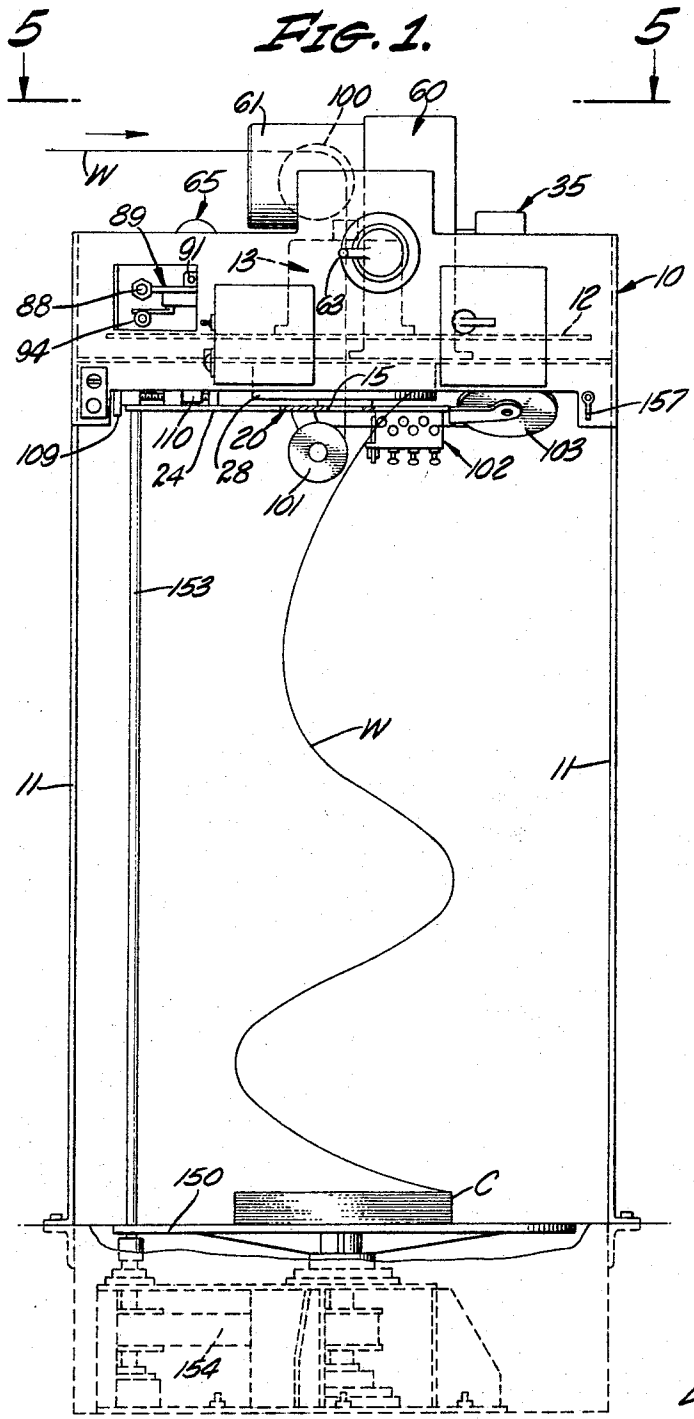
Sept. 6, 1966 D. P. WHITACRE 3,270,978

WIRE-COILING MACHINE WITH DIFFERENTIAL DRIVE

Filed Oct. 28, 1964 4 Sheets-Sheet 1

FIG. 1.



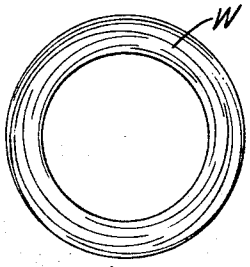


FIG. 2.

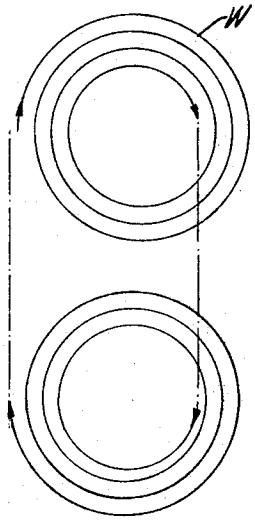


FIG. 4.

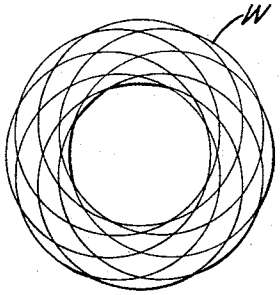


FIG. 3.

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WIRE-COILING MACHINE WITH DIFFERENTIAL DRIVE

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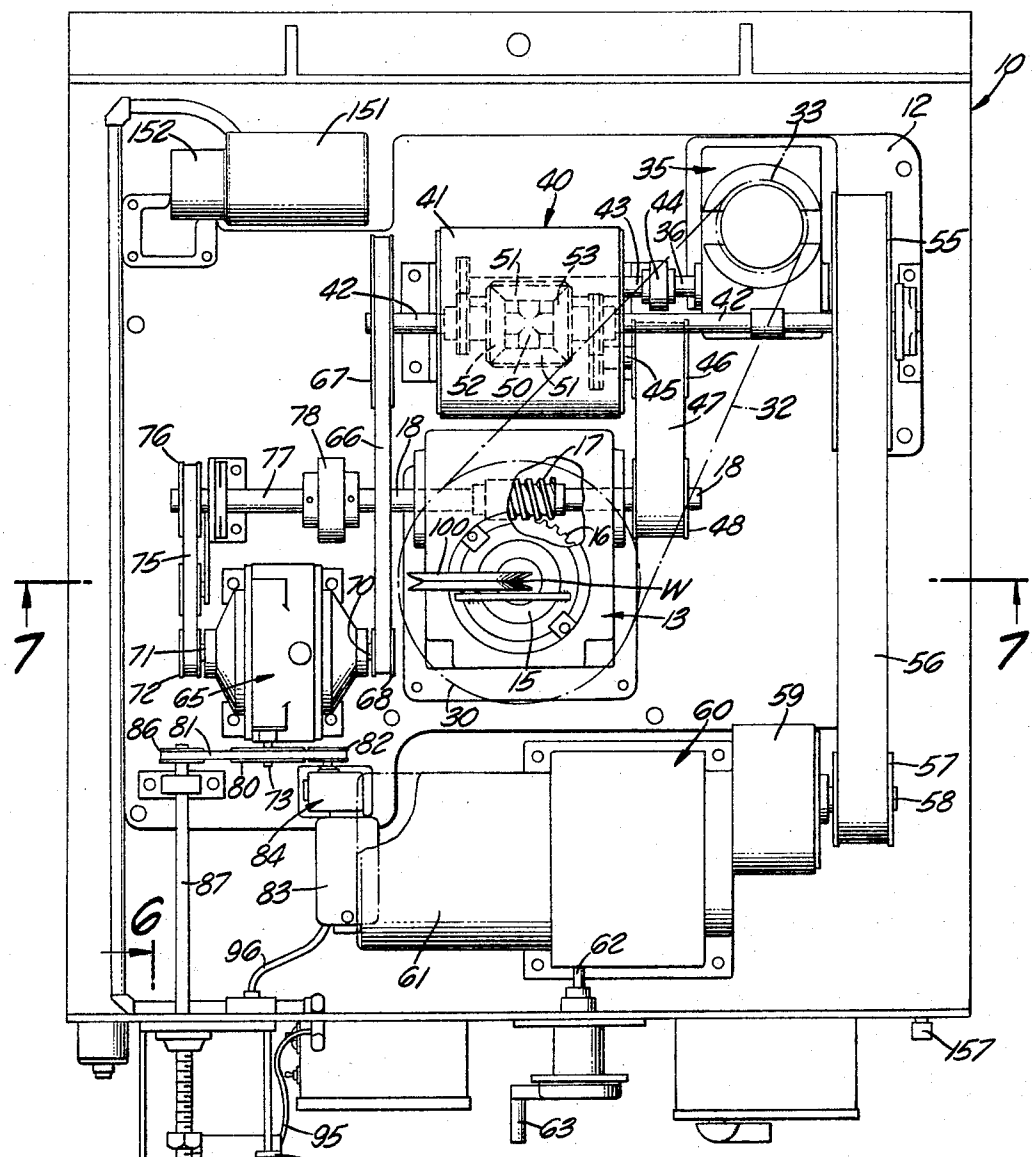


FIG. 5.

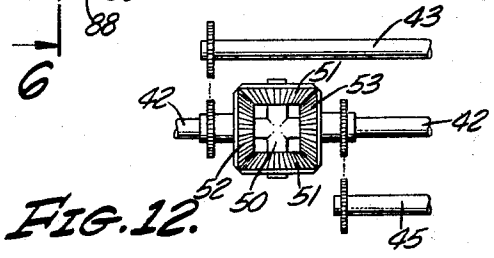


FIG. 12.

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WIRE-COILING MACHINE WITH DIFFERENTIAL DRIVE

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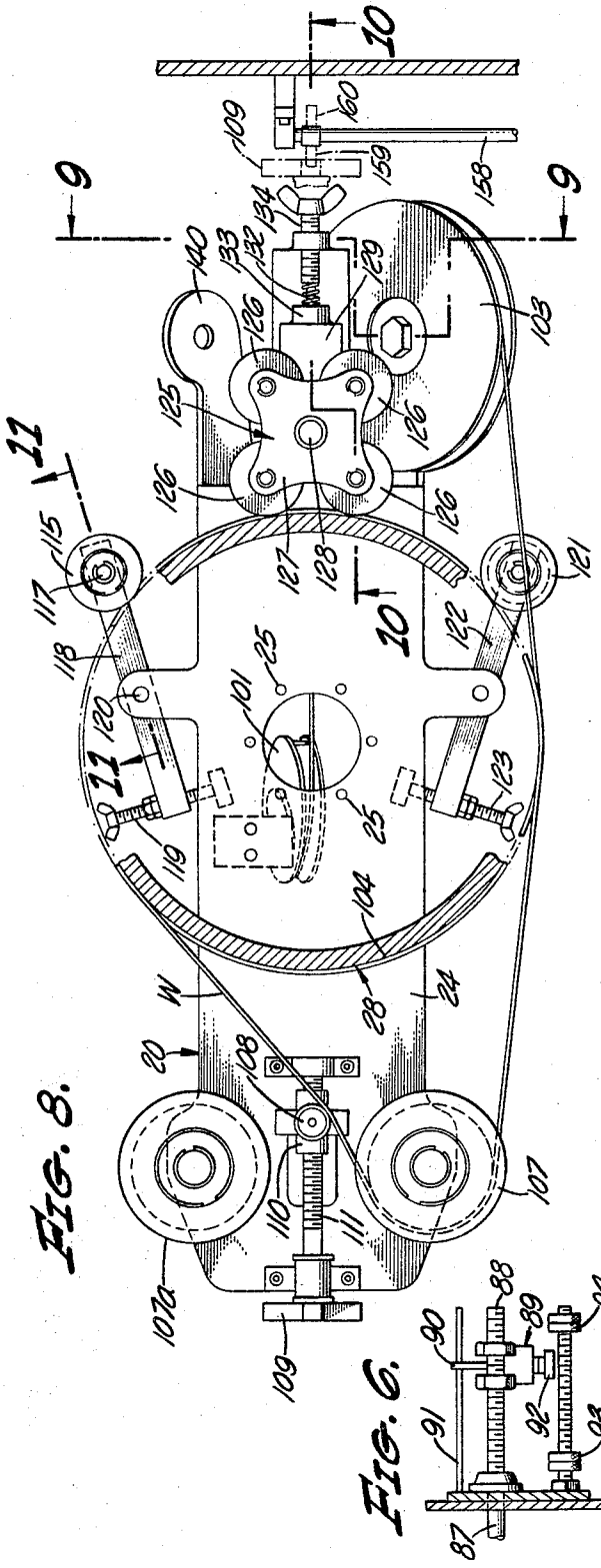


FIG. 8.

FIG. 6.

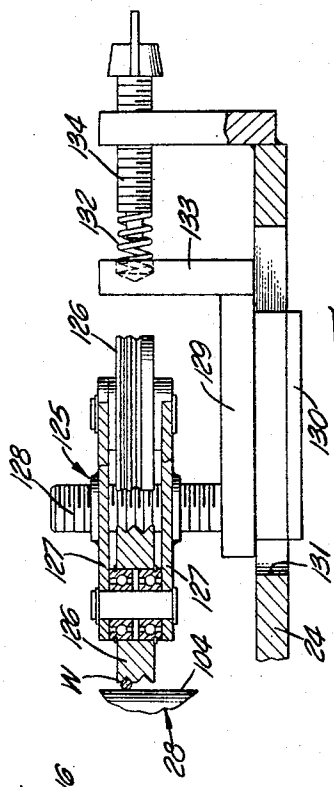


FIG. 10.

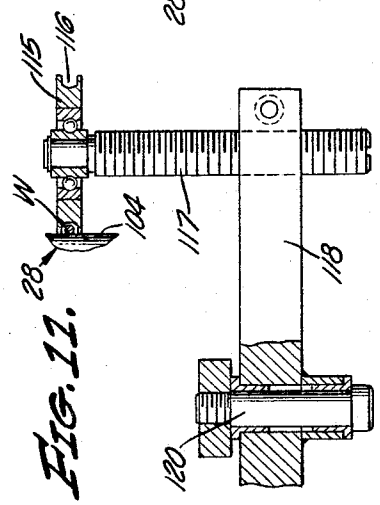


FIG. 11.

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WIRE-COILING MACHINE WITH DIFFERENTIAL DRIVE

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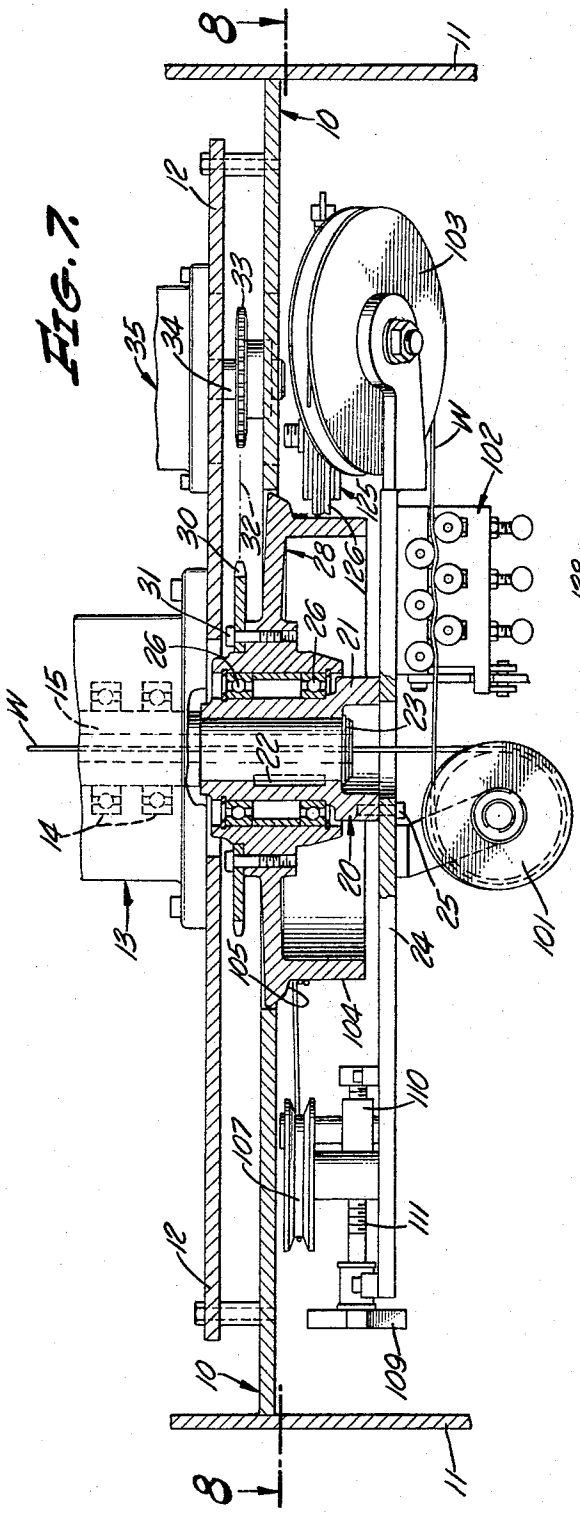


Fig. 7.

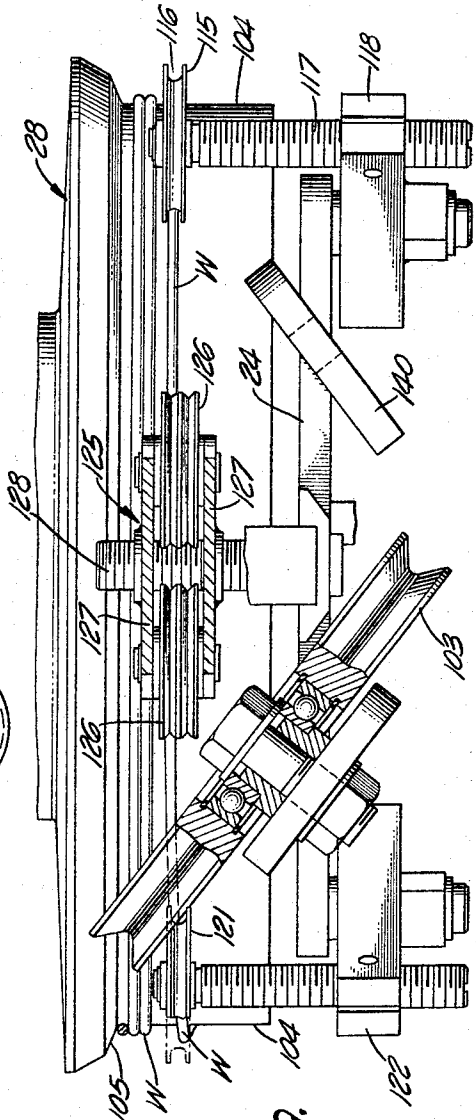


Fig. 9.

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United States Patent Office

3,270,978

Patented Sept. 6, 1966

3,270,978
WIRE-COILING MACHINE WITH DIFFERENTIAL DRIVE

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Filed Oct. 28, 1964, Ser. No. 407,103
9 Claims. (Cl. 242—82)

This invention relates to an improved wire coiling and packaging machine. Conventional machines for coiling and packaging wire are of two general types: the first employs a stationary block or capstan on which wire is wound by means of a rotating flyer; the second uses a rotating block or capstan, and the flyer is replaced by a stationary support for wire-carrying pulleys.

The present invention is directed to a wire-coiling machine in which both the block and the flyer are mounted to rotate about a common axis, and wherein a differential drive mechanism is provided for rotating the block and for rotating the flyer at varying relative speeds. The purpose is to provide a novel form of coiling machine on which several types of coils may be produced, as desired. Thus, the coiling machine of this invention readily produces coils of wire in any one of three types: (a) a random-pattern coil of substantially concentric loops, (b) a coil in which the loops are all of the same diameter but are circumferentially staggered, and (c) a coil comprising a series of layers, each layer being spirally wound, alternate layers comprising inward-wound spirals and outward-wound spirals. Only the type (b) coil requires a turntable to receive the coil. Wire coils of type (c) are very compact and contain a maximum amount of wire for a given diameter and length of wire coil.

The principal object of this invention is to provide a novel form of wire-coiling machine in which the wire convolution diameter in the coil may be readily changed without changing the diameter of the capstan and without changing the linear speed of wire drawn into the machine. Another object of this invention is to provide a novel form of wire-coiling apparatus for making type (c) coils as above described and without requiring the use of a rotary turntable for supporting the coil, such apparatus also being readily capable of making type (a) coils if desired, as described above, and capable of making type (b) coils if a turntable is provided. Another object is to provide a device of this type having a rotary block and rotary flyer mounted for concentric turning movement and driven by a differential drive mechanism. Another object is to provide novel control means for the differential drive mechanism.

Other and more detailed objects and advantages will appear hereinafter.

In the drawings:

FIGURE 1 is a side elevation showing a preferred embodiment of this invention.

FIGURE 2 is a top view of a random-pattern coil which may be produced by the device of FIGURE 1.

FIGURE 3 is a plan view of a second form of coil which may be produced by the machine. In this coil, the loops are of the same diameter but circumferentially staggered. The coil is supported on a turntable.

FIGURE 4 is a diagrammatic illustration of a third form of coil which may be produced by the machine, the coil comprising a series of layers, each layer being spirally wound and adjacent layers being spiraled inwardly and spiraled outwardly, respectively.

FIGURE 5 is a plan view taken substantially on the lines 5—5 as shown in FIGURE 1.

FIGURE 6 is a fragmentary detail taken substantially on the lines 6—6 as shown in FIGURE 5.

FIGURE 7 is a sectional elevation taken substantially on the lines 7—7 as shown in FIGURE 5.

FIGURE 8 is a sectional plan view taken substantially on the lines 8—8 as shown in FIGURE 7.

FIGURE 9 is a side elevation taken substantially on the lines 9—9 as as shown in FIGURE 8.

FIGURE 10 is a sectional detail taken substantially on the lines 10—10 as shown in FIGURE 8.

FIGURE 11 is a sectional detail taken substantially on the lines 11—11 as shown in FIGURE 8.

FIGURE 12 is a diagrammatic illustration showing the internal construction of the differential drive mechanism.

Referring to the drawings:

The stationary frame generally designated **10** includes the supporting legs **11** and includes a platform **12** supporting a worm gear drive unit **13**. This unit **13** contains axially spaced bearing assemblies **14**, which rotatably support a hollow, vertical shaft **15**. A worm gear **16** (FIGURE 5) is fixed on this hollow shaft **15** and is driven by a worm pinion **17** fixed on the horizontal shaft **18**.

A rotary-flyer assembly generally designated **20** includes a hub **21** (FIGURE 7) which is fixed to the lower portion of the vertical shaft **15** by means of key **22** and retainer ring **23**. The rotary-flyer assembly **20** also includes a horizontal arm **24** fixed to the hub **21** by suitable fastenings **25**. Rotatably mounted on spaced bearings **26** on the hub **21** is the capstan or block **28**. The block **28** and the rotary-flyer assembly **20** are thus both mounted for turning movement about the axis of the hollow vertical shaft **15**. A driven sprocket **30** is fixed to the block **28** by suitable fastenings **31** and is driven by chain **32** from driving sprocket **33**. This sprocket **33** is fixed on the shaft **34** projecting downward from worm drive unit **35**. The driving shaft of this worm drive unit **35** is shown at **36**. From this description it will be understood that the rotary-flyer assembly **20** is driven from the power-input shaft **18** of the worm drive unit **13**, and the block **28** is driven by the power-input shaft **36** of the worm drive unit **35**.

A differential drive mechanism generally designated **40** is provided for driving both the shafts **18** and **36**. As shown in the drawings, this differential drive unit **40** includes a housing **41** rotatably supporting a power-input shaft **42**, which projects from both ends of the housing. Housing **41** also supports a driven shaft **43**, which is connected by coupling **44** to drive the shaft **36**. The housing **41** also supports the driven shaft **45**, which carries pulley **46**. This pulley **46** is connected by belt **47** to pulley **48**, which is fixed on the shaft **18**. The shaft **18** projects from both sides of the worm gear unit **13**.

The internal mechanism of the differential drive unit **40** is conventional and as shown in FIGURES 5 and 12 includes a spider **50** fixed to the shaft **42** and carrying rotatable bevel gears **51**. These bevel gears **51** mesh with bevel gears **52** and **53**, chain-connected to driven shafts **43** and **45**, respectively. From this description, it will be understood that when torque is applied to the driving shaft **42**, gearing within the housing **41** acts to apply torque to the driven shafts **43** and **45**. The relative rotary speeds of these driven shafts is controlled in the manner described below. The driving shaft **42** receives power from the pulley **55**, driven by belt **56** from the driving pulley **57**, and the driving pulley **57** is fixed on the output shaft **58** of gear-reduction unit **59**, forming a part of the prime mover **60**. This prime mover **60** preferably includes a variable-speed electric motor **61** having a control shaft **62** for regulating the speed of the output shaft **58**. A crank handle **63** is fixed to this speed-control shaft **62** and placed in a conveniently accessible position

in an exposed location on the frame **10**. The prime mover **60** is supported on the platform **12**.

Means are provided for controlling the relative rates of rotation of the driven shafts **43** and **45** of the differential drive unit **40**, and as shown in the drawings this means includes a variable speed drive unit **65**, supported on the platform **12** and driven by belt **66** on pulleys **67** and **68**. The pulley **67** is fixed to the power-input shaft **42**, which extends through the differential drive unit **40**. The input shaft **70** fixed to the pulley **68** rotates at constant speed according to the speed setting of the prime mover **60**. The output shaft **71**, however, to which pulley **72** is fixed, turns at a speed and in a direction regulated by the control shaft **73**. The internal construction of the variable speed unit **65** forms no part of the present invention, it being only essential that the device **65** vary the speed and direction of the driven shaft **71** relative to the driving shaft **70** in accordance with the rotational position of the shaft **73**. It has been found that the device sold by Cleveland Worm and Gear Division, Eaton Manufacturing Company, Cleveland, Ohio, under the mark "Speed Variator" gives satisfactory results. That device provides variable speeds over a wide range in stepless increments. The pulley **72** fixed on the variable speed output shaft **71** is connected by belts **75** to pulley **76** fixed on shaft **77**. A coupling **78** connects the aligned shafts **77** and **18**. Accordingly, the power for rotating the shaft **18** comes from pulley **48** via belt **47** and the differential gearing within the differential drive unit **40**, but the speed of rotation of the shaft **18** is controlled by means of the variable speed unit **65**. This will be apparent from a consideration of the diagram of FIGURE 12. Power supplied to shaft **42** drives the spider **50** and the bevel gears divide the torque equally between the driven shaft **43** which drives the rotary-flyer assembly **20**, and the driven shaft **45** which drives the block **28**. If there were no speed regulating connection (and none is shown in FIGURE 12) then either of the driven shafts **43** or **45** might be turned while the other remains at rest, depending on the load driven by each of these shafts. When the speed regulating connection **66**, **65**, **75**, **77** and **78** is applied between the driven shaft **42** and the shaft **18** driven by shaft **45** through belt **47**, the relative speeds of the shafts **43** and **45** are fixed, for any one setting of the variable speed device **65**.

The speed control shaft **73** has a pulley **80** fixed thereto and driven by means of belt **81** from a drive pulley **82**. This drive pulley **82** is rotated by means of a small electric motor **83** and speed-reduction unit **84**. The belt **81** also passes around pulley **86** fixed on shaft **87**, having a threaded portion **88**. A traveling nut assembly **89** is mounted on the threaded portion **88** and moves longitudinally when the shaft **87** rotates. As shown in FIGURE 6, a projection **90** on the assembly **89** slides along the stationary guide rod **91** to prevent rotation of the assembly **89**. A switch-actuating arm **92** pivoted on the assembly **89** engages adjustable limit stops **93** and **94** to define the limits of travel of the assembly **89**. Electrical switches, not shown, are provided on the assembly **89**, and these are connected by wiring **95** and **96** to control operation of the electrical motor **83**. Thus, when the switch-actuating arm **92** of the traveling nut assembly **89** engages the limit stop **94**, the direction of rotation of the motor **83** is reversed to cause the shaft **87** to reverse direction of rotation and cause the traveling nut assembly **89** to reverse its directtion of longitudinal travel. Similarly, when the switch-actuating arm **92** engages the limit stop **93**, the direction of rotation of the motor **83** is again reversed.

When the speed-control shaft **73** is stationary, the speed ratio between the driving shaft **70** and the driven shaft **71** of the unit **65** remains constant. When the motor **83** is operated, the speed-control shaft **73** is turned at a constant speed in one direction until the traveling-nut assembly **89** reaches the end of its travel in one direction, thereby reversing the direction of rotation of the motor **83**. The speed-control shaft **73** is then turned in the other direction until the assembly **89** reaches the other end of its travel, at which time the direction of turning of the speed-control shaft **73** is again reversed. This has the effect of gradually increasing and decreasing the speed of the output shaft **71** and hence the speed of the rotary-flyer assembly **20** fixed to the hollow shaft **15**.

A pulley **100** receives wire W under tension from a source, not shown, and directs it down through the hollow center of the shaft **15**. The rotating arm **24** of the flyer assembly **20** carries a second pulley **101** which receives the stretch of wire W passing through the hollow shaft **15** and directs the wire through the killer-block assembly **102**, which functions to remove "memory" of the wire. The wire W then passes around the third pulley **103**, which is also mounted on the rotating arm **24**. As shown in FIGURE 8, the wire from the third pulley **103** then contacts the drum surface **104** of the block **28** through a short arc and then passes around the idler pulley **107**, also mounted on the rotary arm **24**. A cast-controlling roller **108** (FIGURE 8) is mounted for radial adjustment on the arm **24** and serves to impart any necessary reverse bend to the wire W in order that it may later fall by gravity from the drum surface **104** of the block **28** having the desired circular cast. Adjustment of the radial position of the idler **108** on the arm **24** is accomplished by rotating the starwheel **109** to cause the nut **110** to travel along the threaded shaft **111**. The idler **108** is carried on the nut **110**. The wire W then passes around the drum surface **104** of the block **28** to form several wraps, the first wrap or convolution lying adjacent the flange **105** (FIGURE 7) at the upper end of the drum surface **104**. The starwheel **109** may be adjusted without stopping the machine. This is accomplished by turning the exposed handle **157** and the horizontal shaft **158** (FIGURE 8), secured thereto, thereby swinging one of two lugs **159** or **160** into the path of travel of the starwheel **109** as it rotates with the flyer assembly **20**. This mechanism is described and claimed in my copending application for Coil Winding Machine, Serial No. 328,951, filed December 9, 1963, now Patent No. 3,214,111, issued October 26, 1965.

A splitter roller **115** has a peripheral groove **116** for reception of the wire W, and this roller is adjustably positioned by means of the threaded rod **117** and arm **118**, to hold it in contact with the drum surface **104** of the block **28** at the desired height. Pressure of the roller **115** against the drum surface **104** is developed by means of the thumb screw **119**. The arm **118** is pivotally mounted at **120** on the support arm **24**. A similar grooved splitter roller **121** is mounted on pivot arm **122** and maintained in contact with the drum surface **104** by means of the thumb screw **123**. Both of the splitter rollers **115** and **121** engage the last convolution of wire on the drum **104** before it drops by gravity to form a coil C.

Interposed between the location of the splitter rollers **115** and **121** and positioned to contact the lowermost convolution of wire passing through the grooved rollers **115** and **121** is a pressure roll assembly, generally designated **125**. Four duplicate rollers **126** are mounted on this assembly **125** between parallel plates **127**. A central threaded pivot post **128** supports the plate **127** and is carried on a slide member **129** having a key portion **130** projecting through a slot **131** on the arm **24**. A spring **132** extending between the flange **133** and the adjusting screw **134** acts to hold the last convolution of wire W against the drum surface **104** under pressure. Each pressure roller **126** has two grooves, so that when wear occurs after a period of use the wire W may be transferred to the other groove. Moreover, two pairs of rollers **126** are provided in order to double the service life.

The arrangement of pulleys shown in the drawings produces a left-hand helix in the coil C. When it is desired to produce a coil C having a right-hand helix, the rotary flyer **20** is turned in the opposite direction, the

pulley **103** is shifted to the angular mount **140**, and the idler pulley **107***a* is used instead of the idler **107**. In such case, the last convolution of wire on the block **28** passes through the splitter roller **115** before descending by gravity to form the coil C.

If the device is to be used for making coils C of the general type shown in FIGURE 2, no turntable is required. The diameter of the coil is determined by the position of the control shaft **73**, and this control shaft **73** remains at rest while the block **28** and rotary flyer **20** are driven through the differential drive mechanism **40**. The speed ratio between the shafts **70** and **71**, and hence the speed ratio of the block **28** and rotary flyer **20**, remains constant.

If the coil of the type shown diagrammatically in FIGURE 3 is to be made by the machine, no turntable is necessary, but the speed-control shaft **73** is constantly rotated, first in one direction and then in the other, by means of the motor **83** and the adjustable reversing mechanism **88** and **89**. When the block **28** and rotary flyer **20** are both turning at maximum speed in the same direction, the diameter of the wire convolution between delivered to the coil is a minimum. Conversely, when the difference in rotary speed of the block **28** and flyer **20** is at a maximum, the diameter of the convolution of wire being delivered to the coil is at a maximum. The median position of the control shaft **73** determines the outer diameter of the coil being formed. Each layer of the coil comprises a spiral, adjacent spiral layers being of opposite hand.

When it is desired to produce a coil of the type shown in FIGURE 4, wherein the loops are all of the same diameter but are circumferentially staggered, the turntable **150** is employed. This turntable is driven by the motor **151** (FIGURE 5), reduction unit **152**, and both mounted on the platform **12** and connected to drive the turntable by means of the vertical shaft **153** and driving connection **154**. The turntable rotates at constant speed. In forming the type of coil shown in FIGURE 4, it is also necessary to use the convolution control cage shown in my copending application, Serial No. 328,950, filed December 9, 1963. This device serves to shift the convolutions of wire laterally as they descend from the block **28**, so that each convolution is eccentrically positioned with respect to the axis of the turntable.

It will be observed that regardless of which type of coil is being formed by the machine, the linear rate of movement of wire W into the machine remains constant. This is true even when producing spiral type of coils, as diagrammatically shown in FIGURE 3, when the block **28** and rotary flyer **20** turn at cyclically varying speeds.

Having fully described my invention, it is to be understood that I am not to be limited to the details herein set forth, but that my invention is of the full scope of the appended claims.

I claim:

1. In a wire-coiling machine, the combination of: a block mounted to rotate about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a first driven member connected to said block and a second driven member connected to said rotary-flyer assembly, said differential drive device having a power input member, means for driving said power input member, and adjustable control means for regulating the speed ratio between said block and said rotary-flyer assembly.

2. In a wire-coiling machine, the combination of: a stationary frame, a block mounted to rotate on the frame about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a power input member and two power output members, means connecting one of said power output members to turn said block, means connecting the other of said power output members to turn said rotary-flyer assembly, means for driving said power input member, and adjustable control means for regulating the speed ratio between said block and said rotary-flyer assembly.

3. In a wire-coiling machine, the combination of: a block mounted to rotate about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a first driven member connected to said block and a second driven member connected to said rotary-flyer assembly, said differential drive device having a power input member, means for driving said power input member, and means for alternately increasing and decreasing the relative speeds of said block and said rotary-flyer.

4. In a wire-coiling machine, the combination of: a stationary frame, a block mounted to rotate on the frame about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a power input member and two power output members, means connecting one of said power output members to turn said block, means connecting the other of said power output members to turn said rotary-flyer assembly, means for driving said power input member, control means for regulating the speed ratio between said block and said rotary-flyer assembly, and means for cyclically operating said control means for alternately increasing and decreasing the relative speeds of said block and said rotary-flyer.

5. In a wire-coiling machine, the combination of: a block mounted to rotate about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, the wire falling by gravity from the block to form a coil beneath the block, a differential drive device having a first driven member connected to said block and a second driven member connected to said rotary-flyer assembly, said differential drive device having a power input member, means for driving said power input member, and means for changing the speed ratio between said block and said rotary-flyer assembly to control the diameter of said coil.

6. In a wire-coiling machine, the combination of: a block mounted to rotate about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a first driven member connected to said block and a second driven member connected to said rotary-flyer assembly, said differential drive device having a power input member, a speed-changing device having a driving shaft and a driven shaft, common means for driving said power input member and said driving shaft, means connecting said driven shaft to one of said driven members, and control means for regulating the speed ratio between said driving shaft and said driven shaft.

7. In a wire-coiling machine, the combination of: a block mounted to rotate about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a first driven member connected to said block and a second driven member connected to said rotary-flyer assembly, said differential drive device having a power input member, a speed-changing device having a driving shaft and a driven shaft, common means for driving said power input member and said driving shaft, means connecting said driven shaft to said second driven member, and control means for regulating the speed ratio between said driving shaft and said driven shaft.

8. In a wire-coiling machine, the combination of: a stationary frame, a block mounted to rotate on the frame about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a power input member and two power output members, means connecting one of said power output members to turn said block, means connecting the other of said power output members to turn said rotary-flyer assembly, means for driving said power input member, means including a speed-changing

device having a control shaft for regulating the speed ratio between said block and said rotary-flyer assembly, driving means for rotating said control shaft, and adjustable means for cyclically reversing the direction of rotation of said driving means at predetermined intervals.

9. In a wire-coiling machine, the combination of: a stationary frame, a block mounted to rotate on the frame about a vertical axis, a rotary-flyer assembly mounted to rotate about said axis for wrapping wire upon said block, a differential drive device having a power input member and two power output members, means connecting one of said power output members to turn said block, means connecting the other of said power output members to turn said rotary-flyer assembly, means for driving said power input member, and control means for determining the speed ratio between said block and said rotary-flyer assembly, whereby the algebraic sum of the rotary speeds of said block and said rotary-flyer assembly remains constant for any given speed of said power input member.

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