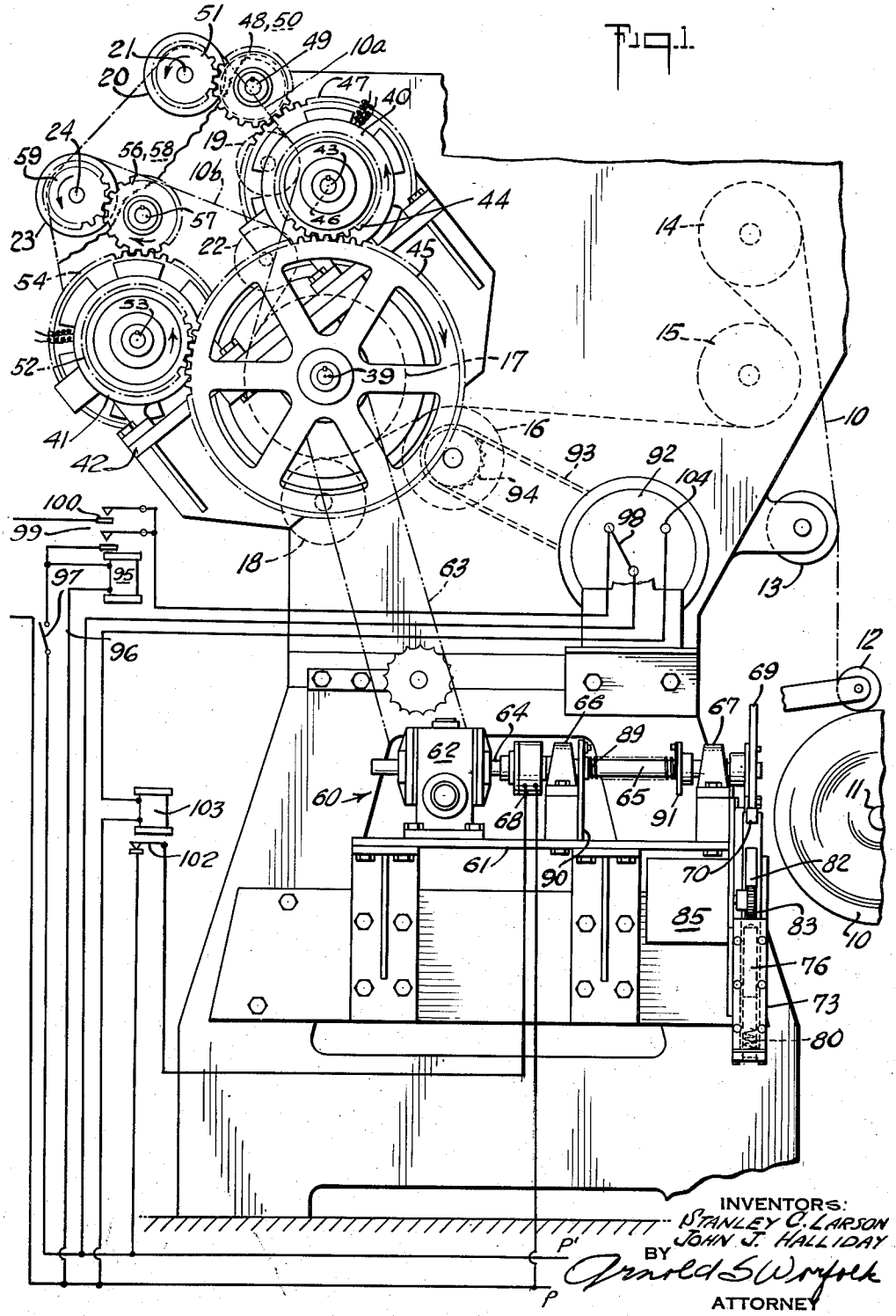
April 4, 1961 S. C. LARSON ET AL 2,978,200

APPARATUS FOR WINDING MATERIAL WITH PROGRAMMED TENSION

Original Filed Dec. 3, 1954 4 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

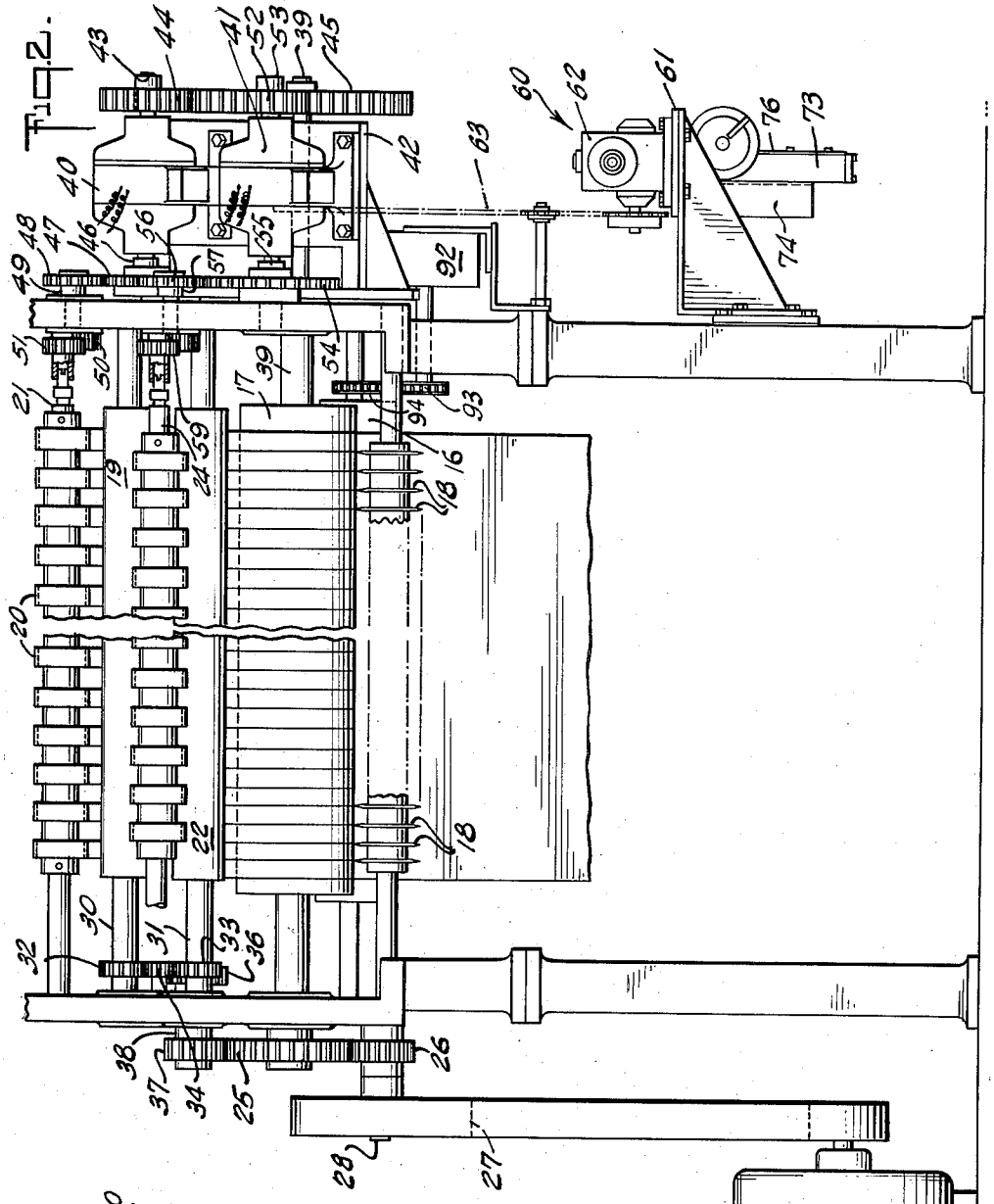
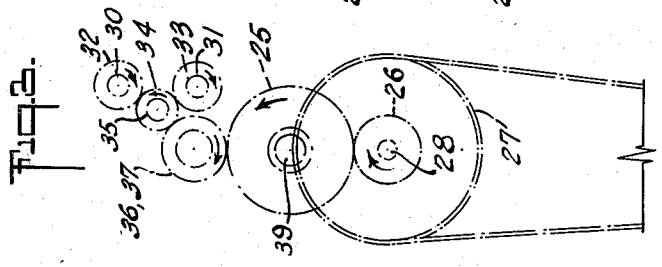


Fig. 3.



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APPARATUS FOR WINDING MATERIAL WITH PROGRAMMED TENSION

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Fig. 4

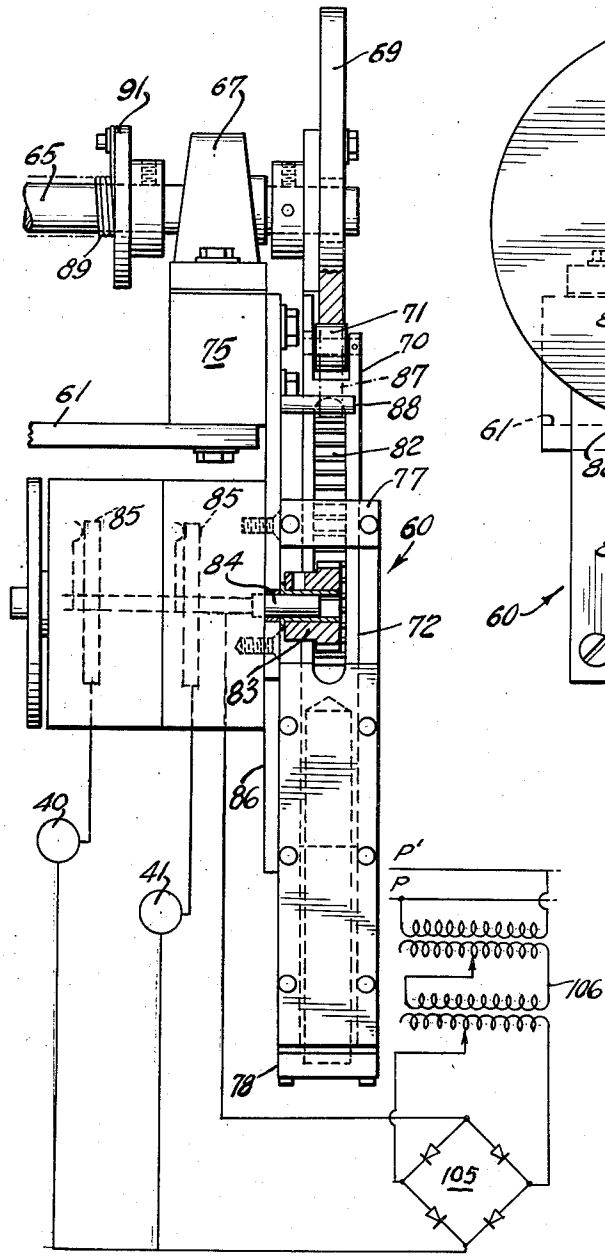
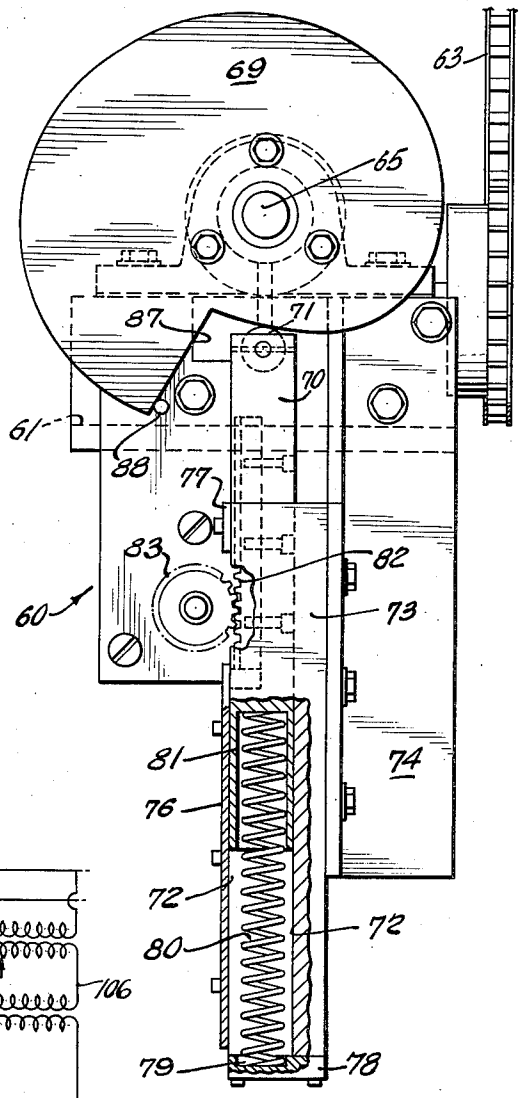


Fig. 5.



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APPARATUS FOR WINDING MATERIAL WITH PROGRAMMED TENSION

Original Filed Dec. 3, 1954 4 Sheets-Sheet 4

Fig. 7.

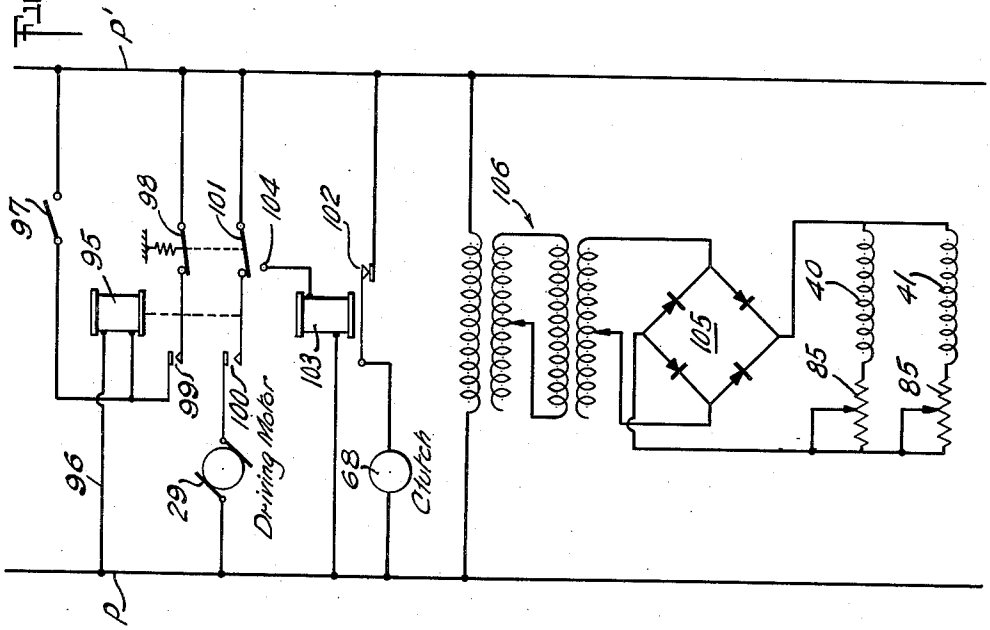
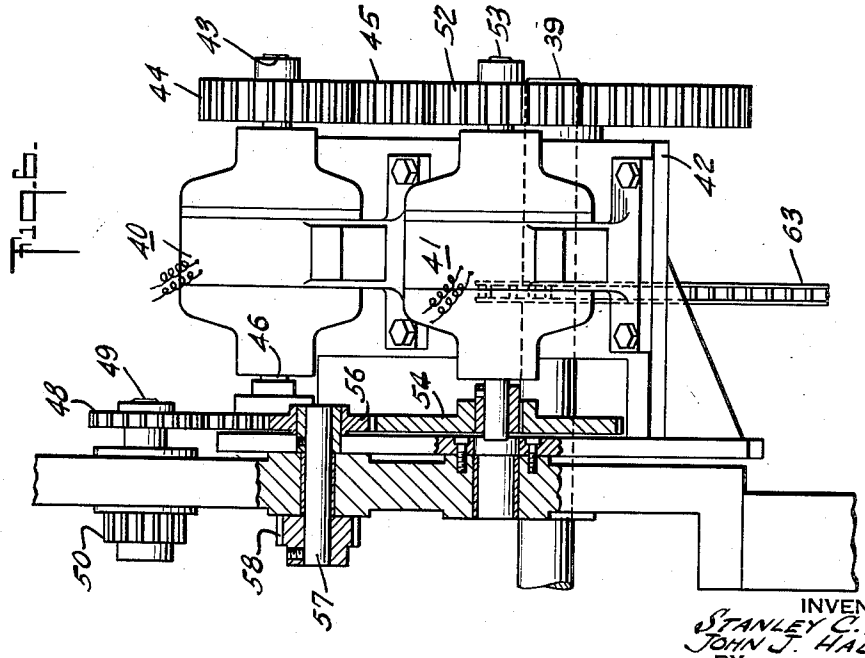


Fig. 6.



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United States Patent Office 2,978,200
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2,978,200

APPARATUS FOR WINDING MATERIAL WITH PROGRAMMED TENSION

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Continuation of application Ser. No. 472,938, Dec. 3, 1954. This application Apr. 26, 1960, Ser. No. 24,808

10 Claims. (Cl. 242—75.51)

This invention relates to a machine for winding pressure-sensitive adhesive tape at tension regulated according to a predetermined program.

Pressure-sensitive adhesive tape is usually wound on a core arranged on a mandrel to which constant wind-up torque is applied. With constant torque, tension in the tape, as the roll grows in size, gradually decreases so that in the finished roll tension in its outer convolutions is less than in its inner convolutions. Assuming wind-up tension so regulated in the outer convolutions to provide tightness sufficient to give a roll a neat appearance, it happens often that the inner convolutions have greater tightness than desired with the result that it is difficult to unwind the tape as it nears the core. In some instances there is a transfer of the adhesive to the back side of the tape to the extent that a portion of the tape near the core must be discarded.

In U.S. Patent 2,876,893 to B. B. Blackford et al. whose application Ser. No. 452,996 filed August 30, 1954 was co-pending with application Serial Number 472,938, filed December 3, 1954, now forfeited, of which this application is a continuation, there is described a roll of normally tacky pressure-sensitive adhesive tape wound under a tension regulated in accordance with a predetermined program. In a roll of tape so wound, any condition of tension throughout the many convolutions of the roll can be obtained. Thus, convolutions near the core can be wound with tension less than that in the outer convolutions, so that it is just as easy to unwind the tape as it approaches the core as it is at the start of the roll. Indeed, by selecting the appropriate winding program, tension in the extreme outermost convolutions of the roll can be made greater than in the convolutions near the core, so that a roll of tape will result having a neat appearance, little likelihood of becoming deformed during shipment of the tape and before its use, and which, nevertheless, will have tension in the inner convolutions sufficiently low to permit easy unwinding.

The invention has been illustrated as applied to a web-slitting machine of the score-cutting type. In such a machine a traveling web, which may be coated on one side with a normally tacky pressure-sensitive adhesive, is drawn from a bundle roll and guided by means of suitable rolls through the machine to a slitting station where the web is cut longitudinally into narrow strips or tapes. Alternate strips pass to one mandrel supporting a plurality of cores on which the strips are wound, whereas the remaining strips pass to a second mandrel similarly equipped with cores for the same purpose. Such machines are provided usually with stopping and starting devices whereby, after the leading ends of the strips of tape are started on their respective cores, operation of the machine may be inaugurated and continued until predetermined lengths of tape have been wound up, whereupon the machine may be brought to rest and a new set of cores brought into position ready for the next wind-up operation.

In accordance with the present invention the wind-up mandrels are driven through clutches so designed that the torque transmitted by them can be continuously varied. The variation in torque is so planned as to provide a predetermined tension in the tape throughout its wind-up operation.

In the embodiment of the invention selected for illustration, the mandrels are driven each through a clutch that employs fine, stainless steel particles mixed with a dry lubricant and which when magnetized create a low transmitting bond between the driving and driven parts of the clutch. The amount of tractive force exerted by te particles between the rotative parts can be varied infinitely from zero to complete engagement, the tractive force being in direct ratio to the amount of electrical energy applied to effect magnetization. The electrical energy is regulated by means of a rheostat, which is settable to vary the electrical energy supplied throughout the period the rolls of tape are being wound up. Specifically, this variation in the setting of the rheostat is controlled by an edge cam which may be set to make one revolution throughout the wind-up operation and whose edge contour determines the setting of the rheostat. A reduction gear driven from the drive shaft through which rotation is imparted to the mandrels rotates the edge cam once for each series of revolutions required to wind up a complete roll of tape. With such a construction, it is apparent that by varying the contour of the edge cam according to a predetermined pattern, any given tension can be wound into the rolls of tape.

Also in accordance with the invention, the mechanism includes a clutch device operable automatically as the wind-up operation is commenced simultaneously to initiate rotation of the edge cam to control the wind-up tension and automatically, as the wind-up operation is completed, to terminate rotation of the edge cam and facilitate its restoration to initial position.

A better understanding of the invention may be had from the following description read in conjunction with the accompanying drawings wherein:

Fig. 1 is a side elevation, looking from the right, of a machine equipped with the present improvements;

Fig. 2 is a front elevation of the machine shown in Fig. 1;

Fig. 3 is a diagrammatic illustration of a portion of the gear train through which various parts of the machine are driven from the main drive shaft;

Fig. 4 is a partial side elevation of a portion of the cam-control device illustrated in Fig. 1 but on somewhat larger scale;

Fig. 5 is a rear-end elevation, partly in section, of the cam-control device illustrated in Fig. 4;

Fig. 6 is a front elevation partly in section and on a somewhat larger scale of the clutch devices illustrated in Fig. 2; and

Fig. 7 is a circuit diagram of the electrical equipment on the improved machine.

As illustrated, a bundle roll of adhesive, sheet or web material, **10** is supported on a mandrel **11** at the rear of the machine (Fig. 1). The web material is pulled upwardly off the bundle roll, past guide rollers **12** and **13** and then over and around the upper of a pair of vertically-spaced, horizontally-disposed S-rolls **14** and **15**. Both the rolls **14** and **15** which are arranged directly one above the other are positively driven (means not shown) and, since the adhesive side of the web **10** is in contact with the upper roll **14** for about three quarters of its periphery, the tension exerted on the adhesive web is sufficient to pull it with facility off the bundle roll. After leaving the surface of upper roll **14**, web **10** passes through the space between it and lower roll **15**, toward the rear of the latter, and then around lower roll **15**

from whence it travels in a forward direction toward the front of the machine.

From roll **15** the web passes over a guide roll **16** (positively driven) and then under a platen roll **17** where the sheet is slit longitudinally into a plurality of tapes of narrow width **10***a* and **10***b* by a gang of circular knives **18** spaced along and located beneath the platen roll and in edgewise engagement therewith (Figs. 1 and 2). After the slitting operation, every other strip of tape **10***a* passes over a pull or guide roll **19** supported at its opposite ends for rotation in bearings presented in the side frames of the machine near the front. From the guide roll **19** the tapes **10***a* travel to a series of wind-up cores **20** spaced along a mandrel **21** which is detachably mounted at its opposite ends on devices journaled for rotation in the machine. A pull or guide roll **22**, cores **23**, and core-supporting mandrel **24** provide similar disposition for the intermediate strips of tape **10***b*. The guide roll **22** and mandrel **24** are mounted in the same fashion as guide roll **19** and mandrel **21** in the machine side frames.

The S-rolls **14** and **15** adjacent the rear of the machine, platen roll **17**, the two guide rolls **19** and **22**, and the two mandrels **21** and **24** for support of the tape cores, are all driven by a mechanism which may be standard for the particular type of machine illustrated except that, contrary to usual, the mandrels **21**, **24** are rotated under torque that is predetermined in manner subsequently described.

The platen roll **17**, which in effect is the main shaft of the machine, is journaled at its opposite ends in the machine side frames. It is equipped at its left end outside the machine frame with a gear **25** driven through a pinion **26** which, together with a belt pulley **27** affixed to it, is rotatively mounted on a stud **28** projecting laterally from the machine frame (Figs. 2 and 3). The pulley **27** is belt-driven from a motor **29** suitably fixed on the floor or on a stationary part of the machine. The two pull or guide rolls **19** and **22** over which the strips of tape **10***a* and **10***b* pass after leaving platen **17** are mounted on shafts **30**, **31** journaled at their opposite ends in the machine side frame. On the left end of each shaft **30**, **31**, just inside the side frame, there is fixed respectively a gear **32**, **33**. An intermediate pinion **34**, rotatably arranged on a stud **35** projecting inwardly from the machine left side frame, meshes with both said gears to insure rotation of both pull rolls in the same direction. A pair of pinions **36** and **37** fixed at opposite ends of a short counter shaft **38** journaled in the side frame mesh, one with the intermediate pinion **34** on stud **35** and the other with the gear **25** disposed on the platen shaft. According to this arrangement, the adhesive sheet from the bundle roll, as it threads through the machine, passes around the bottom of the platen roll with its non-adhesive side in contact therewith. After the adhesive sheet is slit into the two series of tapes, one series passes over and around the pull roll **19** and the other series over and around the corresponding pull roll **22** with their adhesive sides in contact with the rolls which, to promote the travel of the tapes through the machine, rotate in a direction opposite to the direction of rotation of the platen roll. Since the pull rolls **19** and **22** are positively driven and since the tapes have their adhesive surfaces in contact with the rolls as they pass around them, any degree of tension can be wound into the individual rolls of tape depending upon the torque exerted on the wind-up mandrels **21** and **24** from a minimum determined by the amount of pull required to break the adhesion between the tapes and the pull roll over which it travels to a maximum as determined by the tensile strength of the tape itself.

Variable torque to control tension in the tapes being wound up on mandrels **21** and **24** is derived from a main shaft **39** on which the platen **17** is mounted through mechanism which includes a pair of variable torque clutch units **40** and **41**, provided one unit for each mandrel and mounted both on a bracket **42** secured to the main frame of the machine at the right (Figs. 1, 2, and 6). The clutch **40** includes a pair of relatively moveable parts between which variable torque is transmitted. One part is equipped with a shaft **43** extending to the right and which at its end is equipped with a gear **44** meshing with a large gear **45** fixed at the right end of the platen roll. The other part of the clutch is provided with a similar shaft **46** coaxial with the first and which likewise is provided with a gear **47** fixed thereon and which meshes with a pinion **48** fixed on a small counter shaft **49** journaled in the adjacent machine frame. A similar pinion **50** fixed at the opposite end of the counter shaft inside the machine frame meshes with a pinion **51** fixed at the adjacent end of the mandrel **21**. With this arrangement, rotation of the platen shaft **39**, in a clockwise direction looking at the machine from the right, rotates the mandrel **21** in a counter-clockwise direction imparting to the mandrel, as it rotates, a torque which is directly dependent upon the amount of energy transmitted by the relatively moveable parts of the clutch **40**.

The other mandrel **24** is driven in the identical manner from the gear **45** fixed on the platen shaft, i.e., between the gear **45** and the mandrel **24** there is the clutch unit **41**, a pinion **52** meshing with the gear **45** and fixed on a shaft **53** associated with the driving side of the clutch, and a train of gears leading to the mandrel which includes a gear **54** on a shaft **55** associated with the driven side of the clutch and pinion connections **56**, **57**, **58**, and **59** which per se and with respect to their mountings are in all respects similar to corresponding elements **48**, **49**, **50**, and **51** previously described.

The clutch illustrated by way of example is a magnetic clutch of the type sold by The Clark Manufacturing Co. of Cleveland, Ohio under the name "Dynamatic Drive" and described in U.S. Patents 2,519,449; 2,525,571; 2,543,394 and 2,580,869. In such a mechanism the amount of torque transmitted depends upon the extent to which the clutch is energized and this in turn on the amount of electrical energy supplied to it. In accordance with the present invention, the electrical energy supplied to the clutches is controlled at all times to regulate the amount of torque transmitted to the mandrels. The driving torque, of course, is counter-balanced by the resistance offered to the mandrels' rotation and this in turn is equal for practical purposes to the summation at any instant of the products of the radius of the individual rolls of tape by the tension in that stretch of the tape between the mandrels and the pull rolls **19** and **22** as the case may be. Since the thickness of tape in each roll is approximately the same, all rolls being wound will have substantially the same radius at any given instant and the same wind-up tension. This tension, accordingly, can be determined by regulating the torque transmitted to the mandrels.

The amount of electrical energy transmitted to the clutches at any time is determined by a unit **60** mounted on a bracket **61** secured to the base frame of the machine at the right (Figs. 1, 2, 4, and 5). This unit consists of a reduction-gear unit **62** of suitable type fixed on the bracket **61** and which is driven by chain **63** from main drive shaft **39** of the machine, i.e., the shaft on which the platen **17** is mounted. The reduction gear has a fore-and-aft driven shaft **64** arranged in coaxial alignment with another fore-and-aft shaft **65** located just to the rear thereof and which is mounted for rotation in spaced bearing **66**, **67** fixed on the bracket **61**. A magnetic clutch **68** located between the shaft section **64** and **65**, will, when energized, connect the sections together so that the rear section is driven by the reduction gear and, when de-energized, disconnect the sections so that the rear section is free for independent rotation.

At the rear end of the rear-most shaft section **65** there is fixed an edge cam **69** whose edge, as it rotates, en-

gages a cam follower 71 mounted for rotation at the upper end of a bar member 70 constrained for sliding movement in a vertical direction. For efficiency in operation, the vertically-movable member 70 is arranged directly beneath the axis of shaft 65 on which cam 69 is mounted, so that as the cam is rotated, movement of the vertical member is effected radially with respect to the cam and in amount as determined by the configuration of the cam's edge.

Vertically-movable bar member 70, generally square in configuration, is constrained for sliding movement in a vertical guideway 72 presented in the front face of a vertically-disposed bar 73 secured to a rearwardly-extending leg of a correspondingly-disposed angle iron 74 whose other leg extends laterally toward the machine frame and is secured at the top to a block 75, which supports the rear bearing member 67. The guideway 72 is closed by a face plate 76 suitably secured in place on the bar 73 to retain the vertically-movable member 70 in the guideway throughout its sliding movement. A narrow horizontal plate 77 as long as the plate 76 wide spans the guideway 72 near the top of the bar 73 likewise to retain the vertically-movable member 70 in the guideway.

When the vertically-moving member 70 is in its topmost position, the bar 73 in which it slides extends down beyond its lower end a distance sufficient to accommodate at least the full stroke of the moveable member, as determined by the contour of the overlying cam 69. The guideway 72 is closed at the bottom by a plate 78 secured to the bar 73 at its lower end and it is formed in its top surface with a recess 79 to accommodate the lower end of a compression spring 80 which reacts between said plate and the upper end of a pocket 81 drilled vertically into the lower end of the vertically-movable member 70. The arrangement is such that the vertically-moveable member 70 is constrained always to follow in its vertical movement the contour of the edge cam 69 as the latter rotates.

The vertically-movable member 70 presents a toothed rack section 82 in that one of its faces which rides adjacent the inner surface of the closing plates 76 and 77 and in the opening defined by the inner opposed edges of these plates, the rack teeth mesh with a pinion gear 83 fixed on the end portion of a shaft 84 which is the extension of the rotor shaft of a rheostat 85 fixed on a plate 86 depending from the journal-supporting post 75. The rheostat is mounted on the front face of the plate 86 and its rotor shaft 84 extends rearwardly through the plate to receive the pinion 83. As will be presently described, the rheostat has a double resistance connected one in series with the energizing winding of each of the magnetic clutches 40 and 41 and the arrangement is such that, as the bar 70 moves downwardly, as determined by the contour of cam 69 during its rotation and against opposition of spring 80, the rheostat is adjusted through operation of the rack and pinion 82, 83 to control magnetization of the clutches in manner to increase the torque exerted on the mandrels 21, 24. On the other hand, when the vertical bar moves upwardly under influence of the spring 80 and likewise as determined by the contour of cam 69 during its rotation, rheostat 85 is adjusted to decrease magnetization of the clutches and reduce the torque transmitted to the mandrels.

The normal position of the cam 69 is determined by the engagement of a radial abutment 87 thereon with a fixed horizontal pin 88 extending rearwardly from the fixed plate 86. Normally, this position is maintained by a helical spring 89 encircling the shaft section 65 and which is attached one end to a fixed part 90 of the bracket support 61 and the other end to a flange 91 fixed to and which rotates integrally with the shaft section 65 (Figs. 1 and 4). Also in the normal position of the parts, the magnetic clutch 68 is energized so that as a tape wind-up operation is inaugurated, cam 69 is rotated in a clockwise direction, looking at the parts from the rear. Rotation of the cam in this direction tensions the helical spring 89 and, of course, moves bar 70 downwardly as the radial dimension of the cam increases with a resultant increase in torque transmitted to the mandrels.

When the rolls of tape being wound upon the mandrels have reached a given size, operation of the machine is arrested. Clutch 68 is simultaneously de-energized, thereby effecting disengagement between shaft sections 65 and 64. Upon such disengagement, shaft section 65 and, consequently, cam 69 mounted thereon are restored to their normal positions, under the action of helical spring 89, by counter-clockwise rotation of the cam until its radially-disposed abutment 87 engages the fixed pin 88. Also during restoration of cam 69, bar 70 is likewise restored to its normal position by the reaction of spring 80, this operation being accompanied by a resetting of rheostat 85 to an adjustment corresponding to the torque desired to be transmitted by the clutch members 40, 41 at the initial stage of the wind-up operation.

Since the platen roll 17 on main shaft 39 has the same peripheral speed as the web 10 in its travel through the machine, a given number of revolutions of main shaft 39 correspond to the length of the rolls of tape the machine is set to handle at any given time. By using a reduction gear 62 with ratio of that given number of revolutions to one, shaft 65 and, consequently, cam 69 are made to partake of one revolution for each cyclic period required to wind-up such a length of tape.

Attention should also be called to the fact that the peripheral speed of guide roll 16 is also the same as the linear speed of travel of the web through the machine. Consequently, as regards to roll 16, a fixed number of revolutions of its shaft will correspond to the length of tape to be wound into rolls on the wind-up mandrels. Accordingly, in order to stop the machine automatically after a given length of tape has been wound on the mandrels, there is provided a counting mechanism 92 of any suitable type driven by chain 93 from a sprocket 94 on the shaft of roller 16 and which, when it has counted up a given number of revolutions representing the length of tape to be wound on the mandrel, serves to operate mechanism to stop operation of the machine and also to de-energize magnetic clutch 68, which in the manner previously described, operates to permit restoration of the cam member 69 to its normal position (Fig. 1).

Further assistance in understanding the operation of the machine may be had by reference to the circuit diagram shown in Fig. 7 and particularly in Figs. 1 and 4. Therein it will be observed that there is a relay 95 whose winding is connected with one power line P through lead 96 and with return power line P' by way of two paths, one through a normally-open button switch 97 and the other through normally-closed switch 98 in series with a pair of normally-open relay contacts 99 adapted to be closed when relay 95 is energized. Relay 95, when energized, also acts to close another pair of normally-open relay contacts 100 in series with a normally-closed switch 101. Contacts 100 when closed establish an electrical circuit from power line P, through main driving motor 29 of the machine and through switch 101, when closed, to return power line P'. Assuming that the leading ends of the slitted tape which stretch between the slitting knives 18 and the mandrels 20 and 23 have been attached to cores on the mandrels, button switch 97 is momentarily closed to inaugurate operation of the machine. The closing of switch 97 establishes a connection through the winding of relay 95 which, when energized, closes both pairs of its associated contacts 99 and 100. Closing of relay contacts 99 establishes a holding circuit through relay 95, while closing of relay contacts 100 starts the driving motor 29.

It will also be recalled that magnetic clutch 68, in the normal position of the parts, is energized to connect reduction gear 62 with control cam 69. For this purpose, clutch 68 is connected between power leads P and P'.

through a pair of normally-closed contacts **102** associated with a relay **103** whose winding is connected between power leads P and P' through a normally-open switch which conveniently may comprise a second pole **104** of the switch **101** if the latter be a double pole switch, and which is adapted to be closed to energize relay **103** when switch **101** is moved to open the circuit through the driving motor **29.**

With this arrangmeent, the control cam **69** will rotate through its normal cycle upon inauguration of machine operation through momentarily pressing button switch **97.** When counting device **92** has completed a cycle representing the amount of tape to be wound up into rolls on the cores located on the mandrel, it automatically but momentarily opens switches **98** and **101,** which may be conveniently tied together for conjoint operation and closes the circuit through relay **103.** The result is that motor **29** is stopped, the holding circuit through relay **95** is disestablished and the relay **103** operates to open contacts **102** in the energizing circuit of magnetic clutch **68** in the control cam shaft. Clutch-control relay **103** has a time-delay factor, so that even though it is energized but momentarily, its contacts **102** remain open long enough to permit cam **69** to be restored to its normal position in manner previously described before such contacts close again to establish the energizing circuit through magnetic clutch **68.**

In the circuit diagram (Fig. 7), the energizing windings of the variable torque magnetic clutches **40, 41** are represented by the coils with corresponding legends. In series with these coils are adjustable resistances **85** which represent the windings of rheostat **85.** In other words, variable resistances **85** are those which are varied under the control of the cam **69** to control the torque transmitted by clutches **40, 41** to their respective mandrels. The magnetic-clutch windings **40, 41** are powered by direct current furnished through a bridge rectifier **105** connected by suitable transformer bank **106** to the main power lines. The secondaries of the transformers **106** are adjustable to regulate the level of power transmitted to establish appropriate torque to effect the winding up of the tape, but once the general level of the torque has been established, the programmed variation in the torque, which is the subject of this invention, is controlled throughout the entire wind-up period as a result of adjusting the rheostat **85** in accordance with the contour of edge cam **69.**

From what has been said it is apparent that any program of tension can be wound into the rolls of tape merely by using, in the machine, a control cam **69** of the desired contour. In general, it might be said that the apparatus of the present invention is particularly applicable for winding up rolls of tape pursuant to the programs delineated in said Patent 2,876,893 previously referred to.

The invention has been described in connection with one embodiment thereof, but many others are included within its spirit. For instance, any apparatus which may be used to transmit a predetermined signal for a given period to a variable torque device could be utilized in carrying out the invention, as could also other types of clutches so long as it is possible to adjust and control the amount of torque transmitted by them. The invention, therefore, is to be limited only by the scope of the appended claims.

The invention claimed is:

1. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, an adjustable device presenting a pattern varying throughout a range of adjustment according to a desired predetermined program of tension for winding the given length of material throughout its length, actuating devices for the pulling means and for the adjustable device including common driving means for both and acting throughout said cycle correspondingly to advance the given length of material through the machine and the adjustable device over said range, connections for rotating the mandrel to wind thereon said given length of material and which include means for transmitting an adjustable torque to the mandrel from said driving means, and means operable throughout said cycle under the control of the device which presents the pattern for adjusting the torque transmitted by said connections to secure throughout the finished roll of material tensional characteristics in accordance with said predetermined program.

2. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of material through the apparatus for winding on the mandrel, an adjustable cam device having a control surface presenting a pattern varying throughout a range of adjustment according to a desired predetermined program of tension for winding the given length of material throughout its length, actuating devices for the pulling means and for the adjustable cam device including driving means common to both and acting throughout said cycle correspondingly to advance the given length of material through the machine and the adjustable cam device over said range, connections for rotating the mandrel to wind thereon said given length of material and which include means for transmitting an adjustable torque to the mandrel from said driving means, and means operable throughout said cycle under the control of the cam device which presents the pattern for adjusting the torque transmitted by said connections to secure throughout the finished roll of material tensional characteristics in accordance with said predetermined program.

3. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, an adjustable cam device having a control surface presenting a pattern varying throughout a range of adjustment according to a desired predetermined program of tension for winding the given length of material throughout its length, actuating devices for the pulling means and for the adjustable cam device including driving means common to both and acting throughout said cycle correspondingly to advance the given length of material through the machine and the adjustable cam device over said range, connections for rotating the mandrel to wind thereon said given length of material and which include means for transmitting an adjustable torque to the mandrel from said driving means, and means operable throughout said cycle under the control of the cam device which presents the pattern for adjusting the torque transmitted by said connections to secure throughout the finished roll of material tensional characteristics in accordance with said predetermined program, said cam device having an initial setting from which it is moved during the winding cycle and means operable to reset the cam in its initial position after each winding cycle.

4. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, an adjustable device presenting a pattern varying throughout a range of adjustment according to a desired predetermined program of tension for winding the given length of material throughout its length, actuating devices for the pulling means and for the adjustable device including driving means common to both and acting throughout said cycle correspondingly to advance the

given length of material through the machine and the adjustable device over its range, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of the electrical energy supplied to it, and an electrical circuit through which said clutch is energized under the control of the device which presents the pattern defining the predetermined program.

5. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, an adjustable device presenting a pattern varying throughout a range of adjustment according to a desired predetermined program of tension for winding the given length of material throughout its length, actuating devices for the pulling means and for the adjustable device including driving means common to both and acting throughout said cycle correspondingly to advance the given length of material through the machine and the adjustable device over said range, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of the electrical energy supplied to it, and an electrical circuit in which said clutch is included together with a circuit element variable under the control of the device which presents the pattern defining the predetermined program to regulate the electrical energy transmitted through the circuit to the clutch.

6. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, a cam device having a surface configuration varying in accordance with a predetermined program of tension under which the material is to be wound throughout its given length during the winding cycle, driving means for said pulling means and for the cam device continuously and positively to adjust said cam device throughout said cycle proportionally to the travel of said given length of material through the machine, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of electrical energy supplied to it, and an electrical circuit in which said clutch is included together with a circuit element variable under the control of the cam device to regulate the electrical energy supplied to the clutch.

7. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, a cam device having a surface configuration varying in accordance with a predetermined program of tension under which the material is to be wound throughout its given length during the winding cycle, driving means for said pulling means and for the cam device continuously and positively to adjust said cam device throughout said cycle proportionally to the travel of said given length of material through the machine, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of electrical energy supplied to it, and an electrical circuit in which said clutch is included together with a circuit element variable under the control of the cam device to regulate the electrical energy supplied to the clutch, said connections for rotating the mandrel including a rotatable shaft from which also is driven a shaft by which the cam device is adjusted.

8. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, a cam device having a surface configuration varying in accordance with a predetermined program of tension under which the material is to be wound throughout its given length during the winding cycle, driving means for said pulling means and for the cam device continuously and positively to adjust said cam device throughout said cycle proportionally to the travel of said given length of material through the machine, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of electrical energy supplied to it, and an electrical circuit in which said clutch is included together with a circuit element variable under the control of the cam device to regulate the electrical energy supplied to the clutch, said connections for rotating the mandrel including a rotatable shaft, means for driving the cam from said shaft including a normally engaged clutch, and means for disengaging said clutch at the end of a winding cycle.

9. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, a cam device having a surface configuration varying in accordance with a predetermined program of tension under which the material is to be wound throughout its given length during the winding cycle, driving means for said pulling means and for the cam device continuously and positively to adjust said cam device throughout said cycle proportionally to the travel of said given length of material through the machine, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of electrical energy supplied to it, an electrical circuit in which said clutch is included together with a circuit element variable under the control of the cam device to regulate the electrical energy supplied to the clutch, said connections for rotating the mandrel including a rotatable shaft, means for driving a shaft by which said cam device is adjusted from said rotatable shaft and including a normally engaged clutch, means for disengaging the clutch, and resilient means operating to restore the cam adjusting shaft to its normal position upon disengagement of said clutch.

10. Apparatus for winding material into rolls with tension according to a predetermined program, said apparatus including a mandrel on which the material is wound during a winding cycle, means for pulling a given length of the material through the apparatus for winding on the mandrel, means operable to terminate the winding cycle, a cam device having a surface configuration varying in accordance with a predetermined program of tension under which the material is to be wound throughout its given length during the winding cycle, driving means for said pulling means and for the cam device continuously and positively to adjust said cam device throughout said cycle proportionally to the travel of said given length of material through the machine, connections for rotating the mandrel to wind thereon said given length of material comprising a clutch electrically energized and operable to transmit torque according to the extent of electrical energy supplied to it, an electrical circuit in which said clutch is included together with a circuit element variable under the control of the cam device to regulate the electrical energy su-

plied to the clutch, said connections for rotating the mandrel including a rotatable shaft, means for driving a shaft by which said cam device is adjusted from said rotatable shaft and including a normally engaged clutch, resilient means operable to restore the cam device to normal position upon disengagement of said clutch, and means under the control of the cycle terminating means for effecting disengagement of the clutch and for arresting operation of the machine.

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