

March 22, 1960

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2,929,576

APPARATUS FOR DISTRIBUTING A STRAND INTO COIL FORM

Filed Aug. 25, 1958

5 Sheets-Sheet 1

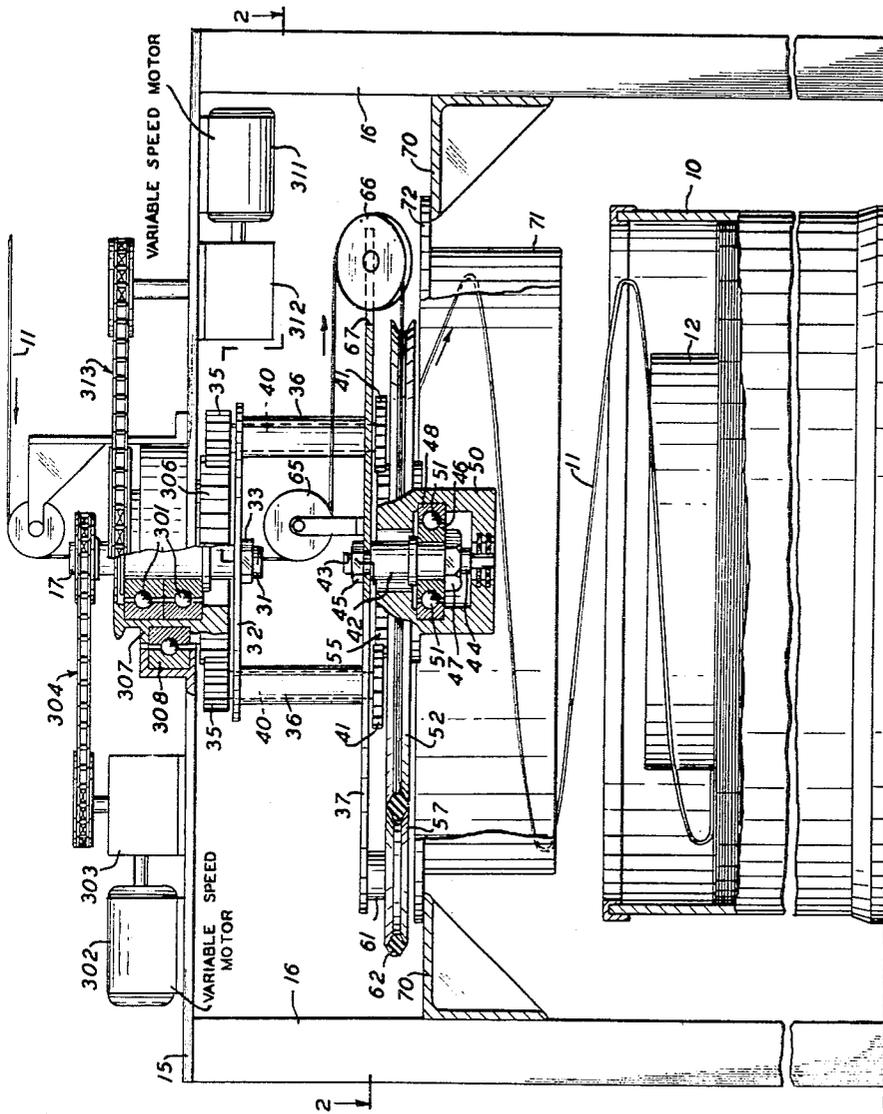


FIG. 1

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5 Sheets-Sheet 2

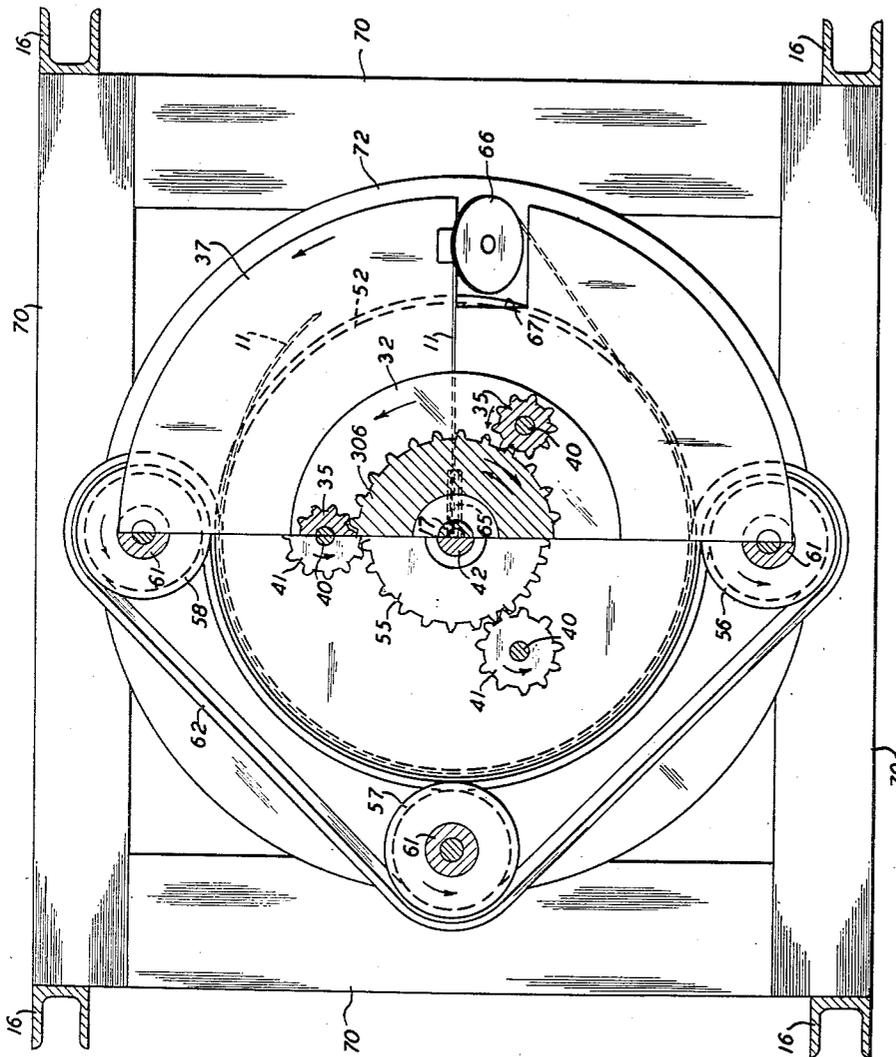


FIG. 2

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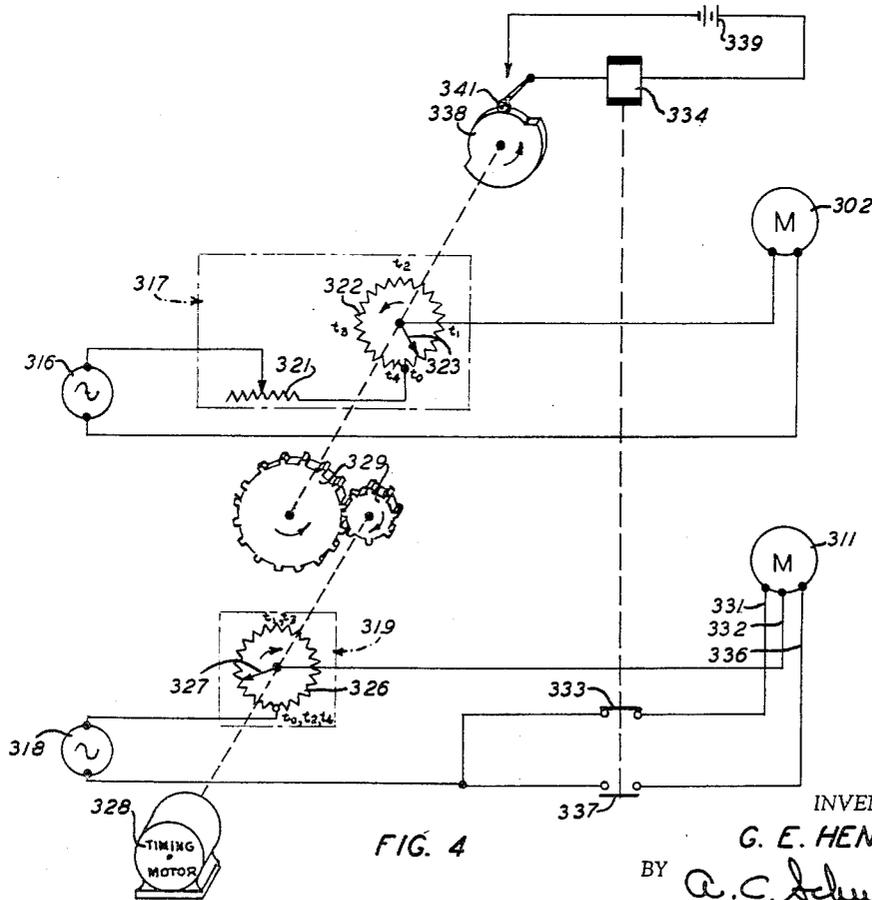
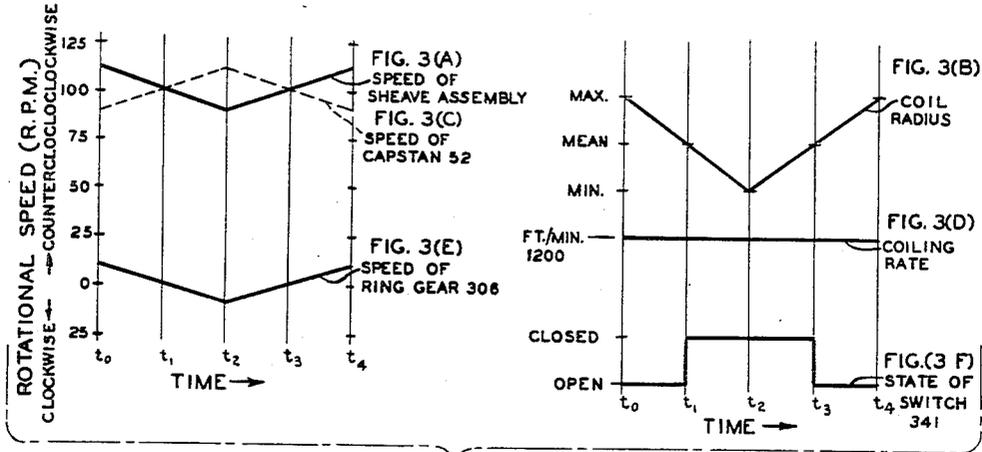
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5 Sheets-Sheet 5

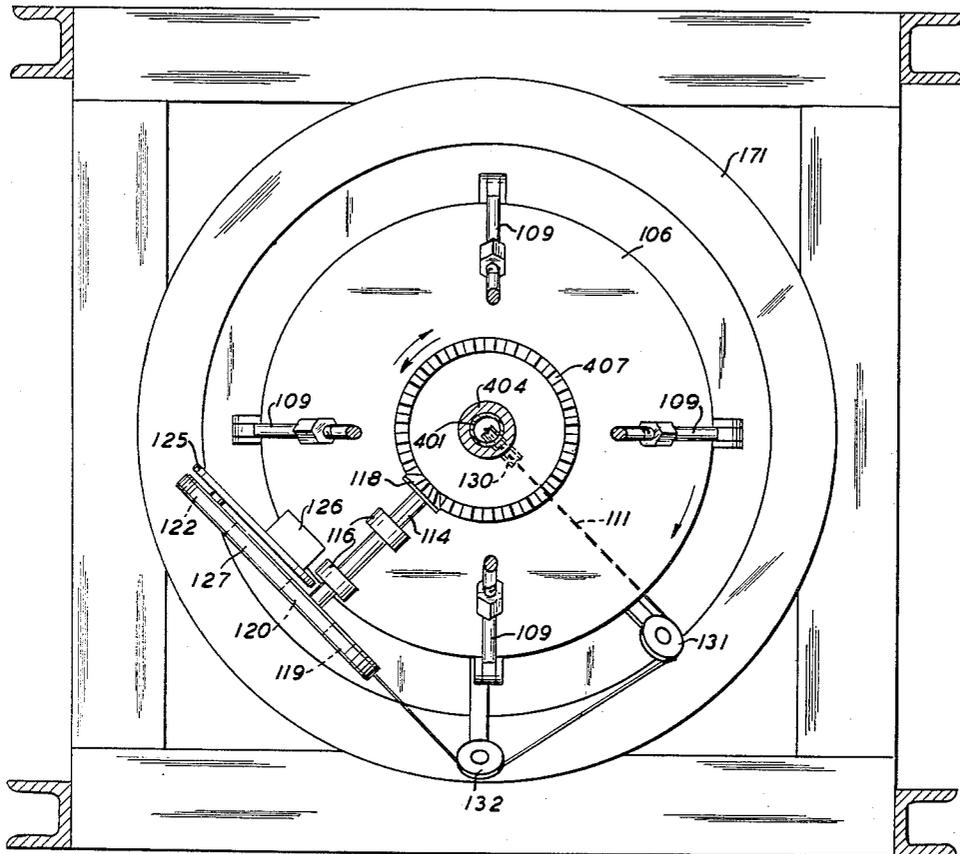


FIG. 6

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2,929,576

APPARATUS FOR DISTRIBUTING A STRAND INTO COIL FORM

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Application August 25, 1958, Serial No. 756,823

5 Claims. (Cl. 242—82)

The present invention relates generally to apparatus for distributing a strand into coil form, and relates more particularly to apparatus for distributing a strand in a continuous succession of coils having varying radii.

This application is closely related to and is a continuation-in-part of my copending application Serial No. 509,209, filed May 18, 1955 and entitled "Apparatus for Distributing Filamentary Material into Coil Form."

An object, therefore, of the invention is to provide apparatus for distributing a strand into coil form.

Another object of the invention is to provide apparatus for distributing a strand in a continuous succession of coils having varying radii.

A more specific object of the invention is to provide apparatus for distributing a strand along a descending helical path having an alternately increasing and decreasing radius for collection in a container in the form of a succession of coils having alternately increasing and decreasing radii.

A further object of the invention is to provide improvements of the strand-distributing apparatuses disclosed in my copending application, which improvements enable collection of the strand in a continuous succession of coils having alternately increasing and decreasing radii, while the coiling rate or throughput of the strand is maintained constant.

With these and other objects in view, an apparatus for distributing a strand into the form of a coil, illustrating certain features of the invention, may include a rotatable capstan capable of discharging the strand. Means are provided for causing the strand-discharge point (by which is meant those portions of the capstan which are last to contact the strand) to revolve about the axis of the coil to be formed at variable speeds so regulated that the strand is distributed along a descending helical path having a variable radius for collection in a continuous succession of coils having varying radii. Means are provided for rotating the capstan at speeds so synchronized with the speed of revolution of the strand-discharge point that the coiling rate is maintained substantially constant.

The strand coils are preferably collected in a container mounted below the capstan. It is also preferable to revolve the discharge point according to the cycle wherein the speed of revolution alternately increases uniformly from a minimum speed to a maximum speed and then decreases uniformly back to the minimum speed. With this arrangement, the strand is collected in the container in a succession of coils having alternately increasing and decreasing radii.

In particular, the invention contemplates modifications of the structure illustrated in both embodiments of my copending application allowing rotation of the capstan at predetermined synchronized speeds designed to maintain a constant coiling rate while the point of discharge of the strand from the capstan is revolved at variable speeds.

Other objects and advantages of the invention will appear from the following detailed description of particular

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embodiments thereof, when read in conjunction with the appended drawings, in which:

Fig. 1 is a front elevation of a strand-distributing apparatus illustrating a first embodiment of the invention, with portions broken away for clarity, portions of Fig. 1 being generally similar to Fig. 1 of my copending application;

Fig. 2 is a horizontal section taken generally along the line 2—2 of Fig. 1 in the direction of the arrows, being generally similar to Fig. 2 of my copending application;

Fig. 3(A) to 3(F) are graphs indicating the behavior of various factors with respect to time, according to one illustrative example;

Fig. 4 is a schematic drawing of an electromechanical control means for operating the apparatus of Figs. 1 and 2 so as to achieve the cycle of Fig. 3;

Fig. 5 is a front elevation of an apparatus illustrating a second embodiment of the invention, with portions broken away for clarity, portions of Fig. 5 being substantially the same as illustrated in Fig. 4 of my copending application, and

Fig. 6 is a horizontal section taken generally along the line 6—6 of Fig. 5 in the direction of the arrows.

First embodiment

Referring now in detail to the drawings, and in particular to Figs. 1 and 2, a strand-distributing apparatus is shown which is generally similar to that disclosed in the first embodiment of my copending application, Figs. 1 and 2, but which includes certain modifications and additional elements allowing operation in accordance with the principles of this invention. For convenience, certain elements forming a part of my copending application and common to this application have been given the same numerals formerly applied; whereas, modified and additional elements forming a part of this invention only have been given numerals starting with the numeral 301.

As in my copending application, a container such as an open-topped barrel 10 is provided to receive a strand 11, such as a bare wire or an insulated conductor, to be collected in a succession of coils occupying an annular area between the inner periphery of the barrel 10 and the outer periphery of a cylindrical core 12 mounted at the center of the barrel 10. The barrel 10 is stationary throughout the operation and is shown in its correct strand-receiving position below a platform 15, which is supported above the floor on a plurality of vertical channel irons 16—16.

A rotatable, vertical, hollow shaft 17 is mounted for rotation in an inner pair of bearings 301—301 located near the center of the platform 15, and the strand 11 is advanced therethrough by a capstan 52, from top to bottom as viewed in Fig. 1. The shaft 17 is rotated at preselected varying speeds (assumed to be in a counterclockwise direction as viewed in Fig. 2) by a variable-speed motor 302, through the intermission of a gear box 303 and a sprocket-and-chain transmission designated generally by the numeral 304. In my copending application, a constant-speed motor was provided to rotate the shaft 17, that application contemplating rotation at constant speed throughout the strand-distributing operation to distribute the strand 11 in a succession of coils having a constant radius.

A rotatable ring gear 306 is fixed to and depends from a supporting ring 307, which in turn is mounted for rotation with respect to the platform 15 by means of an outer bearing 308 and which is further mounted for independent rotation with respect to the shaft 17 by means of the inner bearings 301—301. The ring 307 and thus the ring gear 306 connected thereto are rotated by means of a second variable-speed motor 311, through the intermission of a second gear box 312 and a second

sprocket-and-chain transmission designated generally by the numeral 313.

The ring gear 306 is rotated by the motor 311 at varying speeds during the strand-distributing operation, which speeds are synchronized with the rotational speed of the shaft 17 in order to operate the apparatus in accordance with the principles of this invention. In my copending application, a fixed gear was provided in place of the rotatable gear 306 to provide for distribution of the strand 11 in coils having a constant radius; whereas, the combination of rotating the shaft 17 at varying speeds with rotating the gear 306 at synchronized, varying speeds allows distribution of the strand 11 in a succession of coils having alternately increasing and decreasing radii in order to provide more uniform collection of the strand 11 in the annular area between the barrel 10 and the core 12.

The remaining structure illustrated in Figs. 1 and 2 is generally similar to that illustrated in my copending application, and allows distribution of the strand 11 in a descending helical path to form a coil in the barrel 10. The rotatable shaft 17 terminates with a threaded stub 31, to which a circular plate 32 is secured by a nut 33 for counterclockwise rotation with the shaft 17, as viewed in Fig. 2. A plurality of spur gears 35—35 are mounted to the upper side of the plate 32 for rotation about their own axes and in meshing engagement with the ring gear 306, so that counterclockwise revolution of the spur gears 35—35 about the ring gear 306, when the plate 32 is rotated, causes counterclockwise rotation of the spur gears 35—35 about their own axes. As illustrated in Fig. 1, a plurality of sleeves 36—36 are secured between the under surface of the plate 32 and the upper surface of a second circular plate 37, which is thus constrained to rotate in a counterclockwise direction about the central axis of the apparatus with the circular plate 32 and the shaft 17 at the variable speeds directed by the motor 302.

The sleeves 36—36 are located, one in axial alignment with each of the spur gears 35—35, and a plurality of rotatable shafts 40—40 are mounted within the sleeves 36—36, being secured at their upper ends to the spur gears 35—35 and at their lower ends to a second plurality of spur gears 41—41. With this arrangement, the counterclockwise axial rotation induced in the upper set of spur gears 35—35 as they revolve about the ring gear 306 is transmitted to the lower set of spur gears 41—41.

A rod 42 having an upper threaded end 43 is secured for rotation with the lower plate 37 by a nut 45, and an inner ball bearing race 46 is secured near a lower threaded end 44 of the rod 42 by a nut 47. A cylindrical, cup-like member 50 is mounted about the rod 42 for rotation with respect thereto, being secured to an outer ball bearing race 48 designed to cooperate with the inner race 46 to retain ball bearings 51—51 therebetween. The cup-like member 50 is secured to the under surface of the capstan 52, which is a grooved belt-type capstan.

A second ring gear 55 is secured to the upper surface of the capstan 52 and meshes with the lower spur gears 41—41, so that any rotation imparted to the ring gear 55 by the spur gears 41—41 is also imparted to the capstan 52. The lower spur gears 41—41 revolve in a counterclockwise direction about the ring gear 55, since they are carried by the rotating plate 37. This revolution would tend to rotate the ring gear 55 and thus the capstan 52 in a counterclockwise direction if the gears 41—41 did not also rotate about their own axes. As the spur gears 41—41 rotate in a counterclockwise direction about their own axes, they would tend to rotate the ring gear 55 and thus the capstan 52 in a clockwise direction. The net rotation of the capstan 52 is determined by difference between the two oppositely-acting tendencies just mentioned and is regulated by the relative gear ratios provided.

The relative gear ratios may be set, generally, in ac-

cordance with the principles of my copending application; that is, the ratio between the upper ring gear 306 and the upper spur gears 35—35 is set at about 4:1 and that between the lower ring gear 55 and the lower spur gears 41—41 is set at about 2:1. With this arrangement (assuming that the upper ring gear 306 were stationary as in my copending application), the lower ring gear 55 and the capstan 52 will rotate in a clockwise direction at precisely the same speed that the shaft 17, the upper plate 32, and the lower plate 37 are rotated in a counterclockwise direction by the motor 302.

A plurality of sheaves 56, 57 and 58 are mounted for rotation about their own axes to the under surface of the lower plate 37 by suitable bearings 61—61, the sheaves being positioned adjacent to the periphery of the capstan 52 at equally spaced intervals. An endless idler belt 62 is wound around portions of the periphery of the sheaves 56, 57 and 58 so that one side of the belt 62 engages a portion of the periphery of the grooved capstan 52, preferably about 180° of the periphery. The strand 11 is fed between the periphery of the capstan 52 and the belt 62 at a point near the sheave 56 at the bottom of the Fig. 2, passes around the periphery of the capstan 52 through an arc of about 180°, and is discharged into space at a point near the sheave 58 upon rotation of the capstan 52 in a clockwise direction as viewed in Fig. 2.

Since the sheaves 56, 57 and 58 and the belt 62, together constituting the sheave assembly, are carried by the rotating lower plate 37, they revolve about the periphery of the capstan 52 in a counterclockwise direction as viewed in Fig. 2 independently of the clockwise rotation imparted to the capstan 52 by the lower spur gears 41—41. A first guide pulley 65 (Fig. 1) is mounted for rotation about its own axis and is carried on the upper surface of the rotating plate 37 for revolution about the center of the apparatus. The pulley 65 is designed to receive the strand 11 after it passes through the hollow shaft 17 and to direct the strand to a second guide pulley 66. The second pulley 66 is also mounted for rotation about its own axis and is carried within a notch 67 formed in the plate 37 for revolution about the center of the apparatus. The pulley 66 is designed to receive the strand 11 from the pulley 65 and to direct the strand toward the grooved capstan 52 in a line generally tangent thereto and near the point of contact between the sheave 56 and the capstan 52.

Since the guide pulleys 65 and 66 are both carried by the rotating plate 37, they will revolve about the periphery of the capstan 52. Therefore, the position of the guide pulleys 65 and 66 with respect to that of the sheaves 56, 57 and 58 is maintained fixed, so that the strand 11 always engages the capstan 52 near the point of contact between the capstan 52 and the sheave 56.

Assuming, as in my copending application, that the upper ring gear 306 is stationary, then the strand 11 is discharged into space by the capstan 52 at exactly the same rate that the sheaves 56, 57 and 58 (and thus the strand-discharge point) are revolving about the periphery of the capstan 52. Hence, according to the principles of that application, the strand 11 will be distributed into the barrel 10 along a descending helical path, as illustrated in Fig. 1, having a radius substantially equal to the radius of the capstan 52. Centrifugal force will tend to increase this radius, but a cylindrical, shell-like deflecting member 71 having a diameter intermediate between that of the barrel 10 and the core 12 serves to direct the strand 11 into the barrel 10 in a coil having a mean radius approximately halfway between that of the barrel 10 and the core 12. The deflector member 71 is provided with a mounting flange 72 secured to a plurality of horizontal angle irons 70—70, which in turn are secured to the vertical channel irons 16—16.

With this arrangement, the strand 11 may be collected in the barrel 10 in a continuous succession of coils, build-

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ing up within the container to a desired height, at which time the barrel 10 may be removed from under the distributing apparatus and an empty barrel substituted therefor. Changeover may be accomplished easily, automatically, and without interrupting the process by using the metering, accumulating and cutting apparatus disclosed in my copending application.

If the ring gear 306 were stationary, as assumed above, the radii of the strand coils will be substantially constant and the distribution will be more-or-less random between the core 12 and the barrel 10. The object of this invention is to distribute the strand in coils of varying radii, alternately increasing and decreasing, in order to provide for more uniform distribution of the strand 11 into the annular collection area.

According to the principles of this invention, distribution of the strand 11 in coils of varying radii is accomplished by varying the speed at which the strand-discharge point is revolved. This is controlled by the variable-speed motor 302, which is set to revolve the sheaves 56, 57 and 58, as a unit, at alternately increasing and decreasing speeds. As the speed of the discharge point is increased, the radius of the strand coils being formed is successively increased and, conversely, when the speed of the discharge point is decreased, the radius of the coils being formed is successively decreased.

If the ring gear 306 were to remain stationary, it can be seen that the rate at which the strand 11 is discharged by the capstan 52 would also be varied, since the speed of rotation of the capstan 52 (given particular gear ratios) is directly dependent on the speed of the motor 302, as described both hereinbefore and in my copending application. The present device is so constructed as to vary the rotational speed of the capstan 52 (and thus the strand-discharge rate) inversely with respect to the speed of revolution of the sheave assembly (and thus that of the strand-discharge point) in order that the overall coiling rate (by which is meant the throughput or speed at which the strand 11 is withdrawn from a prior process) is maintained constant. The overall coiling rate is made up of the sum of two components: (1) the discharge from the rotating capstan 52, equal to the rotational speed of the capstan 52 times the capstan circumference; and (2) the wrap imparted by the revolving sheave assembly, equal to the revolution speed of the sheave assembly times the capstan circumference. The coiling rate is maintained constant by increasing the capstan speed above the mean when the sheave assembly is revolved at speeds below the mean, and vice versa.

These synchronized speeds may be realized by rotating the upper ring gear 306 by means of the second variable-speed motor 311 at speeds varying according to a predetermined pattern, synchronized with the speed of the first variable-speed motor 302. Independent rotation of the ring gear 306 controls only the rotational speed of the capstan 52 (the strand-discharge rate) and does not affect the speed of revolution of the sheaves 56, 57 and 58 (the strand-wrapping rate), the discharge rate and the wrapping rate being additive to determine the coiling rate.

Referring again to the general plan of operation just described, the motor 302 is driven at alternately decreasing and increasing speeds during a predetermined time cycle in order to revolve the sheaves 56, 57 and 58, and thus the strand-discharge point, at alternately decreasing and increasing speeds, as depicted in Fig. 3(A), in a counterclockwise direction as viewed in Fig. 2. This operates to distribute the strand 11 in coils having alternately decreasing and increasing radii, as depicted in Fig. 3(B). During the same time interval, the capstan 52 is rotated at alternately increasing and decreasing speeds, as depicted in Fig. 3(C), synchronized so that the absolute sum of the capstan speed and that of the sheave assembly is constant, so as to maintain a constant coiling rate, as indicated in Fig. 3(D).

Rotation of the motor 302 at alternately decreasing

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and increasing speeds, as described above, also causes rotation of the lower spur gears 41—41 on the shafts 40—40 at alternately decreasing and increasing speeds and revolution of the gears 41—41 about the ring gear 55 at alternately decreasing and increasing speeds, which combined motions would operate as before described to rotate the capstan 52 at alternately decreasing and increasing speeds if the ring gear 306 were fixed as in my copending application.

However, if the ring gear 306 is rotated at a relatively slow speed in a clockwise direction, as viewed in Fig. 2, such rotation augments the rotational speed of the upper spur gears 35—35 and thus the rotational speed of the lower spur gears 41—41, thus increasing the rotational speed of the capstan 52 and the strand-discharge rate.

According to a first pattern of operation, based on the gear ratios specified in my copending application (which are designed to provide equal and opposite rotation of the capstan and the sheaves when the gear 306 is stationary), the ring gear 306 is rotated at gradually increasing then decreasing speeds in the clockwise direction, as indicated in Fig. 3(E)—times t_1 to t_3 , as the motor 302 rotates at gradually decreasing then increasing speeds below its mean speed. This operates to increase then decrease the speed of rotation of the capstan 52 above its mean value during this portion of the cycle so as to maintain a constant coiling rate or throughput.

Conversely, if the gear 306 rotates slowly in a counterclockwise direction, the rotation of the upper spur gears 35—35 and thus of the lower spur gears 41—41 and the capstan 52 is retarded; thus, according to the first pattern of operation, the ring gear 306 is rotated at gradually increasing then decreasing speeds in the counterclockwise direction, as depicted in Fig. 3(E)—times t_3 to t_4 and t_0 to t_1 , as the motor 302 rotates at gradually increasing then decreasing speeds above its mean speed. This operates to decrease then increase the speed of rotation of the capstan 52 below its mean value during these portions of the cycle so as to maintain a constant coiling rate.

According to one specific example illustrated in Fig. 3(A), the variable speed motor 302 may rotate the shaft 17 so as to revolve the sheaves 56, 57 and 58 at 110 r.p.m. at a time t_0 , 100 r.p.m. at a time t_1 (the mean), 90 r.p.m. at a time t_2 , 100 r.p.m. at a time t_3 , and 110 r.p.m. at a time t_4 . The time t_4 corresponds to the time t_0 and constitutes the end of one full cycle of operation.

Referring now to Fig. 3(E) and utilizing a 4:1 ratio for the upper gears and a 2:1 ratio for the lower gears, at the time t_0 , the ring gear 306 is rotated by the motor 311 at a speed of 10 r.p.m. in a counterclockwise direction in order to set the rotational speed of the capstan 52 at a value of 90 r.p.m., as indicated in Fig. 3(C). The strand coiling rate is then 110 r.p.m. \times 6 ft. circumference = 660 ft. per min. (wrap) plus 90 r.p.m. \times 6 ft. = 540 ft. per min. (discharge), the desired total of 1200 ft. per min. indicated in Fig. 3(D).

The ring gear 306 is rotated by the motor 311 at decreasing speeds in the counterclockwise direction between the times t_0 and t_1 in order to increase the capstan speed from 90 r.p.m. to 100 r.p.m. at the time t_1 , at which time the rotational speed of the ring gear 306 is zero. At the time t_1 , the mean conditions have been reached and the apparatus operates substantially as described in my copending application, the sheave assembly revolving at 100 r.p.m. in one direction and the capstan 52 rotating at 100 r.p.m. in the opposite direction to wrap the strand at 600 ft. per min. and discharge the strand at 600 ft. per min., together giving the desired constant coiling rate of 1200 ft. per min.

The ring gear 306 is rotated at increasing speeds in a clockwise direction between the times t_1 and t_2 , reaching a maximum speed of 10 r.p.m. at the time t_2 , thus increasing the capstan speed from 100 r.p.m. to 110 r.p.m.

at the time t_2 and maintaining the constant coiling rate for the strand 11. Between the times t_2 and t_3 , the ring gear 306 is rotated at decreasing speeds in the clockwise direction reaching zero at the time t_3 , thus decreasing the rotational speed of the capstan 52 from the maximum of 110 r.p.m. back to the mean speed of 100 r.p.m. Between the times t_3 and t_4 , the ring gear 306 is rotated at increasing speeds in the counterclockwise direction reaching a maximum speed of 10 r.p.m. at the time t_4 , in order to decrease the capstan speed from the mean value of 100 r.p.m. back to the minimum of 90 r.p.m. (as at the time t_0), which co-operates with the 110 r.p.m. maximum sheave-assembly speed to maintain the constant coiling rate.

An electromechanical apparatus for directing the operation in accordance with Figs. 3(A) to 3(E) is depicted in Fig. 4. As there seen, the motor 302 may be a variable-speed A.C. motor energized from a source 316 and having a field designated generally by the numeral 317. The motor 311 may be a reversible, adjustable-speed A.C. motor energized from a source 318 and having a field designated generally by the numeral 319. The field 317 for the motor 302 includes a first rheostat 321 regulated to provide the minimum setting for the motor 302 and a second rheostat 322, which is circularly wound and has a rotary wiper arm 323 designed to control the speed of the motor 302 according to the desired cycle of operation.

The field 319 for the motor 311 includes a circularly wound rheostat 326 and a rotary wiper arm 327 therefore for regulating the speed of the motor 311 in accordance with the cycle of operation illustrated in Fig. 3. The wiper arms 327 and 323 are rotated by a timing motor 328, a pair of two-to-one speed-reducing gears 329—329 being interposed between the wiper arms 327 and 323 so that the wiper arm 327 rotates at double the speed of the wiper arm 323.

The motor 311 may be energized across a pair of conductors 331 and 332 to induce rotation of the ring gear 306 in a counterclockwise direction when a first contact 333 of a control relay 334 is closed and may also be energized across the conductor 332 and a conductor 336 (alternative to the conductor 331) when a second contact 337 of the control relay 334 is closed. The contact 333 is closed between the times t_0 and t_1 , the contact 337 is closed between the times t_1 and t_3 , and the contact 333 is again closed between the times t_3 and t_4 by means of a timing cam 338 which is rotated by the timing motor 323 at the same speed as the slower wiper arm 323.

The control relay 334 may be energized from a battery 339 when a cam-following switch 341 is closed by the cam 338 between the times t_1 and t_3 to close the contact 337 and open the contact 333. During the other half of the cycle, the cam-following switch 341 is open so that the relay 334 is de-energized and the contacts 333 and 337 are reversed. Fig. 3(F) illustrates the state of the cam-operated switch 341 as a function of time, corresponding with the operation illustrated in Figs. 3(A) to 3(E).

According to second and third patterns of operation, the desired, inversely proportional speeds may be realized by rotating the ring gear 306 at varying speeds in one direction only. This is a desirable arrangement, as the motor 311 need only be a variable-speed motor as distinguished from the reversible, variable-speed motor required under the first pattern of operation.

According to the second pattern, the ratio between the ring gear 306 and the spur gears 35—35 is made somewhat less than 4:1 and/or the ratio between the ring gear 55 and the spur gears 41—41 is made somewhat greater than 2:1. These ratios are set so that the speed of rotation of the capstan 52, without the effect of rotating the ring gear 306, is equal to or less than the desired, minimum capstan speed when the motor 302 is rotating at its maximum speed. Then, the ring gear 306 is rotated at varying speeds in a clockwise direction only, to aug-

ment the capstan speed by the amount required to maintain the desired, constant coiling rate. The gear 306 is either stationary (capstan speed equal to the desired value at the maximum sheave speed) or is rotated at a minimum speed (capstan speed less than the desired value at the maximum sheave speed) when the motor 302 operates at maximum speed. The gear 306 is rotated at gradually increasing speeds as the motor 302 operates at decreasing speeds so as to provide the desired increasing capstan speed, and the gear 306 is rotated at gradually decreasing speeds as the motor 302 operates again at increasing speeds.

A third pattern of operation corresponds to the second, except that the ratio of the gear 306 to the gears 34—34 is made somewhat greater than 4:1 and/or the ratio between the gear 55 and the gears 41—41 is made somewhat less than 2:1. According to this pattern, the capstan speed (without the effect of rotating the ring gear 306) is equal to or greater than the desired speed when the motor 302 is rotating at its minimum speed. The ring gear 306 is rotated in a counterclockwise direction only, to retard the capstan 52, at increasing speeds when the motor 302 operates at increasing speeds and at decreasing speeds when the motor 302 operates at decreasing speeds.

Second embodiment

Considering now the second embodiment of the invention, illustrated in Figs. 5 and 6, a strand-distributing apparatus is shown which is generally similar to that disclosed in the second embodiment of my copending application, Figs. 3 to 5, but which includes certain modifications and additional elements allowing operation in accordance with the principles of this invention. Certain elements common to both this and my copending application have been given the same numerals formerly applied, while modified and additional elements forming a part of this invention only have been given numerals starting with the numeral 401.

The apparatus illustrated in Figs. 5 and 6 is designed to distribute a strand 111 into a barrel 110 having a central core 112, which may be substantially the same as the barrel 10 and core 12 illustrated in the first embodiment of the invention. The strand 111 advances downward through a hollow shaft 401, around each of three guide pulleys 130, 131 and 132, and then to a grooved capstan 119 which serves to advance the strand and to distribute the same in a descending helical path into the barrel 110 for collection in the form of a continuous succession of coils.

An endless belt 127 passes about a portion of the periphery of the capstan 119 and also about portions of the periphery of three sheaves 120, 122 and 123, which are spaced about the capstan 119 in contact therewith and function to tension the belt 127 and determine the angle of contact (preferably about 180°) between the belt 127 and the capstan 119.

The capstan 119 and the sheaves 120, 122 and 123 are all mounted for rotation about their own axes to a mounting plate 125, which in turn is revoluble about the axis of the shaft 401, the axis of the shaft 401 being made coincident with the center line of the barrel 110. The mounting plate 125 is secured by a bracket 126 (Fig. 6) to the upper surface of a horizontal annular disc 106, which in turn is mounted in a bearing 107 for relative rotation with respect to the shaft 401.

The disc 106 is connected by a plurality of adjustable rods 109—109 to a supporting ring 101, which is formed with a sprocket 102 permitting rotation thereof by a variable speed motor 402 through a gear box 403 and a chain 124, the ring 101 being supported for rotation with respect to a stationary sleeve 404 by suitable bearings 105—105. The shaft 401, the sleeve 404, the motor 402 and the gear box 403 are all supported by a fixed platform 115 located near the top of the apparatus, the shaft

401 being rotatably mounted with respect to the table 115 in a suitable bearing 406.

A beveled ring or sun gear 407 is secured near the lower end of the shaft 401 and meshes with a bevel gear 118, which in turn is connected by a shaft 114 to the capstan 119 to cause rotation thereof for advancing the strand 111. The shaft 114 is mounted for rotation in a pair of bearing members 116—116, which are secured to the plate 106. In order to distribute the strand 111 into the barrel 110, the motor 402 is energized to rotate the supporting ring 101 and the disc 106 connected thereto so as to revolve the mounting plate 125 and the capstan 119 carried thereby about the shaft 401.

Assuming that the disc 106 is rotated in a clockwise direction, as viewed in Fig. 6, then the capstan 119 will revolve in a clockwise direction about the shaft 401 and the bevel gear 118 carried thereby will travel in a clockwise path about the sun gear 407. As the bevel gear 118 travels in a clockwise direction about the sun gear 407, it will be constrained to rotate about its own axis in a counterclockwise direction, as viewed in Fig. 5, so as to impart counterclockwise rotation to the capstan 119.

The strand 111 is discharged into space by the rotation of the capstan 119, but the point where the strand 111 leaves the capstan 119 is caused to revolve about the shaft 401, the axis of the coil to be formed, since the capstan 119 is carried by the plate 125, which in turn is secured to the rotating disc 106. With this arrangement, the strand 111 is continuously distributed in a descending helical path into the barrel 110 forming a coil therein having a radius proportional to the speed of revolution of the discharge point. In this embodiment of the invention, the coiling rate or throughput is determined solely by the speed of rotation of the capstan 119 (the strand-discharge rate), there being no wrap component since the sheaves 120, 122 and 123 do not revolve about the capstan 119. A cylindrical, shell-like deflecting member 171 is mounted above the barrel 110 and serves to constrain the advancing strand 111 to fall in the desired descending helical path.

In my copending application, it was stated that the speed of revolution of the strand-discharge point (the entire capstan-and-sheave unit) should be set equal to the strand-discharge rate and this was accomplished by selecting the proper relative sizes for the sun gear 407 (which was stationary), the bevel gear 118, and the capstan 119. In accordance with the principles of this invention, it is proposed to vary the speed at which the strand-discharge point is revolved (as in the first embodiment) in order to distribute the strand in coils having varying radii, while maintaining the coiling rate (here the rotational speed of the capstan 119) substantially constant.

The variable-speed motor 402 is designed to revolve the capstan 119 about the shaft 401 at varying speeds between a predetermined maximum above the desired strand speed and a predetermined minimum below the desired strand speed in order to distribute the strand in a succession of coils having alternately increasing and decreasing radii. If the ring gear 407 were stationary, the rotational speed of the capstan 119, and thus the strand-discharge speed and coiling rate, would be directly proportional to the speed of the motor 402. In order to maintain the strand speed constant, the sun gear 407 is rotated by a variable speed motor 408, through a gear box 409 and a sprocket-and-chain transmission designated generally by the numeral 410, at speeds synchronized with the speed of the motor 402 so as to maintain the rotational speed of the capstan 119 about its own axis substantially constant.

When the capstan 119 is revolving at decreasing speeds below the mean, the rotational speed of the capstan 119 would tend to decrease accordingly (if the sun gear 407 were stationary); however, the sun gear 407 is rotated at increasing speeds in a counterclockwise direction, as

viewed in Fig. 6, synchronized so as to augment the rotational speed imparted solely by the revolution of the capstan 119 by the amounts required to maintain the rotational speed of the capstan 119 and thus the coiling rate substantially constant. Conversely, when the capstan 119 revolves at increasing speeds above the mean, the sun gear 407 is rotated at increasing speeds in a clockwise direction so as to retard the rotation of the capstan 119 by synchronized amounts required to maintain the rotational speed constant during this part of the cycle.

The synchronized operation of the motors 402 and 408 may be accomplished by utilizing the apparatus illustrated in Fig. 4, as described hereinbefore, to achieve a cycle generally similar to that illustrated in Figs. 3(A) to 3(E). However, if the same six-foot circumference capstan were employed, the rotational speed, Fig. 3(C), of the capstan 119 would be constant at 200 r.p.m. to give the constant coiling rate of 1200 ft. per min., as in Fig. 3(D). The speed of revolution, Fig. 3(A) would then vary between 220 r.p.m. and 180 r.p.m.

As in the first embodiment of this invention, it might be more practical to alter the gear ratio between the sun gear 407 and the bevel gear 118 to allow controlled rotation of the sun gear 407 in one direction only.

It will be manifest that this invention is not limited to the specific details described in connection with the above embodiments of the invention, but that various modifications may be made without departing from the spirit and scope thereof.

What is claimed is:

1. In combination with a strand-feeding device of the type having a rotatable capstan, a plurality of sheaves rotatable about their own axes and positioned about the periphery of the capstan, and a belt wound endlessly around the sheaves and holding the strand against a portion of the capstan periphery so that the strand is discharged upon rotation of the capstan; the improvement which comprises means for causing the changing portion of the capstan which is last contacted by the strand at any instant to revolve about a vertical axis at variable speeds so regulated that the strand is distributed along a descending helical path having a variable radius for collection in a continuous succession of coils having variable radii and having an axis substantially coincident with the vertical axis, and means for rotating the capstan at speeds so synchronized with the speed of revolution of said changing portion of the capstan which is last contacted by the strand that the coiling rate is maintained substantially constant.

2. In combination with a strand-feeding device of the type having a rotatable capstan, a plurality of sheaves mounted adjacent to the periphery of the capstan and spaced therearound, and a belt wound endlessly around the sheaves and in contact with the strand on the peripheral surface of the capstan for holding the strand in driving contact therewith over an arc on the capstan periphery; the improvement which comprises means for revolving the sheaves as a unit around the axis of the capstan at alternately increasing and decreasing speeds so that the strand is distributed along a descending helical path having an alternately increasing and decreasing radius for collection in a continuous succession of coils having varying radii, and means for rotating the capstan at variable speeds so synchronized with the speed of revolution of the sheaves that the coiling rate is maintained substantially constant.

3. In combination with a strand-feeding device of the type having a first ring gear, a rotatable hollow shaft through which the strand is passed, a first plate attached to the shaft for rotation therewith, a first plurality of gears rotatably mounted on the first plate and designed to mesh with the first ring gear, a second plate spaced from and secured for rotation with the first plate, a second plurality of gears rotatably mounted on the second plate and driven by the first plurality of gears, a second

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ring gear mounted rotatably with respect to the second plate and designed to mesh with the second plurality of gears and to be driven thereby, a rotatable capstan secured to the second ring gear, a plurality of sheaves secured rotatably to the second plate and adjacent to the periphery of the capstan, and a belt wound endlessly around the sheaves and in contact with the strand on the peripheral surface of the capstan for holding the strand in driving contact therewith over the whole of a continuous arc on the periphery thereof; the improvement which comprises a first variable-speed motor for rotating the hollow shaft at alternately increasing and decreasing speeds in a particular direction so as to rotate the capstan in one direction to discharge the strand and so as to revolve the sheaves and thus the strand-discharge point about the axis of the capstan in the opposite direction at alternately increasing and decreasing speeds, a second variable-speed motor for rotating the first ring gear at variable speeds, and control means for synchronizing the two motors so that the rotational speed of the capstan varies inversely with the speed of revolution of the sheaves to maintain a constant coiling rate.

4. In combination with a strand-feeding device of the type having a base, a ring gear mounted to the base, a capstan mounted rotatably on the base for discharging the strand, and a planetary gear secured for rotation with the capstan and designed to mesh with the ring gear; the improvement which comprises variable-speed means for revolving the capstan and the planetary gear secured thereto about the axis of the ring gear, whereby the revolution of the planetary gear about the ring gear induces rotation of the capstan for discharging the strand and the revolution of the capstan causes the strand-discharge point to revolve about the axis of the ring gear at variable speeds so that the strand is distributed along a descending helical path having a varying radius for collection in the form of a continuous succession of coils having varying radii and an axis aligned with that of the

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ring gear, and means for rotating the ring gear at variable speeds so synchronized with the speed of the capstan-revolving means as to maintain the rotational speed of the capstan substantially constant.

5. In combination with a strand-feeding device of the type having a hollow shaft through which the strand is passed, a ring gear secured to the hollow shaft, a plate mounted for relative rotation with respect to the hollow shaft, a second shaft mounted rotatably on the plate, a planetary gear secured to one end of the second shaft and designed to mesh with the ring gear, a rotatable capstan secured to the other end of the second shaft, a plurality of sheaves mounted to the plate for rotation about their axes and adjacent to the periphery of the capstan, a belt wound endlessly around the sheaves and in contact with the peripheral surface of the capstan, and means for directing the strand between the belt and the capstan periphery after the strand passes through the hollow shaft; the improvement which comprises a first variable-speed motor for revolving the plate and the elements carried thereby about the axis of the hollow shaft at alternately increasing and decreasing speeds, whereby the planetary gear revolves about the ring gear to induce rotation of the capstan on the second shaft for discharging the strand and the strand-discharge point revolves about the axis of the ring gear at alternately increasing and decreasing speeds, a second variable-speed motor for rotating the hollow shaft and the ring gear secured thereto at variable speeds, and means for synchronizing the two motors so as to maintain the rotational speed of the capstan substantially constant.

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