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Benton

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[54] **GRAVURE PRINTING PRESS WITH ENDLESS PRINTING BELTS**

[76] Inventor: **Robert C. Benton,** 18 Canoebrook Dr., Princeton Junction, N.J. 08550

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[52] **U.S. Cl.** **101/151,** 101/178

[51] **Int. Cl.** **B41f 9/02**

[58] **Field of Search** 101/150, 151, 152, 171, 101/174, 175, 176, 178–182, 212, 216

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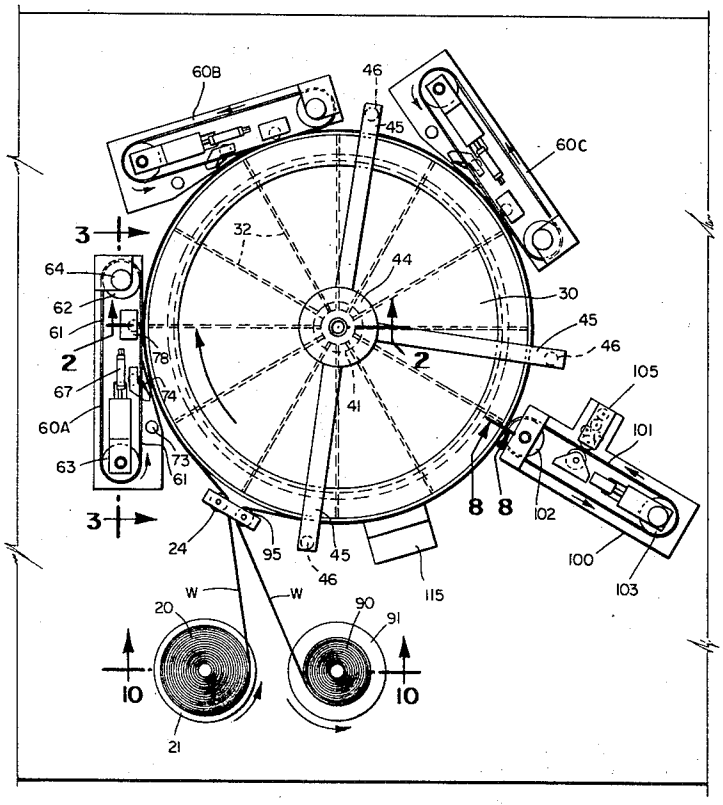
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Primary Examiner—J. Reed Fisher
Attorney, Agent, or Firm—Paul & Paul

[57] **ABSTRACT**

A printing press includes a large drum driven rotatably. A continuous printing web, of paper or other material, is wound about the circumferential surface of the drum and pulled by the drum from a supply reel and delivered to a driven take-up reel. A plurality of printing units are positioned about the circumferential surface of the rotatable drum at spaced-apart locations. One or more of these units may be gravure units, as for printing different colors. These gravure units include endless gravure belts driven at a speed corresponding to that of the peripheral surface of the drum. The length of the gravure belt is variable, thereby to provide a variable cut off or image length. Floating pressure rollers press the gravure belts against the printing web and against the drum periphery. Alignment means are provided for aligning the gravure belts with the drum.

14 Claims, 14 Drawing Figures



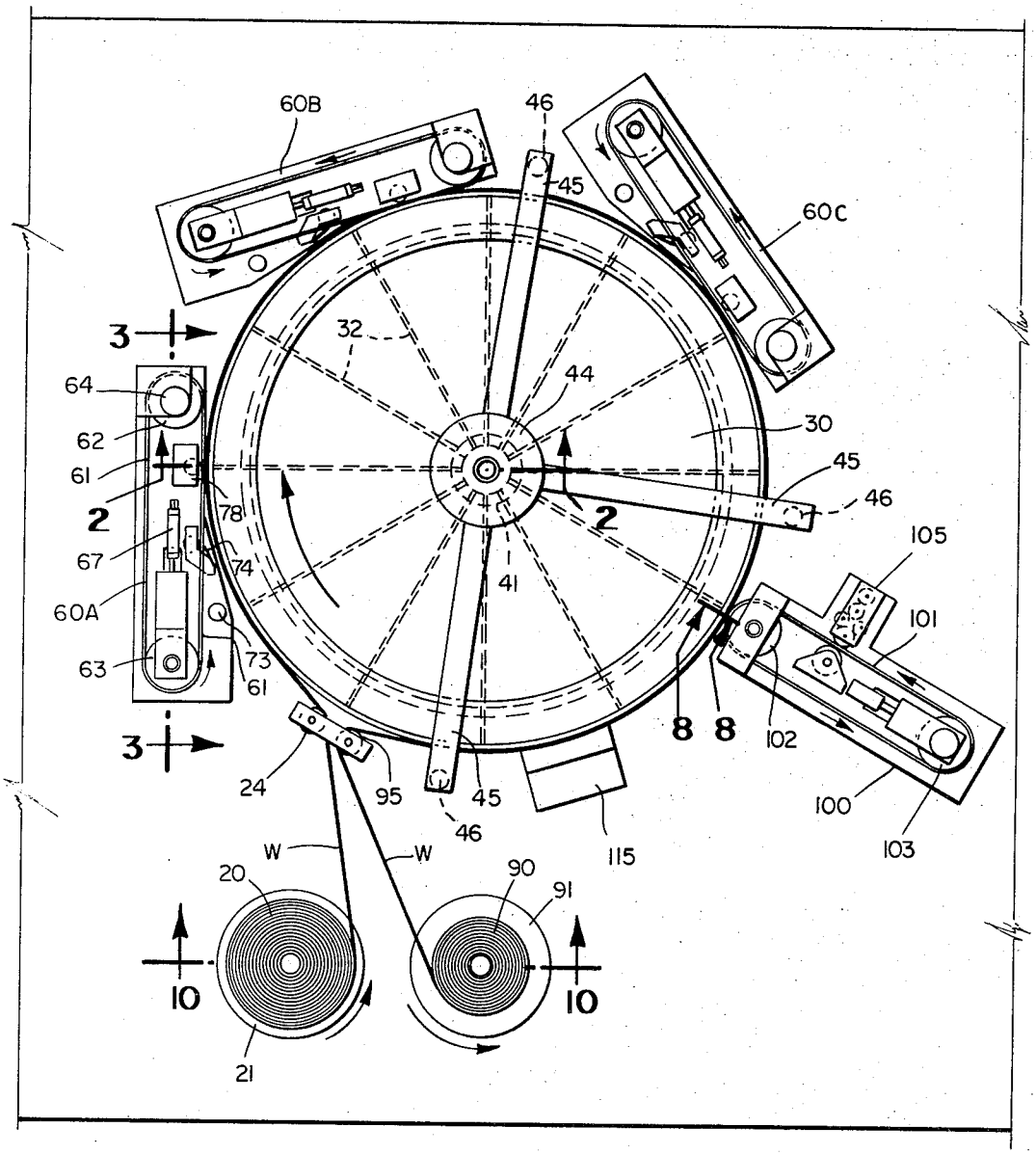

60B
46
45
60C
3
32
64
44
62
30
61
45
2
78
46
2
105
67
74
41
60A
101
73
63
61
8
8
102
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24
95
45
46
115
100
103
W
W
20
90
91
10
10
21

Fig. 1

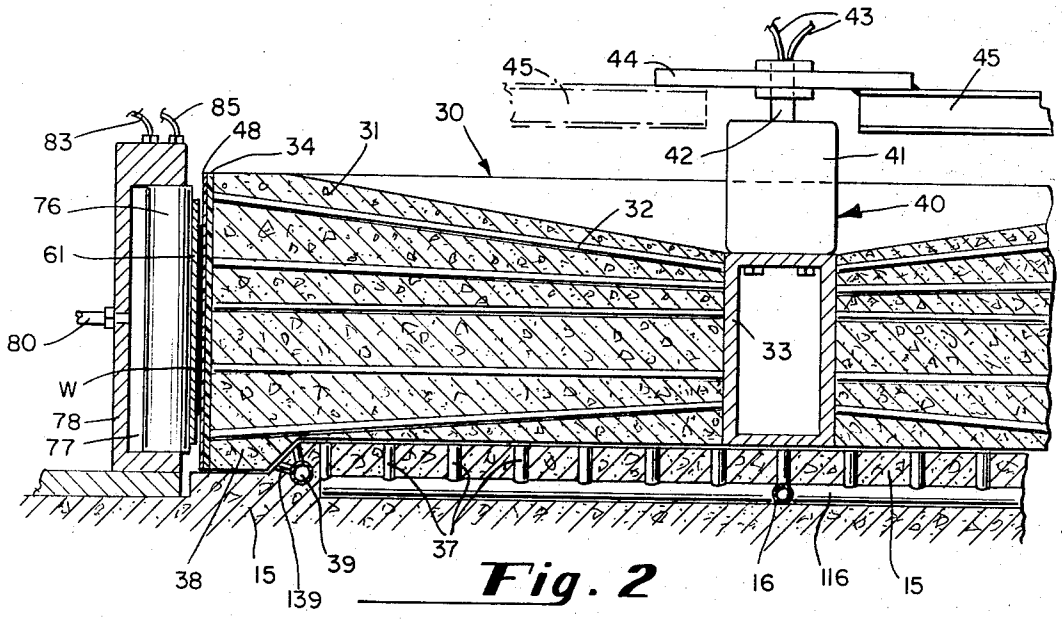


Fig. 2

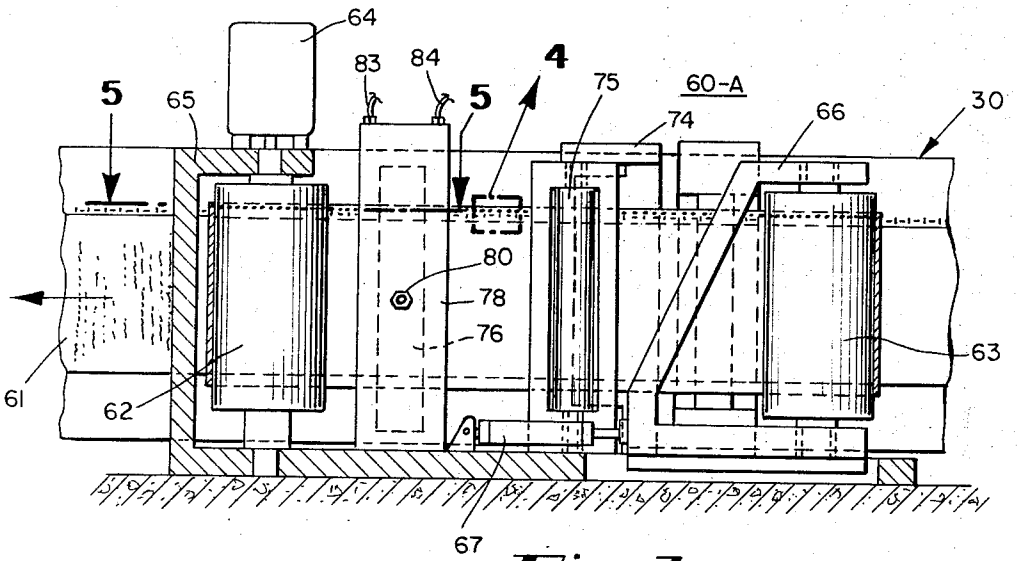


Fig. 3

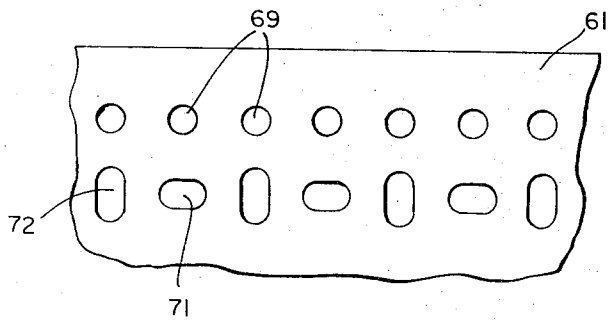


Fig. 4

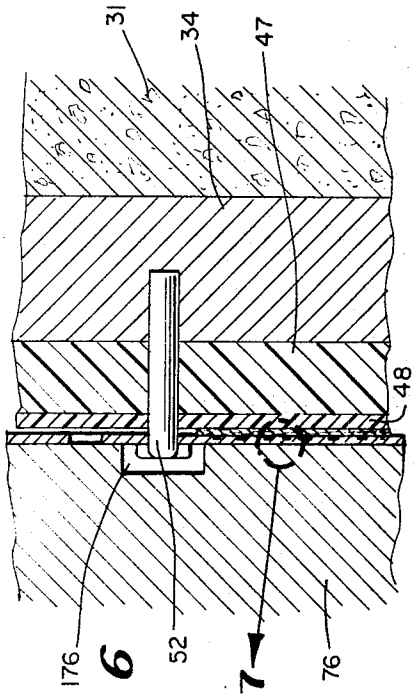


Fig. 6

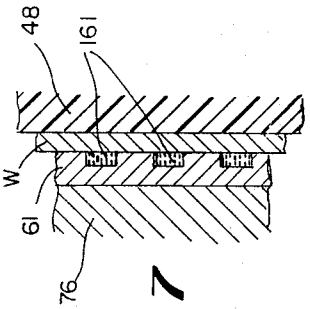


Fig. 7

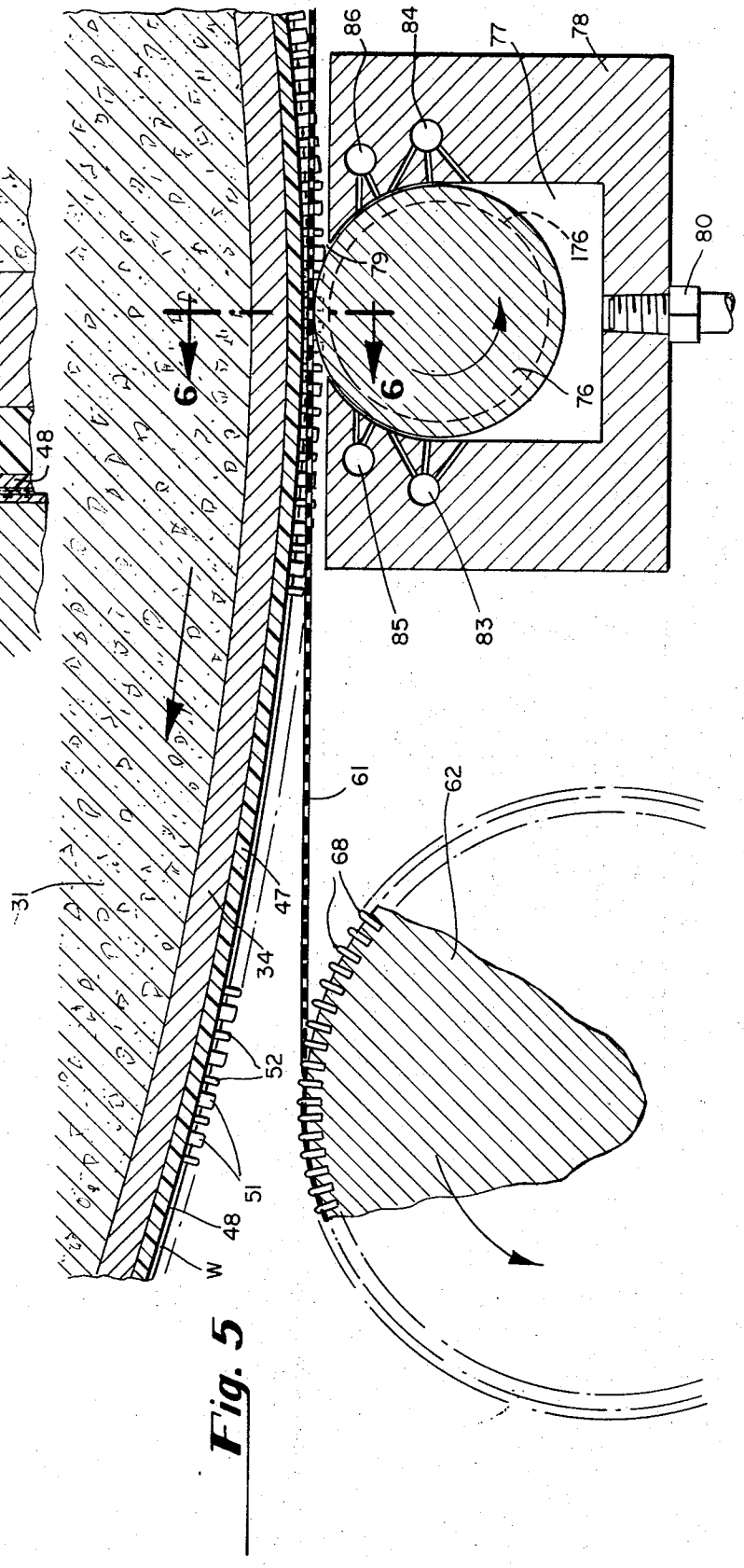


Fig. 5

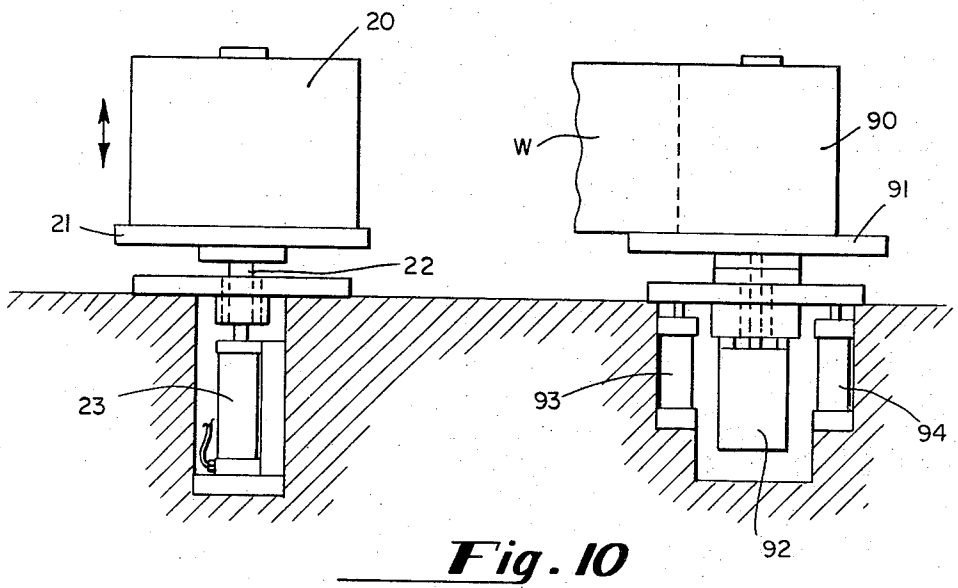


Fig. 10

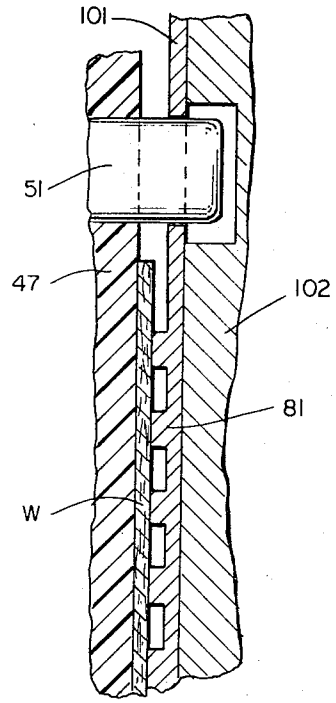


Fig. 8

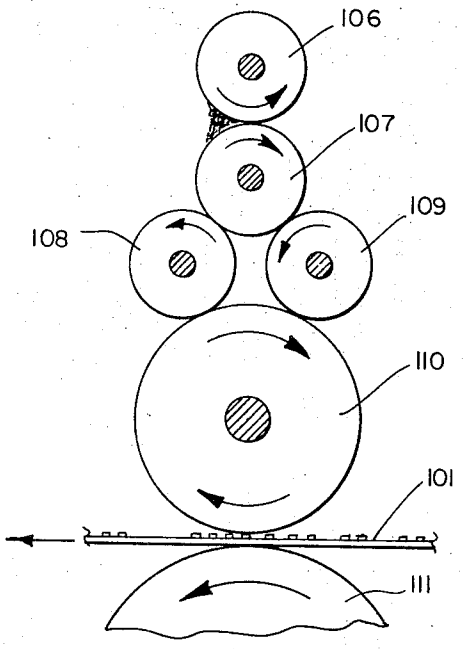


Fig. 9

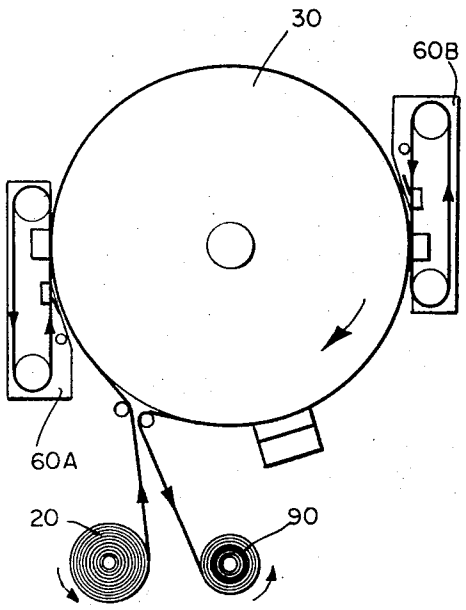


Fig. 11

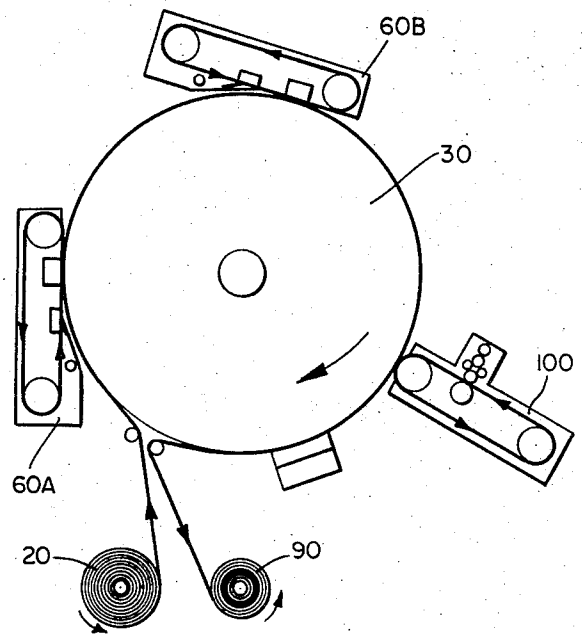


Fig. 12

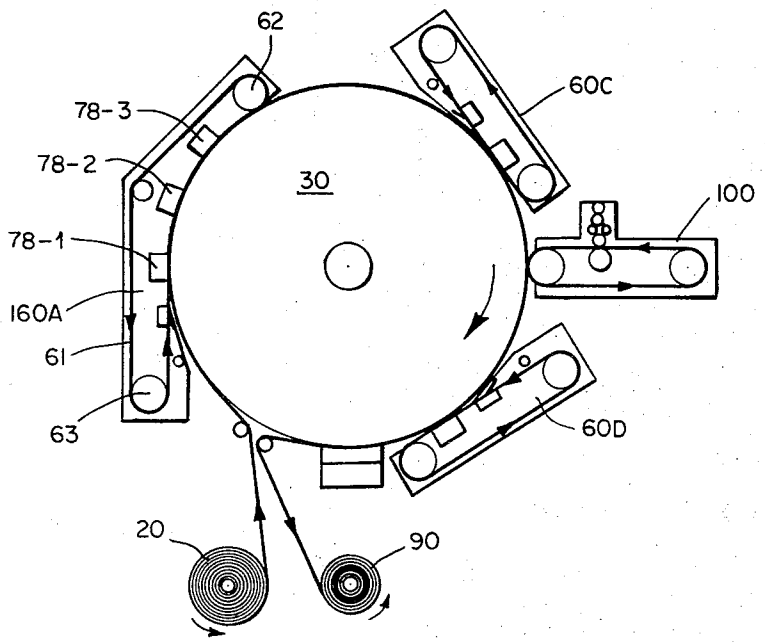


Fig. 13

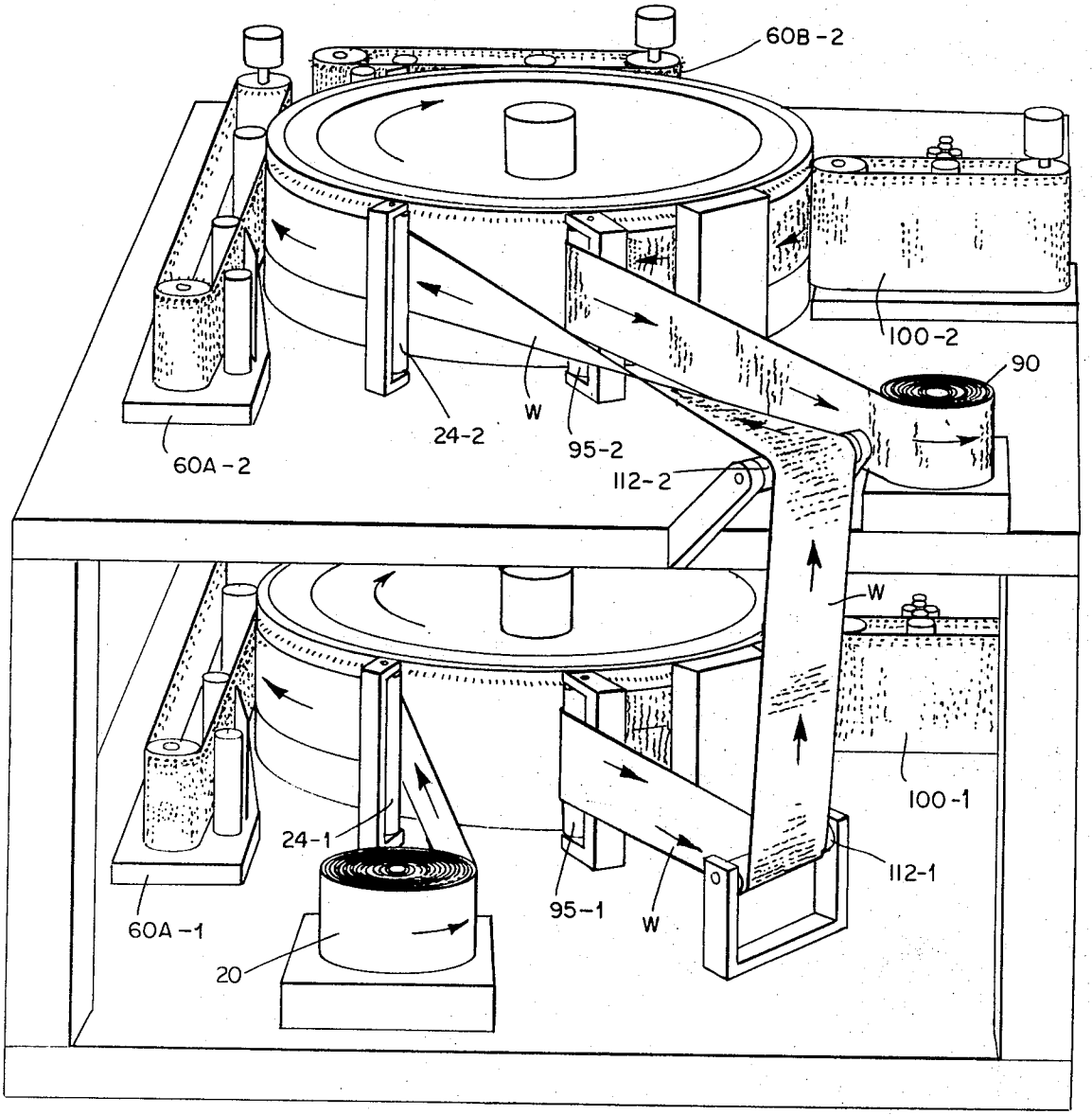


Fig. 14

GRAVURE PRINTING PRESS WITH ENDLESS PRINTING BELTS

BACKGROUND OF THE INVENTION

The present invention relates to printing, and particularly to printing presses. There are presently known a wide variety of methods of printing. These known methods include, for example, relief printing (which includes letterpress and flexography), planographic printing (which includes offset lithography and screenless lithography), gravure printing (which includes photogravure and rotogravure), screen printing (sometimes referred to as silk screen processing), and electrostatic printing (which includes Xerography).

The present invention relates to an improved method and apparatus, primarily for color gravure printing, but relief printing or offset printing units may also be included.

As is known, gravure printing involves the cutting, usually by etching, of various sizes of minute cells or wells below the surface of the plate or cylinder. Ink is applied to the etched surface to flood the wells, after which the surface of the plate or cylinder is scraped of excess ink, as by a doctor blade. The ink remaining in the etched wells is transferred, by a combination of pressure and suction, to a printing web. The characteristic feature, in gravure printing, is that the image areas are below the surface of the plate or cylinder. This is in contrast to relief or planographic printing, where the image areas are either on the surface or raised above the surface of the plate or cylinder.

Gravure printing is used advantageously in color printing since the depth of the image cells or wells may be varied, whereby an ink film of varying thickness may be transferred to the printing web. It is the ability of the deeper cells to transfer more ink to the printing web that accounts for the range of tonal values, and the depth of tone, that are characteristic of gravure printing.

SUMMARY OF THE INVENTION

A principal object of the present invention is to provide an improved method and printing press for gravure printing, either in black and white or in a plurality of different colors.

Another object is to provide improved gravure printing means having important economical advantages over techniques heretofore employed.

Another object is to provide, in gravure printing apparatus, means providing a variable cutoff or image length.

Another object is to provide a multi-color gravure printing press capable of printing both sides of the web in a single pass through the press.

Another object is to provide an improved method and apparatus for printing, by gravure and/or other techniques, on one or both sides of a printing web while the plane of the web is vertical.

Another object is to provide, in apparatus as aforesaid, an improved pressure-applying device for holding the etched gravure surface against the printing web.

The foregoing and other objects and advantages are achieved by providing endless gravure belts the lengths of which are variable. The gravure belts are used cooperatively with a large driven drum which functions as the common impression cylinder.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic plan view of a printing press apparatus embodying the present invention, in one form;

FIG. 2 is an elevational view, partly in section, looking along the line 2—2 of FIG. 1;

FIG. 3 is an elevational view looking along the line 3—3 of FIG. 1;

FIG. 4 is an enlarged view of a fragmentary portion of the gravure belt located at the dot-and-dash rectangular area 4 in FIG. 3;

FIG. 3 is a plan view, in section, looking down along the line 5—5 of FIG. 3;

FIG. 6 is an elevational view, in section, looking along the line 6—6 of FIG. 5;

FIG. 7 is an enlarged view, in section, of the area shown in the dot-and-dash circle 7 in FIG. 6;

FIG. 8 is an elevational view, in section, looking along the line 8—8 of FIG. 1;

FIG. 9 is an enlarged schematic view of the arrangement of the rollers at the relief printing station;

FIG. 10 is an elevational view of the paper supply and take-up reels looking along the line 10—10 of FIG. 1;

FIG. 11 is a view similar to FIG. 1 showing schematically the arrangement for multiple color printing;

FIG. 12 is a view similar to FIG. 1 showing schematically an alternate arrangement for multiple color printing;

FIG. 13 is a view similar to FIG. 1 showing schematically another alternate arrangement for multiple color printing; and

FIG. 14 is a schematic view in perspective of a dual printing press in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 10, a supply roll 20 of continuous printing web W (which will usually be paper but which may be other material) is supported on a reel 21 supported on a vertical shaft 22 for free rotation. By suitable means, as by the piston 23 (FIG. 10), the elevation or vertical position of the roll 20 of web W is adjustable.

After being pulled by a large drum 30 about its circumferential periphery, the web W is wound up on a variable speed take-up reel 91 driven by a motor 92 (FIG. 10). The elevation or vertical position of take-up reel 91 is adjustable, as by a pair of pistons 93 and 94.

Returning now to FIG. 1 the printing web W travels from the supply roll 20 and, guided by guide rolls 24 and 95, is pulled about the circumferential periphery of a large drum 30 which is mounted for rotation, in the illustrated embodiment, in a horizontal plane about a certical center axis. In the illustrated embodiment, the plane of the continuous web W is vertical as it moves from the supply reel 20 and passes around the vertical periphery of the drum 30. The drum 30 functions as the common impression cylinder for the multi-station apparatus shown in FIG. 1.

A presently preferred form of construction of the common impression cylinder or drum 30 will now be described, with particular reference to FIGS. 1, 2 and 5. Drum 30 is large in diameter. For example, it may

have a diameter of the order of 21 feet, and it may be driven at a rotational speed of the order of 60 r.p.m. The drum **30** is preferably made of ferro concrete having substantially zero contraction. The ferro concrete **31** may be reinforced by radial steel rods **32** which extend from a steel hub **33** radially outwardly to an annular steel band **34** which defines the circumferential periphery of the drum **30.**

Drum **30** may preferably be supported for rotation on an air bearing. In FIG. **2,** the air bearing is illustrated as a generally circular concrete base **15** having therein an air duct system fed by a high pressure air supply duct **16.** The air duct system includes a plurality of radial pipes **116** each having a plurality of vertical jets **37** extending upwardly therefrom which discharge high pressure air toward the under-surface of the drum **30.** The air duct system may also include an annular pipe **39** having discharge jets **139** projecting outwardly and upwardly therefrom at inclined angles for projecting air (at lesser pressure than that projected from jets **37**) against the inclined surface of the depending annular flange portion **38** of drum **30.** By the air means just described, drum **30** is raised sufficiently above the base to allow the driven drum to rotate without frictional engagement between the drum and its base. Jets **139,** by projecting air against the inclined surface of the depending annular flange portion **38** assist in guiding the drum in its rotational movement.

Drum **30** may preferably be driven by a hydraulic motor **40** having a rotatable housing **41** mounted on and secured to hub **33** of the drum. The motor housing **41** is driven rotationally about a fixed shaft **42** supported in a fixed plate **44** which in turn may be supported on radially-extending I-beam frame members **45** which are supported, at their outward ends, on vertical columns **46,** seen in phantom in FIG. **1.** Motor **40** is driven by hydraulic fluid supplied to the motor through lines **43.**

As already mentioned, drum **30** may preferably be formed of zero-contraction ferro concrete **31,** reinforced by radial steel rods **32,** and embraced circumferentially by an annular steel band **34.** When drum **30** is rotated at its expected speed, of the order of 60 r.p.m., the centrifugal forces on the steel encircling band **34** are very large. To assist or to enable the band **34** to successfully oppose such centrifugal forces, the steel band **34** may be reinforced with continuous fiberglass filaments **47** wrapped around the outer surface of the steel band **34** and held in place by an epoxy. Alternatively, high tensile steel wire may be wrapped about the steel band in lieu of the fiberglass continuous filaments. A polyurethane film **48** may be sprayed on to the reinforcing filaments (or wire) and cured in place to provide a smooth resilient surface for the printing operation.

Projecting radially from the circumferential surface of drum **30,** at regular intervals, are a plurality of locating pins **51** and **52.** These pins preferably are rectangular in cross-section, with pins **51** being so oriented that their long dimension is horizontal, while pins **52** are so oriented that their long dimension is vertical. The pins **51** and **52** occupy alternating positions.

Referring again to FIG. **1,** and in accordance with the present invention, a plurality of printing units may be positioned about the circumferential surface of drum **30,** to function as different printing stations. In FIG. **1,** four printing stations are shown. Three of the stations, identified as **60A, 60B** and **60C,** are provided with gravure printing units. The fourth station **100** is provided with a relief printing unit.

FIGS. **11, 12** and **13** illustrate schematically other combinations of printing stations positioned about the periphery of drum **30.** In FIG. **11,** two gravure printing units are indicated. In FIG. **12,** two gravure printing units and one relief printing unit are illustrated. In FIG. **13,** three gravure printing units and one relief printing unit are shown, with one of the gravure units **60A** being extended and having three pressure rolls in sequence, as will be described later. It will be understood that FIGS. **11–13** are merely representative of some of the various combinations of printing stations which may be positioned about drum **30.**

In FIG. **1,** except for the image information etched into the gravure belts **61,** and possibly also except for the color of the ink, printing units **60A, 60B** and **60C** are identical to each other, each being a gravure printing unit. Accordingly, it will be necessary to describe but one of these units. Printing unit **60A** will be described.

The gravure printing unit **60A** includes an endless gravure belt **61** trained about a pair of spaced-apart cylinders **62** and **63** rotatable about vertical axes. In FIG. **1,** the cylinders **62** and **63** are so positioned that one reach of the gravure belt **61** is tangent at one point to the peripheral surface of the drum **30.** This is the printing point. Gravure belt **61** may be of stainless steel, or of a copper-aluminum-phosphor alloy, into the surface of which tiny image cells or wells **161** are etched. These wells **161** face, of course, toward the web W and the drum **30.**

As seen best in FIG. **3,** gravure belt **61** is driven by one cylinder **62** driven as by a hydraulic motor **64.** The drive cylinder **62** is fixed in a fixed U-frame **65** and rotates about a vertical axis. The other cylinder **63,** which is mounted for free rotation about a vertical axle, is supported in an A-frame **66** the position of which is movable and also adjustable, as by means of a piston **67.** Piston **67** may be used to adjust the tension on gravure belt **61,** and also, within limits, to change the position of the cylinder **63** to accommodate to gravure belts of different lengths. It is to be noted that one of the important aspects of the printing press of the present invention is the employment of gravure belts, rather than gravure cylinders or plates. The use of gravure belts has the important advantage of accommodating to variable cut-off or variable image lengths by using belts of different lengths. To achieve this objective, it is contemplated by the A-frame **66** may be physically moved, along with piston **67,** to a new location to take care of a change in belt length beyond the limits of piston **67.**

Both the drive cylinder **62,** and also the freely rotatable cylinder **63,** are provided with sprocket pins **68** which project radially and which are adapted to be received within sprocket holes **69** provided in the gravure belt **61** along both the upper and lower edge portions. Sprocket holes **69** are seen in FIG. **4.** The gravure belt **61** is also provided with a series of generally rectangular holes **71** and **72** for receiving the rectangular locating pins **51** and **52** which project radially from the drum **30.** These holes **71** and **72** cooperate with pins **51** and **52** to locate the gravure belts **61,** both vertically and laterally, with the peripheral edge of the drum **30.**

Ink is applied to the etched surface of the gravure belt by flooding, spraying or other suitable applicator means **73**, and the excess ink is scraped from the surface of the belt **61**, as by a doctor blade **74** having a back-up roller **75**.

As the gravure belt **61** moves, in the direction indicated by the arrow in FIG. **1**, beyond the inking means **73** and doctor blade **74**, the belt **61** approaches, on a line tangent to the drum **30**, the print point located at the point of tangency. At the print point, a floating pressure roller **76** is provided for maintaining the gravure belt **61** pressed against the printing web W which in turn is thereby pressed against the peripheral surface of drum **30**. It is largely because of the pressure applied by the pressure roller **76** that the ink in the tiny etched image wells **161** of the gravure belt **61** is transferred to the printing web W.

In accordance with the present invention, and as seen best in FIG. **5**, pressure roller **76** is preferably mounted in what may be termed a floating manner. Pressure roller **76** is contained within a chamber **77** of a sub-housing **78** mounted on the base of the gravure unit **60A**. The walls of the chamber **77**, at that half of the sub-housing **78** nearer to the drum **30**, are semi-circular in cross-section, having a curvature corresponding to the curvature of one half of the peripheral surface of the pressure roller **76**. There is, however, a vertical gap or opening **79** in the semi-circular wall of subhousing **78** through which a portion of pressure roller **76** may project.

Air pressure applied to chamber **77** through a conduit **80** urges pressure roller **76** toward the opening **79** in the sub-housing **78** wall and causes a portion of the pressure roller **76** to project beyond the face of the sub-housing **78**. High pressure air, projected from jets which communicate with high pressure ducts **83, 84, 85** and **86**, prevents the wall surface of pressure roller **76** from actually contacting the semi-circular wall of the chamber **77** and keeps the pressure roller **76** centered in the semi-circular portion of the chamber. By the pressurized air delivered through duct **80**, the pressure roller **76** is forced outwardly from the interior of chamber **77** and presses against the gravure belt **61**, which in turn presses against the printing web W, which in turn presses against the polyurethane surface **48** of the drum **30**. When the reaction force of the drum **30**, web W, and gravure band **61** equals the applied force of the pressure roller **76**, the position of the roller **76** becomes stabilized.

It is to be noted that the printing web W is so positioned vertically, relative to the peripheral surface of drum **30**, that the upper edge of web W is below the locating pins **51** and **52** which project horizontally from the drum periphery. These pins **51** and **52** pass through the holes **71** and **72** provided in the gravure belt **61** and extend in an annular recess **176** provided in the peripheral surface of the pressure roller **76**. As the gravure belt **61** is pulled past the printing point, the movement of the belt causes the pressure cylinder **76** to rotate about its own axis, in the direction indicated by the arrow in FIG. **5**.

Separate motor drives have been shown for the drum **30**, printing web W, and gravure belt **61**. The speeds at which these drives are operated are, of course, interrelated. The surface speed of gravure belt **61** is slightly higher than the peripheral surface speed of drum **30**. Thus, the edges of the locating or alignment holes **71**, **72** in the belt pull slightly on the locating pins **51** and **52**.

As already indicated hereinabove, and as illustrated in FIG. **1**, two additional gravure printing stations **60B** and **60C** may be provided at spaced-apart locations about the periphery of the drum **30**. The equipment at stations **60B** and **60C** may be identical, or substantially identical, to that at the gravure station **60A**. Stations **60B** and **60C** may, of course, print different information and in different colors. In the equipment illustrated in FIGS. **11** and **12**, two different colors may be printed by gravure printing techniques. In the equipment of FIG. **13**, three different colors may be gravure printed.

In FIG. **1**, and also in FIGS. **12** and **13**, a station identified as **100** is illustrated. This is a relief printing station using band techniques. In station **100**, a relief band **101** is trained about a driven roller **102** and a freely-rotatable roller **103**. The axis of rotation of rollers **102** and **103** is vertical. The freely-rotatable roller **103** is movable and also adjustable, as to the position of its axis, to accommodate to different lengths (variable cut-offs or image lengths). Minor adjustments are made by piston **104**. Printing is achieved by means of an inking roll assembly **105**. An enlarged view of roll assembly **105** is shown in FIG. **9**.

Referring now to FIG. **9**, ink is supplied to the nip of a pair of rolls **106** and **107** which are mounted on vertical axes. The outermost roll **106** functions as a doctor roll. The innermost of the two rolls **106** and **107** oscillates back and forth along its axis and may be referred to as the oscillator roll. Oscillator roll **107** contacts the surfaces of two further rolls **108** and **109** which function as spreader rolls. Spreader rolls **108** and **109** are likewise caused to oscillate back and forth along their axes. Spreader rolls **108** and **109** are in contact with a contact inking roll **110** which makes contact with the raised surfaces of the relief images of the relief printing band **101**. A back-up roll **111** is provided for the contact inking roll **110**.

FIG. **14** is a schematic representation of a dual printing press embodying the features of the present invention and adapted to print on both sides of the web W in a single pass through the press. In FIG. **14**, two presses P-1 and P-2 are stacked, one above the other. Each of the presses, P-1 and P-2 may be identical to that of FIG. **1**, but, for purposes of simplifying the drawing, the presses P-1 and P-2 have been illustrated as having but two gravure printing units and one relief printing unit. In FIG. **14**, the web W is pulled, from the supply roll **20**, past vertical guide roller **24-1** and about the periphery of the lower drum **30-1**, then out past vertical guide roller **95-1**, up past horizontal guide rollers **112-1** and **112-2**, past vertical guide roller **24-2**, about the periphery of the upper drum **30-2**, and out past vertical guide roller **95-2** to the take-up reel **91**. In passing from the lower vertical guide roller **95-1** to the upper vertical guide rollers **24-2**, the web W, as it passes over the horizontal rollers **112-1** and **112-2**, is reversed, so that the side of the web W which was printed by the lower press P-1 is now facing the peripheral surface of the upper drum **30-2**, thus exposing the other side of the web W to the printing units of the upper press. Thus, by the means illustrated in FIG. **14**, both sides of the web W may be printed in a single pass through the pass.

In FIG. **1**, a drier **115** is shown following the last of the printing stations for drying the ink on the web W prior to roll-up of the web into roll **90** on take-up reel **91**. In some cases, it may be desirable to provide a drier between each printing station, as well as between the final printing station and the take-up reel.

In FIG. **13**, gravure printing station **160A** illustrates a modification of gravure station **60A** described hereinabove. In station **160A**, gravure belt **61** is considerably lengthened, and drive roller **62** and free roller **63** are so positioned that belt **61** follows the curved peripheral surface of drum **30**, rather than being tangent thereto at one point. A plurality (three) printing points are illustrated, each provided with its own floating pressure roller, each roller housed in its own sub-housing, identified **78-1, 78-2, 78-3.** By the means illustrated, the printing image on the web W becomes more dense at each of the printing stations.

Other variations and modifications may be provided within the concept disclosed.

For example, while drum **30** has been described as preferably supported on an air bearing, it may, of course, be otherwise supported. Or, in lieu of an air bearing, an oil bearing may be used.

In the preferred embodiments, the axis of the drum **30** is vertical, the printing web W is vertical, and the image-carrying surface of the gravure belt **61** is vertical. In these embodiments, ink is retained in the tiny image cells **116** by capillary action. It is contemplated, however, that endless gravure belts **61** may also be used in presses in which the drum **30** is rotated on a horizontal axis, and in which the web W is printed by gravure belts which are horizontally disposed.

What is claimed is:

1. Printing apparatus comprising:

a. a cylindrical drum mounted for rotation;

b. a continuous printing web entrained about the peripheral surface of said drum;

c. at least one movable endless belt carrying image areas on a surface facing the web on the peripheral surface of said drum and adjacent thereto at at least one point;

d. means for rotating said drum;

e. means for moving said image-carrying belt;

f. pressure means for urging said image-carrying belt against said web on the peripheral surface of said drum at said point of adjacency;

g. said pressure means comprising a floating pressure roller;

h. a sub-housing having a chamber in which said pressure roller is floated;

i. said sub-housing having a wall facing said web, said wall having an opening therein; and

j. pressurized air supply means providing high pressure air to said chamber for urging said floating pressure roller toward said opening in said wall of said sub-housing and for causing a portion of said pressure roller to project from said wall of said sub-housing.

2. Printing apparatus according to claim **1** wherein:

a. said movable image-carrying belt is an endless gravure belt having image wells therein.

3. Printing apparatus according to claim **1** wherein:

a. a pair of spaced-apart sprocket rollers are provided each rotatable about a vertical axis and about which said endless belt is trained;

b. said sprocket rollers are so positioned that one reach of said belt is along a line tangent to the periphery of said drum at said point of adjacency.

4. Printing apparatus according to claim **1** wherein a plurality of movable image-carrying endless belts are provided at spaced-apart positions about the periphery of said drum.

5. Printing apparatus according to claim **4** wherein:

a. at least two of said movable image-carrying belts are gravure belts each of which has a reach movable along a line tangent to the periphery of said drum at a different spaced-apart point;

b. one of said gravure belts carries in its image wells ink of one color and the other of said gravure belts carries in its image wells ink of another color.

6. Printing apparatus according to claim **1** wherein:

a. said cylindrical drum is made of ferro concrete with steel rod reinforcements;

b. said concrete has an annular steel band embracing its periphery;

c. said annular steel band is reinforced against centrifugal forces by having wrapped thereabout a continuous filament of high-strength material.

7. Printing apparatus according to claim **6** wherein said high-strength material is mono-filament fiberglass.

8. Printing apparatus according to claim **6** wherein said high-strength material is high tensile wire.

9. Printing apparatus according to claim **6** wherein:

a. the peripheral surface of said drum is provided with radially-extending locating pins;

b. the peripheral surface of said floating pressure roll is provided with an annular recess for receiving the projecting ends of said locating pins.

10. Printing apparatus according to claim **1** wherein:

a. high pressure fluid means are provided for lifting said drum slightly off its mounting to allow for substantially friction-free rotation of said drum.

11. Printing apparatus according to claim **1** wherein:

a. said continuous web is obtained from a supply roll and wound around the peripheral surface of said drum;

b. take-up means are provided for receiving said web after it has passed around the periphery of said drum;

c. drive means are provided for driving said take-up means.

12. Printing apparatus according to claim **1** wherein:

a. said drum is mounted for rotation in a horizontal plane about a vertical axis;

b. said continuous printing web is vertically disposed on the vertical peripheral surface of said drum;

c. said image area surface of said endless belt is vertically disposed at the point of adjacency to said web.

13. Printing apparatus according to claim **12** wherein:

a. a second cylindrical drum is provided mounted for rotation about a vertical axis and having a substantially vertical peripheral surface;

b. at least one movable second endless belt which carried image areas on a substantially vertical surface is provided for said second drum, said second image-carrying surface facing the peripheral surface of said second drum and being adjacent thereto at at least one point;

c. means are provided for interposing said continuous web in vertically-disposed position between said second image-carrying belt and said peripheral surface of said second drum at said point of adjacency;

d. pressure means are provided for urging said second image-carrying belt against said interposed web and said peripheral surface of said second drum; and

e. said continuous web being common to said first and second drums but having opposite surfaces facing said first and second image-carrying belts.

14. Printing apparatus according to claim **1** wherein:

a. said wall of said sub-housing facing said web having an opening therein toward which said floating pressure roller is urged by said pressurized air supply means is semi-circular in cross-section;

b. said pressurized air supply means includes air jets positioned to prevent said roller from engaging the surface of said semi-circular wall.

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