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WEB REGISTRATION DEVICE

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1 Claim. (Cl. 271—2.6)

1. This invention relates to a registering device for controlling the feed of a moving web such as a web of paper or metal foil to be cut into blanks for making folded boxes or packages, or a web to be printed in a plurality of steps which must be maintained in registration as in color printing.

In a specific embodiment the invention may be applied to a web of aluminum foil or the like carrying a recurring printed pattern which is fed continuously past a cutting knife for cutting into individual blanks. In this embodiment the invention provides means for accurately maintaining the cutting knife in register with the printed pattern on the foil so that the pattern appears in the proper location on each cut blank.

An object of the invention is to provide a novel and improved registering system of the above type which is suited for maintaining accurate registration during commercial operations.

Another object is to provide a registering system of the above type which is adapted to operate on a continuously moving web and is designed to advance or retard the feed of the web to the cutting knife as required for maintaining accurate registration.

Another object is to provide a system of the above type in which the correction is introduced continuously during a cycle in response to an error which is determined at a given point in each cycle.

Another object is to provide a system of the type above described in which the correction rate is a function of the direction and magnitude of the observed error.

Various other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

In accordance with one embodiment of the invention as applied to a moving web of aluminum foil or the like carrying a printed pattern and adapted to be cut into blanks, a light modulating index is printed on the web in predetermined relationship to each blank area. A beam of light is focused on the path of the index area and is refected therefrom onto a photoelectric cell in a manner such that the reflected light is altered during the passage of the index area. The signal produced by the photoelectric cell in timed relation to the actuation of the knife is applied to an amplifier circuit of a type which is adapted to drive a correction motor in a direction and at a rate which are functions of the indicated error. The correction motor is connected through a differential to the driving means for the feed roller and introduces a lead or lag in the feed roller drive which is determined by the error signals received from the photoelectric cell.

The motor control circuit includes an amplifier system which is connected to control the operation of a pair of saturable core transformers, the outputs of which are connected in opposition to the control winding of an induction motor. A feed-back generator capable of producing a voltage which is a function of its speed is driven by the induction motor. The amplifier system includes an inverter stage comprising a pair of tubes with their cathodes coupled by a biasing resistor in such a manner that their plate currents vary in opposite sense. The signal from the photoelectric cell, suitably amplified, is applied to the grid of one of the inverter tubes and the signal derived from the generator is applied to the grid of the other inverter tube in such a manner that the combined effect of the signals causes the induction motor to operate in a direction and at a rate which is a function of the input signal.

For causing the correction motor to operate continuously over a complete cycle of the cutting knife, a so-called "memory circuit" is introduced into the input of the inverter stage. This circuit includes a condenser which is charged by the input signal from the photoelectric cell and maintains its charge through a complete cycle of operation. The condenser is connected to the input circuit of the inverter stage in such a way that the amplified voltage is maintained constant throughout a full cycle of operation of the cutting knife and constitutes a basis for comparison with the signal in the feed-back circuit during such cycle.

Although the novel features which are believed to be characteristic of this invention are pointed out more particularly in the claim appended hereto, the nature of the invention will be better understood by referring to the following description taken in connection with the accompanying drawings in which a specific embodiment thereof has been set forth for purposes of illustration.

In the drawings:

Fig. 1 is a diagrammatic representation of a registering system embodying the present invention as applied to a travelling web to be cut into box blanks or the like; and

Fig. 2 is a schematic diagram of the amplifier system for controlling the operation of the correction motor.

Referring to the drawings more in detail, the invention is shown as applied to a travelling web which may comprise a strip of metal foil to
be cut into lengths for forming box blanks. The foil may carry a suitable printed pattern not shown to appear on the various sides of the folded box. The marginal edge of the web 10 is assumed to have a light reflecting surface on which are printed suitable index areas 11 in predetermined relationship to the patterns for the various blanks to be cut from a material having a different light reflecting characteristic from that of the foil surface and are adapted to modulate the reflected light as the position of the light spots.

In the embodiment shown the web 10 is fed by a pair of feed rollers 12 which are driven by a shaft 13 which is connected by bevelled gears 14 and a shaft 15 to one side 16 of a differential 17. The other side 18 of the differential 17 is driven from a drive shaft 20 through bevelled gears 21 and a shaft 22. The web 10 is cut into blanks by a rotating knife 23 which is carried on a roller 26 which is mounted on a shaft 27 driven through bevelled gears 28, shaft 29 and bevelled gears 30 from a drive shaft 31. A stationary anvil 31 cooperates with the rotating knife 25 for severing the web 10 when the knife 25 is brought into registration therewith.

It will be evident that in the absence of a correction device any error in the position of the rotating knife 25 with respect to the travelling web 10 will result in a improper positioning of the printed pattern on the folded box formed from the blank. Likewise in the case of a printed web in which various colors, for example, are to be printed in succession, the error in registration would tend to offset the printing of the various colors and would result in an imperfect product.

In accordance with the present invention a light beam 35 is produced from a source 36 which is energized from mains 37. Light from the source 36 is focused by lens 38 through an aperture plate 40 onto the marginal portion of the printed web 10 in the shape of a rectangular light spot 41. Light from this spot 41 is reflected from the surface of the foil and passes through a focusing lens 42 onto a photoelectric unit 43 which is a phototube. Further in detail in Fig. 2 and is adapted to produce a signal, the value of which is dependent upon the position of the light spot 41 with respect to the index area 11 at the timed instant. The correction signal thus produced is applied by a light beam 44 through an insulation 45 which is contacted by a contact 46 on a lever 47 actuated by a cam 41 mounted on the shaft 27. A similar insulated microswitch 49 is contacted by a contact 50 on a lever 50 contacted by a cam 51 mounted on the shaft 27. Springs 52 and 53 hold their respective levers 50 and 47 against their cams. The cams 47 and 51 are relatively adjustable about the shaft 27 to vary the duration of the closed period and may be secured by set screws 54. The assembly microswitch assembly including the levers 45 and 50 is mounted on a support 55 to which both levers 46 and 50 are electrically connected and is adapted to be rotatably adjusted about the shaft 27 for varying the timing of the closed period. The support 55 is shown as provided with a manual adjustment shaft 59 for the above purpose.

The microswitch 49 is connected by a lead 58 to a control mechanism 50 which is shown in more detail in Fig. 2 and is provided with an output shaft 61 which is driven in a direction and at a rate which is a function of the error signal. The shaft 61 is connected by bevelled gears 62, shaft 63, bevelled gears 64 and shaft 65 to the cage of the differential 17 and is adapted to produce a relative adjustment between the position of the feed rollers 12 and of the rotating knife 25 to correct the error in registration indicated by the error signal.

Referring to Fig. 2, a photoelectric cell 70 is connected to ground by a lead 71 and a resistor 72 and is index area 11 is a material of a suitable source of D. C. potential.

The voltage produced by the photoelectric cell 70 is amplified by an amplifier tube 80 of standard type which is provided with a control grid 81 connected by a lead 82 to the ground lead 71 of the photoelectric cell and with an anode 83 which is connected by a lead 84 to a source of plate potential such as the 90 volt lead 73. The amplifier tube 80 is provided with a cathode 85 which is connected by a lead 86 to a potentiometer 87, thence by a lead 88 and through a resistor 89 to a source of constant biasing voltage, for example, —105 v. The elements 70—85 constitute the unit 43 of Fig. 2.

The potentiometer 87 is provided with an adjustable tap 90 which is connected by the lead 44 of Fig. 1 to the microswitch 48. The second microswitch 49 is connected by the lead 58 to the grid 55 of an amplifier tube 56. A condenser 50 is connected between the grid 55 and ground. This condenser is of sufficient capacity to receive a charge proportional to the applied error signal and to retain this charge until the microswitches 45 and 46 are again closed. The cathode 51 of the tube 56 is connected to one side of a potentiometer 95 having a variable tap 99 which is connected through a cathode biasing resistor 100 and a lead 101 to a source of biasing potential such as the —105 v. source. The anode 102 of the tube 55 is connected by a lead 103 to an impedance coupling network comprising resistors 105, 106 and 107, thence by a lead 108 to the control grid 109 of an amplifier tube 110. The resistor 105 is connected by a lead 111 to a return lead 112 which in turn is connected to the 90 v. lead 73. The resistor 107 is connected by a lead 113 to the resistor 100.

The tube 110 is shown as provided with a screen grid 115 which is connected by a lead 116 to the lead 112 thence to the 90 v. lead 73. The tube 110 is also provided with a cathode 125 connected to ground by a switch 126 and which is connected by a lead 146 to the saturating winding 119 of a saturable core transformer 120 having a primary 121 and a secondary 122. The other side of the saturating winding 119 is connected by a lead 123 to a source of D. C. potential such as 300 v. source. A protective resistor 124 is shown as connected across the saturating winding 119.

An amplifier tube 130 has a cathode 131 connected by a lead 132 to the potentiometer 98, and has an anode 135 connected by a lead 136 to an impedance coupling network comprising resistors 138, 139 and 140, thence by a lead 141 to the control grid 142 of an amplifier tube 143. The resistor 138 is connected to the lead 123 and thence to the 90 v. lead 73. The resistor 140 is connected by a lead 144 to the resistor 100. The amplifier tube 143 is provided with a cathode 150 connected by a lead 151 to ground. The screen grid 154 of the tube 143 is connected by a lead 155 to the lead 112 and thence to the 90 v. lead 73 and signal.

The anode 156 of the tube 143 is connected by a lead 157 to the saturating winding 158 of a sec-
ond saturable core transformer 189 having a primary 165 and a secondary 161. The other side of the saturating winding 156 is connected to the lead 123 and thence to the 300 v. source. A protective resistor 162 is connected across the saturating winding 156.

Primaries 121 and 160 are supplied in series from a 110 v. 60 cycle source by mains 165 and 167. The main 165 is connected by a lead 166 to the primary 121, thence by a lead 168 to the primary 160, thence by a lead 169 to the alternating current supply mains 167.

A two-phase induction motor 170 is shown as provided with a rotor 171, an energizing winding 172 and a control winding 173. The energizing winding 172 is connected across the alternating current supply mains 165, 167. The secondaries 132 and 161 of the saturable core transformers are connected in series opposition to the control winding 173 of the motor by means of leads 175, 176 and 177. A phasing condenser 178 is connected across the control winding 173.

The rotor 171 of the motor 170 is connected to the shaft 61. This shaft carries a D. C. generator 180 having an armature, connected by brushes 181 and 182 and leads 193 and 194 to a resistor 185, a potentiometer 186 and a resistor 187 in series. The lead 184 is grounded at 188. The potentiometer 186 is provided with a variable tap 192 which is connected by a lead 190 to the control grid 191 of the tube 130.

In the operation of this device the microswitches 45 and 49 are closed by the cams 47 and 51 for a short interval during each cycle of operation of the cutting knife 25. The cams 47 and 51 are individually adjustable so as to control the duration of the closed periods, such a period may, for example, be of the order of .005 second. The support 55 is rotated with respect to the shaft 27 so that this closed period will occur when the device is in proper registration at the instant that the light spot 41 from the light source 36 is equally divided between the index mark 11 and the foil surface at the leading edge of the index mark. Under these conditions a given voltage is produced by the photoelectric cell 10 which corresponds to correct registration and the voltage is either increased or decreased as the case may be, if the position of the web 10 at the instant of closing of the microswitches either lags or leads the correct position. In the embodiment illustrated, if the web 10 should lead its proper position, the leading edge of the index area 11 will have advanced beyond the midpoint of the light spot 41 and a signal of lesser intensity will be produced by the photo-electric cell 10, whereas if the web 10 should lag its correct position the index area 11 will intercept a lesser portion of the light rays and a signal of higher intensity will be produced by the photo-electric cell.

The voltage from the photoelectric cell 70 is applied to the control grid 81 of the amplifier tube 80 and controls the plate current of that tube. A voltage is thus produced at the tap 90 of the potentiometer 87 which is a function of the plate current and is likewise a function of the applied voltage from the photoelectric cell 70. In operation, suitable adjustment is made of the tap 90 of the potentiometer 87 so that the tap is connected at the zero voltage position under conditions of proper registration. In this way a negative voltage is obtained at the tap 90 when an error appears in one direction and a positive voltage is obtained when an error appears in the opposite direction.

The voltage produced at the tap 90 is supplied through the microswitches 45 and 49 at the instant that these switches are both closed, to the control grid 95 of the tube 96. This voltage also charges the condenser 200 which is of a size such that it becomes fully charged to the applied voltage during the instant of closing of the switches 45 and 49 and retains this voltage through a complete cycle of operation, that is until the switches are again closed at the next cycle. The condenser 200 thus comprises a "memory circuit" which retains a voltage corresponding to the registration error during the entire cycle.

The operation of the amplifier tubes 110 and 143 controls the saturating current which passes through the windings 119 and 158 of the saturable core transformers 120 and 156. If the saturating current supplied to the transformer 120 is in balance with that supplied to the transformer 158, the voltages supplied by the secondaries 122 and 161 are balanced out and no resultant voltage is applied to the control winding 173 of the motor 170. If, however, the voltages in the secondaries 122 and 161 are unbalanced, a resultant voltage is applied to the control winding 173 which causes the motor 170 to rotate in one direction or the other depending upon the phase of the applied voltage, and at a rate which is dependent upon the magnitude of the applied voltage.

The amplifier tubes 96 and 130 and associated resistors 98 and 100 and networks 104 and 137 form an inverting and combining stage whose output is the amplified sum or difference of the error and feed-back input signals. The amplifier tubes 110 and 143 form a stage of amplification between the inverter and the saturable core reactors 120 and 159.

The adjustments are made so that with a zero error signal on the grid 95 and a zero feedback signal on the grid 91 the saturable core transformers 120 and 159 are in balance relationship and zero control voltage is supplied to the control winding 173 of the motor 170. If now a plus or minus error signal is applied to the grid 95 the space current in the tube 96 is altered in either a positive or negative direction with a corresponding change in the space current in the tube 110 and the saturating current in the winding 119. The space current in tube 95, flowing through the self biasing resistor 100, varies the cathode potential of the tubes 96 and 98, thereby producing a corresponding variation in the saturating current in the winding 119. The inverter stage thus produces an opposite change in the saturating currents to the two transformers 120 and 159 in response to an error signal on the grid 95.

The saturation of the two transformers 120, 159 thus becomes unbalanced and a resultant voltage is supplied to the control winding 173 of the motor 170 which causes the motor to operate.

The motor 170 drives the generator 180 and causes the latter to apply a voltage to the potentiometer 186 which is dependent upon the direction and speed of rotation of the generator. The
Voltage at the tap 189 is applied to the control grid 191 of the tube 130 of the inverter stage and produces an effect which opposes the effect of the error signal.

Assuming, for example, an error signal of ±9 v. range and that the amplifier network is adjusted so that an error signal of ±2 v. will cause the motor 170 to operate at full speed, it is evident that the motor 170 will operate at constant speed when the error signal is between ±2 v. and ±3 v. If the feed-back signal which is produced by the generator 180 is adjusted to a value of 7 v. at full generator speed, the difference between the error signal and the feed-back signal at full speed would amount to 2 v. which produces maximum torque on the motor 170. At any intermediate value of error signal the motor will drive the generator at a speed to produce maximum torque conditions, i. e. a 2 v. difference between error signal and feed-back signal. Hence the feed-back causes the motor 170 to operate at a variable speed which is a function of the error signal voltage. The voltages referred to above are illustrative only.

The operation of the motor 170 will continue under the control of the voltage across the condenser 200 until the microswitches 45 and 49 are again closed in the next cycle, at which time a new error voltage is received and applied to the condenser 200 and the operation of the device is modified accordingly.

It will be noted that in the above described device a correction is continuously applied until the error signal is returned to zero. The rate of correction is varied in accordance with the amount of the error signal. The device is extremely sensitive and prevents appreciable error from developing by initiating a correction as soon as the first error signal is received.

Index areas should extend along the web several times the width of the light beam to avoid possibility of a sudden large error allowing an index area to jump ahead of the light ray and cause spoilage of a number of blank discs due to successive partial corrections, all in the wrong direction, before the next area is reached. It has been found that a light image having a length along the web of ¼ inch and a width of ¼ inch is suitable for the above purpose and may be produced to produce an 18 volt fluctuation at the tap 99 between conditions of maximum light reflection and minimum light reflection. This voltage differential is sufficient for obtaining an accurate and rapid follow up.

By deriving the error signal from the potentiometer 81 in the cathode lead to the amplifier tube a high input impedance is produced which eliminates electrical loading of photoelectric circuit. This prevents distortion of the voltage signal and insures a true indication of the light intensity on the photoelectric tube. The potentiometer 87 may, for example, have a value of 7500 ohms and the resistor 89 may have a value of 30,000 ohms. This resistance in the cathode circuit produces a low impedance source for the charging voltage to the condenser 200 which is required for the practically instantaneous charging of the condenser during the short closed period of the microswitches. The value of the capacity 178 is such as to produce a 90° phase relationship between the voltages in the windings 172 and 173. The voltage in the winding 173 may lead or lag the voltage in the winding 172 dependent upon a plus or minus error signal.

The feed-back from the generator 180 may be adjusted to correspond to the speed at which the machine is operating. If, for example, the machine is cutting 120 lengths of foil a minute the correction rate may be limited to .03 inch per cycle and the mechanism may be adjusted to maintain registration within this limit of error.

The correction system above described compensates for printing errors, slippage of feed rolls, or error in feed roll speed and maintains accurate registry throughout the entire operation.

Although a specific embodiment of the invention has been described, it is to be understood that the invention is capable of various uses and that changes and modifications may be made therein as will be readily apparent to a person skilled in the art. The invention is only to be restricted in accordance with the scope of the following claim.

What is claimed is:

A correction motor control circuit for traveling webs having recurrent index areas with contrasting light modulating characteristics, continuous web feed means and means deriving an error signal from said index areas corresponding to variations from correct web registration, said control circuit comprising a correction motor connected to modify the operation of said feed means, follow-up means comprising a feed-back signal generator driven by said motor, balanced combining and amplifying channels responsive to the combined effect of said error signal and said feed-back signal and connected to control said correction motor in a sense to maintain correct web registration, each channel including a signal amplifier tube having a control grid, means applying said error signal to one of said control grids, and a condenser in circuit with said last control grid connected to be charged by the error signal and adapted to retain its charge during a complete cycle of operation for maintaining the error signal input to said channels.

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