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Huffman

[11] **3,841,216**

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[54] **METHOD OF AND APPARATUS FOR CORRECTING DEVIATIONS IN LENGTH AND REGISTRATION IN A CONTINUOUS STRIP OF MATERIAL**

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[21] Appl. No.: **312,816**

[52] **U.S. Cl.** **101/181,** 101/248, 101/426, 226/30

[51] **Int. Cl.** **B41f 5/06**

[58] **Field of Search** 101/181, 248, 426; 226/29, 226/30, 31, 2

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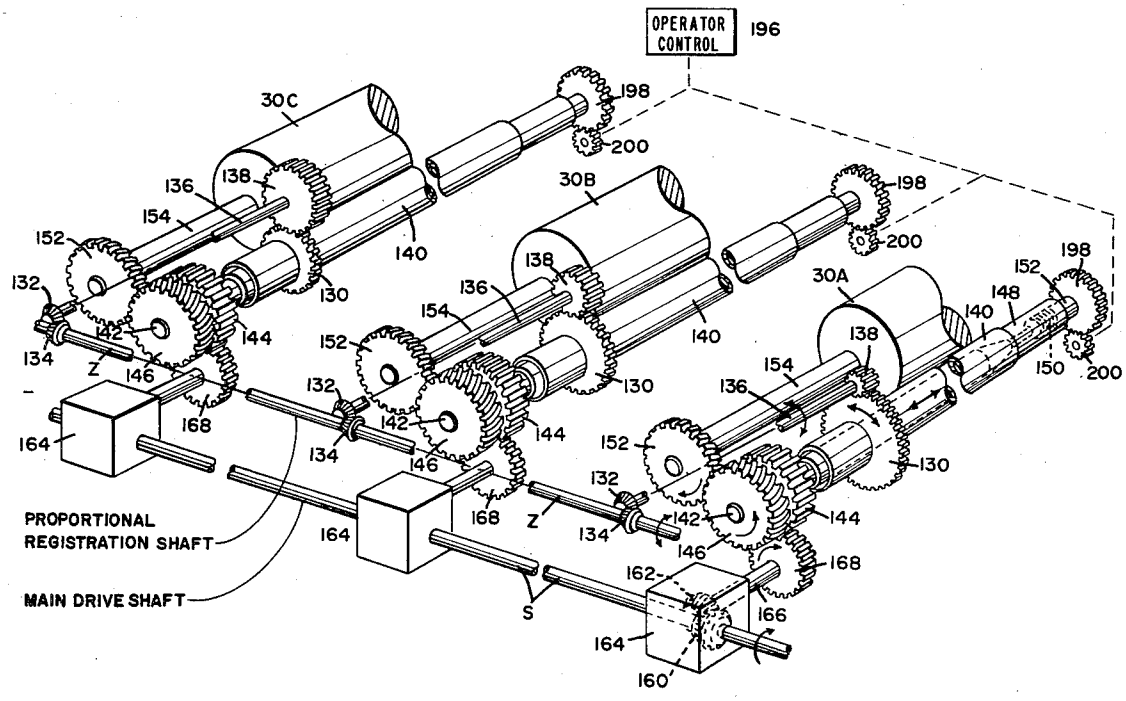
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[57] **ABSTRACT**

A length of a rewound strip of material, a surface of which has been provided with register indicia at regular, equally spaced intervals on its first or prior pass through a multistation printing and/or processing device, is automatically fed to the device at a rate such that it will match the register indicia applied to the strip during its first pass through the device, and in such a manner that changes in the feed rate of the strip material to the device produces a simultaneous and proportional change in the phase relationship between the printing cylinders and the strip of material at each printing station of the device and a similar change in the web path length at each processing station of the device whereby to compensate for and correct deviations in registration of the strip of material on its second pass through the device wherein deviations in registration are a function of variations in the register indicia length or metering of the strip material.

16 Claims, 4 Drawing Figures



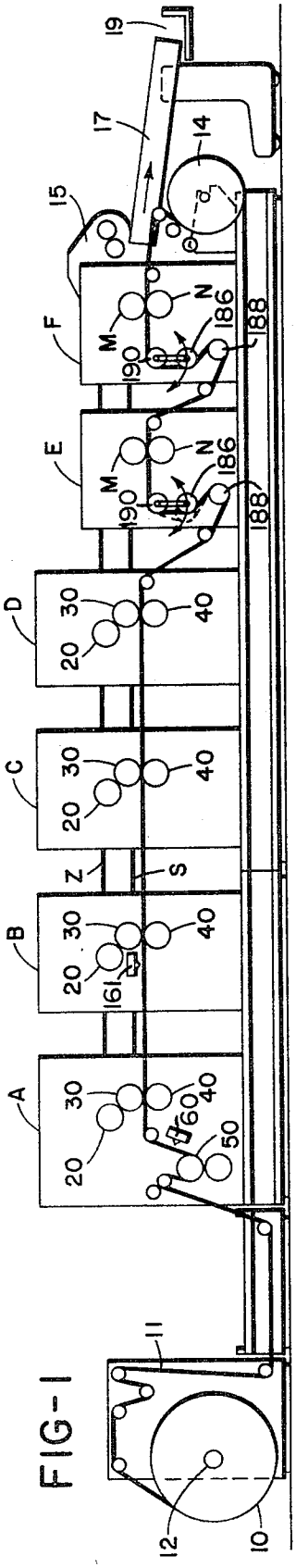


FIG-1

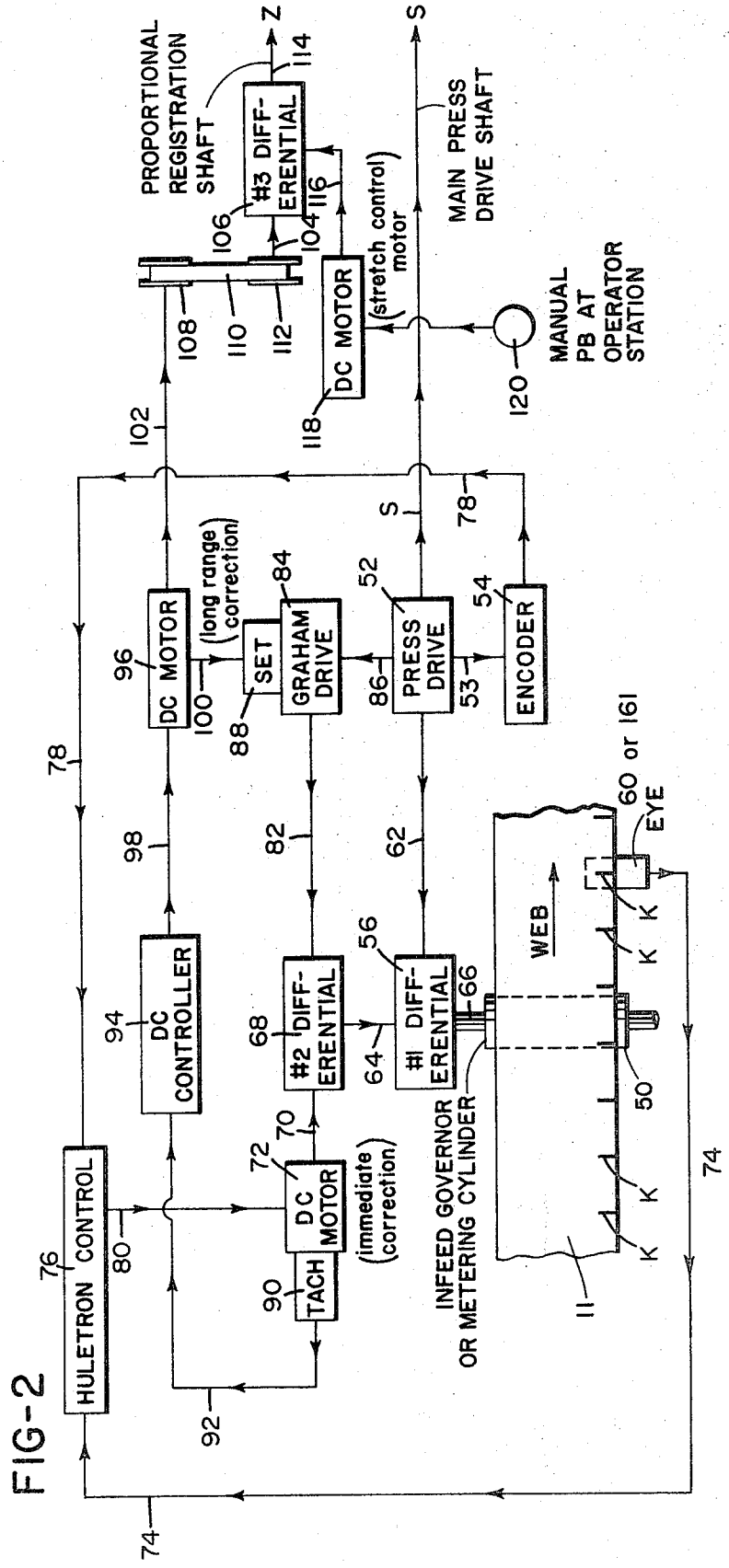

PROPORTIONAL REGISTRATION SHAFT
#3 DIFFERENTIAL
MAIN PRESS DRIVE SHAFT
DC MOTOR
(stretch control) motor
MANUAL PB AT OPERATOR STATION
DC MOTOR
(long range) correction
SET
GRAHAM DRIVE
PRESS DRIVE
ENCODER
DC CONTROLLER
#2 DIFFERENTIAL
#1 DIFFERENTIAL
INFEED GOVERNOR OR METERING CYLINDER
WEB
EYE
HULETRON CONTROL
DC MOTOR
(immediate) (correction)
TACH

FIG-2

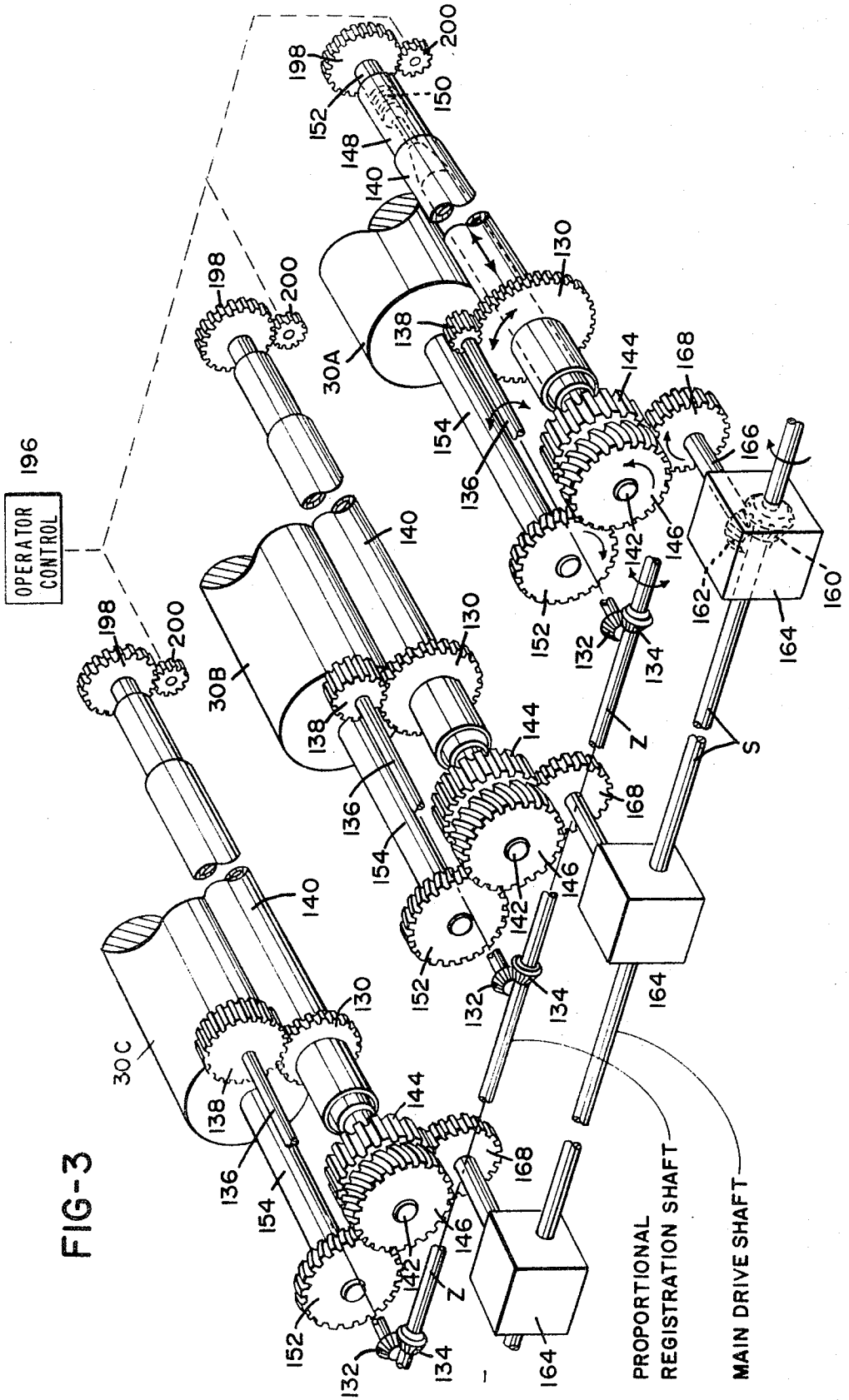

OPERATOR CONTROL
196
198
200
150
152
148
140
130
30A
138
154
136
144
168
166
146
142
162
160'
164
132
134
30B
30C
Z
S
PROPORTIONAL REGISTRATION SHAFT
MAIN DRIVE SHAFT

FIG-3

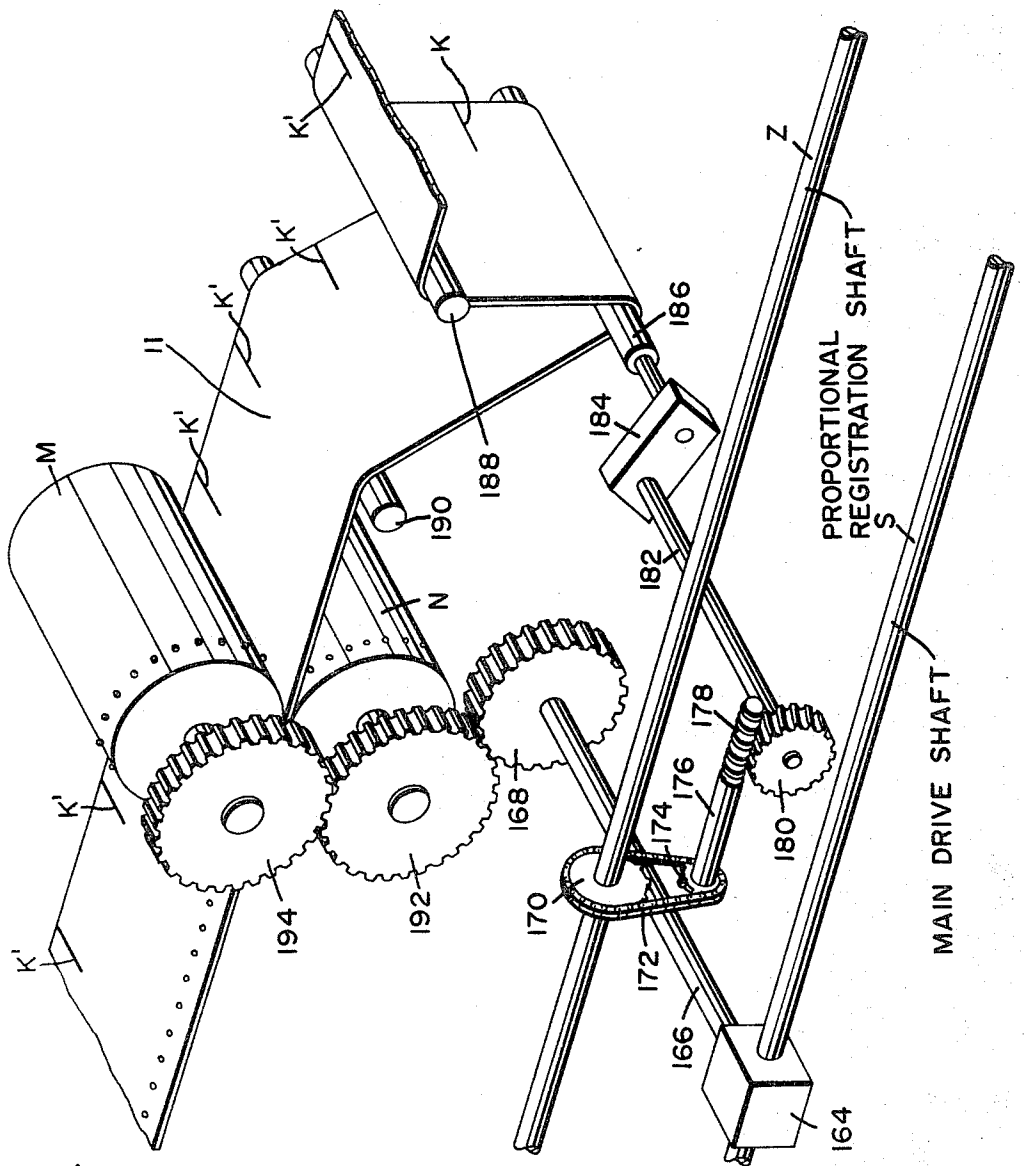

K
K'
K'
K'
K'
K'
K'
K'
11
M
N
186
184
188
190
182
Z
PROPORTIONAL REGISTRATION SHAFT
S
MAIN DRIVE SHAFT
178
176
174
180
168
170
172
166
164
194
192

FIG-4

METHOD OF AND APPARATUS FOR CORRECTING DEVIATIONS IN LENGTH AND REGISTRATION IN A CONTINUOUS STRIP OF MATERIAL

BACKGROUND OF THE INVENTION

This invention relates to a method of and apparatus for continuously and automatically matching the register indicia of a continuous strip of material during its second pass through a press or processing device to the register indicia applied to said strip during its first pass through said press or device.

At the present time, trial and error procedures are pursued, entailing expensive "set-up" time in an effort to initially correlate or match the register indicia on an endless strip of material during its second pass through a press or processing device with the register indicia applied to the strip during its first pass through the press, by controlling the operational characteristics of the infeed governor or metering cylinder. However, once the desired register indicia match or synchronization has been obtained, the expenditure of further "set-up" time is required to individually and independently adjust the phase relationship at each of a plurality of printing locations and adjust the web path at each processing location of the device in an effort to effect registration at each said printing or processing locations.

As stated in my co-pending patent application, Serial No. 312,893, now abandoned, filed concurrently herewith, two primary factors are involved when corrections are applied to the several printing and processing locations of a printing press.

The first factor is based upon the fact that the length of the web path for strip of material between the infeed governor or metering cylinder and a particular printing or processing location is different for each of said locations. That is, the web path length from the infeed governor or metering cylinder to the first printing station is considerably shorter than the web path length from the infeed governor or metering cylinder to the second, third, and subsequent printing stations. Therefore, if a change is made in the feed rate for metering more or less strip material through the press, its proportional effect through the press will change, and the amount of change is proportional to the length of the web path from each particular printing or processing location or station back to the infeed governor or metering cylinder.

The second factor is a function of the weight of the paper stock, the amount of moisture being added to the paper during printing and/or the amount of moisture removed from the paper during drying; said factors collectively determine what will hereinafter be referred to as a "stretch factor" which is not only proportional to the length of the web but is also affected by the paper and the printing process itself.

Under normal operating conditions, a thick or heavier paper will stretch or become elongated less than a thin or lighter paper for a given press, and for any given weight or thickness of paper the more ink and water applied to the paper during the printing process the greater will be the stretch.

In resolving the problem, it will be noted that one factor is fixed, viz the length of the web within the press, whereas the other factor is variable.

Proportional registration during the second pass of a strip of material at each printing or processing station may be accomplished by determining, by any suitable means, the stretch factor present in the strip of material, and of then altering the relationship at each station for proportionally compensating for the given stretch. This can be accomplished by determining variations in stretch length in those instances in which a differential infeed governor or metering cylinder is used, by utilizing a proportional registration shaft which, by suitable gearing, imparts a simultaneous adjustment at each of the printing or processing stations, wherein each individual adjustment is proportional to the length of the strip of material at each particular station independently of the operational characteristics of the governor or metering cylinder.

In those instances in which a differential governor or metering cylinder is used, proportional registration during the second pass may also be accomplished by utilizing a differential wherein one input is fixed, being the correction which comes from changes in the rate at which the strip of material is fed by the infeed governor or metering cylinder, and wherein the other input is variable, being a function of and proportional to the variable conditions of paper stretch, moisture content, tension and the like. The arithmetic sum of the aforesaid fixed and variable inputs to the differential determines the output of the differential. This output of the differential is applied to a proportional registration shaft which, by suitable gearing, imparts a simultaneous adjustment at each of the printing or processing stations, and wherein each individual adjustment is proportional to the length of the strip of material at each particular station.

The present invention utilizes proportional registration to simultaneously maintain precise register at each of a plurality of printing or processing stations or locations and provides means for enabling an operator, by observing a deviation in registry to correct registration at all of the stations by simultaneously and proportionally altering the phase relationship of the printing and processing at each of said stations to compensate for and correct the deviation in registration. The invention also contemplates the use of automatic means such as, by way of example, an electric eye reading a printed spot or a pin wheel actuated by and thereby reading punched holes in the strip of material for detecting deviation in registry and of utilizing such means to correct registration at all of the stations by simultaneously and proportionally altering the phase relationship of the printing and processing at each of said stations to compensate and correct the deviation in registration.

When an electric eye is used to control the operating characteristics of the infeed governor or metering cylinder of a multi-station press to alter the rate at which the strip of material is metered to the press sudden or erratic changes in the metering rate creates or results in a condition known as "hunting" which causes serious problems in registration, even in those instances in which the infeed governor or metering cylinder is driven by a differential.

The present invention compares the signal generated by an encoder driven by the main press shaft, with the signal generated by an electric eye "seeing" the register indicia on the web or strip of material. Differences in the phase of these signals is utilized to increase or decrease the output of one differential the output of

which comprises one of two inputs to a second differential the output of which drives the infeed governor or metering cylinder, whereby sudden or erratic changes in the metering rate of the strip of material is avoided.

DESCRIPTION OF THE PRIOR ART

The prior art discloses means for automatically controlling the rate at which webs or strips of material are metered to a multi-station press, utilizing an electric eye which stroboscopically "sees" a mark on the web as it leaves the infeed governor or metering cylinder. The operating and control characteristics of these prior art devices are best described as being sudden and erratic whereby to create, rather than reduce the problem of registry in the press.

The prior art discloses means for enabling an operator to mechanically change the phase relationship of the processing cylinders of a multi-station web processing device relative to a strip of material being subjected to a processing operation. When, by way of example, a strip of material is subjected to a plurality of printing or processing operations the operator endeavors to manually, independently and individually change the phase relationship of the processing or printing cylinders of each station relative to the strip of material being processed in an effort to obtain registration.

The prior art also discloses means for automatically controlling the registry at each particular printing or processing station by independently and individually correcting the registry at each particular station. It is possible, but expensive to utilize a plurality of automatic sensing and correcting means, one at each of a plurality of printing or processing stations in order to maintain automatic registration at each station. However, it should be understood that the use of automatic sensing means at each station does not and would not result in, nor utilize proportional registration as taught by the subject invention.

If it be assumed that a press should have as few as six color-printing and processing stations, and if independent, automatic control means could be obtained at a cost of $5,500.00 per station, the cost of the controls alone would add $33,000.00 to the cost of the press. The adjustment and maintenance of six individual automatic control means would add considerble maintenance and expense to the operating costs of such a system.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagramatic view of a typical, multi-station printing press which embodies the teachings of the present invention.

FIG. 2 is a block diagram representation of the manner in which the operating characteristics of the infeed governor or metering cylinder is maintained in phase with register indicia applied to the web during a preceding pass through the press, and of the manner in which changes in said operating characteristics cause the proportional registration shaft to be driven to automatically and simultaneously compensate for deviation in registry at each of the various printing and/or processing stations of the press.

FIG. 3 is a perspective view illustrating the manner in which actuation of the proportional registration shaft is utilized for simultaneously correcting registration of the printing cylinders at each of the printing stations of a press.

FIG. 4 is a perspective view illustrating the manner in which the proportional registration shaft is utilized to effect the desired registry at printing or processing stations by changing the web path length at said stations.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 the numeral **10** denotes generally, a roll of strip material which has been rewound after having had register indicia applied to one or both surfaces thereof at regular, equally spaced intervals, incident to the first or a prior pass of the material through a press or other device, such as, by way of example, is described in my co-pending patent application Ser. No. 312,893, now abandoned. Roll 10 is suitably and conventionally mounted for rotation about axis 12 whereby the web or continuous strip of material 11 is fed to the press to be wound upon roll 14 at the opposite end thereof, or to be presented to a folder 15, and thence delivered in folded condition to conveyor 17 and piler 19.

The letters A, B, C, and D indicate a plurality of printing towers, each of which collectively comprise what is hereinafter referred to as a printing station or location. Each printing station includes a plate cylinder **20,** a blanket cylinder **30,** and an impression cylinder **40.**

Station A includes a conventional infeed governor or metering cylinder **50** which determines and controls the rate at which the sheet material **11** is metered into the press from roll **10.**

The letters E and F denote, generally, stations where processing, such as, by way of example, punching, numbering, perforating and the like is accomplished.

It should be understood that the subject invention is neither concerned with nor directed to the particular structural details of the elements constituting printing stations A, B, C, and D, nor the processing stations E and F, except insofar as said devices have been modified as will hereinafter be more fully explained.

With reference now to FIG. **2,** it will be noted that web **11** has been provided with register indicia indicated by the letters K, said indicia having been applied during a previous pass of the web through the press. Indicia K is on the lower or undersurface of web **11** as it passes through the press of FIG. **1,** it being understood that additional printing or indicia, such as K′ of FIG. **4** will be applied to the other surface of the strip on its second pass through the press, as in FIG. **1,** in precise and exact registration with the indicia K applied to the strip on its first or prior pass through the press. It should, of course, be understood that if desired the register indicia K may be on the upper surface or on both surfaces of the web.

As web **11** is metered to the press, its speed is controlled by the infeed governor or metering cylinder **50.** An electric eye, or sensing means, denoted generally by the numeral **60,** is adapted to stroboscopically "read" or "see" the previously applied register indicia K.

The press is driven by main drive shaft S by means of a suitable motor driven transmission indicated by the numeral **52.** The main line shaft S drives the press at a given speed and an optical encoder or signal producing means **54** driven as at **53** continuously measures the angular rotation of shaft S.

In those instances in which the main drive shaft S is driving the infeed governor cylinder **50**, through the No. **1** differential **56** at the same peripheral speed as the linear speed at which web **11** is passing through the press, the phase relationship of the output signals of electric eye **60** and encoder **54** will remain constant and equal, viz, in phase.

An object of the present invention is to teach a method and provide means to cause this phase relationship to remain constant. In other words, infeed governor cylinder **50** will be speeded up or slowed down so that its peripheral speed will cause the indicia marks K on web **11** to pass under electric eye **60** in phase with the press repeat of the web as indicated by encoder **54**, which, as indicated, measures the angular rotation of the main press drive shaft S.

To summarize, web **11** passing through the press is driven by the infeed governor or metering cylinder **50** to cause the indicia marks K to pass eye **60** in phase, or in synchronization with the press repeat. In the event that the indicia-mark signal from eye **60** and the signal generated by encoder **54** are out of phase with each other, the rotational speed of the infeed governor or metering cylinder **50** will be varied to cause web **11** to be metered to the press at a speed to match the press repeat rate read by encoder **54**. This is accomplished by means of the two inputs **62** and **64** to the **1** differential **56**, the output **66** of which drives cylinder **50**.

Input **62** to differential **56** is from the main press drive shaft S the speed of which is indicated and measured by encoder **54**. The other input **64** to differential **56** is the output **64** of the **2** differential **68**. Thus the speed of the infeed governor or metering cylinder **50** for a given rotational speed of the press main drive shaft S can be varied by varying its input which is controlled by output **64** of differential **68**. Input **70** to differential **68** is the output of the immediate correction reversible, DC motor or first drive means **72**.

Input **74** to the Hurletron controller or first control means **76** is the output signal from electric eye **60**, whereas input **78** is the output signal from encoder **54**.

The Hurletron controller **76** compares the two input signals **74** and **78** from electric eye **60** and encoder **54**, respectively. If signal **74** from the electric eye **60** is lagging signal **78** from encoder **54**, the Hurletron controller **76** will produce an amplified output signal or first control signal **80** to the DC motor **72** causing said motor to add rotation to input **70** of differential **68**. This causes infeed governor or metering cylinder **50** to speed up, thus advancing the output signal **74** from electric eye **60** relative to the output signal **78** from encoder **54**.

If signal **74** from electric eye **60** leads signal **78** from encoder **54**, the combination of these two signals in the Hurletron controller **76** will produce an amplified output signal **80** to motor **72** causing it to rotate in an opposite direction thereby producing negative rotation to input **70** of differential **68** thus slowing down the rotational speed of the infeed governor or metering cylinder **50**, causing web **11** to slow down and bringing the output signal **74** of electric eye **60** into desired phase relationship with output signal **78** of the encoder **54**. The polarity or direction of rotation of the output of DC motor **72** is in relationship whether the output signal **74** of electric eye **60** either leads or lags the output signal **78** of encoder **54**.

In this manner web **11** is fed or metered into the press at the correct speed, that is, at a rate such that it will match the register indicia applied to the strip during its first pass through the device at which time the register indicia K was applied to a surface of the web at regular, equally spaced intervals.

The aforesaid method and apparatus for correlating the operational speed of the infeed governor or metering cylinder **50** to signals **74** and **78** of the electric eye **60** and encoder **54** is objectionable in that it is likely to cause erratic fluctuations in the linear speed of web **11** with a result that the desired and accurate registration control of the web will not be achieved.

The aforesaid operating characteristics of governor **50** are considerably enhanced and the erratic fluctuations minimized, if not eliminated, by introducing a second input **82** to differential **68** wherein the operating characteristics of input **82** is determined by the output of a variable speed Graham Drive or second drive means **84** having one input **86** from the press main drive shaft S. The ratio of the input to the output of the Graham Drive **84** is controlled by setting the ratio adjustment mechanism **88**, designated by legend SET. If the ratio of adjustment mechanism **88** of the Graham Drive **84** is set correctly to deliver or output the proper speed into input **82** of differential **68**, the requirements of maintaining proper phase relationship between the outputs of signals **74** and **76** from electric eye **60** and encoder **54**, respectively, are satisfied, thus eliminating the erratic or rapid changes produced by the immediate correction DC motor **72** through input **70** to differential **68**.

Therefore, in the overall picture, the "immediate" corrections being fed to the infeed governor or metering cylinder **50** by motor **72** is minimized. This is done by attaching a tachometer **90** to the output of DC motor **72**, and when the phase relationship of the signals **74** and **78** require or call for an immediate correction from DC motor **72**, the direction or polarity of this correction and its magnitude is measured by tachometer **90**. The tachometer **90** feeds an output signal **92** to a standard DC motor controller **94**, the function of which is to take the magnitude and polarity of the tachometer signal **92** and to amplify it into a signal to drive the long range DC motor **96** via output **98**.

It will be noted that the operational characteristics of motor **96** follow the corrections which are imparted via shaft **70** to differential **68**. As the immediate correction motor **72** is called upon to deliver an immediate positive correction to differential **68**, the long range DC motor **96** will be actuated to make a corresponding increase in the ratio setting **88** via shaft **100** of the Graham Drive **84** which causes the input **82** of differential **68** to also increase after input **70** to the differential **68** was increased by the immediate correction DC motor **72**. The time lag of correction **82** from the Graham Drive to the differential **68** relative to correction **70** to the differential is variable, and in actual practice it may approximate a **0.5** to **1.0** second lag. The result of this change in the long range correction motor **96** is such that the ratio adjustment mechanism **88** of the Graham Drive **84** is moved to a setting to correct the long range or the trend of the phase relationship deviations between signals **74** and **78** of the electric eye **60** and encoder **54**, respectively. When this happens, the immediate correction DC motor **72** will then be used only to make immediate small corrections in register rather

than continuously inputing large corrections to differential **68** for major differences between the phase relation of signals **74** and **78.** The result is a smoother and exceedingly accurate metering control.

While the long range DC motor **96** is matching the metering rate of web **11** with encoder **54,** a correction factor is imparted to the proportional registration shaft Z for simultaneously and proportionally adjusting the phase relationship of the cylinders of each press location A, B, C, and D relative to web **11,** and simultaneously and proportionally controlling the web length relative to the processing cylinders of processing stations E and F, whereby to compensate for the different lengths of web being metered into the press by the infeed governor or metering cylinder **50.**

As illustrated in FIG. **2,** the output **102** of the long range DC motor **96** is placed in driven relationship with input shaft **104** of differential **106** via pulley **108,** belt **110,** and pulley **112.** The output **114** of differential **106** drives the proportional registration shaft Z.

Differential **106** has a second input **116** from the DC stretch control motor **118** which is adapted to be manually operated by a manually operable push button **120** at the operator's station adjacent the discharge end of the press.

The manual input to motor **118** enables actuation of the proportional registration shaft through differential **106** to accommodate changes in the stretch length of web **11** which are not proportional to, but which, in fact, are independent of the changes in the speed of infeed governor or metering cylinder **50.**

It will be noted that the long range DC motor **96** input to differential **106** is utilized to accomplish changes in the proportional registration shaft Z, which changes are proportional to the changes in the speed of infeed governor or metering cylinder **50.**

Proportional registration at stations A, B, C, and D may be effected by the mechanism illustrated in FIG. **3,** which provides means for imparting a phase correction factor to the various blanket cylinders **30** of said stations while the press is running or stopped.

Rotary motion of the proportional registration shaft Z is imparted to each of gears **130** through bevel gears **132** and **134,** shaft **136,** and pinion gear **138.** Gear **130** is fixed relative to sleeve **140,** which loosely houses shaft **142** to which pinion gears **144** and **146** are keyed, said shaft being mounted in suitable bearings, not illustrated. A nut **148** in driven relationship with sleeve **140** is provided with internal threads which engage the externally threaded portion **150** of screw **152** which is suitably restricted against axial movement relative to the frame of the press, by means not illustrated, but which are clearly illustrated in FIG. **5** of my aforesaid co-pending patent application, Ser. No. 312,893, now abandoned.

Rotation of sleeve **140** imparts the same rotation to nut **148** since screw **152** is axially restricted relative to the frame of the press. Rotary motion of nut **148** causes an endwise axial movement of shaft **142** which produces an identical axial movement in spur gear **144** and helical gear **146,** both of which are fixed to shaft **142.** The axial shifting of helical gear **146** relative to helical gear **152** causes an angular phase shift to occur between blanket cylinder shaft **154** and shaft **142.**

The gear ratio for each set of pinions **138** and gears **130,** at each of stations A, B, C, and D, respectively, are selected by the press manufacturer whereby to satisfy the particular drive requirements for the cylinders of each station. That is, the rotational output of the proportional registration shaft Z is geared into each station of the device at which printing or other processing is applied to the strip of material **11.**

The ratio of pinion **138** and gear **130** of station A is such that a change in the proportional registration shaft Z accomplishes a length register change at station A of the proper amount to be in proportion between the web path length between the infeed governor or metering cylinder **50** and cylinder **30A** of station A and the change in Graham setting **88** for long range web speed correction.

If, by way of example, and solely for purpose of illustration, it be assumed that the infeed governor cylinder **50** is set to meter **96''** of strip material in a given number of press revolutions or repeats, and if it be further assumed that the length of web path of the strip material **11** from the infeed governor or metering cylinder **50** to the blanket cylinders **30** of each of stations A, B, C, and D are **50'', 200'', 350''** and **446'',** respectively; and if the distance from cylinder **50** to cylinders M–N of stations E and F is **500''** and **700'',** respectively, the ratios for the pinions **138** and gear **130** at each of stations A, B, C, and D would be:

A. 50/96
B. 200/96
C. 350/96
D. 446/96

With further reference to FIG. **3,** it will be noted that each of the various blanket cylinders **30** are driven by the main drive shaft S by means of hypoid gears **160** and **162** in gear boxes **164,** shafts **166,** pinion gears **168** and **144,** helical gears **146** and **152,** and shafts **154.**

Registration at stations E and F may be accomplished by imparting a correction factor to the web path length control utilizing, by way of example, the means illustrated in FIG. **4,** wherein rotary motion of proportional registration shaft Z is imparted to sprocket **170,** chain **172,** sprocket **174,** shaft **176,** worm gear **178,** worm wheel **180,** shaft **182,** fulcrum arm **184,** and roll **186.** It will be noted that strip **11** passes over roller **188,** under roller **186,** and thence over roller **190,** wherein rollers **188** and **190** are fixed position, rotatable rollers. Movement of fulcrum arm **184** will change the web path length between rollers **188** and **190** for shifting web **11** lengthwise relative to cylinders M and N.

The device of FIG. **4** alters the web path length from station E back to the infeed governor or metering cylinder **50,** whereas the type of compensation illustrated in FIG. **3** alters the phase relationship of cylinders **30A, 30B, 30C** and **30D** relative to the web **11** in order to accomplish length register rather than changing the web path length to accomplish register.

The output of the proportional registration shaft Z at station F is proportional to the length of web between stations E and F and not proportional to the length of web **11** from station F to the infeed governor or metering cylinder **50** since a portion of the required correction has already been made at station E through the ratio of sprockets **170** and **174.**

The ratio of sprockets **170** and **174** at stations E and F in the present example would be:

E. 596/96
F. 104/96

to provide the desired proportional registration drive at each of these stations.

It will be noted that gears **192** and **194** of cylinders M and N are driven by gear **168** via shaft **166** and gears **160** and **162** in gear box **164** by main drive shaft S.

The numeral **196** designates generally a plurality of operator controls which may be in the form of a crank or motor operated gear in driven relationship with gears **198** and **200** for rotating screw **152** to provide axial movement to shaft **142** for thereby enabling an operator to individually and independently adjust the phase relationship of the blanket cylinders of each tower on an individual basis and without in any way effecting the adjustment or phase relationship of the other towers or stations A, B, C and D. Likewise, similar control means may be provided at each of towers E and F for accomplishing individual and independent web path control.

In those instances in which register indicia K is applied to the upper surface of web **11** at station A, during its first pass through the press, and electric eye **161** may be utilized for stroboscopically "seeing" the applied indicia just prior to, or in advance of blanket cylinder **30** of station B. Eye **161** will read the length of the press repeat length as indicated by the register indica applied to the web at printing station A. The indicia-mark-signal **74** from electric eye **161** will be transmitted to the Hurletron control **76** where it is compared witb signal **78** generated by the encoder **54.** Any differeneces in signals **74** and **78** will cause the rotational speed of the infeed governor or metering cylinder **50** to be increased or decreased, in the manner heretofore described with reference to electric eye **60** to make the repeat length constant. It should be understood that when an electric eye, such as **161** is used, electric eye **60** is omitted, or inactivated, and visa versa.

MODUS OPERANDI

After web or strip material **11** from the rewound roll **10** has been threaded through the various printing and processing stations which collectively constitute the press, the press is operated with the register indicia K, which was applied to the web during its previous pass through the press, on the underside of the web, whereby to be stroboscopically "seen" by electric eye **60** of FIG. **1.**

When the press is operated electric eye **60** stroboscopically "sees" reference indicia K on web **11** as manifest by a signal **74** which is fed to the Hurletron control **76** where the electric eye signals are continuously and automatically compared with signals **78** generated by encoder **54.**

If the signal **74** from the electric eye **60** lags signal **78** from the encoder **54,** the Hurletron controller **76** will, as earlier indicated, produce an amplified output signal **80** to the DC motor **72** causing it to add rotation to input **70** of differential **68.** The direction or polarity of this correction and its magnitude is measured by tachometer **90** which feeds an output signal **92** to the DC controller **94** which amplifies and transmits said signal to DC motor **96.** Actuation of the DC motor **96** changes the adjustment **88** of the Graham Drive **84** thereby changing the ratio of the Graham Drive output **82** to its input **86,** said output **82** being transmitted to differential **68** for thereby modifying output **64** of differential **68.** The output **64** of the differential **68** comprises one of the two inputs to differential **56.** The output of differential **56** is in driven relationship with the infeed governor or metering cylinder **50,** it being noted that the other input **62** to differential **56** comes directly from the press main drive **52.**

In other words, as the DC motor **72** is called upon to put an immediate positive direction correction to input **70** of differential **68,** the long range DC motor **96** literally follows the corrections which are inputed to the said differential by motor **72,** whereby a corresponding increase in the ratio setting **88** of the Graham Drive **84** which causes the input **82** to the differential **68** to increase.

The result of actuation of the long range DC motor **96** is that the Graham Drive ratio **88** moves to a setting to correct the trend of the phase deviations between signals **74** and **78.** Under these circumstances the immediate correction motor **72** is utilized now only to make immediate but small corrections in registration rather than continuously inputting large corrections for major differences in trend. The net result is a smoother and more accurate register control.

Actuation of motor **96** as a result of any phase differences in the signals from eye **60** and encoder **54** also changes one of the inputs, **104,** to differential **106,** the output **114** of which is in driving relationship with the proportional registration shaft Z.

Rotation of proportional registration shaft Z will simultaneously alter the phase relationship of each of blanket cylinders **30** of the various printing stations A, B, C, and D, with respect to web **11,** such as, by way of example, the means illustrated in FIG. **3.**

Rotation of shaft Z will also shift roller **186,** FIG. **4,** for thereby changing the path length of web **11** relative to cylinders M and N of stations E and F.

The aforesaid adjustments to each of the printing and processing stations will automatically compensate for the changes induced by changes in the rate at which the web is fed to the press by the infeed governor or metering cylinder **50.**

The use of a tandem differential arrangement as exemplified by differential **68** and **56** effectively eliminates "hunting" which has heretofore plagued the industry.

By locating electric eye **60** adjacent but after the infeed governor or metering cylinder **50** as illustrated in FIG. **1,** I have been able to quickly, effectively, efficiently and accurately control the register indicia repeat of web **11** during its second pass through the press whereby it will match the register indicia applied to the web on its first pass through the press. The web will be presented to the various stations of the press in such a manner as to enable the indicia which is applied to the upper surface of the web on its second pass to be in precise register with the register indicia K on the lower surface of the web as applied during the first pass of the web through the press.

Any deviation in registration caused by the "stretch factor" of the strip as it passes through the press, may be expeditiously compensated for by actuating the proportional registration shaft Z, independently of the control for the infeed governor or metering cylinder **50,** such as, by way of example, by actuation of motor **118.**

With particular reference now to FIG. **4,** the numeral K indicates the register indicia on the undersurface of web **11,** which was applied to the web during its initial pass through the press. The reference characters K′ indicate generally reference indicia applied to the upper

surface of web **11** during its second pass through the press, wherein indicia K' is in precise and exact registry with indicia K.

In those instances in which the web is to be subjected to punching, perforating and similar operations, it is desirable to perform such operations on the web during its second pass through the press in order not to weaken the web during its second pass through the press, it being noted that the web is continuously subjected to a predetermined tension while in the press.

As used in the claims, the term "metering control" broadly refers to means such as the stroboscopic electric eyes **60** and/or **161** and the means by which said electric eyes effect a change in the metering rate in the infeed governor or metering cylinder, such as, by way of example, is diagrammatically illustrated in FIG. **2.**

The term "predictable stretch" of the strip material refers to changes which occur in the length of the strip material when the rate of metering of said material changes, and at which time proportional registration is simultaneously accomplished at each station.

The term "unpredictable stretch" of the strip material refers to changes which occur in the space between register indicia on the strip of material because of fibre stretch, bond, etc. under a given tension condition independently of the meter control, and at which time proportional registration is simultaneously accomplished at each station by manual means, such as, by way of example, push button **120** of FIG. **2.**

What is claimed is:

1. The method of synchronizing the metering rate of a continuous strip of material during its pass through a multi-station device with register indicia previously applied to the strip and of simultaneously correcting deviations in register at each station, wherein the device includes an infeed means and printing cylinders at the stations and drive means connected with the infeed means and cylinders to drive them and feed the web through the device, comprising the steps of: sensing the rotational speed of the cylinders and obtaining a press-repeat signal therefrom; sensing the spacing of the register indicia on the strip as the strip passes through the device and obtaining a register indicia signal therefrom; feeding the said signals to a first controller and comparing the said signals and obtaining an immediate correction signal therefrom; utilizing said immediate correction signal to obtain a further signal which is a function of the immediate correction signal; feeding said further signal to a second controller and modifying said further signal to obtain a long range correction signal which is representative of the trend of the immediate correction signals; and controlling operation of said infeed means in dependence on both the immediate correction signal and the long range correction signal to thus obtain accurate registration control and prevent sudden and erratic changes in the metering rate of the device.

2. A method as called for in claim **1,** wherein the press repeat is constant, and wherein the spacing of the register indicia of the rewound strip of material is variable.

3. A method as called for in claim **21,** wherein the phase relationship of said press-repeat and register indicia signals are compared to indicate the presence and extend of deviations in phase between the spacing of the register indicia and press repeat for determining the amount of alteration to be imparted to the rate of metering of the strip of material in order to match the spacing of the register indicia with the press repeat.

4. A method as called for in claim **1,** wherein the stretch of the strip of material is predictable.

5. A method as called for in claim **1,** wherein the register indicia was previously applied to the strip of material at regular, equally spaced intervals.

6. A method as called for in claim **1,** which includes the steps of generating a signal each time the register indicia on the strip of material passes a predetermined point; generating a signal in synchronization with each press repeat; and of comparing the phase relationship of said generated signals to indicate the presence and extent of deviations in phase between the spacing of the register indicia and the press repeat for determining the amount of alteration to be imparted to the rate of metering of the strip of material in order to match the spacing of the register indicia with the press repeat.

7. A rotary printing press including a plurality of printing stations and of the type which includes a variable speed infeed means to control the rate at which a continuous strip of material having preapplied register indicia thereon is fed to the press; said printing stations including printing cylinders; press drive means connected with the infeed means and the printing cylinders to drive said infeed means and the cylinders of each station; means connected with the printing cylinders for altering the phase relationship of the printing cylinders relative to said strip of material; sensing means adjacent said strip of material to translate the spacing of the register indicia into a register-induced signal as the register indicia passes a predetermined point as the strip of material passes through the press; signal producing means connected with said press drive means to translate the rotational speed of said cylinders into press-repeat signals; first control means connected with said sensing means and said signal producing means to compare said register-indicia induced and said press-repeat induced signals to obtain a first control signal; a pair of differential gear units connected in tandem between said press drive means and said infeed means to selectively vary the speed of the infeed means to match the register indicia on said strip of material with the press repeat; first drive means connected to said first control means and to one of said differential units and responsive to said first control signal to provide one input to said one differential unit which is a function of said first control signal for effecting immediate corrections in registration, a second drive means connected to said first drive means and to said one differential unit to provide another input to said one differential unit which is a function of the first control signal and the press repeat for effecting long range corrections based on the trend of the immediate corrections, the output of said one differential unit comprising a variable input to the other differential unit, said press drive means connected to said other differential unit to provide another input thereto which is substantially constant, the output of said other differential unit connected to drive said infeed means, whereby hunting is prevented and accurate registration control is achieved.

8. A rotary printing press as called for in claim **7,** wherein the said predetermined point is located in the press after the first printing station and immediately in advance of the printing cylinders of a subsequent station.

9. A rotary printing press as called for in claim 7, wherein the said predetermined point is disposed between the infeed means and the printing cylinders of the first station of said press.

10. A rotary printing press as called for in claim 9, wherein the first drive means for said one differential unit comprises a first electric motor connected to provide said one input of said one differential; and said second drive means to drive the other input to said differential including a variable speed transmission and a second electric motor connected to alter the output of said variable speed transmission.

11. A rotary printing press as called for in claim 10, wherein the speed and direction of rotation of said first electric motor is controlled by the first control signal and first control means, which are responsive to differences in the phases of said register-induced and said press-repeat induced signals.

12. A rotary printing press as called for in claim 10, including second control means connected to be driven by said first electric motor, and wherein the speed and direction of rotation of said second electric motor is controlled by said second control means driven by said first electric motor.

13. A rotary printing press as called for in claim 10, wherein a tachometer is connected to be driven by said first electric motor and the tachometer has an output connected to the second electric motor, so that the speed and direction of rotation of said second electric motor is a function of the output of said tachometer.

14. A rotary printing press as in claim 7, wherein means is connected with the printing cylinders of each station to simultaneously and proportionally vary the phase relationship of each of the cylinders relative to the strip of material, said means including said variable speed transmission having a power input connected thereto and an output connected to drive a proportional registration shaft, which is connected in driving relationship to the printing cylinders of each station.

15. A rotary printing press as called for in claim 14, wherein the said second electric motor is connected to the variable speed transmission and comprises the input thereto, the output of the variable speed transmission connected to drive a differential unit which is connected to the proportional registration shaft to simultaneously and proportionally vary the phase relationship of the cylinders of each of said printing stations relative to the strip of material being processed.

16. A rotary printing press as called for in claim 15, wherein the said variable speed transmission comprises a differential one input of which is in driven relationship with the said second electric motor, the other input of which is in driven relationship with a third electric motor which includes manually operable control means.

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