes closed and operates the switch to its final home position corresponding either to 0° or 180° position.

The fourth circuit, including the card reading switch **501**, scans the card and the sector-indicating indentations on the card, and in this manner, with the aid of the card, and with the aid of the stepping switch, switches into the circuit of the azimuth motor **73** the desired variable resistor. These variable resistors **2420–2423**, FIG. 24, in turn, determine the thickness of the deposited layer in the respective sectors A–E, FIGS. 2, 3 and 4. Therefore, this circuit may be called the thickness controlling circuit which controls the thickness of the deposited layer.

The fifth circuit, having contacts 4B, R2C, 7C, 3C, 2C, 1C, etc., and the spin switch **1101** counts the number of the spin revolutions being made by casing **37** with the aid of the spin switch **1101**, and steps the stepping switch by energizing relay R6 at the end of each 360° revolution. This circuit is in operation only during the beauty ring winding operation, and, therefore, it is used for counting the number of the beauty rings wound on casing **37**.

From the above description of the five circuits, it follows that the control system, insofar as the control of the thickness of the deposited layer is concerned, does not depend on the revolutions of the carcass but does depend on the relative transverse position, i.e., the azimuth position, of the carcass with respect to the ribbon.

Beauty ring cycle.—If in the second circuit switch **1381** is placed into the open circuit position, illustrated in FIG. 18, then it will require three complete revolutions of casing **37** and wheel **42** to step the stepping switch from the 20° position to the 50° position at the end of the third revolution, i.e., when the spin switches **1100–1102** are all back in the notches **1200–1202**. And during all of the above three revolutions and three positions—20°, 30° and 40°—the azimuth motor will remain disconnected because contacts 1B, 2B, 3B and 7B remain open. In the fourth position, when the stepping switch is in the 50° position, the cam switches #1 and #4 are both in the low, or notched, portions of their respective cams #1 and #4, and, therefore, the circuit to the azimuth motor relay R5 becomes closed through contacts 1B. Accordingly, winding of the ribbon on the first sidewall per se, i.e., after the beauty ring winding cycle is completed, begins with the stepping switch being at the 50° position. It, therefore, follows that the beauty ring sectors of the stepping switch are the 20°, 30° and 40° sectors.

Proceeding now with a more detailed description of the beauty ring cycles, in order to produce beauty ring No. 1, the programmer should have the azimuth motor always disconnected during the first spin turn. The azimuth motor is disconnected during the first spin turn because the stepping switch is in the 10° position during the first 360° spin of wheel **42**, and, therefore, only the cam switch No. 4 is in the notch **1922** of its cam #4. Therefore, when switch **1101** is on contact **1366** at the very beginning of the revolution, and contacts R2C close upon depression of the starting kick switch **135**, contacts 1C, 2C, 3C and 7C are all closed, switch **1371** is closed and the stepping relay R6 is energized simultaneously with the closing of switch **135**. Because of the spin rotation of the casing, the spin switch **1101** is immediately transferred to contact **1365**. This opens the fifth circuit, relay R6

becomes de-energized and rotates all of the cams to the 20° position. Upon completion of the first 360° spin of wheel **42**, the spin switch **1101** again is transferred to contact **1366**, at which time relay R6 is again energized and after the spin switch **1101** leaves contact **1366** because of the spin rotation, it is transferred again to contact **1365** which opens the circuit of relay R6 and steps the stepping switch from the 20° position to the 30° position. Again, there is no azimuth rotation because the azimuth relay R5 still remains de-energized because of the open condition of contacts 1B, 2B, 3B and 7B.

If switch **1381** is in the "one beauty ring" position, which is the position illustrated in FIGS. 14 and 16, contacts 5A are closed, and contacts 6A are open, with the result that a circuit is now established for the stepping relay R6 over the now closed contacts 4B, conductor **1392**, closed contacts 5A, switch **1381**, conductors **1380** and **1378**, closed contacts **1377**, relay R6 and conductor **1388**, which completes the circuit. This energizes the stepping relay R6, whereupon the self-interrupting contacts **1377** open and step the stepping switch to the 40° position. At this point, contacts 6A close, which completes again the second circuit for energizing relay R6 through the beauty ring sector switch **1381**, but over contacts 6A rather than contacts 5A, and relay R6 turns the stepping switch from the 40° position to the 50° position. During all of the above stepping, the azimuth motor relay R5 remains de-energized because contacts 1B, 2B, 3B and 7B remain open, and, therefore, there is no azimuth rotation. Accordingly, if switch **1381** is in the position illustrated in FIGS. 14 and 16, only one beauty ring is produced, because the stepping switch is stepped very quickly from the 20° position to the 50° position automatically, and upon reaching the 50° position, there is the beginning of that operation of the entire programmer which corresponds to the winding of ribbon **38** in sector A of the casing beyond the beauty ring portion of this sector.

It is is now desired to produce two beauty rings, then the selector switch **1381** is placed into the position illustrated in FIG. 17, at which time sector **1381** is connected only to contact 6A. According to FIGS. 19 and 20, contacts 6A remain open when the spin switch is in the 10°, 20° and 30° positions. At the end of the first spin revolution, switch **1101** is on contact **1366** and again returns to contact **1365** at the beginning of the second spin revolution, with the result that the stepping switch steps from the 20° position to the 30° position. At the 30° position, cam #5 closes contacts 5A, but since sector **1381** of the switch is now connected only to contacts 6A, no circuit is established through this switch to the stepping relay R6, and, therefore, the second beauty ring is wound until the completion of the revolution and transfer of the spin switch **1101** again to contact **1366** and then to contact **1365**, which again energizes and then de-energizes relay R6, with the result that the stepping switch is stepped from the 30° position to the 40° position. In this position contacts 6A become closed, and, therefore, relay R6 becomes immediately energized through contacts 6A and switch **1381**, whereupon the self-interrupting contacts **1377** open the circuit and produce the next step of the stepping switch from 40° to 50°, whereupon the winding of the two beauty rings is completed, and the programmer is in that position which corresponds to the winding of the ribbon on the sidewall portion of sector A.

If beauty ring selector switch **1381** is in the position illustrated in FIG. 18, it does not make any contacts with the contacts 5A and 6A, and, therefore, it becomes necessary for the spin switch **1101** to make three complete excursions from contact **1365** to contact **1366** and back to contact **1365**, and this can be accomplished now only by wheel **42** making three complete revolutions, i.e., by winding a three-layer beauty ring.

Thus, the operation of the beauty ring selector switch **1381** is made possible because of the fact that contacts 1C, 2C, 3C, 7C and R2C all remain closed during this phase of the operation of the programmer, since cams #1, #2, #3 and #7 have no notches on their cams in these 10° through 40° sectors. Also, there are no indentations on card **920**, and moreover, the card scanning switches **501** and **502** are at a standstill because there is no azimuth rotation, and switch **501** remains open. Therefore, the only two parallel circuits that may be operative during the beauty ring winding phase are the second and fifth circuits. Accordingly, the operation of the beauty ring selector switch **1381** is either to bypass or not to bypass first the 30° position and then the 40° position of the cams when no more than one beauty ring is desired. When two beauty rings are desired, then the bypass beauty ring selector switch **1381** is in the position of that in FIG. 17, and it bypasses only the 40° position, and when it is in the three beauty ring position, illustrated in FIG. 18, it does not bypass the 30° and the 40° positions. The fifth circuit, including the spin switch **1301**, and contacts R2C, 7C, 3C, 2C, 1C, etc., as mentioned before, counts the number of complete revolutions made by the casing **37** during this beauty ring cycle.

In this manner it is possible to wind either one, two or three layer beauty rings at the beginning of the cycle. The percentage of overlap between the succeeding and preceding turns at this phase of operation is 100% overlap, and the angle of inclination is 0°.

Operation of programmer in sectors A–E.—Upon the completion of the beauty ring operation, irrespective of the number of beauty rings wound, the stepping switch is in the 50° position, at which time the cam switches #1 and #4 are in the lowered, or notched, portions on their cams. Therefore, contacts 1C are open and contacts 1A and 1B are closed. Contacts 1B are in series with the azimuth relay R5 and closed switch **1363**. Therefore, the azimuth relay R5 is energized over its circuit, and connects the azimuth motor **73** over the now closed contacts **2442** to its source of direct current power connected to conductors **2441** and **2440**. Therefore, energization of relay R5 energizes the azimuth motor **73** and motor **73** remains energized until the completion of the entire winding period, except for the beauty rings at the end of the cycle, at which time the azimuth motor **73** becomes disconnected in the manner described later. The speed or rotation of the azimuth motor is controlled by the circuit illustrated in FIG. 24. This speed changes from sector-to-sector, variable resistors **2420–2423** controlling this speed, the feed-back circuits also contributing to the control of this speed. The interval of time during which any given resistor remains in the circuit of the azimuth motor during this winding portion of the cycle is determined by the card **920** and the positions of the indentations **941–945** on scale **927** on the card. The 50° position of the stepping switch corresponds to sector A, FIG. 2, as indicated in FIG. 20 at the bottom of the table. At this instant only contacts 1A and 1B are closed, contacts 1A connecting variable resistor **2420** to the timer circuit of the azimuth motor **73**, and more particularly, into the circuits of the magnetic amplifier **2430**, the spin speed tachometer **916**, the thickness transducer **93**, and the azimuth tachometer **2425**, the outputs of all of these circuits being combined across the output resistor **2435**. The voltage appearing across the resistor **2435** is then used to control the conductivity of the silicon-controlled rectifier **2438** which controls the magnitude of direct current supplied to the armature **2439** of the azimuth motor **73**, thus controlling the speed of rotation of this motor.

Since variable resistor **2420** establishes the speed of the azimuth motor **73** during the operation of motor **73** through sector A, at which time there is a maximum rate of azimuth travel, variable resistor **2420** has the lowest resistance value as compared to the remaining three variable resistors. Therefore, variable resistor **2420**

establishes the maximum rate of the azimuth travel. This rate of the azimuth rotation continues through the entire sector A. Contacts 2A, 3A and 7A are now open, and, therefore, the three remaining variable resistors 2421, 2422 and 2423 are disconnected from the timer circuit by the stepping switch. These are the variable resistors for sectors B, C and D respectively. The operation of the machine through sector A continues in the above manner until the card-scanning switch 501 in the fourth circuit, becomes momentarily closed when the card-scanning roller 503, FIG. 5, is momentarily raised by detent 941, FIG. 9, and then opened again after leaving detent 941. Such closing and opening of switch 501 steps the stepping switch from the 50° position to the 60° position, terminating the winding cycle in sector A, and simultaneously starting the winding cycle in sector B without any interruption or stopping of the azimuth motor 73. The total duration of this winding cycle through sector A, therefore, is determined by the lateral position of detent 941 on card 920.

In the 60° position, cams #2 and #4 have notches which close, at this time, contacts 2A, 2B, 4A, 4B and open contacts 1A, 1B, 2C and 4C. Therefore, variable resistor 2420 is disconnected and variable resistor 2421 connected in series with the signal winding 2427 of the magnetic amplifier 2430. Variable resistor 2421 has a higher resistance than variable resistor 2420, and, therefore, the speed of the azimuth motor 73 is decreased, causing an increase in the thickness of the deposited layer of elastomer in sector B.

The sequence of operation of the programmer in the succeeding sectors C, D and E, is identical to that in sectors A and B. The card-scanning switch 501 continues scanning the card until all sectors have been scanned. Sector E begins when the scanning switch 501 is lifted from detent 944 and ends when switch 501 leaves detent 945. The stepping switch relay R6 continues to be under the exclusive control of the fourth circuit, which includes contacts R2E and the card-scanning switch 501, switch 501 closing the circuit every time it encounters a detent in the card, and again opening the circuit after it leaves the detent, thus energizing the stepping switch relay R6 every time switch 501 traverses the card detent. During this card-scanning there is also a sequential closing of contacts 1B, 2B, 3B and 7B, and again of contacts 1B at the end of the cycle, with the result that the four variable resistors 2420–2423 and then again 2420 become connected in sequence into the circuit of magnetic amplifier 2430. The same variable resistor 2420 is used for monitoring the azimuth rotation during sector A as well as during sector E, and therefore, the normal speed of the azimuth rotation in sectors A and E is identical.

From the above description it follows that in FIGS. 19 and 20 sector A corresponds to the 50° position; sector B corresponds to the 60° position; sector C to the 70° position; sector D to the 80° position, and sector E to the 90° position. The stepping switch cams which control the programmer during this winding of the ribbon in sectors A through E are cam #1 for sector A; cam #2 for sector B; cam #3 for seotor C; cam #7 for sector D, and once more, cam #1 for sector E. During this phase of operation of the programmer, i.e., when the winding progresses from sector A through sector E, the azimuth motor relay R5 remains energized through contacts 1B, 2B, 3B and 7B, and again 1B, the above enumerated contacts being closed in sequence in the manner described above. The use of contacts 1B, 2B, 3B and 7B is necessary in the circuit of relay R5 because it is necessary to keep relay R5 de-energized during the winding of beauty rings at the beginning and the end of the entire winding cycle. According to the table in FIG. 20, all of these contacts remain open during the beauty ring positions of the stepping switch which are the 20°, 30°, 40°, 100°, 110° and 120° positions. The companion contacts 1A, 2A, 3A and 7A are then used for connecting and disconnecting the desired four variable resistors 2420–2423 into and out of the circuits of the magnetic amplifier 2430 to obtain the desired speed of rotation of the azimuth motor 73.

At the completion of the winding cycle, which takes place after the completion of the winding operation through sector E, with or without any beauty rings, depending upon the setting of switch 1381, the stepping switch is stepped to the 100° position. In the 100° position, only cam #4 has a notch, which is the long notch 1922. Notch 1922 is as long as the entire ribbon-winding cycle. All the remaining cam followers are on the high portions of their respective cams at 100° position. This means that the control of the stepping switch relay now is again transferred to the fifth circuit, including contacts R2C, 7C, 3C, 2C and 1C. This circuit is controlled by the spin switch 1101 which produces a single step of the stepping switch for each complete revolution of wheel 42. Therefore, it corresponds exactly to that phase of operation of the programmer which was previously recited in connection with the 10° and 20° positions of the stepping switch, i.e., the programmer completes the remaining portion of that turn which was started at the time of closing spin switch 1101 of the ribbon lying on the casing in a single plane perpendicular to the spin axis, which is equivalent to beauty ring No. 1 described previously.

The programmer, therefore, is so arranged that it winds one, or two, or three beauty rings at the beginning as well as at the end of the cycle, the 100° position on the stepping switch corresponding to the first beauty ring; the 110° position corresponding to the second beauty ring, and the 120° position corresponding to the third beauty ring if the beauty ring selector switch 1381 is set for three beauty rings.

It is possible to wind an identical number of beauty ring turns on both sidewalls if the beauty ring selector switch 1381 is allowed to remain in the same position at the beginning as well as the end of the cycle. However, it is also possibly manually to change the setting of this switch while the machine is winding B, C and D sectors, and, therefore, a different number of turns can be produced at the beginning and at the end of the winding cycle. As a rule, this is desirable only in connection with the "white sidewall" casings where there is no necessity of having two beauty rings. In such case switch 1381 is turned to "one turn" position after the first ring has been completed. In such a case, the second beauty ring is eliminated altogether.

Upon completion of the second beauty ring winding cycle, if such is desired, the stepping switch is shifted to the 130° position, at which time it is only the cam switch #6 that is in notch 1923 of cam #6, all of the remaining cam switches being on the high positions of their respective cams, including switch #4, which now is lifted by cam #4 from its notch 1922 to the high position 1924 of this cam, with the result that contacts 4C now become closed. Contacts 6B also become closed, and, therefore, closing of these two sets of contacts, 6B and 4C, closes the first circuit to the stepping switch, which includes conductor 1385, now closed contacts 4C, 6B, conductor 1378, self-interrupting contacts 1377, the stepping relay R6 and conductor 1388. This is the circuit which produces a continuous and very fast stepping of the stepping switch relay R6 until this circuit is interrupted. Therefore, the stepping switch, at this time, is transferred almost instantaneously from the 130° sector to 140°, 150°, 160°, 170°, and then 180° sector, at which time the above circuit is interrupted because contacts 5C and 6C become open. It is the opening of contacts 5C that disconnects all power from the entire programmer, with the result that the entire programmer comes to rest. In order to produce the above, it becomes necessary to disconnect from busses 1308 and 1309 the circuit of relay R1 which is connected across these busses between points 1313 and 1311. To disconnect this circuit, contacts 5C, as well as

contacts 6C, must be opened, and they are opened at the end of the winding cycle at the 0° and 180° positions, which are the two identical "home" positions. Therefore, the entire winding cycle is terminated and the machine and its programmer come to rest automatically at the end of the winding cycle. The above means that all of the relays become de-energized, including relay V1, which controls the operation of the actuators 62, FIG. 1, and 80, FIG. 6. The compressed air connections to these cylinders become reversed by the three-way valve V2, with the result that the stitcher and the spin wheel arm 58 are returned to its original position indicated by dotted lines in FIG. 1, i.e., the position which swings the spin wheel 59 and stitcher 53 away from casing 37. This means that casing 37 immediately comes to rest. The extruder motor 15 also becomes disconnected because de-energization of relay R1 opens contacts R1A which disconnect power from buss 1323, thus disconnecting the extruder. Therefore, all of the elements of the machine come to rest.

Machine for making new tires with the first method

FIG. 25 is a perspective view of a machine suitable for depositing a variable thickness layer on a casing 2500 of a new tire in the course of its original manufacture. The casing 2500 is mounted on a collapsible drum 2501 of known construction, which is rotatably mounted on an axle 2504 held by a column 2502. It is rotated around axle 2504 by means of the spin motor 54 as in the earlier figures. In FIGS. 1 and 2, the azimuth motor 73 rotates casing 37 around vertical azimuth axis 36, because casing 37 has the shape of a toroid. In FIG. 25 the casing has the shape of a hollow right cylinder, and, therefore, it is necessary to obtain the longitudinal azimuth shift, or movement, of the casing along, or in the direction of, its spin axis. To obtain such transverse linear "azimuth" shift, drum 2501 and its carriage 2510 are provided with four wheels 2515 and 2516 (only two are visible) which are mounted on two rails 2505 and 2506, which are parallel to axle 2504. Accordingly, drum 2501 and its entire carriage 2510 are shifted along rails 2506 and 2505 by means of a chain 2507. Ends 2508 and 2509 of chain 2507 are connected to carriage 2510. The chain is rotated by a motor 2512 which corresponds to the azimuth motor 73 in FIGS. 1 and 2, and it is this motor that produces the lateral, or transverse, "azimuth" movement of drum 2501 and its carriage 2510. Extruder 13 corresponds to the similarly numbered extruder in FIGS. 1 and 2, and ribbon 38, produced by the extruder, is wound on casing 2500 in the same manner as illustrated in FIG. 1A as the drum and its carriage are shifted laterally in the direction of an arrow 2517. Upon the completion of the winding cycle, the azimuth motor 2512 is automatically disconnected in the same manner as described previously, de-energizing additionally, in this case, an electrical clutch 2520, which corresponds in its function to the relay-operated three-way valve V2 and cylinder 80 in FIGS. 1 and 9, whereupon the carriage 2510 is manually returned to its original position. The azimuth motor 2512 is mounted in a cabinet 2522, and this cabinet includes the programmer identical to that illustrated in FIGS. 13, 14 and 24. As in the earlier figures, a suitably calibrated card 2525, such as that illustrated in FIG. 9, is used for controlling the machine. The card advancing mechanism 2528 is similar to that illustrated in FIG. 1. It is connected to a pulley 2524 driven by the azimuth motor 2512 when the azimuth motor is connected by means of the electrical clutch 2520 to the pulley gear drive 2526.

The operation of the machine illustrated in FIG. 25 otherwise is similar to the operation of the machine illustrated in FIGS. 1–24 with the differences being pointed out in connection with the description of FIGS. 27 and 28 which correspond to FIGS. 19 and 20 for the retreading machine.

The pattern produced on the new, or "green" tire casing 2600 is illustrated in FIG. 26 as a cross-section of the upper portion of casing 2500 of FIG. 25, and drum 2501 and a variable thickness layer 2530. The elastomeric layer 2630 includes two beauty rings 2631 and 2632. The two sidewall portions 2633 and 2634 extend beyond the bead portions 2635 and 2636 to provide a layer of rubber which generally is wrapped around the beads after the outer portions of drum 2601 are collapsed (for simplicity, drum 2601 is illustrated as a solid piece; collapsible drums are well known in the tire art) so as to permit concave rollers (not shown) to wrap the overhanging rubber layers 2633 and 2634 around their respective beads 2635 and 2636.

Upon completion of this operation, the drum is collapsed completely and the casing is ready for compression molding.

As in FIGS. 2 and 3 the casing is subdivided into five sectors A–E, which were described in conjunction with the description of similar sectors at the introductory part of the specification and are also described below in connection with the description of FIGS. 27 and 28.

In FIG. 25 there is also illustrated a portion of the conveyor 2540 which feeds the large size elastomeric ribbon 2541 from a container 2542 into extruder 13. Ribbon 2541, as mentioned previously, may be from 2" to 4" wide and from ¼" to 1" thick, the actual size of ribbon 2541 depending on the size of the casings 2500 and the size of extruder 13 being used. Heavy duty tires require large amount of rubber and this, in turn, requires increasing of the dimensions of the ribbon 38 from a more common 1" x 0.25" cross-section for conventional passenger cars and truck tires to a larger size ribbon 38 for the "off-the-road" tires, i.e., bulldozers, graders, earth-movers, etc. Ribbon 38 then may be as large as 4" wide and from ⅛ to ½" thick which requires a larger size ribbon 2540 for feeding an extruder which is many times larger than that shown in FIG. 25.

Programmer for new tires.—The programmer for the new tires essentially is identical to the one described earlier. The minor changes are described below.

FIG. 27 illustrates the shape of the cams for winding the ribbon on carcass 2600 and FIG. 28 is the table indicating the degrees and the positions of the notches or the low points on the cams.

Before describing FIGS. 27 and 28, it should be pointed out that the only difference which exists between FIGS. 19 and 20 and FIGS. 27 and 28 is that due to the fact that in this case the beauty rings 2631 and 2632, FIG. 26, are now positioned within their respective sectors A and E, while in FIGS. 2, 3 and 4 the beauty rings 3 and 3A are positioned in the outer edges of their respective sectors A and E. With this change in the positions of the two beauty rings, the cams of the stepping switch were modified to produce this change in the operation of the programmer. These changes in the location of the notches on the seven cams of the stepping switch are now also illustrated in FIG. 26 where the corresponding sector positions are indicated in degrees. Thus, the first portion A_1 of sector A now corresponds to the 30° position, the rings correspond to the 40°, 50° and 60° positions, and the remaining portion A_{11} of sector A corresponds to the 70° position.

Sectors B, C and D, which are identical to those in FIGS. 19 and 20, are now located on the 80°, 90° and 100° positions respectively. The changes in sector E correspond to the changes in sector A. It is now subdivided into sectors E_1 and E_{11}, with sector E_1 corresponding to 110° position and sector E_{11} corresponding to 150° position on the cams. The last turn 2634 is completed when the stepping switch is in the 160° position.

In view of the earlier very detailed description of the programmer and of the stepping switch in connection with FIGS. 19 and 20, there is no need for a detailed description of the operation of the programmer when the seven cams of the switch are changed in the manner indicated

in FIGS. 27 and 28. This should follow and should be understood by those skilled in the art in the light of the earlier description.

Size of ribbon **38**.—There may be occasions in which the width of the ribbon may not be sufficiently wide for the desired thickness of tread. In general, the width of the ribbon can be made wider and thicker for larger size tires, and especially the so-called off-the-road tires, such as tires used by bulldozers, earth-movers, tractors, and other special vehicles requiring tires of large size and having especially thick treads. Suitable dimensions for ribbon **38** for such applications may be as large as 4"–6" and ½"–1/10" thick. Extrusion of a ribbon having such large dimensions requires a large extruder and a large horsepower motor which may be in the order of 40–50 HP. Heavy equipment of this type is costly and can be afforded only by specialty shops.

Programmer for depositing two layers

It is possible to deposit a reasonably thick layer of elastomer with a narrower and thinner ribbon and lighter equipment, which is less costly, by depositing two variable thickness layers on top of each other.

FIGS. 29 and 30 illustrate the cam configuration and programming of the stepping switch for depositing two variable thickness layers **3100** and **3102** on a new tire carcass **3104** illustrated in FIG. 31. FIG. 35 illustrates that portion of the schematic diagram of FIG. 14 which requires the addition of cam #8 and of switches **3500** and **3501** for either including or excluding cams #1 and #8 in the circuit of the stepping switch relay R6 and self-interrupting switch **1377**.

FIG. 35 indicates that, when the ganged switches **3500** and **3501** are on their upper contacts **3503** and **3504**, the programmer corresponds, or is identical, to the one disclosed in FIG. 14 since cam #8 is eliminated altogether. Therefore, the machine winds the first layer **3100** on carcass **3104** in the same manner as it has been described earlier in connection with FIG. 26. It is to be understood also that, at this time, a card illustrated in FIG .33 is to be used in the machine with one indentation **3300** being at a zero reading on scale **3301**, and the remaining nine indentations **3304**–**3312** being on the second scale **3302**. The two scales **3301** and **3302** are two linear scales which correspond to the linear travel of drum **2601** in FIG. 25, which is especially true of scale **3302**. After the completion of the first layer **3100**, the machine is stopped automatically by the programmer, card **3303** is replaced with the second card **3400**, and the machine is then manually returned to a new starting position indicated by an indentation **3401** on scale **3403**. Card **3400** has now indentations **3404**, **3405** and **3406** on scale **3402**. The machine is then ready to deposit the second layer **3102** on the carcass. Before doing so, it also will be necessary to adjust the settings of the variable resistors **2421**, **2422** and **2423** and of the resistive network **2460** so as to produce the desired thickness of the second layer **3102** and thus the ultimate combined thickness of the two layers **3100** and **3102**. The thickness of the two layers **3102** and **3100**, in the majority of cases, is different and, therefore, it becomes necessary to reset the resistors.

It is to be noted that only sectors B, C and D are used for depositing the second layer **3102** since in the illustrated example the sidewall portions of the layer can be produced during the first winding cycle when layer **3100** is deposited on carcass **3104**.

It is also possible to use a card of the type illustrated in FIG. 34 for "recapping" tires. In recapping, the desired pattern is that illustrated in FIG. 32. In this case only three sectors, B, C and D, are used for depositing the desired layer **3200** which does not extend beyond the crown of the carcass.

In all prior programmers described in this specification, the cards used for controlling the programmer are used, in a sense, for subdividing, electrically, the casing into a plurality of sectors by generating an electrical signal, or a pulse, at the point of transition from one sector to the next sector. The total width of the layer deposited on the casing, therefore, is also indicated on such a card, with one edge of the layer being indicated by the first indentation on the lower scale and another edge being indicated by the last indentation on the upper scale. The stepping switch is then used for introducing different resistors into the circuit of the magnetic amplifier for each sector for changing the current supplied to the armature of the azimuth motor during each sector. Even though the above system uses a limited number of sectors, five sectors in all, it nevertheless produces smooth desired transitions, or variations in the thickness of the deposited layer, by depositing different thickness in the three basic sectors, which are the sidewall, the shoulder and the crown sectors. The thickness of the layer in the two sidewall sectors is the same and it is also the same in the two shoulder sectors.

A variable amplitude cam

It is possible to obtain even better and smoother transitions, or variations in the thickness of the deposited layer, by placing a card, or a cam, of the type disclosed in FIG. 36 which is a linear cam **3600**. The effective length **3601** of such cam, along the X axis, is then made to represent the width of the elastomeric layer to be deposited on the casing, and the variations in the height "*h*" of the cam, along the Y axis, is made to represent the desired thickness of the layer. This variable height "*h*" of the cam, which corresponds to the variable amplitude of the cam along the Y axis, is then scanned in synchronism with the azimuth movement of the casing by means of a transducer **3806**, and the signal produced by such transducer is then used in the programmer for contributing its share in controlling the final signal that is used for controlling the current flowing through the armature of the azimuth motor.

The same cam can also be used for starting and terminating the winding cycle by providing two indentations **3602** and **3603** along the lower edge **3610** of the cam. The system of the above type is disclosed in FIGS. 37 through 40.

Referring to FIG. 36 once more and describing it now more in detail, it illustrates a side view of the variable amplitude cam **3600** having a straight edge **3610** at the bottom and a variable height "*h*" edge **3612** on the top. The lower edge **3610** is also provided with two indentations **3602** and **3603** which are used for actuating a scanning switch **3606** by closing contacts **3604** and **3605** when the scanning wheel **3613**, mounted on the scanning arm **3614** of the switch, is in notch **3602** or **3603**. Contacts **3604** and **3605** remain open when the cam follower wheel **3613** is between notches **3602** and **3603**. The variable amplitude edge **3612** of cam **3600** is scanned by means of a transducer **3806**, which is also shown in FIG. 38. Transducer **3806** is provided with a scanning wheel **3616** and a scanning arm **3617**, which move up and down a magnetic plunger, or a core, of the three winding transformer **3805**–**3807**–**3808**, FIG. 38, which will be described later in connection with the description of FIG. 38.

A dotted line **3618** diagrammatically indicates that switch **3606** and transducer **3806** are mechanically mounted on a slidable frame, such as slidable carriage **505** illustrated in FIG. 5, and this frame is moved along the X axis, or the length of cam **3600**, in the same manner as carriage **505** in FIG. 5. This is illustrated by an arrow **3619**. The cam, therefore, is scanned in synchronism with the azimuth rotation or azimuth movement of the casing in the same manner as card **920** in FIG. 9 and cards **3303** and **3400** are scanned in the prior systems by interconnecting the pulley **77** mounted on shaft **36**, FIG. 1, with the carriage **505** which, in the prior systems, supports the two card-scanning switches **501** and **502** and in this case supports the scanning switch **3606**

and transducer **3806**. Although the illustrated cam **3600** is a linear cam, it is alos possible to use an arcuate cam whenever it is desired to scan such a cam by means of radius arm connected directly to the azimuth shaft **36**.

Programmer for the second method

The schematic diagram of the programmer using the variable amplitude cam is illustrated in FIGS. 37 and 38. This schematic diagram is for a programmer which deposits a variable thickness layer without any beauty rings either on a new or a used casing. The programmer, which includes the beauty rings, is illustrated in FIGS. 42, 43 and 44 and will be described later.

Referring to FIG. 37, alternating current is furnished to the programmer by busses **3708** and **3711**. The power relay **R1** is connected across the busses and in series with a power relay actuating push button **173**. A relay holding circuit includes a push button **177** and contacts R1A. Therefore, power relay **R1** becomes energized when push button **173** is momentarily closed, whereupon it locks itself by means of the locking circuit including contacts R1A and push button switch **177**. Power to the remaining programmer is furnished by means of buss **3723** which becomes energized over contacts R1B or relay **R1** after relay **R1** becomes energized. The indicating light circuits in FIG. 37 are similar to those used in the programmer illustrated in FIGS. 13 and 14. They include the similarly numbered red light **172**, green light **171** and amber light **170**. The green light **171** is in series with the spin switch **1100** and the amber light **170** is in series with the azimuth starting switch **3604**, which is a part of the cam scanning switch **3606** in FIG. 36. A program starting relay **R2** is connected in series with the switches **1100** and **3604**, a program starting push button **3707** and contacts R7A of relay **R7**. Since relay **R2** is connected in series with the spin switch **1100** and the azimuth starting switch **3604**, the programmer can be started only when the spin switch **1100** and the azimuth switch **3604** are closed. Switch **1100** is closed when the tire casing **37** and wheel **42** are in proper angular position which has been called previously as "the proper starting spin position," and switch **3604** is closed when the wheel supporting brackets **44–48–46**, and the azimuth shaft **36** are also in the proper starting azimuth position, which is indicated on protractor **96**, and is also indicated by the amber light **170**. With the switches **1100** and **3604** in closed position, and the program starting switch **3707** momentarily depressed by the operator, relay **R2** becomes energized and locks itself over contacts R2A and R7A. This places the programmer in operation.

The extruder has two relays, **R7** and **R3**, for starting the extruder. Relay **R7** is used for actuating relay **R3** and relay **R3** is a heavy duty relay which connects the three phase power to the extruder motor. The above relay arrangement is used for actuating the extruder so that it would be possible to operate the extruder by itself to warm it up and to obtain properly shaped and extruded ribbon which would be suitable for winding. After relay **R1** has been energized and contacts R1B close, thus connecting power to buss **3723**, relay **R7** can be energized by closing pushbutton **3706**. Relay **R7** then becomes energized and closes its contacts R7A, R7B, R7C. When contacts R7C close, rectifier **3762** becomes energized and relay **R6** also becomes energized over the now closed contacts **2C**, **3A** and **3777**. Relay **R6** steps the stepping switch from the home position to the 10° position, at which time contacts **2A** and **3C** become closed, thus closing the locking circuit for relay **R7**. Contacts R7B now are also closed and, therefore, relays **R3** and **V1** can be either started or stopped by manually operating switch **3709**, thus either starting or stopping the operation of the extruder prior to the actuation or energization of the remaining portion of the programmer, which is accomplished by closing the pushbutton switch **3707**.

The circuit for the spin motor is identical to that disclosed in FIG. 13, and, therefore, is designated here by a block **3715**. It becomes energized after contacts R7B become closed, i.e., upon energization of relay **R7**. The next circuit includes relay **V2** which is connected in series with contacts **R2B**. This relay corresponds to similarly numbered relay **V2** in FIGS. 1, 2, and 13, and performs the same function: it actuates the air valve which supplies compressed air to two actuators **62** and **80**, illustrated in FIGS. 1, 2 and 6.

The rectifier **3762** corresponds to the rectifier **1362** in FIG. 14 except that this rectifier now is connected in series with contacts R7D of relay **R7**. This is the rectifier which supplies D.C. power for a positive operation of the relays **R5** and **R6**.

The remaining circuits relate to the azimuth motor relay **R5** and the stepping switch relay **R6**. Before describing these circuits, it is necessary to describe the stepping switch cams shown in FIG. 39 since the operation of these two relays is controlled by these cams.

Referring now more in detail to FIGS. 39 and 40, cam **3900** has only one notch **3904** in the 20° position of this cam; cam **3901** has not notch **3905** which includes the 10°, 20° and 30° positions, and cam **3903** has notches **3905** and **3906** at 30° and 40° positions. Notch **3905** is the first home position, which is the 0° position, and notch **3906** is in the 40° position, which, again, is the second home position. The cycle of the stepping switch, therefore, is completed every 40°, and, therefore, there are nine cycles recorded around the 360° portion of the cams.

The table in FIG. 40 contains the same information that is contained in FIG. 39, namely, the location of the low points or notches on the three cams **3900**, **3901** and **3903** that are used for operating the stepping switch in FIG. 37 in accordance with the second method for winding the type of pattern which is illustrated in FIG. 26, except that the beauty rings are eliminated.

Proceeding now with the description of relays **R5** and **R6**, they are connected to rectifier **3762** over various contacts. The circuit of relay **R5**, which is the aziumth motor relay, includes contacts **1B** and **2B**. According to FIGS. 39 and 40 (and FIGS. 22 and 23), contacts **1B** are open in the 10° position, closed in the 20° position and open again in the 30° and 40° positions of the stepping switch. Contacts **2B** are closed during the 10°, 20° and 30° positions and open at 0° and 40° positions which are the home positions. Accordingly, the azimuth motor and its relay **R5** become energized and remain energized only during the 20° position of the switch. Also, relay **R5** becomes energized only after the first complete 360° ribbon turn has been wound on the casing, at which time the spin switch **1101**, which is in series with the fourth circuit, including contacts **1C** and **R2C**, becomes first energized and then de-energized because of the closing and opening of the spin switch **1101** upon the completion of one revolution. The third circuit for relay **R6** includes contacts **1A**, the cam-actuated switch **3605** (see also FIG. 36), which is a part of switch **3606**, and a pushbutton switch **1371**. This circuit remains open during the entire winding cycle except when switch **3605** and contacts **1A** are closed. Contacts 1A are closed during the 20° position of the stepping switch because of the low portion **3904** on cam **#1** at the 20° position of the cam. Switch **3605** closes at the beginning and the end of the cycle which enables the programmer to wind the first and the last turns without any azimuth rotation of the casing. This circuit becomes closed and then opened after arm **3614** senses indentation **3603** and the stepping switch then is turned from the 20° position to the 30° position for winding the last turn without any azimuth movement.

The entire layer, except for the first and the last turns, is thus wound when the switch is in the 20° position. The first turn is wound when the switch is in the 10° position, and the last turn is wound when the switch is in the 30° position. In the 20° and 30° positions, contacts **1B** are open and, therefore, the azimuth relay **R5** is disconnected.

Contacts 2B, however, are closed which permits the operation of the stepping switch relay R6. The operation of the relays R5 and R6, therefore, can be summarized as follows: relay R5 is closed only during the 20° position, and relay R6 is stepped from the 0° home position to 10° position after contacts R1B close and energize rectifier 3762. At 0°, contacts 2B are closed and contacts 1B are open. At 10°, contacts 1C and R2C are closed and relay R6 is stepped from 10° to 20° by closing and then opening the spin switch 1101 at the end of the first complete turn. In the 20° position, winding of the entire layer, except for the first and last turns, takes place. Contacts 1A are now closed, and, therefore, when switch 3605 closes and then opens, relay R6 is energized and the stepping switch is stepped from 20° to 30° position. In the 30° position, contacts 1B are open, and, therefore, the azimuth motor relay R5 is de-energized, switch 3605 is open, contacts 3A are open, and therefore, the only circuit that can energize relay R6 is the circuit which includes contacts 1C, R2C and switch 1101. After completion of the last turn, switch 1101 closes and then opens, which steps the switch to the 40° position, thus completing the operating cycle, at which time the entire system is de-energized and contacts 3A close again to prepare relay R6 for immediate energization upon the starting of the next cycle.

The remaining portion of the programmer is illustrated in FIG. 38. FIG. 38 is a modified version of FIG. 24, the modifications being numbered with numerals of the 3800 series while all the remaining elements, corresponding to those in FIG. 24, bear the same numerals as those used in FIG. 24.

The main difference resides in the introduction of the cam reader 3806, which is the transducer responsive to the variable height "*h*" of cam 3600, FIG. 36, which represents the desired variation in the thickness of the elastomeric layer along its width. The combined signal of the tachometer 916 and of transducer 93 is impressed on the step-up transformer 3800 and then on a transistor amplifier 3802. The output of amplifier 3802 is impressed on step-up transformer 3804 which impresses this combined signal on the primary 3805 of transducer 3806. The opposing secondaries of transducer 3806 are connected to a multi-stage transistor voltage amplified 3808 corresponding to the transistor amplifiers 2412, 2413 and 2416 in FIG. 24, whereupon the control signal is impressed on the step-up transformer 2415 and the full wave rectifier 3809. This rectifier is connected across the signal winding 2427 which also receives the opposing signal from tachometer 2425 in the manner described previously. The remaining connections and the function of the magnetic amplifier 2430 are identical with those described in connection with FIG. 24, and, therefore, need no additional description.

From the description of FIG. 38, as compared with FIG. 24, it follows that the difference between the two figures resides in the elimination of resistors 2420–2423 and of the stepping switch contacts 1B, 2B, 3B and 7B, and the function performed by these resistors and contacts in FIG. 24 now has been transferred to transducer 3806 which scans and responds to the variable height, or amplitude, of cam 3600. Smoother transitions and finer adjustment of the desired thicknesses of the elastomeric layer can be obtained with the system disclosed in FIG. 38 than what can be obtained with FIG. 24.

The programmer in the second method is simpler than the first, sector method, and there are no sudden changes in the azimuth speed in the second method, which always is an advantage in any variable speed system. By the same token, the variable speed system is more advantageous than any start-stop system since any sudden starts and sudden stops are difficult to achieve with high degree of accuracy.

The second method including the beauty rings

FIGS. 41, 42, 43 and 44 illustrate the second method, i.e., the same type of system and method as that illustrated in FIGS. 36–40 but applied to the retreading of used tires or making of new tires, as shown in FIGS. 25 and 26 which require winding of two beauty rings 2631 and 2632. Because of the presence of the beauty rings, it becomes necessary to modify FIGS. 36–40.

FIG. 41 illustrates the modified version 4100 of cam 3600 of FIG. 36, which has provisions to furnish the necessary signals for depositing a variable thickness layer which also includes two beauty rings located at the desired portions of the sidewalls. Since there is no azimuth movement while the beauty rings are wound, it becomes necessary to interrupt the azimuth movement twice at the desired moments during the ribbon-winding cycle. This is the system disclosed below which uses the second method, i.e., the variable amplitude cam.

In FIG. 41 switch 4106 has only one switch 3605, which now stops the azimuth motor and the cam-scanning movement three times instead of only once as in FIGS. 36–40. Switch 3605 stops the azimuth motor twice for winding two beauty rings, and once more at the end of the cam-scanning cycle and one revolution ahead of the termination of the ribbon-winding cycle and stopping of the spin motor. This is accomplished now by providing three indentations 4104, 4102 and 4103 along the lower edge 4110 of the cam. Indentations 4101 and 4102 are located along the lines 4112 and 4113 which coincide with the corresponding positions of the left edges of the two beauty rings along the X axis of cam 4100 and indentation corresponds to the position of the left edge of the last turn produced without any azimuth movement. The location of switch 3604 now has been transferred to engage a side-face 4105 of cam 4100 and this face now is provided with an outwardly or inwardly projecting indentation 4116 corresponding to the indentation 940 in FIG. 9 which indicates the desired azimuth starting point along the X axis of the cam. Therefore, indentation 4116 actuates a switch 4104 and closes its contacts when its scanning arm 4107 engages indentation 4116. The casing 37 and wheel 42, FIG. 1, are then in the proper azimuth starting position and the circuit of the azimuth light 170, FIG. 37, becomes closed and the light energized. It becomes necessary to position switch 4104 so as to scan face 4105 rather than in the manner shown in FIG. 36 to prevent scanning of the beauty ring indentations 4101, 4102 and 4103 by switch 4104.

The transducer 3806 performs the same function in FIG. 41 as in the earlier figures. All these cam-scanning elements 3616, 4116 and 3613 are aligned with respect to each other so that the electrical signals produced by these three elements are properly synchronized with respect to their common position on and along the X axis, i.e., all three are located along a common vertical axis 4108 and are mounted on a common scanning arm 4118 moved by the azimuth motor as in the earlier systems.

FIGS. 43 and 44 illustrate the four cams which are required for operating the programmer, and FIG. 42 illustrates only that portion of the schematic diagram which differs from that shown in FIG. 37. The remaining portion of the programmer of FIG. 42 is identical to that shown in FIG. 37.

Referring to FIGS. 43 and 44, cam #1 has detents at 10°, 60° and 100°; cam #2 has a detent from 10° to 110°; cam #3 has detents at 0°, 50°, 90° and 130°; and cam #4 has detents at 0°, 40°, 80° and 120–130°. The same information also appears in FIG. 44.

Referring now to FIG. 42, in FIG. 42 the holding circuit of relay R7 now includes contacts R7C connected in series with two stepping switch contacts 2A and 3C. The two contacts 2A and 3C are connected in parallel with each other and are shunted with a high resistor 4200 which acts as an arc suppressor. Therefore, during the operating cycle of the programmer, but not including

the "home" position 0°, 130° and 250°, contacts 2A or 3C control the operation of the extruder.

Examination of FIGS. 42 and 43 indicates that contacts 2A and 3C are open in the "home" positions of the stepping switch, which are the 0°, 130° and 250° positions. Contacts 2A remain closed from 10° to 110° and contacts 3C close at 100° position and remain closed up to and including 120° position; therefore, relays R7 and R3 remain energized between 10° and 120°, including the 10° and 120° positions, which means that the extruder remains energized during the entire operating cycle and is de-energized at the home position of the stepping switch, which is also the case in the earlier programmers. Therefore, the extruder circuit is the same as before, except that the numbering of one set of contacts has been changed from 4C to 3C.

The only remaining change relates to the beauty ring selector switch **1381** which now is included in the circuit of relay R6 in the same manner as the similarly numbered switch in FIG. 14. The two contacts which are now in series with this switch are contacts 3B and 4B which perform the same function as contacts 5A and 6A in FIG. 14. As explained earlier in connection with FIGS. 13, 14, the number of turns wound at the beauty ring positions, with 100% overlap, depends on the setting of switch **1381**; these settings are illustrated in FIGS. 16, 17 and 18 and were described earlier. The position of switch **1381** determines the number of turns the wheel of the casing must make in order to step the stepping switch from 30° to 60° position. The maximum turns is three, minimum turn is one. These turns are counted by the spin switch **1101**. This beauty ring system, using the second method, is applicable to the new and used tires.

The operation of this circuit was described twice before, first in connection with FIGS. 13 and 14, and then in connection with FIGS. 27 and 28. Since its operation is identical to the earlier description, it need not be repeated here; the reader is referred to the earlier descriptions.

Comparison of the start-stop system with the variable speed system

In the introductory part of the specification it has been mentioned that it is possible to obtain azimuth movement by using two basic systems.

The first system is the variable speed system disclosed here in which the azimuth movement is continuous throughout the entire winding cycle except for the first and last turns when there is no azimuth movement. The only other possible system is the one in which the azimuth movement takes place during a fraction of the revolution and then it is stopped, whereupon the 360° turn is finished with no azimuth movement. This is the system disclosed in the application for patent Serial No. 196,542, mentioned previously. When the start-stop system is compared with the continuous variable speed system, one arrives at the following conclusions: it is possible to obtain a higher precision and accuracy with the variable speed system beacuse it has a much wider range of azimuth adjustment that the start-stop system. Stated differently, the minimum as well as the maximum displacement of the ribbon per revolution can be obtained more readily with the variable speed system than with the start-stop system, and this is especially so insofar as the minimum displacement is concerned. In the start-stop system one can reach such limits as a fraction of a second for connecting and disconnecting the azimuth motor. It is obvious that the electrical and mechanical inertias preclude such rapid starting and stopping. Moreover, when such rapid starting and stopping is attempted, problems are encountered with the stitching of the ribbon.

The variable speed system, therefore, for all practical purposes, is the only system that can function effectively and accurately when a very fast operation is desired and also when heavy equipment for retreading heavy duty tires and off-the-road tires or making of new off-the-road tires is under consideration. In such systems, the extruded ribbon may be as large as 4 inches wide and approximately ¼ inch thick or thicker.

This specification discloses two types of variable speed systems. In the first system the azimuth speed is changed from sector to sector, while in the second system the azimuth speed is varied by a variable amplitude cam, and therefore, there may be an infinite number of variations in the azimuth speed. The most flexible and accurate system, and the system that has the widest range, is the one in which the azimuth speed may have any number of variations. Therefore, it is the preferred system.

What we claim as new is:

1. A method of depositing a variable thickness elastomeric layer along an outer periphery of a tire casing during a single operating cycle, said method including the steps of locally extruding a flat elastomeric ribbon having a width greater than the maximum thickness of said layer, applying the free end of said ribbon to a point along one edge of said layer, thereafter spinning said casing around its spin axis and simultaneously moving at a variable rate said casing in the direction of said spin axis to make said ribbon follow a path of a variable pitch spiral, generating a variable magnitude signal during said cycle, varying one of the parameters of said signal in synchronism with and to the extent so as to make said signal represent the desired thickness of said layer at any given instant of said cycle, and controlling said rate of transverse movement with the aid of said signal to make said ribbon follow said variable pitch signal.

2. A method of winding an elastomeric ribbon on a casing of a pneumatic tire having left and right sidewalls and shoulders, and a crown between said left and right shoulders, said method including the steps of providing a mechanical indicia of said casing; subdividing said indicia and through said indicia also said casing, at least into said right and left sidewall sectors, right and left shoulder sectors and a crown sector, providing a source of said ribbon by locally extruding said ribbon, positioning said casing at a predetermined distance with respect to said source, and then winding a continuous variable pitch spiral across the outer periphery of said casing by spinning said casing around a spin axis, controlling the speed of said spinning by continuously making said speed of spinning correspond to the speed of said extruding, simultaneously automatically and continuously moving said casing at a predetermined rate within each sector along the path having at least a vector component parallel to said spin axis to produce a predetermined percentage of overlap of the respective succeeding turns over the respective preceding turns within each sector, scanning said indicia in synchronism with said moving to produce an electrical signal at the beginning of each sector, changing said fixed rate of movement in response to said electrical signal, and controlling said predetermined rate within each sector as a function of the speed of said spinning and as a function of the thickness of said ribbon and by maintaining said rate constant as long as said thickness and said spinning remain constant.

3. A method of depositing a variable thickness elastomeric layer along an outer periphery of a tire casing during a single operating cycle, said method including the steps of locally extruding a flat elastomeric ribbon having a width greater than the maximum thickness of said layer, applying the free end of said ribbon to a point along one edge of said layer, thereafter spinning said casing around its spin axis and simultaneously moving at a variable rate said casing in the direction of said spin axis to make said ribbon follow a path of a variable pitch spiral with succeeding turns overlapping corresponding preceding turns to a variable degree, generating a first variable magnitude electrical signal, varying an instantaneous magnitude of said first signal in synchronism with the variation in the rate of extrusion of said ribbon, generating a second variable magnitude electrical signal in synchronism with

the desired variation in the thickness of said layer during a corresponding time interval of said cycle, combining said first and second signals to generate a third variable magnitude electrical signal and controlling the rate of said transverse movement with the aid of said third signal for depositing said variable thickness layer.

4. The method of depositing a variable thickness elastomeric layer along an outer surface of a tire casing, said method including the steps of locally extruding said ribbon, spinning said casing around its spin axis to wind said ribbon around said casing, simultaneously producing a variable rate movement between said casing and said ribbon in the direction having at least a vector component parallel to said axis, generating a first signal having a variable amplitude corresponding to the instantaneous speed of extrusion of said ribbon, generating a second electrical signal having a variable amplitude corresponding to the instantaneous thickness of said ribbon at the moment of its extrusion, generating a third signal having a variable amplitude corresponding to the variable thickness of said layer, combining said first, second and third signals to generate a fourth variable amplitude signal, and controlling said rate of transverse movement with the aid of said fourth signal for depositing said variable thickness layer.

5. The method of depositing a variable thickness elastomeric layer along an outer surface of a tire casing, said method including the steps of locally extruding said ribbon, spinning said casing around its spin axis to wind said ribbon around said casing, simultaneously producing a variable rate movement between said casing and said ribbon in the direction having at least a vector component parallel to said axis, generating a first signal having a variable amplitude corresponding to the instantaneous speed of extrusion of said ribbon, generating a second electrical signal having a variable amplitude corresponding to the instantaneous thickness of said ribbon at the moment of its extrusion, generating a third signal having a variable amplitude corresponding to the variable thickness of said layer, combining said first, second and third signals to generate a fourth variable amplitude signal, generating a fifth variable magnitude signal proportional to the power required to produce said variable rate movement, combining said fourth and fifth signals to obtain a sixth signal, and controlling said power to obtain said variable rate movement by means of said sixth signal for depositing said variable thickness layer.

6. A method of depositing an elastomeric layer by winding an elastomeric ribbon along an outer periphery of a tire casing during a single operating cycle, said layer having first and second edges, a transverse dimension between said first and second edges corresponding to the width of said layer and a varying thickness along the length of said transverse dimension, said method including the steps of locally extruding an elastomeric ribbon, applying the free end of said ribbon to a point located along said first edge, thereafter spinning said casing around its spin axis to wind said ribbon around the periphery of said casing, simultaneously producing a variable rate transverse movement between said casing and said ribbon in the direction of said transverse dimension for obtaining a variable lateral displacement and a variable degree of overlap between succeeding and adjacent preceding turns of said ribbon, and to make said ribbon follow a variable pitch spiral as long as said transverse movement continues, supplying a mechanical indicia representing said fixed transverse dimension along an X axis of said indicia and the variable thickness of said layer along the Y axis of said indicia, scanning said indicia simultaneously along said X and Y axes in synchronism with said transverse movement to produce a variable amplitude electrical signal as the result of said scanning, making the amplitude of said signal correspond to the desired thickness of said layer at a corresponding instant in said cycle, and controlling said rate of transverse movement with the aid of said electrical signal.

7. The method as defined in claim 6 which also includes the additional step of interrupting said transverse movement and said scanning at first and second spaced and predetermined points on said fixed transverse dimension and first and second spaced and predetermined points on said X axis while continuing said spinning around said spin axis to wind first and second beauty rings on said carcass lying in first and second planes passing through said first and second points on said carcass, said planes being perpendicular to said spin axis.

8. An automatic control system for a ribbon-winding machine for depositing a variable thickness elastomeric layer by winding an elastomeric ribbon along an outer surface of a pneumatic tire casing, said system including a source of said elastomeric ribbon, first means for spinning said casing around its spin axis, first control means to control said first means for continuously making the peripheral speed of said casing at the point of application of said ribbon to said casing equal to the rate of supplying said ribbon by said source, second means for obtaining a continuous, transverse, controlled relative movement between said casing and said source, and third means continuously to control said second means, said third means having fourth means for increasing, decreasing or maintaining constant the rate of said continuous transverse relative movement in synchronism with the predetermined transverse positions of said ribbon and said casing at the instant of stitching of said ribbon to said casing.

9. The automatic control system as defined in claim 8 in which said third and fourth comprise an electronic programmer controlling the operation of said second means, said programmer having a card, first and second scales on said card indicating the width of said elastomeric layer and indicia on said first scale indicating one edge of said layer and indicia on said second scale subdividing said width into a plurality of sectors, means coupled to said second means for scanning said indicia in synchronism with the transverse movement between said casing and said source, and means for converting said scanning into electrical signals in response to said indicia, said last means impressing said electrical signal on said second means; said second, third and fourth means, in response to said signals, altering the rate of said transverse movement from sector to sector of said layer.

10. The automatic control system as defined in claim 9 in which said electronic programmer control includes additional means to control the magnitude of said output signal as a function of the speed of said spinning and as a function of the thickness of said ribbon.

11. A machine for depositing a variable thickness layer of an elastomer onto a surface of a tire casing by winding an elastomeric ribbon on said casing during a single operating cycle, said machine including a local source of said elastomeric ribbon; first means for rotatively supporting said casing; a spin motor coupled to said casing around a spin axis; an azimuth motor coupled to said first means for moving said first means and said casing in a transverse direction with respect to said ribbon and said source; and a programmer having second means to connect said azimuth motor to a source of power and to said first means after one complete first revolution of said casing around said spin axis at the beginning of said cycle and disconnect said motor from said source and said first means prior to one complete last revolution of said casing around said spin axis at the end of said cycle, and second means for automatically regulating the speed of rotation of said azimuth motor to deposit said variable thickness layer of said elastomer on said casing during a single transverse travel of said casing with respect to said source; said second means including third means for changing the speed of said azimuth motor at predetermined transverse positions of said casing with respect to said source.

12. The machine as defined in claim 11 in which said third means includes a cam having a length along the X

axis and a variable height along the Y axis, said variable height having a magnitude along said Y axis adjusted so as to correspond to the desired thickness of said layer across said casing and along said X axis, and indicia means along the length of said cam and along said X axis to indicate the location of first and second side edges of said layer.

13. The machine as defined in claim **11** in which said azimuth motor is a direct current motor having a field winding and an armature, and said source is a source of direct current connected to said field winding and said armature, a silicon controlled rectifier connected in series with said armature, and a magnetic amplifier making said rectifier conductive to supply current to said armature and to control the speed of said azimuth motor, a first electrical tachometer actuated by said spin motor, a first transducer measuring the thickness of said ribbon, said first tachometer and said first transducer being serially connected to each other and to said magnetic amplifier for controlling the magnitude of the output signal produced by said amplifier as a function of the speed of said spin motor and the thickness of said ribbon, and a second electrical tachometer driven by said azimuth motor, said second tachometer being also connected to said magnetic amplifier to control current supplied to the armature of said azimuth motor so as to make said current continuously proportional to the instantaneous load connected to said azimuth motor.

14. The machine as defined in claim **13** which also includes a second transducer connected in series with said first transducer, said second transducer continuously indicating the desired instantaneous thickness of said layer across the width of said layer.

15. The machine as defined in claim **13** in which said programmer also includes a plurality of resistor means, and means for connecting one resistor means at a time into the circuit of said magnetic amplifier for changing the armature current of said azimuth motor.

16. A machine for depositing a variable thickness layer of an elastomer on a casing of a pneumatic tire by winding an elastomeric ribbon on said casing, said layer including first and second beauty rings, said machine including a spin motor for spinning said casing around a spin axle, an extruder for extruding said ribbon, an azimuth motor for moving said casing in transverse direction with respect to said extruder and said ribbon, and a programmer for controlling said spin and azimuth motors during the ribbon winding cycle of said machine, said programmer including first means for continuously controlling the speed of said spin motor during the entire ribbon winding cycle to make the speed of said winding of said ribbon on said casing equal to the speed of extrusion of said ribbon by said extruder, a first source of electric power, and second means for connecting said azimuth motor to said first source of power after completion of the first revolution of said casing around said spin axis at the beginning of said cycle and disconnecting said azimuth motor while winding said beauty rings and then reconnecting said azimuth motor to said source, said programmer also having third means for regulating the speed of said azimuth motor and again disconnecting said azimuth motor from said source one spin revolution prior to the completion of said cycle.

17. A ribbon winding machine capable of automatically depositing a variable thickness layer of an elastomer on a casing for a pneumatic tire by winding said ribbon on said casting, said machine including a source of ribbon; a spin axle for rotatively supporting said casing, a spin motor for spinning said casing around said spin axle; and an azimuth motor for moving said casing in a transverse direction with respect to said source of ribbon; a source of power for said azimuth motor; and a programmer controlling said spin motor and said azimuth motor, said programmer including: first means to control the speed of said spin motor to make the speed of winding said ribbon equal to the speed of extrusion of said ribbon, and second means for regulating the speed of said azimuth motor, said second means including third means for determining the instants when said speed is to be altered.

18. A ribbon winding machine capable of automatically depositing a variable thickness layer of an elastomer on a casing of a pneumatic tire by winding a continuous variable pitch spiral of said ribbon on said casing during a single, continuous operating cycle of said machine, said machine including a source of ribbon, a spin motor for spinning said casing around its spin axle, an azimuth motor for moving said casing and said ribbon relative to each other in the direction of said spin axle, a source of power for said azimuth motor, and a programmer for operating said azimuth motor, including: first rotary means having a first set of contacts sequentially opened and closed by said first rotary means, a second set of contacts operated with the aid of said spin axle, a first circuit jointly controlled by said first and second set of contacts to connect and disconnect said azimuth motor to and from said source at first and second predetermined instants of said cycle, said first and second instants being at predetermined and manually selectable number of turns of said casing around said spin axle immediately after the beginning and just prior to the termination of said cycle, respectively, and a second circuit means including a second set of contacts operated by said rotary means, and means to alter the current supplied by said source to said azimuth motor determined by the relative position of said carcass and said source of ribbon with respect to each other.

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