United States Patent

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[54] **WEB-FED ROTARY PRINTING PRESS**
18 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **101/153,** 101/228; 226/143
[51] **Int. Cl.** **B41f 9/00,** B41f 13/54, B65h 17/26
[50] **Field of Search** ..... 101/153, 219—228; 226/143

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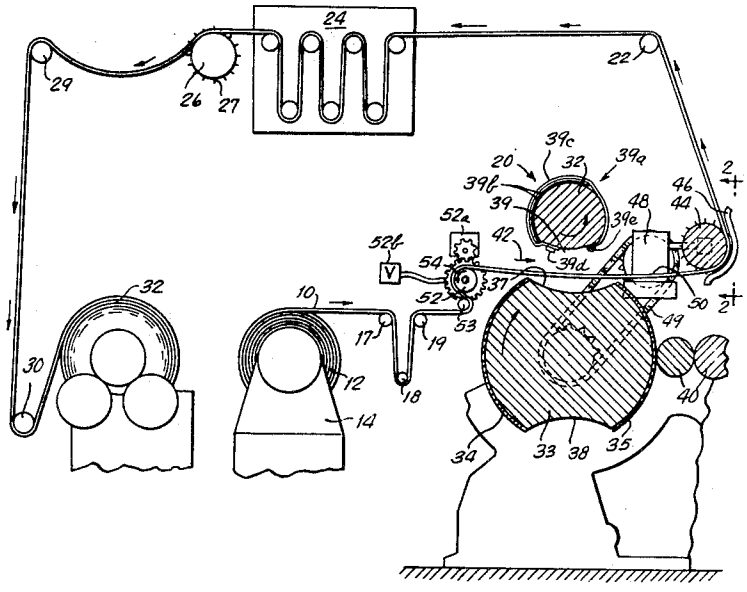
ABSTRACT: A rotary press for printing repeated impressions on a continuous punched web, having a printing couple which feeds the web intermittently and releases the web between successive feeding periods, sprocket means positioned on one side of the printing couple for engaging successive punched holes in the web, web-drawing means slidably engaging the web on the other side of the printing couple for exerting on the web a tensioning force directed away from the sprocket means, and means for actuating the sprocket means and the web-drawing means to index the web forwardly past the sprocket means each time the printing couple feeds the web and to retract the web past the printing couple each time the printing couple releases the web, in such manner as to produce a net predetermined increment of web advance through the printing couple between the start of one web-feeding period and the start of the next.



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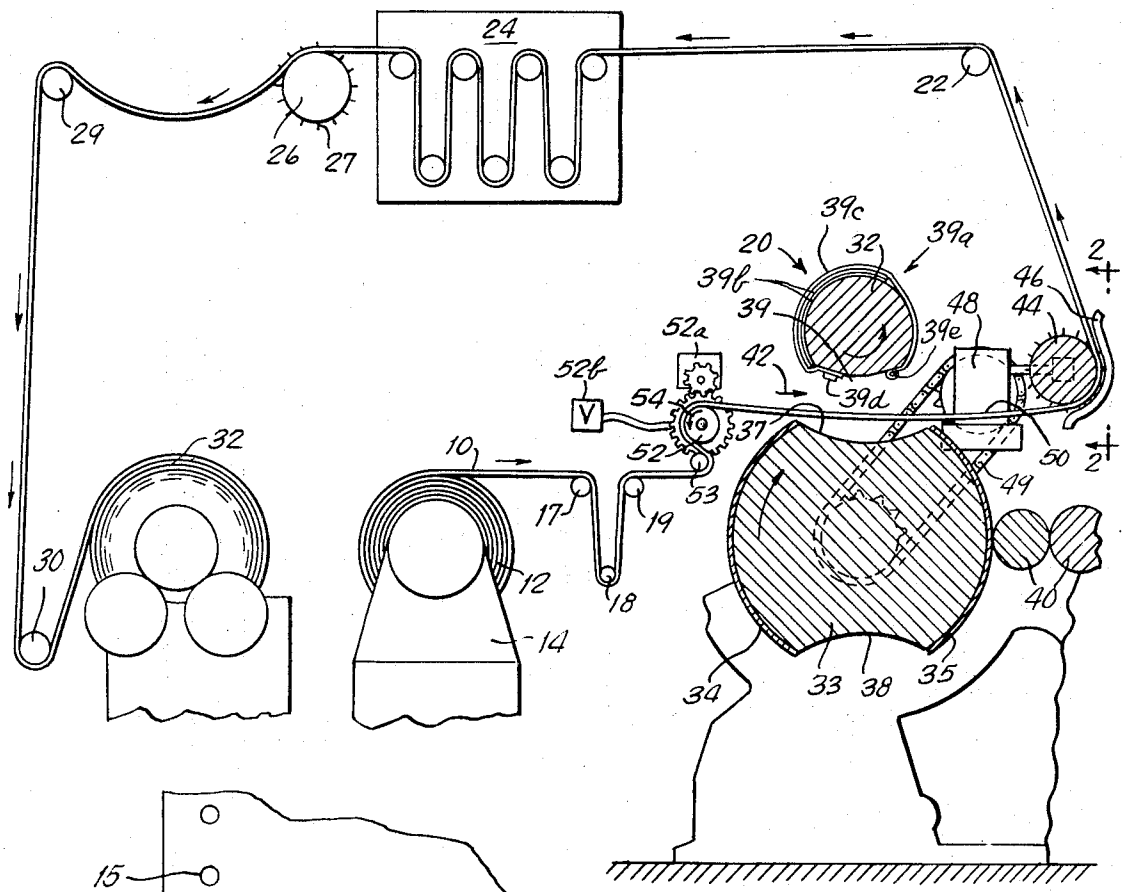
SHEET 1 OF 2

Fig. 1.



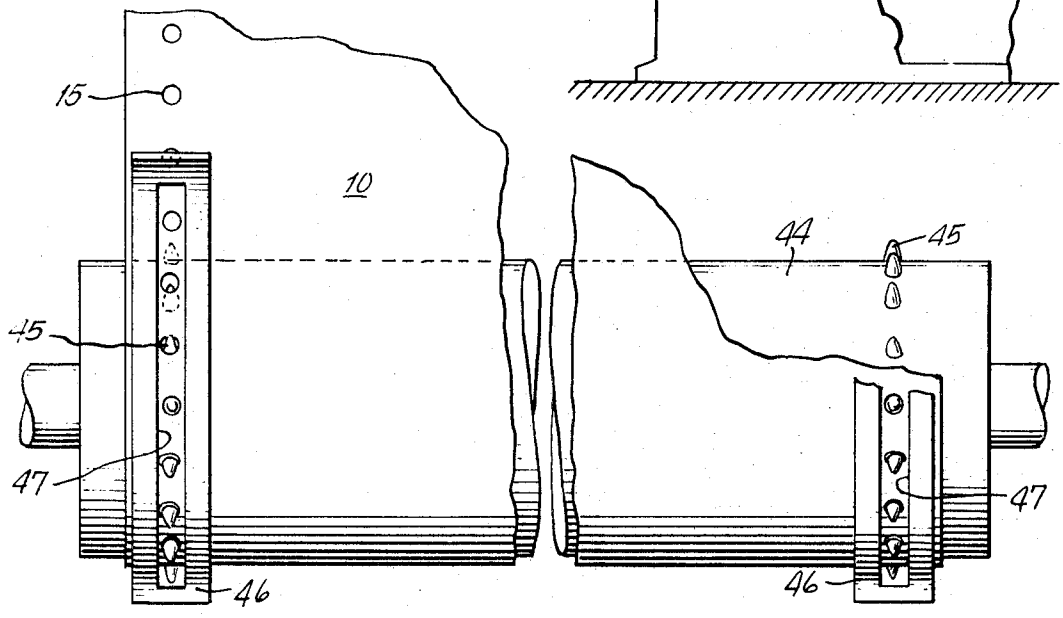


Fig. 2.

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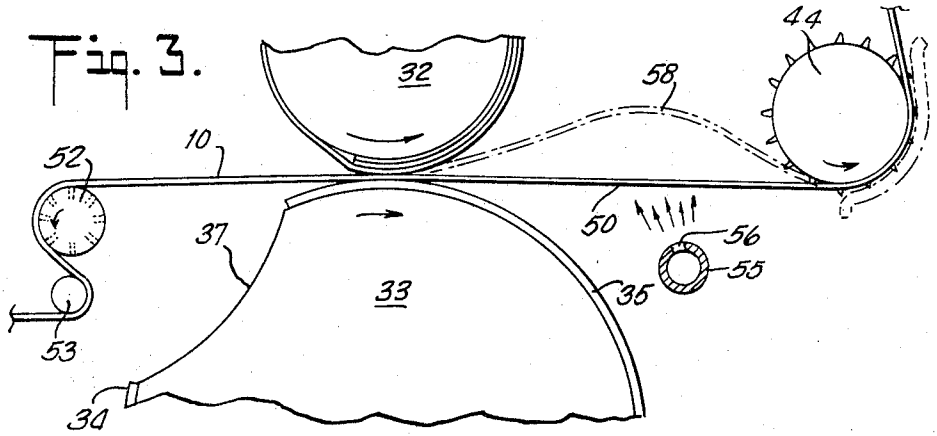
Fig. 3.



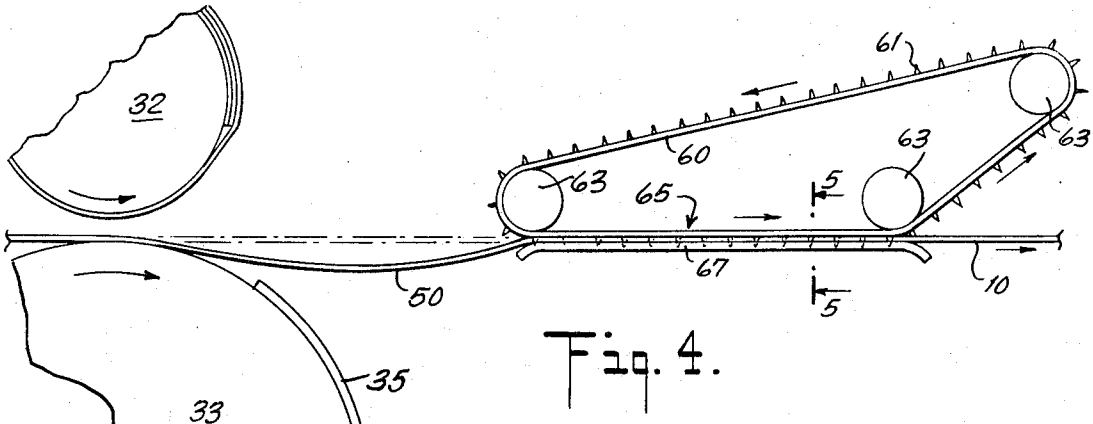


Fig. 4.

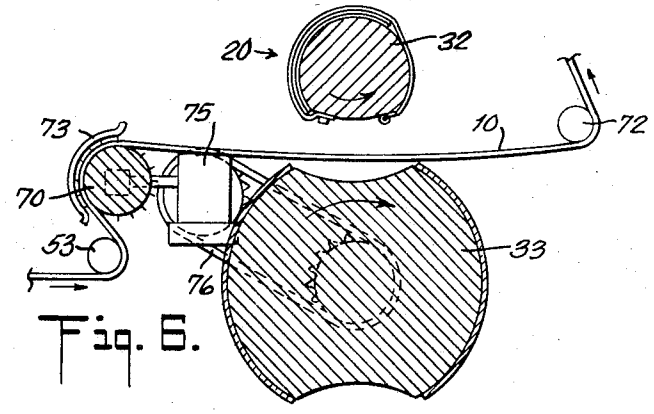
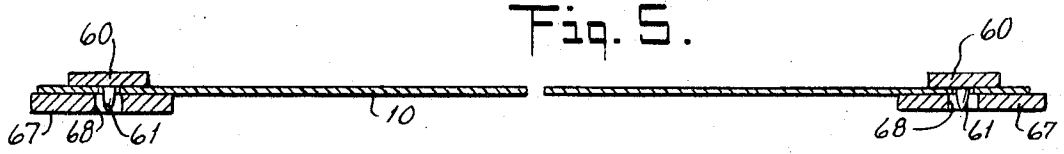


Fig. 6.

Fig. 5.



WEB-FED ROTARY PRINTING PRESS

BACKGROUND OF THE INVENTION

This invention relates to web-fed rotary printing presses, and especially to presses wherein a continuous punched web is fed intermittently forward while being printed with repeated impressions, incorporating new and improved means for maintaining proper web register. In an important specific aspect, the invention is directed to rotary intaglio presses incorporating such means.

A typical rotary intaglio press includes a printing couple comprising an impression cylinder and a plate cylinder which bears one or more curved intaglio printing plates, together with suitable means for inking and wiping the plate or plates. Paper to be printed is supplied, either in separate sheets or as a continuous web, to the nip of the printing couple. As the plate and impression cylinders rotate, the paper is pressed between them, receiving an intaglio impression from the plate and concomitantly being fed forward by the rotary motion of the cylinders.

In conventional sheet-fed rotary intaglio presses, the plate or plates usually extend only partially around the plate cylinder so that the circumference of this cylinder includes one or more gaps, i.e. portions which are depressed in relation to the surfaces of the plates. Correspondingly, the impression cylinder bears a circumferential packing which extends only part way around its periphery and constitutes a raised portion of the impression cylinder circumference. The paper being printed is gripped and fed by the printing couple only while a plate is being carried by the plate cylinder past the impression cylinder, and while the packing portion of the impression cylinder is simultaneously being carried past the plate cylinder; at all other times during the operating cycle of the printing couple, there is a space or opening between the cylinders larger than the thickness of the paper. Consequently, although the cylinders rotate continuously, feeding of paper by the printing couple is intermittent.

If a continuous web of paper is advanced through a printing couple of the intermittent feeding type just described, so as to be printed with repeated intaglio impressions, it is gripped and fed forwardly by the printing couple (between a plate of the plate cylinder and the packing of the impression cylinder) only during a part of each operating cycle of the printing couple, being released each time there is a space between the cylinders larger than the web thickness. Problems have heretofore been encountered in attempting to control the position of the web when thus released so as to maintain proper web register and especially to ensure that successive impressions will be properly and regularly located along the web. These problems have prevented ready conversion or adaptation of conventional sheet-fed rotary intaglio presses to web-fed operation. Instead, web-fed rotary intaglio presses of known types have commonly employed printing couples in which the plate and impression cylinders have continuous uniformly cylindrical surfaces without gaps, providing continuous feeding of the web throughout each complete cycle of plate cylinder rotation. One disadvantage of such continuous feeding is that, unless the length of the printed impression is substantially equal to the circumference of the plate cylinder, successive impressions printed on the web are more or less widely spaced with extended blank or unprinted areas between them, which is undesirably wasteful of paper.

A particular cause of difficulty in maintaining proper web register in web-fed intaglio printing operations, encountered even in presses of the continuous feeding type, is the dimensional distortion of the paper that occurs as the web passes through the nip of the printing couple. This distortion, which results from the high printing pressures required in intaglio printing, may significantly affect both the length of the individual printed impression and the relative position of successive impressions along the web. The extent of such dimensional distortion is not constant, but may vary from point to point even along a single web of extended length.

Ordinarily, a continuous printed web is ultimately divided into plural individual sheets (e.g. each bearing a single impression) as by cutting, perforating and/or fan-folding operations. Other finishing operations, such as overprinting or numbering of each impression, are also commonly effected. Accurate web register in the apparatus employed for these finishing operations is essential to ensure proper positioning of the cuts, perforations, folds, overprints or numerals relative to each impression. The dimensional distortion introduced in an intaglio printed web incident to printing of the intaglio impressions has heretofore presented serious obstacles to attainment of acceptable accuracy of register of the printed web for finishing operations such as those mentioned above. In particular, ordinary tension control of web position at the printing couple has not been found effective to achieve accurate web register. Continuous web printing would nevertheless afford advantages as compared with printing of separate sheets, particularly from the standpoint of simplifying feeding and subsequent handling of the paper and facilitating reregister of the printed paper for finishing operations, if sufficiently accurate register could be attained.

Thus it would be desirable to attain high accuracy of register in rotary intaglio printing of an intermittently fed web. It would also be desirable to provide an intermittently fed continuous web press in which the increment of web advance corresponding to each impression may be adjusted to conform to the desired length of the individual sheets into which the web is to be divided, i.e. so that the extent of incremental web advance may be varied in accordance with changes in impression length and/or sheet length, with maintained accuracy of register; such a press would be advantageously versatile and economical in operation, being capable of use to imprint webs for division into sheets of a variety of different lengths without excessive spacing or waste of paper between sheets. Further, it would be desirable to provide such a press by relatively simple conversion of a sheet-fed press of conventional character, or in other words, to enable ready adaptation of existing sheet-fed equipment to web-fed operation having the foregoing advantages.

Stated broadly, the foregoing considerations respecting the desirability of attaining highly accurate register of an intermittently fed continuous web on which repeated impressions are imprinted, are applicable to types of rotary printing other than intaglio printing, i.e. printing operations in general wherein the printing couple itself effects positive feeding of the web.

Among expedients that have been proposed for effecting or maintaining register of a continuous web is the use of punched paper, i.e. a web having one or more rows of holes regularly spaced along the longitudinal dimension of the web for engagement by a sprocket or like toothed indexing element. Assuming that successive impressions on a web are printed in accurate register with such punched holes, the holes would readily enable precise reregister of the web as for overprinting or other finishing operations e.g. of the various types referred to above, by simple alignment of the holes with an indexing sprocket in the apparatus wherein such finishing operations are performed. Therefore, in intaglio and other rotary printing, it would be especially desirable to attain accurate register of repeated printed impressions on a web with holes punched in the web.

SUMMARY OF THE INVENTION

The present invention broadly contemplates the provision of a press for printing repeated impressions on a continuous punched web while advancing the web forwardly by a predetermined increment in correspondence with the printing of each impression thereon, including the combination of a rotary printing couple for alternately engaging the web to print an impression thereon while feeding the web forwardly, and releasing the web, during successive periods of each of repetitive operating cycles; cyclically movable sprocket means positioned in the path of advance of the web on one side of the

printing couple for positively engaging successive punched holes of the web; web-drawing means positioned in the path of advance of the web on the side of the printing couple remote from the sprocket means for slidably engaging the web and exerting thereon a tensioning force tending to draw the web along the path in a direction away from the sprocket means; and means for actuating the sprocket means and the web-drawing means to effect forward movement of the web past the sprocket means during each period of feed of the web by the printing couple and rearward movement of the web past the printing couple during each period of release of the web by the printing couple, in such manner as to produce a net forward advance of the web past the printing couple equal to the predetermined increment between the initiation of one period of feed of the web and the initiation of the next period of feed of the web. This actuating means includes drive means synchronized with the printing couple for intermittently cyclically moving the sprocket means to index the web forwardly past the sprocket means during each period of feed of the web by the printing couple, and means for actuating the web-drawing means to exert the tensioning force on the web at least during each period of release of the web by the printing couple.

The drive means is arranged to effect a net forward indexing movement of the sprocket means, in each operating cycle (i.e. between the start of one period of feed of the web by the printing couple and the start of the next such period), corresponding precisely to the desired predetermined increment of web advance, which may (for example) be equal to the desired ultimate sheet length. During each period of web feed by the printing couple, the extent of forward web movement at least on the side of the printing couple adjacent to the sprocket means is somewhat greater than the aforementioned predetermined increment. When the web is released by the printing couple, it is free to move relative thereto, and the sprocket means and web-drawing means cooperate to effect a corrective rearward movement of the web to compensate for the amount of overfeed or excessive web advance during the feeding period.

Specifically, during the web-release period the web-drawing means tends to draw the web away from the sprocket means, while the positive engagement of the sprocket means with the punched holes of the web limits the extent of movement of the web. Once the sprocket means becomes stationary and the web is drawn taut between the sprocket means and drawing means, the web can move no further, though it is kept taut by the drawing means so as to be precisely positioned relative to the printing couple, owing to the fact that the drawing means engages the web slidably (i.e. permitting relative sliding motion of the web and drawing means) while exerting the tensioning force thereon.

Thus, the ultimate position of the web relative to the printing couple, attained at the completion of rearward motion of the web during each web-release period, is solely and precisely determined by the position of the sprocket means. Since the net forward indexing movement of the sprocket means during each operating cycle is, as stated, exactly equal to the desired predetermined increment of web advance, the net forward advance of the web relative to the printing couple between the start of one web-feeding period and the start of the next is likewise equal to such predetermined increment, regardless of variations in the amount of forward feeding of the web by the printing couple; i.e. the net forward advance of the web during each operating cycle is determined solely by the indexing movement of the sprocket means and is independent of the amount of web feed by the printing couple, inaccuracies or variations in such amount of web feed being compensated for by the retraction of the web effected when the printing couple releases it.

In this way, maintained and highly accurate register between the punched holes of the web and the succession of impressions printed on the web is positively assured. The web may be readily subjected to overprinting, numbering, folding, perforating, cutting and/or other finishing operations with accurate register achieved by engagement of appropriate sprocket means in the finishing apparatus with the punched holes of the web. For example, the web may rerun through the same press (or through another similarly arranged press embodying the invention) to receive an overprint in register with each impression.

In an important specific aspect, the invention may be embodied in rotary intaglio printing apparatus, having an intermittent feeding printing couple wherein the plate cylinder bears one or more intaglio printing plates which extend only partially around the circumference of the cylinder, leaving at least one gap in the cylinder circumference, and wherein the impression cylinder bears a raised packing extending only partially around its circumference. During those periods of the operating cycle when the web is pressed between a plate and the impression cylinder packing, the web is advanced forward thereby, concomitantly receiving an impression; but at all other times during the printing couple operating cycle, there is a space between the cylinders larger than the web thickness, so that the web is released for retraction. Although an intaglio printing couple as described may not itself effect accurately controlled advance of paper, lack of precision or control of feed of the web by the nip does not adversely affect the accuracy of web register, because as explained above, such register is attained through the sprocket means, independently of the printing couple.

The described printing couple may be of the type heretofore conventionally used in sheet-fed presses, and thus as a further particular advantage, the press of the invention may readily be provided by modifying a conventional sheet-fed press, i.e. by substituting for the sheet-feeding and handling instrumentalities suitable web-feeding and handling instrumentalities including the above-mentioned sprocket means, web-drawing means, and actuating means for the sprocket and web-drawing means. Similarly, offset and other types of sheet-fed rotary presses of the intermittent feed type may be modified in accordance with the invention to provide a web-fed press for performing such offset or other types of printing operations.

In intaglio printing presses embodying the invention, dimensional distortion of the web occurring at the printing couple does not affect the desired accurate register between the punched holes of the web and the impressions printed on the web, because such dimensional distortion is imparted to the row or rows of holes, which are prepunched on the web, i.e. prior to advance of the web to the printing couple. Especially for intaglio printing, the sprocket means (which controls the web register) is very preferably disposed beyond the printing couple so that the web undergoes distortion before it engages the sprocket means, and this distortion is reflected in the positioning of the web relative to the printing couple by the sprocket means, for superior freedom from impairment of web register by dimensional distortion. The web-drawing means in such case is disposed ahead of the printing couple.

In an exemplary embodiment of the invention having this preferred arrangement, the printing couple is arranged to overfeed the web; i.e. the extent of forward advance of the web effected by the printing couple as it prints each impression is somewhat greater than the desired predetermined increment of web advance. The sprocket means, on the other hand, is set to index the web forward during each feeding period by an amount exactly equal to such predetermined increment. The sprocket means is held stationary when the web is released by the printing couple; hence its engagement with the web holes limits the extent of retraction of the web by the web-drawing means during such release period. Thus the retraction of the web in effect compensates for the overfeeding of the web by the printing couple and draws the web back through the printing couple into a position precisely determined by the position of the sprocket means, so that the net increment of forward web advance through the nip of the printing couple between the start of one feeding period and the start of the next is precisely determined by an equal to the increment of indexing of the web by the sprocket means dur-

ing the feeding period, even though there is also tension control of web position (provided by the web-drawing means) at the area of the nip. In this way, there is achieved highly accurate positioning of successive impressions in relation to each other and to the holes of the web; yet, owing to the fact that the printing couple overfeeds the web and creates slack in the web between the printing couple and sprocket means, there is no tension on the web between the printing couple and sprocket means such as might tend to distort or tear the punched holes of the web (or even tear the web itself) in the event of minor differences in speed between the printing couple and the sprocket means.

Means may be provided for displacing the slack portion of the web, intermediate the printing couple and the sprocket means, to aid in achieving buildup of this slack portion and also to maintain a light positive forward tension on the web as it leaves the nip of the printing couple. The direction of such displacement is preferably chosen so as to lift the web from the plate cylinder (in intaglio printing apparatus) on the outlet side of the printing couple, and thereby to overcome the tendency of the web to adhere to the plate cylinder after passing the nip.

To enable the predetermined increment of web advance to be varied (e.g. to correspond to different desired sheet lengths and/or impression lengths), the drive means employed to effect cyclical movement of the sprocket means may be adjustable to vary the extent of movement of the sprocket means during each web-feeding period.

Further features and advantages of the invention will be apparent from the detailed description hereinbelow set forth, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a rotary intaglio printing press embodying the present invention in a particular form:

FIG. 2 is a fragmentary view of the indexing sprocket means of the press of FIG. 1, taken along the line 2–2 of FIG. 1;

FIG. 3 is an enlarged view of the printing couple and web register elements of the press of FIG. 1;

FIG. 4 is a view of an alternative form of sprocket means that may be employed in the press of FIG. 1;

FIG. 5 is an enlarged sectional view taken along the line 5–5 of FIG. 4; and

FIG. 6 is a fragmentary schematic view of another embodiment of the invention.

DETAILED DESCRIPTION

Referring first to FIG. 1, the invention in its illustrated form is shown as embodied in a rotary intaglio press for printing successive intaglio impressions on a continuous web **10** of paper which is fed from a supply roll **12** rotatably mounted on an upstanding bracket **14**. The web, which is prepunched with one or more longitudinal rows of regularly spaced holes **15** (as shown in FIG. 2), is led from the roll **12** over a guide roller **17**, around a floating roller **18** and a further guide roller **19** to a printing couple **20** (hereinafter further described) which prints successive intaglio impressions on the web. From the printing couple, the printed web is advanced upwardly over another guide roller **22** to a suitable form of drying unit represented at **24**, and thence over a pin feed cylinder **26** bearing on its outer surface plural projections or pins **27** which positively engage the punched holes **15** of the web. From cylinder **26**, the web is led over further guide rollers **29** and **30** to a positively driven rewind roll **32**, on which it is wound for storage and/or transfer to other apparatus for subsequent printing, cutting, perforating or like operations.

In a general sense, the elements just described (except for the printing couple) form no part of the present invention, any may be conventional instrumentalities for supplying, guiding, drying and rewinding a continuous web in a printing press; accordingly these features, which are well known in the art and are shown merely in simplified schematic form as representative of suitable elements for performing their respective stated functions, need not be described in detail. Further, while the apparatus has been shown as arranged for operation with a prepunched web, the web as provided on the supply roll **12** may be unpunched and the holes **15** may be imparted to the web by passing it through a suitable conventional form of punching apparatus (not shown) e.g. positioned intermediate the roll **12** and guide roller **17**.

The printing couple **20** may be in itself an entirely conventional intermittent feed-type printing couple as heretofore commonly used in sheet-fed rotary intaglio presses. Thus, in one illustrative example, it may be constituted by an impression cylinder **32** and a plate cylinder **33** respectively mounted above and below the web **10** for rotation about parallel axes which extend transversely of the direction of advance of the web. The plate cylinder bears, on opposite sides of its circumference, a pair of curved intaglio printing plates **34** and **35** which conform to the cylindrical periphery of the cylinder **33** but extend only partially around the circumference of the cylinder, and gaps **37** and **38** are formed in the circumference of the plate cylinder between the facing edges of the two plates. The gaps **37** and **38** are shown as recesses in the plate cylinder circumference, but may simply constitute exposed portions of a continuous cylindrical plate cylinder if there is a substantial radial distance (i.e. large relative to the web thickness) between the outer surfaces of the plates and the cylinder surface. The plates **34** and **35** are of equal length, and similarly the gaps **37** and **38** are equal to each other in circumferential extent around the cylinder **33**. A gap **39** may be provided in the impression cylinder **32** for register with the gaps of the plate cylinder, only a single such gap being shown since the ratio of the impression cylinder and plate cylinder radii in the illustrated printing couple is 1:2 so that the impression cylinder rotates twice for each rotation of the plate cylinder. If the ratio of these radii is 1:1 for example, two opposed gaps **39** might be provided in the impression cylinder for register respectively with the two gaps of the plate cylinder.

The impression cylinder bears on its circumference a packing **39*a***, comprising one or more backup boards **39*b*** conforming to the periphery of the impression cylinder and a blanket **39*c*** extending around the impression cylinder, over these boards. The blanket is secured at one end to the cylinder **32** by a blanket clamp **39*d*** positioned within impression cylinder gap **39**, and at its other end by a blanket tension reel **39*e*** also carried by cylinder **32** within the gap **39**. The circumferential extent of the boards **39*b*** constitutes a raised portion of the impression cylinder surface, ordinarily or commonly extending only partially around such surface. It will be understood that the described packing arrangement may be itself conventional in character, as heretofore employed in rotary intaglio printing couples of the intermittent-feeding type.

The plate cylinder **33** is so positioned in relation to the impression cylinder **32** that each time one of the plates is carried past the impression cylinder, the portion of web **10** interposed between the two cylinders is pressed between that plate and the raised packing portion of the impression cylinder. However, except during those portions of each operating cycle of the printing, couple when a plate of cylinder **33** and the raised packing portion of the impression cylinder **32** are pressing the web between them, there is a space larger than the thickness of the web between the two cylinders.

Each of the plates **34** and **35** bears on its outer surface an intaglio impression. Conventional inking means, represented by rollers **40**, are positioned adjacent to the cylinder **33** so as to come in contact with the surface of each intaglio plate as it passes the inking means and to impart ink to the intaglio design on the plate. As the cylinder **33** continues to rotate, each plate comes into contact with a suitable conventional wiping means (not shown) which removes excess ink from the plate before the plate rotates upwardly into printing engagement with the web **10**.

The printing couple is continuously driven by conventional means (not shown) so that the two cylinder **32** and **33** undergo

continuous unidirectional rotation in the directions represented by the arrows on these cylinder in FIG. 1. As the printing cylinder 33 rotates, each of the plates 34 and 35 is successively carried past the inking means and the wiping means and into contact with the lower surface of the web 10, while the rotation of the impression cylinder carries its raised packing portion into contact with the opposite surface of the web, pressing the web against the plate, so that as the cylinders continue to rotate an intaglio impression is printed on the web. Concomitantly, the printing couple feeds the web forwardly (in the direction indicated by arrow 42 in FIG. 1) ; i.e. the rotational movement of the plate and impression cylinders pressing against the web effects forward advance of the web. As further rotation of the impression cylinder 32 carries the raised packing portion out of engagement with the web, the web is released from the nip of the printing couple, since the space between the two cylinders, as stated, is then greater than the thickness of the web. When the next plate comes into contact with the web, and the raised packing portion is again carried into contact with the web, the web is again pressed against the plate and fed forwardly while receiving a further intaglio impression from this plate.

In the present embodiment of the invention, the extent of forward feeding of the web by the printing couple during each period of contact of a plate with the web is somewhat greater than the desired predetermined increment of web advance between the start of one web-feeding period and the start of the next; i.e. the printing couple slightly overfeeds the web during each feeding period. The adjustment of the printing couple to provide the desired amount of feeding of the web will be readily apparent to one skilled in the art.

Specifically, in the form of printing couple shown, the length of the plates is always the same, although different plates may print impressions of different length. The extent of forward feeding of the web effected concomitantly with the printing of each impression is determined by the length of the raised portion of the packing 39*a* around the circumference of the impression cylinder 32, and this may be varied as desired by changing the length of the backup boards 39*b*.

As a particular feature of the invention, sprocket means shown as a pin feed cylinder 44 is positioned in the path of advance of the web from the printing couple (i.e. between the printing couple and guide roller 22), this cylinder being mounted for rotation about an axis extending transversely of the direction of web advance. Cylinder 44 bears on its outer surface regularly spaced pins or projections 45 arranged in a number of rows equal to the number of rows of punched holes on the web and positioned to positively engage the rows of web holes. The web may bear one or more rows of holes extending, for example, along one or both margins of the web and/or along a central portion of the web, depending on such factors as the width of the web and the position of the impressions thereon; in FIG. 2, the web is shown for purposes of illustration as having two rows of holes 15 respectively extending longitudinally along its opposite side margins, and the cylinder 44 is correspondingly shown as bearing two rows of regularly spaced pins 45 respectively positioned to positively engage the two rows of web holes.

Suitable means are provided for assuring maintained positive engagement of the pins 45 with the web holes 15 as the web passes around the cylinder 44. For example, the web may be held in engagement with the cylinder by suction through holes (not shown) in the cylinder surface, the holes communicating with a chamber or passage in the interior of the cylinder connected to means for continuously evacuating such chamber or passage. Alternatively, the web may be held in the requisite proximity to the cylinder by web-engaging means such as a fixed guide or roller positioned in adjacent relation to the cylinder 44, the web passing between the cylinder and the engaging means. In the form shown in FIGS. 1—3, the web-engaging means comprises a pair of curved metal guide member 46 positioned adjacent to the cylinder 44 conforming generally to the peripheral contour of the cylinder and spaced therefrom by a distance less than the height of the pin 45. These guides 46 are respectively aligned with the two rows of pins 45, and each of them has a slot 47 (extending in the direction of rotation of the cylinder) to accommodate free rotation of the pins 45 past the guides 46 incident to rotation of the cylinder 44. The web is led from the printing couple around the cylinder 44 and upwardly therefrom to the roller 22, being threaded between the cylinder 44 and guides 46, which serve to hold the web holes 15 in positive engagement with the pins 45 as the web passes the cylinder 44.

Preferably, the cylinder 44 is relatively small in diameter, to afford a short contact length between the cylinder and the web, i.e. so that only a small number of successive web holes are simultaneously engaged by pins of the cylinder. Stated generally, a short contact length between cylinder and web is preferred for operations such as intaglio printing wherein the web undergoes significant dimensional distortion at the nip of the printing couple, since such distortion tends to produce minor variations in spacing between successive web holes.

The pin feed cylinder 44 is driven for intermittent rotary movement in synchronized relation with the feeding of the web by the printing couple 20, by means of a high precision intermittent rotary indexing drive 48, e.g. a cam and follower drive of a type which converts a continuous unidirectional rotary input motion to an intermittent unidirectional rotary output motion. For assured maintained accuracy of synchronization, the input to the drive 48 is very preferably taken from the continuously rotating plate cylinder 33 by an appropriate drive-transmitting linkage which may be of the antibacklash type, such as antibacklash gears, but is shown for simplicity in FIG. 1 as a chain and sprocket 49. The drive 48 is adapted to effect rotation of the cylinder 44 through a precise predetermined angle during each period of forward feeding of the web by the printing couple, and to hold the cylinder 44 stationary throughout each period of release of the web by the printing couple, the angular velocity of cylinder 44 (after initial acceleration) being not greater than the average angular velocity of the printing couple. Specifically, the drive is set to rotate the cylinder 44, in each period of web advance, by such amount as to index the web forwardly past the cylinder 44 by a desired predetermined increment.

This predetermined increment of web indexing, which determines the relative position of successive impressions on the web, may for example be selected to be equal to the desired length of individual sheets into which the web is ordinarily cut or otherwise divided. Commonly, it is desirable that successive impressions be spaced apart along the web to provide an unprinted margin extending entirely around each impression, but in some cases it may be desired to imprint the impressions in contiguous relation along the web, or even to effect overlapping of the edge portions of successive impressions to create special edge design effects in particular instances. In any event, the increment of web indexing past the cylinder 44 is made precisely equal to the desired repeat length (i.e. the distance between the leading edges of successive impressions printed on the web) and is, as stated, somewhat less than the extent of web advance effected by the printing couple during each web-feeding period. Accordingly, each time the web is fed forwardly by the printing couple and concomitantly indexed by the cylinder 44, a slack portion is created in the web at locality 50 intermediate the printing couple and the cylinder 44.

If the press is to be used only to print impressions of a single length, with a constant spacing between the leading edges of successive impressions, so that a single fixed magnitude of repeat length is desired for all webs printed by the press, the drive 48 may be arranged to provide a single fixed incremental indexing motion of the cylinder 44. However, to enable the variation in the aforementioned repeat length, the drive 48 may be of such character as to permit adjustment in the amount of rotation of cylinder 44 effected during each indexing period, and thereby to vary the length of the increment of web advance past the cylinder 44, for example when the plates

on the plate cylinder **33** are replaced with other plates for printing impressions of a different length. One type of indexing apparatus suitable for use as the drive **48**, and affording this feature of adjustability in magnitude of output indexing motion, is disclosed in the copending application of Salvatore F. D'Amato, Kenneth R. Williams and Clifford D. Guertin, Ser. No. 748,546, filed July 29, 1968, now U.S. Pat. No. 3,483,772, entitled Rotary Indexing Apparatus and assigned to the same assignee as the present application.

As a further particular feature of the invention, a web-drawing means is provided ahead of the printing couple, i.e. in the path of advance of the web to the printing couple, for slidingly engaging the web and exerting thereon a rearwardly directed tensioning force effective to retract the web during the periods of web release by the printing couple. Although the drawing means may be of a type adapted to engage the web only intermittently, such as an arrangement of reciprocating finger elements which move into and out of engagement with the web, conveniently the web-drawing means has a surface which continuously slidably engages the web and which continuously or intermittently moves (by reciprocating or rotary motion) relative to the web in a direction opposed to the direction of forward feeding of the web by the printing couple. Means are provided for actuating the web-drawing means to exert the aforementioned tensioning force on the web at least during the periods of web release. This actuating means includes means for effecting motion of the web-engaging surface and may further include means for promoting adherence of the web to the surface, as by suction.

In the press of FIG. **1**, the web-drawing means is shown as a conventional type of vacuum roller **52** mounted (intermediate the guide roller **19** and the printing couple **20**) for rotation about an axis transverse to the direction of web advance. Actuating means for the roller in the illustrated embodiment includes a suitable mechanical drive *52a* for effecting rotation of the roller **52** and an evacuating device *52b* for holding the web against the roller by suction in the manner hereinafter described, both drive *52a* and evacuating device *52b* being conventional elements as heretofore used with vacuum rollers. The web is led from roller **19** around a small guide roller **53** and thence over the vacuum roller **52** from which it passes directly to the printing couple.

The vacuum roller **52** is rotated (e.g. continuously) by the drive *52a* in a direction opposite to the direction of forward advance of the web as indicated by arrow **54** in FIGS. **1** and **3**, and has plural openings in its surface leading to a hollow space or passage within the roller which is connected to the evacuating device *52b*, which evacuates the interior of the roller to create suction at these openings tending to hold the web against the roller surface and thereby to impart the rotational motion of the roller to the web. Thus the roller exerts a rearwardly directed force on the web. When the web is being fed forwardly by the printing couple **20** in the manner already described, it slides forwardly over the roller **52** against this rearwardly directed force, which is sufficiently small to permit such sliding advance of the web over the vacuum roller without excessive tension that might tear the web. However, upon release of the web by the printing couple, the suction of the vacuum roller on the web causes it to adhere to the roller surface and to be pulled backward by the rotary motion of the roller, i.e. retracted, through the space between the plate and impression cylinders, taking up slack created at locality **50** during the forward feeding period. When the web is again engaged and fed forwardly by the nip of the printing couple, it once again slides over the vacuum roller **52** against the rearward force exerted thereby. The suction created by the evacuating device *52b* and acting on the web may be of a continuous constant value or, if desired, it may be controlled as by suitable valve means (not shown) operating in synchronized relation with the printing couple so that the suction is either reduced or entirely cut off during periods of forward web feed by the printing couple. In some instances, the frictional engagement of roller **52** with the web may be sufficient to exert the desired tensioning force on the web when the roller is rotated rearwardly, and in such case it is unnecessary to employ suction to hold the web against the roller.

The operation of the described press may now be readily understood. With the web threaded through the press in the manner shown in FIG. **1** and described above, and the printing couple **20** continuously driven, the web is intermittently fed forward by the printing couple, and receives an intaglio impression from one of the plates **34** and **35** during each such feeding period. Concomitantly with the forward advance of the web by the printing couple, the drive **48** rotates pin feed cylinder **44** to advance the web past the pin feed cylinder by an increment precisely equal to the desired repeat length, and since this latter increment is less than the extent of web advance effected by the printing couple, a slack portion or loop is created in the web at locality **50** between the printing couple and the cylinder **44**. Tension on the web between the cylinder **44** and the printing couple is thereby avoided; hence there is no danger or tearing of the web or enlargement of the holes **15** such as might otherwise occur owing to minor variations in speed between the printing couple and the cylinder **44**. Notwithstanding that the average angular velocity of the cylinder **44** is not greater than the average angular velocity of the printing couple, it will be understood that the velocity imparted to the web by the printing couple may not be precisely constant throughout the length of each impression. At the end of each period of feeding of the web by the printing couple, i.e. when the trailing edge of the raised packing portion of cylinder **32** passes out of engagement with the web so that the web is released from engagement between the cylinders **32** and **33**, the cylinder **44** is arrested and held stationary by the drive **48**.

As long as the web is being fed forwardly by the printing couple, it is caused to slide over the vacuum roller **52** against the rearwardly directed force exerted by the vacuum roller on the web. However, as soon as the web is released by the pring printing couple, the vacuum roller retracts the web rearwardly through the space between the impression cylinder **32** and plate cylinder **33**, taking up the slack of the web at locality **50** until the web is taut between roller **52** and cylinder **44**. Because cylinder **44** is stationary through the period of web release, the engagement of pins **45** with holes **15** in the web holds the web against further retraction, once it is pulled taut; the rearwardly moving web is thus halted at a position (in relation to the printing couple) precisely determined by the position to which the cylinder **44** was turned during the preceding feeding period, although the roller **52** continues to rotate, once again in slipping relation to the web. Since the angular displacement of the cylinder in each feeding period corresponds exactly to the desired repeat length, the net increment of web advance past the printing couple from the start of one feeding period to the start of the next is exactly equal to that repeat length. In other words, although the printing couple overfeeds the web during each feeding period, the continuous rearwardly directed force exerted by the vacuum roller retracts the web after each feeding period by whatever extent is necessary to take up the amount of such overfeeding, so that the net forward advance of the web between the imprinting of successive impressions is solely determined by the indexing of the web by the pin feed cylinder **44**.

As a result of the described operation, highly accurate register of the intaglio impressions on the web with the punched holes **15** therein is achieved. Notwithstanding subsequent dimensional variations in the web that may occur as the web is dried, this register between the impressions and the holes is retained so that the web may (for example) be thereafter advanced through another press to receive overprinted impressions with register maintained by engagement of appropriate sprocket means in the second press with the punched holes of the web. Indeed, instead of being rewound on a roll as shown at **32** in FIG. **1**, the web may be immediately delivered (after drying) to a second press identical to that shown in FIG. **1**, and if the punched holes of the web are initially properly aligned with the pins of a feed cylinder corresponding to cylinder **44**)

in the second press, overprinting impressions may be imparted to the web by the second press in precisely aligned and accurately maintained register with the first impressions throughout the entire length of the web. Similarly, the printed web may be rerun through the first press after replacement of the plates **34** and **35** with other plates carrying a different impression for overprinting each original impression on the web, or the web may be subjected to other finishing operations (e.g. perforating, fan-folding and/or cutting) in suitable apparatus having sprocket means for engaging the web holes. In each case, the accurate register of the successive impressions on the web with the web holes assures correspondingly accurate register of the web impressions for such finishing operations to be readily achieved by the use of such sprocket means.

The synchronization between the initiation of each web-feeding period by the printing couple and the start of indexing motion of the pin feed cylinder may be such that the cylinder starts either slightly subsequent to, concurrently with, or slightly prior to the beginning of the feeding period. Owing to the fact that the printing couple rotates continuously at a constant velocity, the surfaces of the impression and plate cylinders are already moving at that velocity when they grip the web at the start of each feeding period. However, if the web is then stationary, it must initially undergo acceleration up to the printing couple velocity. The pin feed cylinder, being also stationary, must also undergo acceleration before reaching its steady state velocity during each indexing. By initiating the indexing motion of the pin feed cylinder slightly prior to the start of the period of web feed by the printing couple, i.e. during the latter portion of the web release period while the web is still free to move relative to the printing couple, the web may be accelerated by the pin feed cylinder so that when the nip of the printing couple engages the web at the start of the web feeding period, the web is already moving at approximately the velocity of the printing couple; such acceleration of the web by the pin feed cylinder is advantageous in reducing dimensional distortion of the web since acceleration of the web by the printing couple tends to aggravate web distortion especially in the vicinity of the leading portion of each impression.

Means may be included in the press of FIG. **1** for positively displacing the web upwardly at the locality **50** of the slack portion of the web (intermediate the printing couple and the pin feed cylinder **44**) so as to produce a light or moderate tension on the outlet side of the printing couple contributing to the buildup of the slack portion of the web and aiding in proper advance of the web from the printing couple, especially by pulling the web from the plates of cylinder **33**, to which the web tends to adhere. While mechanical means (not shown) engaging the web may be used for this purpose, such means being arranged to release the web for retraction thereof by the vacuum roller **52** when the web is released by the printing couple, the desired displacement of the web slack portion may also be effected as shown in FIG. **3** by means for creating a flow of gas at the locality **50** of slack in the web so as to cause an inequality of gas pressures on opposite sides of the web and thereby to displace the slack portion of the web upwardly, in the direction of lower pressure. This pressure-creating means is shown in FIG. **3** as a pipe **55** extending transversely beneath the web at locality **50** and having a plurality of upwardly directed apertures **56** through which an air current is blown to cause the slack portion of the web to bulge upwardly, as indicated at **58**. As stated, this upward bulge aids in producing buildup of the slack portion of the web and also provides moderate tension on the outlet side of the printing couple to aid in proper advance of the web therefrom, lifting the web from the intaglio plates to which it may tend to adhere. Preferably, the supply of air to the pipe **55** is controlled by a valve (not shown) in synchronized relation to the operation of the printing couple in such manner that upon each release of the web by the printing couple, the air current is either reduced or shut off, thereby minimizing or preventing undesired upward fluttering of the web while the web is being retracted by the vacuum roller.

Although as stated, highly accurate register of the web is achieved with the press shown in FIG. **1**, still further enhancement of accuracy of web register may if desired be attained through the use of auxiliary web register control means, including means e.g. of conventional character for sensing the web position and responding to even very minor deviations from desired register by effecting corresponding minor adjustments in the position of the pin feed cylinder, for example during those portions of the operating cycle when the pin feed cylinder is stationary. That is to say, the described press is adaptable to use with positive register control means because the arrangement of the pin feed cylinder enables ready adjustment of the register control by minor alteration in cylinder angular orientation.

In FIG. **4**, there is shown an alternative form of sprocket means, i.e. for use in place of the pin feed cylinder **44**. This alternate sprocket means comprises a pair of endless bands **60** disposed to extend respectively along opposite side margins of the web **10**, and each bearing on its surface a row of regularly spaced pins **61** positioned and shaped for positive engagement with successive holes **15** of the web. The bands **60** are mounted on rollers **63** for unidirectional parallel cyclical movement in the direction of forward web advance, and their paths of travel include an essentially planar portion **65** (between adjacent rollers **63**) in which the pins of the bands engage the holes of the web. Means are provided for maintaining the desired positive engagement of the pins **61** in the web holes **15**, such means being shown in FIGS. **4** and **5** as comprising two flat guide members **67** extending in adjacent parallel relation to the flat portions **65** of the bands, and spaced from the bands by a distance less than the vertical extent of the pins **61**, which project through longitudinal slots **68** formed in the guide members and aligned with the pins.

The rollers **63** are intermittently rotated by the drive **48** in such manner as to effect intermittent cyclical indexing movement of the bands **60**, i.e. to advance the web past the bands **60** during each period of feed of the web by the printing couple **20**, by an increment precisely equal to the desired repeat length. This intermittent motion of the bands is synchronized with the operation of the printing couple so that the bands are held stationary throughout each period of web release by the printing couple. Since the printing couple, as before, overfeeds the web, slack is created at locality **50** during each feeding period in the same manner as in the structure shown in FIGS. **1—3**.

Since the bands **60** and guides **67** engage only the marginal portions of the web, the sprocket means of FIGS. **4—5** is particularly adapted for printing operations in which the upper web surface is printed instead of (or in addition to) the lower web surface, and which therefore require avoidance of contact between the "wet" (i.e. freshly printed) impressions on the upper web surface and the sprocket means. It may also be noted that the form of sprocket means shown in FIGS. **4** and **5** is arranged to provide an extended contact length between the sprocket means and web, i.e. a relatively large number of web holes are simultaneously engaged by pins of the sprocket means. As stated above, a short contact length is preferred for intaglio printing, wherein the web tends to undergo dimensional distortion; if desired, the bands **60** may be arranged to have a short contact length with the web (e.g. equivalent to that of the cylinder **44** in FIGS. **1—3**), as by appropriate positioning of the rollers **63**. However, especially for printing operations (e.g. offset printing) not involving substantial dimensional distortion of the web, extended contact length between web and sprocket means as shown in FIG. **4** is entirely satisfactory.

In the embodiments of the invention thus far described, the sprocket means is positioned beyond the printing couple, and hence any distortion of the web at the printing couple is imparted to the web before it engages the sprocket means, with the result that the positioning of the web by the sprocket means reflects such distortion. In this way, inaccuracies of web register resulting from dimensional distortion at the printing couple are minimized. However, as shown in FIG. **6**, in a

modified embodiment of the invention, affording adequate accuracy of register for many printing operations, the sprocket means may be positioned ahead of the printing couple and the web drawing means positioned beyond the printing couple.

In FIG. 6, there is shown a pin feed cylinder 70 (corresponding in structure and arrangement to the pin feed cylinder 44 in FIGS. 1—3) positioned ahead of the printing couple 20, and a vacuum roller 72 positioned beyond the printing couple. In this embodiment the printing couple as before comprises an impression cylinder 32 and a plate cylinder 33, continuously rotating and adapted during each operating cycle to successively feed the web forwardly while printing an impression thereon, and to release the web. The web, advancing toward the printing couple, passes around a guide roller 53 and over the pin feed cylinder 70, which has guide members 73 positioned in adjacent relation thereto for maintaining positive engagement of the web holes with the pins of cylinder 70. The web advances from the cylinder 70 through the nip of the printing couple and thence around vacuum roller 72, which may be a conventional vacuum roller similar to the roller 52 of the embodiment of FIGS. 1—3.

Pin feed cylinder 70 is driven by a suitable indexing drive 75, in synchronized relation to the operation of the printing couple, the input of drive 75 being shown as taken from the plate cylinder 33 by a chain and sprocket arrangement 76.

During each operating cycle, prior to the engagement of the web by the nip of the printing couple, the pin feed cylinder 70 begins to rotate forwardly to accelerate the web to a velocity not less than the average velocity of the printing couple. Cylinder 70 continues to rotate and thus to index the web forwardly, throughout the period of feed of the web by the printing couple, and the vacuum roller 72 rotates continuously forward so as to advance the web from the printing couple while maintaining tension thereon.

The forward indexing movement of the cylinder 70 during each web feeding period indexes the web past the cylinder 70 by an amount greater than the desired increment of web advance between the start of one web-feeding period and the start of the next. Upon release of the web by the printing couple at the end of each web-feeding period, the cylinder 70 is rotated by drive 75 in reverse direction, pulling the web rearwardly, by an amount equal to the difference between the extent of forward indexing of the web and the desired predetermined increment of web advance. The forwardly rotating vacuum roller 72 maintains a forwardly directed tensioning force on the web as the pin feed cylinder retracts the web. Consequently, when the described rearward rotation of the cylinder 70 is completed (and the cylinder is held stationary by the drive 75, before the initiation of the next forward indexing and web-feeding period), the web has undergone a net incremental advance past the printing couple equal to the aforementioned desired predetermined increment.

In other words, in the embodiment of FIG. 6, rearward movement of the web during each web release period, as well as forward indexing of the web during each web-feeding period, is effected by the sprocket means against the tensioning force of the web-drawing means. The excessive forward indexing of the web past the sprocket means, together with the start of forward indexing prior to the web-feeding period and the selection of the angular velocity of cylinder 70 at a value not less than the average angular velocity of the printing couple, prevents excessive tension on the web between the cylinder 70 and the printing couple such as might cause tearing of the web. Also, as in the above-described embodiments, the incremental advance of the web in the press of FIG. 6 is determined by the sprocket means independently of the forward feeding of the web by the printing couple.

Since the embodiments of the invention shown employ a printing couple of the type heretofore conventionally used in sheet-fed rotary intaglio printing presses, it will be appreciated that such a sheet-fed press may be readily modified in accordance with the invention to provide an intermittently fed continuous web rotary intaglio press, i.e. by substituting for the sheet-feeding and handling instrumentalities the web register elements of the invention and associated web supply and handling means. Similarly, sheet-fed presses for performing other printing operations such as offset, letterpress, or gravure printing, etc., having rotary printing couples of the intermittent-feeding type, may be modified in like manner to provide web-fed presses in accordance with the invention.

It is to be understood that the invention is not limited to the features and embodiments herein specifically set forth but may be carried out in other ways without departure from its spirit.

I claim:

1. In a press for printing repeated impressions on a continuous punched web while advancing said web forwardly by a predetermined increment in correspondence with the printing of each impression thereon, in combination:

a. a rotary printing couple for alternately engaging said web to print an impression thereon while feeding said web forwardly, and releasing said web, during successive periods of each of repetitive operating cycles;

b. cyclically movable sprocket means positioned in the path of advance of said web on one side of said printing couple for positively engaging successive punched holes of said web;

c. web-drawing means positioned in the path of advance of said web on the side of said printing couple remote from said sprocket means for slidably engaging said web and exerting thereon a tensioning force tending to draw said web along said path in a direction away from said sprocket means; and

d. means for actuating said sprocket means and said web-drawing means to effect forward movement of said web past said sprocket means during each period of feed of said web by said printing couple and rearward movement of said web past said printing couple during each period of release of said web by said printing couple, in such manner as to produce a net forward advance of said web past said printing couple equal to said predetermined increment between the initiation of one period of feed of said web and the initiation of the next period of feed of said web, said actuating means including:

i. drive means synchronized with said printing couple for intermittently cyclically moving said sprocket means to index said web forwardly past said sprocket means during each period of feed of said web by said printing couple; and

ii. means for actuating said web-drawing means to exert said tensioning force on said web at least during each period of release of said web by said printing couple.

2. A press as defined in claim 1, wherein said sprocket means is positioned ahead of said printing couple, wherein said tensioning force tends to draw said web forwardly along said path, and wherein said drive means cyclically moves said sprocket means to index said web forwardly during each period of feed of said web by an a amount greater than said predetermined increment and rearwardly during at least a portion of each period of release of said web by said printing couple by an amount equal to the difference between said amount of forward indexing of said web and said predetermined increment.

3. A press as defined in claim 1, wherein said sprocket means is positioned beyond said printing couple and said tensioning force tends to draw said web rearwardly along said path.

4 In a press for printing repeated impressions on a continuous punched web while advancing said web forwardly by a predetermined increment in correspondence with the printing of each impression thereon, in combination:

a. a rotary printing couple for alternately engaging said web to print an impression thereon while feeding said web forwardly by an amount greater in length than said predetermined increment, and releasing said web, during successive periods of each of repetitive operating cycles;

b. cyclically movable sprocket means positioned in the path of advance of said web from said printing couple for positively engaging successive punched holes of said web;

c. web-drawing means positioned in the path of advance of said web to said printing couple for slidably engaging said web and exerting thereon a rearwardly directed tensioning force;

d. drive means synchronized with said printing couple for intermittently cyclically moving said sprocket means to index said web forwardly by said predetermined increment past said sprocket means during each period of feed of said web by said printing couple, a slack portion of said web being created between said printing couple and said sprocket means during each period of feed of said web, and said drive means maintaining said sprocket means stationary for at least a portion of each period of release of said web by said printing couple; and

e. means for actuating said web-drawing means to exert said tensioning force on said web at least during said period of release of said web by said printing couple, said tensioning force being effective to retract said web past said printing couple during said period of release of said web by said printing couple and thereby to take up said slack portion of said web.

5. A press as defined in claim **4**, wherein said web-drawing means has a movable surface continuously slidably engaging said web and said actuating means includes means for moving said surface in a direction opposite to the direction of feeding of said web.

6. A press as defined in claim **5**, wherein said web-drawing means comprises a roller, said surface being a cylindrical surface of said roller and said surface-moving means comprising means for rotating said roller in a direction opposed to the direction of feeding of said web.

7. A press as defined in claim **5**, wherein said actuating means further includes vacuum means for holding said web in engagement with said surface by suction.

8. A press as defined in claim **4**, wherein said rotary printing couple is continuously driven and comprises a plate cylinder and an impression cylinder respectively mounted on opposite sides of said web for rotation about parallel axes, said plate cylinder bearing at least one curved intaglio printing plate, said plate cylinder being spaced from said impression cylinder by a distance greater than the thickness of said web, and said plate cylinder and impression cylinder having cooperating surface portions so dimensioned and oriented that said impression cylinder presses said web against said plate during each rotation of said plate cylinder.

9. A press as defined in claim **8**, further including means positioned adjacent to the path of advance of said web intermediate said printing couple and said sprocket means for displacing said slack portion of said web to exert light tension on said web between said printing couple and said sprocket means.

10. A press as defined in claim **9**, wherein said means for displacing said slack portion of said web comprises means for creating a flow of gas effective to produce an inequality of gas pressures on opposite sides of said slack portion of said web thereby to displace said slack portion toward that side of said web having the lower pressure acting thereon.

11. A press as defined in claim **4**, wherein said sprocket means comprises a cyclically movable member bearing on its periphery a plurality of projections shaped and positioned to engage successive punched holes of said web, and means for maintaining said web in contact with said cyclically movable member to retain the holes of said web in positive engagement with said projections.

12. A press as defined in claim **11**, wherein said means for maintaining said web in contact with said cyclically moving member includes an element positioned in adjacent relation to said cyclically movable member and engageable with said web, said web passing between said cyclically movable member and said element.

13. A press as defined in claim **11**, wherein said cyclically movable member has a cylindrical periphery and is mounted for rotation about its geometric axis.

14. A press as defined in claim **11**, wherein said cyclically movable member comprises an endless band and said sprocket means further includes rollers supporting said band for cyclical movement.

15. A press as defined in claim **4**, wherein said rotary printing couple includes a continuously driven plate cylinder, and wherein said drive means comprises rotary input indexing means for converting continuous rotary input motion to intermittent rotary output motion, and means for transmitting continuous rotary motion from said plate cylinder to said indexing means as the input motion of said indexing means.

16. A press as defined in claim **4**, wherein said drive means is adjustable to vary the extent of cyclical movement of said sprocket means during each period of intermittent movement of said sprocket means and thereby to vary the extent of said predetermined increment of indexing of said web past said sprocket means.

17. A press as defined in claim **4**, wherein said drive means initiates cyclical movement of said sprocket means subsequent to the initiation of each period of feed of said web.

18. A press as defined in claim **4**, wherein said drive means initiates cyclical movement of said sprocket means prior to the initiation of each period of feed of said web.