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3,441,233

APPARATUS FOR WINDING AND UNWINDING SHEET MATERIAL OR THE LIKE

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Sheet 1 of 2

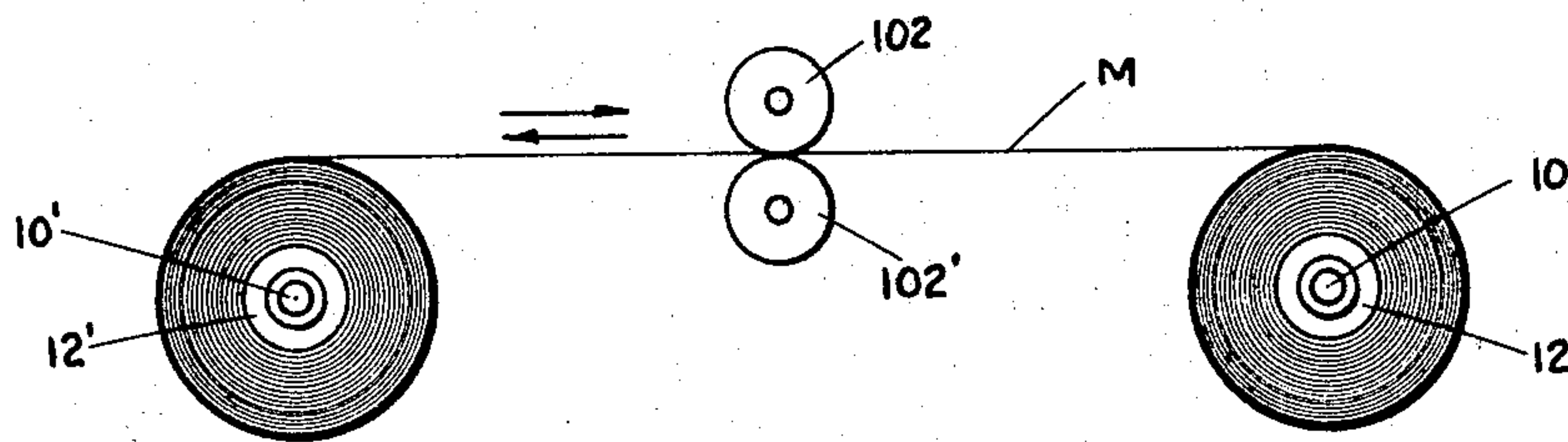


FIG. 1

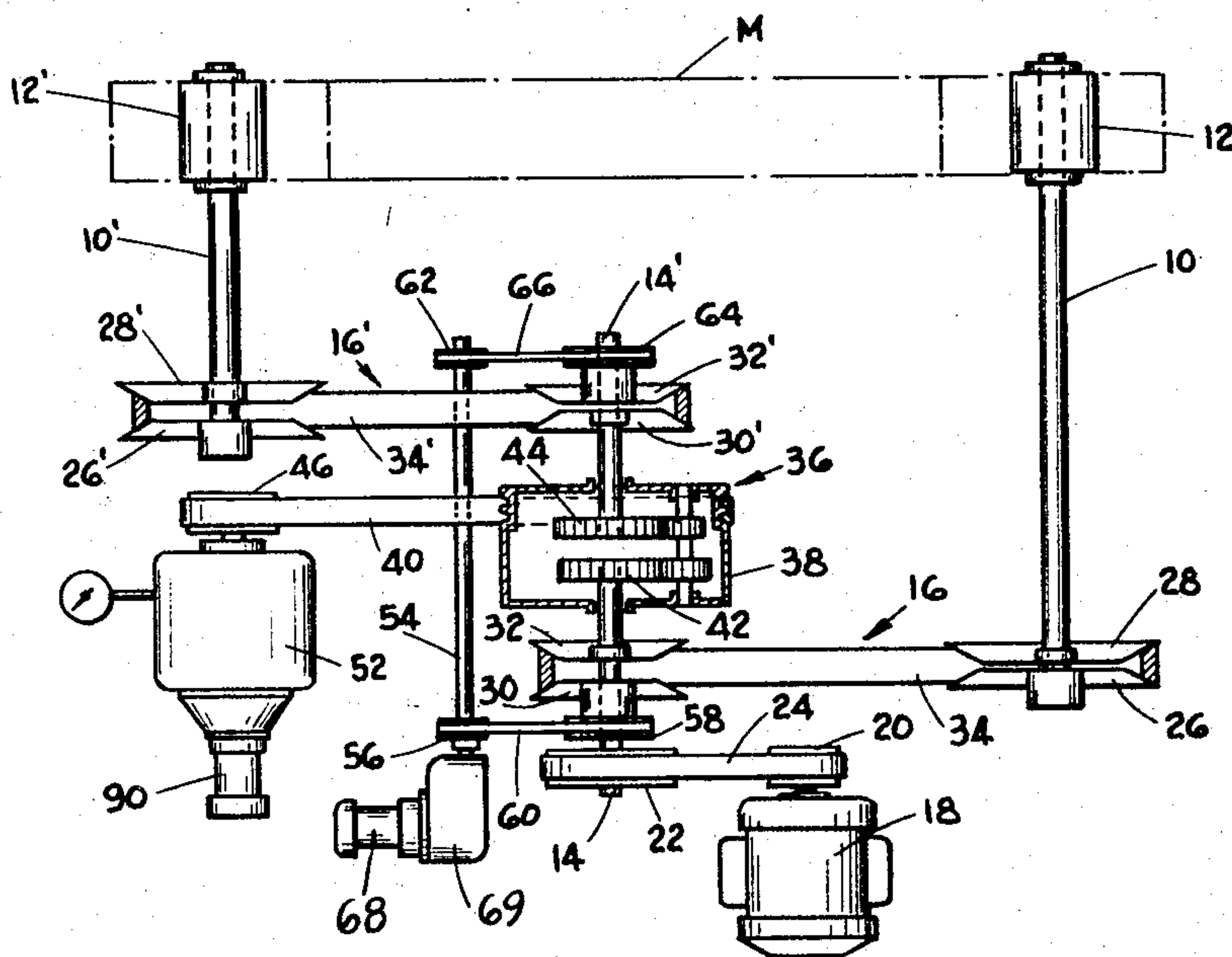


FIG. 2

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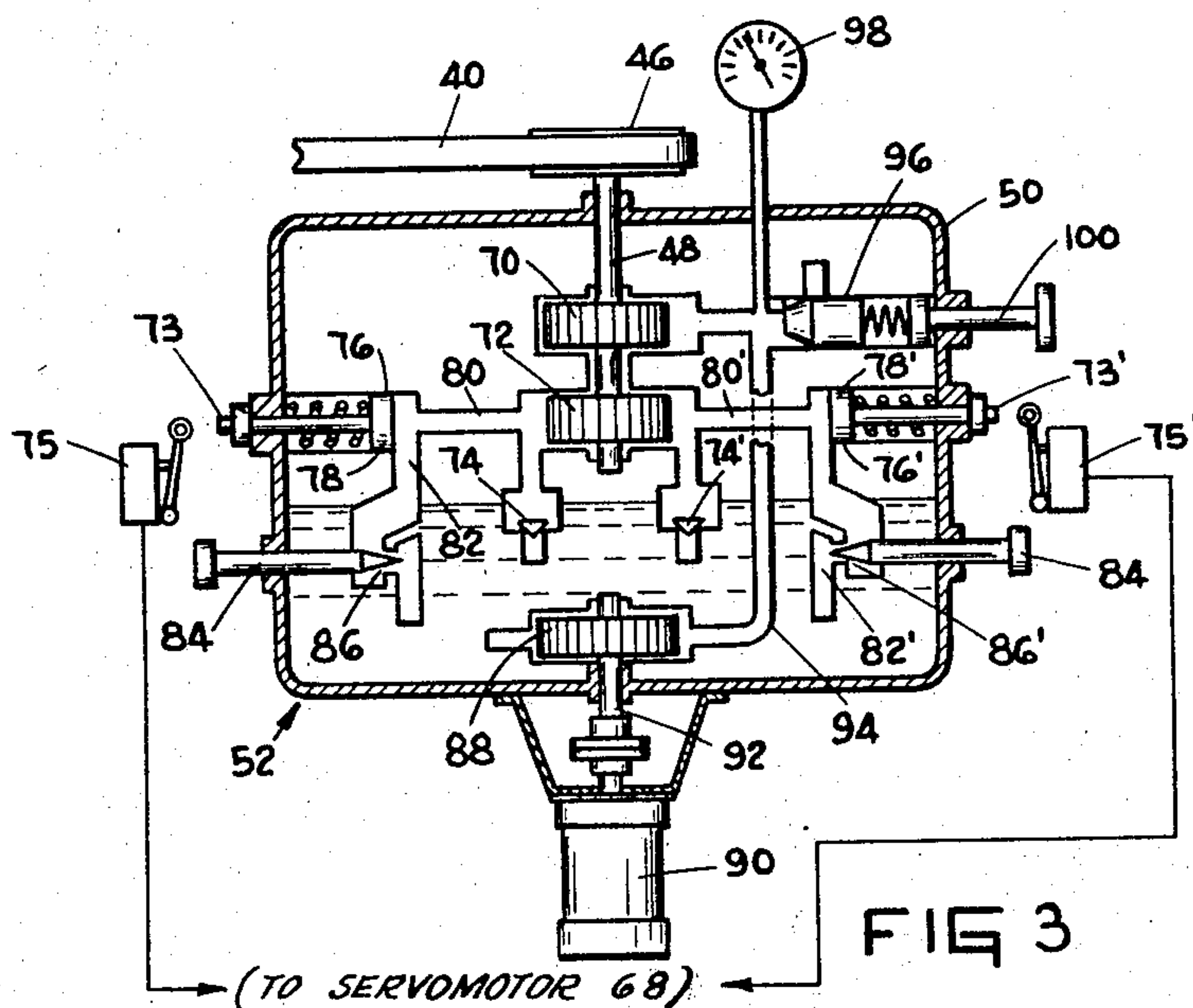


FIG. 3

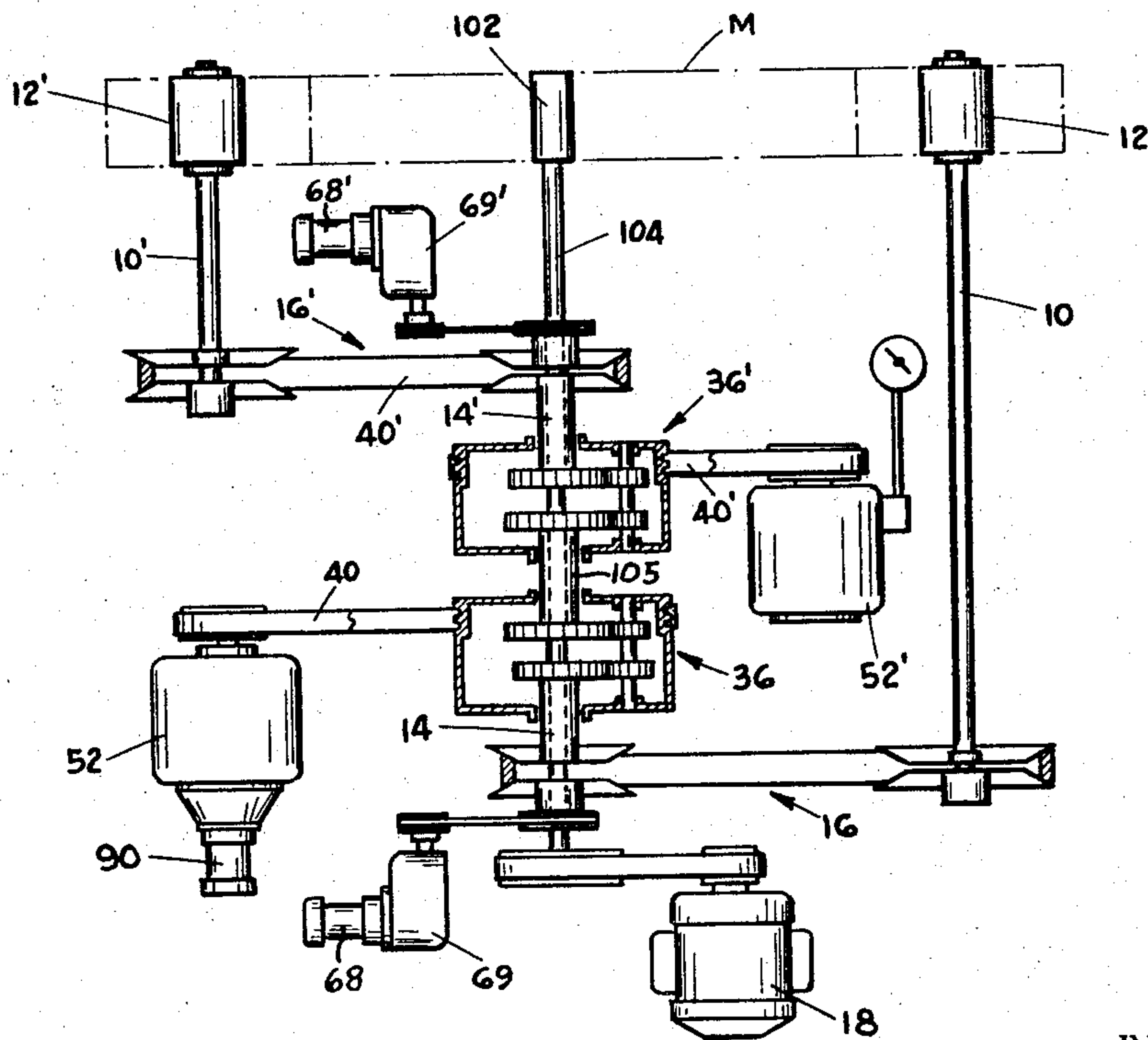


FIG. 4

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APPARATUS FOR WINDING AND UNWINDING SHEET MATERIAL OR THE LIKE

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100,908

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12 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for unwinding sheet, strip, wire or filament material under controlled conditions of speed and tension which employs a differential transmission intermediate the respective drive shafts for the shafts upon which the drums are mounted for the material being unwound and wound, and vice versa. Automatic variable transmission means are respectively provided for each pair of drive and drum shafts. Control means responsive to the differential transmission controls a servomotor in circuit with the respective automatic variable transmissions to correlate the rates of rotation of the respective drum shafts and thereby control the speed and tension upon the material running between the drum shafts.

The invention relates to improvements in apparatus for unwinding and winding sheet or strip material, wire, filament or the like under controlled conditions.

There are a number of applications where it is desired to unwind sheet, strip, wire, filament or the like from a drum, spool or the like onto another drum or the like under controlled conditions of linear speed and tension of and upon the running material. The initial difference in diameters and continuing change in diameters of the material wound drum and of the drum upon which the material is being wound presents the problem of maintaining constant linear speed and tension upon the running sheet, strip wire, filament or the like being processed. For example, in a cloth dyeing machine, generally referred to as a "jigger," there are two shafts having a drum or spool mounted on each shaft. On one of the drums, there is placed a roll of cloth which must be unrolled or unwound onto the second drum. When the operation has been completed, the movement is reversed and the procedure is repeated as often as required. The same problems of maintaining constant speed and constant tension upon the material being unwound from one drum and onto the other are present when other materials such as paper strip, paper sheet, wire, or other sheet, strip and filament materials are unwound or uncoiled from one roll onto another.

An object of the invention is to provide apparatus which in unwinding material from one rotatably mounted drum and onto another rotatably mounted drum is accomplished under controlled conditions of linear speed and tension, the apparatus inducing means for automatically adjusting the speed of the material being unwound and the tension imposed upon the material as it is being unwound from one drum and onto the other drum.

Another object of the invention is to provide an apparatus of the kind under consideration having control means for automatically correcting the linear speed and tension of and upon the material being unwound and wound when there is a variance from predetermined speed and tension values.

A further object of the invention is to provide apparatus of the type under consideration which includes

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intermediate positively driven roll means for pressing the running material.

These, and other objects and advantages of the invention will be apparent from the following detailed description, taken in conjunction with the drawings illustrating a preferred embodiment of the invention, in which:

FIG. 1 is a diagrammatic view showing a pair of spaced shafts having drums fixed thereto and material being unwound from one drum and onto the second drum, this view also showing roll means for applying pressure to the material between the drums;

FIG. 2 is a diagrammatic view illustrating apparatus for controlling the speed and tension of and upon the running material as it is being unwound from one drum and onto the other drum;

FIG. 3 is a diagrammatic view of a preferred form of control means suitable for inclusion in the system shown in FIG. 2; and

FIG. 4 is a diagrammatic view showing a modification of the invention, this view being similar to FIG. 2, except that this view additionally illustrates means for controlling pressure upon the running material, the pressure being applied, for example, by rolls intermediate the spaced winding and unwinding drums.

Referring to the drawings, particularly FIGS. 1 and 2, apparatus in accordance with the invention comprises a pair of spaced shafts 10 and 10' upon which are mounted drums or spools 12, 12' fixed for rotation with their respective shafts. The material M to be processed, whether sheet, strip, wire or filament, is unwound from one drum and onto the other drum, and then the direction of winding may be reversed if desired and as often as necessary.

A drive shaft 14 is provided for one of the drum shafts, and a second drive shaft 14' is provided for the other drum shaft. Automatic variable speed transmission means 16 is provided intermediate drum and drive shafts 10, 14 and a second automatic variable speed transmission means 16' is provided for the drum and drive shafts 10', 14'. Preferably, and as illustrated, the drive shafts 14 and 14' are coaxially aligned and one of the drive shafts is rotated by a suitable rotating mechanism 18, such as an electric, hydraulic or pneumatic motor. The motor drive means 18 may drive the drive shaft either directly or through the medium of a pulley and belt arrangement comprising a pulley 20 connected to the motor shaft and a pulley 22 fixed to the drive shaft with a belt 24 extending around the pulleys. The motor drive means 18 may be connected either to the drive shaft 14 as shown, or to the drive shaft 14'.

Each of the automatic variable speed transmissions 16, 16' preferably comprises a pair of pulley members 26, 28 mounted on the drum shaft 10 with one of the pulley members resiliently mounted for movement toward and away from the other pulley member, as is well known in the art. Similarly, a pair of pulley members 30, 32 are mounted on the related drive shaft 14, one pulley member being spring mounted for movement toward and away from the other pulley member. A belt 34 having a trapezoidal cross-section engages the respective opposing faces of the pulley members 26, 28 and 30, 32 and extends between the assemblies of pulley members on the respective drum and drive shafts. The same automatic variable transmission arrangement may be provided for the drum and drive shafts 10', 14', like elements being indicated by the same element numbers primed. The rate of rotation of each drum shaft is varied to the extent that a pair of opposed pulley members are spaced from one another, thereby presenting differing diameters provided by the opposed angulated pulley faces to the belt. When the pulley faces move apart against the action

of the spring, the shaft upon which the assembly is mounted increases in speed, and when the pulley faces move toward one another the belt rides on a larger diameter and the shaft's rate of rotation is decreased.

The drive shafts 14, 14' are connected or coupled to one another by a differential transmission means 36. The differential action is such that the rotation of the drive shaft 14 at a predetermined rate of rotation, rotates the drive or driven shaft 14' at a predetermined rate of rotation. Preferably, the differential transmission means is of the type comprising planetary pinion assemblies related to sun gears within a rotating gear case or housing 38, the outer periphery of which is provided with grooves to receive a belt or belts 40. One of the planet gears 42 of the differential transmission is connected to the drive shaft 14 and another planet gear 44 is connected to the other drive shaft 14'. The belt 40 extends to and around a pulley 46 connected and fixed to a shaft 48 extending out from a casing 50 within which is housed control means 52 (see also FIG. 3.).

The differential transmission means 36 is of a known construction. The unit comprises the grooved rotatably mounted gear case or housing 38 which, for the application, furnishes the output of the unit. The housing is rotatably mounted upon ball bearings mounted on central members of the assembly. Rotation of the gear housing is accomplished through helical planet gear assemblies, each consisting of a pair of gears of appropriate size splined to a common shaft. These assemblies revolve in needle bearings carried by the rotatably mounted housing. The planet assemblies engage two sun gears, with torque reaction for the gear train being provided by one of the sun gears which is keyed to a hub having an external flange for attachment to a suitable restraining device. The hub assembly is mounted on needle bearings. Power is transmitted through the differential action between the planet assemblies and the stationary sun gear, to the adjacent sun gear which is keyed to a hub. The hub is provided with a bore receiving the shaft provided with a key for connection to the output or input hub as the case may be. The unit is filled with oil to ensure lubrication for the parts.

When power is transmitted from the drive shaft 14 entering the differential transmission assembly, a predetermined rate of rotation is imparted to the drive shaft 14' and the grooved housing 38 rotates at a predetermined rate of rotation. The speedup of one planet gear results in the slow down of the other planet gear, and vice versa, thereby reflecting commensurate changes in the drive shafts 14, 14'. It will be of course understood that the direction of rotation of the drive shaft 14' and of the grooved housing 38 depends upon the direction of rotation of the input drive shaft 14. A differential transmission unit of this kind is manufactured and sold in France by Redex of Paris, and in the United States by Plessey Airborne Corporation of Hillside, N.J.

Referring to FIGS. 2 and 3, the control means 52 is responsive to and actuated by the differential transmission means 36 by the intermediate belt 40. The control means is in circuit with a control shaft 54 which preferably is mounted in suitable bearings to extend substantially parallel to the drive shafts 14, 14', also the drum shafts 10 and 10'. The control shaft is connected to the drive shaft 14 by a pulley and belt arrangement comprising the pulley 56 on the control shaft 54 and a pulley 58 on the drive shaft 14, with a belt 60 around the pulleys. The control shaft 54 is also connected to the drive shaft 14' by a pulley arrangement comprising a pulley 62 fixed to rotate with the control shaft and a pulley 64 fixed to rotate with the drive shaft 14', the pulleys being connected by an intermediate belt 66.

The control shaft 54 is rotated by servomotor 68 having a gear reducer 69 which may be directly or indirectly connected to the control shaft. The servomotor is actuated and controlled by the control means 52 which in turn is responsive to the differential trans-

mission means 36, or to the rate and direction of rotation of the grooved housing 38 of such differential transmission.

In greater detail and with reference to FIG. 3, the control means 52 comprises a gear pump 70 which acts as a brake and is controlled by the belt 40 coming off the differential transmission 36. The pump 70 is mounted on the shaft 48 which is connected to the pulley 46 rotated by the belt 40. Conversely, the gear pump 70 also acts as a hydraulic motor to control the differential transmission means 36, depending upon the direction of rotation of the grooved housing 38 of the differential transmission means. A gear pump 72 also is keyed onto the shaft 48, such pump being rotatable in either direction. The pump 72 is in communication with a pair of intake and back pressure valves 74, 74', there being one valve on each side of such pump. Each side of the pump 72 also is in communication with two chambers or cylinders 76, 76', the chambers having the pistons 78, 78', respectively. Preferably, each of the pistons is spring mounted, and has a contact portion, the respective portions 73, 73', which extend to the exterior of the control means housing 50. Suitable seals are provided for the contact providing spindles where they extend from the housing. The contacts 73, 73' are engageable with a pair of microswitches 75, 75', respectively, which are in circuit (not shown) with the servomotor 68.

The cylinders 76, 76', in addition to being in communication with the gear pump 72 and the respective valves 74, 74' by means of intermediate piping 80, 80' are also in communication with a reservoir provided by the control means casing 50 through the medium of suitable piping 82, 82'. The lower ends of the piping are positioned in the reservoir or bath of a suitable hydraulic fluid such as oil. Also, suitable adjustable valve spindles 84, 84' are threaded through the casing 50 with their front working ends adjustable with respect to orifices 86, 86' in communication with the piping 82, 82', respectively, to thereby control the initial pressure upon the pistons 78, 78'.

The control means 52 further includes an auxiliary gear pump or the like 88 which is positioned within the hydraulic fluid reservoir, such pump being controlled by a suitable rotating mechanism preferably in the form of a hydraulic motor 90. The pump 88 is mounted on the shaft 92 of the motor, the shaft extending through the casing 50, and as it is known in the art, the shaft is provided with suitable seals. The auxiliary pump 88 is connected to the gear pump 70 by tubing 94, the tubing also being in communication with a cylinder 96 and a manometer 98. An adjustable valve 100 is mounted in the cylinder to enable adjustment of the hydraulic pressure furnished and received by the gear pump 70 acting as a drive or brake means.

When the shaft 48 is rotated by the drive furnished by the differential 36, the belt 40 cooperable with the pulley 46 for the shaft 48, the hydraulic pressure rises on the left side of the pump 72 as viewed in FIG. 3. The faster the rotation of this pump, the faster the rise in pressure. As a result, piston 78 is retracted so that contact 73 engages the microswitch 75, thereby actuating the servomotor 68. Closing the circuit by the engagement of the contact 73 with the microswitch 75 imparts one direction of rotation to the servomotor. On the other hand, when the contact 73' engages the microswitch 75', the servomotor 68 is caused to rotate in the other direction. Thus, the direction of rotation of the servomotor 68 correspondingly determines the direction of rotation of the control shaft 54.

The manner of operation of the system disclosed in FIGS. 1 and 2, and apart from the pressure rollers designated 102, 102', is as follows. The drum shafts 10, 10' are connected to one another by the material M which is being unwound from the drum 10' and onto the drum

10, or vice versa. Thus, the rates of rotation of the drum shafts 10, 10' are related to one another in inverse ratio to the diameters provided by the material respectively being unwound from one drum and being wound onto the other drum. A given ratio corresponds to the correct adjustment of the variable speed transmissions 16, 16'. Given that these two transmissions are equalized when the diameters provided by the material on the drums 12, 12' are equal, the rate of rotation of the drive shaft 14 is proportional to the linear speed of the material being unwound from one drum and onto the other. In this condition, the grooved gear housing 38 of the differential mechanism 36 is stationary or motionless.

If the system is not in correct adjustment, the grooved gear housing 38 rotates in the same direction as the error in adjustment. Upon rotation, the grooved gear housing 38 acts upon the control means 52 causing one of the pistons 78 or 78' to move in its cylinder to cause the contact 73 or 73' to engage either the microswitch 75 or 75', depending upon the direction of rotation of the grooved gear housing 38 and therefore, the direction of rotation of the belt 40. When contact is made between the contact 73 and the microswitch 75, or the contact 73' and the switch 75', the servomotor 68 is actuated to rotate in one direction or the opposite direction. As a result, the control shaft 54 is rotated in one direction or the opposite direction, whereupon, and simultaneously, the automatic variable speed transmissions 16, 16' are driven in a direction which allows the difference in speed causing the housing to rotate to be cancelled out.

In addition, and during the running of the material M between the drums 12, 12', the pump 70 of the control means 52 is operated by the differential transmission means 36 through the medium of its rotatable housing 38 and the intermediate belt 40. The pump 70 is drawn or operated by the pressure provided by the hydraulic fluid which is always applied on the same side, whatever the direction in which this pump is rotated. This pressure is applied in the appropriate direction, and as a result, tension is applied to the running material M, the tension being self-correcting to a constant value. The selected predetermined pressure adjustment within the control device for the hydraulic fluid is obtained by means of the described adjustable valve 100. Such adjustment determines the rate that the auxiliary pump 88 is driven by the motor 90 to furnish an output which is greater than necessary to feed the main pump 70 when it operates as a receiver in the case of maximum inaccuracy of synchronization.

From the foregoing description, it will be apparent that the control means 52 has a double function. It acts to stretch the material M as it is being unwound from one drum and onto the other, and insures that the automatic adjustment of the variable speed transmission means 16, 16'. The described apparatus therefore furnishes simultaneous control of the drum shafts 10 and 10' in whatever direction the material M is being unwound from one drum and onto the other.

The system includes a circuit which comprises two automatic variable speed transmissions controlled by a common servomotor with the system including a differential transmission means which measures the inaccuracy of synchronization. The sensing of the inaccuracy of synchronization is transmitted by the differential transmission means 36 to the control means 52. The control means acts to ensure that the running material M is maintained at a desired and controlled speed and tension. The control means 52, which is responsive to the sensing differential transmission 36, automatically corrects the changing conditions provided by the changing diameters of material on the drums 12, 12'. As a result, the running material M is maintained at a constant speed and tension.

FIG. 4 illustrates a system which includes intermediate rolls 102, 102' (FIG. 1) as used in a "Jigger." For such an application, the system is doubled in the respects that

there are a second differential transmission 36' and a second control means 52'. Also, there is a second or separate servomotor 68'. Thus, for the drum shaft 10 there are the drive shaft 14, the intermediate automatic variable speed transmission 16, the differential 36 connected to the control means 52 by the belt 40, with the servomotor 68 in circuit with the control means 52 and the drive shaft 14. Correspondingly, the drum shaft 10 is provided with the drive shaft 14' and the intermediate connecting automatic variable speed transmission 16', the drive shaft for this drum shaft being connected to the differential 36'. The control means 52' is responsive to this latter differential transmission and connected thereto by the intermediate belt 40'. The second servomotor 68' is in circuit with the control means 52' and with the automatic variable speed transmission 16' for the pair of drum and drive shafts 10', 14'. Since a separate servomotor is used in conjunction with the circuits for each drive shaft, a control shaft as hereinbefore described is unnecessary.

The power means 18 as hereinbefore described in connection with the system of FIG. 2 is either directly or indirectly connected to the drive shaft 14. Also, to furnish power means for rotating the roll 102, a drive shaft 104 is provided for rotation by the same motor means 18 which imparts rotation to the drive shaft 14. For this purpose, the drive shaft 14, also the drive shaft 14', are each provided with a bore to allow the roll drive shaft 104 to extend therethrough. A sleeve 105 is positioned intermediate the differentials 36, 36', the shaft 104 extending through the sleeve. Also, the roll drive shaft 104 extends through the differential transmission means 36, 36' whereby the roll drive shaft, the drive shaft 14 and the drive shaft 14' are all driven by the motor 18.

The foregoing described relationship of parts permits the roll 102 to be rotated at a constant linear speed while permitting the drive shafts 14, 14' to rotate at different speeds by virtue of the related differential transmission means. Thus, the roll 102 which with the roll 102' provides a bight for the running material M is rotated at a constant linear speed with relation to the desired constant linear speed for the running material which is engaged and tensioned by the pair of rolls, and the desired angular speed and variable torque of the drum shafts 10 and 10' as compared with the constant angular speed of the roll drive shaft 104 are obtained to impart the desired constant linear speed and constant tension upon the running material.

In the system illustrated in FIG. 4, a hydraulic motor 90 is only required for one of the control means, for example, the control means 52 and the auxiliary pump 88 also serves the second control means 52' so that the adjustment of tension upon the material M on both sides of the rolls 102, 102' is obtained by the valves of the control means 52 only.

It is believed that the advantages and improvements of the invention will be apparent from the foregoing detailed description of a preferred embodiment of the invention.

I claim:

1. Apparatus for unwinding and winding material from and upon spaced drums comprising a pair of spaced drum shafts, a pair of drive shafts, one for each drum shaft, a pair of automatic variable speed transmission means, one for each pair of drum and drive shafts, differential transmission means coupling the drive shafts, motor means for rotating the drive shafts, control means responsive to the differential transmission means, and a servomotor responsive to the control means, said automatic variable speed transmission means being responsive to the operation of the servomotor.

2. Apparatus as set forth in claim 1 wherein the differential transmission means comprises a planetary variable speed drive having a planet gear connected to one drive shaft and a second planet gear connected to the other

drive shaft, the planet gears being housed in a rotatably mounted housing, the housing being connected to the control means.

3. Apparatus as set forth in claim 1 wherein the control means comprises a switch in circuit with the servomotor, a hydraulically operated pump, the shaft of the pump being connected to the differential transmission means, the pump being in communication with a pair of cylinders, one on each side of the pump, each cylinder having a piston formed to provide a contact for engagement with the switch.

4. Apparatus as set forth in claim 1 wherein the differential transmission means comprises a planetary variable speed drive having a planet gear connected to one drive shaft and a second planet gear connected to the other drive shaft, the planet gears being housed in a rotatably mounted housing; and wherein the control means comprises a switch in circuit with the servomotor, a hydraulically operated pump, the shaft of the pump being connected to said rotatably mounted housing, the pump being in communication with a pair of cylinders, one on each side of the pump, each cylinder having a piston formed to provide a contact for engagement with the switch.

5. Apparatus as set forth in claim 1 wherein each of the automatic variable speed transmission means comprises a pair of pulley members mounted on each drive shaft and a pair of pulley members mounted on each drum shaft, one pulley member of each pair of pulley members being resiliently mounted for movement toward and away from the other pulley member, and a belt extending between the pulley members on a drum shaft and the pulley members on a drive shaft.

6. Apparatus as set forth in claim 1 including a control shaft connected to the servomotor, means connecting the control shaft to one of the drive shafts and means connecting the control shaft to the other drive shaft.

7. Apparatus for unwinding and winding material from and upon spaced drums comprising a pair of spaced drum shafts, a pair of drive shafts in axial alignment, one for each drum shaft, a pair of automatic variable speed transmissions, one for each pair of drum and drive shafts, a pair of differential transmission means each connected to a respective drive shaft, the two differential transmission means being coupled to one another, a roll shaft extending through the drive shafts and through the two differential transmission means, motor means for rotating the drive shafts and for rotating the roll shaft, a pair of control means, one for each differential transmission means and respectively responsive thereto, and a servomotor responsive to each of the respective control means,

each automatic variable speed transmission means being responsive to the operation of each servomotor.

8. Apparatus as set forth in claim 7 wherein the same motor means operates the drive shafts and the roll shaft.

9. Apparatus as set forth in claim 7 wherein each differential transmission means comprises a planetary variable speed drive having a planet gear connected to one drive shaft and a second planet gear connected to the other differential transmission means, the planet gears being housed in a rotatably mounted housing, the housing of each differential transmission being connected to the respective control means.

10. Apparatus as set forth in claim 7 wherein each control means comprises a switch in circuit with the servomotor, a hydraulically operated pump, the shaft of the pump being connected to its respective differential transmission means, the pump being in communication with a pair of cylinders, one on each side of the pump, each cylinder having a piston formed to provide a contact for engagement with the switch.

11. Apparatus as set forth in claim 7 wherein each differential transmission means comprises a planetary variable speed drive having a planet gear connected to one drive shaft and a second planet gear connected to the other differential transmission means, the planet gears being housed in a rotatably mounted housing; and wherein each control means comprises a switch in circuit with the servomotor, a hydraulic operated pump, the shaft of the pump being connected to the rotatably mounted housing of a respective differential transmission means, the pump being in communication with a pair of cylinders, one on each side of the pump, each cylinder having a piston formed to provide a contact for engagement with the switch.

12. Apparatus as set forth in claim 7 wherein each of the automatic variable speed transmission means comprises a pair of pulley members mounted on each drive shaft and a pair of pulley members mounted on each drum shaft, one pulley member of each pair of pulley members being resiliently mounted for movement toward and away from the other pulley member, and a belt extending between the pulley members on a drum shaft and the pulley members on a drive shaft.

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