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UK CL (Edition L) B6C CBBQ CBCA CBCB CBCX CJB CKA CKE CKF CKW CLD CMA CML CMP
INT CL^5 B41F 7/02 7/04 7/12 27/10 27/12 30/00 30/06

(54) **Eliminating gutter crash in offset perfectors.**

(57) In an offset perfector of the kind in which a web of printstock passes between two adjacent blanket cylinders, and of the kind in which each blanket cylinder has a respective associated plate cylinder, and of the kind wherein all four cylinders have substantially parallel axes contained in a common plane, flexural and torsional vibrations resulting from gutter crash are obviated by eliminating (or substantially eliminating) the gutters which cause the vibrations.

Thus, as described, the blanket cylinders are fitted with seamless-sleeve blankets, and the plate cylinders are fitted either with seamless-sleeve printing plates or by plates so fitted that the gutter is effectively less than 80 thousandths of an inch wide.

The blanket cylinders preferably comprise rubber blanket layers supported on expansible nickel sleeves.

Access to the ends of "in situ" cylinders to enable "on-press" exchange of interference-fit seamless blanket or printing sleeves is via "door-like" closures in the machine frame, which closures releasably engage the cylinder-end bearing. Compressed air fed to peripheral apertures in the cylinder creates an air-cushion which expands the sleeves during the exchange.

The consequent reduction in vibration and bearing loading allows the following improvements in machine construction:

(a) elimination of direct running contact between adjacent cylinders via dedicated "bearer" surfaces.
(b) adoption of equal sized printing and blanket cylinders, thereby enabling a reduction of torsional oscillations by adoption of simplified machine drives wherein a drive shaft (210 or 226) directly drives a blanket cylinder via a 1:1 bevel gear (212 or 228), and the other cylinders are driven by 1:1 gearing directly meshing with neighbouing cylinders. Separate parts of a press may be driven in synchronism by independent motors from a single control point, thereby further reducing torsional vibrations due to a long drive shaft.

The consequent reduction of both flexural and torsional vibrations is stated to enable the machine to run at up to 3500 ft per minute before generating vibrations at the resonant frequency of the overall machine structure.

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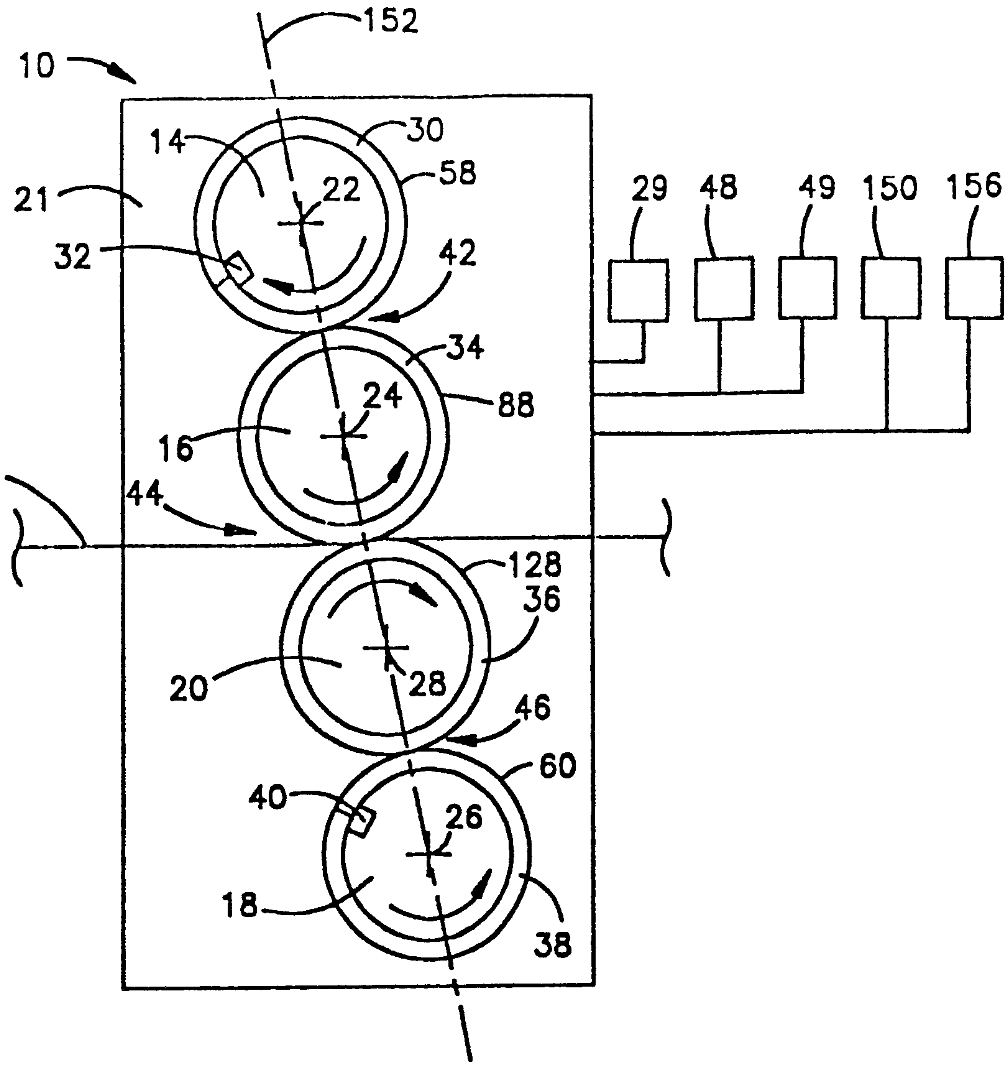
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Fig.1

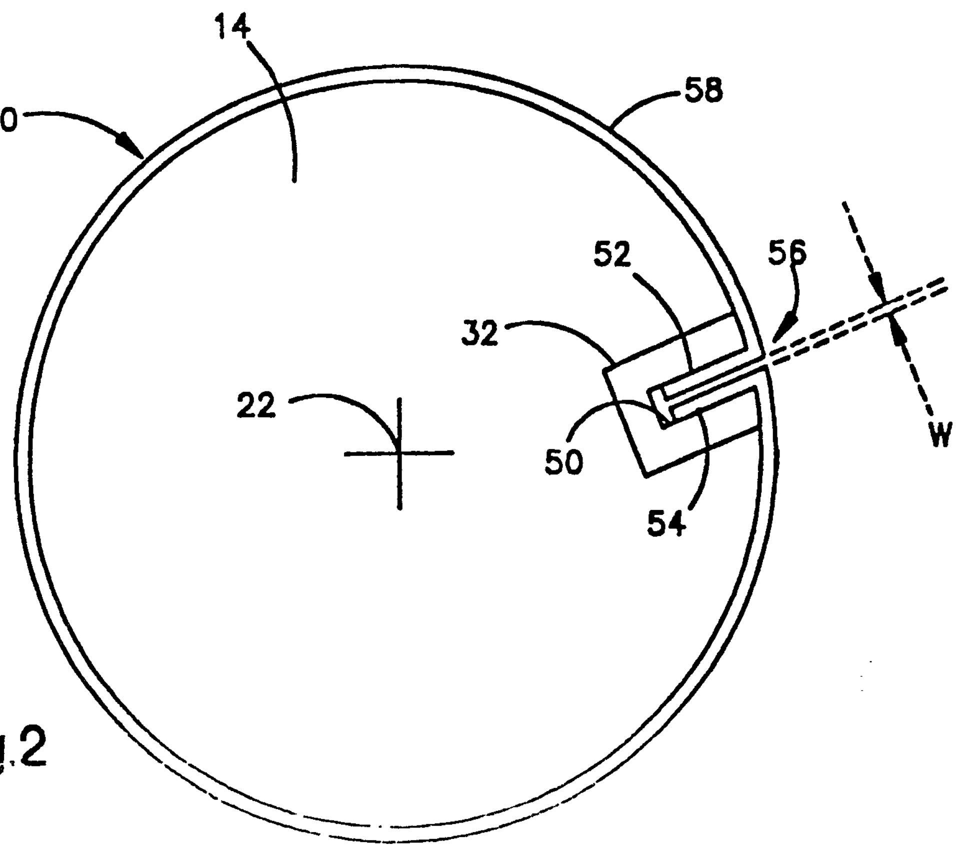
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Fig.2

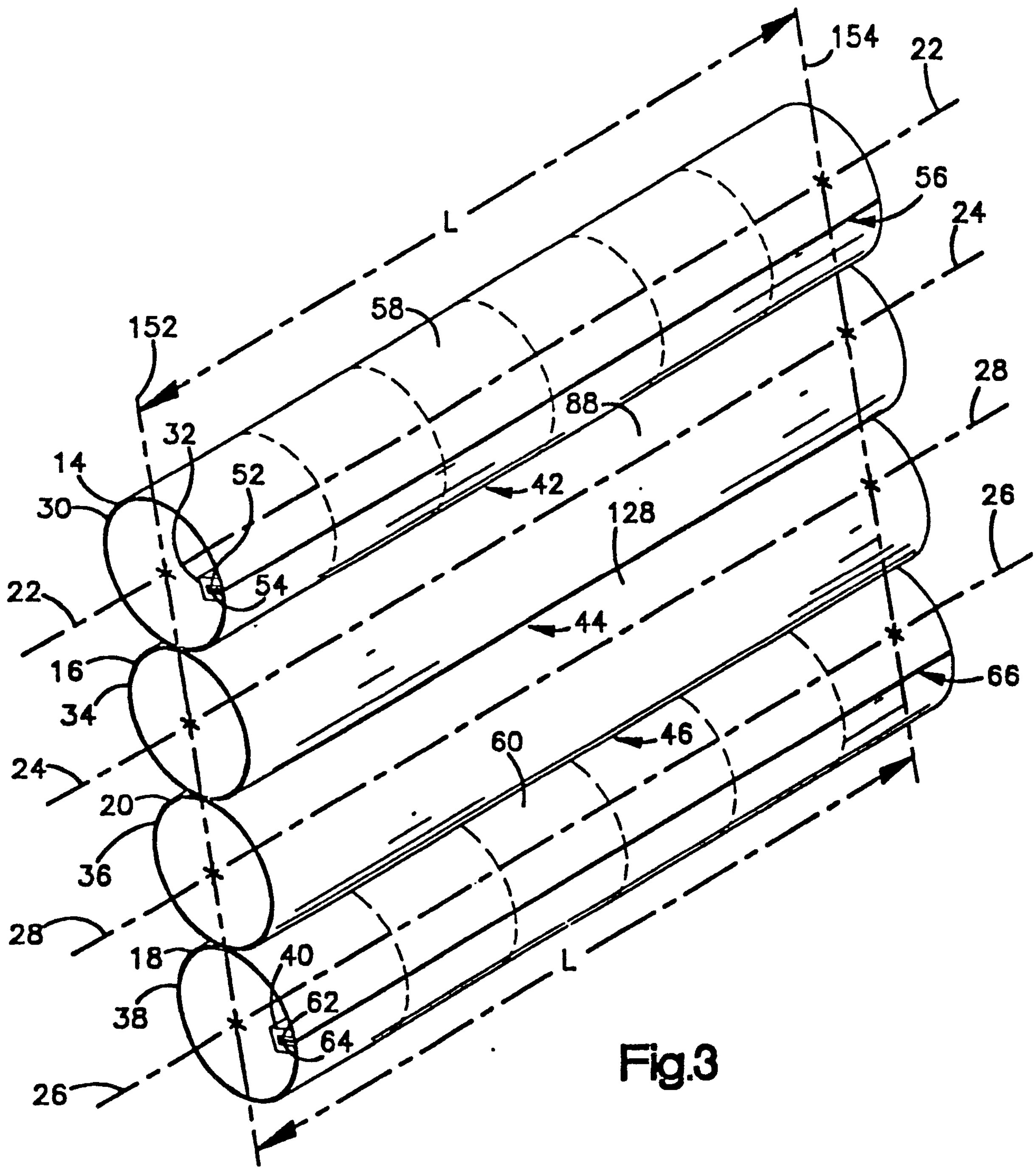

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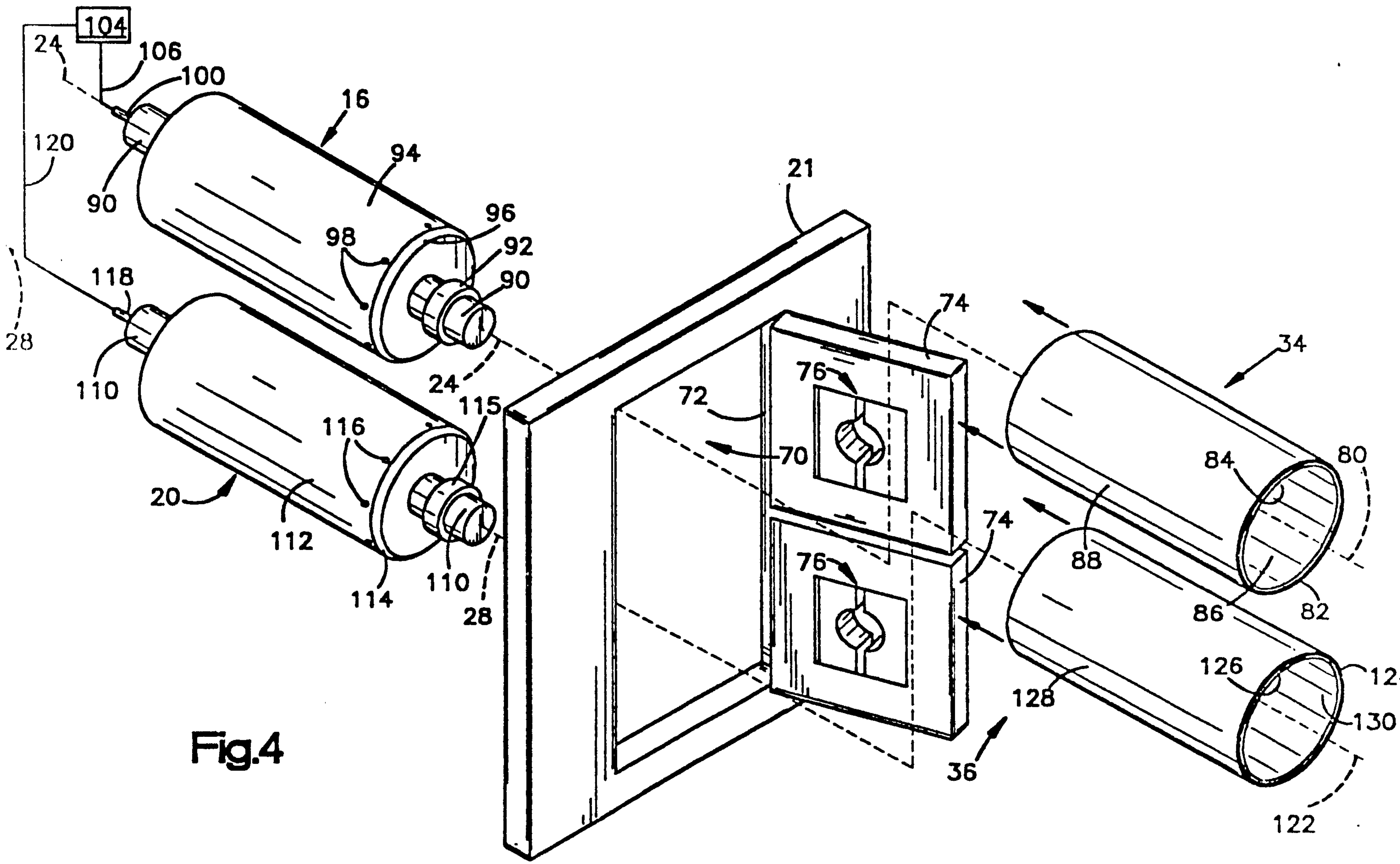
Fig.3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72
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Fig.4

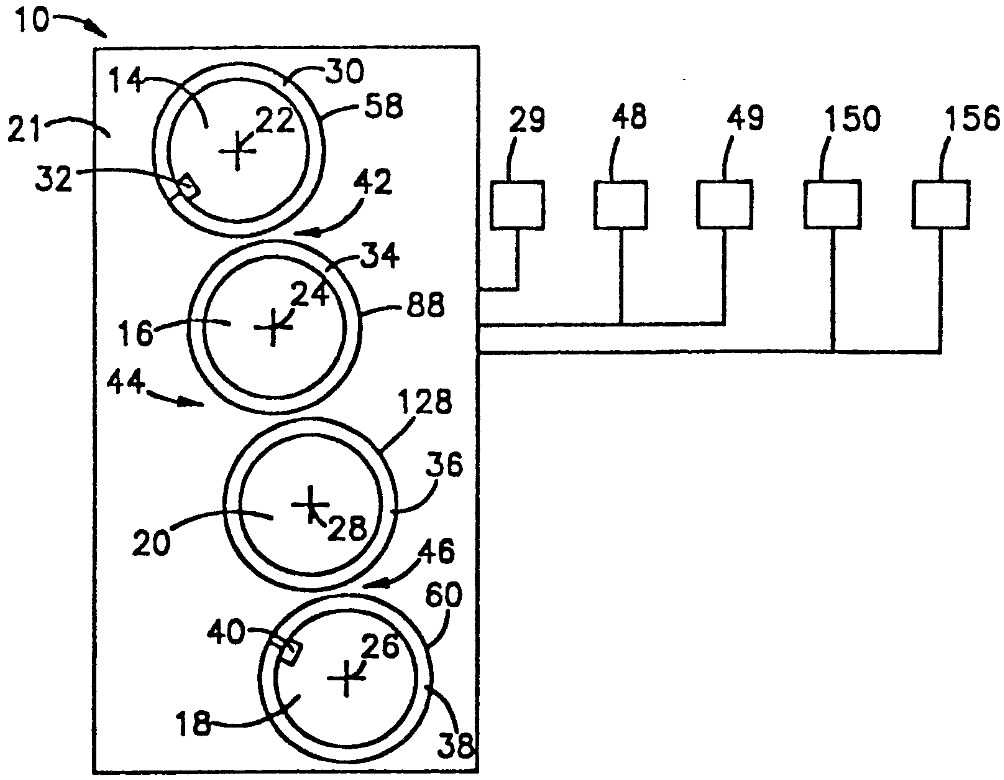
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Fig.5

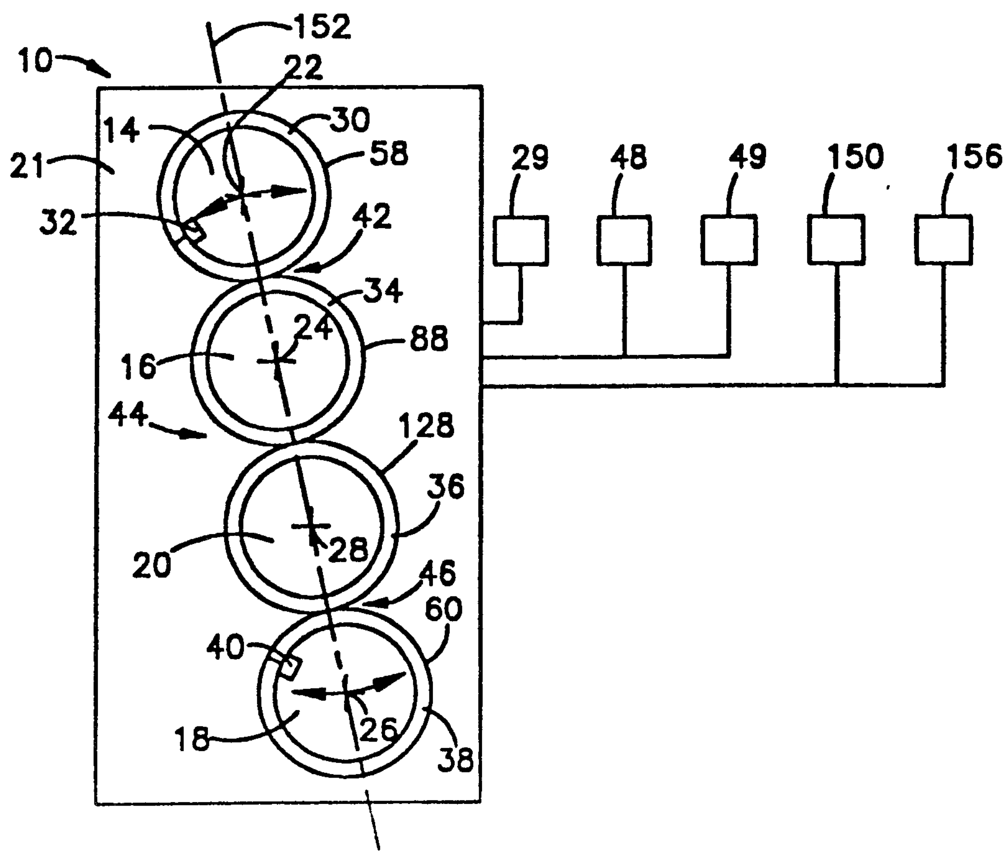
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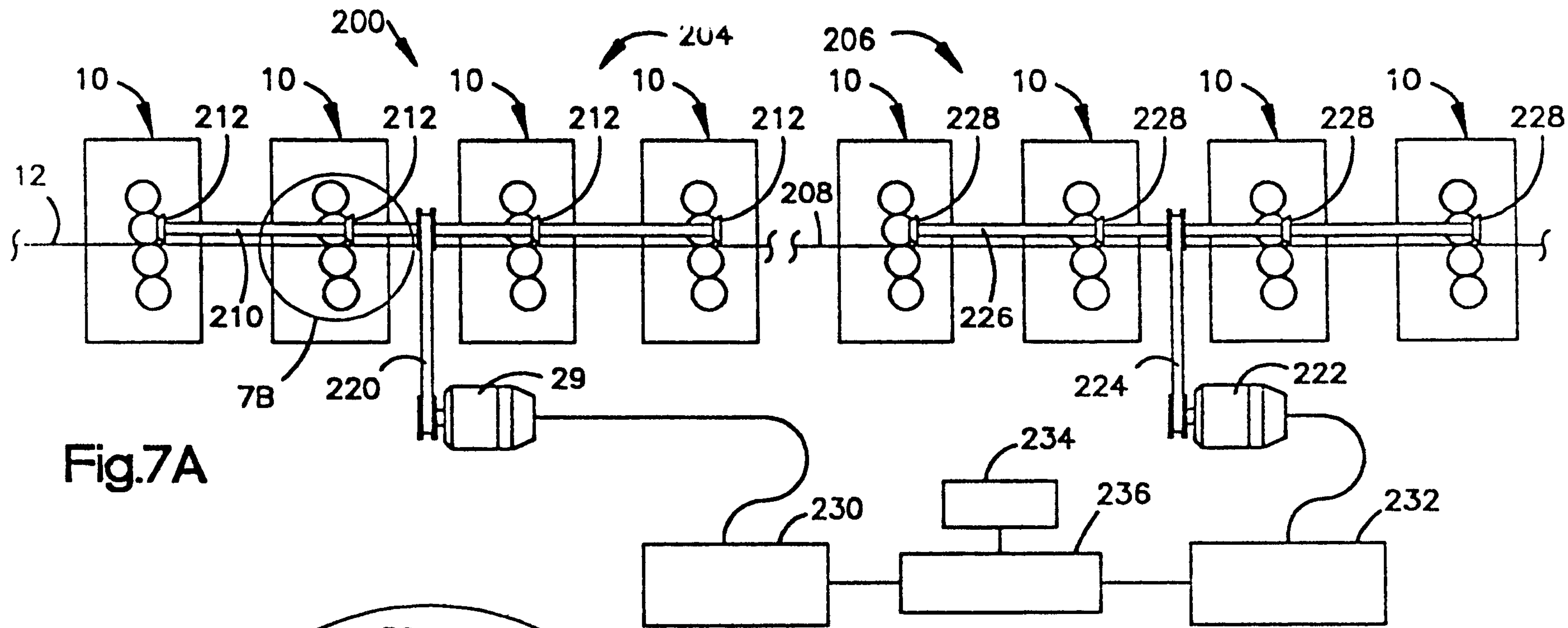
Fig.6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226
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222
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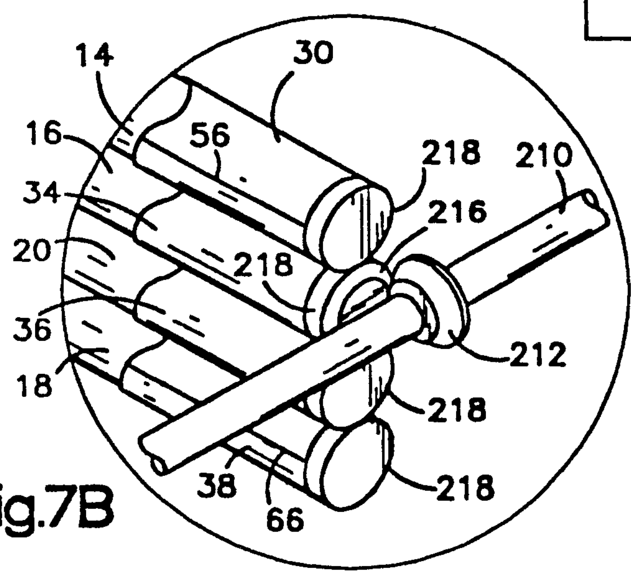
232

Fig.7A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36
212
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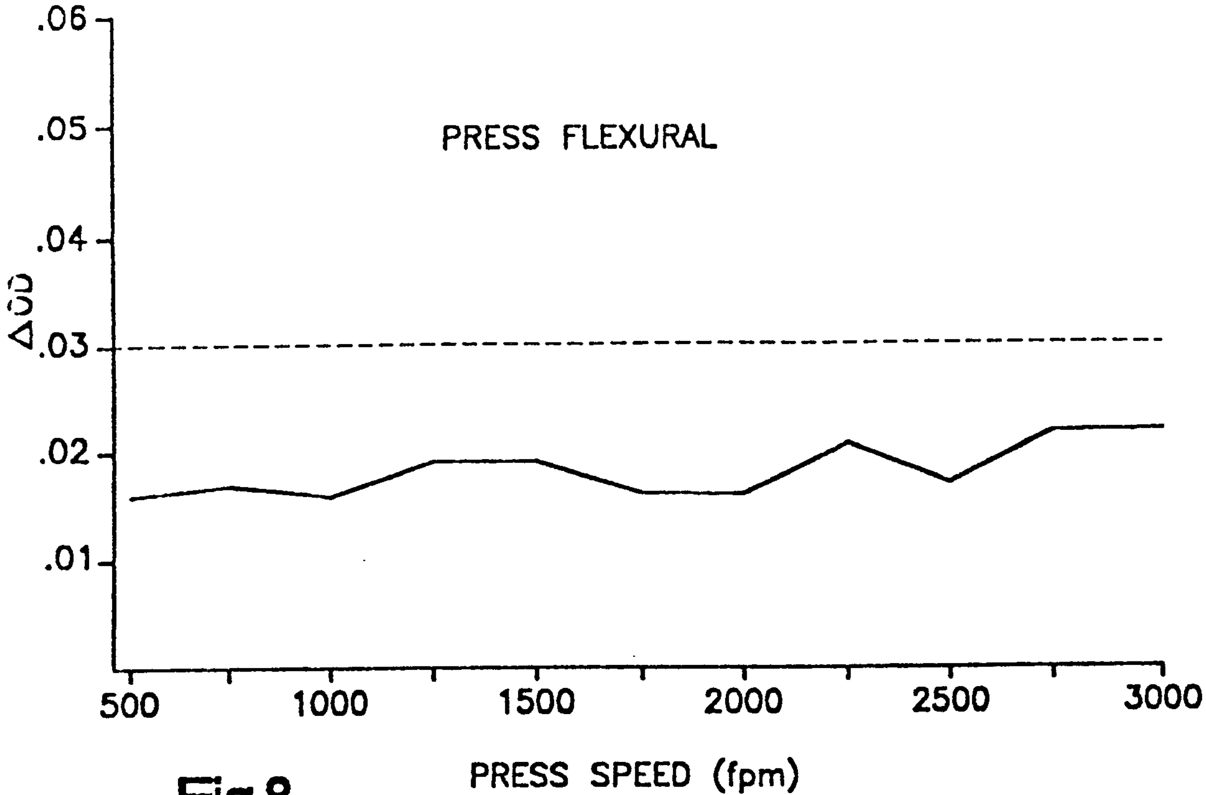
66
218

Fig.7B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.05
.04
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.02
.01
ΔOD
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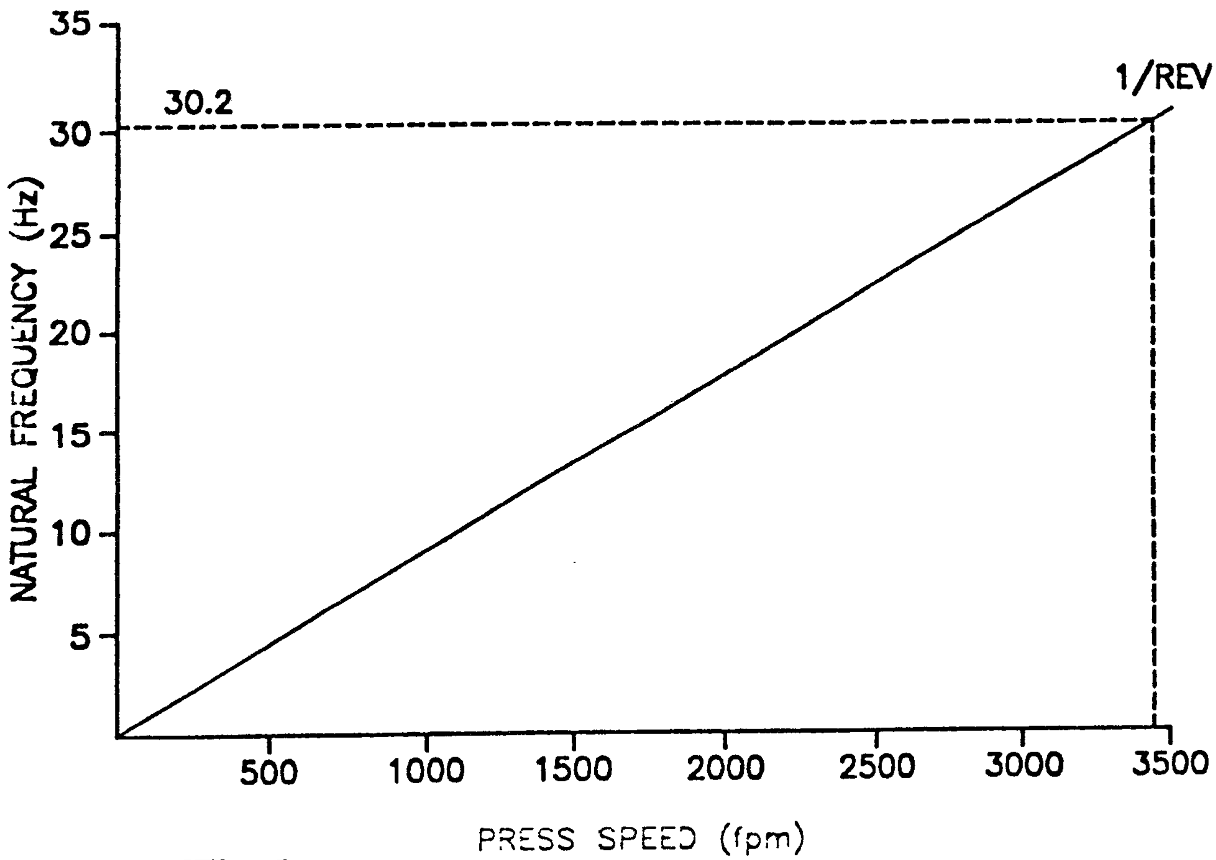
1000
1500
2000
2500
3000
PRESS SPEED (fpm)

Fig.8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30
25
20
15
10
5
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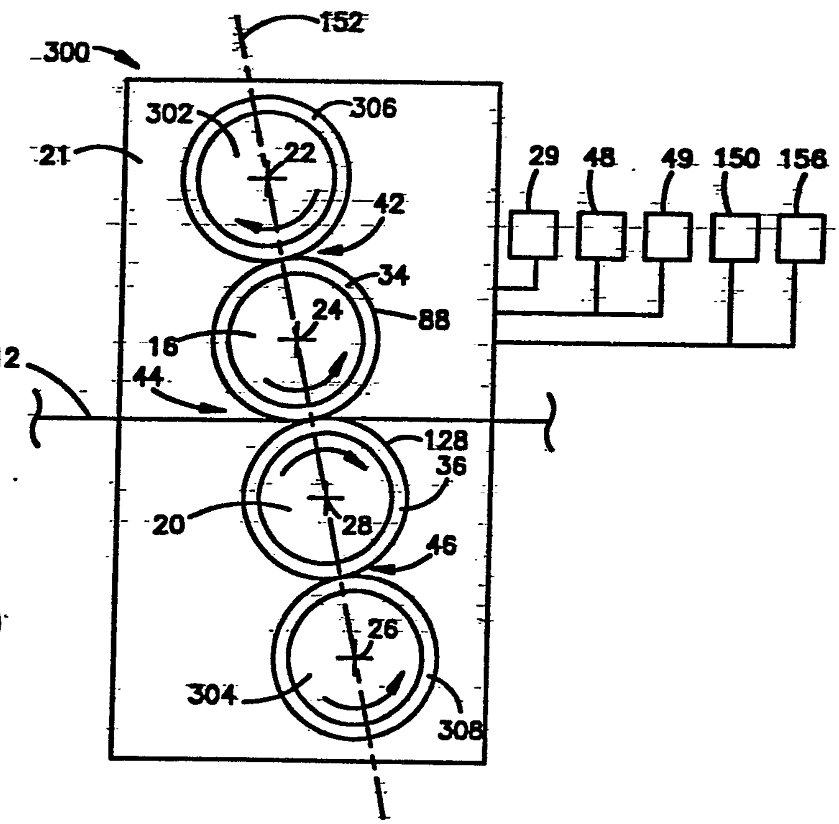
1/REV
500
1000
1500
2000
2500
3000
3500
PRESS SPEED (fpm)

Fig.9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308

Fig.10

OFFSET LITHOGRAPHIC PRINTING PRESS

Field of the Invention

The present invention relates to a printing press, and particularly relates to an offset lithographic printing press.

Background of the Invention

An offset lithographic printing press includes a plurality of printing units arranged in a row. A web of printing material extends longitudinally through the row of printing units. Each of the printing units has a plurality of rotatable printing cylinders, including upper and lower plate cylinders and upper and lower blanket cylinders. The web extends through a nip between the upper and lower blanket cylinders in each of the printing units.

When the printing cylinders rotate in a printing unit, a printing plate on the upper plate cylinder transfers an inked image to a printing blanket on the upper blanket cylinder. The printing blanket on the upper blanket cylinder subsequently transfers the inked image to the upper side surface of the web. A printing plate on the lower plate cylinder and a printing blanket on the lower blanket cylinder similarly transfer an inked image to the lower side surface of the web. Inked images are thus printed on opposite sides of the web as the web is moved successively between the blanket cylinders in each of the printing units in the printing press.

The printing units vibrate when the printing cylinders rotate. The vibrations are caused in part by shock loading where the printing plates and printing blankets move in rolling surface contact between the respective cylinders. The vibrations are also caused in part by dynamic forces transmitted through the rotating parts that are interconnected between the printing cylinders and a motor which rotates the printing cylinders. Such parts include the gears that mesh between the printing cylinders in an individual printing unit, the gears that connect the individual printing units with a common drive shaft, and the drive shaft itself.

The vibrations in the printing press can cause relative movement between the surfaces of the printing plates, the printing blankets and the web. The vibrations can thereby cause the inked images to become smeared. Moreover, the vibrations increase with the press speed. The speed and efficiency of a printing operation are therefore limited by the vibrations in the printing press.

Summary of the Invention

In accordance with the present invention, a printing press is constructed to experience a minimum amount of vibrations, and to minimize the effects of the vibrations that do occur, when printing on opposite sides of a web of printing material. The printing press thereby maximizes the quality of the printed images as well as the speed and efficiency of the press.

In a preferred embodiment of the present invention, a printing unit for a printing press comprises a rotatable upper plate cylinder, a rotatable upper blanket cylinder, a rotatable lower plate cylinder, and a rotatable lower blanket cylinder. A first tubular printing blanket is releasably supported on the upper blanket cylinder. A second tubular printing blanket is releasably supported on the lower blanket cylinder. The tubular printing blankets have gapless cylindrical outer printing surfaces. The cylinders are supported in a frame in an in-line stack. Additionally, all of the cylinders are of the same diameter.

The printing unit is thus constructed to operate with a minimum amount of vibrations. The printing blankets have gapless cylindrical outer printing surfaces. The printing blankets therefore move in rolling surface contact with the adjoining printing plates without the degree of shock loading which is caused by conventional printing blankets that have gaps at their printing surfaces. Since the cylinders are supported in an in-line stack, there is a minimum tendency for a shock load to vibrate the cylinders in such a manner as to smear the inked images. Furthermore, all of the cylinders are of the same diameter. This combination of features is found to minimize the frequencies of both torsional and flexural vibrations in the printing unit. Importantly, the torsional vibrations in the printing unit remain below their natural resonant frequencies throughout the entire range of operating speeds of the printing unit.

In accordance with another feature of the present invention, printing plates on the plate cylinders define narrow gaps extending axially along the length of the plate cylinders. Each gap has a width of only 0.080 inches or less. The cylindrical outer surfaces of the printing plates are therefore interrupted by the gaps only in that slight amount, and the fluctuations in surface pressure between the rotating cylinders are minimized accordingly. The resulting vibrations are likewise minimized so that the printing unit runs at high speeds as smoothly as possible and without the need for commonly used bearers.

Brief Description of the Drawings

The foregoing and other features of the present invention will become apparent to one skilled in the art to which the present invention relates upon consideration of the following description of the invention with reference to the accompanying drawings, wherein:

Fig. 1 is a schematic view of a printing apparatus constructed in accordance with the present invention;

Fig. 2 is a schematic view of parts of the apparatus of Fig. 1;

Fig. 3 is a schematic view of parts of the apparatus of Fig. 1;

Fig. 4 is a schematic view showing parts of the apparatus of Fig. 1 in different positions;

Fig. 5 is a schematic view illustrating operation of a feature of the apparatus of Fig. 1;

Fig. 6 is a schematic view illustrating operation of another feature of the apparatus of Fig. 1;

Fig. 7A is a schematic view of a printing press including the apparatus of Fig. 1;

Fig. 7B is an enlarged partial view of the apparatus of Fig. 7A;

Figs. 8 and 9 are graphic presentations of test data obtained in accordance with the present invention; and

Fig. 10 is a schematic view of another printing apparatus constructed in accordance with the present invention.

Description of Preferred Embodiment

A printing unit 10 constructed in accordance with the present invention is shown schematically in Fig. 1. The printing unit 10, by way of example, is an offset lithographic printing unit for printing an opposite sides of a web 12. The printing unit 10 includes an upper plate cylinder 14 and an upper blanket cylinder 16 above the web 12, and a lower plate cylinder 18 and a lower blanket cylinder 20 below the web 12. The cylinders 14-20 are supported in a frame having a pair of side walls 21, one of which is shown in Fig. 1.

The upper plate cylinder 14 has a longitudinal central axis 22. The upper blanket cylinder 16 has a longitudinal central axis 24, and the lower plate cylinder 18 has a longitudinal central axis 26. The lower blanket cylinder 20 has a longitudinal central axis 28. A motor 29 drives a gear train in the printing unit 10 which is connected to the cylinders 14-20. The motor 29 thus rotates each of the cylinders 14-20 about its respective axis as indicated by the arrows shown in Fig. 1.

The upper plate cylinder 14 carries a printing plate 30 which defines an image to be printed. The printing plate 30 is formed as a thin metal sheet, and is mounted on the cylinder 14 by wrapping the sheet around the cylinder 14. A locking mechanism 32 in the cylinder 14 holds the printing plate 30 securely on the cylinder 14. The upper blanket cylinder 16 carries a printing blanket 34. The printing blanket 34 is formed as a tube which is mounted on the cylinder 16 by sliding the tube telescopically over the cylinder 16. Another tubular printing blanket 36 is similarly mounted on the lower blanket cylinder 20, and another printing plate 38 is held on the lower plate cylinder 18 by a locking mechanism 40.

When the cylinders 14-20 are being rotated by the motor 29, ink is supplied to both of the printing plates 30 and 38 by an inker system 48. The inker system 48 includes ink reservoirs and inker rolls, as is known in the art. A dampening system 49 simultaneously supplies dampening liquid to the printing plates 30 and 38. The dampening system 49 similarly includes dampening liquid reservoirs and dampener rolls which are known in the art. Each of the printing plates 30 and 38 has surface portions that are receptive to ink and repellant to dampening liquid, and surface portions that conversely are receptive to dampening liquid and repellant to ink. The ink and the dampening liquid separately adhere to the former and the latter surface portions, respectively. Inked images are thus formed on the printing plates 30 and 38.

The inked image on the upper printing plate 30 is transferred to the upper printing blanket 34 at the nip 42 between the upper plate cylinder 14 and the upper blanket cylinder 16. The upper printing blanket 34 subsequently transfers the inked image to the upper side surface of the web 12 at the nip 44 between the upper and lower blanket cylinders 16 and 20. The lower printing plate 38 transfers its inked image to the lower printing blanket 36 at the nip 46 between the lower plate cylinder 18 and the lower blanket cylinder 20. The lower printing blanket 36 subsequently transfers that inked image to the lower side surface of the web 12 at the nip 44. The printing unit 10 thus prints simultaneously on opposite sides of the web 12.

The upper printing plate 30 and the upper plate cylinder 14 are shown in greater detail in Fig. 2. As shown in Fig. 2, the locking mechanism 32 in the upper plate cylinder 14 defines a recess 50. The recess 50 extends into the cylinder 14, and extends axially along the length of the cylinder 14. The printing plate 30 has opposite longitudinal edge portions 52 and 54 which extend into the recess 50. The locking mechanism 32 holds the longitudinal edge portions 52 and 54 in the recess 50, and thus holds the printing plate 30 on the cylinder 14.

When the upper printing plate 30 is mounted on the upper plate cylinder 14 as shown in Fig. 2, its opposite longitudinal edge portions 52 and 54 define a gap 56. The gap 56 extends axially along the length of the printing plate 30, and has a width W extending circumferentially between the two opposite longitudinal edge portions 52 and 54. The gap 56 moves through the nip 42 between the upper plate cylinder 14 and the upper blanket cylinder 16 each time the upper plate cylinder 14 rotates about its axis 22. Since the gap 56 interrupts the cylindrical outer surface 58, it causes the surface pressure between the upper printing plate 30 and the upper printing blanket 34 to drop momentarily each time it moves through the nip 42. The gap 56 thus causes fluctuations in the surface pressure between the plate 30 and the blanket 34 during a printing operation.

The fluctuations in surface pressure that are caused by the gap 56 are transmitted as shock loads to the other cylinders. The shock loads transmitted to the blanket cylinders 16 and 20 can urge the printing blankets 34 and 36 to vibrate relative to the printing plates 30 and 38 and relative to the web 12. Such vibrations, if excessive, could cause the inked images to become smeared. However, the width W of the gap 56 in the preferred embodiment of the invention is equal to 0.080 inches or less, and is most preferably equal to 0.040 inches or less. The interruption in the outer printing surface 58, the shock loading, and the resulting vibrations are thus diminished in accordance with the present invention.

As shown in Fig. 3, the lower printing plate 38 on the lower plate cylinder 18 similarly has an outer surface 60 and opposite longitudinal edge portions 62 and 64 which are held in the associated locking mechanism 40. The opposite longitudinal edge portions 62 and 64 of the lower printing plate 38 thus define a gap 66 like the gap 56. The width of the gap 66 also is equal to 0.080 inches or less, and is most preferably equal to 0.040 inches or less. The gaps 56 and 66 move through the nips 42 and 46 (Fig. 1) at the same time.

In the particular embodiment of the invention shown in the drawings, the lengths L (Fig. 3) of the printing plates

30 and 38 are equal to 54 inches. The gaps 56 and 66 are 0.060 inches wide. The total distance measured circumferentially around each of the plates 30 and 38, including the width of the respective gap 56 or 66, is 22.25 inches. Since image-defining areas of the surfaces 58 and 60 are spaced apart circumferentially across the gaps 56 and 66, the gaps 56 and 66 contribute to waste in the web 12. However, the narrow gap widths in accordance with the present invention enable the amount of waste to be held to a minimum.

The blanket cylinders 16 and 20, the printing blankets 34 and 36, and a sidewall 21 of the frame are shown in greater detail in Fig. 4. As indicated by the arrows shown in Fig. 4, the printing blankets 34 and 36 are movable telescopically over the blanket cylinders 16 and 20. The sidewall 21 of the frame has an inner surface 70 defining an opening 72 through which the blankets 34 and 36 pass when they are moved over the cylinders 16 and 20. The sidewall 21 also has a pair of doors 74. Each of the doors 74 supports a clamping assembly 76. When the doors 74 are open as shown in Fig. 4, the blankets 34 and 36 are movable longitudinally past the doors 74 and through the opening 72. The doors 74 also have closed positions (not shown) in which they extend across the opening 72 and block movement of the printing blankets 34 and 36 through the opening 72. When the doors 74 are in their closed positions, the clamping assemblies 76 on the doors 74 are located in positions to support the cylinders 16 and 20 for rotation about their axes 24 and 28.

As shown in Fig. 4, the upper printing blanket 34 has a central axis 80, a printing portion 82 and a supporting sleeve 84. The sleeve 84 is relatively rigid, and has a gapless cylindrical inner mounting surface 86. The sleeve 84 is preferably formed of nickel. The printing portion 82 is flexible, and has a cylindrical shape with a gapless cylindrical outer printing surface 88. In the particular embodiment shown in the drawings, the outer printing surface 88 of the blanket 34 has the same 54 inch length L of the printing plates 30 and 38, as shown in Fig. 3, and has a circumference of 22.281 inches. The circumference of the outer surface 88 of the blanket 34 is slightly (0.025 inches) greater than the combined circumferential dimensions of the outer surface 58 of the plate 30 and the gap 56 because the outer surface 88 of the blanket 30 is indented by the plate 30 at the nip 42, as is known. In this particular embodiment of the invention, the blanket 34 thus has a length to circumference ratio of 2.42. The length to circumference ratio of a printing blanket constructed in accordance with the invention can have a different value, but is preferably at least approximately 1.70.

As further shown in Fig. 4, the upper blanket cylinder 16 has a pair of stub shafts 90 for supporting the cylinder 16 to rotate about its axis 24. A bearing assembly 92 is supported on the stub shaft 90 adjacent to the sidewall 21. the bearing assembly 92 is releasably clamped in the associated clamping assembly 76 when the door 74 is closed. The cylinder 16 also has a cylindrical outer surface 94 and a chamfered edge surface 96 at one axial end of the outer surface 94. The outer surface 94 of the cylinder 16 has a diameter which is slightly greater than the inside diameter of the sleeve 84 in the blanket 34. The chamfered edge surface 96 of the cylinder 16 slopes radially inward from the outer surface 94, and has a diameter at its axially outer end which is slightly less than the inside diameter of the sleeve 84.

The upper blanket cylinder 16 further has a plurality of air flow openings 98 at the outer surface 94. The air flow openings 98 are arranged in a circumferential array closely spaced from the chamfered edge surface 96, and communicate with an air flow inlet 100 through passages within the cylinder 16. The air flow inlet 100 communicates with a source 104 of pneumatic pressure through a pneumatic line 106.

The blanket 34 is mounted on the cylinder 16 by moving the blanket 34 telescopically over the cylinder 16. Because the outer surface 94 of the cylinder 16 has a diameter which is slightly greater than the inside diameter of the sleeve 84 in the blanket 34, the sleeve 84 is forced to expand diametrically when it is moved against the chamfered edge surface 96 in a direction axially toward the cylindrical outer surface 94. When the inner mounting surface 86 of the sleeve 84 is moved axially over the air flow openings 98 at the outer surface 94 of the cylinder 16, pneumatic pressure is directed from the source 104 to the air flow openings 98. Pressurized air then flows radially outward from the openings 98 and impinges upon the inner mounting surface 86 of the sleeve 84 to further expand the sleeve 84 diametrically. The pneumatic pressure directed against the inner mounting surface 86 of the sleeve 84 expands the sleeve 84 continuously as the sleeve 84 is moved axially over the outer surface 94 of the cylinder 16. When the blanket 34 is moved axially into its installed position on the cylinder 16, the pneumatic pressure is relieved. The sleeve 84 in the blanket 34 then elastically contracts diametrically against the outer surface 94 of the cylinder 16. The blanket 34, which has an initial inside diameter less than the diameter of the outer surface 94 of the cylinder 16, is thus installed on the cylinder 16 with an interference fit.

The blanket 34 is subsequently removed from the cylinder 16 by again expanding the sleeve 84 diametrically under the influence of pneumatic pressure, and by sliding the blanket 34 axially off the cylinder 16 when the blanket 34 is in its expanded condition. The nickel material of the sleeve 84 has the optimum elasticity for installing and removing the blanket 34 in the foregoing manner when subjected to standard shop air pressure of 90 psi.

The lower blanket cylinder 20 and the lower printing blanket 36 are constructed like the upper blanket cylinder 16 and the upper printing blanket 34. The lower blanket cylinder 20 has a pair of stub shafts 110, a cylindrical outer surface 112, and a chamfered edge surface 114. A bearing assembly 115, which is constructed like the bearing assembly 92, is supported on the stub shaft 110 adjacent to the sidewall 21. A circumferential array of air flow openings 116 at the outer surface 112 communicate with an air flow inlet 118 through passages within the cylinder 20. The inlet 118 communicates with the source 104 of pneumatic pressure through a pneumatic line 120.

The lower printing blanket 36 has a central axis 122, a flexible printing portion 124, and a relatively rigid nickel supporting sleeve 126. The sleeve 126 has a cylindrical inner mounting surface 130 which is elastically expandable under the influence of pneumatic pressure. The lower blanket 36 is thus movable telescopically over the lower blanket cylinder 20 in the same manner as described above concerning the upper blanket 34 and the upper blanket cylinder 16. The flexible printing portion 124 of the lower blanket 36 has a gapless cylindrical outer printing surface 128. The outer printing surface 128 is of the same size as the outer printing surface 88 on the upper blanket 34.

When the printing plates 30 and 38 and the printing blankets 34 and 36 are mounted on the cylinders 14-20 as described above, the outer surfaces 58 and 60 of the plates 30 and 38 have nearly the same diameter as the outer surfaces 88 and 128 of the blankets 34 and 36. The diameter of the plate cylinders 14 and 18 is different from the diameter of the blanket cylinders 16 and 20, but only in the slight amount which is attributable to the slightly differing sizes of the printing plates 30 and 38 and printing blankets 34 and 36. That slight amount is not a substantial portion of the diameters of the cylinders 14-20. The cylinders 14-20 are thus considered to be of equal diameter in the context of the present invention, and to have cylinder diameter ratios of 1:1.

The printing unit 10 also includes a throw-off mechanism 150. The throw-off mechanism 150 moves the cylinders 14-20 relative to each other between printing positions (Fig. 1) and thrown-off positions (Fig. 5). When the cylinders 14-20 are in their printing positions, the printing plates 30 and 38 and the printing blankets 34 and 36 are held in surface contact at the nips 42 and 46. The printing blankets 34 and 36 can then transfer the inked images from the printing plates 30 and 38 to the opposite sides of the web 12 at the nip 44. When the throw-off mechanism 150 has moved the cylinders 14-20 into their thrown-off positions, the printing plates 30 and 38 and the printing blankets 34 and 36 are spaced from each other across the nips 42, 44 and 46. The throw-off mechanism 150 thus moves the cylinders 14-20 as necessary to provide clearance for the printing plates 30 and 38 and the printing blankets 34 and 36 to be mounted on and taken off their respective cylinders as described above.

When the cylinders 14-20 are located in their printing positions, their axes 22-28 all intersect a pair of straight lines 152 and 154, as shown in Fig. 3. The cylinders 14-20 are thus arranged in an in-line stack. The cylinders 14-20 may deviate slightly from the ideal positions shown in Fig. 3 and still be considered to be located in an in-line stack. However, a line extending between adjacent cylinder axes is preferred not to be inclined more than 4° relative to the line 152 or the line 154. The cylinders 14-20 may deviate further from the ideal positions shown in Fig. 3 as a result of dimensional tolerances in the construction of the printing unit 10, and/or as a result of adjustments in the positions of the cylinders 14-20. In such cases the cylinders 14-20 would still be considered to be arranged in an in-line stack as long as they are located substantially on or close to the lines 152 and 154. Additionally, the lines 152 and 154 are inclined approximately 15° from a vertical line for canting at the nip 44.

When the gaps 56 and 66 at the printing plates 30 and 38 move through the respective nips 42 and 46 at the blanket cylinders 16 and 20, the resulting shock loads are transmitted through all of the cylinders 14-20. Because the cylinders 14-20 are arranged in an in-line stack, the shock loads are transmitted across the nips 42, 44 and 46 in directions parallel, or substantially parallel, to the lines 152 and 154. The shock loads are thus directed across the nips 42, 44 and 46 in directions that are perpendicular, or substantially perpendicular, to the directions in which the printing surfaces 58, 88, 128 and 60 move through the nips 42, 44 and 46. If the shock loads were parallel to the directions in which the printing surfaces 58, 88, 128 and 60 move through the nips 42, 44 and 46, adjacent printing surfaces could speed up or slow down relative to each other. The inked image moving through the associated nip could then become smeared. However, the shock loads in the printing unit 10 are perpendicular to the directions of movement of the printing surfaces 58, 88, 128 and 60 through the nips 42, 44 and 46, and therefore do not interfere substantially with movement of the printing surfaces 58, 88, 128 and 60 through the nips 42, 44 and 46. The arrangement of the cylinders 14-20 in an in-line stack thus diminishes the detrimental effect of the shock loading caused by the gaps 56 and 66 at the plate cylinders 30 and 38.

The printing unit 10 further includes a skew mechanism 156. The skew mechanism 156 moves the plate cylinders 14 and 18 to adjust the angular positions of the printing plates 30 and 38 relative to the printing blankets 34 and 36. Specifically, the skew mechanism 156 moves one end of the upper plate cylinder 14 relative to its other end. The end of the axis 22 shown in Fig. 6 then moves to the right or left as viewed in Fig. 6. The upper plate cylinder 14 is thus skewed relative to the upper blanket cylinder 16, and the relative angular positions of the upper printing plate 30 and the upper printing blanket 34 are adjusted accordingly.

In the preferred embodiment of the present invention, the skew mechanism 136 moves the end of the axis 22 of the upper plate cylinder 14 along a circular path centered on the axis 24 of the upper blanket cylinder 16. The skew mechanism thus changes the relative angular positions of the upper printing plate 30 and the upper printing blanket 34 without changing the surface pressure between the plate 30 and the blanket 34. The skew mechanism 156 likewise moves the axis 26 of the lower plate cylinder 18 along a circular path centered on the axis 28 of the lower blanket cylinder 20.

When the skew mechanism 156 moves the plate cylinders 14 and 18, the ends of the axes 22 and 26 shown in Fig. 6 are moved transversely off of the line 152. However, the axes 22 and 26 are moved by the skew mechanism 156 only in small amounts which do not remove the plate cylinders 14 and 18 from the in-line stack of cylinders. The adjustments made by the skew mechanism 156 therefore do not interfere with the ability of the in-line stack to direct the shock loads through the cylinders 14-20 in directions parallel to the lines 152 and 154, as described above.

The printing unit 10 described above with reference to Figs. 1-6 is a typical printing unit constructed in accordance with the present invention. A printing press 200 including a plurality of the typical printing units 10 is shown schematically in Fig. 7A. The printing units 10 in the printing press 200 are arranged in a row in two successive groups 204 and 206. The web 12 moves longitudinally through all of the printing units 10 in the first group 204. A second web 208 moves longitudinally through all of the printing units 10 in the second group 206. Each successive one of the printing units 10 prints a differently colored image over the image printed on the associated web 12 or 208 by the preceding printing unit 10. The printing press 200 thus prints multi-color images on the webs 12 and 208.

A first drive shaft 210 extends longitudinally between the printing units 10 in the first group 204. The first drive shaft 210 supports a plurality of bevel gears 212, including a individual bevel gear 212 at each one of the printing units 10 in the first group 204. As shown in greater detail in Fig. 7B, each one of the bevel gears 212 on the first drive shaft 210 meshes with a bevel gear 216 in the respective printing unit 10. Each one of the bevel gears 216 is fixed to the upper blanket cylinder 16 in the respective printing unit 10, and has a 1:1 angular velocity ratio with the respective bevel gear 212 on the first drive shaft 210. Therefore, each of the upper blanket cylinders

16 in the first group 204 completes one revolution about its axis upon each revolution of the first drive shaft 210.

As further shown in Fig. 7B, a drive gear 218 is fixed to the upper blanket cylinder 16 adjacent to the bevel gear 216. The drive gear 218 rotates with the upper blanket cylinder 16 under the influence of the first drive shaft 210. Additional drive gears 218 are fixed to the other cylinders 14, 18 and 20, and a similar set of drive gears 218 (not shown) is fixed to the other ends of all of the cylinders 14-20. Each of the drive gears 218 meshes with the adjacent drive gear 218, and has an angular velocity ratio of 1:1 with the adjacent drive gear 218. Therefore, each of the cylinders 14, 18 and 20 completes one revolution about its axis along with the upper blanket cylinder 16 upon each revolution of the first drive shaft 210.

As noted above with reference to Fig. 1, the gear train comprising the drive gears 218 is driven by the motor 29. As shown in Fig. 7A, the motor 29 rotates the first drive shaft 210 through an endless drive member 220. In the same manner, the cylinders in the second group 206 of printing units 10 are rotated by a second motor 222, a second endless drive member 224, and a second drive shaft 226 with bevel gears 228. The motors 29 and 222 are actuated by respective controllers 230 and 232 in response to signals received from an operator's control panel 234. The actuation of the motors 29 and 222 is coordinated by a communication link 236 so that the webs 12 and 208 are moved simultaneously through the two groups 204 and 206 of printing units 10 in the printing press 200.

Each printing unit 10 has one or more natural resonant frequencies of flexural vibration. The natural resonant frequencies of flexural vibration are determined by inherent features of the printing unit 10. Each printing unit 10 further has imperfections that cause the cylinders to bend when the printing unit 10 is operating. Such imperfections include the axially extending printing plate gaps 56 and 66. These imperfections act as forcing functions that cause the printing unit 10 to vibrate flexurally. The frequency of the flexural forcing functions varies with the press speed.

A conventional printing unit has one or more press speeds at which the actual frequency of flexural forcing functions will be equal to a natural resonant frequency. As compared with flexural forcing functions occurring at other frequencies, large flexural forcing functions occurring at a natural resonant frequency will cause a larger amplitude of flexural vibration and thus will have a more detrimental effect on the print quality.

Each printing unit 10, as described above, is constructed so that the actual amplitude of the flexural forcing functions cannot become large at press speeds within the operating range of the printing unit 10. This is accomplished in part by inhibiting and minimizing the forcing functions that cause flexural vibrations.

Specifically, the gaps 56 and 66 at the upper and lower printing plates 30 and 38 act as forcing functions that cause the cylinders to vibrate flexurally. In accordance with the present invention, the widths of the gaps 56 and 66 are minimized. The corresponding forcing functions are thus inhibited. Additionally, the upper and lower printing blankets 34 and 36 have gapless cylindrical outer printing surfaces 88 and 128, whereas conventional printing blankets have gaps that are similar to the gaps 56 and 66 in the printing plates 30 and 38. The present invention thus eliminates the forcing functions which would otherwise be attributable to gaps in the printing blankets 34 and 36. Furthermore, the effects of any flexural vibrations are reduced in accordance with the present invention by the in-line stack of cylinders. As a result of these features of the invention, each printing unit 10 can be operated at press speeds throughout a range of 0-3,500 feet per minute with low amplitudes of flexural vibration.

Print quality can be measured in terms of the visibly noticeable change in optical density. As shown in Fig. 8, a printing press constructed like the printing press 200 produced visibly noticeable changes in optical density (ΔOD) below the design goal of only 0.03 throughout a range of press speeds extending from 500 to 3,000 feet per minute. Such a small change in optical density has previously been difficult to achieve with cylinders with a 1:1 ratio that are 50 or more inches in length because of the flexural vibrations experienced by such long cylinders. Such a small change in optical density has been particularly difficult to achieve at high press speeds with prior art printing presses because of the large amplitudes of flexural vibration which occur at high press speeds.

Each printing unit 10 further has one or more natural resonant frequencies of torsional vibration. The natural resonant frequencies of torsional vibration are determined by the mass and torsional stiffness of the rotating parts. The forcing functions that cause torsional vibrations include imperfections in the gears and shafts, imbalances in the cylinders, out-of-round portions of the cylinders, imperfections in the drive belts, uneven operation of the motors, and the like. Further in accordance with the invention, the printing units 10 are also designed to have relatively high natural resonant frequencies of torsional vibration, as well as to have diminished forcing functions that cause torsional vibrations. As a result, the actual frequencies of torsional vibration in the printing units 10 are relatively low, and remain below the natural resonant frequencies throughout the operating range of press speeds. The detrimental effects of the torsional vibrations are minimized accordingly.

The design features of the printing press 200 that address the natural resonant frequencies of torsional vibration include the cylinder diameter ratios of 1:1, which have lower mass than 1:2 or 2:2, the gear drive ratios of 1:1, and the shaftless connection between the first and second groups 204 and 206 of printing units 10. These design features of the printing press 200 are found to provide a spring mass system which has natural resonant frequencies of torsional vibration that are relatively high.

The design features of the printing press 200 that address the torsional forcing functions include the cylinder diameter ratios of 1:1, the drive shaft gear ratios of 1:1, and the shaftless connections between the groups 204 and 206 of printing units 10 and the folder. These design features of the printing press 200 are found to provide forcing functions that only coincide with the repeat of the printed image. These design features are found to diminish and/or eliminate all other torsional forcing functions in each of the printing units 10.

As shown in Fig. 9, a printing press constructed like the printing press 200 operated throughout a wide range of press speeds without vibrating torsionally at a frequency that is equal to a natural resonant frequency of torsional vibration. Specifically, as shown in Fig. 9, the actual frequency of torsional vibrations in the printing press did not reach the natural resonant frequency level of 30.2 Hz until the press speed approached 3,500 feet per minute.

As a result of the smooth operation of the printing units 10, the cylinders can be constructed without bearers. As known in the art, bearers are mounted on a cylinder in positions to establish rolling surface contact with bearers on an adjacent cylinder. The rolling surface contact between the bearers tends to hold the adjacent cylinders from moving out of their printing positions under the influence of shock loading or vibrations in the printing unit. In view of the smooth operation of the printing unit 10 which is achieved by the foregoing features, bearers are omitted. As shown in Fig. 7B, rolling surface contact between the adjacent cylinders is established only by the engaged printing plates and blankets.

A differently constructed printing unit 300 is shown schematically in Fig. 10. The printing unit 300 has parts that are the same as corresponding parts of the printing units 10 described above. Those parts of the printing unit 300 have the same reference numbers as the corresponding parts of the printing unit 10. The printing unit 300 differs from the printing unit 10 in that upper and lower plate cylinders 302 and 304, as well as upper and lower printing plates 306 and 308, differ from the plate cylinders 14 and 16 and the printing plates 30 and 38.

The upper and lower printing plates 306 and 308 in the printing unit 300 are tubular members which are received telescopically over the upper and lower plate cylinders 302 and 304, respectively. The upper and lower printing plates 306 and 308 therefore do not have gaps like the gaps 56 and 66 described above with reference to the printing plates 30 and 38. Moreover, the upper and lower plate cylinders 302 and 304 do not have printing plate locking mechanisms like the locking mechanisms 32 and 40 in the plate cylinders 14 and 18 described above. Instead, the printing plates 306 and 308 are held on the plate cylinders 302 and 304 with an interference fit. The interference fit holding the printing plates 306 and 308 on the plate cylinders 302 and 304 is similar to the interference fit which holds the printing blanket 34 and 36 on the blanket cylinders 16 and 20.

In combination with the tubular printing blankets 34 and 36, the tubular printing plates 306 and 308 entirely eliminate the flexural and torsional forcing functions that are otherwise attributable to gaps in such parts of a printing unit. In the absence of such forcing functions, the associated flexural and torsional vibrations will not occur in the printing unit 300 and will therefore be avoided throughout an even greater range of press speeds.

From the above description of the invention, those skilled in the art will perceive improvements, changes and modifications. Such improvements, changes and modifications within the skill of the art are intended to be covered by the appended claims.

CLAIMS:

1. An offset printing apparatus for transferring inked images to opposite sides of a web of printing material, said apparatus comprising:

a rotatable upper plate cylinder;

a rotatable upper blanket cylinder;

a first tubular printing blanket releasably supported on said upper blanket cylinder, said first tubular printing blanket having a gapless cylindrical outer printing surface;

a rotatable lower plate cylinder;

a rotatable lower blanket cylinder between said upper blanket cylinder and said lower plate cylinder;

a second tubular printing blanket releasably supported on said lower blanket cylinder, said second tubular printing blanket having a gapless cylindrical outer printing surface;

frame means for supporting said cylinders in an in-line stack; and

all of said cylinders being of the same diameter.

2. Apparatus as defined in claim 1 further comprising upper and lower printing plates respectively extending circumferentially around said upper and lower plate cylinders, each of said printing plates having a

cylindrical outer surface and opposite longitudinal edge portions, said edge portions of each of said printing plates being spaced from each other to define a gap extending axially along the respective cylindrical outer surface, the width of each of said gaps being 0.080 inches or less.

3. Apparatus as defined in claim 2 wherein the width of each of said gaps is approximately 0.040 inches.

4. Apparatus as defined in claim 1 further comprising upper and lower printing plates respectively supported on said upper and lower plate cylinders, each of said printing plates having a gapless cylindrical outer printing surface.

5. Apparatus as defined in claim 1 further comprising drive means for rotating said cylinders throughout an operating range of speeds, said drive means causing torsional vibrations of said apparatus at varying frequencies throughout said operating range of speeds, said frequencies all being less than the lowest natural resonant frequency of torsional vibration of said apparatus.

6. Apparatus as defined in claim 5 wherein said operating range of speeds extends from 0.0 to approximately 3400 feet per minute.

7. Apparatus as defined in claim 1 further comprising drive means including a plurality of drive gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, said frame means including means for supporting said cylinders in printing positions wherein said first and second printing plates are in rolling surface contact respectively with said first and second tubular printing blankets, said cylinders bearing upon each other only through said printing plates and said printing blankets when in said printing positions, whereby said apparatus is free of bearers in rolling surface contact between said cylinders.

8. Apparatus as defined in claim 1 further comprising drive means including a plurality of drive gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, each meshing pair of said drive gears having an angular velocity ratio of 1:1.

9. Apparatus as defined in claim 8 wherein said frame means supports said cylinders in a first printing

unit, and further comprising a second printing unit having second printing cylinders and respective individual second drive gears fixed to each end of said second printing cylinders, said drive means further comprising a first drive shaft extending between said first and second printing units, a first motor for rotating said first drive shaft, and a pair of first shaft gears supported on said first drive shaft to rotate with said first drive shaft, each of said first shaft gears being associated with said drive gears in a respective one of said printing units to rotate said cylinders in said respective printing unit upon rotation of said first drive shaft, each of said first shaft gears having a 1:1 angular velocity ratio with said associated drive gears.

10. Apparatus as defined in claim 9 further comprising a plurality of third printing units having third printing cylinders and respective individual third drive gears fixed to each end of said third printing cylinders, said drive means further comprising a second drive shaft spaced longitudinally from said first drive shaft, a second motor for rotating said second drive shaft, and a plurality of second shaft gears supported on said second drive shaft to rotate with said second drive shaft, said second drive shaft extending between said third printing units, each of said second shaft gears being associated with a respective one of said third drive gears to rotate the respective

third printing cylinders upon rotation of said second drive shaft, said second shaft gears having a 1:1 angular velocity ratio with said third drive gears.

11. Apparatus as defined in claim 1 wherein each of said first and second tubular printing blankets has a length to circumference ratio of at least approximately 1.7.

12. Apparatus as defined in claim 11 wherein each of said length to circumference ratios is at least approximately 2.4.

13. Apparatus as defined in claims 2 or 4 further comprising drive means for rotating said cylinders throughout an operating range of speeds, said drive means causing torsional vibrations of said apparatus at varying frequencies throughout said operating range of speeds, said frequencies all being less than the lowest natural resonant frequency of torsional vibration of said apparatus.

14. Apparatus as defined in claim 13 wherein said operating range of speeds extends from 0.0 to approximately 3400 feet per minute.

15. Apparatus as defined in claim 13 further comprising drive means including a plurality of drive

gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, said frame means including means for supporting said cylinders in printing positions wherein said first and second printing plates are in rolling surface contact respectively with said first and second tubular printing blankets, said cylinders bearing upon each other only through said printing plates and said printing blankets when in said printing positions, whereby said apparatus is free of bearers in rolling surface contact between said cylinders.

16. Apparatus as defined in claim 13 further comprising drive means including a plurality of drive gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, each meshing pair of said drive gears having an angular velocity ratio of 1:1.

17. Apparatus as defined in claim 16 wherein said frame means supports said cylinders in a first printing unit, and further comprising a second printing unit having second printing cylinders and respective individual second

drive gears fixed to each end of said second printing cylinders, said drive means further comprising a first drive shaft extending between said first and second printing units, a first motor for rotating said first drive shaft, and a pair of first shaft gears supported on said first drive shaft to rotate with said first drive shaft, each of said first shaft gears being associated with said drive gears in a respective one of said printing units to rotate said cylinders in said respective printing unit upon rotation of said first drive shaft, each of said first shaft gears having a 1:1 angular velocity ratio with said associated drive gears.

18. Apparatus as defined in claim 17 further comprising a plurality of third printing units having third printing cylinders and respective individual third drive gears fixed to each end of said third printing cylinders, said drive means further comprising a second drive shaft spaced longitudinally from said first drive shaft, a second motor for rotating said second drive shaft, and a plurality of second shaft gears supported on said second drive shaft to rotate with said second drive shaft, said second drive shaft extending between said third printing units, each of said second shaft gears being associated with a respective one of said third drive gears to rotate the respective third printing cylinders upon rotation of said second drive

shaft, said second shaft gears having a 1:1 angular velocity ratio with said third drive gears.

19. Apparatus as defined in claim 13 wherein each of said first and second tubular printing blankets has a length to circumference ratio of at least approximately 1.7.

20. Apparatus as defined in claim 19 wherein each of said length to circumference ratios is at least approximately 2.4.

21. An offset printing apparatus for transferring inked images to opposite sides of a web of printing material, said apparatus comprising:

a rotatable upper plate cylinder;

a first printing plate extending circumferentially around said upper plate cylinder, said first printing plate having a first cylindrical outer surface and opposite longitudinal edge portions, said edge portions being spaced from each other to define a first gap extending axially along said first cylindrical outer surface between said edge portions, the width of said first gap being 0.080 inches or less;

a rotatable upper blanket cylinder;

a first tubular printing blanket releasably supported on said upper blanket cylinder, said first tubular printing blanket having a gapless cylindrical outer printing surface;

a rotatable lower plate cylinder;

a second printing plate extending circumferentially around said lower plate cylinder, said second printing plate having a cylindrical outer surface and opposite longitudinal edge portions, said edge portions of said second printing plate being spaced from each other to define a second gap extending axially along said second cylindrical outer surface between said edge portions of said second printing plate, the width of said second gap being 0.080 inches or less;

a rotatable lower blanket cylinder between said upper blanket cylinder and said lower plate cylinder;

a second tubular printing blanket releasably supported on said lower blanket cylinder, said second tubular printing blanket having a gapless cylindrical outer printing surface; and

frame means for supporting said cylinders in an in-line stack.

22. Apparatus as defined in claim 21 wherein the width of each of said gaps is approximately 0.040 inches.

23. Apparatus as defined in claim 21 further comprising drive means for rotating said cylinders throughout an operating range of speeds, said drive means

causing torsional vibrations of said apparatus at varying frequencies throughout said operating range of speeds, said frequencies all being less than the lowest natural resonant frequency of torsional vibration of said apparatus.

24. Apparatus as defined in claim 23 wherein said operating range of speeds extends from 0.0 to approximately 3400 feet per minute.

25. Apparatus as defined in claim 21 further comprising drive means including a plurality of drive gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, said frame means including means for supporting said cylinders in printing positions wherein said first and second printing plates are in rolling surface contact respectively with said first and second tubular printing blankets, said cylinders bearing upon each other only through said printing plates and said printing blankets when in said printing positions, whereby said apparatus is free of bearers in rolling surface contact between said cylinders.

26. Apparatus as defined in claim 21 further comprising drive means including a plurality of drive

gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, each meshing pair of said drive gears having an angular velocity ratio of 1:1.

27. Apparatus as defined in claim 26 wherein said frame means supports said cylinders in a first printing unit, and further comprising a second printing unit having second printing cylinders and respective individual second drive gears fixed to each end of said second printing cylinders, said drive means further comprising a first drive shaft extending between said first and second printing units, a first motor for rotating said first drive shaft, and a pair of first shaft gears supported on said first drive shaft to rotate with said first drive shaft, each of said first shaft gears being associated with said drive gears in a respective one of said printing units to rotate said cylinders in said respective printing unit upon one rotation of said first drive shaft, each of said first shaft gears having a 1:1 angular velocity ratio with said associated drive gears.

28. Apparatus as defined in claim 27 further comprising a plurality of third printing units having third printing cylinders and respective individual third drive

gears fixed to each end of said third printing cylinders, said drive means further comprising a second drive shaft spaced longitudinally from said first drive shaft, a second motor for rotating said second drive shaft, and a plurality of second shaft gears supported on said second drive shaft to rotate with said second drive shaft, said second drive shaft extending between said third printing units, each of said second shaft gears being associated with a respective one of said third drive gears to rotate the respective third printing cylinders upon rotation of said second drive shaft, said second shaft gears having a 1:1 angular velocity ratio with said third drive gears.

29. Apparatus as defined in claim 21 wherein each of said first and second tubular printing blankets has a length to circumference ratio of at least approximately 1.7.

30. Apparatus as defined in claim 29 wherein each of said length to circumference ratios is at least approximately 2.4.

31. Apparatus as defined in claim 23 further comprising drive means including a plurality of drive gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing

with said drive gears fixed to another of said cylinders, said frame means including means for supporting said cylinders in printing positions wherein said first and second printing plates are in rolling surface contact respectively with said first and second tubular printing blankets, said cylinders bearing upon each other only through said printing plates and said printing blankets when in said printing positions, whereby said apparatus is free of bearers in rolling surface contact between said cylinders.

32. Apparatus as defined in claim 23 further comprising drive means including a plurality of drive gears, said drive gears including a respective individual drive gear fixed to each end of each of said cylinders, said drive gears fixed to each of said cylinders meshing with said drive gears fixed to another of said cylinders, each meshing pair of said drive gears having an angular velocity ratio of 1:1.

33. Apparatus as defined in claim 32 wherein said frame means supports said cylinders in a first printing unit, and further comprising a second printing unit having second printing cylinders and respective individual second drive gears fixed to each end of said second printing cylinders, said drive means further comprising a first drive shaft extending between said first and second

printing units, a first motor for rotating said first drive shaft, and a pair of first shaft gears supported on said first drive shaft to rotate with said first drive shaft, each of said first shaft gears being associated with said drive gears in a respective one of said printing units to rotate said cylinders in said respective printing unit upon one rotation of said first drive shaft, each of said first shaft gears having a 1:1 angular velocity ratio with said associated drive gears.

34. Apparatus as defined in claim 33 further comprising a plurality of third printing units having third printing cylinders and respective individual third drive gears fixed to each end of said third printing cylinders, said drive means further comprising a second drive shaft spaced longitudinally from said first drive shaft, a second motor for rotating said second drive shaft, and a plurality of second shaft gears supported on said second drive shaft to rotate with said second drive shaft, said second drive shaft extending between said third printing units, each of said second shaft gears being associated with a respective one of said third drive gears to rotate the respective third printing cylinders upon rotation of said second drive shaft, said second shaft gears having a 1:1 angular velocity ratio with said third drive gears.

35. Apparatus as defined in claim 23 wherein each of said first and second tubular printing blankets has a length to circumference ratio of at least approximately 1.7.

36. Apparatus as defined in claim 35 wherein each of said length to circumference ratios is at least approximately 2.4.

37. An offset printing apparatus substantially as hereinbefore described with reference to the accompanying drawings.

...aminer's report to the Comptroller under Section 17 (The Search report)	GB 9325592.5
Relevant Technical Fields (i) UK Cl (Ed.M) B6C: CBBQ, CBCA, CBCB, CBCX, CKA, CKE, CKF, CLD, CJB, CMA, CML, CMP, CKW. UKC (ii) Int Cl (Ed.5) IPC	Search Examiner F MILES Date of completion of Search 16 FEBRUARY 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii)	Documents considered relevant following a search in respect of Claims :- 1, 21

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	EP 0421145 A	(HEIDELBERGER) note seamless sleeve blanket and manner of fitting it	1,21
Y	EP 0131813 A	(ROLAND) note sizes and relative dispositions of cylinders	1,21
Y	US 5031297 A	(NELSON) note acknowledgement of seamless nickel printing sleeves (Column 1; lines 36-49)	1,21
Y	US 4913048 A	(TITTGEMEYER) note seamless plate and blanket sleeves (Column 2; lines 3-6) and manner of fitting them	1,21
Y	US 4823693 A	(KOBLER) note seamless plate and blanket sleeves (Column 3; lines 36-49) and manner of fitting them	1,21
Y	US 4437402 A	(FISCHER) note sizes and relative dispositions of cylinders	1,21
Y	US 4125073 A	(BAIN) note sizes and relative dispositions of cylinders. Note also acknowledgement of source of vibrations in this arrangement	1,21
Y	GB 0535076 A	(CHAMBON) example showing that close contact of the ends of a plate on a print cylinder is old art	1,21

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).