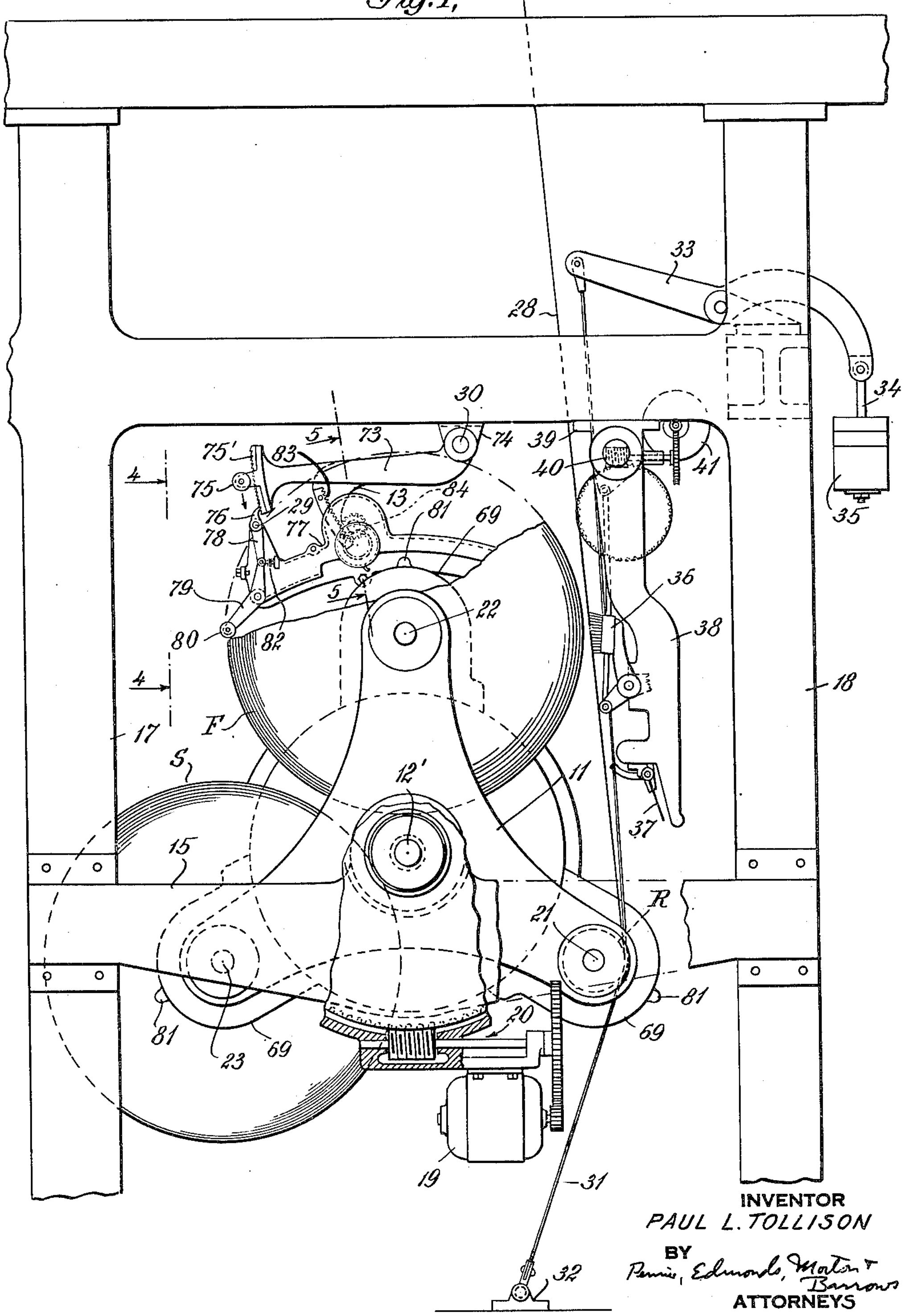
June 17, 1952 P. L. TOLLISON 2,601,071

WEB ROLL ACCELERATING APPARATUS

Filed Jan. 21, 1949 6 Sheets-Sheet 1

Fig. 1.



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WEB ROLL ACCELERATING APPARATUS

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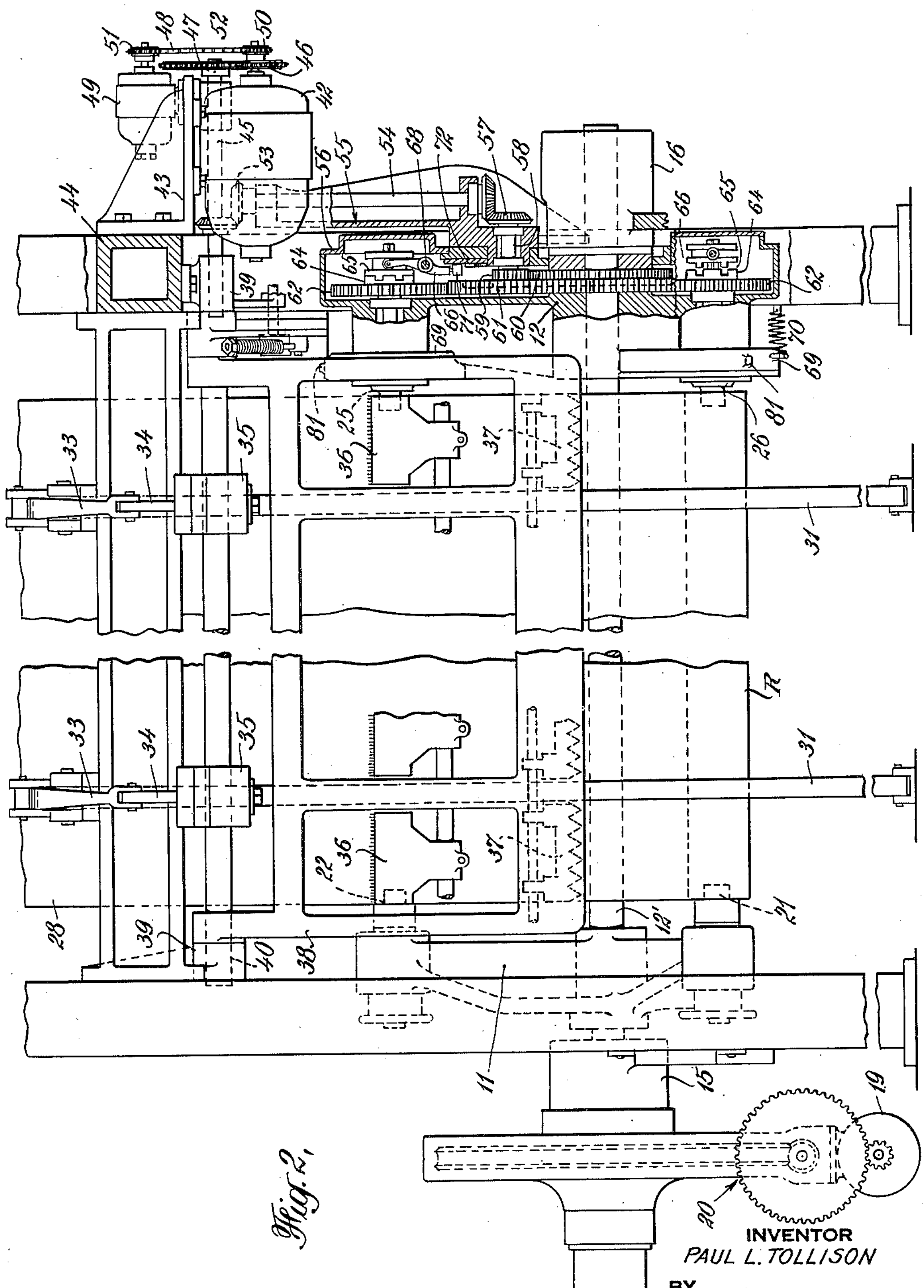

Fig. 2.

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WEB ROLL ACCELERATING APPARATUS

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Fig. 3.

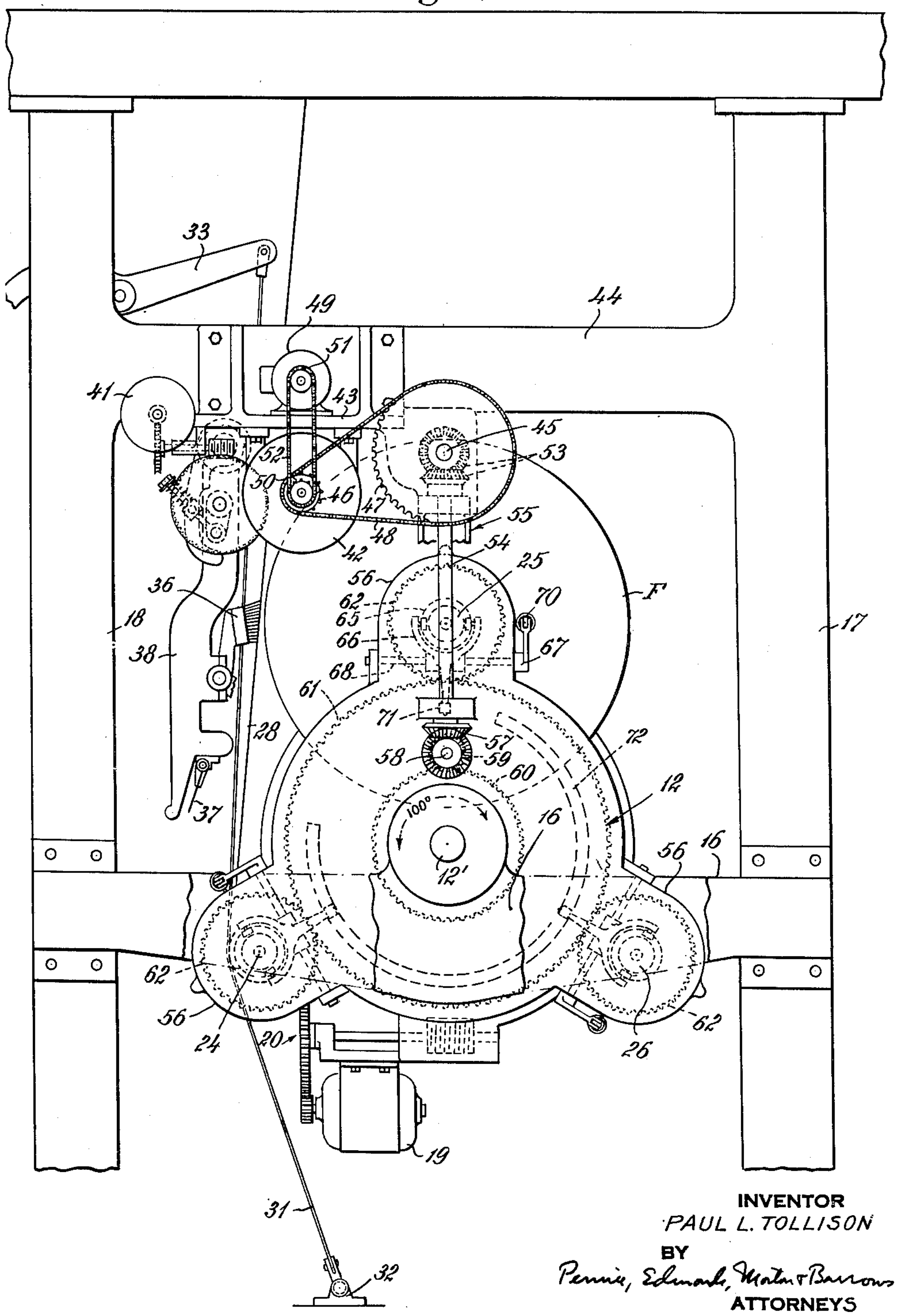

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Fig. 4,

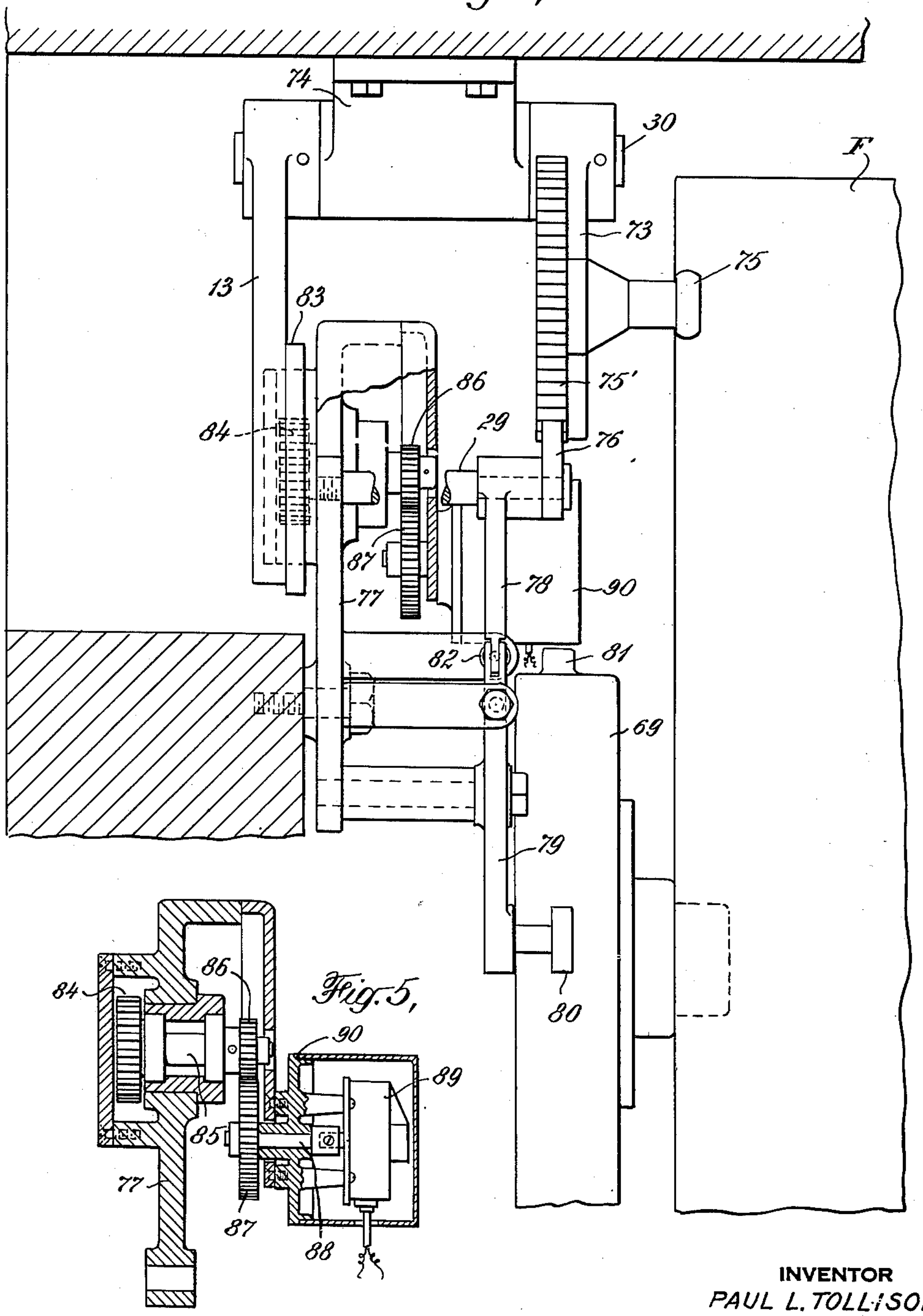

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Fig. 6,

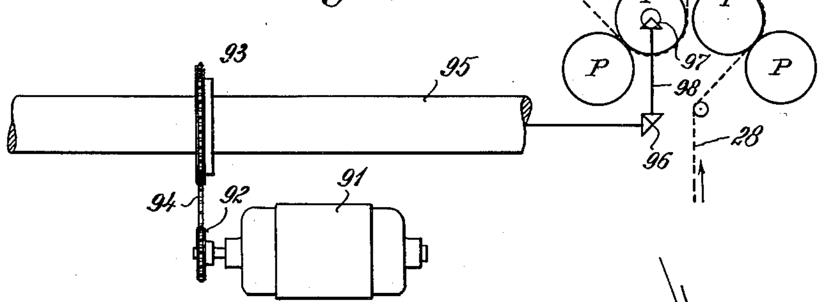


Fig. 7,

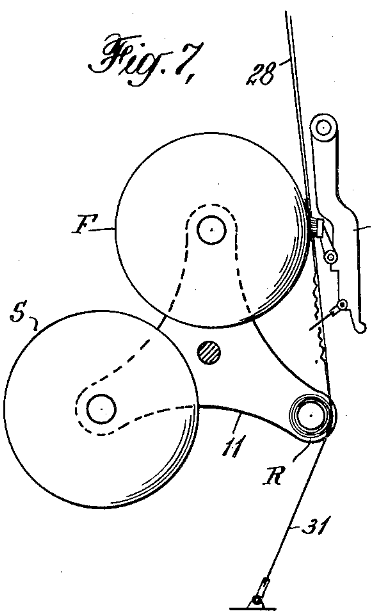


Fig. 8,

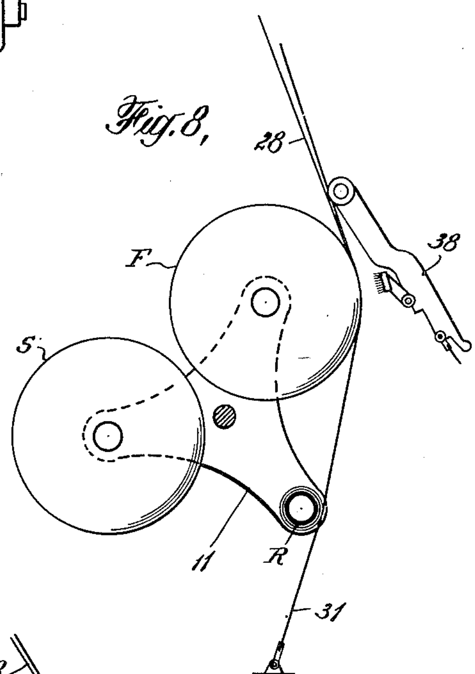
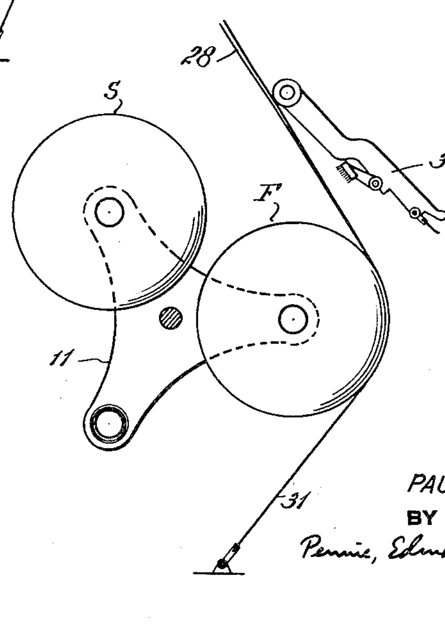


Fig. 9,



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WEB ROLL ACCELERATING APPARATUS

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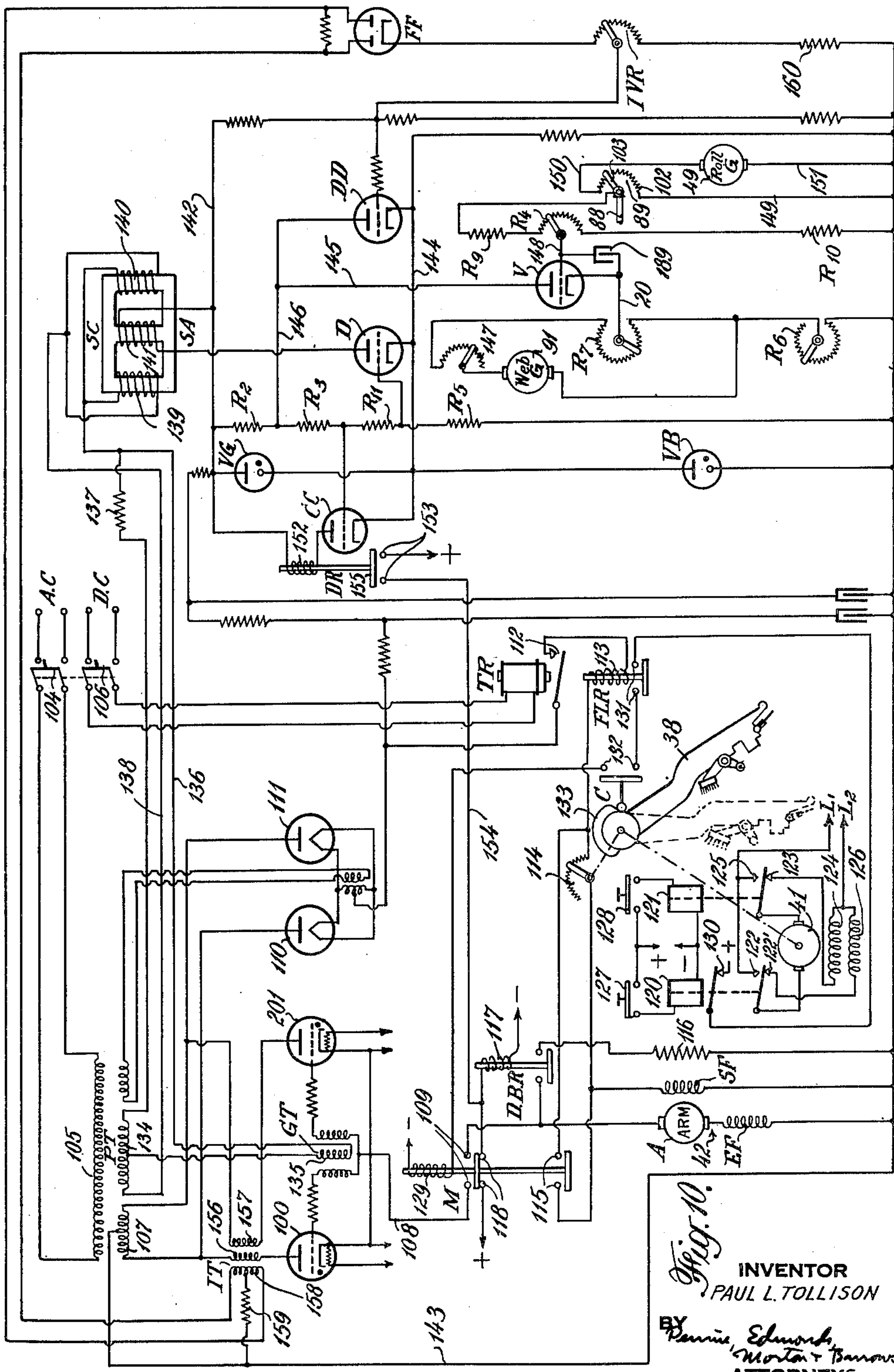

Fig. 10.

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2,601,071

UNITED STATES PATENT OFFICE

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WEB ROLL ACCELERATING APPARATUS

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Application January 21, 1949, Serial No. 71,896

11 Claims. (Cl. 242—58)

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This invention relates to web splicing apparatus and more particularly concerns improved apparatus for accelerating a fresh web roll to running web speed in preparation for splicing the fresh roll web to a running web, and for retarding the rotation of such fresh roll when its speed exceeds that of the running web, and after its web has been spliced to the running web.

In many operations involving the feeding of webs to web consuming apparatus, it is necessary or desirable that a flexible web running from a roll be replaced by a web from a fresh roll while the web is running at full operating speed to the web consuming apparatus. Thus, in the supply of paper web to printing presses, it is customary to employ paper web rolls and to splice the web from a fresh roll to the web running from a depleted roll without stopping or materially retarding the rate of travel of the running web. This operation has been accomplished by rotatably mounting the fresh roll on a movable support, such as a web roll reel, accelerating the fresh roll to a rotative speed or angular velocity such that its surface speed or peripheral velocity equals the linear velocity of the running web, then moving the fresh roll into contact with the web running from an expiring roll to effect a splice between the running web and the leading end of the fresh roll web, and finally severing the old web behind the splice. The running web is maintained under tension, and to this end, straps, belts or like flexible tension applying means are provided to engage the surface of the roll from which the web runs to the web consuming apparatus and so to retard the rotation of such roll. During fresh roll acceleration, at the time the splice is made and for an interval thereafter, the fresh roll is either not in a position to engage the running tension means at all or is not in a position to engage this means sufficiently to provide adequate tension. No tension is applied from the conventional tension means to the fresh roll while it is accelerating, and if the speed of the web consuming apparatus falls at this time, the new roll web may be moving faster than the running web when the splice is made, which causes an undesirable overrun of the web. It is accordingly desirable to provide means other than the conventional running web tension means to retard the fresh roll rotation until the fresh roll has been spliced and has thereafter moved to a position where it engages the running web tension means sufficiently to be adequately retarded by such engagement.

It is preferable that the new roll be accelerated

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by a driving force applied through its axis. New rolls are frequently somewhat non-circular and for that reason are difficult to drive from means engaging their cylindrical surfaces. Furthermore, a roll surface engaging drive may interfere with the adhesive or other splice-forming material carried at the leading edge of the new roll web. On the other hand, axial drive of the new roll involves regulating the rotative speed or angular velocity to which the roll is accelerated in accordance with the diameter of the particular roll in use, since a given peripheral velocity is attained by lower angular velocity in large diameter rolls than in small ones. In practice, web rolls vary in diameter to such an extent that the rotative speed to which they are accelerated must be varied from roll to roll to provide a peripheral velocity that is satisfactory for effecting the splice to a web running at a predetermined speed. When it is considered that the running web speed also varies, and that for satisfactory splicing the linear speeds of the running web and fresh roll web must be substantially identical, it will be appreciated that the problem of accelerating the new roll to splicing speed through axial drive is a difficult one.

With the foregoing considerations in mind, it is an object of the present invention to provide improved means involving axial drive for rapidly bringing a fresh web roll up to splicing speed in an accurate and dependable manner, and this despite variations in the size of the fresh roll being accelerated and variations in the speed of the web consuming apparatus and hence of the running web. The invention has for a further object the provision of improved means for retarding the rotation of the fresh roll by a force applied through the roll axis both before the splice is made if the running web speed falls below the fresh roll surface speed, and after the splice is made, regardless of web speed changes, so as to avoid web overrunning at the time of the splice and to maintain tension on the running web during the interval after the splice when the new roll is being moved to a position in which a retarding tension producing force is applied to its surface by conventional running web tension means.

The above and other objects of the invention are carried out by employing an electric motor to drive each fresh roll and accelerate it to speed through its axis and by employing improved mechanism for governing the speed to which the roll is accelerated by the motor. This is done by providing two generators, preferably of the type known as tachometer generators, one of which is driven from or at a speed bearing a fixed relation to the speed of the fresh roll, and the other of which is driven from or at a speed bearing a fixed relation to the speed of the running web or web consuming apparatus. The operating energy applied to the fresh roll driving motor, and, if and when necessary, a dynamic braking force applied to the fresh roll by this motor, is controlled in accordance with the relation and difference between the roll speed and web speed voltages generated by the two generators. According to the invention, the roll speed voltage delivered by the fresh roll driven generator for comparison with the web speed voltage is modified by the diameter of the individual fresh roll being accelerated. This is preferably accomplished by means of a variable resistance unit, usually in the form of a potentiometer, that is mechanically set by the fresh roll itself to change the fresh roll speed voltage in direct proportion to changes in diameter of the particular fresh roll being accelerated. This mechanism modifies the roll speed voltage employed for comparison with the web speed voltage to take into account the particular diameter of fresh roll being accelerated.

The fresh roll and running web speed voltages are compared by an electronic control circuit that acts to apply operating energy to the fresh roll driving motor when the roll speed voltage is lower than the web speed voltage, the magnitude of this energy varying directly with the difference between these voltages. The control mechanism also acts to apply dynamic braking to the roll drive motor if the web speed voltage drops more than a predetermined small amount below the roll speed voltage, thus preventing overrun of the web if the web consuming apparatus slows down during fresh roll acceleration or before the splice is made. Dynamic braking is also applied after the splice is made and during the interval while the new roll is moved to fully engage conventional running web tension means.

In describing the invention in detail, reference will be made to the accompanying drawings in which an embodiment thereof has been illustrated.

In the drawings—

Fig. 1 is an end elevation of a web roll reel and associated mechanism embodying the invention and shown in the position in which a fresh web roll is accelerated to web speed in preparation for a splice;

Fig. 2 is a front elevation of the mechanism of Fig. 1;

Fig. 3 is an end elevation of the mechanism, viewed from the opposite end from that shown in Fig. 1;

Fig. 4 is a rear elevation of the fresh roll calipering part of the mechanism shown in Fig .1;

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 1;

Fig. 6 is an elevation of the web speed generator and a diagrammatic representation of means for driving the same from the web consuming apparatus;

Fig. 7 is a diagrammatic end elevation of a web roll reel showing the running web tensioning means, with the reel in the position at which a splice is made;

Figs. 8 and 9 are elevations similar to Fig. 7 showing the reel respectively in the position where the running web tensioning means is partly effective and in the position in which such tensioning means is wholly effective to retard a newly-spliced-in web roll; and

Fig. 10 is a diagrammatic illustration of the fresh roll driving motor and its control mechanism and circuits.

In Figs. 1, 2 and 3 there is shown a movable web roll support in the form of a three-arm reel including spaced three-arm spiders 11 and 12 carried on and fixed against rotation relative to a central reel shaft 12'. The shaft 12' is journalled in bearings carried by brackets 15 and 16 secured to columns 17 and 18. The reel may be rotated by a motor 19 connected to the shaft 12' through a gear train 20. Each of the spiders 11 and 12 carries roll supporting spindles at the ends of its arms, the spindles of the spider 11 being designated 21, 22 and 23 and those of the spider 12 being designated 24, 25 and 26. The spindles provide rotatable supports for the web rolls. Referring to Fig. 1, the rolls may be designated the running roll R from which the web 28 is running to the press or other web-consuming apparatus, the fresh roll F that is about to be spliced to the running web 28, and a spare roll S that has been mounted in the reel spindles 23 and 26 to replace an exhausted roll that has been removed. In Fig. 1, the reel is shown in a position such that the fresh roll F is in the speed-up position it occupies while being accelerated to running web speed in preparation for a splice. The spiders 11 and 12 and the mechanism associated therewith may be mounted for adjustment axially of the reel shaft 12' for side register, as described in Patent No. 1,957,122.

Means are provided for applying running tension to the running web 28. This means is here shown as a series of straps 31, one end of each of which is secured to a bracket 32 fixed to the foundation. The other ends of the straps 31 are severally connected to pivoted levers 33 carrying weight rods 34 with removable weights 35 thereon. As is apparent from Figs. 1 and 7, the fresh roll F in the speed-up and splicing positions of the reel is not retarded by the straps 31. After the splice is made, the reel moves the newly-spliced-in roll F forward and the straps 31 engage increasing arcs of its surface, as shown in Fig. 8, until full running tension is applied by the straps 31 at the running position of the reel shown in Fig. 9.

The splice is executed at the proper time by known mechanism such as described in detail in Patent No. 2,148,094. The construction and operation of such mechanism will be briefly described herein and reference may be made to the noted patent for structural and operating details. The splicing apparatus includes web pressing brushes 36 and web cutting knives 37 pivotally supported on a frame termed the brush arm 38 that is pivotally secured at 40 to the bracket 39 fixed to the columns 17 and 18. As shown in Fig. 2, the several brushes 36 and knives 37 are disposed so as to be extended into contact with the web between adjacent pairs of the tension straps 31. A brush arm motor 41, carried by the bracket 39, is operatively connected to the brush arm 38 through reduction gearing and crank arms so that it lifts and lowers the brush arm under control of the operator. When the running roll R has run off to the point where the operator considers a roll replacement will soon be necessary, the reel is turned to the speed-up position shown in Fig. 1 and the brush arm 38, which is initially in the position illustrated in Figs. 9 and 10, is lowered by operation of the motor 41 to the operative position shown in Figs. 1 and 3. The fresh roll F is then accelerated to web speed, as will be explained, and thereafter, when the running roll R has run off to the point where a splice must be made, the brushes 36 are extended to press the running web 23 against the fresh roll surface, the paste carrying leading end of the fresh roll web engages and sticks to the running web and the knives 37 are extended to sever the old web behind the splice, as is illustrated in Fig. 7. The brush arm 38 is then raised and at the same time the reel is turned forward, that is, in the direction of the arrow in Fig. 1, to progressively move the newly-spliced-in roll F to its running position, as illustrated in Figs. 8 and 9. It will be understood that known mechanism is employed to effect and control the described coordinated movements of the brush arm, the brushes, the knives and the reel. Suitable mechanism of this nature is shown in Patent No. 2,148,094, referred to above. The fresh roll accelerating and retarding mechanism of the present invention is preferably coordinated with the splicing operation by contacts controlled by the position of the brush arm 38, as will be described.

An electric motor 42 is provided for accelerating each successive fresh web roll to running web speed and for retarding the rotation of such roll, as will be explained. The motor 42 is shown mounted on a bracket 43 fixed to a cross beam 44 (Figs. 2 and 3). It is connected to drive a cross shaft 45 through suitable means, such as the sprockets 46, 47 and the chain 48. A roll speed tachometer generator 49 is mounted on the bracket 43 and is directly connected to the motor 42 by a suitable means, such as the sprockets 50 and 51 and the chain 52, so that this generator rotates at a speed and accordingly generates a voltage bearing a fixed relation to the angular velocity or rotative speed at which the fresh roll turns.

Roll driving power is transmitted to each fresh roll in turn by mechanism now to be described. The shaft 45 is connected by bevel gears 53 to a vertical shaft 54 journalled in the banjo frame 55. The banjo frame 55 is stationary, and the reel spider 12, including the spindle clutch housings 56, turns with the reel shaft 12' relative thereto. Roll driving power from the shaft 54 is transmitted through the bevel gears 57 and a stub shaft 58 to a pinion 59. The pinion 59 engages a gear 60 fixed to a large gear 61 concentric therewith and rotatably journalled on the hub of the spider 12. The large gear 61 engages three spindle drive gears 62 mounted respectively on the shafts of the three spindles 21, 22 and 23. Each of the gears 62 is operatively connected to its spindle shaft by a clutch including a toothed element 64 fixed to the gear 62 and a complementary movable toothed element 65 splined to but slidable along the spindle shaft. A pivotally mounted yoke 66 engages a circumferential slot in the movable clutch element 65 and is normally biased to a clutch engaging position by a spring 70 connected between an arm 67 on the yoke pivot shaft 68 and the spindle journal housing 69 (Figs. 2 and 3). The lower end of the lever forming the yoke 66 carries a roller 71 that is engaged and disengaged by a cam 72 fixed to the stationary banjo frame 55 as the spider 12 turns. This action of the cam 72 engages and disengages the clutch element 65 from the clutch element 64. As shown in Fig. 2, the cam 72 has a gap therein extending for about 100° to reel rotation, starting at a point just before each spider arm reaches its upper vertical position and continuing to a point just above the horizontal position of the spider arm adjacent the running web. With this arrangement, the clutch elements 64 and 65 of each spindle are engaged to operatively connect the spindle and thus the web roll carried thereby to the roll driving motor 42, as the spindle approaches the roll speed-up position in which the spindle 25 is shown in Fig. 3. The clutch elements are disengaged when the spindle approaches the running position illustrated by the roll F in Fig. 9. The spindle drive and clutch mechanism herein described is disclosed in more detail in Patent No. 2,148,094.

In accordance with the present invention, the roll speed voltage generated by the generator 49 is modified in accordance with the diameter of each fresh roll that is accelerated to splicing speed. The fresh roll calipering and associated mechanism employed for this purpose is shown in Figs. 1, 4 and 5. A roll measuring arm 73 is pivotally supported above the spider 12 by suitable means, such as a bracket 74. A roller 75 at the free end of the arm 73 is disposed to be engaged by the periphery of a fresh web roll as it moves toward the speed-up position (Figs. 1 and 4). The arm 73 carries a ratchet 75'. The ratchet 75' is normally engaged by a spring pressed pawl 76 pivotally connected to a fixed frame 77 by a shaft 29. The pawl 76 is connected by an arm 78 to a bell crank lever 79, the lower arm of which carries a roller 80 disposed in the path of projections 81, one of which is fixed on the spindle journalled housing 69 of each arm of the reel spider 12. A spring 82 biases the pawl 76 and its operating mechanism toward the ratchet engaging position.

A rack 83, fixed to move with the arm 73 through a rack arm 13 and the pivot shaft 30 of the arm 73, engages a pinion 84 carried by a stub shaft 85 journalled in the frame 77 (Figs. 4 and 5). The shaft 85 carries a pinion 86 engaging a gear 87 fixed to the movable contact operating shaft 88 of a potentiometer 89 that is carried in a housing 90 fixed to the frame 77, as shown in Figs. 4 and 5. The potentiometer is electrically connected to the output circuit of the roll speed voltage generator 49, as will be described.

With the described arrangement, as each arm of the spider 12 approaches its upper vertical position and the web roll carried by the spindle on such arm is disposed beneath the roller 75 on the measuring arm 73, the projection 81 engages the roller 80 and lifts the lower arm of the bell crank lever 79, thus disengaging the pawl 76 from the ratchet 75' and permitting the arm 73 to descend until it is arrested by engagement of its roller 75 with the surface of the web roll. As the reel advances, the peripheral surface of the web roll lifts the arm 73 to a position corresponding to the diameter of the roll, and the arm is held in this position by engagement of the pawl 76 with the ratchet 75'. The movement of the arm 73 is transmitted to the shaft 88 of the potentiomeer 89 and the potentiometer is thus set to a position corresponding to the diameter of the fresh roll that is being moved to the roll speed-up position.

The running web speed voltage generator 91 is driven from the web-consuming apparatus at a speed bearing a fixed relation to the speed of the running web, whereby the voltage it generates varies directly with the running web speed. As illustrated in Fig. 6, the generator is connected by suitable means, such as the sprockets 92 and 93 and a chain 94, to a shaft 95 that drives the web-consuming apparatus, in the illustrated case, a printing press indicated by the printing unit PC. As is illustrated in Fig. 6, the shaft 95 drives the unit PC through the bevel gears 96 and 97, the shaft 98 and the shaft of one of the impression cylinders I of the printing unit that is represented by the plate cylinders P, P and the impression cylinders II. These cylinders directly engage the running web 28 and accordingly the speed at which the generator 91 is driven bears a direct relation to the linear speed of the running web.

The apparatus for applying and controlling the operating energy for the fresh roll driving motor 42 and the dynamic braking of this motor to retard fresh roll rotation will now be described. This apparatus is illustrated in Fig. 10.

The roll drive motor 42 is a compound wound direct current motor having an armature A, a shunt field SF and a series field EF. Energy for operating this motor is derived from an alternating current power source AC through a rectifier employing grid controlled gas filled tubes of the type known as "Thyratrons," two of which are illustrated at 100 and 201. By employing rectifier tubes of this type and an electronic control circuit which governs the firing of these tubes, the amount of energy supplied to the motor 42 may be very rapidly varied and accurately controlled. The rectifier power supply does not, however, permit dynamic braking of the motor by merely decreasing the potential of the supply below the potential generated by the motor when it is driven by the momentum of the rotating fresh web roll and this for the reason that a rectifier conducts electric current in one direction only. For this reason, the mechanism is arranged to connect a dynamic braking resistor 116 across the motor armature A and series field EF to provide dynamic braking or retardation of the motor and thus retardation of the rotation of the fresh web roll when required. In general, the electronic control circuit compares the fresh roll speed voltage generated by the generator 49 to the running web speed voltage generated by the generator 91 and supplies operating energy or applies dynamic braking to the roll drive motor 42 in accordance with the relation and relative magnitude of these voltages. More specifically, the circuit acts to supply operating energy to the roll drive motor 42 in an amount directly proportional to the difference between the roll speed voltage and the web speed voltage when the relative value of these voltages indicates that the fresh roll speed is less than the running web speed, and to apply dynamic braking to the motor when the relative value of these voltages indicates that the fresh roll speed exceeds the running web speed by more than an exceeding small percentage.

As has been explained, the fresh roll speed voltage employed for comparison with the running web speed voltage is modified in accordance with the diameter of the particular web roll being accelerated. As shown in Fig. 10, the resistor 102 of the roll diameter responsive potentiometer 89 is connected across the terminals of the roll speed generator 49, and the movable arm 103 of this potentiometer, which is moved by the shaft 88 as has been explained, is raised to increase the proportion of the generated voltage delivered to the output circuit in comparison with the web speed voltage as the fresh roll diameter increases and is lowered to decrease the proportion of such voltage so delivered as the diameter of the fresh roll decreases. Thus, with a relatively large diameter fresh roll, the roll speed voltage employed for comparison is higher for a given angular velocity of roll rotation than with a relatively small diameter fresh roll. The roll speed voltage employed for comparison is thus modified directly with the fresh roll diameter to indicate the peripheral velocity of each fresh roll that is to be accelerated, despite differences in diameter between the individual rolls.

Referring to Fig. 10, alternating current from the source AC is supplied to the primary winding 105 of a power transformer PT through a switch 104. The switch 104 is connected to operate in unison with a field control switch 106 which supplies direct current from a source DC to a time delay relay TR, the contacts 112 of which are connected in the shunt field current supply circuit, as will be described. The relay TR is of the delayed closing type and its contacts 112 do not close until a predetermined time interval has elapsed, following its energization. This permits the various tubes of the circuit to warm up to operating cathode temperatures before the shunt field circuit is closed.

The secondary winding 107 of the power transformer PT supplies energy to the circuits of the rectifier tubes 100 and 201 and these anode circuits include in their common cathode return circuit 108 the series field EF and the armature A of the roll drive motor 42. This circuit is controlled by a main contactor M, the front contacts 109 of which are included in the common cathode return circuit, as shown. The shunt field SF of the motor is energized from a rectifier comprising the tubes 110 and 111, energized from the power transformer secondary winding 107 through a circuit including the contacts 112 of the relay TR, the coil 113 of a field loss relay FLR and a variable resistor 114. The variable resistor 114 is operatively connected to and varied by the movement of the brush arm 38, and is arranged to be completely cut out of the field circuit when the brush arm is in its lowered operative position as shown in broken lines in Fig. 10, and to be completely cut in that circuit when the brush arm is in its fully raised inoperative position. The front contacts 115 of the main contactor M shunt out the variable resistor 114 when the main contactor is closed. The dynamic braking resistor 116 is connected across the armature A and series field EF of the motor 42 when the dynamic braking relay DBR is energized. The coil 117 of the dynamic braking relay may be energized through a circuit including the back contacts 118 of the main contactor M so that dynamic braking is applied and is controlled by the position of the brush arm 38 when the main contactor M is deenergized and so opened. To simplify the drawing, the energy for the dynamic braking relay circuit and for other control circuits has been indicated by plus and minus signs.

The brush arm drive motor 41 is energized from a source indicated at L_1, L_2 under the control of a raise contactor 120 and a lower contactor 121. When the raise contactor 120 is energized, the motor 41 is energized to operate in a direction that raises the brush arm 38 through a circuit including the front contact 122 of the raise contactor, the back contact 123 of the lower contactor 121, and the motor field 124. When the lower contactor 121 is energized, the motor 41 is energized to operate in a direction to lower the brush arm 38 through a circuit including the front contact 125 of the lower contactor, the back contact 122' of the raise contactor, and the motor field 126. The raise and lower contactors may be energized in any known manner, as, for example, by the mechanism disclosed in the aforesaid Patent No. 2,148,094. To simplify the present disclosure, there is shown a raise switch 127 for energizing the raise contactor 120 and a lower switch 128 for energizing the lower contactor 121, the circuits controlled by these switches being apparent from the drawing.

The operating coil 129 of the main contactor M is energized by a circuit including the back contact 130 of the raise contactor 120, the front contacts 131 of the field loss relay FLR and the contacts 132 of the brush arm operated contactor C. The contactor C is operated by a cam 133 connected to be turned by movement of the brush arm 138 and arranged to close the contacts 132 in all brush arm positions except its fully raised inoperative position. Thus, the main contactor M is energized to supply operating energy to the roll drive motor 42 when the brush arm 38 is moved down from its inoperative position and is thereafter normally maintained energized until the brush arm is fully raised after a splice is made and the newly spliced roll is advanced by the reel to running position.

In the event that the shunt field SF of the motor 42 is deenergized for any reason, as, for example, by failure of one or both of the rectifier tubes 110 and 111, the field loss relay winding 113 is deenergized and the contacts 131 of this relay open, thereby breaking the main contactor energizing circuit, disconnecting the roll drive motor 42 from its source of operating energy and applying dynamic braking to this motor.

The amount of operating energy supplied to the roll drive motor 42 by the rectifier tubes 100 and 201 is controlled by an electronic control circuit responsive to the difference between web speed voltage and the fresh roll speed voltage as modified by the fresh roll diameter. A center tapped secondary winding 134 of the power transformer PT is connected in a phase shifting bridge circuit that controls the phase relation between the grid potential and the cathode potential of the rectifier tubes 100 and 201 and so governs the firing and the average current supplied by these tubes. One leg of this bridge circuit runs from the center tap of the secondary winding 134 through the primary winding 135 of a grid transformer GT and to the common wire 136. The secondary windings of the grid transformer GT are respectively connected in the grid circuits of the tubes 100 and 201, as shown. A second leg of the bridge circuit runs from one end of the transformer secondary winding 134 through a resistor 137 to the common wire 136. The third leg of the bridge circuit runs from the opposite end of the transformer secondary winding 134 through the wire 138 in parallel through the two alternating current windings 139 and 140 of the saturable core reactor SC to the common wire 136.

The saturable core reactor SC carries a direct current winding 141 connected in the anode circuit of a grid controlled vacuum tube D. The described bridge circuit acts in a known manner in response to an increase in the current in the winding 141 of the saturable core reactor to cause

the rectifier tubes 100, 201 to fire or conduct current earlier in the cycle of the alternating current impressed on their anode circuits and thus to pass a larger average anode current and so increase the operating energy supplied to the armature A and series field EF of the roll drive motor 42. A decrease in current through the winding 141 of the saturable core reactor similarly causes a smaller average current to be supplied to the motor 42 by the rectifier tubes 100 and 201. Thus, the amount of operating energy supplied to the roll drive motor is varied directly with changes in the anode current of the tube D.

Energy for operating the tube D and the other control tubes to be described is derived from the rectifier including the tubes 110 and 111 through the wire 142. By means of the series connected voltage regulator tubes VG and VB, the wire 142 is held at a steady positive potential with respect to the negative or return wire 143 that leads to the center tap of the transformer secondary winding 107, from which the rectifier tubes 110 and 111 are energized. A wire 144 is connected between the two voltage regulator tubes VG and VB and so is held at a positive potential approximately half that maintained on the wire 142.

The anode circuit of the tube D runs from the anode of that tube to the direct current winding 141 of the saturable core reactor SC to the wire 142, and from the cathode of the tube D to the wire 144. The grid of the tube D is connected to an intermediate point in a voltage dividing resistor circuit extending between the wires 142 and 143 and including the resistors R2, R3, R11 and R5. The potential applied to the grid of the tube D is varied by a grid controlled vacuum tube V, the grid and cathode potentials of which are respectively varied in accordance with changes in running web speed voltage and fresh roll speed voltage, as will now be explained.

The anode of the tube V is connected through the wires 145 and 146 to a point between the resistors R2 and R3. The cathode of this tube is connected through the wire 20 to the moving contact of a potentiometer R7, the resistor of which is connected in series with the terminals of the running web speed generator 91. A variable resistor 147 is included in this series circuit. The cathode circuit of the tube V is connected to the negative return wire 143 through a variable resistor R6, which provides adjustable negative grid bias for the tube V. The grid circuit of the tube V is completed through the return wire 143, a resistor R10, the resistor and the movable contact of a potentiometer R4 and the wire 148. A grid condenser 189 is connected between the grid and the cathode of the tube V. The resistor of the potentiometer R4 is connected to receive current proportional to the voltage generated by the fresh roll speed generator 49 as modified by the fresh roll diameter responsive potentiometer 89. To this end, the resistor of potentiometer R4 is connected through the resistor R9 to the movable arm 103 of the potentiometer 89, and the resistor of the potentiometer 89 is connected in series with the fresh roll speed generator 49 through the wires 149, 150, 151 and 143.

The tube V is of the sharp cut-off type and the constants of the described circuits of this tube are so chosen that when the peripheral velocity of the fresh roll, as determined by the terminal voltage of the generator 49 modified by the roll diameter responsive potentiometer 89, matches the running web speed as determined by the generator 91, the grid of the tube V will be biased negative with respect to its cathode to an extent that the tube will operate on the steep portion of its characteristic curve, and will pass just enough anode circuit current to fix the bias of the grid of the tube D at a point where the anode current of that tube will cause the power rectifier tubes 100 and 201 to supply just sufficient energy to the roll drive motor 42 to drive the fresh roll at the matched speed against the friction and windage load thereon. When the fresh roll speed is below the matched speed condition described, the grid of the tube V is at a lower potential with respect to its cathode than that obtaining under matched speed conditions and the tube V becomes non-conducting, thereby raising the potential on the grid of the tube D so that an increased amount of energy is supplied to the roll drive motor 42. The described circuit thus operates to supply to the roll drive motor 42 an amount of energy directly proportional to the excess of web speed voltage over roll speed voltage as modified by fresh roll diameter. With this arrangement, each fresh roll is accelerated to an angular velocity or rotative speed such that its peripheral velocity is equal to that of the running web, and is held at such speed until the splice is made.

When the fresh roll is at a standstill or is turning slowly, its inertia imposes a heavy load on the motor 42, and means are provided to limit the current drawn by this motor under such conditions and so to protect the motor and the rectifier tubes 100 and 201 against damage or failure due to overload. A rectifier tube FF is supplied with alternating current by a transformer IT having primary windings 156 and 157 connected, respectively, in the anode circuits of power supply rectifier tubes 100 and 201. The secondary winding 158 of the transformer IT has a center tap connected to the negative return wire 143 through the resistor 159. The cathode of the rectifier tube FF is connected through the resistor of a potentiometer IVR and the fixed resistor 160 to the negative return wire 143. With this arrangement, a direct current voltage proportional to the armature current of the motor 42 is produced across the resistor of the potentiometer IVR. A predetermined part of this potential is impressed on the control grid of a current limit tube DD, the anode of which is connected to the wire 146 and the cathode of which is connected to the wire 144. The cathode potential of the tube DD is held by the voltage regulator tubes VG and VB at a value considerably more positive than the negative return wire 143. The value of the fixed resistor 160 and the setting of the potentiometer IVR are so chosen that the grid of the tube DD is biased negative with respect to its cathode to an extent that the tube is non-conductive for all values of armature current in the motor 42 below a predetermined maximum safe value. If the motor armature current exceeds the safe maximum value, the potential on the grid of the tube DD rises to and past the cut-off point, and the tube DD, which has a sharp cut-off, becomes conductive, drawing current through the resistor R2 and so drawing the grid of the tube D negative and phasing back the firing point of the rectifier tubes 100 and 201, thus reducing the armature current supplied by these tubes to the motor armature circuit to a safe value. It sometimes happens that the speed of the press or other web consuming apparatus drops while a fresh roll is being accelerated or after the roll has been brought to web speed but before the splice is made. This, of course, results in a drop in running web speed. If the running web speed thus decreases to a value that is above the peripheral velocity of the fresh roll, the result of the decrease is merely to lower the potential of the cathode of the tube V, and so lower the fresh roll speed at which matched speed conditions obtain, as described above. If the running web speed falls appreciably below the peripheral velocity of the fresh roll, due to a considerable drop in web speed during fresh roll acceleration or to an appreciable drop in web speed after the fresh roll has reached matched speed, it is advisable to retard the rotation of the fresh roll so that no overrun of the web can result when the splice is made. Retarding of the fresh roll under these circumstances is accomplished under control of the tube V through a tube CC, the anode circuit of which is connected to the wire 142 through the winding 152 of a relay DR. The cathode of the tube CC is connected to the wire 144 and its grid is connected between the series connected resistors R3 and R11. The back contacts 153 of the relay DR are connected in a circuit including the wire 154 that energizes the dynamic braking relay DBR and so connects the dynamic braking resistor 116 across the armature A and series field EF of the motor 42 when the movable contact 155 of the relay DR drops. A sudden drop in running web speed to a value appreciably below the peripheral velocity of the fresh roll draws the cathode of the tube V so far negative with respect to its grid that the tube operates well above its cut-off point, drawing full anode current through the wires 145 and 146 and thus drawing the grid of the tube CC so far negative that the relay DR drops its movable contact 155, thus applying dynamic braking to the roll drive motor. As soon as the speed of the fresh roll drops to a value such that its peripheral velocity substantially equals that of the running web, the cathode to grid potential of the tube V is reduced to the point where the anode circuit current of this tube drops, thus permitting the grid of the tube CC to become more positive, with the result that the winding 152 of the relay DR receives sufficient energy to lift the movable contact 155, thus deenergizing the dynamic braking relay DBR and discontinuing dynamic braking of the fresh roll.

The constants of the described circuits are so chosen that a decrease in running web speed to a value only slightly (i. e., about one-half of one percent) below the peripheral velocity of the fresh web roll does not alter the cathode to grid potential of the tube V sufficiently to operate this tube above the steep portion of this characteristic curve, and thus does not result in sufficient current in the anode circuit of the tube V to cause dynamic braking, as described. In such a case, the result of the drop in running web speed is merely to reduce the amount of operating energy supplied to the fresh roll drive motor 42 by drawing the potential of the grid of the tube D slightly more negative than it was at the matched speed condition. As the operating energy for the motor 42 is thus slightly reduced, the friction load on the motor, the fresh roll and the driving connection therebetween, is sufficient to promptly reduce the roll speed to a value that matches the web speed, and the cathode potential of the tube V is thereby so reduced relative to its grid potential that energy sufficient to maintain the fresh roll at the matched speed is supplied to the roll drive motor 42.

The operation of the disclosed mechanism will now be explained. Some time during the running off of the web from the running roll R, the operator advances the reel to place the fresh roll F in the speed-up position shown in Figs. 1 and 3. The power switches 104 and 106 are closed at or prior to this time and have remained closed for a sufficient interval to permit heating of the cathodes of the rectifier tubes 100, 201, 110 and 111 to operating temperature. The relay TR has accordingly closed its contacts 112. As the fresh roll F moves to the speed-up position, the roll size potentiometer 89 is set by the fresh roll F, as has been explained, to a position in which it modifies the voltage generated by the roll speed generator 49 so as to produce at the grid of the tube V a voltage corresponding to the peripheral velocity of the particular fresh roll. Also during advancing of the roll F to speed-up position, the clutch 64, 65 of the fresh roll spindle 22 is engaged by movement of the roller 71 off the cam 72, and in this manner the motor 42 and the roll speed generator 49 are operatively connected to the fresh roll F.

When from the size of the depleted running roll R the operator judges that a roll replacement is necessary, he lowers the brush arm 38 to its vertical operating position, as shown in Figs. 1, 3 and 7, by closing the lower switch 128. The initial downward movement of the brush arm from its raised inoperative position closes the contactor C. This energizes and closes the main contactor M through a circuit including the contacts 132 of the contactor C, the contacts 131 of the field loss relay FLR and the back contact 130 of the raise contactor 120. Closure of the main contactor M applies operating energy from the rectifier tubes 100 and 201 to the armature and series field circuit of the roll drive motor 42, which then starts and accelerates the fresh roll. The amount of energy supplied to the motor 42 is reduced in proportion to the reduction of the amount by which the running web speed voltage of the generator 91 exceeds the roll speed voltage of the generator 49 as modified by the roll size potentiometer 89, and when these voltages are matched, which occurs when the peripheral velocity of the fresh roll matches the linear velocity of the running web 28, the amount of operating energy supplied to the motor 42 is just enough to maintain roll rotation at the matched speed.

If during acceleration or prior to splicing, the press or other web consuming apparatus slows down enough to bring the web speed more than about one percent below the peripheral velocity of the fresh roll, the relay DR drops its contact 155 and energizes the dynamic braking relay DBR, thus connecting the resistor across the motor armature A and series field EF to apply dynamic braking and retard the fresh roll speed to a value at which its peripheral velocity again matches the speed of the running web. When the fresh roll has thus been retarded to matched speed, the relay DR lifts its contact 155, deenergizes the dynamic braking relay DBR and so disconnects the resistor 116 from the motor armature circuit.

After the splice is made, the brush arm 38 is raised by closing of the raise switch 127, and at

the same time the reel is advanced progressively through the position shown in Fig. 8 to the running position shown in Fig. 9. The raise switch may be closed and the reel advanced by automatic mechanism initiated by the operation of the knives 37 at the conclusion of the splicing operation, as is disclosed in Patent No. 2,148,094. To simplify the present disclosure such automatic mechanism is not shown. Energization of the raise contactor 120 opens the energizing circuit for the main contactor M and so disconnects operating energy from the motor armature A and series field EF. Deenergization of the main contactor M also energizes the dynamic braking relay DBR through the back contacts 118 and opens the shunt, including the front contacts 115, around the brush arm operated variable resistor 114. Dynamic braking is thus applied to retard the newly-spliced-in roll immediately after the splice is made and before the roll is moved into contact with the tension straps 31. As the new roll F moves progressively into greater peripheral contact with the straps 31, the value of the variable resistor 114 is increased by upward movement of the brush arm 38, thus reducing the shunt field current and the dynamic braking retardation of the newly-spliced-in roll. When the brush arm 38 reaches its fully raised inoperative position, the contactor C is opened by the cam 133 and this maintains the main contactor M deenergized despite the fact that the raise contactor 120 is then deenergized due to opening of the raise switch 127 by the operator. At the running position of the reel, the clutch of the fresh roll spindle is disengaged by movement of the roller 71 onto the cam 72.

I claim:

1. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a web roll support, an electric motor connected to drive a roll on said support through its axis, a running web speed generator driven from said web consuming apparatus at a speed proportional to the speed of travel of said running web, a fresh roll speed generator driven from said motor at a speed proportional to the angular velocity of a roll on said support, means for supplying operating energy of variable magnitude to said motor, means for variably reducing the voltage generated by said roll speed generator directly with and in proportion to the initial diameter of a fresh roll on said support, and means responsive to the relation between the voltage generated by said web speed generator and the voltage generated by said roll speed generator as reduced by said voltage reducing means for governing the amount of energy supplied to said motor.

2. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a web roll support, an electric motor connected to drive a roll on said support through its axis, a running web speed generator driven from said web consuming apparatus at a speed proportional to the speed of travel of said running web, a fresh roll speed generator driven from said motor at a speed proportional to the angular velocity of a roll on said support, means for supplying operating energy of variable magnitude to said motor, means for variably reducing the voltage generated by said roll speed generator, movable means responsive to the diameter of a fresh web roll on said support for setting said voltage reducing means to

reduce the roll speed generator voltage directly with and in proportion to the diameter of a fresh web roll on said support, and control means responsive to the amount by which the voltage generated by said web speed generator exceeds the voltage generated by said roll speed generator as reduced by said voltage reducing means for supplying to said motor from said energy supply means an amount of energy proportional to such excess.

3. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a web roll support, an electric motor having an armature and a series field connected to drive a roll on said support through its axis, a running web speed generator driven from said web consuming apparatus at a speed proportional to the speed of travel of said running web, a fresh roll speed generator driven from said motor at a speed proportional to the angular velocity of a roll on said support, means for supplying operating energy of variable magnitude to said motor, means responsive to the amount by which the voltage generated by said web speed generator exceeds the voltage generated by said roll speed generator for supplying to said motor from said energy supply means an amount of energy proportional to such excess, a resistor, and means responsive to an excess of roll speed generator voltage over web speed generator voltage for electrically connecting said resistor in series with the armature and series field of said motor to apply dynamic braking to a web roll driven by said motor.

4. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a web roll support, an electric motor having an armature and a series field connected to drive a roll on said support through its axis, a running web speed generator driven from said web consuming apparatus at a speed proportional to the speed of travel of said running web, a fresh roll speed generator driven from said motor at a speed proportional to the angular velocity of a roll on said support, means for supplying operating energy of variable magnitude to said motor, means for variably reducing the voltage generated by said roll speed generator, movable means responsive to the diameter of a fresh web roll on said support for setting said voltage reducing means to reduce the roll speed generator voltage directly with and in proportion to the diameter of a fresh roll on said support, means responsive to the amount by which the voltage generated by said web speed generator exceeds the voltage generated by said roll speed generator as reduced by said voltage reducing means for supplying to said motor from said energy supply means an amount of energy proportional to such excess, a resistor, and means responsive to an excess of roll speed generator voltage over web speed generator voltage for electrically connecting said resistor in series with the armature and series field of said motor to apply dynamic braking to a roll driven by said motor.

5. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a movable fresh roll support, an electric motor connected to drive a roll on said support through the axis of such roll, a running web speed generator driven by said web consuming apparatus at a speed proportional to the linear velocity of said running web, a roll speed generator driven by said motor at a speed proportional to the angular velocity of a fresh roll on said support, a potentiometer connected across the output circuit of said roll speed generator, a movable arm connected to operate said potentiometer having a part thereof disposed in the path of movement of the peripheral surface of a roll on said movable support whereby said arm is moved and said potentiometer is set by movement of a fresh roll on said support to reduce the voltage generated by said roll speed generator directly with and in proportion to the diameter of such roll, and means governed by the voltages generated by said generators for supplying to said motor an amount of operating energy proportional to the amount by which the voltage generated by said web speed generator exceeds the voltage generated by said roll speed generator as reduced by said potentiometer.

6. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a fresh web roll support, an electric motor having an armature and a series field connected to drive a roll on said support, web speed responsive means driven by said web consuming apparatus, roll speed responsive means driven by said motor, a resistor, and means responsive to an excess of the roll speed indicated by said roll speed responsive means over the web speed indicated by said web speed responsive means for connecting said resistor in series with the armature and series field of said motor.

7. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a fresh web roll support, an electric motor having an armature and a series field connected to drive a roll on said support, web speed responsive means driven by said web consuming apparatus, roll speed responsive means driven by said motor, means responsive to an excess of the web speed indicated by said web speed responsive means over the roll speed indicated by said roll speed responsive means for supplying operating energy to said motor, a resistor, and means responsive to an excess of the roll speed indicated by said roll speed responsive means over the web speed indicated by said web speed responsive means for connecting said resistor in series with the armature and series field of said motor.

8. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a fresh web roll support, an electric motor connected to drive a roll on said support through the roll axis, a web speed responsive generator driven by said web consuming apparatus, a roll speed responsive generator driven by said motor, means for variably reducing the voltage generated by said roll speed generator, means responsive to an excess of web speed generator voltage over roll speed generator votage as reduced by said voltage reducing means for supplying to said motor an amount of operating energy proportional to such excess, and roll calipering mechanism responsive to the diameter of a roll on said support for setting said variable voltage reducing means to reduce the rool speed generator voltage in direct proportion to the diameter of the roll.

9. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a web roll reel rotatable to move a fresh web roll to a position in which it is accelerated in preparation for splicing its web to the running web, an electric

motor connected to drive a roll on said reel through the roll axis, a running web speed generator driven by said web consuming apparatus at a speed proportional to the linear velocity of the running web, a roll speed generator driven by said motor at a speed proportional to the angular velocity of the motor driven roll, means for variably reducing the voltage generated by said roll speed generator, means for setting said voltage reducing means to reduce the roll speed generator voltage in direct proportion to the diameter of a fresh roll comprising an arm connected to said voltage reducing means and disposed in the path of roll movement by said reel to the roll accelerating position, and means responsive to an excess of web speed generator voltage over roll speed generator voltage as reduced by said voltage reducing means for supplying to said motor an amount of operating energy proportional to such excess.

10. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a fresh web roll support, a direct current motor having an armature, a series field and a shunt field, connected to drive a roll on said support, a brush arm for effecting a splice between the running web and the web of a roll on said support and movable between an operative position and an inoperative position, means for initiating movement of said brush arm from its operative position toward its inoperative position, means for connecting a source of operating energy to the armature and series field of said motor, a shunt field energizing circuit, a variable resistor selectively connectible in said shunt field energizing circuit, a dynamic braking resistor, means responsive to operation of said brush arm movement initiating means for disconnecting said source of operating energy from said motor armature and said series field and connecting said dynamic braking resistor thereto and simultaneously connecting said variable resistor in said shunt field energizing circuit, and means for progressively reducing the value of said variable resistor as said brush arm moves from its operative to its inoperative position.

11. Web roll accelerating apparatus comprising the combination with web consuming apparatus and a web running thereto, of a fresh web roll support, a direct current motor having an armature, a series field and a shunt field, connected to drive a roll on said support, a web speed generator driven by said web consuming apparatus, a roll speed generator driven by said motor, a brush arm for effecting a splice between the running web and the web of a roll on said support and movable between an operative position and an inoperative position, means for initiating movement of said brush arm from its operative position toward its inoperative position, means for connecting a source of operating energy to the armature and series field of said motor, a shunt field energizing circuit, a variable resistor selectively connectible in said shunt field energizing circuit, a dynamic braking resistor, means responsive to an excess of roll speed generator voltage over web speed generator voltage for connecting said dynamic braking resistor to said motor armature and series field, means responsive to operation of said brush arm movement initiating means for disconnecting said source of operating energy from said motor armature and series field, connecting said dynamic braking resistor thereto and connecting said variable resistor in said shunt field energizing circuit, and means for progressively reducing the value of said variable resistor as said brush arm moves from its operative to its inoperative position.

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