

Aug. 25, 1936.

D. R. SHOULTS

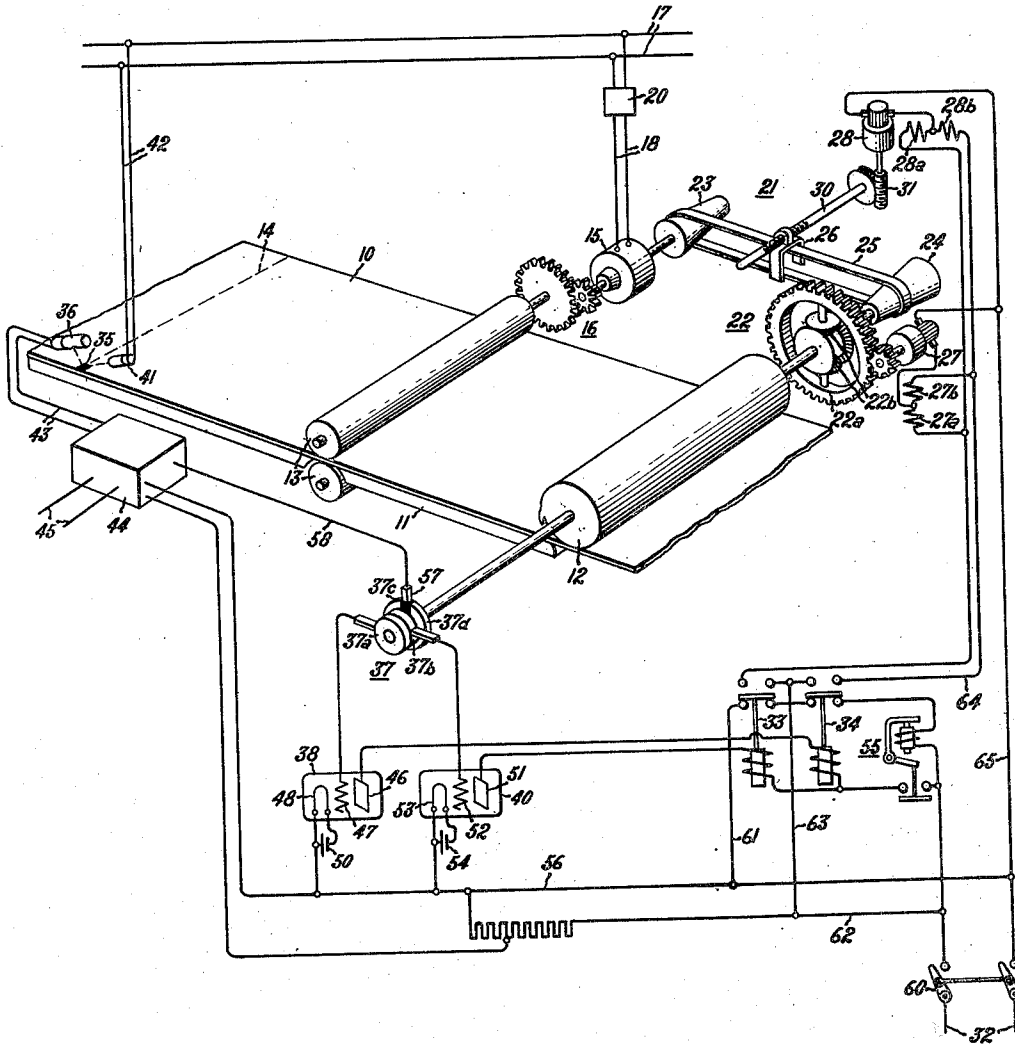
2,052,255

CONTROL SYSTEM

Filed July 21, 1932

2 Sheets-Sheet 1

Fig. 1.



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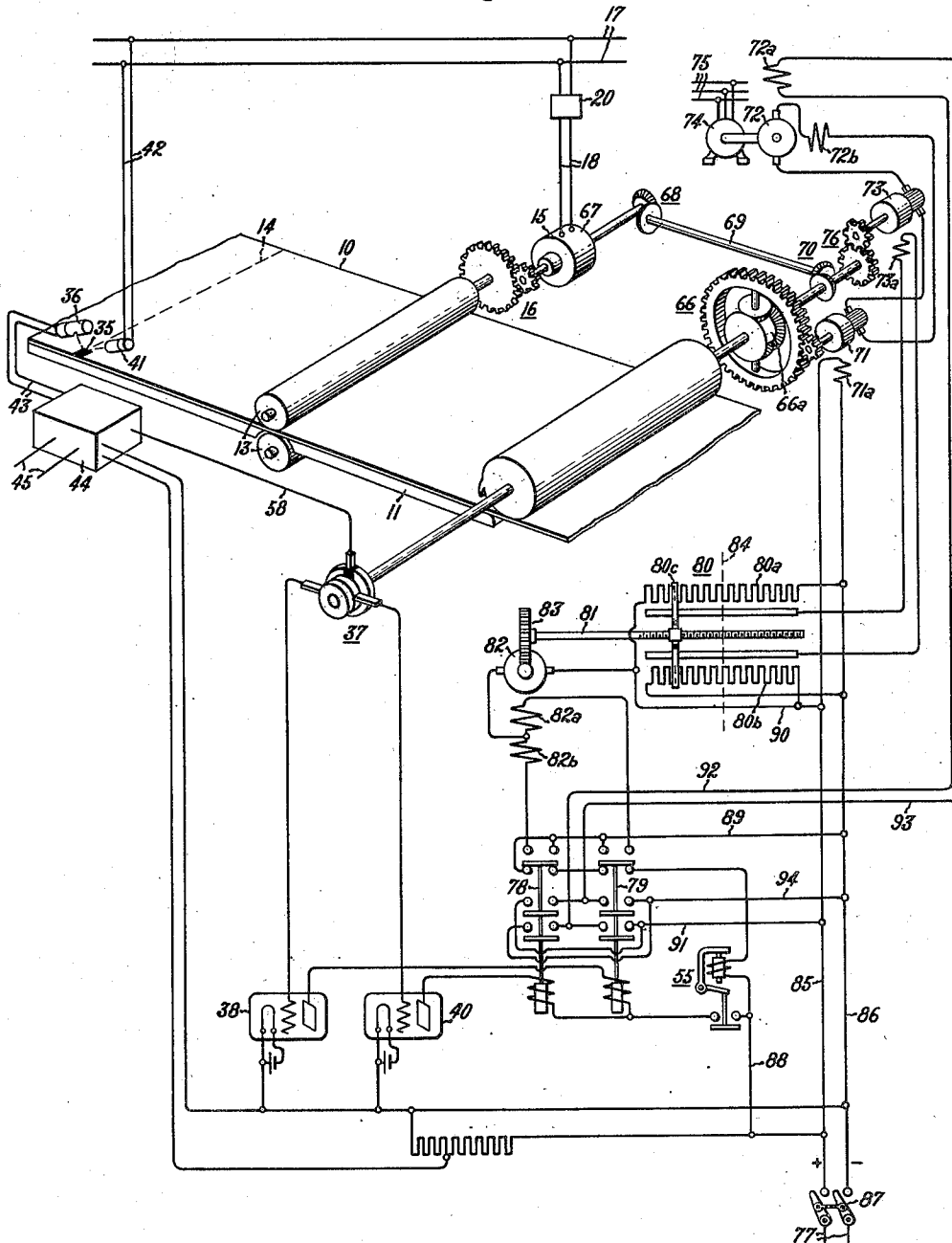
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2 Sheets-Sheet 2

Fig. 2.



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UNITED STATES PATENT OFFICE

2,052,255

CONTROL SYSTEM

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Application July 21, 1932, Serial No. 623,795

23 Claims. (Cl. 164—68)

This invention relates to control systems, more particularly to systems for controlling the operation of machines having an element operating upon a strip of material, and it has for an object the provision of a simple, reliable and efficient control system of this character.

More specifically the invention relates to systems for controlling the operation of machines in which an element is required to operate in predetermined relationship with the strip of material such for example as machines for cutting a strip of material into bag lengths or package wrapper lengths in register with designs, labels, or other matter previously printed on the strip. In cutting machines of this character, which usually consist of a rotary cutting knife and a pair of draw rolls for feeding the strip to the knife, it is difficult to maintain the cuts in proper register even with exactly calculated gear ratios because of variable factors such as slippage, and stretch or shrinkage of the strip due to varying moisture conditions of the atmosphere. These variables may be cumulative so that each successive cut is made with greater error. In case the cut is not being made in proper register, it is necessary to compensate for the error.

The present invention is an improvement of the invention disclosed in application Serial No. 457,589, William R. King, filed May 30, 1930, now Patent No. 2,002,374 granted May 21, 1935, which invention was made by the said William R. King prior to my invention and which is assigned to the assignee of the present invention; and I do not herein claim anything disclosed in the King application.

A further object of the invention is the provision of means eliminating "hunting", i. e. continued alternate cutting of the strip on opposite sides of the successive desired points of cut off. An additional object of the invention is the provision of means for compensating for cumulative errors between the strip and cutter.

In carrying the invention into effect in one form thereof, both the cutting element of the machine and the element for feeding the strip to the cutting element are driven at suitable relative speeds and means are provided for effecting a correction in the relative speeds of the strip and the cutting element together with a differential device for effecting a space correction in the relative positions of the strip and the cutting element. These two corrections are separate from each other. The "positional" or "space" correction may be considered a correction which takes place comparatively rapidly for

the purpose of correcting the amount of register and the speed ratio correction as a correction for maintaining the register for a relatively long period until changing conditions are encountered which require corrections.

In a specific embodiment of the invention, the strip is provided during the printing process with index markings in predetermined relationship with the labels or other printed matter, and suitable light sensitive means controlled by these index markings function through suitable control apparatus to introduce a correction in the relative speeds of the strip and cutting element and also to actuate the differential device to produce the required space correction in the relative position of the strip and cutting element.

In illustrating the invention in one form thereof, it is shown as embodied in a system for controlling the cut-off operation of a bag cutting or package wrapper cutting machine, but it will be understood that this application of the invention is shown merely for the purpose of illustration and that the invention may be utilized generally for controlling machines having an element for performing various operations on a strip of material in predetermined registry with designs, labels, or other matter on the strip.

For a better and more complete understanding of the invention reference should now be had to the following specification and to the accompanying drawings in which Fig. 1 is a simple diagrammatic representation of an embodiment of the invention and Fig. 2 is a simple diagrammatic representation of a modification.

Referring now to the drawings, a strip of material 10 such for example as a material from which bag lengths or package wrapper lengths are to be cut is fed from a supply roll (not shown) over a table 11 to a suitable cutting device such for example as that represented by the rotary cutting knife 12, by means of a pair of draw rolls 13. The strip 10 is provided with designs, labels or other printed matter (not shown) at each section, such for example as the section of the strip between the broken line 14 and a similar line obscured by the cutting knife 12, at which lines it is desired to sever the strip for the purpose of forming articles such as package wrapper lengths or bag lengths upon which the design, label or other matter is properly centered.

The feed rolls 13 are driven by any suitable driving means, such for example as that represented by the electric motor 15 to the drive shaft of which the shafts of the rolls 13 are mechanically connected by gearing 16. As shown, the

motor 15 is supplied from a suitable source of power such for example as that represented by the upper and lower supply lines 17 to which the motor is connected by the conductors 18; a motor starting device 20 of any suitable type being included in circuit therewith.

The rotary cutting knife 12 may be driven by any suitable driving means, the speed of which may be varied or adjusted to provide for adjustment of the relative operating speeds of the cutter and the moving strip so as to cause the cutter to operate in a predetermined relationship with respect to the sections of the strip, i. e. to sever the strip at the predetermined cut-off lines 14. For the purposes of illustration, however, the cutter 12 is shown in the drawings as being driven by the electric motor 15 to the drive shaft of which the shaft of the cutter 12 is mechanically connected by means of the variable speed transmission device 21 and the differential device 22. As shown, the variable speed transmission device 21 comprises a pair of cone pulleys 23 and 24 connected together by a driving belt 25, the position of which upon the surfaces of the pulleys is varied by means of a belt shifter 26. The pulley 23 is fixedly mounted on the drive shaft of the motor 15 for rotation therewith and the pulley 24 is connected to the cutting knife 12 by means of the differential device 22, which is illustrated as comprising a differential gearing mechanism having its input element directly connected to the pulley 24 and its output element directly connected to the drive shaft of the rotary cutting knife 12 and also having a third element illustrated as an annular gear wheel 22a provided with internal planetary pinions 22b mounted for rotation about an axis fixed with respect to the member 22a and meshing with the input and output element of the differential device. This differential gearing system 22 serves to provide the correction in space relationship between the desired cut-off points of the strip 10 and the blade of the rotary cutting knife 12. Under normal operating conditions, the third element 22a of the differential device is held stationary, and the remaining two elements, i. e., the input and the output elements act as a direct gearing system between the driven pulley 24 and the drive shaft of the rotary cutting knife. If a space correction is necessary, rotation of the third element of the differential device will cause this correction to be made and when the movement of the third element ceases, the correction is maintained. Further correction in either direction when necessary is made by rotation of this third element in the proper direction.

As shown, the third element 22a of the differential device is rotated by a small pilot motor 27 to the drive shaft of which this third element is connected through suitable reducing gearing. The pilot motor 27 is provided with a split series field winding comprising the two oppositely wound portions 27a, 27b for the purpose of effecting operation of the motor in respectively opposite directions when one or the other of these two portions is energized. Similarly the belt shifter 26 of the variable speed transmission device 21 is operated in a forward or reverse direction to vary the position of the belt 25 upon the surfaces of the cone pulleys 23 and 24, by means of a small pilot motor 28 to the drive shaft of which the screw 30 of the belt shifter is connected through reduction worm gearing 31. The motor 28 is also provided with a series field winding comprising the two oppositely wound portions

28a and 28b for the purpose of effecting rotation in respectively opposite directions when one or the other of these two portions is energized. It will thus be seen that by energizing the motor 28, the variable speed transmission 21 is actuated to vary the speed relationship between the rotary cutting knife 12 and the strip 10, and that when the motor 27 is energized the differential device 22 is actuated to effect a correction in the space relationship between the strip and the cutting knife.

Energization of the pilot motors 27 and 28 and energization of one or the other of the oppositely wound portions of the split field windings is controlled by suitable electromagnetic switching mechanism illustrated as a pair of contactors 33 and 34. The directional contactor 33 when actuated to its upper position serves to connect the pilot motor 27 to a suitable source of power, represented by the two supply lines 32, in series relationship with the portion 27a of its field winding to effect rotation of the motor in a given direction, for example the forward direction, and also serves to connect the pilot motor 28 to the same source of power in series relationship with the portion 28a of its winding to effect rotation of the motor 28 in the forward direction. Similarly the operation of the contactor 34 to its upper position serves to connect the pilot motor 27 to the source 32 in series relationship with the portion 27b of its field winding and also serves to connect motor 28 to the source 32 in series relationship with the portion 28b of its field winding. The connections of the motors 27 and 28 are so chosen that when both are simultaneously energized the correction in both the speed and space relationships of the strip 10 and the cutting knife 12 are made in the same sense; that is to say, if the motor 27 is energized to move the blade of the cutting element closer to a point on the strip 10, the motor 28 is energized to increase the speed of the cutting element 12 with respect to the speed of the strip 10.

As shown in the drawings, the sheet 10 is provided at suitable intervals with indicia or index markings shown as black spots 35 which are preferably printed upon the strip when the design, label or other matter is printed thereon. These spots are all positioned on the strip in a predetermined relationship with respect to the printed matter, or with respect to the cut-off lines 14. No particular relationship between the position of the index markings and the cut-off lines is necessary since it is only necessary that the same relationship obtain between each of the markings and the printed matter or cut-off line with which it is associated.

The operation of the pilot motors 27 and 28 to effect relative space and speed corrections respectively between the strip 10 and the cutting knife 12 is automatically controlled by means of the control system illustrated in the drawings as comprising a light sensitive device 36, preferably a photo-electric cell, which responds to the passage of the index marks 35 and a cooperating selector switch 37 controlled in accordance with the position of the rotary knife 12, to energize one or the other of the electric valves 38 and 40 in the respective output circuits of which the operating coils of the contactors 33 and 34 are connected. As shown, the light sensitive device 36 is mounted above the strip 10 and in such a position with respect to a source of light 41 as to be influenced by a beam of light reflected from the strip. The light source 41 is illustrated as an ordinary in-

candescent lamp suitably mounted above the strip and supplied with energy from a suitable source such for example as that represented in the drawings by the supply lines 17 to which the lamp is connected by means of the conductors 42. The light sensitive device 36 is so positioned with respect to the rotary knife 12 that one of the index marks 35 interrupts the reflection of light to the light sensitive device when one of the cut-off lines of the strip 10 is in some predetermined position, for example at the point of cut-off on the table 11. When one of the index markings 35 is in the position shown with respect to the light source 41 and the light sensitive device 36 shown in the drawings, the light reflected from the strip to the light sensitive device 36 is interrupted or at least is greatly diminished, and this interruption or diminution of received light causes the light sensitive device 36 to produce a controlling impulse, i. e., a change in the magnitude of the current flowing in the electrical circuit 43 in which it is connected.

Since the impulses produced in the electric circuit 43 when dark spots diminish the light received by the light sensitive device 36 are very feeble, it is necessary to amplify these impulses in order that they may be transmitted and utilized to control the energization of the electric valves 38 and 40. Accordingly, a suitable amplifying device 44 is interposed in the circuit between the light sensitive device 36 and the electric valves 38 and 40 and this amplifying device is connected to a suitable electrical source by means of conductors 45.

Although the electric valves 38 and 40 may be of any suitable type, they are preferably of the three electrode type as illustrated; the valve 38 being provided with a plate or anode 46, a control electrode or grid 47 and a cathode 48 illustrated as being of the filamentary type, heated to the required degree of incandescence by electrical energy supplied to it from a suitable source 50, and the valve 40 being similarly provided with an anode 51, a grid 52 and a cathode 53 supplied with energy from a source 54. The electric valves 38 and 40 are preferably of the type having a small quantity of an inert gas such for example as mercury vapor introduced into the envelope after exhaust. The presence of this gas within the envelope serves to change the usual pure electron discharge into an arc stream, the starting of which is controlled by applying a suitable positive bias to the grid and thus constituting the device an electrostatically or grid controlled arc rectifier. Once the flow of current has been initiated in the anode circuits of the electric valves the grid is powerless to control the flow of current thereafter which can only be interrupted by interrupting the anode circuit itself or by reducing the potential applied to the anode substantially to zero.

The anodes 46 and 51 of the electric valves 38 and 40 are respectively connected with the positive side of the direct current source 32 in series relationship with the respective operating coils of the directional contactors 34 and 33. The controlling impulses produced by the passage of the index markings 35 beneath the light sensitive device 36 is of extremely brief duration, in practice often less than 1/100 of a second. A positive impulse applied to the grids of the electric valves however for such a brief duration is sufficient to initiate the flow of current in the anode circuit of the electric valves and this current will continue to flow until the anode circuits are interrupted, even though the index markings 35 have passed

out of cooperative relationship with the light sensitive device 36. A suitable switching device 55 having a magnetic circuit designed to provide a time element in its drop-out operation serves to interrupt the anode circuit of the electric valves 38 and 40 a predetermined interval of time after the flow of current is initiated therein. Cathodes 48 and 53 of the electric valves are connected to the negative side of the supply source 32 by means of the conductor 56 with the result that the anodes 46 and 51 are positively biased with respect to the cathodes and as shown, the grids 47 and 52 are respectively connected to segments 37_a and 37_b of the selector switch 37, which segments are insulated from each other and respectively connected to the opposite sectors 37_c and 37_d, which are insulated from each other as illustrated and upon the periphery of which bears a brush 57 connected to the amplifying apparatus 44 by means of conductor 58. The electric valves 38 and 40 may either be of the type designed to prevent the initiation of current flow in the anode circuit until a sufficiently positive bias is applied to the grid or alternatively their grids may be provided with suitable negative bias connections which are not shown but which are well understood by persons skilled in the electrical art. The selector switch 37 is so arranged on the shaft of the rotary knife 12 that the brush 57 is in contact with the insulating portion between the segments 37_c and 37_d at the instant that the index mark 35 interrupts the beam of light reflected from the strip to the light sensitive device 36 if the rotary knife 12 is in such a relationship with respect to the strip as to sever it at the proper point of cut off. Thus it will be seen that when the knife 12 is in correct registry with the printed matter on the strip 10 the passage of the index marks 35 to interrupt the light beam received by the light sensitive device 36 does not cause any impulses to be transmitted to the grids 47 and 52 of the electric valves.

With the above understanding of the elements and apparatus and their organization in the completed system, the operation of the system itself will readily be understood from the detailed description which follows:

To place the system in operation the switch 60 is first operated to the closed position to connect the operating coil of the time element relay 55 to the source 32 over a circuit that is readily traced from the positive side of the source 32 through the left-hand pole of the switch 60, the operating coil of relay 55, the auxiliary contacts of contactors 34 and 33 in their lower position, and thence by conductors 61 and 56 to the right-hand pole of the switch 60 and the negative side of the source 32. The relay 55 in responding to the energization of its operating coil is operated to its upper or closed position in which its contact connects the anodes 46 and 51 of the electric valves 38 and 40 to the positive side of the supply source 32. The driving motor 15 is started by the starting device 20 and thereafter the feed rolls 13 feed the strip 10 to the rotary knife 12 at the desired rate. As long as the necessary predetermined relationship exists between the rotary knife and the printed matter on the strip 10, the index marks 35 interrupt the light received by the light sensitive device 36 at the instant that the brush 57 bears upon the insulated portion of the selector switch 37 between the segments 37_c and 37_d and no corrective action is made.

In case the cut is not being made in register

with the printed matter on the strip it is necessary to make a correction in the space relationship between the rotary knife and the strip and it is further desirable simultaneously to alter the velocity relationship of the rotary knife and feed rolls to compensate for the error which first causes the knife to become out of registry with the strip. Assume for example, that due to some cause the knife becomes out of register with the printed matter on the strip so that the cut is made after the cut-off line has passed the point on the table at which the cut is made. That is to say, the knife is cutting late. The brush 57 is in contact with the segments 37c at the instant that an index mark 35 interrupts the beam of light received by the light sensitive device 36 which causes an impulse to be transmitted through the circuit 43 to the amplifying apparatus 44 and in turn causing a positive bias to be applied to the grid 47 of electric valve 38. The positive bias applied to the grid 47 initiates the flow of current in the anode circuit of the electric valve 38 thereby energizing the operating coil of directional contactor 34, which in response to the energization of its operating coil is operated to its upper position to connect the armature windings of pilot motors 27 and 28 to the supply source 32. The index mark 35 immediately passes out of cooperative relationship with light sensitive device 36 thereby removing the positive bias from the grid 47 of electric valve 38 but as previously pointed out once the flow of current in the anode circuit of the electric valve is initiated, it is maintained until the circuit is interrupted. Consequently, the contactor 34 remains operated to its upper position after the index mark 35 has passed out of cooperative relationship with light sensitive device 36. The connection of motor 27 to the supply source 32 is traced over a circuit extending from the positive side of the supply source 32 by conductors 62 and 63, contact of directional contactor 34 in the upper position thereof, conductor 64, winding portion 27b of the split field winding, armature of motor 27 and thence by conductor 65 to the negative side of the supply source 32 and the connections for the motor 28 are traced in parallel with those of the motor 27 from the conductor 64 through the winding portion 28b of the split field winding, the armature of motor 28 and thence to conductor 65.

The motor 27 rotates the third element 22a of the differential device 22 in such a direction as to cause an additional or increased movement of the rotary knife 12 thereby effecting a correction in the space relationship between the knife 12 and the strip 10. Simultaneously the motor 28 actuates the belt shifter 26 of the variable speed transmission 21 to shift the belt in such a direction on the surfaces of the cone pulleys 23 and 24 as to increase the speed of the rotary knife 12 with respect to the speed of the feed rolls 13 of the strip 10. The reduction ratio of the gearing 31 is very large in comparison with the reduction ratio between the motor 27 and the differential device 22 so that the correction in relative speed of the knife and the strip is very slight in comparison with the space correction in the relative position of the knife 12 and the strip 10. The relative speed correction is purposely made small in comparison with the space correction so that the speed correction will act merely as a "follow-up" to the main space correction.

The operation of directional contactor 34 to

its upper position interrupts the energizing circuit for the operating coil of relay 55 and after a predetermined interval of time determined by the design of the magnetic circuit of this relay, the contact of this relay descends to its lower position in which it interrupts the anode circuit of electric valve 38 thereby rendering the valve inactive and interrupting the energization of directional contactor 34, the contact of which accordingly descends to its lower position in response to the deenergization of its operating coil. Contactor 34 in descending to its lower position disconnects the pilot motors 27 and 28 from the supply source 32 and accordingly the rotation of these motors ceases. In the lower position of the contactor 34, the energizing circuit for the time element relay 55 is reestablished and the system is in a reset condition to repeat the above described operation.

If the rotary knife 12 becomes out of register with the strip 10 so that the cut is made early instead of late, the brush 57 is in contact with the segment 37a of the selector switch 37 at the instant that the index mark 35 passes beneath the light sensitive device 36 thereby causing a positive bias to be applied to the grid 52 of the electric valve 40 and in turn energizing directional contactor 33. Contactor 33 in responding to the energization of its operating coil moves to its upper position in which it interrupts the energizing circuit of the time element relay 55 and in which it connects the pilot motors 27 and 28 to the source 32 in series relationship with the portions 27a and 28a thereby causing these motors to rotate in directions opposite to those previously described, and causing relative space and relative speed corrections between the rotary knife 12 and the strip 10 to be made in the opposite sense to the corrections previously described and in the same relative amounts.

It will, therefore, be seen that if the cut is being made out of registry with the printed matter on the strip the system functions to introduce a correction in the space relationship between the relative position of the strip and the rotary knife 12 and simultaneously alters the velocity relationship between the strip and the knife so as to compensate for the error which first causes the knife to become out of registry. This method of introducing the necessary compensation for out of register effectually prevents "hunting", that is to say it prevents continuous alternate cutting of the strip on opposite sides of the desired point of cut off for the successive cuts.

The system of the modification of Fig. 2 is in most respects similar with the system of Fig. 1; the principal difference being that means are provided for actuating and controlling the differential device 66 in such a manner as to introduce both the space and relative speed correction between the strip and the rotary knife. As shown, the input element 65a of the differential device 66 is directly connected to the shaft of the drive motor 67 by means of bevel gearing 68, shaft 69 and bevel gearing 70. The third element of the differential device 66 is rotated by means of an electric motor 71, the armature of which is connected in a closed loop in series relationship with the armature winding of an electric generator 72 and a second electric generator 73. The generator 72 is driven at a speed which is preferably substantially constant by any suitable means such for example as the alternating current motor 74 supplied from a

5 suitable source represented by the three supply lines 75 whilst the electric generator 73 is connected to the drive shaft 69 by means of bevel gearing 70 and suitable reduction gearing 76 so that when the machine is in operation, it is driven continuously and at a speed proportional to that at which the machine is driven. The generator 72 is provided with a separately excited field winding 72_a which is arranged to be 10 connected to the direct current source 77 by means of the reversing contactors 78 and 79 for energization in one direction or the other, depending upon which of the contactors is actuated to its closed position. As shown, the generator 72 is also provided with a series field winding 72_b for the purpose of compensating for the IR drop of the loop circuit comprising the armatures of the three machines 71, 72 and 73 respectively.

20 Similarly the generator 73 is provided with a separately excited field winding 73_a which is arranged to be connected to the source 77 in series relationship with a reversible variable rheostat 80 shown as comprising two resistance sections 80_a and 80_b connected in parallel with each other to the source 77 and a cooperating movable contact arm 80_c the position of which along the resistance sections 80_a and 80_b is varied by means of a screw 81, which in turn is rotated by a suitable electric motor 82 to the shaft of which the screw 81 is connected by means of gearing 83. As shown, the motor 82 is of the direct current type and is provided with a split series field winding comprising the two winding portions 82_a and 82_b either of which may be connected to the source 77 in series relationship with the armature when one or the other of the directional contactors 78, 79 is operated to the upper closed position. When the movable contact arm 80_c is in a mid-position between the terminals of the resistance sections 80_a and 80_b as represented by the broken line 84 no voltage is applied to the field winding 73_a of generator 73 and when the position of this arm is changed to either side of this mid-position, the amount of resistance in circuit with the field winding 73_a is decreased and the direction of current flow in the field winding 73_a is dependent upon the direction in which the arm 80_c is moved from its mid-position.

50 The electric motor 71 is also provided with a separately excited field winding 71_a which as shown is directly connected to the source 77 by means of conductors 85 and 86.

55 With the above understanding of the elements and apparatus and their organization in this modification of the invention, the operation of the modified system itself will be readily understood from the following detailed description:

60 To place the system in operation, the manually operated switch 87 is operated to the closed position in which an energizing circuit is established for the time element relay which may be traced from the positive side of the source 77 by conductor 88, operating coil of time element relay, upper contact of directional contactors 78 and 79 in the lower position thereof, conductor 89, and thence by conductor 86 and switch 87 to the negative side of the supply source 77. The time element relay in responding to the energization of its operating coil closes its contact to connect the anode of the two electric valves to the positive side of the supply source 77 in series relationship with the operating coils of directional contactors 78 and 75 79 respectively.

In the event that the index mark on the strip interrupts the light received by the light sensitive device at the instant that the brush of the selector switch is in contact with the insulated portion thereof, no positive bias is applied to the grids of the electric valves and accordingly no correcting action is initiated.

However, if the knife becomes out of register with the strip so that the cut-off line passes the point of the table at which the cut-off takes place before the knife blade is in a position to make the cut, that is to say, if the knife is late with respect to the strip, the brush is in contact with the left-hand segment of the selector switch at the instant that an index mark on the strip interrupts the beam of reflected light received by the light sensitive device with the result that a positive bias is applied to the grid of the left-hand electric valve, thereby establishing current flow in the anode circuit thereof and energizing the operating coil of reversing contactor 79. The contactor 79 in responding to the energization of its operating coil moves to its upper or closed position in which its upper main contact interrupts the energizing circuit for the operating coil of the time element relay and completes an energizing circuit for the motor 82 that is traced from the positive side of the supply source 77 by conductors 85 and 90, the armature of motor 82, the upper portion 82_a of the split field winding and thence through the upper main contact of the directional main contactor 79 in the upper position thereof and thence by conductors 89 and 86 to the negative side of the supply source 77. Simultaneously with this operation contactor 79 connects the separately excited field windings 72_a of electric generator 72 to the source 77 over the following circuit: from the positive side of the supply source 77 by conductors 85 and 91, lower main contact of reversing contactor 79 in the upper closed position thereof, conductor 92, field winding 72_a of generator 72 conductor 93, intermediate main contact of contactor 79 in the upper closed position thereof and thence by conductors 94 and 86 to the negative side of the supply source 77.

The generator 72 in response to the energization of its field winding supplies a current to the motor 71 causing it to rotate the third element of the differential device 56 and thereby introduce additional movement in the rotation of the rotary cutting knife so as to effect a space correction in the relative position of the strip and the knife. The motor 82 in response to its connection to the source 77 rotates the screw 81 in such a direction as to cause the movable contact arm 80_c to be actuated toward the left to reduce the amount of resistance in circuit with the field winding 73_a of the generator 73 thereby causing this generator to increase the amount of current that it has been supplying to the motor 71 thereby causing the speed of the latter to be increased and accordingly to effect a correction in the relative speed of the strip and the rotary cutting knife.

At the end of a predetermined interval of time, the time element relay interrupts the anode circuit of the electric valve thereby rendering the valve inactive and deenergizing the contactor 79. The contactor 79 in responding to the deenergization of its operating coil descends to the lower position in which it is illustrated, thereby disconnecting the rheostat motor 82 from the source 77 and also disconnecting the field winding 72_a of generator 72 from the source 77. When the field winding of the generator 72 is deenergized this 75

generator no longer supplies current to the motor 71 and consequently the motor 71 makes no further correction in the space relationship between the strip and the rotary cutting knife. However, when the rheostat motor 82 is stopped the contact arm 80 of the rheostat remains in the position which it occupied at the instant the motor 82 was deenergized, with the result that the generator 73 remains energized at the value of energization that obtained at the instant the motor 82 ceased rotating. Consequently, the generator 73 continues to supply current to the motor 71 which continues rotation at a speed dependent upon the rotation of the generator 73 so as to continue rotation of the rotating cutter knife at the increased speed necessary to compensate for the error which first caused the knife to become out of registry with the strip.

The descent of directional contactor 79 to the lower position in which it is illustrated reestablishes the energizing circuit for the operating coil of the time element relay, the contacts of which thereupon move to their upper closed position leaving the system in a reset condition to repeat the above described operation.

It will be clear from the above described operation that had the rotary knife been early with respect to the cut-off point, that the selector switch brush would have been in contact with the right-hand segment of the contact disc at the instant an index mark interrupted the beam of reflected light received by the light sensitive device with the result that a positive potential would have been applied to the grid of the right-hand electric valve thereby initiating current flow in the anode circuit and energizing the operating winding of reversing contactor 78. The contactor 78 in responding to the energization of its operating coil performs functions similar to those described in connection with the energization of contactor 79 but in the reverse sense. Since the operations resulting from the energization of the contactor 78 are in the reverse sense but otherwise identical with the operation described in connection with contactor 79 it is believed unnecessary to an understanding of the invention to repeat a description of these operations.

In illustrating the invention, the differential is shown as located between the main motor drive shaft and the cutter, and the adjustable speed transmission is shown as located between the main motor drive shaft and the cutter, but it is perfectly feasible to interchange the positions of any of these units and still obtain the necessary relative adjustments between the draw rolls and cutter.

Although in accordance with the provisions of the patent statutes, this invention is described as embodied in concrete form, it will be understood that the apparatus and connections shown and described are merely illustrative and that the invention is not limited thereto, since alterations and modifications will readily suggest themselves to persons skilled in the art without departing from the true spirit of this invention or the scope of the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A control system for a device having an element operating on a strip of material and means for feeding the strip to said element, comprising a variable speed driving connection including a differential device between said feeding means and said element, and means actuated by the

strip for controlling said driving connection to vary the relative speeds of said feeding means and said element and for controlling said driving connection to introduce an additional correction for the positional relationship of the strip and said element.

2. A control system for a device having an element operating on a strip of material and means for feeding the strip to said element, comprising a variable speed driving connection including differential mechanism between said feeding means and said element, and means actuated by the relative positions of the strip and said element for controlling said driving connection to introduce a relatively permanent correction in the speeds of said feeding means and said element and for momentarily controlling said driving connection to introduce an additional correction for the positional relationship of the strip and said element.

3. A control system for a device having an element operating on a strip of material and means for feeding the strip to said element comprising means for varying the relative speed between said element and said feeding means, a differential device for effecting a change in the relative positions of the strip and said element, and means controlled by the strip for actuating said speed varying means and said differential device.

4. A control system for a device having an element operating on a strip of material and means for feeding the strip to said element comprising means for varying the relative speed between said element and said feeding means, a differential device for effecting a change in the relative positions of said strip and said element, and light sensitive means controlled by the strip for actuating said speed varying means and said differential device.

5. A control system for a machine having an element operating upon a strip of material and means for feeding the strip to said element comprising means for varying the speed relationship between said element and said feeding means, a mechanical differential device for effecting a change in the relative positions of the strip and said element, and light sensitive means controlled by the strip and a time element device cooperating therewith for actuating said speed varying means and said differential device for a predetermined interval of time.

6. A control system for a machine having an element for operating on a strip of material and means for feeding the strip to said element comprising means for varying the speed relationship between the strip and said element, a mechanical differential device connected to said element for effecting a change in the relative positions of the strip and said element, electric motor means for actuating said speed varying means and said differential device and means controlled by the strip for controlling said motor means.

7. A control system for a machine having an element operating on a strip of material and means for feeding the strip to said element comprising means for varying the speed relationship between the strip and said element, a mechanical differential device for effecting a change in the relative positions of the strip and said element, electric motor means for actuating said speed varying means and said differential device, and means comprising a light sensitive device controlled by the strip and electromagnetic switching mechanism controlled by said light sensitive de-

vice for selectively effecting operation of said motor means in opposite directions.

8. A control system for a machine having an element operating on a strip of material and means for feeding the strip to said element comprising means for varying the speed relationship between the strip and said element, a mechanical differential device for effecting a change in the relative positions of the strip and said element, electric motor means for actuating said speed varying means and said differential device, and means comprising a light sensitive device controlled by the strip and electro-magnetic switching mechanism controlled by said light sensitive device for selectively energizing said motor means for operation in opposite directions.

9. A control system for a machine having a device for operating on a strip of material and a device for feeding the strip to said operating device comprising driving means for said devices, means for varying the speed relationship between the strip and said operating device, a mechanical differential device connected between said driving means and one of said devices, means for varying the relative positions of the strip and said operating device comprising means for actuating said differential device, means comprising a light sensitive device and electric valve apparatus controlled thereby for controlling said speed varying means and said differential actuating means, and a time element device for interrupting the operation of said speed varying means and said differential actuating means after a predetermined time interval.

10. A control system for a device operating upon a strip of material and a device for feeding the strip to said operating device comprising driving means, driving connections including a variable speed transmission between said driving means and one of said devices, a differential device connected between said driving means and one of said devices, and means responsive to a departure of said strip from a predetermined relationship with respect to said operating device for actuating said differential device to effect a space correction in the relative positions of the strip and said operating device and for actuating said variable speed transmission to effect a change in the relative speeds of the strip and said operating device.

11. A control system for a device for severing a strip of material and a device for feeding the strip to said severing device comprising driving means, driving connections including a variable speed transmission between said driving means and one of said devices for varying the relative speeds of the strip and one of said devices, a differential device connected between said driving means and one of said devices for effecting a space correction in the relative positions of the strip and said severing device, and means comprising a light sensitive device controlled by the strip and motor means controlled by said light sensitive device for actuating said variable speed transmission and said differential device.

12. A control system for a device for severing a strip of material provided with reference indicia and a device for feeding the strip to said severing device comprising driving means, driving connections including a variable speed transmission between said driving means and one of said devices for varying the relative speeds of the strip and said severing device, a differential device connected between said driving means and one of said devices, electric motor means provided with

oppositely wound field windings for actuating said variable speed transmission and said differential device, and means comprising a light sensitive device responsive to said indicia and switching mechanism controlled by said light sensitive device for selectively energizing said field windings to effect operation of said motor means in respectively opposite directions.

13. A control system for a device for severing a strip provided with reference indicia and a device for feeding the strip to said severing device comprising driving means, driving connections including a variable speed transmission between said driving means and one of said devices for varying the speed relationship between the strip and said severing device, a mechanical differential device connected between said driving means and one of said devices for introducing a space correction in the relative positions of the strip and said severing device, reversible electric motor means for actuating said differential device and said variable speed transmission device, means comprising a light sensitive device and electromagnetic switching mechanism controlled by said light sensitive device for selectively energizing said motor means for operation in respectively opposite directions and a time element device for rendering said motor means inactive after a predetermined interval of time.

14. A control system for a device operating on a strip of material and a device for feeding the strip to said operating device comprising driving means, driving connections including a differential device between said driving means and one of said devices, and means controlled by the strip for actuating said differential device to effect both a change in the relative speeds of the strip and said operating device and a space correction in the relative positions of the strip and said operating device.

15. A control system for a device operating on a strip of material and a device for feeding the strip to said operating device comprising driving means, driving connections including a mechanical differential device between one of said devices and said driving means, an electric motor for actuating said differential device, and means controlled by the strip for causing said electric motor to actuate said differential to vary the relative speeds of said operating device and the strip and to introduce a space correction in the relative positions of the strip and said operating device.

16. A control system for a device for severing a strip of material and a device for feeding the strip to said severing device comprising driving means, driving connections including a mechanical differential device between one of said devices and said driving means, an electric motor for actuating said differential device, an electric generator for energizing said motor to effect a change in the relative speeds of said severing device and the strip, and means controlled by the strip for controlling the energization of said generator.

17. A control system for a device for severing a strip of material provided with reference indicia and a device for feeding the strip to said severing device comprising driving means, driving connections including a mechanical differential device between one of said devices and said driving means, an electric motor for actuating said differential device, an electric generator for supplying said motor, a rheostat for varying the magnitude and direction of the excitation of said

generator, and light sensitive means controlled by said indicia for controlling said rheostat.

18. A control system for a device for severing a strip of material provided with reference indicia and a device for feeding the strip to said severing device comprising driving means, driving connections including a mechanical differential device between one of said devices and said driving means, an electric motor for actuating said differential device, an electric generator for energizing said motor to effect a change in the relative speeds of the strip and said severing device, a second electric generator for energizing said motor to effect a space correction in the relative positions of the strip and said severing device, and light sensitive means controlled by said reference indicia for controlling the energization of said generators.

19. A control system for a machine having a device for severing a strip of material and a device for feeding the strip to said severing device comprising means for driving said machine, driving connections including a mechanical differential device between one of said devices and said driving means, an electric motor for actuating said differential device, a generator for energizing said motor to effect a space correction in the relative positions of the strip and said severing device, a second generator driven at a speed proportional to the speed of said machine for energizing said motor to effect a change in the relative speeds of the strip and said severing device, a reversible motor operated rheostat for controlling the energization of said second generator, electromagnetic switching mechanism for controlling the energization of said first generator and means controlled by the strip for controlling the operation of said rheostat and said electromagnetic switching mechanism.

20. A control system for a machine having a device for severing a strip of material provided with reference indicia and a device for feeding the strip to said severing device comprising means for driving the machine, driving connections including a mechanical differential device between one of said devices and said driving means, an electric motor for actuating said differential device, a generator for energizing said motor to effect a space correction in the relative positions of the strip and said severing device, a second generator driven at a speed proportional to the speed of said machine for energizing said motor to effect a change in the relative speeds of the strip and said severing device, the armatures of said motor and generators being connected in series relationship, electromagnetic reversing switch mechanism for controlling the energization of

said first generator, a reversible motor operated rheostat for controlling the energization of said second generator, light sensitive means controlled by said reference indicia for energizing said switching mechanism and the operating motor of said rheostat, and a time element device for deenergizing said switching mechanism and said rheostat motor after a predetermined interval of time.

21. In a control system for a web cutter, comprising, a cutter, a web feeding device, a motor for driving said cutter and feeding device, a localizer for changing the relative position of the cutter and parts of the feeding device, a speed changing device for changing the relative speeds of the cutter and feeding device, a source of light and light sensitive means operatively associated with the web, motors for operating said localizer and speed changer respectively, control circuits for said motors, thermionic means for effecting the energization of said control circuits to cause the operation of said motors cooperating with said light sensitive means and means for effecting the energization of said thermionic means when the cutter and web are not in normal operating position, whereby the localizer and speed changer operate to reestablish the normal operating position between the web and cutter.

22. In a control system for apparatus operating on a web, in combination, a web cutter, a motor for driving the cutter, a web feeding mechanism, transmission mechanism, speed control means for changing the speed relation between the cutter and the web feeding mechanism, position adjusting means for changing the relative position of certain parts of said feeding mechanism and cutter, and means responsive to a predetermined change in relationship between the cutter and the web to control the operation of said control means and position changing means.

23. In a control system for apparatus operating on a web having indicia thereon, in combination, a web cutter, a motor for driving the cutter, transmission devices, a web feeding mechanism driven by said motor, said transmission devices including a speed changer for changing the relative speed of the cutter and web feeding mechanism, and a localizer for changing the relative position of the cutter and certain elements of the web feeding mechanism, a source of light and light sensitive means operatively associated with said web, and means controlled from said light sensitive means for controlling the operation of said transmission mechanism when the position of the indicia on the web has changed a predetermined amount relative the cutter.

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