Nov. 21, 1939. J. K. DOUGLAS 2,181,049

HYDRAULIC DRIVE

Filed Jan. 19, 1939 2 Sheets-Sheet 1

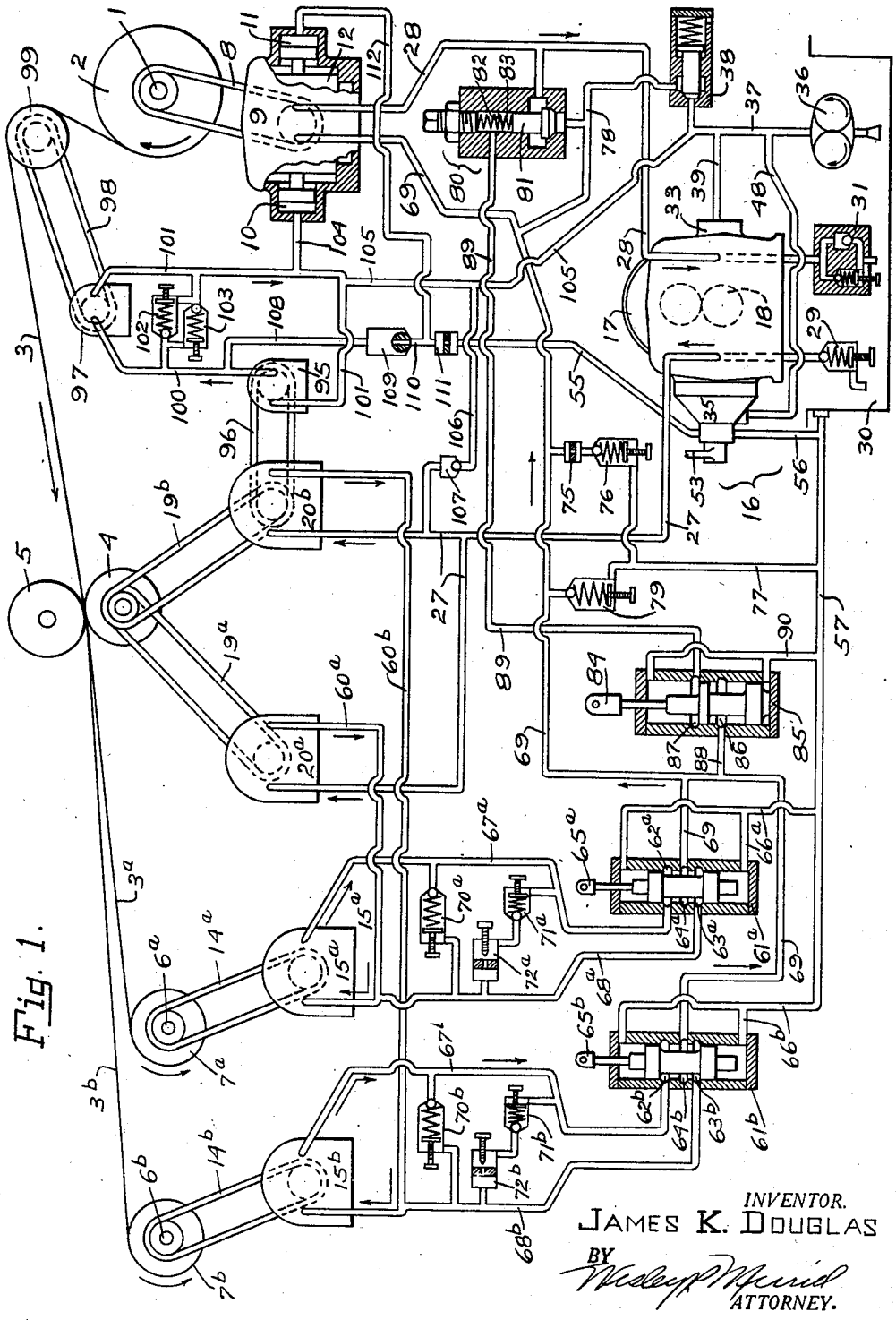


Fig. 1.

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Fig 2.

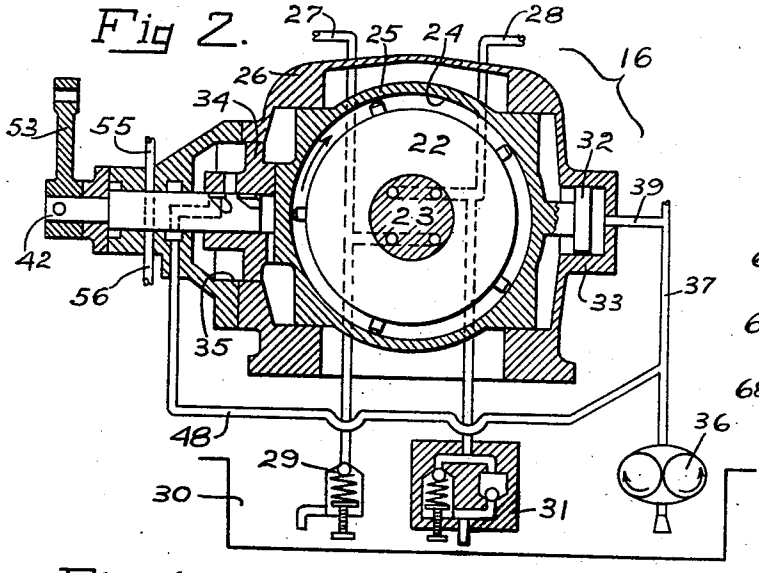


Fig. 5.

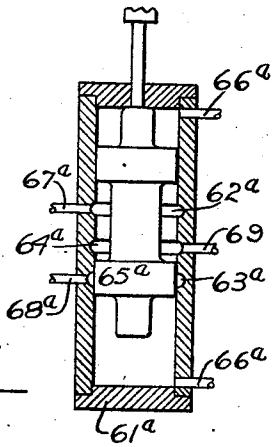


Fig. 4.

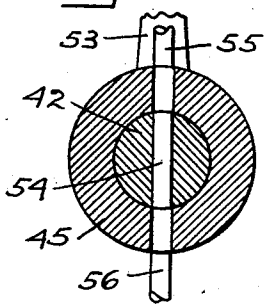


Fig. 7

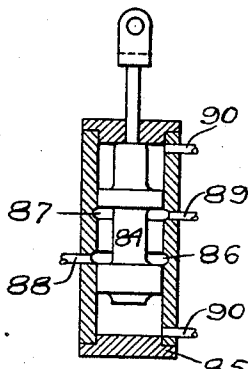


Fig. 6.

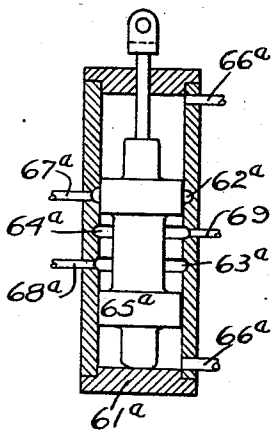
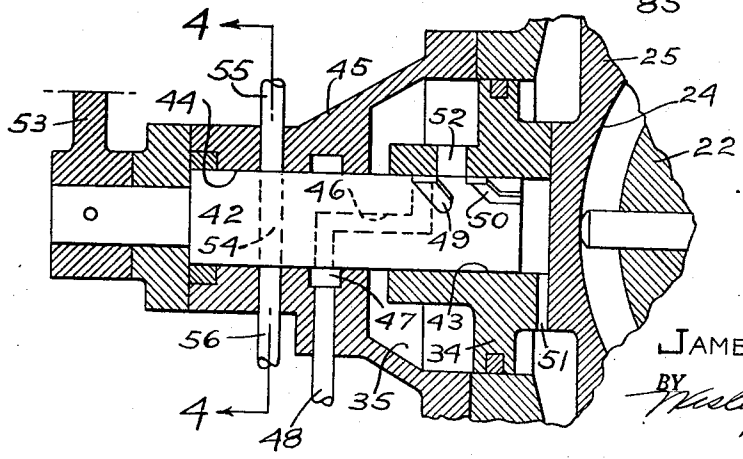


Fig. 3.



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2,181,049

HYDRAULIC DRIVE

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Application January 19, 1939, Serial No. 251,675

20 Claims. (Cl. 164—65)

This invention relates to hydraulic drives of the type employed to drive machines which unwind paper or other sheet material from parent rolls and wind it into new rolls.

Such machines require that the parent rolls be gradually accelerated as they decrease in diameter, that the rewound rolls be gradually decelerated as they increase in diameter, that the parent rolls resist the unwinding of the material therefrom in order to maintain tension upon the material between the parent rolls and the rewound rolls, and that the tension on the material be controlled in order to control the density of the rewound rolls.

While the parent roll resists rotation in order to maintain tension upon the material during the rewinding thereof, it is desirable that that part of the drive connected to the parent roll be able at times to drive or tend to drive the parent roll in order that the material may be readily threaded through the machine and in order to compensate in part for the friction of the parent roll and its drive during certain parts of the rewinding process.

A drive constructed according to the invention is particularly adapted for driving a machine which unwinds paper from a parent roll, cuts the taper into strips and then rewinds the strips into individual rolls.

Paper as manufactured ordinarily contains defects and such defects are removed by stopping the machine, severing the strips at each side of the defect, then pasting the severed ends together and then continuing the winding of the strips. A greater amount of defective material will be removed from one strip than from another strip with the result that the rewound rolls do not increase in diameter at the same rate. It is therefore desirable that the rewound rolls be driven simultaneously but independently of each other.

The present invention has as an object to provide a drive in which that part of the drive connected to the parent roll will cause or permit material to be unwound from the parent roll at a predetermined rate regardless of the diameter of the parent roll or the pull on the material.

Another object is to provide a machine, having a plurality of winding shafts for winding strips of sheet material thereon, with a drive which will rotate the shafts simultaneously but independently of each other and control the tension on each strip independently of the tension on another strip.

Another object is to provide a machine, having an unwind shaft for supporting a parent roll of sheet material, a slitter for cutting the sheet material into a plurality of strips and a rewind shaft for winding each strip into a roll, with a drive having means for driving the slitter at a predetermined speed, means for causing or permitting the material to be unwound from the parent roll at a speed proportional to the slitter speed, means for driving the rewind shafts simultaneously but independently of each other and means for controlling the pull exerted by each rewind shaft upon the strip connected thereto independently of the pull exerted by another rewind shaft upon the strip connected thereto.

Another object is to provide a machine of the above character with a drive which is adjustable to vary the speed thereof through a wide range.

Other objects and advantages will appear from the following description of a hydraulic drive embodying the invention and shown schematically in the accompanying drawings in which the views are as follows:

Fig. 1 is a diagrammatic view showing the invention embodied in a drive for a slitting machine having a shaft to support a parent roll of paper, a slitter for cutting the paper into a plurality of strips and a plurality of rewind shafts for drawing the paper from the parent roll through the slitter and winding the strips into individual rolls, the parts being shown in the positions occupied when the machine is idle.

Fig. 2 is in part a section through a pump, which supplies liquid for energizing the hydraulic motors that drive the several parts of the machine, and in part a diagram of a portion of the hydraulic circuit.

Fig. 3 is a detail view showing on a larger scale the pump control valve shown in Fig. 2, the valve being shown in the position occupied when the pump is at zero stroke.

Fig. 4 is a section taken on the line 4—4 of Fig. 3.

Fig. 5 is a view showing a bypass and brake valve with its valve member in position to cause a hydraulic motor to drive a winding shaft.

Fig. 6 is a view similar to Fig. 5 but showing the valve member in position to cause a brake load to be applied to the hydraulic motor.

Fig. 7 is a view showing another valve with its valve member in position to increase the drop in pressure across a hydrodynamic machine which is connected to the shaft that supports the parent roll of paper.

For the purpose of illustration, the invention has been shown embodied in a drive for a slitting

machine of which, since it per se forms no part of the present invention, only as much has been shown as is necessary for an explanation of the functions of the drive.

The slitting machine includes an unwind shaft 1 on which a roll 2 of paper 3 is fixed to rotate therewith, a slitter shown as consisting of a backing roll 4 and a plurality of rotary knives 5 coacting with roll 4 to trim the edges of paper 3 and to cut it into a plurality of strips, and a plurality of winding shafts 6 which correspond in number to the number of strips into which paper 3 is to be cut and upon which the strips are to be wound into finished rolls 7. As shown, the machine includes two winding shafts 6^a and 6^b, and slitter 4—5 is adapted to cut paper 3 into two strips 3^a and 3^b which are wound, respectively, upon shafts 6^a and 6^b into rolls 7^a and 7^b.

Unwind shaft 1 is connected by a drive 8 to a hydrodynamic machine 9 which functions to permit paper 3 to be unwound from roll 2 at a uniform rate, as will presently be explained, and which has two opposed servo-motors 10 and 11 for moving its slide block 12 in one direction or the other to adjust its displacement and thereby compensate for the decrease in the diameter of roll 2 as paper 3 is unwound therefrom.

Paper ordinarily has defects therein which are removed by severing the strip at each side of the defect, discarding the portion containing the defect and then pasting together the adjacent ends of the other two portions of the strip. It is ordinarily necessary to cut a greater amount of defective material from one strip than from another strip with the result that the rolls of the winding shafts do not increase in diameter at the same rate.

The finished rolls should be of the same diameter. Therefore, when the roll on one winding shaft reaches the correct size, the machine is stopped, the strip severed from the finished roll which is then removed from its shaft, a new core is fixed upon that shaft, the severed end of the strip is fastened to the core and the machine is operated until the roll on the other shaft reaches the correct size.

It is therefore necessary that the winding shafts be driven simultaneously but independently of each other. As shown, shafts 6^a and 6^b are driven, respectively, through drives 14^a and 14^b by hydraulic motors 15^a and 15^b which are connected in parallel with each other and energized by liquid supplied by a pump 16 driven by a prime mover 17 through a drive 18.

In order that the liquid supplied by pump 16 may be equally divided between winder motors 15^a and 15^b, slitter 4—5 is connected by two drives 19^a and 19^b to two hydraulic motors 20^a and 20^b which are thus mechanically synchronized, both slitter motors are connected to pump 16 in parallel with each other, and each slitter motor has a winder motor connected in series therewith.

It is to be understood that, if slitter 4—5 simply trimmed the edges of paper 3 so that only one winding shaft would be required, the winding shaft and the slitter would each be driven by a motor of suitable size and the two motors would be connected to pump 16 in series with each other. Also, if slitter 4—5 were adapted to slit paper 3 into more than two strips, a winding shaft would be provided for each strip, each winding shaft would be driven by a separate motor, the slitters would be driven by as many motors as there were winder motors, each winder motor would be connected in series with a slitter motor and all of the slitter motors would be connected to pump 16 in parallel with each other.

Any suitable type of pump may be employed but, for the purpose of illustration, pump 16 has been shown as being of the rolling piston type which is fully illustrated and described in Patent No. 2,074,068. It is deemed sufficient to state herein that pump 16 has its pistons and cylinders arranged radially in a cylinder barrel 22 which rotates upon a stationary valve shaft or pintle 23 having formed therein ports and passages through which liquid flows to and from cylinders, that the outer ends of the pistons re-act against an annular reaction surface 24 which in practice is formed in a separate rotatable thrust member carried by a slide block 25 but which has been shown as being formed in slide block 25, that pump 16 will discharge liquid in a direction and at a rate depending upon the direction and the distance the axis of reaction surface 24 is offset from the axis of cylinder barrel 22, and that slide block 25 is arranged in a casing 26 which permits it to be moved transversely of pintle 23 but prevents it from moving in any other direction.

When cylinder barrel 22 is rotated in the direction of the arrow and slide block 25 is offset towards the right as viewed in Fig. 2, pump 16 will deliver liquid into a channel 27, which is connected to the passages in pintle 23 on one side of the centerline thereof, and liquid will be returned to pump 16 through a channel 28 which is connected to the passages in pintle 23 on the other side of its centerline, pump 16 being protected from excessive pressures by a high pressure relief valve 29 which is connected to its outlet.

If the liquid returned to pump 16 through channel 28 is insufficient to supply pump 16, liquid may be drawn from a reservoir 30 by pump 16 through a foot valve 31 which is connected to its inlet and consists of a relief valve which discharges into reservoir 30 and a check valve which permits liquid to be drawn freely from reservoir 30 by pump 16 but prevents liquid being discharged into reservoir 30 except through the relief valve.

Slide block 25 is adapted to be moved toward the left by a piston 32 which abuts or is fixed to the right side of slide block 25 and fitted in a cylinder 33 carried by casing 26, and it is adapted to be moved toward the right by a piston 34 which abuts or is fixed to the left side of slide block 25 and fitted in a cylinder 35 carried by casing 26. Piston 34 has a considerably larger effective pressure area than piston 32 in order that it may move slide block 25 toward the right when cylinders 33 and 35 are simultaneously supplied with liquid at the same pressure.

Liquid for operating servo-motors 32—33 and 34—35 and for other purposes is supplied by a gear pump 36 which has been shown separated from pump 16 but which in practice is arranged in the casing of pump 16 and driven in unison therewith according to the usual practice.

Gear pump 36 draws liquid from reservoir 30 and discharges it into one end of a channel 37 the other end of which is connected to the inlet of a resistance valve 38 so that gear pump 36 maintains pressure in channel 37 at all times.

Cylinder 33 is connected to channel 37 by a channel 39 so that slide block 25 is constantly urged toward the left by a gear pump liquid acting upon piston 32.

The delivery of liquid to cylinder 35 is controlled by a rotary follow-up valve 42 which is journaled in coaxial bores 43 and 44 formed, respectively, in piston 34 and in the end wall or head 45 of cylinder 35 as best shown in Fig. 3.

Valve 42 has a duct 46 formed therein with its outer end in constant communication with an annular port 47 which is formed in the wall of bore 44 and connected by a channel 48 to channel 37. The inner end of duct 46 opens into a spiral groove 49 which is formed in the peripheral surface of valve 42 and normally closed by the wall of bore 43. The arrangement is such that gear pump pressure prevails in groove 49 at all times. A second spiral groove 50 is formed in the peripheral surface of valve 42 a short distance from groove 49 and opens into the right end of bore 43 from which a drain channel 51 extends through the hub of piston 35.

Grooves 49 and 50 are normally arranged upon opposite sides of a port 52 which extends through the hub of piston 34 into communication with the interior of cylinder 35 and is of a width equal to the distance between grooves 49 and 50 so that rotation of valve 42 in one direction or the other will open one or the other of grooves 49 and 50 to port 52. Valve 42 is adapted to be rotated by means of a lever 53 which is fixed upon the outer end thereof and has rotary movement through a given angular distance, for instance 50°, from the central or neutral position shown in Fig. 4, the movement of lever 53 in each direction being ordinarily limited by stops not shown.

When lever 53 is moved toward the right or in a clockwise direction in respect to Fig. 4, groove 49 will open to port 52 and permit liquid from gear pump 36 to flow through channels 37 and 48, port 47, duct 46, groove 49 and port 52 into cylinder 35. The liquid entering cylinder 35 will move piston 34 and slide block 25 toward the right for the reason that piston 34 has a considerably greater pressure area than piston 32 which is also subjected to gear pump pressure. Piston 34 will start to move as soon as groove 49 opens to port 52 and it will continue to move as long as valve 42 is rotated. As soon as rotation of valve 42 ceases, port 52 will move out of communication with groove 49 and movement of piston 34 and slide block 25 will cease.

When lever 53 is moved toward the left or in a counter-clockwise direction in respect to Fig. 4, groove 50 will open to port 52 and permit liquid to escape from cylinder 35 through port 52 and groove 50 into the right end of bore 43 which is open to drain through channel 51, thereby permitting the gear pump liquid acting upon piston 32 to move it and slide block 25 toward the left.

Piston 32 will start to move slide block 25 and piston 34 toward the left as soon as groove 50 opens to port 52 and it will continue to move as long as valve 42 is rotated. As soon as rotation of valve 42 ceases, port 52 will move out of communication with groove 50 and trap the liquid remaining in cylinder 35, thereby stopping further movement of slide block 25 and holding it in adjusting position. Slide block 25 may thus be moved in one direction or the other by swinging lever 53 in one direction or the other, and the distance through which slide block 25 is moved is dependent upon the angular distance through which lever 53 is moved.

For a purpose to be presently explained, valve 42 has a transverse passage 54 (Fig. 4) extending therethrough and adapted to connect a channel 55, which communicates with bore 44 at a point spaced from port 47, to a channel 56 which has one of its ends communicating with bore 44 at a point diametrically opposite channel 55 and its other end connected to a drain channel 57 which discharges into reservoir 30.

When valve 42 is in its neutral position at which time pump 16 is at zero stroke and no liquid is being delivered thereby, passage 54 connects channel 55 to channel 56 so that liquid may escape from channel 55 into drain channel 57. When valve 42 is rotated from its neutral position to thereby cause pump 16 to deliver liquid, it blocks the ends of channels 55 and 56 so that no liquid can escape from channel 55 into drain channel 57.

As previously explained, each winder motor is connected in series with a slitter motor and both slitter motors are connected to pump 16 in parallel with each other.

As shown, channel 27 is divided into two branches and connected to the inlets of slitter motors 20^a and 20^b the outlets of which are connected, respectively, by two channels 60^a and 60^b to the inlets of winder motors 15^a and 15^b. Since the slitter motors are mechanically synchronized and of the same size, the liquid discharged by pump 16 is equally divided between motors 15^a and 15^b by motors 20^a and 20^b.

In order that the winder motors may remain idle when the slitter motors are operating and in order that a brake load may be applied to each winder motor, two bypass and brake valves 61^a and 61^b are provided.

Valve 61^a has three ports 62^a, 63^a and 64^a formed in its casing and controlled by a valve member 65^a which is fitted in the casing, and valve 61^b has three ports 62^b, 63^b and 64^b formed in its casing and controlled by a valve member 65^b which is fitted in the casing. The casings of valves 61^a and 61^b have both ends thereof connected to drain channel 57 by channels 66^a and 66^b, respectively, to prevent the movement of valve members 65^a and 65^b from being hampered by gas or liquid entrapped in the ends of the valve casings.

Ports 62^a and 62^b are connected, respectively, by channels 67^a and 67^b to the outlets of motors 15^a and 15^b. Ports 63^a and 63^b are connected, respectively, by channels 68^a and 68^b to channels 60^a and 60^b intermediate the ends thereof. Ports 64^a and 64^b are connected by a branched channel 69 to one port of hydrodynamic machine 9 the other port of which has return channel 28 connected thereto.

When valves 61^a and 61^b are adjusted as shown in Fig. 1, each winder motor will have its inlet connected to its outlet so that the liquid discharged by pump 16 will not drive the winder motors but will flow through channel 27, motors 20^a and 20^b, channels 60^a and 60^b, channels 68^a and 68^b, valves 61^a and 61^b and channel 69 to hydrodynamic machine 9 and drive or tend to drive it as will presently be explained.

In order that valves 61^a and 61^b may cause a brake load to be applied to each of motors 15^a and 15^b, two relief valves 70^a and 70^b have the inlets thereof connected, respectively, to channels 67^a and 67^b and the outlets thereof connected, respectively, to channels 68^a and 68^b.

When motors 15^a and 15^b are running and valve members 65^a and 65^b are each shifted to

the position shown in Fig. 6, ports 62a and 62b will be blocked and the liquid discharge by motors 15a and 15b will be forced through relief valves 70a and 70b which resist the passage of liquid therethrough and thereby apply brake loads upon motors 15a and 15b.

During the winding operation, liquid is supplied to each of the winder motors at a substantially uniform rate and the strips are delivered to the winding shafts at a substantially uniform rate but, since the rewound rolls increase in diameter as the strips are wound thereon, it is necessary that each winding shaft be driven at a high speed when the roll thereon is small and that it be gradually decelerated as the roll thereon increases in diameter.

This is accomplished by delivering liquid to each winder motor at a rate in excess of the rate required to cause it to drive its winding shaft at the highest speed necessary, bypassing the excess liquid through a resistance valve and increasing the bypassing rate in accordance with the increase in the diameter of the roll on the winding shaft driven by that motor.

As shown, a resistance valve 71a and an orifice choke 72a are connected in series between channel 68a and channel 67a so that the liquid discharged by motor 20a into channel 60a in excess of the liquid required to drive motor 15a may flow from channel 60a through channel 68a, choke 72a and resistance valve 71a into channel 67a, and a resistance valve 71b and an orifice choke 72b are connected in series between channel 68b and channel 67b so that the liquid discharged by motor 20b into channel 60b in excess of the liquid required to drive motor 15b may flow from channel 60b through channel 68b, choke 72b and resistance valve 71b into channel 67b.

Since the tension on a strip being wound into a roll is determined by the diameter of the roll and the torque of the motor that drives it and since the torque of a constant stroke hydraulic motor is proportional to the drop in pressure across it, choke 72a is always so adjusted that it offers substantially no resistance to the relatively small volume of liquid that is bypassed when the diameter of roll 7a is smallest and resistance valve 71a is so adjusted that it causes the pressure in channels 68a and 60a to exceed the pressure in channel 67a by the amount necessary to cause motor 15a to exert the correct torque when roll 7a is of minimum diameter.

The particular machine chosen for illustration is ordinarily employed to slit and wind paper which requires that the paper be tightly wound near the cores of the rewound rolls and that the rolls gradually decrease in density toward the peripheries thereof, in which case choke 72a is fully opened, so that it does not offer any resistance at any time to the passage of liquid therethrough, and resistance valve 71a is adjusted as explained above so that the torque of motor 15a remains constant with the result that the tension on strip 3a gradually decreases as roll 7a increases in diameter. Consequently, roll 7a gradually decreases in density as it increases in diameter.

If it is desired that the density of the rewound roll be approximately uniform, the torque of the winding motor must be gradually increased as the rewound roll increases in diameter in order to maintain an approximately uniform tension upon the strip.

This may be accomplished by so adjusting choke 72a that, when roll 7a reaches its maximum diameter at which time liquid is being bypassed at the maximum rate, the resistance offered by choke 72a together with the resistance of resistance valve 71a is sufficient to enable motor 15a to exert upon strip 3a a tension at least as great as the desired tension.

Then when the diameter of roll 7a is minimum at which time liquid is being bypassed at the minimum rate, choke 72a will offer no resistance to flow of liquid therethrough and the tension on strip 3a will be determined solely by the resistance of resistance valve 71a.

As roll 7a increases in diameter, the rate at which liquid is bypassed will increase with the result that choke 72a will begin to offer resistance to the flow of liquid therethrough and this resistance will increase as the diameter of roll 7a and the bypassing rate increase, thereby causing the torque exerted by motor 15a to gradually increase with the result that the tension on strip 3a is maintained approximately constant.

Since that part of the drive connected to winding shaft 6b functions in exactly the same manner that the part of the drive connected to shaft 6a functions, resistance valve 71b and choke 72b are adjusted in the same manner that resistance valve 71a and choke 72a are adjusted.

While the drive may be adjusted to produce a desired tension on the strip both at the beginning and at the end of the winding operation, the tension will not remain constant throughout the winding operation due to the fact that the resistance of an orifice choke does not vary in proportion to the rate of flow therethrough. However, it is found in practice that the tension is maintained well within the limits ordinarily required.

If it is desired to maintain the tension more nearly constant due to the delicate nature of the material or for other reasons, an orifice choke may be connected in series with each winder motor as disclosed in Patent No. 2,082,473 and then that part of the drive connected to each winder motor would function as explained in that patent.

Bypassing liquid through resistance valves 71a and 71b and through chokes 72a and 72b causes heat to be generated. In order to prevent the liquid in the circuit from becoming overheated and to permit the escape of foreign matter therefrom, at least a part of the liquid discharged into channel 69 is expelled into reservoir 30 and liquid from reservoir 30 is supplied to channel 69 by gear pump 36.

As shown, channel 69 is connected through an orifice choke 75 to the inlet of a low pressure relief valve 76 the outlet of which is connected by a channel 77 to drain channel 57, and the outlet of resistance valve 38 is connected by channel 78 to channel 69 at a point between hydrodynamic machine 9 and the point at which channel 69 is connected to choke 75.

The arrangement is such that, when the drive is in operation, gear pump 36 is constantly supplying cool liquid to channel 69 at a given rate and heated liquid is being expelled from channel 69 through choke 75, relief valve 76 and channel 77 into drain channel 57 at substantially the same rate.

Relief valve 76 is adapted to open at a predetermined pressure, for instance 70# per square inch, and choke 75 is so proportioned that it causes a predetermined drop in pressure, for instance 30# per square inch, between channel 69 and relief valve 76. Consequently, gear pump 36

is enabled to maintain in channel 69 a pressure equal to the combined resistances of choke 75 and relief valve 76, for instance 100# per square inch.

Resistance valve 38 is adapted to open at a pressure, for instance 85# per square inch, which is lower than the pressure maintained in channel 69 due to the resistances of choke 75 and relief valve 76, and it is unaffected by back pressure so that, when gear pump 36 has created in channel 69 a pressure equal to the combined resistances of choke 75 and relief valve 76, resistance valve 38 will remain wide open and consequently have no effect upon the pressure. The function of resistance valve 38 is to assure that there will be at all times sufficient pressure for operating stroke changing servo-motors 32—33 and 34—35.

If hydrodynamic machine 9 should fail to start, all the liquid discharged into channel 69 would be forced through choke 75 and relief valve 76, and this large volume of liquid would cause a large drop in pressure across choke 75 with a corresponding large increase in the pressure in channel 69, thereby enabling hydrodynamic machine to start.

In order to protect gear pump 36 from excessive pressures, there is provided a relief valve 79 which is adapted to open at a pressure higher than the pressure normally maintained in channel 69. Relief valve 79 is ordinarily arranged within the casing of pump 16 as is customary but, for the purpose of illustration, it has been shown as having its inlet connected to channel 69 and its outlet connected to channel 77.

The pressure prevailing in channel 69 in excess of the pressure prevailing in return channel 28 causes hydrodynamic machine 9 to exert upon unwind shaft 1 a rotative force which is determined by this pressure differential and by the displacement of hydrodynamic machine 9.

The drop in pressure across hydrodynamic machine 9 is controlled by a resistance valve 80 having its outlet connected to return channel 28 and its inlet connected to channel 78 and controlled by a valve member 81 which is fitted in a bore 82 formed in the valve casing. Valve member 81 is adapted to be urged toward its seat by liquid supplied to bore 82 and it is continuously urged toward its seat by a spring 83 which is arranged in bore 81 and adapted to permit resistance valve 80 to open under a low pressure, for instance 15# per square inch.

Application of pressure to valve member 81 is under the control of a valve member 84 which is fitted in a valve casing 85 having two annular ports 86 and 87 formed therein and connected, respectively, by a channel 88 to channel 69 and by a channel 89 to bore 82. Valve member 84 controls communication between ports 86 and 87 and between port 87 and a channel 90 which connects both ends of valve casing 85 to drain channel 57.

When valve member 84 is in the position shown in Fig. 1, bore 82 is open to drain channel 57 through channel 89, valve casing 85 and channel 90 so that the pressure in bore 82 is zero and valve member 81 is urged towards its seat solely by spring 83.

When valve member 84 is shifted to the position shown in Fig. 7, pressure extends from channel 69 through channel 88, valve casing 85 and channel 89 to bore 82 so that valve member 81 is urged to its seat by the force of spring 83 and by a force proportional to the pressure prevailing in channel 69.

The displacement of hydrodynamic machine 9 is adjusted in response to a variation in the linear speed of paper 3 relative to the speed of slitter 4—5. This is accomplished by driving a control pump at a speed proportional to the linear speed of paper 3, driving a second control pump at a speed proportional to the speed of slitter 4—5, connecting the two control pumps in series, and operating the stroke control mechanism of hydrodynamic machine 9 in response to the volumetric output of one control pump varying relative to the volumetric output of the other control pump.

As shown, a small control pump 95 is connected by a drive 96 to slitter motor 20^b so that it is driven at a speed proportional to the speed of slitter 4—5, and a second small control pump 97 is connected by a drive 98 to a roller 99 which is driven by paper 3.

It is ordinarily desirable that slitter 4—5 operate at speed which is a certain amount, for instance 20%, faster than the speed of paper 3 in order that it may operate efficiently upon paper 3. Therefore, drives 96 and 98 are so proportioned that the two control pumps will discharge liquid at the same rate when paper 3 is being unwound from roll 2 at the desired rate relative to the speed of slitter 4—5, the slitter speed being determined by the displacement of pump 16 for the reason that slitter motors 20^a and 20^b are connected directly to the outlet of pump 16 by channel 27.

Control pump 95 has its outlet connected by a channel 100 to the inlet of control pump 97 and its inlet connected by a channel 101 to the outlet of pump 97, and two oppositely opening low pressure relief valves 102 and 103 are connected between channels 100 and 101 to protect pumps 95 and 97 from excessive pressures.

Channel 101 is connected intermediate its ends to the stroke adjusting servo-motor 10 of hydrodynamic machine 9 by a channel 104 and to gear pump supply channel 37 by a channel 105 so that channel 101 is supplied with liquid at gear pump pressure and slide block 12 is urged toward full stroke position by servo-motor 10 with a force proportional to gear pump pressure.

Channel 105 is also connected by a channel 106 to the inlet of a check valve 107 which has its outlet connected to channel 27 so that, when the displacement of pump 16 is reduced to zero to stop the machine, gear pump 36 may supply liquid to motors 20^a and 20^b until the machine comes to rest.

Channel 100 is connected intermediate its ends by a channel 108 to the outlet of a check valve 109 the valve member of which has a small hole drilled therethrough, the inlet of check valve 109 is connected by a channel 110 to the inlet of a choke 111 the outlet of which has channel 55 connected thereto, and channel 110 is connected intermediate its ends by a channel 112 to the stroke changing servo-motor 11 on hydrodynamic machine 9.

The arrangement is such that, when pump 16 is at zero stroke at which time passage 54 in pump control valve 42 (Figs. 3 and 4) connects channel 55 to channel 56, liquid from gear pump 36 may flow through channels 37, 105, 101 and 104 to servo-motor 10 and cause it to move slide block 12 to the right until the displacement of hydrodynamic machine 9 is maximum, and liquid is expelled from servo-motor 11 through channels 112 and 110, choke 111, channel 55, passage 54 and channel 56 into drain channel 57.

When pump 16 is adjusted to deliver liquid to drive the motors at which time pump control valve 42 blocks the end of channel 55 so that no liquid can escape therefrom, pump 95 will draw liquid from channel 101 and discharge it into channel 100 and thereby equalize the pressures in channels 100 and 101, and pump 97 will draw liquid from channel 100 and discharge it into channel 101.

If the paper is moving at the correct speed relative to the speed of slitter 4—5, pump 97 will draw liquid from channel 100 at the same rate that pump 95 discharges liquid into channel 100. Consequently, the pressure in channel 100 will be the same as the pressure in channel 101 and this pressure will prevail in both of servo-motors 10 and 11 so that slide block 12 remains stationary.

If paper 3 is moving at too slow a rate, pump 95 will discharge liquid into channel 100 faster than pump 97 draws liquid therefrom, thereby causing the pressure in channel 100 to rise and extend through channel 108, the drilled hole in check valve 109, and channels 110 and 112 to servo-motor 11 and cause it to shift slide block 12 towards the left to decrease the displacement of hydrodynamic machine 9 and thereby increase the speed of the paper 3.

If paper 3 is moving at too fast a rate, pump 97 will draw liquid from channel 100 faster than pump 95 supplies liquid thereto, thereby causing the pressure in channels 100, 108, 110 and 112 and in servo-motor 11 to drop so that servo-motor 10 is enabled to shift slide block 12 towards the right to increase the displacement of hydrodynamic machine 9 and thereby decrease the speed of paper 3.

Since motors 20^a and 20^b have the inlets thereof connected directly to the outlet of pump 16 so that the speed of slitter 4—5 is determined by the displacement of pump 16, since winding shafts 6^a and 6^b can wind strips thereon only as fast as the strips are delivered thereto, since the outlet of hydrodynamic machine 9 is connected by channel 28 to the inlet of pump 16 so that hydrodynamic machine 9 cannot discharge liquid at a rate in excess of the rate required to supply pump 16, and since the displacement of hydrodynamic machine 9 is adjusted in response to a variation in the speed of paper 3 relative to the speed of slitter 4—5, it follows that the speed of the entire machine is determined by the displacement of pump 16.

Operation

Assuming that the several parts of the drive are in the positions shown in Fig. 1, that a parent roll 2 of paper 3 is fixed upon unwind shaft 1, that pumps 16 and 36 are running and that pump 16 is at zero stroke, the drive will function as follows:

Gear pump 36 will draw liquid from reservoir 30 and discharge it through channel 37, resistance valve 38, channels 78 and 69, choke 75, relief valve 76 and channel 77 into drain channel 57, thereby creating in all of channels open to the gear pump a predetermined pressure, for instance 100# per sq. in.

Pump 16 being at zero stroke, the drive is idle and servo-motor 11 is open to drain channel 57 through passage 54 in valve 42 so that slide block 12 of hydrodynamic machine 9 is held in its maximum displacement position by gear pump pressure prevailing in servo-motor 10 as previously explained.

In order to unwind paper from roll 2, pump control valve 42 (Fig. 3) is rotated through a small angular distance to cause pump 16 to discharge liquid at a limited rate into channel 27 and thereby cause slitter 4—5 to operate at a slow speed, but valve 42 is not rotated far enough to completely block the end of channel 55.

As soon as pump 16 starts to deliver liquid into channel 27, it draws liquid from channel 28 and thereby causes resistance valve 80 to create between channel 69 and channel 28 a predetermined pressure differential, for instance 15# per sq. in., which is not sufficient to cause hydrodynamic machine 9 to drive unwind shaft 1 but which is sufficient to overcome the greater part of the friction in hydrodynamic machine 9 and in drive 8 so that paper 3 may be easily unwound from roll 2 by hand.

If it is desired to drive parent roll 2, valve member 84 may be shifted to the position shown in Fig. 7 so that resistance valve 80 is held closed by gear pump pressure. Then when pump 16 delivers liquid into channel 27 and draws liquid from channel 28, the pressure differential between channels 69 and 28 will be equal to gear pump pressure which is sufficient to cause hydrodynamic machine 9 to drive unwind shaft 1 and thereby cause paper to be unwound from roll 2.

The paper pulled from or delivered by roll 2 is led around roller 99, then led through slitter 4—5 which trims and slits it into two strips 3^a and 3^b, and then the ends of the strips are fastened to suitable cores fixed upon winding shafts 6^a and 6^b respectively. With bypass valves 61^a and 61^b adjusted as shown in Fig. 1, winding shafts 6^a and 6^b may be easily rotated by hand.

To cause the machine to operate at high speed, pressure control valve 84—85 is adjusted as shown in Fig. 7, bypass valves 61^a and 61^b are adjusted to block channels 68^a and 68^b but leaving channels 67^a and 67^b in communication with channel 69 as shown in Fig. 5 and lever 53 is operated to rotate valve 42 (Fig. 3) through a sufficient angular distance to block channel 55 and to cause pump 16 to discharge liquid at the rate necessary to cause motors 20^a and 20^b to drive slitter 4—5 at the desired speed.

When valve 84—85 is adjusted, gear pump pressure will hold resistance valve 80 closed. When valves 61^a and 61^b are adjusted, the liquid discharged by slitter motors 20^a and 20^b will cause winder motors 15^a and 15^b to rotate shafts 6^a and 6^b to wind strips 3^a and 3^b thereon as fast as the strips are delivered thereto, and the liquid discharged by the slitter motors in excess of the liquid required by the winder motors will be bypassed through resistance valves 71^a and 71^b which will cause the winder motors to maintain a predetermined tension on the strips as previously explained.

Pump 16 will draw liquid from channel 28 at the same rate that it discharges liquid into channel 27, thereby permitting the liquid flowing through channel 69 at gear pump pressure to energize hydrodynamic machine 9 and cause it to rotate parent roll 2.

Hydrodynamic machine 9 being at full stroke, it will not unwind paper 3 from roll 2 at a speed proportional to the speed of slitter 4—5. Consequently, control pump 95 will discharge liquid into channel 100 faster than control pump 97 draws liquid therefrom so that, channel 55 having been blocked when valve 42 was rotated to

increase the displacement of pump 16, the additional liquid discharged by pump 95 into channel 100 will flow through channels 108 and 112 to servo-motor 11 and cause it to decrease the displacement of hydrodynamic machine 9 with a resultant acceleration of roll 2 until the paper is being unwound therefrom at the correct speed relative to the speed of slitter 4—5 at which time control pump 97 is drawing liquid from channel 100 at the same rate that pump 95 supplies liquid thereto and then further rapid adjustment of hydrodynamic machine 9 will cease.

As roll 2 decreases in diameter, its peripheral speed decreases relative to its rotary speed. Since the speed of paper 3 is the same as the peripheral speed of roll 2, this decrease in speed causes pump 97 to tend to run slower than pump 95 so that pump 95 continuously delivers into channel 100 minute quantities of liquid in excess of the liquid drawn therefrom by pump 97, and these minute quantities cause the displacement of hydrodynamic machine 9 to be gradually reduced in the above described manner with the result that roll 2 is gradually accelerated as it decreases in diameter so that paper 3 is delivered to the winding shafts at a substantially uniform rate.

If the pull on paper 3 is not sufficient to rotate roll 2, hydrodynamic machine 9 will exert sufficient torque to drive it and, if the pull on paper 3 is more than sufficient to rotate roll 2, hydrodynamic machine 9 will retard the rotation thereof for the reason that it cannot discharge liquid into channel 28 any faster than pump 16 draws liquid therefrom. Consequently, paper 3 is unwound at a substantially uniform rate regardless of the pull thereon.

To stop the machine, lever 53 is gradually rotated to reduce the displacement of pump 16 to zero. Since hydrodynamic machine 9 cannot discharge liquid into channel 28 any faster than pump 16 draws liquid therefrom, reducing the displacement of pump 16 to zero causes hydrodynamic machine 9 and roll 2 to be decelerated to a complete stop and the pull on paper 3 gradually stops the winding shafts and winder motors.

If the displacement of pump 16 should be suddenly reduced to zero, the pressure in channel 28 would become high enough to cause liquid to be expelled through foot valve 31 which would exert a heavy brake load on hydrodynamic machine 9 and thereby quickly bring it to rest.

The inertia of slitter 4—5 may drive motors 20^a and 20^b which, as winder motors 15^a and 15^b slow down, must exhaust increasing volumes of liquid through resistance valves 71^a and 71^b which quickly decelerates the slitter. During deceleration of the slitter, motors 20^a and 20^b are supplied with liquid from channel 105 through channel 106 and check valve 107.

If the strip attached to one winding shaft should break during the winding operation, the bypass valve 61^a or 61^b associated with the motor that drives that shaft would be shifted to the position shown in Fig. 6, thereby quickly stopping that winding shaft, and the displacement of pump 16 would be reduced to zero to stop the balance of the machine as previously explained.

If too much paper should be unwound from roll 2, pump control valve 42 may be rotated in a direction to cause pump 16 to discharge into channel 28 in which case hydrodynamic machine 9 would be energized and drive shaft 1 in a direction to wind up the excess paper but the winder motors and the slitter motors would not be energized.

The invention herein set forth is susceptible of various modifications and adaptations without departing from the scope thereof as hereafter claimed.

The invention is hereby claimed as follows:

1. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon said material, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, and means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform.

2. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon said material, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means for adjusting the dis-

placement of said pump from zero to maximum to thereby regulate the speeds of said shafts, and means responsive to the displacement of said pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum.

3. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon said material, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

4. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon said material, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means for adjusting the displacement of said pump from zero to maximum to thereby regulate the speed of said shaft, means responsive to the displacement of said pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

5. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon such material, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said motor and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, and means responsive to the linear speed of said material varying relative to the rate at which said variable pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform.

6. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon such material, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of

said machine, means for directing the liquid discharged by said motor and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said variable pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, and means responsive to the displacement of said variable pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum.

7. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a winding shaft, and means for fixing the end of said material for rotation with said winding shaft, of a hydraulic motor for rotating said winding shaft to cause it to wind said material into a new roll, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motor at a uniform rate in excess of the rate required to cause said motor to drive said winding shaft at a speed sufficient to wind up said material as fast as it is unwound from said parent roll, means for bypassing the liquid discharged by said pump in excess of the liquid required by said motor including a resistance to enable said motor to maintain tension upon such material, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said motor and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said variable pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means responsive to the displacement of said variable pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

8. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speed sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, and means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform.

9. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby,

a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, and means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

10. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means for adjusting the displacement of said pump from zero to maximum to thereby regulate the speeds of said shafts, and means responsive to the displacement of said pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum.

11. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially contant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the rate at which said pump discharges liquid for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means for adjusting the displacement of said pump from zero to maximum to thereby regulate the speeds of said shafts, means responsive to the displacement of said pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

12. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby,

a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, a control pump driven by said slitter, a second control pump driven by said material at a speed proportional to the linear speed thereof, and means responsive to the speed of one control pump varying relative to the speed of the other control pump for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform.

13. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, a control pump driven by said slitter, a second control pump driven by said material at a speed proportional to the linear speed thereof, means responsive to the speed of one control pump varying relative to the speed of the other control pump for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, and means for varying the drop in pressure across said machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

14. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a hydrodynamic machine mechanically connected to said unwind shaft, means for supplying liquid at a predetermined pressure to the inlet of said machine to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, a normally closed channel connecting the outlet of said machine to the intake of said pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, a control pump driven by said slitter, a second control pump driven by said material at a speed proportional to the linear speed thereof, means responsive to the speed of one control pump varying relative to the speed of the other control pump for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means for adjusting the displacement of said pump from zero to maximum to thereby regulate the speed of said slitter, and means responsive to the displacement of said pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum.

15. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means including a resistance for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, said resistances enabling said winder motors to maintain tension upon such strips, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said winder motors and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said chan-

nel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, and means responsive to the linear speed of said material varying relative to the speed of said slitter for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform.

16. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means including a resistance for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, said resistances enabling said winder motors to maintain tension upon such strips, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said winder motors and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the speed of said slitter for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, and means responsive to the displacement of said variable pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum.

17. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means including a resistance for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, said resistances enabling said winder motors to maintain tension upon such strips, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said winder motors and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, means responsive to the linear speed of said material varying relative to the speed of said slitter for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, means responsive to the displacement of said variable pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

18. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said

motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means including a resistance for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, said resistances enabling said winder motors to maintain tension upon such strips, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said winder motors and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, a control pump driven by said slitter, a second control pump driven by said material at a speed proportional to the linear speed thereof, and means responsive to the speed of one control pump varying relative to the speed of the other control pump for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform.

19. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means including a resistance for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, said resistances enabling said winder motors to maintain tension upon such strips, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said winder motors and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, a control pump driven by said slitter, a second control pump driven by said material at a speed proportional to the linear speed thereof, means responsive to the speed of one control pump varying relative to the speed of the other control pump for adjusting said displacement varying means to thereby maintain the speed of said material substantially uniform, and means responsive to the displacement of said variable pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum.

20. The combination, with an unwind shaft, means for fixing a parent roll of web material upon said shaft, a slitter for slitting said material into a plurality of strips, a winding shaft for each strip, and means for fixing the end of each strip to one of said winding shafts to rotate therewith, of a plurality of hydraulic winder motors each individual to a winding shaft for rotating said winding shafts to cause said strips to be wound thereon, a plurality of mechanically synchronized hydraulic slitter motors connected to said slitter to drive the same and of a number equal to the number of winder motors, a variable displacement pump driven at a substantially constant speed and adapted to deliver liquid to said motors at a uniform rate in excess of the rate required to cause said winder motors to drive said winding shafts at speeds sufficient to wind up said strips as fast as they are delivered to said winding shafts, said slitter motors being connected to said pump in parallel with each other and each of said winder motors being connected in series with a slitter motor, means including a resistance for bypassing around each of said winder motors the liquid delivered thereto in excess of the liquid required thereby, said resistances enabling said winder motors to maintain tension upon such strips, a hydrodynamic machine mechanically connected to said unwind shaft, a fluid channel connected to the inlet of said machine, means for directing the liquid discharged by said winder motors and the bypassed liquid into said channel, an auxiliary pump for delivering liquid into said channel, resistance means for permitting liquid to escape from said channel to enable said auxiliary pump to change at least a part of the liquid therein and to maintain therein sufficient pressure to cause said machine to drive said unwind shaft and thereby cause said material to be unwound from said parent roll, a normally closed channel connecting the outlet of said machine to the intake of said variable pump whereby said machine cannot discharge liquid in excess of the liquid consumed by said variable pump, means for varying the displacement of said machine to thereby vary the speed of said unwind shaft, a control pump driven by said slitter, a second control pump driven by said material at a speed proportional to the linear speed thereof, means responsive to the speed of one control pump varying relative to the speed of the other control pump for adjusting said displacement varying

means to thereby maintain the speed of said material substantially uniform, means responsive to the displacement of said variable pump being reduced to zero for causing said machine displacement varying means to increase the displacement of said machine to a predetermined maximum, and means for varying the drop in pressure across said hydrodynamic machine to thereby enable said machine to either rotate said parent roll or to exert sufficient torque to permit said material to be unwound by hand.

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