July 4, 1967 G. N. SANDOR ET AL 3,329,087

REGULATION OF REPETITIVE PATTERN REPEAT LENGTH ON A WEB

Filed Nov. 30, 1964 4 Sheets-Sheet 1

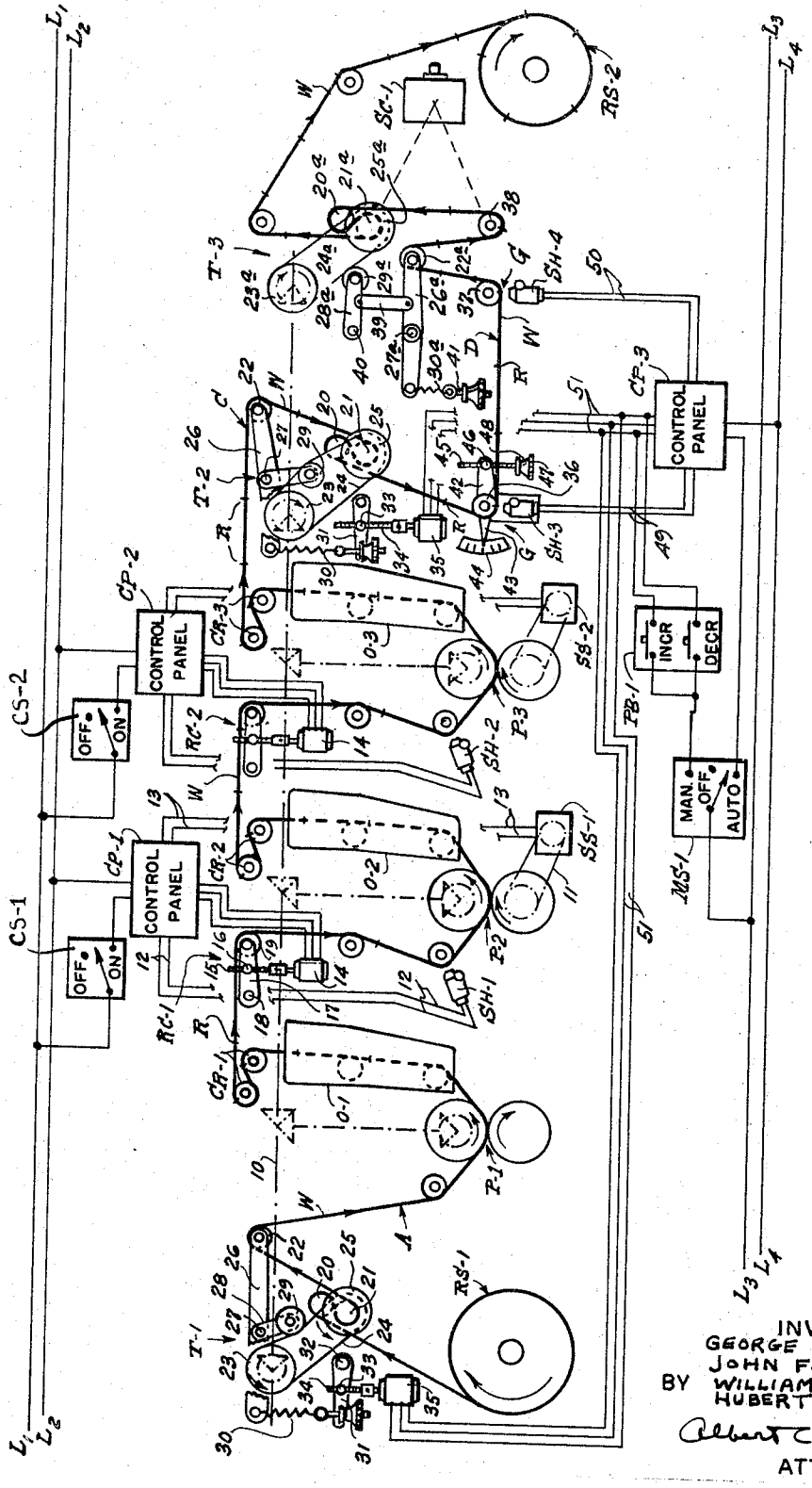


Fig. 1.

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REGULATION OF REPETITIVE PATTERN REPEAT LENGTH ON A WEB

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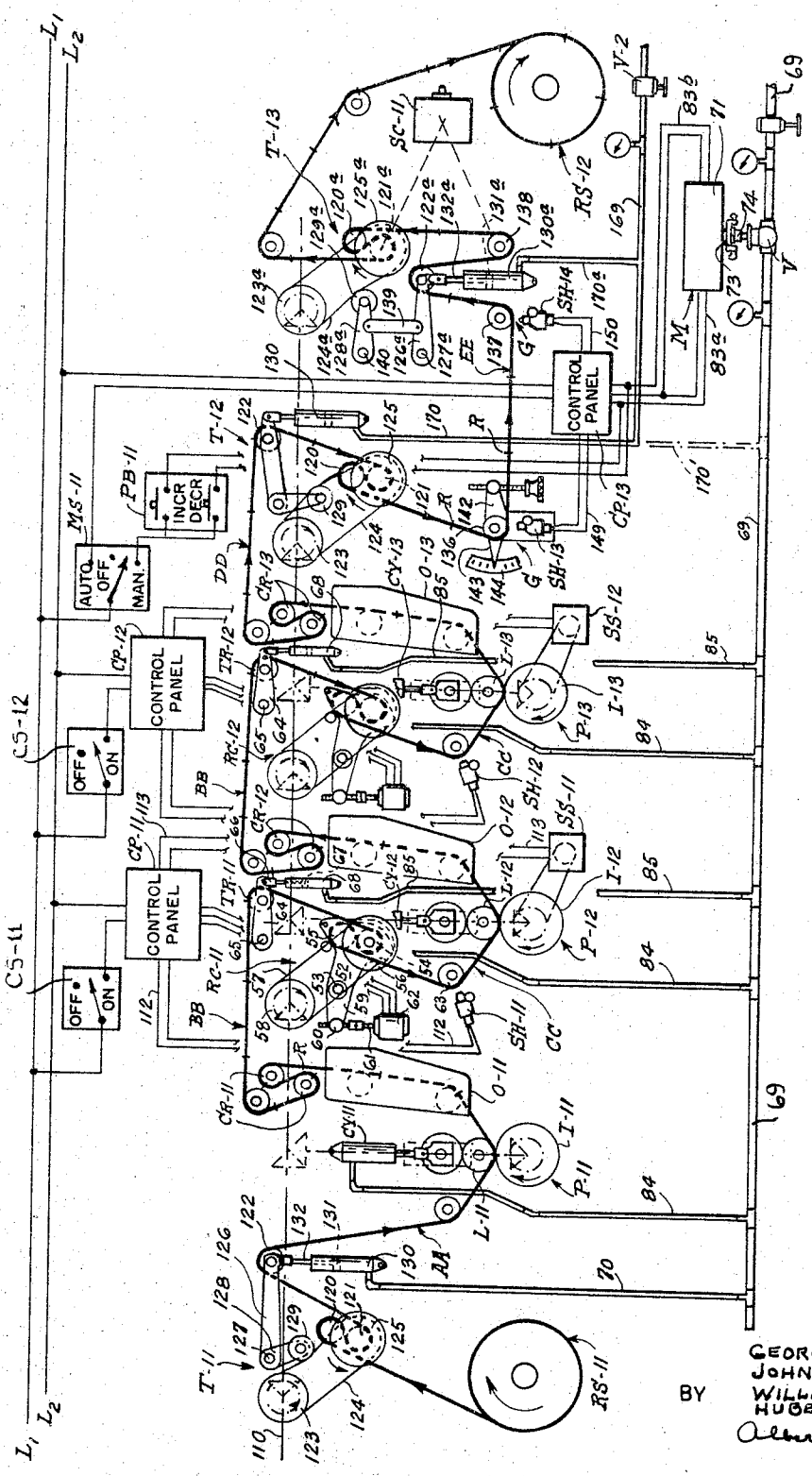


Fig. 2.

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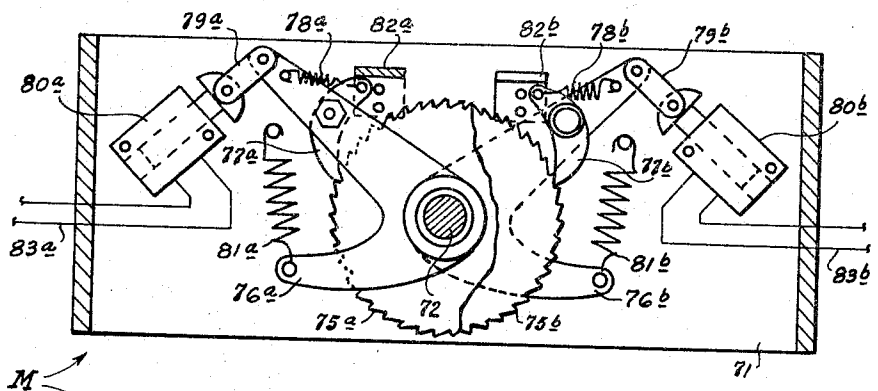
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REGULATION OF REPETITIVE PATTERN REPEAT LENGTH ON A WEB

Filed Nov. 30, 1964 4 Sheets-Sheet 3

Fig. 5.



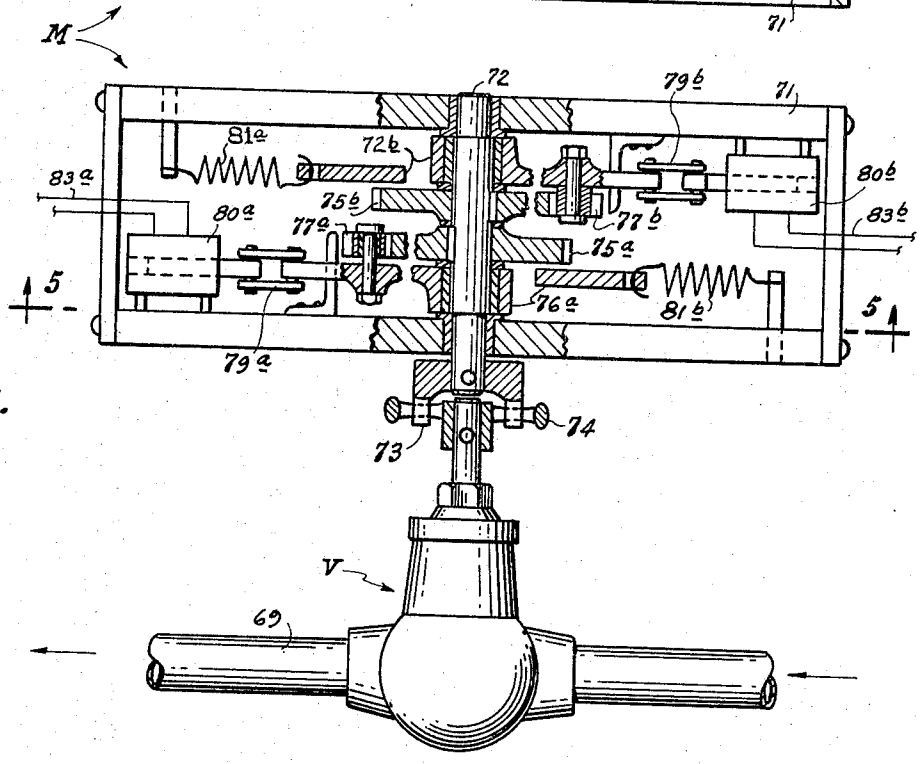


Fig. 4.

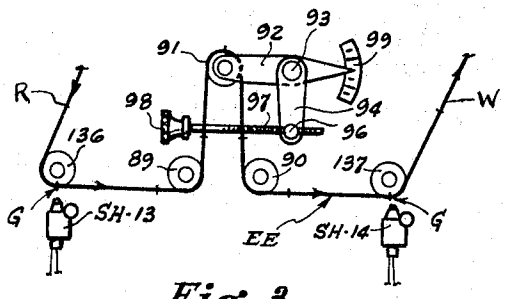


Fig. 3.

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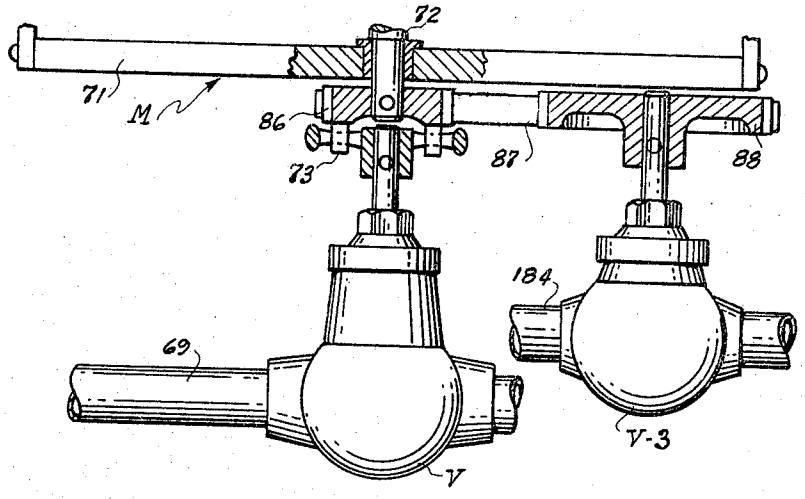
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Fig. 6.



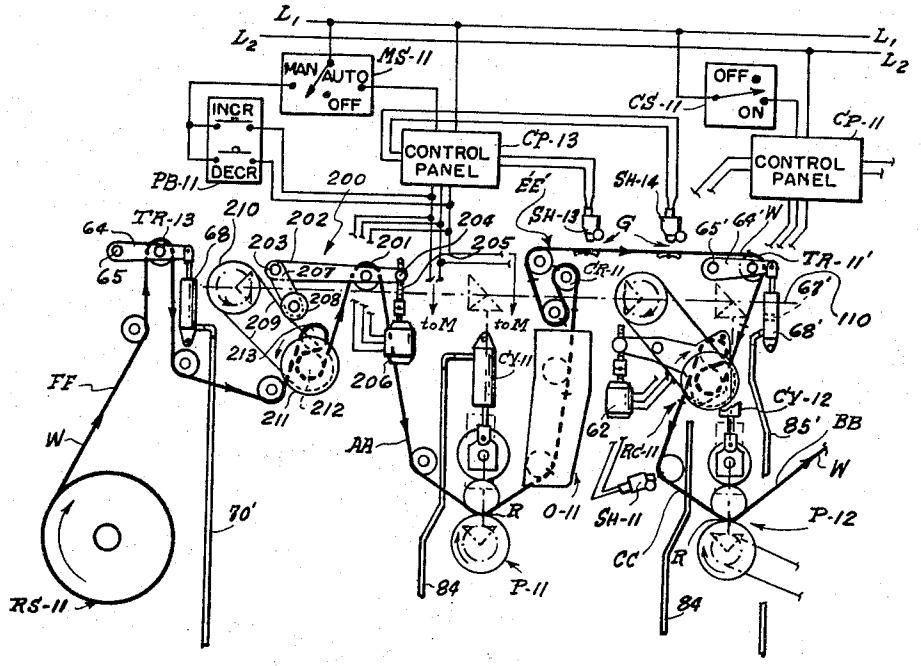


Fig. 7.

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3,329,087

REGULATION OF REPETITIVE PATTERN REPEAT LENGTH ON A WEB

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Filed Nov. 30, 1964, Ser. No. 414,648
30 Claims. (Cl. 101—181)

This invention relates generally to the forming of repetitive patterns on a continuously moving web, for example, as in a rotary, web-fed multi-impression printing press of the gravure, offset, or typographical type, and more particularly is directed to the automatic regulation of the repeat length of the successive repetitive patterns printed or otherwise formed on the web.

It is desirable that the repetitive patterns printed or otherwise formed on the web have exactly the same repeat length when the web is under a normal operating tension in order to facilitate register of the repetitive patterns with other webs or with equipment acting on the web during subsequent web processing operations.

In a machine having printing cylinders or other rotary means for forming repetitive patterns on a continuously moving web, the cylinder diameters and web conditions, for example, temperature, humidity and web thickness, vary from time to time, and may result in variations in the repeat length of the repetitive patterns formed on the web. It has been proposed, for example, in U.S. Patent No. 2,549,605, to W. F. Huck, to vary the tension in the web as repetitive patterns are being printed or otherwise formed on the later with a view to eliminating deviations from a predetermined repeat length of the repetitive patterns. However, in such previously proposed arrangement, the repetitive patterns on the web are scanned at a lead of the web in which the tension may vary, for example, by reason of tension changes enployed for achieving accurate register of portions of the repetitive patterns respectively formed by printing or other web processing units acting successively on the web, or even by reason of the web tension variations introduced in an attempt to obtain a uniform repeat length of the repetitive patterns. If the tension in the run of the web acted on by the printing cylinders is controlled to obtain a uniform repeat length of the repetitive patterns scanned at a run or lead of the web under a varying tension, then such repetitive patterns will not have a uniform repeat length when the web is thereafter relaxed or under a uniform tension.

Accordingly, it is an object of this invention to ensure that repetitive patterns formed on a continuously moving web by printing cylinders or other rotary means have a constant or predetermined repeat length when the tension on the web is relaxed or when the web is under a uniform or constant operating tension.

Another object is to provide an arrangement for maintaining a uniform repeat length which can be employed in web-fed multi-impression printing presses having longitudinal register control means to ensure that the two or more impressions making up each pattern of the required repeat length are accurately registered.

In accordance with this invention, a printing press or other machine having rotary means for forming repetitive patterns on a continuously moving web is provided with tension control means for controlling the tension in a run of the web subject to the action of the rotary means, means operative to maintain constantly a predetermined constant datum tension in a lead of the web beyond the web run which is subject to the action of the rotary means, scanning means detecting deviations from

a predetermined repeat length of the repetitive patterns on the web in the lead under such constant datum tension, and correction means acting upon the tension control means, in response to the detection by the scanning means of a deviation from the predetermined repeat length, to adjust the tension of the web in the run subject to the action of the rotary means in the sense for restoring the predetermined repeat length in the web lead under the predetermined constant datum tension. Since the web lead at which the successive repetitive patterns are scanned is constantly under a predetermined datum tension, the control of the tension in a run of the web subject to the action of the rotary means forming the repetitive patterns in a sense to eliminate deviations from the desired repeat length at the web lead ensures that the uniform repeat length will be maintained when the web is subsequently processed or acted upon either under the predetermined datum tension or under any other uniform operating tension.

The tension in a run of the web subject to the action of the rotary means forming repetitive patterns on the web may be controlled by means acting on the web at a location in advance of the rotary means, by means acting on the web at locations both in advance of the rotary means and between the rotary means and the web lead in which the predetermined datum tension is constantly maintained, by means for varying the contact pressure of the rotary means on the web while forming the repetitive patterns on the latter, or by any combination of such means.

Where the rotary means for forming repetitive patterns on the continuously moving web includes a plurality of printing or other units acting successively on the web to form respective portions of the repetitive patterns, the web lead in which the predetermined datum tension is constantly maintained may extend beyond the last of the units of the rotary means acting on the web, or such web lead may extend between the first unit of the rotary means and the following unit. In either case, longitudinal register control means may act on the web between the successive units of the rotary means to ensure accurate registration of the portions of the repetitive patterns formed by the respective units.

The above, and other objects, features and advantages of the invention, will be apparent in the following detailed description of illustrative embodiments thereof which is to be read in connection with the accompanying drawings forming a part hereof, and wherein:

FIG. 1 is a schematic view of a multi-color web-fed printing press having an arrangement according to the present invention for insuring uniform repeat length of the repetitive patters printed on the web;

FIG. 2 is a schematic view of a multi-color web-fed printing press having an arrangement for maintaining uniform repeat length in accordance with another embodiment of the invention;

FIG. 3 is a detail schematic view illustrating a modification of the arrangement shown on FIG. 2;

FIG. 4 is an enlarged detail view, partly broken away and in section, of a control mechanism included in the embodiment of the invention illustrated on FIG. 2;

FIG. 5 is a sectional view taken along the line 5—5 on FIG. 4;

FIG. 6 is a fragmentary detail view showing a modification of the control mechanism of FIGS. 4 and 5; and

FIG. 7 is a schematic view of a portion of a multicolor web-fed printing press similar to that shown on FIG. 2, but having an arrangement for maintaining uniform repeat length of the repetitive patterns in accordance with still another embodiment of this invention.

In the multi-color web-fed printing press of the typographical type shown on FIG. 1, a web W is unwound from a supply roll carried by an unwind roll stand RS–1, which may be an automatic splicing roll stand of the type disclosed in U.S. patent application Ser. No. 786,843, filed Jan. 14, 1959, by W. F. Huck. The web unwound from the supply roll at the roll stand RS–1 is moved successively through a number of typographical printing units P–1, P–2 and P–3 which repetitively print on the web in different colors so that the web issuing from the last printing unit P–3 has repetitive patterns printed thereon and each made up of superposed multi-colored impressions formed by the several printing units. The printed web may be rewound on a roll stand RS–2 which is also of the type mentioned above, or the printed web may be fed directly to another web processing machine (not shown) which may take any of various forms, for example, a perforating unit, a slitting unit, a cross-cutting unit, an embossing unit or collating rollers associated with a folding unit.

Drying ovens O–1, O–2 and O–3 and cooling rollers CR–1, CR–2 and CR–3 are located after the printing units P–1, P–2 and P–3, respectively, to dry the inked impressions applied to the web by the preceding printing units and to cool the web.

The cylinders of the printing units P–1, P–2 and P–3 are suitably driven from a main press drive shaft 10 which is, in turn, driven from the main press motor (not shown), and register control devices of standard, commercially available type are provided for effecting accurate longitudinal registration of the multi-colored impressions formed on the web by the several printing units to make up each of the repetitive printed patterns. As shown, the devices for longitudinally registering the impressions formed by the printing units P–1 and P–2 may include a scanning head SH–1 of a photoelectric type commercially available from the specialty control department of General Electric Company, Waynesboro, Va., under item No. CR7515–P202–G4. The scanning head SH–1 is located in advance of printing unit P–2 to scan register marks R applied to the web at the preceding printing unit P–1 in predetermined longitudinal positional relationship to the impressions applied by the printing unit P–1. The register marks may be either printed on the web or embossed therein, or in the form of slits or perforations made in the web. The photoelectric scanning head SH–1 is operative to emit a suitable electrical signal when each register mark R passes through the scanned region or area of the web.

A photoelectric selector switch SS–1 which may be of the type commercially available from the specialty control department, General Electric Company, Waynesboro, Va., as item No. CR7515–P145–G4, is driven from a cylinder of printing unit P–2, for example, through a belt and pulley transmission 11, and is operative to emit electrical signals which occur simultaneously with the electrical signals emanating from the scanning head SH–1 when the register marks R, and hence the impressions formed by the printing unit P–1, are accurately registered in the longitudinal direction with respect to the impressions formed by printing unit P–2. However, in the event of a register error, the electrical pulse or signal issuing from the scanning head occurs either before or after the electrical pulse or signal issuing from the selector switch. The electrical pulses or signals issuing from scanning head SH–1 and selector switch SS–1 are fed through conductors 12 and 13, respectively, to a register control panel CP–1 which may be of the type commercially available from the specialty control department, General Electric Company, Waynesboro, Va., as item No. 3S7515–CT100–A1. Such register control panel is operative to amplify the signals received from the scanning head and selector switch, respectively, and to compare such signals so that any timing discrepancy produces an error signal which causes suitable energization of a reversible correction motor 14 forming part of a register control device RC–1.

The register control device RC–1 further includes an adjustment screw 15 coupled to the shaft of motor 14 and engaging in a nut 16 which is pivotally mounted on a carriage 17 rockable about the shaft 18. The carriage 17 carries a freely rotatable roller 19 which engages the web at a lead of the latter located between the cooling rollers CR–1 and the scanning head SH–1. It will be apparent that upward and downward movements of roller 19 from the illustrated position thereof will respectively increase and decrease the distance along the web between printing units P–1 and P–2, and will thereby alter the relative positions along the web of the impressions formed by such printing units. The error signals fed to the reversible motor 14 from control panel CP–1 in response to the detection of a lack of synchronization between the signals from the associated scanning head and selector switch are proportional in magnitude to the detected register error and serve to rotate the motor 14 in the direction and to the extent required for moving or displacing roller 19 so as to correct the detected error. A manually controlled switch CS–1 may be further provided for controlling the operation of motor 14 of register control RC–1.

A register control device RC–2 similarly acts on the web between the cooling rollers CR–2 and the last printing unit P–3, and its operation is controlled, in the same manner as the device RC–1, by a scanning head SH–2, a selector switch SS–2, a control panel CP–2 and a manually controlled switch CS–2 so as to maintain correct longitudinal register of the impressions previously formed by the printing units P–1 and P–2 with the impressions formed by the printing unit P–3.

Although the described register control devices ensure accurate register of the several multi-color impressions forming each printed pattern on the web, the diameters of the printing cylinders and web conditions, for example, temperature, humidity and web thickness, vary from time to time and may result in variations in the repeat length of the repetitive patterns printed on the web. If the web is thereafter subjected to further processing, for example, perforating, cross-cutting, imprinting, embossing or folding, which further processing is to be longitudinally registered with the previously applied repetitive patterns, variations in the repeat length of the printed or other repetitive patterns previously applied, particularly when the web is under a uniform or normal operating tension, will cause difficulty in effecting the desired longitudinal registration of these patterns with the further operations to be performed on the web.

In accordance with the present invention, the accurate maintenance of a predetermined repeat length of the printed patterns repetitively formed on the web W by the printing press of FIG. 1 is achieved by constantly maintaining a predetermined datum tension in a lead of the web having the repetitive patterns printed or formed thereon, detecting deviations from a predetermined repeat length of the repetitive patterns on the web in such lead of the latter and, in response to the detection of a deviation from the predetermined or required repeat length, adjusting the tension in a run of the web on which the repetitive patterns are being formed, that is, subject to the action of at least the first printing unit P–1, in the sense for restoring the predetermined or required repeat length in the web lead under the datum tension.

In the embodiment of the invention shown on FIG. 1, tension in a run of the web W subject to the action of the printing units is controlled by means of a tension control mechanism T–1 acting on the web between the unwind roll stand RS–1 and the first printing unit P–1, and preferably also by a similar tension control mechanism T–2 acting on the web issuing from the last print-

ing unit P–3. Each of the tension control mechanisms T–1 and T–2 is generally of the type disclosed in U.S. Patent No. 2,931,962 to W. F. Huck, and includes drive rollers **20** and **21** around which the web travels in a serpentine manner in the form of an S loop, and a floating sensing roller **22** engaged by the run of the web in which the tension is to be controlled. In the case of the tension control mechanism T–1, the web runs around drive rollers **20** and **21** and then over the floating roller **22** before entering the printing unit P–1, whereas, in the case of the tension control mechanism T–2, the web engages the floating roller **22** upon emerging from the cooling rollers CR–3 of the last printing unit and then runs around the drive rollers **20** and **21**.

Each of tension control mechanism T–1 and T–2 further has a pulley **23** driven through suitable gearing from main press shaft **10** and engaging a V belt **24** which drives a variable diameter pulley **25** coupled to the drive roller **21**. The variable diameter pulley **25** is preferably of the type disclosed in U.S. Patent No. 2,812,666 to W. F. Huck, so that changes in the V belt contacting radius are instantaneously responsive to variations in the tension of belt **24**. Drive roller **20** is driven from drive roller **21** by means of suitable meshing gears (not shown). The floating sensing roller **22** is mounted at one end of a carriage **26** which is rockable intermediate its ends about the axis of a shaft **27**. An arm **28** is also secured to shaft **27** for rocking with the carriage **26** and carries an idler roller **29** which contacts a run of belt **24** between pulleys **23** and **25**. The floating roller **22** is biased against the web by a spring **30** acting on carriage **26**.

Floating roller **22** of each of the tension control mechanism T–1 and T–2 is urged downwardly by its own weight and that of roller **29**, as well as by the tension in the run of web W engaged by roller **22**. In the case of tension control mechanism T–2, floating roller **22** is further urged downwardly by the tension in belt **24** acting on roller **29**. In both mechanisms T–1 and T–2, roller **22** is urged upwardly by the force of spring **30** and, in the case of mechanism T–1, also by the tension of belt **24** acting on roller **29**.

The described forces acting upwardly and downwardly on each floating roller **22** are normally in balance and thus maintain a tension in the engaged run of the web having a magnitude determined by the force exerted by the related spring **30**.

If the tension in the run A of the web engaged by roller **22** of tension control mechanism T–1 falls below the value corresponding to the force exerted by the related spring **30**, the resulting unbalance of forces causes upward movement of floating roller **22** and corresponding movement of roller **29** which loosens belt **24** and permits variable diameter pulley **25** to increase its belt pitch radius so that drive rollers **20** and **21** are driven at a slightly slower speed. Such decrease in the speed of drive rollers **20** and **21** results in correspondingly increased web tension in the run A until the original balance of forces is restored and the floating roller **22** returned to its original position. Conversely, a slight increase in the web tension in the run A causes an increase in the speed of drive rollers **20** and **21** so as to restore the web tension corresponding to the force exerted by spring **30**.

In the case of the tension control mechanism T–2, an increase in the web tension in the run C engaged by its roller **22** beyond that corresponding to the force exerted by the related spring **30** causes downward movement of the floating roller **22** and also of the roller **29** to relax or loosen the drive belt **24** and thereby permit variable diameter pulley **25** to increase its belt pitch radius for reducing the speed of drive rollers **20** and **21**. In this case, the reduced speed of drive rollers **20** and **21** serves to reduce the tension in web run C until the original position of the related floating roller **22** is restored. Conversely, a decrease in the tension in run C below that corresponding to the force exerted by spring **30** of tension control mechanism T–2 results in an increase in the speed of drive rollers **20** and **21** of the latter so as to restore the web tension condition determined by the force of the spring.

In order to permit adjustment of the tensions in the web runs A and C under the control of mechanisms T–1 and T–2, the spring **30** of each tension control mechanism is connected to an arm **31** rockable about a pivot **32** and carrying a pivotally mounted nut **33** engaged by an adjustment screw **34** which is coupled to the shaft of a reversible correction motor **35**. It will be apparent that, when the motor **35** is driven in one direction or the other, the effective length of the related spring **30** is either increased or decreased thereby either increasing or decreasing, respectively, the spring force urging the related floating roller **22** in the upward direction for either increasing or decreasing, respectively, the tension to be maintained in the corresponding run A or C of the web W.

In the embodiment of the invention shown on FIG. 1, the predetermined constant datum tension is constantly maintained in a web lead D which extends between the tension control mechanism T–2 and a further tension control mechanism T–3 which acts on the web in advance of the rewind roll stand RS–2.

The web lead D runs successively under guide rollers **36**, **37** and **38** and, intermediate the rollers **37** and **38**, is looped over the floating sensing roller **22***a* of tension control mechanism T–3. The mechanism T–3 further includes drive rollers **20***a* and **21***a* around which the web travels in a serpentine manner between guide roller **38** and the rewind roll stand RS–2. A pulley **23***a* is suitably driven from main press shaft **10** and engages a belt **24***a* which drives a variable diameter pulley **25***a* coupled to drive roller **21***a*. The floating roller **22***a* is rotatably mounted at one end of a carriage **26***a* rockable, intermediate its ends, on a shaft **27***a*. A link **39** pivotally connects carriage **26***a* to an arm **28***a* which is pivoted at **40** and carries a roller **29***a* in contact with the belt **24***a*. A spring **30***a* is connected between carriage **26***a* and an anchor **41** which is manually adjustable to vary the effective length of the spring, and hence the force exerted by spring **30***a* for biasing roller **22***a* against the web.

In the tension control mechanism T–3, the weight of rollers **22***a* and **29***a*, the tension in web lead D and the tension in belt **24***a* produce forces urging floating roller **22***a* in the downward direction, whereas the force of spring **30***a* urges roller **22***a* in the upward direction. When the tension in web lead D corresponds to that for which spring **30***a* has been adjusted, that is, when the predetermined datum tension exists in web lead D, the described forces are in equilibrium. However, if the tension in web lead D exceeds the predetermined datum tension which is to be constantly maintained therein, the equilibrium of forces is disturbed and roller **22***a* is displaced downwardly to effect corresponding movement of roller **29***a* which relaxes or loosens belt **24***a* and permits variable diameter pulley **25***a* to increase its belt pitch radius so that drive rollers **20***a* and **21***a* are driven at a slightly slower speed and thereby decrease the tension in web lead D. Conversely, if the tension in web lead D decreases below the predetermined datum tension for which spring **30***a* has been adjusted, roller **22***a* moves upwardly to cause an increase in the speed of drive rollers **20***a* and **21***a* and a corresponding increase in the tension in web lead D until the predetermined datum tension has been restored.

In order to detect deviations from a predetermined repeat length of the repetitive patterns on the web in lead D, scanning heads SH–3 and SH–4 are suitably mounted adjacent guide rollers **36** and **37** to scan areas G, G of the web which are spaced apart by a distance along the web lead D that is a whole multiple of the predetermined or desired repeat length. Each of the scanning heads SH–3 and SH–4 may be of the commercially available type mentioned above in connection with scanning heads SH–1

and SH–2. In order to permit adjustment of the repeat length that is to be maintained, the scanning head SH–4 may be fixedly mounted, while the scanning head SH–3 is mounted on a bracket 42 which is turnable about the axis of the adjacent guide roller 36 to move the scanned region of the web circumferentially about the guide roller, and thereby either increase or decrease the distance along the web between the scanned regions of the two scanning heads. The bracket 42 may have a pointer 43 extending therefrom and cooperating with a fixed scale 44 to indicate the magnitude of the repeat length which is to be maintained. Adjustment or turning of bracket 42 about the axis of roller 36 may be effected by an adjustment screw 45 engaging a nut 46 which is pivotally carried by an arm extending from bracket 42. The adjustment screw 45 may be turned by a knob 47 and is suitably mounted in a bearing bracket 48.

Each of the scanning heads SH–3 and SH–4 is operative to emit a suitable electrical signal when each register mark R passes through the related scanned region or area G of the web in lead D. When the printed patterns on the web in lead D have the required or predetermined repeat length, the electrical signals emanating from scanning heads SH–3 and SH–4 occur simultaneously. However, in the event of deviations from the predetermined repeat length of the repetitive patterns on the web in lead D, signals issuing from scanning head SH–3 will occur either before or after the corresponding electrical pulses or signals issuing from scanning head SH–4. The electrical pulses or signals issuing from scanning heads SH–3 and SH–4 are fed through conductors 49 and 50 to a control panel CP–3 which may be of the commercially available type mentioned in connection with the control panels CP–1 and CP–2. The control panel CP–3 is operative to amplify the signals received from scanning heads SH–3 and SH–4, and to compare such signals so that any timing discrepancy produces an error signal which causes suitable energization of the reversible correction motors 35 by way of conductors 51.

If the detected distance between successive register marks R at sensing points G, G is greater than the repeat length to be maintained under the predetermined datum tension in web lead D, then control panel CP–3 appropriately energizes both reversible electric motors 35 to pivot arms 31 in the direction for extending springs 30 and thereby causing mechanisms T–1 and T–2 to increase the tension in the web runs A and C. The increased tension in web runs A and C results in instantaneous feeding of a lower volume of web through the printing units of the press and thereby decreases the repeat length of the printed patterns when the same are scanned or measured at the web lead D in which the predetermined datum tension is constantly maintained. Conversely, when scanning heads SH–3 and SH–4 detect repeat lengths of the printed patterns on the web in lead D that are shorter than the predetermined or required repeat length, motors 35 are energized to decrease the effective lengths of the springs 30 and thereby cause tension control mechanisms T–1 and T–2 to decrease the tension in web runs A and C. The decreased tension in runs A and C instantaneously causes the feeding of a relatively higher volume of web through the printing units and thereby increases the repeat lengths of the printed patterns scanned at the web lead D. Thus, the described arrangement suitably controls the tension in web runs subjected to the action of the printing units so as to maintain a predetermined repeat length of the printed patterns on the web measured under the constant datum tension in web lead D. The manner in which variations of the tension in a web run subject to the action of a printing unit, as described above, are effective to vary the repeat length of printed patterns thus formed on the web, when such repeat length is scanned or measured with the web in a relaxed condition or under a predetermined datum tension, will be apparent from the following. The repeat length of the printed pattern, as applied to the web by the printing unit, is dependent upon the circumference of the printing cylinder, and hence does not vary with changes in the tension in the web run subject to the action of the printing unit. However, when the tension in the web is thereafter relaxed or reduced, for example, to the predetermined datum tension constantly maintained in web lead D, the resulting essentially elastic contraction of the web causes a reduction of the repeat length. The extent to which the repeat length of the printed pattern on the web in the lead D, that is, under the predetermined datum tension, is shorter than the repeat length of the printed pattern as applied or formed on the web under the operating tension at the printing unit will depend upon the extent by which such operating tension, that is, the tension in the web runs A and C, is greater than the datum tension in lead D. If the tension in the web when the latter is printed is very much greater than the datum tension in lead D, then the web will undergo a relatively large elastic contraction when under the relatively smaller datum tension and the measured repeat length will be relatively small. On the other hand, if the tension in the web when the latter is subject to the action of the printing unit is reduced, the elastic contraction of the web and the reduction in the repeat length of the printed patterns on the web in the lead D will be similarly decreased and result in a relatively larger measured repeat length. Thus, as described above, variation of the repeat length of the printed patterns on the web in the lead D can be achieved by suitably varying the tensions in the web runs A and C which are subject to the action of the printing units.

Although the arrangement shown on FIG. 1 adjusts the tension in web run C as well as in web A in order to maintain a uniform or required repeat length at the web lead D, that purpose could be similarly achieved only by adjusting the tension in web run A which is subject to the action of the first printing unit P–1, without similarly adjusting the tension established in web run C by control mechanism T–2. However, if only the tension in web run A is adjusted, increased displacements of the rollers 19 of register control devices RC–1 will be required in order to achieve accurate longitudinal register of the impressions formed by printing units P–2 and P–3 with the impressions formed by the first printing unit P–1. Accordingly, the simultaneous adjustment of the tensions in web runs A and C for maintaining uniform repeat permits register control devices RC–1 and RC–2 to act more rapidly, and therefore more accurately, in achieving color to color register.

The circuitry in control panel CP–3 should preferably include suitable time delay means to allow induced changes in the web tensions in runs A and C to effect changes in the sensed repeat length of the printed patterns on the web in web lead D before causing further changes to be made in the web tensions. The controls for the printing press embodying this invention should also preferably include a main switch MS–1 having selectively engageable contacts for determining the mode of operation, that is, regulation of the repeat length under automatic controls, as described above, or under manually operated controls, and push-button control switches PB–1 having "increase" and "decrease" switches which are manually operable for altering the repeat length when the main switch MS–1 is disposed for such manual control. It is also desirable that an optical web scanning or viewing unit SC–1 be provided to permit the press operator to continually examine the printed web in the lead D, that is, prior to rewinding of the web by the roll stand RS–2. The scanning unit SC–1 may be of the reciprocating type dislosed in U.S. Patent No. 2,971,684, to W. F. Huck. If visual scanning of the printed web by means of the unit SC–1 indicates that the desired repeat length has not been achieved through automatic control of the tension in web run A or in runs A and C, then the press operator can dispose the main switch MS–1 for manual control and cor-

rect the repeat length discrepancy by manually operating the push buttons PB–1.

Referring now to FIG. 2, it will be seen that the present invention is there embodied in a multi-color gravure printing press for accurately controlling the repeat length of the repetitive patterns printed on the continuously moving web. In the relatively simple form of press illustrated, three-color printing is effected by means of three gravure units P–11, P–12 and P–13 which are respectively followed by drying ovens O–11, O–12 and O–13 and by clusters of cooling rollers CR–11, CR–12 and CR–13.

The web to be printed is unwound from a roll stand RS–11 and is acted upon by a tension control mechanism T–11 which adjustably controls the tension in the web run AA subject to the action of the first gravure unit P–11. The tension control mechanism T–11 is of the type disclosed in U. S. Patent No. 3,083,887, to W. F. Huck, and is generally similar to the previously described tension control mechanism T–1 with the exception that its floating roller 122 is biased against the web run AA by means of fluid pressure acting in a cylinder 130 against a piston 131 which is slidable in the cylinder and connected through a rod 132 to a carriage 126 carrying the floating roller and rockable about a shaft 127.

An arm 128 is rockable with carriage 126 about shaft 127 and carries a roller 129 contacting a drive belt 124 between the pulley 123 driven from main press shaft 110 and the variable diameter pulley 125. Drive rollers 120 and 121 driven from the variable diameter pulley 125 are in non-slip engagement with the web in advance of floating roller 122.

Tension in web run AA and the weight of rollers 122 and 129 and the supporting structure thereof give rise to forces tending to move roller 122 downwardly, whereas the fluid under pressure acting in cylinder 130 against piston 131 and the tension in belt 124 give rise to forces urging the floating roller in the upward direction. When the tension in run AA corresponds to the pressure of the fluid in cylinder 130, the above mentioned forces are in equilibrium. An increased tension in web run AA moves roller 122 downwardly, and such movement, in turn, causes an increase in the rotational speed of drive rollers 120 and 121 to decrease the tension in web run AA to a value corresponding to the pressure of fluid in cylinder 130. On the other hand, if the tension in web run AA is decreased, roller 122 moves upwardly and a decrease in the rotational speed of drive rollers 120 and 121 results to restore the tension in web run AA to the value corresponding to the pressure of fluid acting in the cylinder.

The tension in the web run DD extending from cooling rollers CR–13 associated with the last gravure or printing unit P–13 is controlled by a tension control mechanism T–12 which is similar in construction and operation to the mechanism T–11 with the exception that the web run DD first runs over floating roller 122 of mechanism T–12 and then around drive rollers 120 and 121 of the latter. Further, the roller 129 of mechanism T–12 contacts the inside of the upper run of belt 124 to decrease the speed of drive rollers 120 and 121 upon downward movement of floating roller 122 by an increased tension, and conversely, to increase the speed of rollers 120 and 121 when a decreased tension in web run DD permits upward movement of floating roller 122.

Longitudinal register control mechanisms RC–11 and RC–12 act on the web between printing units P–11 and P–12 and between printing units P–12 and P–13, respectively. Further, web tensioning rollers TR–11 and TR–12 act on the web in advance of the register control mechanisms RC–11 and RC–12, respectively. Each of the register control mechanisms RC–11 and RC–12 is preferably of the displaceable carriage type, as disclosed in detail in the copending U.S. patent application Ser. No. 287,622, by W. F. Huck, and includes a carriage 52 displaceable about a pivot 53 and rotatably supporting drive rollers 54 and 55 which are in non-slip engagement with the web. The roller 55 is driven from the roller 54 by suitable gearing (not shown), and the drive roller 54 is rotatably coupled to a variable diameter pulley 56 driven by a belt 57 from a pulley 58. The variable diameter pulley may be of the type disclosed in U.S. Patent No. 2,812,666, to W. F. Huck. The pulley 58 is suitably driven from the main press shaft 110 and is mounted for rotation about a fixed axis, whereas the axis of the pulley 56 is movable toward and away from the axis of pulley 58 in response to rocking of carriage 52 about its pivot 53. The carriage 52 has an arm 59 pivotally carrying a nut 60 engaged by an adjustment screw 61 which is coupled to the shaft of a reversible correction motor 62.

Associated with the described register control mechanism RC–11 are a scanning head SH–11, a selector switch SS–11, and a control panel CP–11 receiving electrical impulses or signals from the scanning head and selector switch through conductors 112 and 113. The scanning lead SH–11 emits electrical pulses or signals in response to the movement of the register marks R with the web over a guide roller 63 located between the related register control mechanism and the next printing unit P–12. The selector switch SS–11 is driven from the printing unit P–12 to emit electrical pulses or signals simultaneously with the pulses or signals emanating from scanning head SH–11 when the impressions formed by printing unit P–11 are in correct longitudinal register with the impression cylinder of printing unit P–12. However, in the event of a register error, the timing discrepancy between the signals from scanning head SH–11 and selector switch SS–11 causes control panel CP–11 to suitably energize correction motor 62 for displacing carriage 52 about its pivot 53. Such displacement of carriage 52 causes similar displacement of the driving rollers 54 and 55 which has the effect of varying the stretch of the web lead CC extending from rollers 54 and 55 to printing unit P–12. It will also be seen that the described displacement of carriage 52 and rollers 54 and 55 in response to actuation of the motor 62 will vary the tension of belt 57, and thereby vary the belt contacting radius of the pulley 58 so as to change the speed of the drive belt for similarly varying the rotational speed of drive rollers 54 and 55 relative to that of the next printing unit. Specifically, movement of rollers 54 and 55 toward printing unit P–12 increase the rotational speed of rollers 54 and 55, and movement of rollers 54 and 55 away from printing unit P–12 decreases their rotational speed. Thus, the effects of the bodily movement and the simultaneous speed variation of rollers 54 and 55 are additive, so that there is a dual effect upon the stretch of the web lead CC extending from these rollers to the next printing unit P–12.

As shown, the register control mechanism RC–12 similarly has a scanning head SH–12, a selector switch SS–12 and a control panel CP–12 associated therewith to sense any register errors between the impressions or register marks R formed at the first printing unit P–11 and the impression cylinder of the last printing unit P–13, and to suitably operate the mechanism RC–12 for correcting such errors.

If the signals from the scanning head SH–11 or SH–12 lag behind those from the related selector switch SS–11 or SS–12, indicating that the register marks formed on the web at printing unit P–11 are lagging behind the required register position with respect to the gravure or impression cylinder of the next printing unit P–12 or P–13, the motor 62 of the register control mechanism RC–11 or RC–12 is operated in the direction to pivot the related carriage 52 in the clockwise direction, as viewed on FIG. 2, so that the rollers 54 and 55 are moved toward the next printing unit P–12 or P–13 to displace the web portion engaged by them toward the next printing unit and to simultaneously increase the rotational speed of the drive rollers 54 and 55. As a result, the stretch of the web lead CC will be reduced to move the register marks on

the web directly to their position of correct register with the gravure cylinder of the printing unit P–12 or P–13. If the signals from the scanning head SH–11 or SH–12 are ahead of those from the switch SS–11 or SS–12, indicating that the scanned register marks on the web are ahead of the required register position with respect to the gravure cylinder of the next printing unit, then motor 62 is operated to rock carriage 52 in the counterclockwise direction, thus displacing rollers 54 and 55 and the web portion engaging them in the direction away from the gravure cylinder of the next printing unit and simultaneously decreasing the speed of drive rollers 54 and 55 so as to increase the stretch in web lead CC for restoring the correct register.

Any displacement of the drive rollers 54 and 55 of course tends also to vary the tension in the web lead BB extending from the preceding printing unit to the drive rollers, but such a variation is prevented by the web tensioning roller TR–11 or TR–12 preceding the register control mechanism RC–11 or RC–12. As seen, each of the web tensioning rollers TR–11 and TR–12 is rotatably mounted in a carriage 64 which is rockable on a shaft 65 and connected to a rod 66 extending from a piston 67 slidable in a cylinder 68. Each web tensioning roller TR–11 or TR–12 is urged upwardly by the pressure of fluid supplied to the related cylinder 68, while the tension in the engaged web run BB urges the web tensioning roller in the downward direction. It will be apparent that the tension in each web run BB will always be determined by the pressure of fluid acting in the related cylinder 68.

In the embodiment of the invention shown on FIG. 2, the predetermined constant datum tension is constantly maintained in a web lead EE which extends between the tension control mechanism TR–12 and a further tension control mechanism TR–13 acting on the web in advance of the rewind roll stand RS–12. The web lead EE runs successively under guide rollers 136, 137 and 138 and, intermediate the rollers 137 and 138, is looped over the floating sensing roller 122*a* of tension control mechanism T–13. The mechanism T–13 further includes drive rollers 120*a* and 121*a* around which the web travels in a serpentine manner between guide roller 138 and the rewind roll stand. A pulley 123*a* is suitably driven from main press shaft 110 and engages a belt 124*a* which drives a variable diameter pulley 125*a* coupled to drive roller 121*a* which is geared to the other drive roller 120*a*. The floating roller 122*a* is rotatably mounted at one end of a carriage 126*a* rockable on a shaft 127*a*. A link 139 pivotally connects carriage 126*a* to an arm 128*a* which is pivoted at 140 and carries a roller 129*a* in contact with belt 124*a*. A cylinder 130*a* has a piston 131*a* slidable therein and connected through a rod 132*a* to the rockable carriage 126*a*.

It will be apparent that the tension control mechanism T–13 operates substantially in the same manner as the tension control mechanism T–3 described with reference to FIG. 1, with the exception that the predetermined datum tension continuously maintained in the web lead EE is dependent upon the pressure of the fluid supplied to the cylinder 130*a*.

In order to detect deviations from a predetermined repeat length of the repetitive patterns on the web in lead EE, scanning heads SH–13 and SH–14 are suitably mounted adjacent guide rollers 136 and 137 to scan areas G, G of the web which are spaced apart by a distance along the web lead EE that is a whole multiple of the predetermined or desired repeat length. As in the previously described embodiment, the scanning head SH–13 may be mounted on a bracket 142 turnable about the axis of the adjacent guide roller 136 to move the scanned region of the web circumferentially about the guide roller, and thereby either increase or decrease the distance along the web between the regions or areas scanned by the two heads. The bracket 142 may have a pointer 143 cooperating with a fixed scale 144 to indicate the magnitude of the repeat length which is to be maintained.

The electrical signals emitted by the scanning heads SH–13 and SH–14 are fed through conductors 149 and 150 to a control panel CP–13 which may also be of the commercially available type mentioned in connection with control panels CP–1 and CP–2 on FIG. 1. The control panel CP–13 is operative to amplify the signals received from the associated scanning heads and to compare such signals so that a timing discrepancy produces an error signal which actuates a regulating mechanism M for adjusting a valve V and thereby varying the pressure of the fluid fed through a supply pipe 69 and a branch pipe 70 to the cylinder 130 of the tension control mechanism T–11. Thus, in the event of deviations from the predetermined repeat length of the repetitive patterns on the web in lead EE, suitable adjustment is made of the tension in at least the web run AA subject to the action of the first printing unit P–11 for restoring the predetermined repeat length at lead EE, as previously described with respect to the embodiment of FIG. 1.

The controls for the printing press of FIG. 2 may also include a main switch MS–11 for determining the mode of operation, that is, manual or automatic control, and push-button control switches PB–11 which, when the main switch MS–11 is set for manual control, may be selectively actuated for either increasing or decreasing the repeat length of the repetitive patterns on the web in run EE. As in the previously described embodiment, an optical web scanning or viewing unit SC–11 is also provided to permit the operator of the press to check the effectiveness of the control of repeat length.

Referring to FIGS. 4 and 5, it will be seen that the regulating mechanism or unit M for actuating the valve V may include a housing 71 having a shaft 72 journalled therein, with one end of shaft 72 extending out of the housing and having a coupling 73 secured thereto and engaging the adjusting wheel 74 on the stem of reduction valve V. Ratchet wheels 75*a* and 75*b* are secured on shaft 72 and have their peripheral teeth raked in opposite directions. Levers 76*a* and 76*b* are rockably mounted on shaft 72 adjacent ratchet wheels 75*a* and 75*b*, respectively. Pawls 77*a* and 77*b* are pivoted on levers 76*a* and 76*b*, respectively, and are urged into engagement with the peripheral teeth of ratchet wheels 75*a* and 75*b*, respectively, by means of springs 78*a* and 78*b* (FIG. 5). Levers 76*a* and 76*b* are connected, as by links 79*a* and 79*b*, to the armatures of solenoids 80*a* and 80*b*, respectively. Springs 81*a* and 81*b* are also connected to levers 76*a* and 76*b*, respectively, and urge the levers to turn in opposite directions tending to extend the armatures of solenoids 80*a* and 80*b*. Angle members 82*a* and 82*b* extend from housing 71 and are engageable by levers 76*a* and 76*b* to stop or limit the turning of the levers by springs 81*a* and 81*b*. The angle members or stops 82*a* and 82*b* are also preferably engageable with the pawls 77*a* and 77*b* to rock the latter out of engagement with the respective ratchet wheels when the levers are in their extreme, spring urged positions against stops 82*a* and 82*b*.

The coils of solenoids 80*a* and 80*b* are connected by conductors 83*a* and 83*b* to the control panel CP–13 so as to be selectively energized by signals received from the control panel when a deviation from the predetermined repeat length is sensed by scanning heads SH–13 and SH–14. During each energization of solenoid 80*a*, lever 76*a* is moved away from stop 82*a* to permit engagement of pawl 77*a* with ratchet wheel 75*a* and to effect turning of shaft 72 through a predetermined angle in the counterclockwise direction, as viewed on FIG. 5. On the other hand, each energization of solenoid 80*b* effects turning of shaft 72 through a predetermined angle in the clockwise direction. Thus, the selective energization of the solenoids 80*a* and 80*b* causes incremental turning of the adjusting wheel 74 of reduction valve V for either increasing or decreasing the pressure of fluid supplied through line 69.

The incremental turning of the adjusting wheel of valve V, and the corresponding incremental change in the pressure acting in cylinder **130** of tension control mechanism T–**11**, provides small increments of web tension adjustment in the run AA. The described arrangement inherently provides a time delay between successive increments of turning of the adjusting wheel of the valve to permit the effect of a tension adjustment at the run AA to be sensed at the lead EE prior to the further adjustment of the fluid pressure for effecting additional adjustment of tension.

Since the cumulative effect of repeated adjustments of the tension in web run AA could result in a loose web or breakage of the web in extreme cases, maximum limits for turning of shaft **72** in both directions are established, for example, by forming teeth on only portions of the ratchet wheels **75***a* and **75***b*.

Fluid under pressure may be supplied to the cylinder **130** of tension control mechanism T–**12** and to the cylinder **130***a* of tension control mechanism T–**13** by way of branch lines **170** and **170***a*, respectively, extending from a supply pipe **169** which has a manually controlled reduction valve V–**2** interposed therein. The valve V–**2** can be manipulated to adjust the pressure of the fluid acting in cylinder **130***a*, and hence the predetermined dataum pressure that is continuously maintained in web lead EE at which the repeat length is sensed or scanned. Where cylinder **130** of tension control mechanism T–**12** also receives its fluid under pressure from pipe **169**, the mechanism T–**12** operates to maintain a constant tension in the web run DD. However, as in the first described embodiment of this invention, the tension in web run DD on FIG. 2 may also be adjusted in response to the detection of deviations from the required repeat length, thereby to minimize the necessary movements of the carriages **52** of register control mechanisms RC–**11** and RC–**12**, and avoid any loss of correct register. Where it is desired to adjust the tension in run DD, as well as in run AA, fluid under pressure is supplied to the cylinder **130** of tension control mechanism T–**12** by way of a branch **170′** extending from the supply pipe **69**, as shown in broken lines on FIG. 2, rather than from the supply pipe **169**.

The embodiment of FIG. 2 further illustrates the possibility of adjusting the tension in a run of the web subject to the action of a printing unit, thereby to restore the desired repeat length at the web lead EE, by means of varying the pressure exerted on the web by the printing couple of one or more of the printing units. More specifically, it will be seen that the printing units P–**11**, P–**12** and P–**13** of the press illustrated on FIG. 2 include inked printing cylinders I–**11**, I–**12** and I–**13**, and elastic pressure rollers L–**11**, L–**12** and L–**13**, respectively, which are urged downwardly to press the web against the related printing cylinders. The pressure on the web between the elastic pressure rollers and the printing cylinders in the several printing units is dependent on the pressure of fluid supplied to cylinders CY–**11**, CY–**12** and CY–**13** having pistons slidable therein and suitably connected to impression cylinders by which the pressure rollers L–**11**, L–**12** and L–**13** are urged downwardly toward the respective printing cylinders. Fluid under pressure may be supplied to the cylinders CY–**11**, CY–**12** and CY–**13** by way of branches **84** extending from supply pipe **69**.

As may be seen, for example, in ASME Paper No. 61–SA–67, "On the Kinematics of Rubber-Covered Cylinders Rolling on a Hard Surface" (1961), by Dr. G. N. Sandor, it is well known that under conditions as described in that paper an increase of pressure between the elastic pressure rollers and the printing cylinders of a gravure printing press tends to cause a localized tension increase in the web and a corresponding reduction in the volume of the web passing through the impression. Hence, such a pressure increase tends to decrease the repeat length of the impressions thus formed when the impressions are measured with the web in a relaxed condition.

In the arrangement shown, fluid under pressure is also supplied from pipe **69** through branches **85** to the cylinders **68** which bias the tensioning rollers TR–**11** and TR–**12** against the web for determining the tension in the runs BB of the web. The action is similar to that described above in reference to branch **70** of pipe **69**, cylinder **130** and web run AA.

The embodiment of the invention shown on FIG. 2 operates as follows:

Scanning by heads SH–**13** and SH–**14** of repeat lengths which are larger than the predetermined repeat length to be maintained for the printed patterns on the web in lead EE causes the regulating device M to effect adjustment of the valve V in the direction for increasing the pressure of the fluid supplied through pipe **69**. The increased pressure of the fluid in pipe **69** acts through branch **70** in cylinder **130** of tension control mechanism T–**11** to increase the tension in web run AA and thereby reduce the repeat length of the repetitive printed patterns, as scanned in web lead EE. The increased fluid pressure also acts through branches **84** in cylinders CY–**11**, CY–**12** and CY–**13**, and thereby also tends to decrease the repeat length as measured at the lead EE.

Conversely, the sensing of repeat lengths that are shorter than the predetermined repeat length to be maintained for the printed patterns on the web in lead EE causes a fluid pressure reduction in supply pipe **69**. Such reduced fluid pressure causes tension control mechanism T–**11** to reduce the tension in web run AA, and the pressure of each printing couple on the web therebetween is similarly reduced. The reductions in web tension in run AA and the reduction of the pressure of the printing couples on the web combine to cause an increase in the repeat lengths when sensed at the web lead EE.

The effect previously described, namely, that increased pressure in a gravure printing unit tends to decrease the repeat length, is based on the assumption that the elastic pressure roller has a solid, homogeneous, volumetrically incompressible, elastic covering. Under certain circumstances the characteristics of the covering on the pressure roller may be altered so as to reverse the previously described pressure, effect, that is, so that an increase in printing pressure would tend to increase repeat length. Such a reversal of the pressure effect may be obtained with a pressure roller provided with a sponge rubber or other soft inner layer covered by a hard rubber or other relatively hard, inelastic outer layer. When the reversed effect is obtained, it can be utilized according to the invention by connecting the conduits **84** to the rod ends rather than the heads of the fluid pressure cylinders CY–**11**, CY–**12**, etc. and applying the main source of impression pressure separately to the heads of these cylinders.

Although both variations of the tension in web run AA and the variation of the pressure of the printing units on the web are used in the arrangement of FIG. 2 for combined action in correcting for repeat length errors or deviations, it is to be understood that either control of web tension in the run AA or control of the pressure exerted by the printing units on the web can be separately employed for effecting the necessary corrections in repeat length.

Where both the tension in web run AA and the pressure of the printing units are controlled for restoring the repeat length to desired distances along the web in lead EE, the fluid under pressure fed to the cylinder **130** of tension control mechanism T–**11** and to the cylinders CY–**11**, CY–**12** and CY–**13** of the printing units may come from a single supply pipe **69** under the control of the valve V. The necessary proportioning of the forces exerted by the tensioning roller **122** and by the pressure rollers L–**11**, L–**12** and L–**13** can then be obtained merely by suitable dimensioning of the cylinders for performing each function.

However, from a practical point of view, it is desirable that pneumatic pressure act in the cylinders **130** and **68**

of the tension control mechanisms, and that hydraulic fluid of substantially higher pressure act in the cylinders CY–11, CY–12 and CY–13, with both the pneumatic and hydraulic pressures being suitably varied in response to the sensing of deviations of repeat length from the desired value so as to tend to restore such predetermined or desired repeat length. As shown on FIG. 6, hydraulic fluid under pressure may be supplied to the cylinders CY–11, CY–12 and CY–13 through a supply pipe **184** having a reduction valve V–3 therein, and which is separate from the pipe **69** through which air under pressure is supplied by cylinders **130** and **68** of the tension control mechanisms under the control of valve V. Where two valves are to be actuated from regulating unit M, the coupling **73** connecting the shaft **72** of regulating device M to valve V may be further provided with a pulley **86** connected through an endless belt **87** with a pulley **88** fixed to the stem of valve V–3. With the arrangement shown on FIG. 6, the pulleys **86** and **88** may be dimensioned so that a predetermined angular displacement of shaft **72** produces a corresponding adjustment of the valve V and a greater angular displacement or adjustment of the valve V–3. Thus in response to deviation from the desired repeat length different changes can be effected in the pressure of the fluid fed to the cylinders **130** and **68** of the tension control mechanisms and in the pressure of the fluid fed to cylinders CY–11, CSY–12 and CY–13 for producing the pressure of the printing units on the web.

Referring now to FIG. 3, it will be seen that a modification is there shown of the means by which the distance along the web lead EE between the scanned areas G, G can be adjusted for varying the repeat length which is to be maintained. In the arrangement of FIG. 3, the scanning heads SH–13 and SH–14 are both fixedly positioned adjacent the guide rollers **136** and **137**. The web lead EE runs under additional guide rollers **89** and **90** which are spaced apart intermediate guide rollers **136** and **137**. Further, web lead EE is looped over an adjustable roller **91** between the guide rollers **89** and **90**. The adjustable guide roller **91** is rotatably mounted in a carriage **92** which is pivoted for rocking about a shaft **93**. The carriage **92** has an arm **94** carrying a pivoted nut **96** which is engaged by an adjustment screw **97** provided with a manually turnable knob **98**. Turning of adjustment screw **97** effects angular displacement of carriage **92** to raise or lower adjustable roller **91** and thereby vary the length along web lead EE between the sensing areas G, G. A scale and pointer **99** are provided for indicating the position of carriage **92**, and hence the predetermined repeat length for which the adjustable roller **91** has been set. It will be understood that the modification illustrated on FIG. 3 may be employed in either the arrangement of FIG. 2 or that of FIG. 1.

In each of the previously described embodiments, the web lead D (FIG. 1) or EE (FIG. 2) in which a predetermined datum tension is constantly maintained has extended beyond the last printing unit P–3 or P–13 of the press. However, it is not necessary that the web lead at which the repeat lengths are scanned be arranged beyond the last printing unit in a multi-color press. For example, in the multicolor gravure printing press shown in part on FIG. 7, and which is generally similar to that of FIG. 2 and has its several parts identified by the same reference numerals, the predetermined constant datum tension is constantly maintained in a web lead E' E' which extends between the cooling rollers CR–11 of the first printing unit P–11 and the register control mechanism RC–11 which is operative to effect longitudinal registration of the impressions formed by the first printing unit P–11 and with the printing cylinder of the second printing unit P–12. The web lead E'E' has the predetermined constant datum tension continuously maintained therein by means of a floating tensioning roller TR–11' which is rotatably mounted in a carriage **64'** pivoted at **65'** and urged upwardly by fluid under pressure supplied through a line **85'** to a cylinder **68'** having a piston **67'** slidable therein and connected to the pivoted carriage **64'**. The line or branch pipe **85'** may be connected to a source of constant pressure, for example, the supply pipe **169** of FIG. 2, so that the roller TR–11' is biased against the web lead E'E' with a constant force corresponding to the desired or predetermined datum tension.

Since the predetermined datum tenison is maintained in the web lead E'E' between printing unit P–11 and the following register control mechanism RC–11, it is apparent that the tension control mechanism TR–13 of FIG. 2 can be eliminated from the arrangement of FIG. 7.

The sensing heads SH–13 and SH–14 are spaced apart along web lead E'E' so that the distance between their sensing areas G, G is a whole multiple of the predetermined or desired repeat length. The distance along the web between the sensing areas G on FIG. 7 may be adjusted by providing arrangements for that purpose similar to those described above with reference to FIGS. 1, 2 and 3.

As in the embodiment of FIG. 2, sensing by heads SH–13 and SH–14 of deviations from the predetermined repeat length causes control panel CP–13 to actuate a regulating unit (not shown), which may be similar to the unit M of FIGS. 4 and 5, for suitably increasing or decreasing the pressure of the fluid applied to the cylinders CY–11, CY–12, etc. by which the pressure of the printing units on the web in the several printing units is regulated for tending to restore the predetermined repeat length. The adjustment of the fluid pressure by the regulating unit may also serve to suitably adjust the tension in the web run AA subject to the action of the first printing unit, for example, by providing a tension control mechanism in advance of the first printing unit that is similar to the tension control mechanism T–11 of FIG. 2. However, in the embodiment of FIG. 7, such tension control mechanism T–11 is replaced by a mechanism **200** which operates in conjunction with a web tensioning roller TR–13 engaging the web between the unwind roll stand RS–11 and the mechanism **200**.

The mechanism **200** includes a web engaging roller **201** rotatably mounted in a carriage **202** that is rockable about a shaft **203**. The carriage **202** further carries a pivoted nut **204** engaged by a screw **205** which is coupled to the shaft of a reversible correction motor **206** so that operation of the motor is effective to rock carriage **202**. An arm **207** is rockable with carriage **202** about shaft **203** and carries a roller engaging a run of a drive belt between a pulley **210** which is suitably driven from the main press shaft **110** and a variable diameter pulley **211**. The mechanism **200** further includes drive rollers **212** and **213** around which the web runs in a serpentine manner in advance of roller **201**. Drive roller **212** is driven from pulley **211**, and drive roller **213** is driven from roller **212** by suitable gears (not shown). The correction motor **205** is suitably connected to control panel CP–13 so as to be suitably energized when scanning heads SH–13 and SH–14 sense deviations from the desired repeat length of the printed patterns on the web in lead E'E'.

The tensioning roller TR–13 is rotatably mounted in a carriage **64** which is pivoted, as at **65**, and connected to a piston **67** slidable in a cylinder **68**. Fluid under a normally constant pressure is supplied to cylinder **68** through a branch pipe **70'** which may extend from the supply pipe **169** of FIG. 2.

When scanning heads SH–13 and SH–14 sense repeat lengths greater than the predetermined repeat length desired for the repetitive patterns on the web in lead E'E' under the constantly maintained datum tension established by tenisoning roller TR–11', the resulting error signals from control panel CP–13 to the motor **206** cause upward rocking movement of carriage **202** and the corresponding movement of roller **201** causes an in-

creased tension in web run AA subject to the action of the first printing unit P–11. The upward rocking movement of carriage 202 causes similar movement of roller 208 to relax or looesn belt 209, thereby to increase the belt pitch radius of the variable diameter pulley 211 for decreasing the rotational speed of drive rollers 212 and 213 and thereby applying increased tension to the web in run AA. The tension increasing effects of the movement of roller 201 and the speed reduction of drive rollers 212 and 213 combine to reduce the repeat length sensed at the lead E'E'.

Conversely, when the repeat length sensed at lead E'E' is less than the predetermined repeat length to be maintained, the resulting signals to motor 206 cause downward movement of roller 201 for reducing the tension in web run AA, and also downward movement of the roller 208 for increasing the tension in drive belt 209 and, accordingly, decreasing the belt pitch radius of pulley 211. Thus, the rotational speed of drive rollers 212 and 213 is increased to also reduce the tension in web run AA, and such tension reduction combines with the tension reduction resulting from downward displacement of roller 201 to increase the repeat length sensed at the web lead EE.

Although the arrangement illustrated in FIG. 7 has the web lead E'E' in which the predetermined datum tension is constantly maintained located between the first printing unit P–11 and the register control mechanism RC–11 in advance of the second printing unit P–12, so that correction of the repeat length is made on the basis of scanning of the impressions formed only by the first printing unit, such relocation of the web lead E'E' does not cause any deficiency in the effectiveness of the repeat length control. In all of the described embodiments of the invention, the magnitude of the repeat length is determined by the first printing unit and the subsequent register control mechanisms RC–1 and RC–2 or RC–11 and RC–12 then function to register the impressions formed by the first printing unit with respect to the subsequent printing units P–2 and P–3 or P–12 and P–13. The arrangement shown on FIG. 7 has the advantage, for example over that illustrated on FIG. 1 or on FIG. 2, of substantially reducing the need for a time delay between successive changes of the tension in the web run AA when deviations from the predetermined repeat length are sensed at the web lead E'E'. In FIGS. 1 and 2, the necessity for a time delay means in the control panel CP–3 or CP–13 results from the fact that a correction in the repeat length resulting from a change in the tension in web run AA is only sensed at the web lead D or EE after the period of time required for the web to run through all of the printing units of the press. On the other hand, in the arrangement of FIG. 7, a correction of repeat length resulting from a change in the tension in web run AA is almost immediately detected at the web lead E'E' which immediately follows the first printing unit P–11.

In some installations according to the present invention, as where the most accurate repeat length control is required, it will be advantageous to include a web preconditioning unit in the processing machine. Such a unit, which would preferably be located between the unwind roll stand RS–1 or RS–11 and the first web tension control mechanism T–1 or T-11, may consist of a web heater serving to heat the web to a constant moderate temperature sufficient to eliminate residual stresses in the unwound web and ensure that it will have a definite or standard moisture content during the subsequent processing operations.

The invention has been described with reference to its specific application to printing presses for ensuring a uniform or predetermined repeat length of the repetitive printed patterns when the tension in the web is relaxed or when the web is under a uniform tension, however, it will be apparent that the invention can be similarly applied to the attainment of uniform, desired repeat lengths of other repetitive patterns formed on a continuously moving web, for example, in perforating or embossing machines.

Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a machine having a rotary means for forming repetitive patterns on a continuously moving web, the combination of

tension control means for controlling the tension in a run of the web subject to the action of said rotary means,

means operative to maintain constantly a predetermined constant datum tension in a lead of said web beyond said web run,

scanning means detecting deviations from a predetermined repeat length of the repetitive patterns on the web in said lead under said constant datum tension, and

correction means acting upon said tension control means, in response to the detection by said scanning means of a deviation from said repeat length, to adjust the tension of the web in said run in the sense for restoring said predetermined repeat length in said web lead.

2. A machine according to claim 1; wherein said scanning means includes two sensors spaced apart by a distance along said lead of the web which is a whole multiple of said predetermined repeat length.

3. A machine according to claim 2; further comprising means for adjusting said distance between said sensors, thereby to adapt them to a change of said predetermined repeat length.

4. A machine according to claim 3; wherein said means for adjusting said distance includes a movable mount for at least one of said sensors to permit displacement of the latter along said web lead.

5. A machine according to claim 3; wherein said means for adjusting said distance includes roller means engaging the web in said lead between said sensors and establishing the path of said lead, and means for displacing said roller means and thereby altering the length of said path.

6. A machine according to claim 1; wherein said tension control means acts on the web in advance of said rotary means.

7. A machine according to claim 1; wherein said tension control means includes a first mechanism acting on the web in advance of said rotary means and a second mechanism acting on the web between said rotary means and said web lead, said first and second mechanisms being operative jointly for restoring of said predetermined repeat length in said web lead by tension adjustments in the web in advance of said rotary means and in the web between said rotary means and said web lead.

8. A machine according to claim 7; wherein said tension control means further includes means for regulating the pressure of said rotary means on said web.

9. A machine according to claim 1; wherein said tension control means includes means for regulating the pressure of said rotary means on said web.

10. A machine according to claim 1; wherein said rotary means includes a plurality of rotary press units acting successively on the web in advance of said web lead for forming respective portions of each repetitive pattern; and

further comprising register control means including rotary web drives driven in synchronism with said

rotary means and acting on the web between the successive units for maintaining accurate register of the portions of the repetitive patterns respectively formed by said rotary press units.

11. A machine according to claim **10**; wherein said tension control means includes means acting on the web in advance of the first of said press units of the rotary means acting on the web and also means acting on the web between the last of said press units of the rotary means acting on the web and said web lead so that restoring of said predetermined repeat length in said web lead is accomplished with minimum disturbance of registration of the portions of the repetitive patterns formed by said press units.

12. A machine according to claim **10**; wherein said tension control means further includes a tension control device acting on the web between each of said rotary web drives and the preceding press unit of said rotary means.

13. A machine according to claim **1**; wherein said rotary means includes a plurality of rotary press units acting successively on the web to form respective portions of each repetitive pattern, said tension control means acts on the web in advance of the first of said press units, and said lead of the web in which the predetermined constant datum tension is maintained is located between said first press unit and a following press unit of said rotary means.

14. A machine according to claim **13**; further comprising register control means acting on the web between said web lead and said following press unit to maintain accurate register of the portions of the repetitive patterns respectively formed by said first press unit and said following press unit.

15. A machine according to claim **1**; wherein said tension control means includes at least a first tension control mechanism comprising

drive rollers engaging the web in advance of said rotary means to drive the web in a non-slip manner,

means for diving said rollers including a drive belt and having a drive ratio which is varied by changing the tension in said belt,

a floating roller engaging the web between said drive rollers and said rotary means,

means biasing said floating roller against the web with a force that is varied by said correction means, and

means responsive to displacements of said floating roller to change the tension in said drive belt, and thereby change the speed at which said drive rollers are driven, in the sense for achieving equilibrium between said force and the effect on said floating roller of the tension in the web engaged by the floating roller.

16. A machine according to claim **15**; wherein said means biasing the floating roller against the web includes a spring, and motor means connected to said spring to vary the force applied by said spring; and

wherein said correction means controls the operation of said motor means.

17. A machine according to claim **15**; wherein said means biasing the floating roller against the web includes a piston movable in a cylinder, and means for supplying fluid under pressure to said cylinder; and

wherein said correction means is operative to vary said pressure of the fluid supplied to said cylinder.

18. A machine according to claim **17**; wherein said tension control means further includes fluid pressure actuated means pressing said rotary means against said web, and means for supplying fluid under pressure to said pressure actuated means; and

wherein said correction means is also operative to vary said pressure of the fluid supplied to said pressure actuated means.

19. In a printing press, the combination of

means for continuously unwinding a web from a supply roll thereof,

a plurality of rotary printing units acting in succession on the web to print respective portions of repetitive printed patterns thereon,

tension control means for controlling the tension in a run of the web subject to the action of at least the first of said printing units,

register control means acting on the web between each of said printing units and the next printing unit to maintain register of the portions of each printed pattern printed on the web by the respective units,

means operative to maintain constantly a predetermined constant datum tension in a lead of the web beyond said web run,

two scanning devices spaced apart along said web lead by a distance equal to a whole multiple of a predetermined repeat length of the printed patterns on the web in said lead and being operative to detect deviations from said repeat length in said lead under said constant datum tension, and

correction means acting upon said tension control means, in response to the detection by said scanning devices of a deviation from said repeat length, to adjust the tension of the web in said run in the sense for restoring said predetermined repeat length in said web lead.

20. A printing press according to claim **19**; wherein said tension control means comprises first and second web tensioning mechanisms having floating rollers respectively engaging the web between said supply roll and said first printing unit and between the last printing unit and said web lead, each of said web tensioning mechanisms further including force applying means biasing the respective floating roller against the web to establish a corresponding tension in the web, propelling means driving the web at a variable speed and means varying the speed at which said propelling means drives the web in response to displacement of said floating roller when the tension in the web fails to correspond to the force biasing the floating roller thereagainst; and

wherein said correction means is operative to vary said force biasing the floating roller of at least said first web tensioning mechanism.

21. A printing press according to claim **20**; wherein said force applying means of each tensioning mechanism includes a spring, and motor means controlled by said correction means for varying the operating length of said spring and, hence, the force applied by the spring for biasing the related floating roller.

22. A printing press according to claim **20**; wherein said force applying means of each tensioning mechanism includes a piston movable in a cylinder, and means for supplying fluid under pressure to said cylinder; and

wherein said correction means includes valve means interposed in said fluid supplying means and being actuated in response to detection of deviations from said repeat length to vary the pressure of the fluid supplied to said cylinder.

23. A printing press as in claim **22**; wherein said tension control means further comprises pistons movable in cylinders which receive fluid under pressure from said fluid supplying means and press said printing units upon the web with a pressure that is varied in response to the detection of deviations from said repeat length.

24. A printing press as in claim **23**; wherein said valve means includes a first valve controlling the pressure of fluid supplied to said cylinder of the force applying means of each tensioning mechanism and a second valve controlling the pressure of fluid supplied to said cylinders for pressing the printing units upon the web; and

wherein said correction means further has means causing different actuation of said first and second valves

in response to the detection of deviations from said repeat length.

25. A printing press as in claim 22; wherein said correction means includes a turnable shaft coupled to said valve means to actuate the latter, two pawl and ratchet mechanisms connected to said shaft and respectively operative to turn the latter in opposite directions, and means selectively operating said pawl and ratchet mechanisms in response to the detection of deviations from said repeat length.

26. A printing press as in claim 25; wherein said tension control means further comprises pistons movable in cylinders which receive fluid under pressure from said fluid supplying means and press said printing units upon the web, said valve means includes a first valve controlling the pressure of fluid supplied to said cylinder of the force applying means of each tensioning mechanism and a second valve controlling the pressure of fluid supplied to said cylinders for pressing the printing units upon the web, and said first and second valves are coupled to said shaft so as to undergo different adjustments upon turning of the latter.

27. A printing press according to claim 19; wherein said tension control means acts on the web between said supply roll and the first of said rotary printing units, and said lead of the web under said constant datum tension extends between said first printing unit and said register control means which acts on the web between said first printing unit and the next printing unit.

28. In a machine having fluid pressure operated regulating means for adjusting the repeat length of repetitive patterns formed on a continuously moving web, the combination of

scanning means detecting deviations from a predetermined repeat length of the repetitive patterns formed on the web,

valve means for controlling the pressure of fluid fed to said regulating means for adjusting the repeat length,

a turnable shaft coupled to said valve means to actuate the latter,

two pawl and ratchet mechanisms connected to said shaft and respectively operative to turn the shaft in opposite directions, and

means responsive to the detection by said scanning means of deviations from said predetermined repeat length to selectively operate said pawl and ratchet mechanisms for turning said shaft in the sense causing said valve means to alter the pressure of fluid to the extent necessary for restoring said predetermined repeat length.

29. In the method of forming repetitive patterns on a continuously moving web by the action of rotary pattern forming means on the web, the steps of

controlling the tension in a run of the web subject to the action of said rotary means,

maintaining constantly a predetermined constant datum tension in a lead of the web beyond said web run,

detecting deviations from a predetermined repeat length of the repetitive patterns on the web in said lead under said constant datum tension, and

in response to the detection of a deviation from said repeat length, adjusting the controlled tension of the web in said run in the sense for restoring said predetermined repeat length in said web lead.

30. A method of regulating the repeat length of repetitive patterns formed on a continuously moving web, comprising the steps of

maintaining constantly a predetermined constant datum tension in a lead of the web having repetitive patterns thereon,

detecting deviations from a predetermined repeat length of the repetitive patterns on the web in said web lead under said constant datum tension, and

in response to the detection of a deviation from said predetermined repeat length, adjusting the tension in a run of the web on which the repetitive patterns are being formed in the sense for restoring said predetermined repeat length in said web lead.

References Cited

UNITED STATES PATENTS

2,500,230	3/1950	Bailey et al.	101—181
2,897,754	8/1959	Spiller et al.	101—180
3,025,791	3/1962	Auerbacher	101—181
3,120,181	2/1964	Thiede	101—181

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