

Aug. 3, 1926.

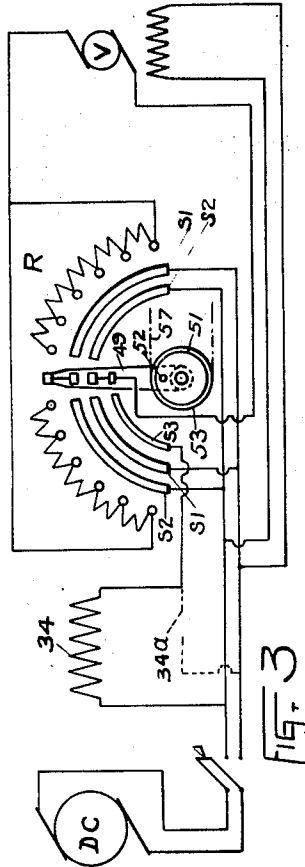
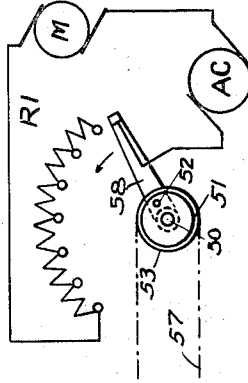
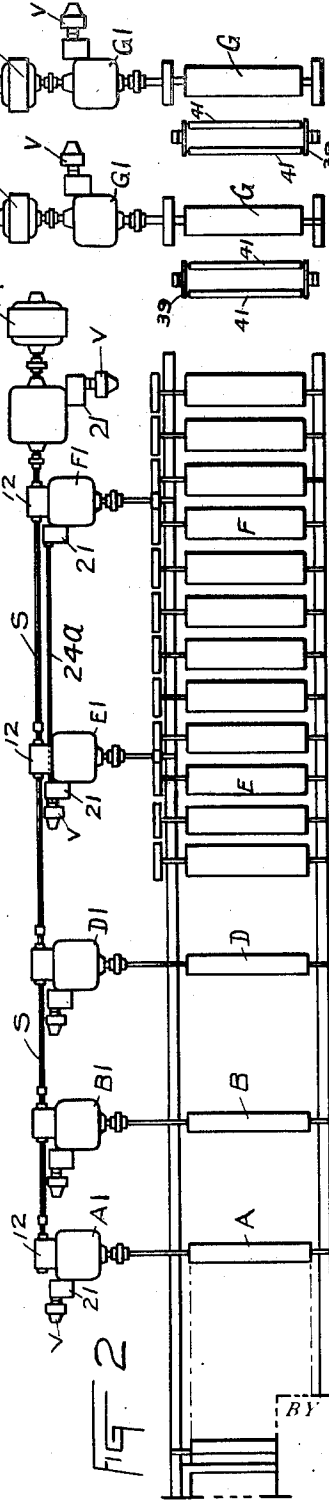
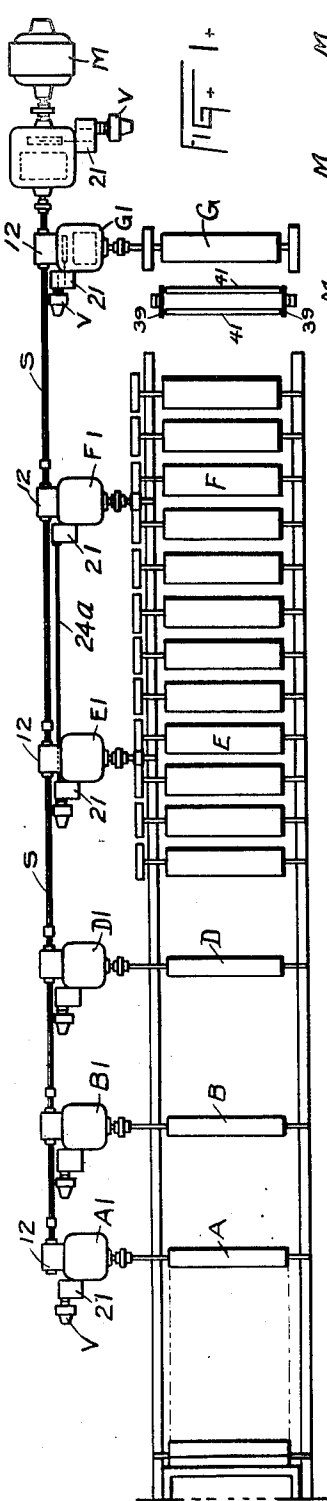
1,594,395

M. T. WESTON

VARIABLE SPEED DRIVING MECHANISM

Filed April 17, 1925

4 Sheets-Sheet 1



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VARIABLE SPEED DRIVING MECHANISM

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4 Sheets-Sheet 2

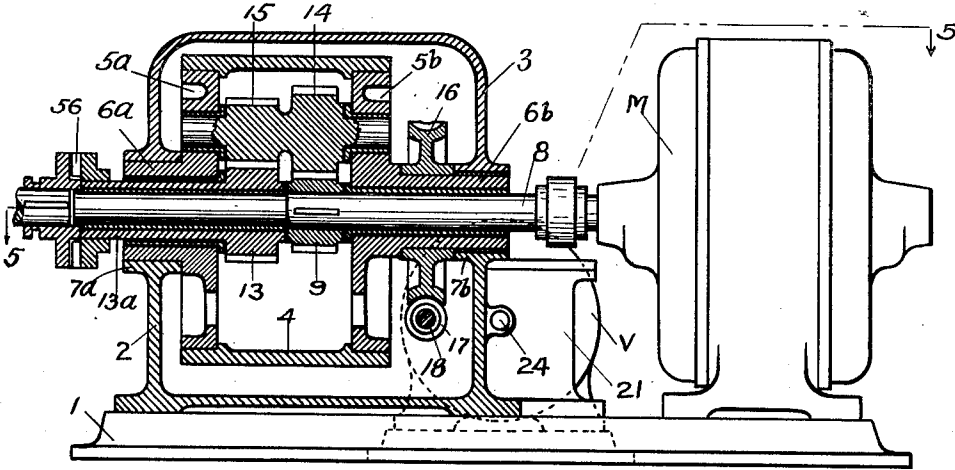


FIG. 4

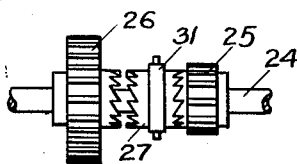


FIG. 16

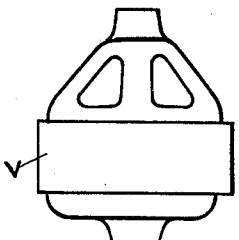


FIG. 5

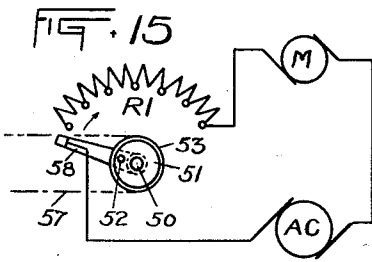


FIG. 15

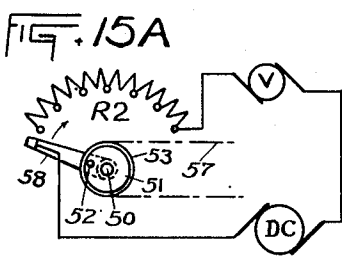
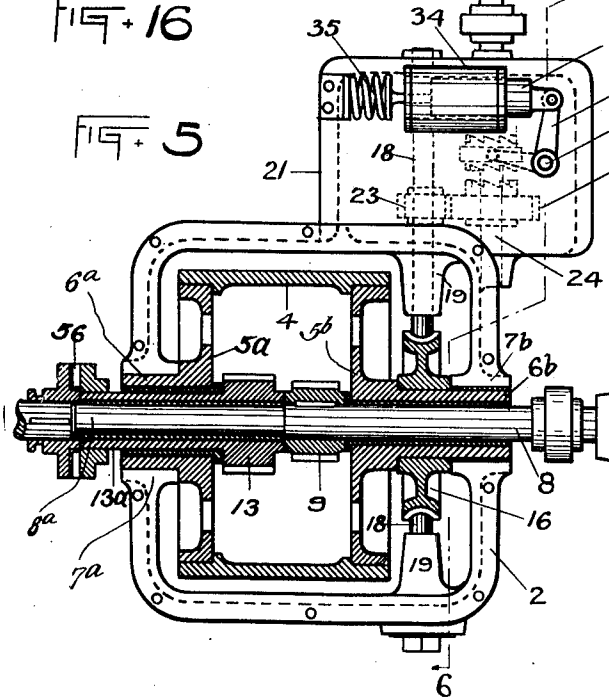


FIG. 15A



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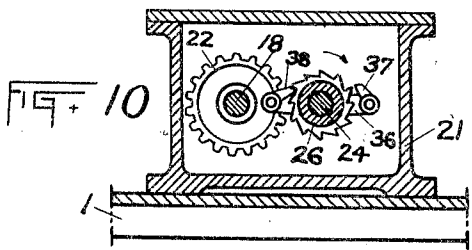
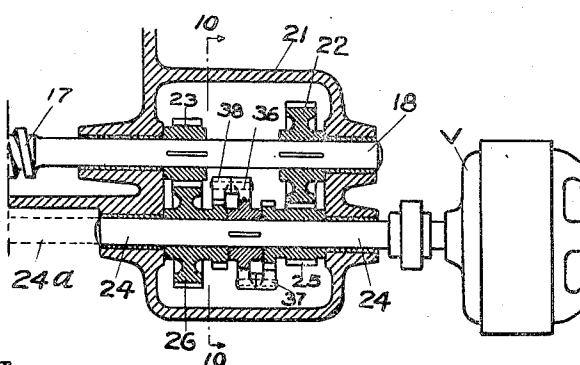
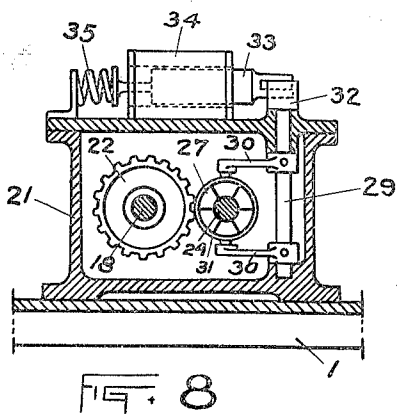
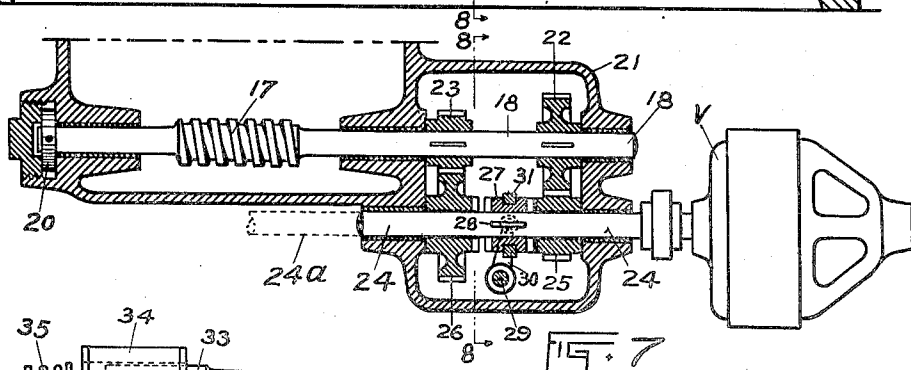
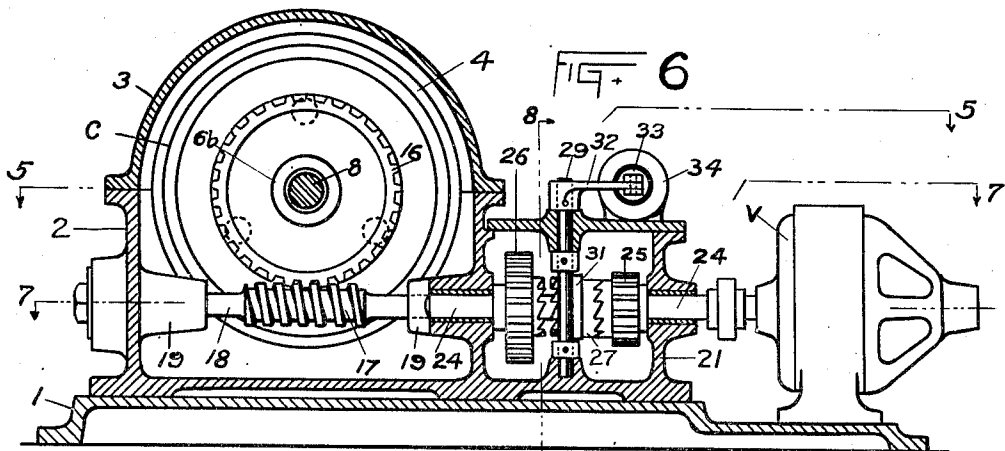
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M. T. WESTON

VARIABLE SPEED DRIVING MECHANISM

Filed April 17, 1925

4 Sheets-Sheet 3



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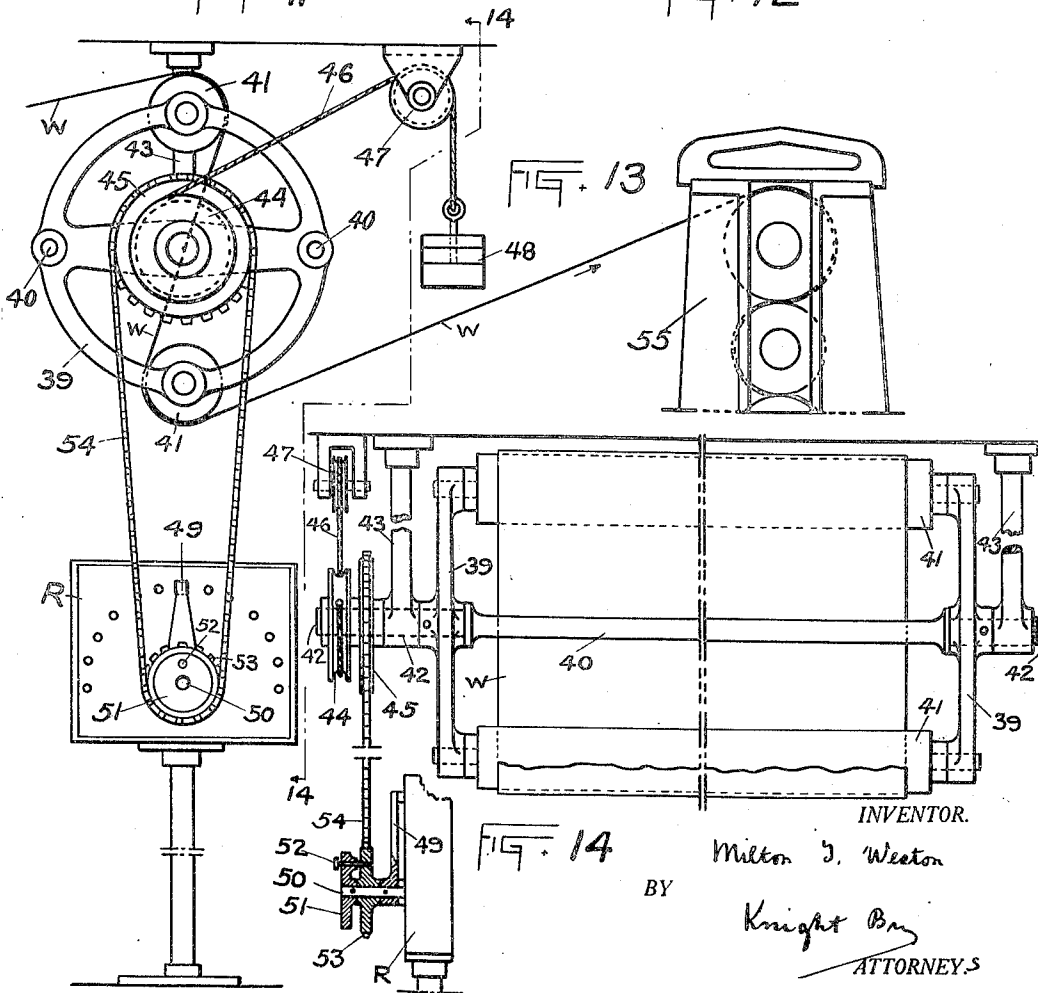
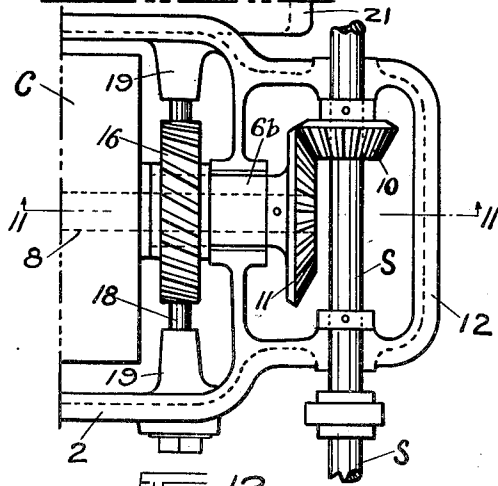
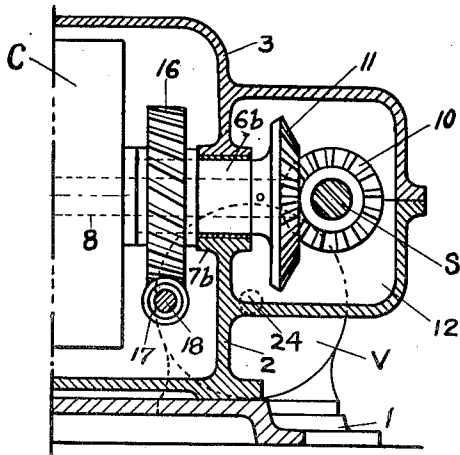
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1,594,395

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VARIABLE SPEED DRIVING MECHANISM

Filed April 17, 1925 4 Sheets-Sheet 4



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# UNITED STATES PATENT OFFICE.

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VARIABLE-SPEED DRIVING MECHANISM.

Application filed April 17, 1925. Serial No. 23,835.

This invention relates more especially to variable speed mechanisms for driving paper making machines and has for its primary object of improved construction whereby a machine of this character can be more simply constructed, more economically operated, and by means of which a more effective control of the machine may be had than is possible in paper making machines of well known type at the present time.

One of the objects of the present invention is to provide an improved variable speed drive whereby the relation between the several sections of a paper making machine may be adjusted to an extreme degree of precision. My invention further contemplates improved positively geared variable speed mechanism whereby one or more sections of a paper making machine may be gradually accelerated in such a manner as to apply the load little by little without throwing an undue burden upon the prime mover at any instant. More specifically stated, my invention in its adaptation to a paper making machine, contemplates starting and driving mechanism of improved construction and arrangement whereby it becomes possible to accelerate one or more sections of a machine of this nature from a shaft or motor rotating at substantially constant speed. For this purpose, I prefer to employ a synchronous motor which by reason of its steady running at constant speed can thus be rendered peculiarly serviceable in connection with paper making machinery.

My invention contemplates variable speed mechanism which is operated in one direction only, or variable speed mechanism which may be operated in either of two opposite directions whereby a machine or machine part driven thru said variable speed mechanism, may have its speed regulated with precision between varying speed limits. Further my invention contemplates variable speed mechanism which is adapted to be operated with changing rates of acceleration or retardation.

More specifically stated, an object of invention resides in the provision of an improved variable speed mechanism whereby a variable speed may be superimposed upon either of a plurality of normal fixed speeds. Such variable speed may be superimposed by operating the variable speed mechanism in

either a forward or reverse direction as referred to the direction of rotation of the operating governor shaft of said mechanism. Thus, according to the embodiment of my invention hereinafter described, "reverse direction" refers to that direction in which the differential cage C is rotated when it is moving counterwise to the governor shaft 8 or the motor 7 which drives it.

In a general way, the present invention contemplates the improved variable speed mechanism per se in its adaptations to the variable driving of one or more machine sections or parts to which a device of this character may be applicable.

Other and further objects of invention will appear in the specification and be pointed out in the appended claims.

The accompanying drawings show an adaptation of my invention to a paper making machine in which—

Figure 1 is a top plan view of a preferred embodiment of my improved differential driving mechanism, shown in its adaptation to the several sections of a paper making machine;

Figure 2 is a similar top plan view of another embodiment of my invention;

Figure 3 is a wiring diagram for the control of reversible variable speed motors in conjunction with a main drive motor.

Figure 4 is a vertical longitudinal section on an enlarged scale of one of the differential units, parts being shown in elevation;

Figure 5 is a combined horizontal section and plan view corresponding to the line 5—5 of Figure 6;

Figure 6 is a combined transverse section and elevation corresponding to the line 6—6 of Figure 5;

Figure 7 is a horizontal section corresponding to the line 7—7 of Figure 6, parts being shown in plan;

Figure 8 is a vertical section corresponding to the line 8—8 of Figures 6 and 7, parts being shown in elevation;

Figure 9 is a horizontal section similar to Figure 7 and showing a modified construction of the clutch mechanism;

Figure 10 is a section on the line 10—10 of Figure 9;

Figure 11 is a fragmentary vertical section corresponding to the line 11—11 of Figure 12 of one of the differential mechanisms showing the gearing connections with the

main power shaft, parts being shown in elevation;

Figure 12 is a top plan view of the same;

Figure 13 is a side elevation on an enlarged scale of one of the web control mechanisms for varying the speed of a variable speed motor;

Figure 14 is a front elevation of the same corresponding to the line 14—14 of Figure 13, parts being broken away and parts shown in section;

Figures 15 and 15<sup>a</sup> show a modified wiring diagram of the direct non-reversing control of the variable speed motors; and

Figure 16 is a detached plan view of the non-reversing dual speed clutch.

The underlying principles of my invention will be understood from the following description of an adaptation thereof to a paper making machine, the essential features of my invention being set forth in the appended claims.

In my copending application, Serial No. 649,938, filed July 6, 1923, I have shown a power shaft S driven by a motor M which preferably operates with a direct current.

In machines of this nature, it is necessary to have variable speed mechanism for varying the speed of the paper machine to suit the particular grade of paper which happens to be passing thru the machine at any given moment. The present practice is to use a single direct current motor for mechanical drives and individual sectional direct current motors in all electrical systems. This makes necessary the employment of heavy and expensive control equipment because all of the current required to drive the entire paper machine must pass through the control apparatus. Furthermore, where alternating current is used elsewhere in the plant it is necessary to install a motor generator set of sufficient size to furnish the full amount of direct current required to drive the entire machine. This motor generator set and its control equipment is not only very expensive but entails a current loss of about 15% in the conversion process.

My present application contemplates the use of a constant speed driving motor M which may take its current direct from the power house without conversion. I prefer a synchronous alternating current motor because of its power factor corrective features which make it very desirable from the viewpoint of the operating engineer. Since it runs at a constant speed it is not necessary to provide complicated control apparatus for it—a starter being all that is necessary. For the same reason it is not necessary to convert the current it uses, consequently the large motor generator set is eliminated as well as the current conversion loss. However, the small variable speed motors *v* require a relatively small amount of direct

current—in practice about 1/10 to 1/20 of the amount required by the main driving motors in either the mechanical or electrical systems. Obviously the control apparatus for such a small amount of current will be relatively simple and inexpensive and in case current conversion is necessary the motor generator set and its control apparatus will be correspondingly small and inexpensive. Other advantages of my present application such as the entire elimination of the cumbersome, unreliable and expensive friction clutches and belts and the ability to control the speed of the entire machine, either as a whole or in units, from 0 to full speed are described and pointed out in the specifications.

#### *Description.*

In carrying out my present invention I provide a base 1 on which is mounted a casing 2, having a removable cover 3. In the casing 2 is mounted a revoluble cage C comprising a cylindrical shell 4 and two end discs 5<sup>a</sup> and 5<sup>b</sup> secured in opposite ends of the said cylindrical shell. Each of the end discs 5<sup>a</sup> and 5<sup>b</sup> has a hollow trunnion 6<sup>a</sup> and 6<sup>b</sup> projecting axially and mounted to revolve in suitable bearings 7<sup>a</sup> and 7<sup>b</sup> in the casing 2. A driving shaft 8 is mounted to revolve in the hollow bore of the trunnion 6<sup>a</sup> and carries a driving pinion 9 keyed to it inside the cage C.

In Figures 4, 5 and 6, I show the driving shaft 8 directly connected to the relatively large motor M, preferably of the synchronous or constant speed type, mounted on the base 1. In Figures 11 and 12, I show the shaft 8 driven by a continuous power shaft S by means of a bevel pinion 10 mounted on said shaft and meshing with bevel gear 11 mounted on the driving shaft 8. The bevel pinion 10 and bevel gear 11 are shown in an extension 12 to the casing 2.

Mounted in the cage 2 is a driven gear 13 adjacent to and in axial alignment with the driving pinion 9 and driving shaft 8. The driven gear 13 is provided with an extended sleeve hub 13<sup>a</sup> as shown clearly in Figures 4 and 5, the said sleeve hub 13<sup>a</sup> being adapted to revolve in the hollow trunnion 6<sup>a</sup> of the end disc 5<sup>a</sup>. Parallel to the axis of the cage C and spaced at equal distances therefrom are the three cluster gears 14 and 15 (only one being shown) which are mounted to revolve in suitable bearings in the end discs 5<sup>a</sup> and 5<sup>b</sup> as clearly shown in the views above referred to. In operation, the driving pinion 9 meshes with cluster gear 14, and cluster pinion 15 meshes with driven gear 13. This construction which is substantially the same as in my copending application, Serial No. 649,938, filed July 6, 1923, functions as a simple speed reducer when the cage C is held so as not to revolve—that is, the ex-

tended sleeve hub 13<sup>a</sup> will have a fixed reduced speed with respect to the driving shaft 8. Revolving the cage in either direction, however, introduces a variation in the speed of the sleeve hub 13<sup>a</sup> with respect to its normal reduced speed when the cage is fixed. When the cage C is revolved in the same direction as the driving shaft 8 the speed of the sleeve hub 13<sup>a</sup> is increased at a rate which is proportional to the speed of the cage. When the cage C is revolved in the direction opposite to the direction of rotation of the driving shaft 8, the speed of the sleeve hub 13<sup>a</sup> will be reduced in proportion to the speed of the cage. When a certain speed of counter rotation of the cage C is reached, the sleeve hub 13<sup>a</sup> will remain stationary and any further increase in the speed of counter rotation will cause the sleeve hub 13<sup>a</sup> to revolve backward, that is, opposite to its normal direction of rotation. I take advantage of this principle in the manner to be described and illustrated hereinafter.

I control the revolution of the cage C in the following manner: A worm wheel 16 is mounted on and keyed to the trunnion 6<sup>b</sup> and meshes with a worm 17, mounted on a transverse shaft 18 adapted to revolve in suitable bearings 19 in the casing 2. A collar 20 (see Figure 7) secured to the worm shaft 18 takes the thrust of the worm 17 in either direction. The worm shaft 18 is shown projecting through the casing 2 into a gear box 21 which is shown attached to the casing 2 but which may be separately mounted on the base 1 if desired. On the worm shaft 18, within the gear box 21, is keyed a relatively large gear 22 and a relatively small pinion 23. Spaced from the worm shaft 18 and parallel to it, within the gear box 21, is a shaft 24, the outer end of which is shown coupled to a relatively small variable speed direct current motor *v* which is mounted on the base 1. On the shaft 24, within the gear box 21, are mounted a pinion 25 meshing with gear 22 and a gear 26 meshing with pinion 23. Both pinion 25 and gear 26 are free to revolve on the shaft 24 and, in Figures 7 and 8, each is provided with a spiral jaw clutch hub adapted to be alternately engaged by the mating spiral jaw clutch member 27 slidable axially on the shaft 24 and caused to rotate with same by the key 28. The mating spiral jaws are so designed that the rotation of the shaft in one direction will cause the pinion 25 to be driven by the clutch member 27 as shown in Figure 6. When the shaft 24 is revolved in the opposite direction the clutch member 27, when brought into engagement with spiral jaw hub of the gear 26, will cause the said gear 26 to revolve with it.

The spiral jaw clutch member 27 is moved axially in the following manner as shown in Figures 7 and 8. A vertical rocker shaft

29 is mounted in the gear box 21 and carries the two lever arms 30 which engage the clutch ring 31 on the slidable jaw members 27. Rocking the shaft 29 will therefore cause the sliding jaw member 27 to engage either the pinion 25 or the gear 26 alternately. On the projecting end of the rocker shaft 29 is a lever arm 32, the outer end of which is attached to the core 33 of a solenoid 34. A compression spring 35 normally forces the core 33 outward to the position shown in Figures 6 and 7 which holds the sliding jaw member 27 in engagement with the pinion 25 which is the position of the parts during the operation of the paper machine to regulate the "draw" between the several sections, as will be explained later. The solenoid coil 34 is in the circuit with the reversing controller R as shown diagrammatically in Figure 3. When the variable speed motor *v* is reversed the solenoid coil 34 is automatically energized and draws in the core 33 which rocks the shaft 29 and moves the sliding jaw member 27 out of engagement with the pinion 25 and into engagement with gear 26. This is the position of the parts when the speed of the paper machine as a whole is regulated and also when any one or more sections of the paper machine is to be stopped without stopping the rest of the machine. This will also be more fully explained later.

A slight modification in the method of driving pinion 25 and gear 26 in opposite directions mechanically and automatically is shown in Figures 9 and 10.

The hubs of the pinion 25 and gear 26 are each provided with ratchet teeth and, like the jaw clutches in Figures 7 and 8 are opposite hand to each other so that rotation of the double pawl arm 36 in one direction will cause pawl 37 to engage the ratchet teeth on the hub of pinion 25, and the rotation of the pawl arm 36 in the opposite direction will cause pawl 38 to engage the ratchet teeth on the hub of the gear 26. The action in this construction is entirely automatic.

In Figures 13 and 14, I show a tension device to automatically control the small variable speed motors *v* from the paper web where the web is sufficiently strong to permit the necessary tension to be applied. This will be applicable only to the units driving the calender and reel sections and possibly a dryer section. The application of this device to calender sections is shown in Figures 1 and 2. This tension device consists essentially of two end spiders 39 held rigidly in spaced relation by the separation bolts 40. The rollers 41 are journaled in the end spiders 39 and the paper web W is passed over them in the manner clearly as shown in Figure 13. Trunnion pins 42 are secured in the hub of each spider 39 and are revolvably mounted in suitable supports 43 which may

be hung from the ceiling as shown. One of the trunnion pins 42 is extended to receive a sheave wheel 44 and a sprocket wheel 45. From the sheave wheel a small cable 46 extends over an idler pulley 47 suitably supported and carries an adjustable weight 48 adapted to maintain the desired tension in the paper web W and also to furnish the motive power to turn the controller arm 49. This is accomplished as follows: On the spindle 50, on which the controller arm 49 is mounted, is secured a hand wheel 51 carrying a slidable pin 52 which is adapted to be moved into and out of engagement with a sprocket wheel 53 revolvably mounted on the spindle 50 adjacent to the said hand wheel 51. Thus the controller R can be operated manually by the hand wheel 51 when the pin 52 is withdrawn from engagement with the sprocket wheel 53. When the controller arm is to be operated automatically by the paper web W, the pin 52 is pushed into engagement with the sprocket wheel 53 which is then caused to partially rotate in either direction by the sprocket chain 54 which is driven by the sprocket wheel 45 actuated by the weight 48.

In Figure 13 the tension device just described is located between a section of the paper machine and a calender section 55 and the paper web W is threaded over the rollers 41 and then passes to the said calender. Referring particularly to this Figure 13 it will be clear that if the length of the paper web W increases before reaching the calender 55 the tension carriages as a whole will rotate slightly in a clockwise direction under the influence of the weight 48, which will also rotate the controller arm 49 in the manner described. The movement of the controller arm will change the speed of the small variable speed motor *v* to cause an increase in speed of the calender 55 to take up the increased length of the paper web or it may control the speed of the previous section to slow it down and thus prevent any further lengthening of the paper web W between the two sections of the paper machine. Obviously if the length of the paper web is shortened between these same two points the tension device will be rotated counter clockwise and the action of the controller R will produce just the opposite effect. The result will be that a substantially uniform length of paper web will be maintained between the sections thus equipped due to the constant weight 48.

Figure 1 shows the preferred form of my present invention. The power shaft is here shown common to all sections of the paper machine which comprises a couch section A, 1st press B, 2nd press D, 1st dryer section E, 2nd dryer section F and calender section G. Each section is directly connected to the power shaft S through the variable speed

unit A<sup>1</sup>, B<sup>1</sup>, D<sup>1</sup>, E<sup>1</sup>, F<sup>1</sup> and G<sup>1</sup>. The preferred form of gearing used to connect the several units is shown in Figures 11 and 12. (However equivalent means such as a worm wheel and worm may be substituted for the bevel gearing shown, if the design of the paper machine should require it.) In these figures the power shaft S is preferably driven by a complete self-contained unit as shown in Figures 4, 5 and 6 which comprises the main driving motor M, directly connected to the variable speed unit, the gear box 21 and the variable speed motor *v*, all mounted on a single base 1. As previously described the small variable speed motor *v* controls the speed of the power shaft S from 0 to full speed and thus the speed of the paper machine as a whole is regulated. The regulation of the speed or "draw" of any one section of the paper machine with respect to any other section or sections is made by varying the speed of the small motor *v* attached to that particular section. As has been previously described the method of stopping any one or several sections of the paper machine temporarily, in case of a break in the paper web, is by reversing the direction of rotation of the small variable speed motor *v*. The faster the motor *v* runs in the reverse direction the slower the unit which it controls will run until the said unit stops. The gearing in the gear box 21 will be so designed that the unit will stop well within the limit of the motor speed so that increasing the speed beyond that point will cause the unit to drive its section in the reverse direction. This is of advantage only in clearing the machine of "broke" etc. and will be only temporary. As a matter of safety for the machine tenders I provide a simple jaw clutch 56 between the several units and the intake shafts of the paper machine sections which can be disengaged when any section is stopped temporarily for cleaning or clearing of "broke." The paper machine as a whole is stopped by cutting off the current to all motors. It will be seen in Figures 1 and 2 that the unit F<sup>1</sup> for the second dry section F is not provided with a variable speed motor *v* but is controlled by shaft 24<sup>a</sup> which is extended from first dryer unit E<sup>1</sup> as indicated in dotted lines in Figures 7 and 9. It is evident that there can be little or no variation of speed between the two dryer sections and the arrangement just described avoids any possibility of error on the part of the machine tender. If, however, a slight variation is desirable this can be definitely determined and obtained by altering the ratio of the gears in the gear box 21 of unit F<sup>1</sup> with respect to the gears in gear box 21 of unit E<sup>1</sup>. This variation will be constant for all speeds and cannot be altered except by changing the ratio of the gears in the gear box of unit F<sup>1</sup>. The speed



of the calender unit may be controlled automatically from the paper web by the tension device shown in Figures 13 and 14, or it may be controlled manually, that is, set for a fixed "draw," like all of the other sections by throwing the sprocket wheel 53 out of engagement as previously described.

Figure 2 shows a slightly different arrangement of my drive wherein the calender sections (two being shown) are separately driven by self contained units similar to the one described for driving the power shaft S and as shown in Figures 4, 5 and 6. These calender units are also shown with automatic control from the paper web by the tension device shown in Figures 13 and 14.

The method of controlling the several units of my drive will be clear by reference to Figure 3 which shows a diagram of the wiring for the driving motors M and the variable speed motors  $v$ . A simple starter or controller  $R^1$  is provided for each main driving motor M and is merely intended to start and stop these motors. This controller  $R^1$  is shown in a circuit including preferably an A. C. source of power or a D. C. source of power where the former is not available. Each of the variable speed motors  $v$  is provided with a reversing controller R which is in a circuit taking its power from a direct current source D. C. The diagram shows armature control for the motors  $v$ , the field current remaining constant. The armature current is shown reversed by the segments  $S^1$  and  $S^2$  cooperating with corresponding terminals on the controller arm 49. Moving the controller arm 49 in a clockwise direction from its neutral position shown in Figures 3 and 13, starts the variable speed motor  $v$  in its normal direction of rotation, which, as previously described introduces the relatively small variation to regulate the "draw" in the paper web. For this purpose, pinion 25 and gear 22 are so proportioned as to cause the motor  $v$  at its maximum speed to revolve the cage C at such a speed that a maximum variation of only 5% will be produced. In practice this variation or "draw" need not be over 5% of the paper speed and since this percentage is distributed over the entire variable speed range of the motors  $v$  the variation for each step in the controller will be very small and furthermore the speed obtained will be constant because there are no uncertain elements to contend with such as slipping belts, friction clutches, etc. It is clear therefore that the "draw" of the paper web can be altered when desired by simply moving the controller arm 49 one step at a time in the proper direction. As previously pointed out, all sections of the paper machine will run at the same rate of speed with respect to the power shaft S when all of the motors  $v$  are stopped. The rotation of the motors in the clockwise direction as

just described, superimposes, so to speak, the variable speed upon the normal speed.

Moving the controller arm 49 in a counter-clockwise direction from its neutral position in Figures 3 and 13 reverses the direction of rotation of the motors  $v$  which, as previously described, will rotate the cage C in the reverse direction with respect to the driving shaft 8 and will subtract from the normal speed of the paper machine section. The ratio of the pinion 23 to the gear 26 both in gear box 21, is proportioned in practice to give a counter revolution of the cage C which, at a predetermined reverse speed of the motors  $v$ , will cause the sleeve hub 13<sup>a</sup> to come to rest thus stopping the machine section. It will be seen therefore that I stop any section of a paper machine by simply reversing the direction of rotation of the variable speed motor  $v$  for that section and bringing it up to a predetermined speed. A specific example will help to make the foregoing clearer. If we assume the speed of the driving shaft 8 to be 600 R. P. M. and the ratio of the gearing in the cage C to be 4 to 1, then the speed of the sleeve hub 13<sup>a</sup> and consequently the machine section shaft to which it is connected will be 150 R. M. P. when cage is stationary. With this particular ratio of gearing in the cage C, one counter revolution of the cage C with respect to the driving shaft 8 will cancel 3 revolutions of the said driving shaft 8. Therefore if the cage C is rotated in a counter direction with respect to driving shaft 8, at 200 R. P. M., the sleeve hub 13<sup>a</sup> and its machine section shaft will remain stationary. If we use a 1500 R. P. M. variable speed motor  $v$  and arranged all the intermediate gearing to give a 200 R. P. M. counter rotation of the cage C at say, 1250 R. P. M. of the motor  $v$ , then we have an excess motor speed of 250 R. P. M. to revolve the cage faster than 200 R. P. M. in the counter direction, which will cause the sleeve hub 13<sup>a</sup> and its machine section shaft to actually rotate counter to the driving shaft 8 and thus reverse that particular machine section. This is desirable principally in the dryer and calender sections to aid in clearing the machine of "broke" and replaces a very cumbersome and expensive reversing gear.

Because of the relatively great starting torque required to start a paper machine from rest, it is desirable to start each section separately. I do this in my drive as follows: The controller  $R^1$  for the main driving motors M and all of the controllers R for the variable speed motors  $v$  are locked together either electrically or mechanically. A mechanical locking arrangement as shown in Figure 3 comprises a sprocket wheel 53 on the spindle of controller arm 58 and a similar sprocket wheel 53<sup>a</sup> on the spindle of con-

troller arm 49. A sprocket chain represented by dotted lines 57 in Figure 3 will cause both to move together in the same direction. Moving the controller arm 58 to start the main driving motor M will therefore move the controller arm 49 in a counter clockwise or reverse direction to start all of the variable speed motors  $v$ . The construction of all starters will be such that the speed of the main driving motor M will be cancelled by the variable speed motors  $v$  operating on the cage C as previously described. When the main driving motor M reaches the desired speed any section can then be started by simply slowing down the speed of the motor  $v$  for that particular section. This is done by pulling pin 52 out of engagement with sprocket wheel 53 and operating the corresponding controller for that particular unit by hand. As the motor  $v$  begins to slow down, the load is thrown on the main driving motor M and the section begins to move and will reach its full normal speed when the motor  $v$  is stopped. All other sections may be started in the same manner. It will be noted that I am able to apply all the power required to drive the entire machine, to any one section to start it, and thus avoid the necessity of over motoring as is the case especially in electric sectional drives where individual motors are provided for the separate sections. The starting torque of some sections is five times the running torque. To combat this the electric sectional systems are sometimes over motored 100%. Furthermore, my system of starting just described enables me to use synchronous motors M even though they have relatively small starting torque because they are brought to full speed before any load of consequence is thrown on them.

In the foregoing description of my invention I have explained the use of a reversing controller R for the variable speed motor  $v$  for automatically operating the change speed gears in the gear box 21, which impart a dual speed to the cage C. It has also been explained above, how running the motor  $v$  in one direction with pinion 25 and gear 22 operating to cause the cage C to revolve at a relatively low speed in the same direction as the driving shaft 8, added to the normal speed of the paper machine the assumed maximum variation of 5% which is sufficient to adjust the "draw" in the paper web and how running the motor  $v$  in the reverse direction automatically disengaged pinion 25 and gear 22 and throw gear 26 and pinion 23 into engagement at the moment of reversal to revolve the cage C at a relatively high speed in the opposite direction with respect to the driving shaft 8 and thus subtracted the 100% variation in speed from the normal speed to bring the sleeve hub 13<sup>a</sup> and its corresponding machine section to rest. While

this may be considered the preferred arrangement it will be clear that is a non-reversing controller like R<sup>1</sup> is used for controlling the variable speed motor  $v$  and the said motor  $v$  is connected to run only in the direction which will impart a reverse direction of rotation to the cage C with respect to driving shaft 8 with pinion 25 and gear 22 operating, the assumed maximum variation of 5% for the entire speed range of the motor  $v$ , will be subtracted from the normal speed of the paper machine instead of being added to it as with the reversing controller R and will function equally well in practice. Such an arrangement is shown in Figures 15 and 15<sup>a</sup> which in effect constitute a single wiring diagram. The several parts shown in Figure 15 correspond substantially to the same parts as shown in the right hand portion of Figure 3, while the parts shown in Figure 15<sup>a</sup> represent a similar controller substituted in place of the reversing controller R shown in the center of Figure 3. The wiring circuits shown in Figures 15 and 15<sup>a</sup> therefore represent, in effect, the elimination of the reversing portion of the controller R including the arcuate contacts S<sup>2</sup>, S<sup>3</sup>, S<sup>4</sup>, S<sup>5</sup> and S<sup>6</sup>. Furthermore, it will be seen by an inspection of Figure 16 that the clutch element 27 is adapted to drive the spur gears 25 and 26 in the same direction, the only change made by shifting the clutch element 27 being a change in speed and without any reversal in the direction of rotation. If a simple controller like R<sup>2</sup> be substituted in Figure 3, the solenoid 34 may be controlled by connecting it in the main circuit with a switch 34<sup>a</sup> as shown in dotted lines in Figure 3.

It will be understood that throwing in the switch 34<sup>a</sup> causes the solenoid to disengage the slow speed gears 25 and 22 and brings the high speed gears 26 and 23 into engagement to give the 100% speed variation and since the motor  $v$  is now running only in the one direction this 100% variation for the entire speed range of the motor  $v$  will also be subtracted from the normal speed of the paper machine and will therefore bring to rest the section of the paper machine which it controls.

It is obvious that I can eliminate the solenoid entirely and operate the lever 32 manually to make the shift from the low speed to high speed.

It will be understood from the foregoing specification that the individual units of a paper making machine may be separately driven and controlled by respective units similar to that shown in Figures 4, 5 and 6, and in the same manner as the two calendar sections shown in Figure 2.

I claim:

1. In a variable speed drive, the combination with variable speed mechanism com-

prising a power-transmitting chain of positively-connected elements, of means positively connected to said variable speed mechanism for supplying power thereto, a positive variable speed motive-power unit, and positive alternate fixed-speed connections interposed between said motive-power unit and said variable speed mechanism, whereby said variable speed mechanism may be accelerated or retarded at changeable rates.

2. In a variable speed drive, the combination with variable speed mechanism comprising a power-transmitting chain of positively-connected elements, of means positively connected to said variable speed mechanism for supplying power thereto, a positive reversible variable speed motive-power unit, means positively connecting said motive-power unit to said variable speed mechanism for accelerating or retarding the latter, said positive connecting means including alternate fixed-speed connections whereby the rate of acceleration or retardation may be changed.

3. In a variable speed drive, the combination with variable speed mechanism, of means connected to said variable speed mechanism for supplying power thereto, and means for accelerating or retarding the speed transmission of said variable speed mechanism, said accelerating or retarding means including alternate fixed-speed connections whereby the rate of acceleration or retardation may be changed.

4. In a machine of the character described, a power-driven element, a web-feeding machine part to be driven, means including variable speed mechanism positively connecting said power-driven element to said machine part, and positive variable speed web-controlled means connected to said variable speed mechanism for accelerating or retarding the speed transmission of said variable speed mechanism, said web-controlled accelerating and retarding means including alternative fixed speed connections for varying the rate of acceleration or retardation.

5. In a machine of the character described, a power-driven element, a web-feeding machine part to be driven, means including variable speed mechanism positively connecting said power-driven element to said machine part, and reversible web-controlled means connected to said variable speed mechanism for accelerating or retarding the speed transmission of said variable speed mechanism.

6. In a machine of the character described, a web-feeding machine part to be driven, means including reversible variable speed mechanism positively driving said machine part, and means for accelerating or retarding said variable speed mechanism, said accelerating and retarding means in-

cluding alternative fixed-speed operating connections, and web-controlled means for controlling the direction of said reversible variable speed mechanism and selectively operating said fixed-speed operating connections.

7. In a variable speed drive, the combination with variable speed mechanism comprising a power-transmitting chain of positively-connected elements, means positively connected to said variable speed mechanism for supplying power thereto, a web-feeding roll driven thru said variable speed mechanism, a reversible variable speed motor for accelerating or retarding said variable speed mechanism, and means positively connecting said motor to said variable speed mechanism, said positive connecting means including alternative fixed-speed connections whereby the rate of acceleration or retardation may be changed, and means for controlling the speed and direction of said motor and for selectively operating said fixed-speed connections.

8. In a machine of the character described, the combination with a web-feeding roller, of positively-driven variable speed mechanism for driving said roller, a variable speed motor operating connections between said motor and said variable speed mechanism, said connections including large and small gears positively connected to said variable speed mechanism, a shaft driven by said motor, a pinion splined to said shaft and movable alternatively into operating connection with one or the other of said gears, an electro-responsive device operably connected to said pinion and web-controlled operating circuits for said motor and electro-responsive device.

9. In a paper-making machine, the combination with a web-driving section of said machine, of a main power-drive therefor including variable speed mechanism, a reversible variable speed motor for varying the transmission speed of said variable speed mechanism, high and low fixed-speed operating connections between said motor and said variable speed mechanism, a solenoid for controlling said high and low fixed speed connections, web-controlled operating circuits for reversibly controlling said motor, and a solenoid-energizing circuit under the control of said motor control circuits.

10. Variable speed driving mechanism comprising a synchronous motor provided with an armature shaft, a driven part under load, and variable speed mechanism connecting said motor to said driven part, said variable speed mechanism including a driving pinion keyed to said armature shaft, and a driven gear keyed to said driven shaft.

11. Variable speed driving mechanism comprising a synchronous motor, a driven shaft, variable speed mechanism connect-

ing said synchronous motor to said driven shaft, and a reversible motor connected to said variable speed mechanism.

12. In a variable speed drive, the combination with variable speed mechanism comprising a power-transmitting chain of positively-connected elements, a synchronous motor positively connected to said variable speed mechanism for supplying power thereto, and variable speed means for accelerating or retarding the speed transmission of said variable speed mechanism whereby a slowly increased load may be applied to said motor while running at full speed.

13. The combination with a synchronous motor, of a driven power shaft, variable speed mechanism connecting said synchronous motor to said driven power shaft whereby the load may be cumulatively applied to said motor while running at full speed, a machine part to be driven by power from said power shaft, and variable speed mechanism positively coupling said machine part to said power shaft.

14. The combination with a motor, of a driven power shaft, variable speed mechanism connecting said motor to said driven power shaft, means connected to said variable speed mechanism for varying the transmission between said motor and driven power shaft, a machine part to be driven by said driven power shaft, variable speed mechanism connecting said machine part to said driven power shaft, and means connected to the last-mentioned variable speed mechanism for varying the transmission between said driven power shaft and said machine part.

15. The combination with a synchronous motor, of a driven power shaft, variable speed mechanism positively connecting said synchronous motor to said driven power shaft, a variable speed motor, positive driving conditions between said variable speed motor and said variable speed mechanism whereby a cumulative load may be applied to said synchronous motor during the full speed operation of said synchronous motor, a machine part to be driven by said driven power shaft, variable speed mechanism positively connecting said machine part to said power driven shaft, a second variable speed motor, and positive driving connections between the last-mentioned variable speed motor and variable speed mechanism whereby the operation of said machine part may be accelerated or retarded.

16. The combination with a motor, of a power shaft, variable speed mechanism connecting said motor to said power shaft, means for operating said variable speed mechanism whereby the transmission between said motor and shaft may be varied, a machine part to be driven by power from said power shaft, variable speed mechanism

connecting said machine part to said power shaft, and means for operating the last-mentioned variable speed mechanism for varying the transmission speed thereof.

17. In a machine of the character described, a power driven element, a web-feeding machine part to be driven, means including variable speed mechanism positively connecting said power-driven element to said machine part, and web-controlled means connected to said variable speed mechanism for accelerating or retarding the speed transmission of said variable speed mechanism, said web-controlled means including a variable speed prime-mover and dual speed change connections between said prime-mover and said variable speed mechanism.

18. A power-drive mechanism comprising a main driving motor, variable speed mechanism connected thereto and adapted to be connected up with a mechanism to be driven, a variable speed motor for accelerating or retarding the operation of said variable speed mechanism, and positively geared means for connecting said variable speed motor to said variable speed mechanism, said positively geared means including a plurality of different fixed-speed connections whereby the rates of acceleration and retardation are changed.

19. A power-drive mechanism comprising a main driving synchronous motor, variable speed mechanism connected thereto and adapted to be connected up with a mechanism to be driven, a variable speed motor for accelerating or retarding the operation of said variable speed mechanism, and positively geared means for connecting said variable speed motor to said variable speed mechanism, said positively geared means including a plurality of different fixed-speed connections whereby the rates of acceleration and retardation are changed.

20. In a paper making machine, the combination with a plurality of sections of said machine, each of said sections being provided with variable speed mechanism through which power is delivered thereto, a governor shaft common to said variable speed mechanisms, a motor for operating said governor shaft, a main power shaft connected to said variable speed mechanisms, a synchronous motor for driving said main power shaft, variable speed mechanism interposed between said synchronous motor and said main power shaft, and means for governing the operation of the last mentioned variable speed mechanism.

21. In a paper making machine, the combination with a plurality of sections of said machine, each of said sections being provided with variable speed mechanism through which power is delivered thereto, a governor shaft common to said variable speed mechanisms, a reversible motor for operat-

ing said governor shaft, a main power shaft connected to said variable speed mechanisms, a synchronous motor for driving said main power shaft, variable speed mechanism  
 5 interposed between said synchronous motor and said main power shaft, and a reversible motor connected up to said last mentioned variable speed mechanism.

22. In a machine of the character described, the combination with a section of  
 10 said machine to be driven, of a main driving motor, driving connections between said main motor and said machine section, said connections including variable speed mechanism,  
 15 an auxiliary motor for operating said variable speed mechanism, rheostats and respectively controlling said motors, and means cooperatively connecting said rheostats.

23. In a machine of the character described, the combination with a section of  
 20 said machine, of a synchronous motor for driving said section, means for controlling the operation of said synchronous motor,  
 25 variable speed mechanism interposed between said synchronous motor and said machine section, a reversible motor for operating said variable speed mechanism, means  
 30 for controlling the operation of said reversible motor, and means cooperatively connecting the controlling means of said synchronous motor with the controlling means of said reversible motor.

24. In a machine of the character described, the combination with a section of  
 35 said machine, of a synchronous motor for driving said section, means for controlling the operation of said synchronous motor, variable speed mechanism interposed between said synchronous motor and said machine section, a motor for operating said variable  
 40 speed mechanism, means for control-

ling the operation of the last mentioned motor, and means cooperatively connecting the controlling means of both of said motors. 45

25. In a machine of the character described, the combination with a section of  
 50 said machine, of a power shaft, variable speed mechanism interposed between said machine section and said power shaft, a reversible motor for operating said variable  
 55 speed mechanism, means for controlling the operation of said reversible motor, a synchronous motor, means for controlling the operation of said synchronous motor, variable speed mechanism interposed between  
 60 said synchronous motor and said drive shaft, and means cooperatively connecting the controlling means of said synchronous motor with the controlling means of said reversible motor.

26. In a machine of the character described, the combination with a section of  
 65 said machine, of variable speed mechanism connected thereto, a motor for governing the operation of said variable speed mechanism, means for controlling the operation of  
 70 said motor, a synchronous motor, a power shaft connected to said variable speed mechanism, other variable speed mechanism interposed between said synchronous motor  
 75 and said power shaft, a motor for governing the operation of the second mentioned variable speed mechanism, means for controlling the last mentioned motor, and means cooperatively connecting the controlling means of said governing motors.

27. The combination with a section of a  
 80 paper machine, of variable speed mechanism for driving said section, and a reversible motive-power unit positively connected to said variable speed mechanism.

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