

March 23, 1965

W. F. HUCK

3,174,428

ROTARY WEB PROCESSING APPARATUS

Filed May 12, 1960

8 Sheets-Sheet 1

Fig. 1

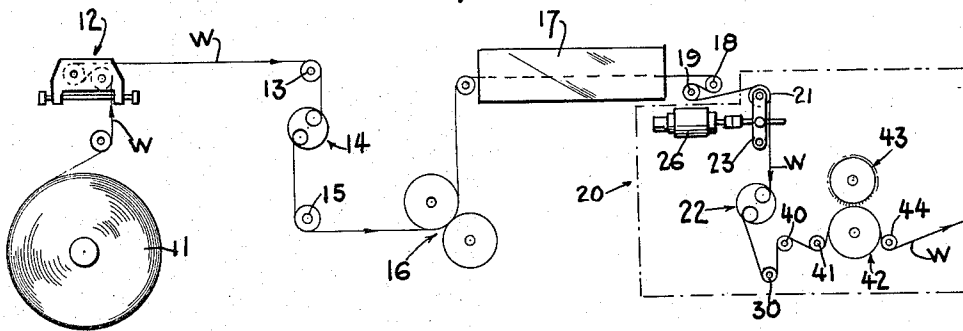
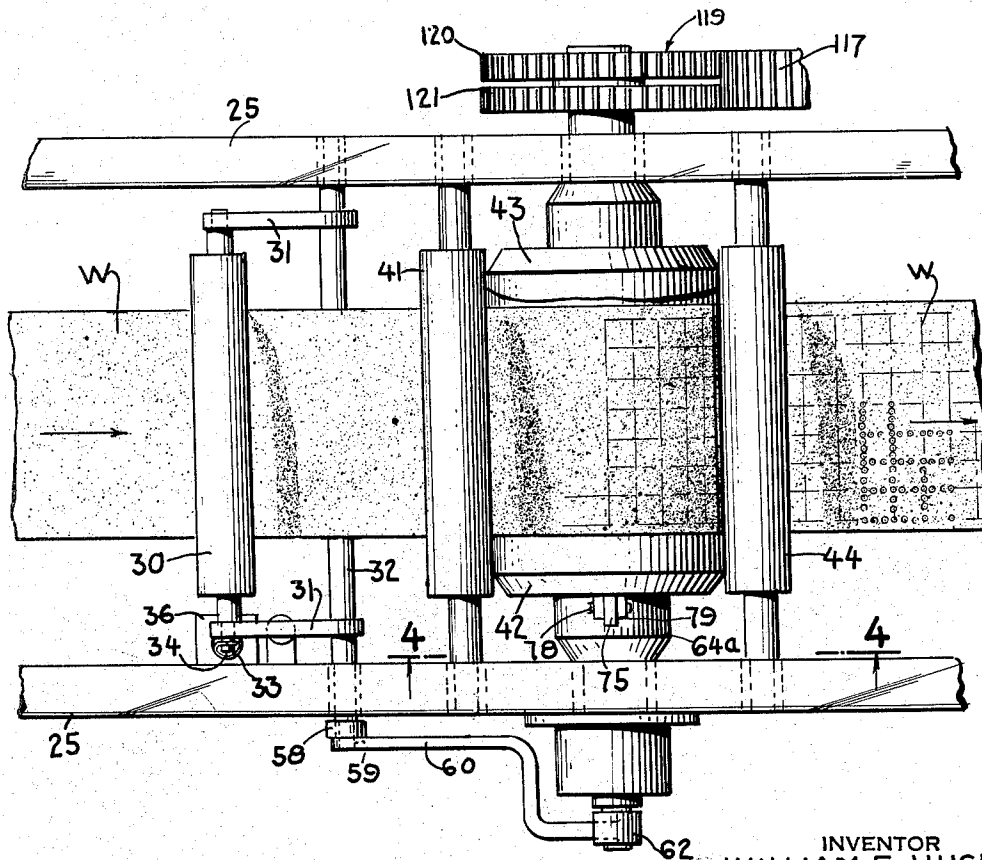


Fig. 3

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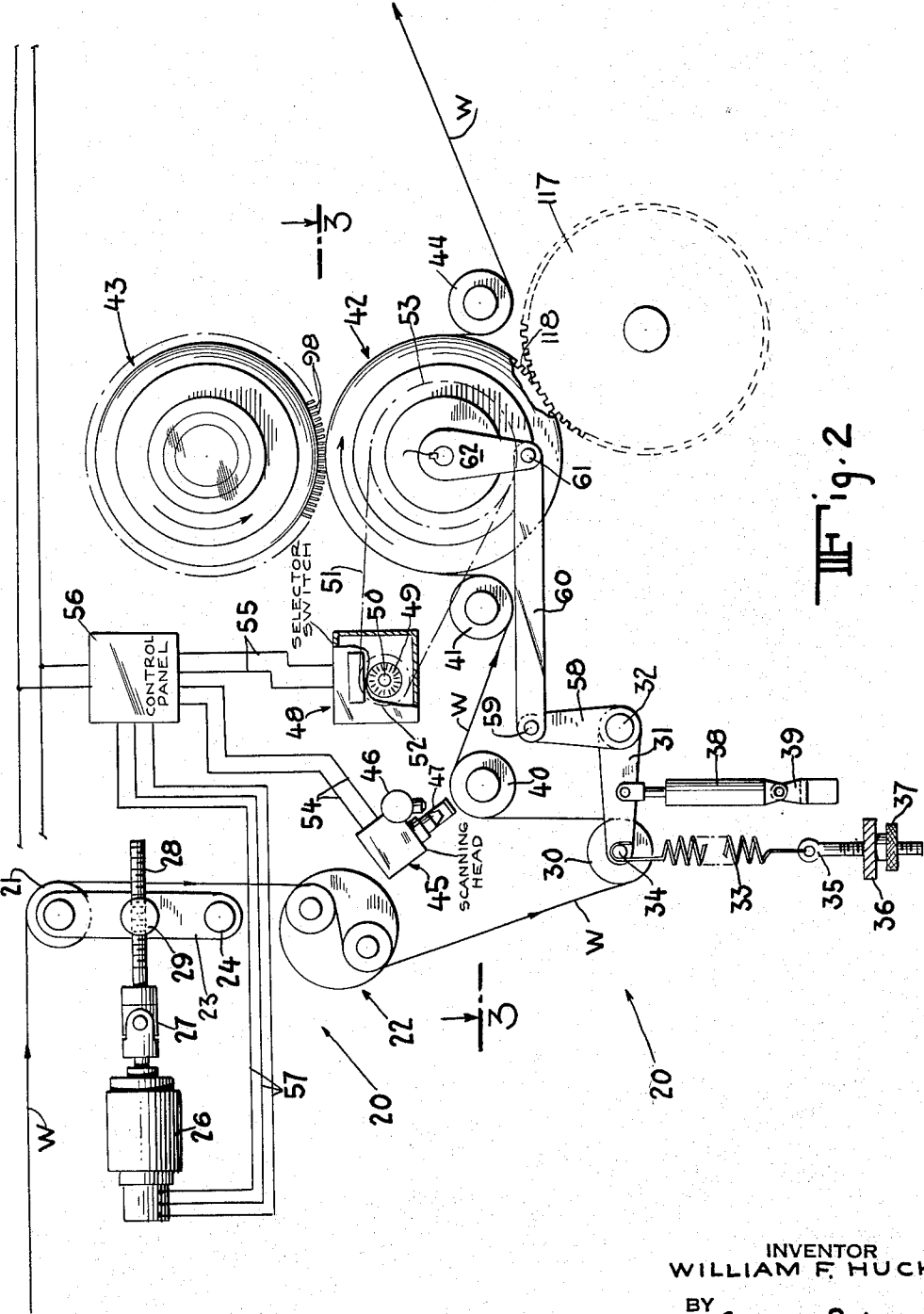
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8 Sheets-Sheet 2



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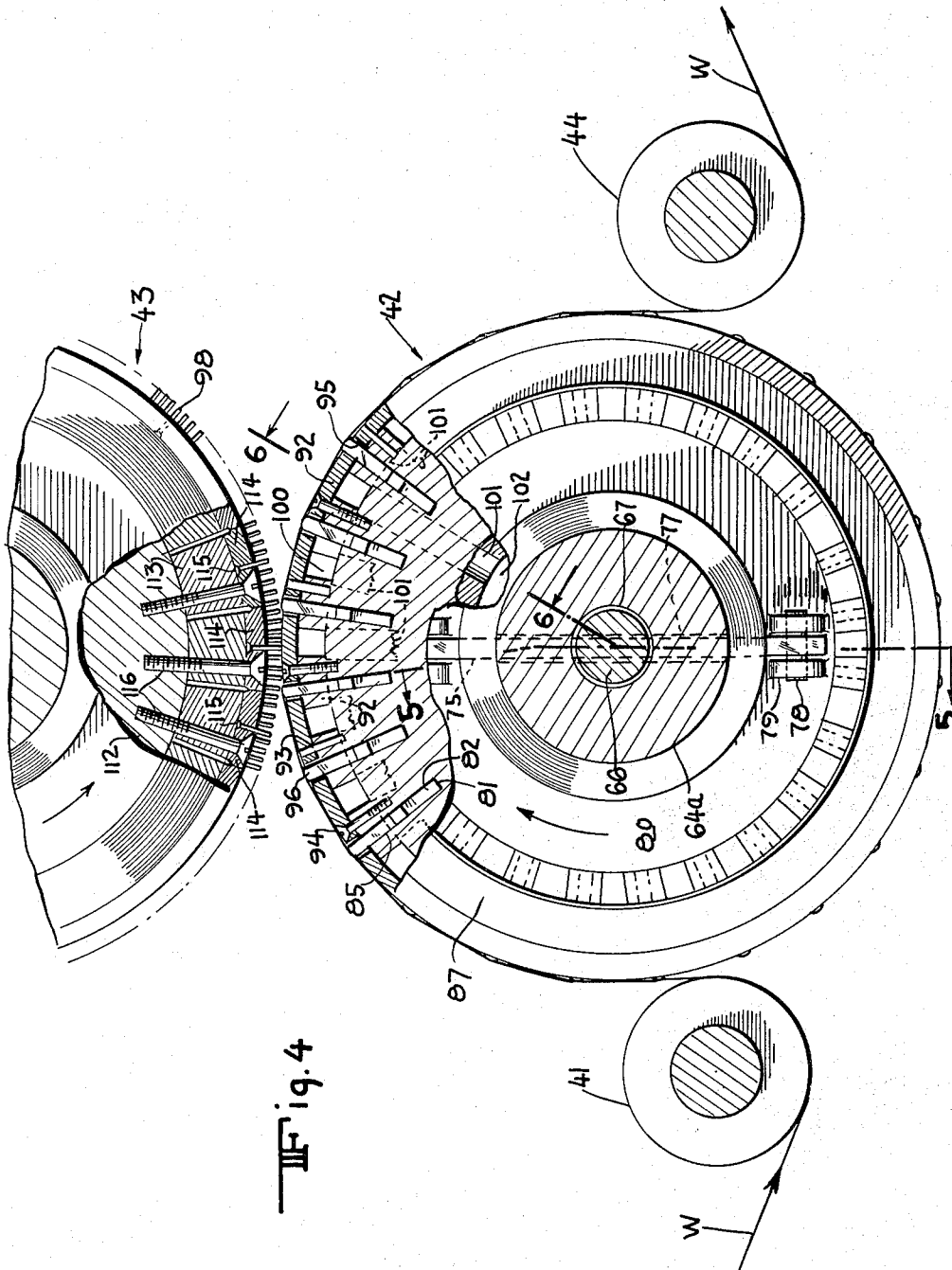
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8 Sheets-Sheet 3



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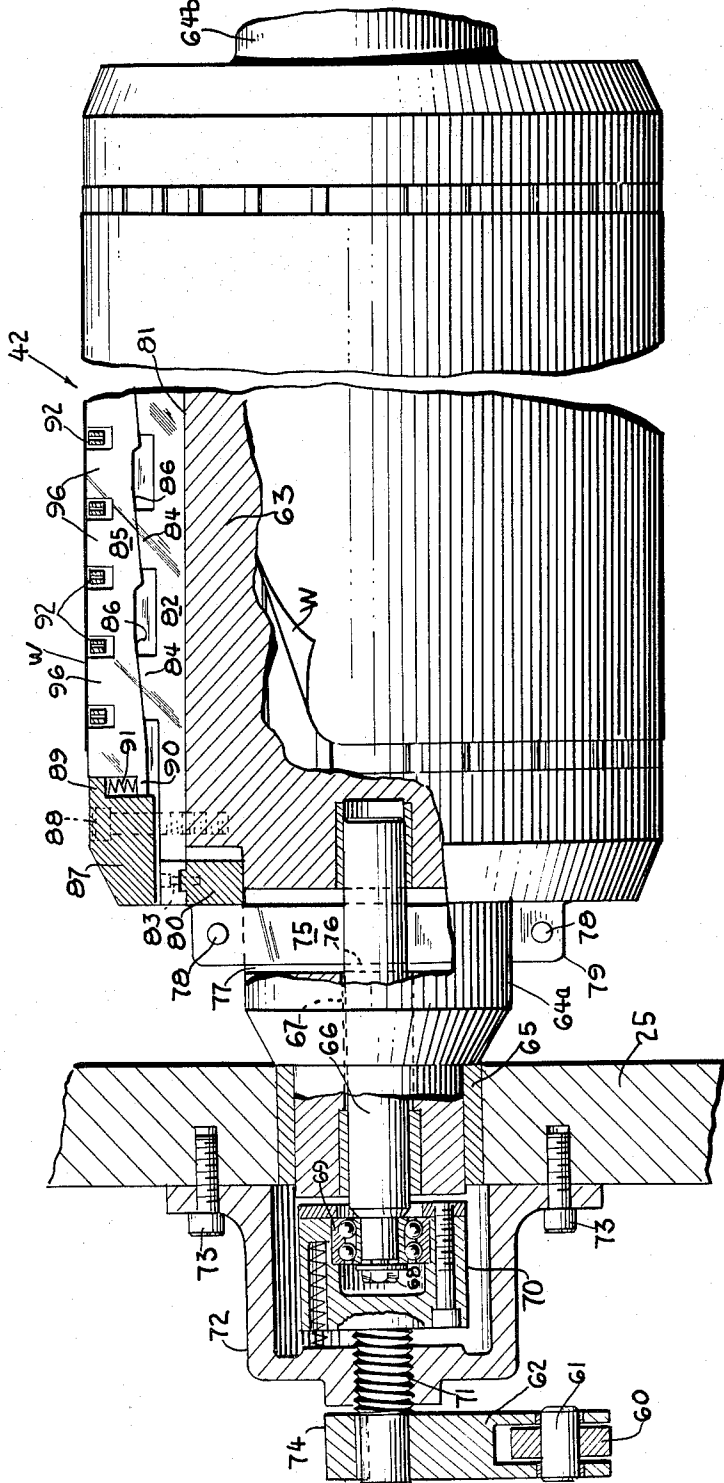
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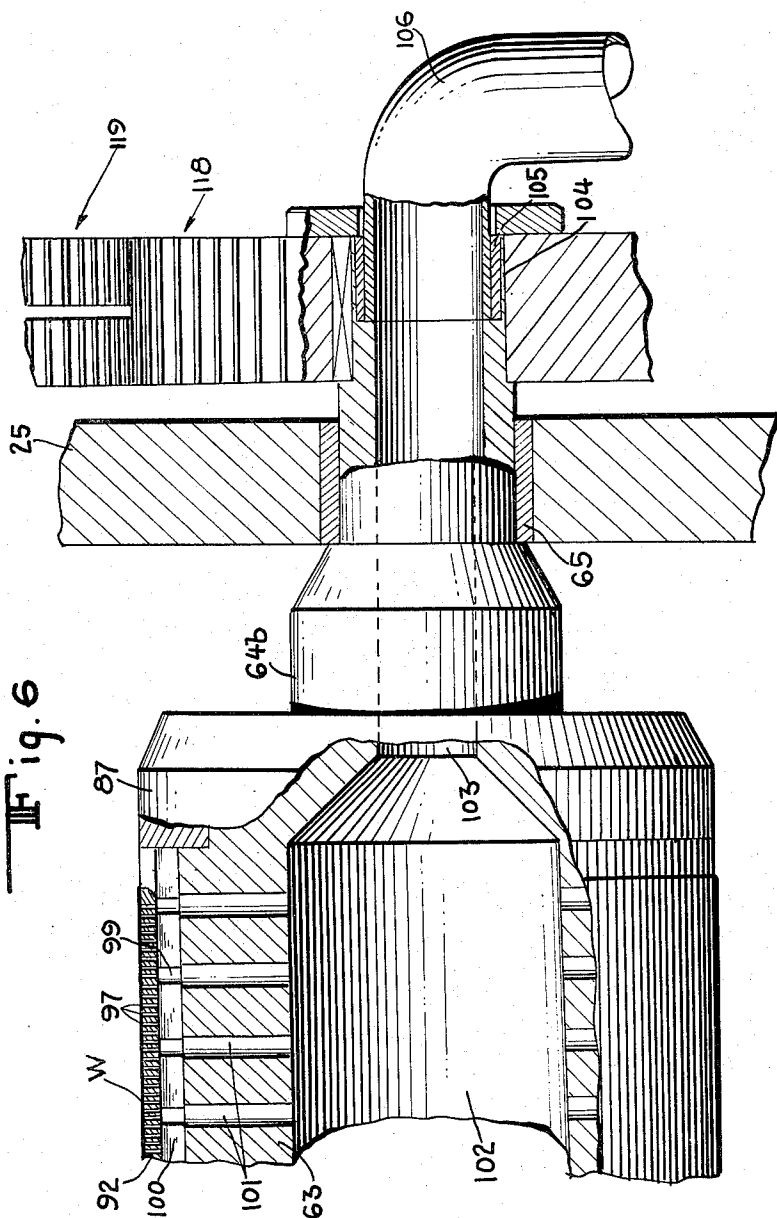
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ROTARY WEB PROCESSING APPARATUS

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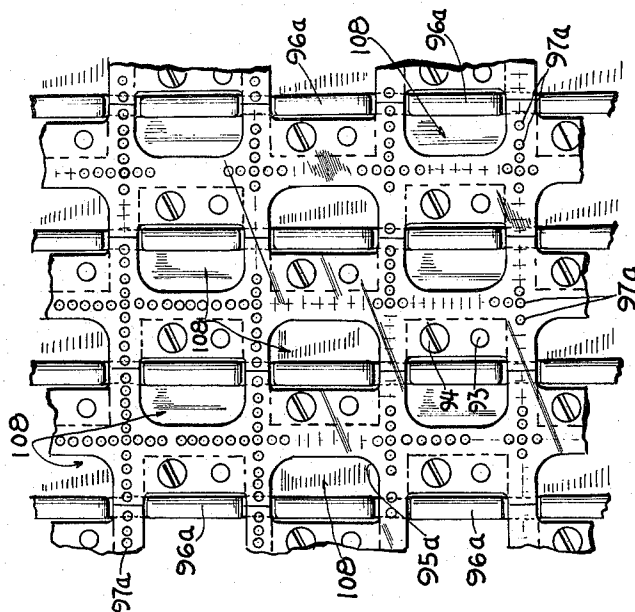
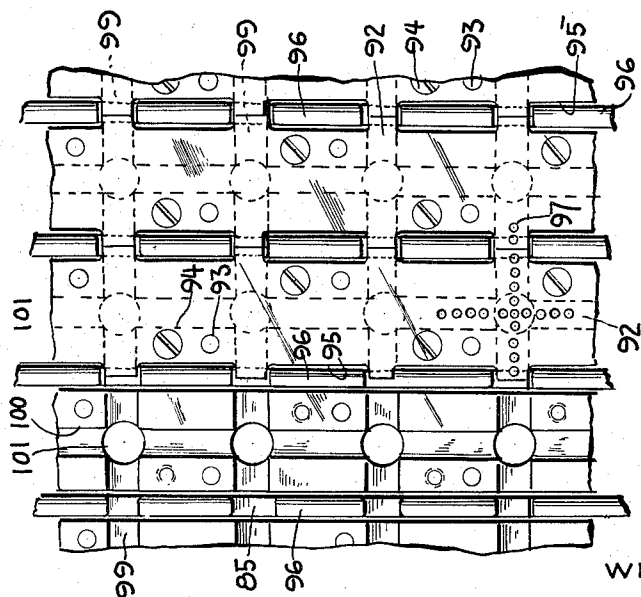
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ROTARY WEB PROCESSING APPARATUS

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8 Sheets-Sheet 6



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ROTARY WEB PROCESSING APPARATUS

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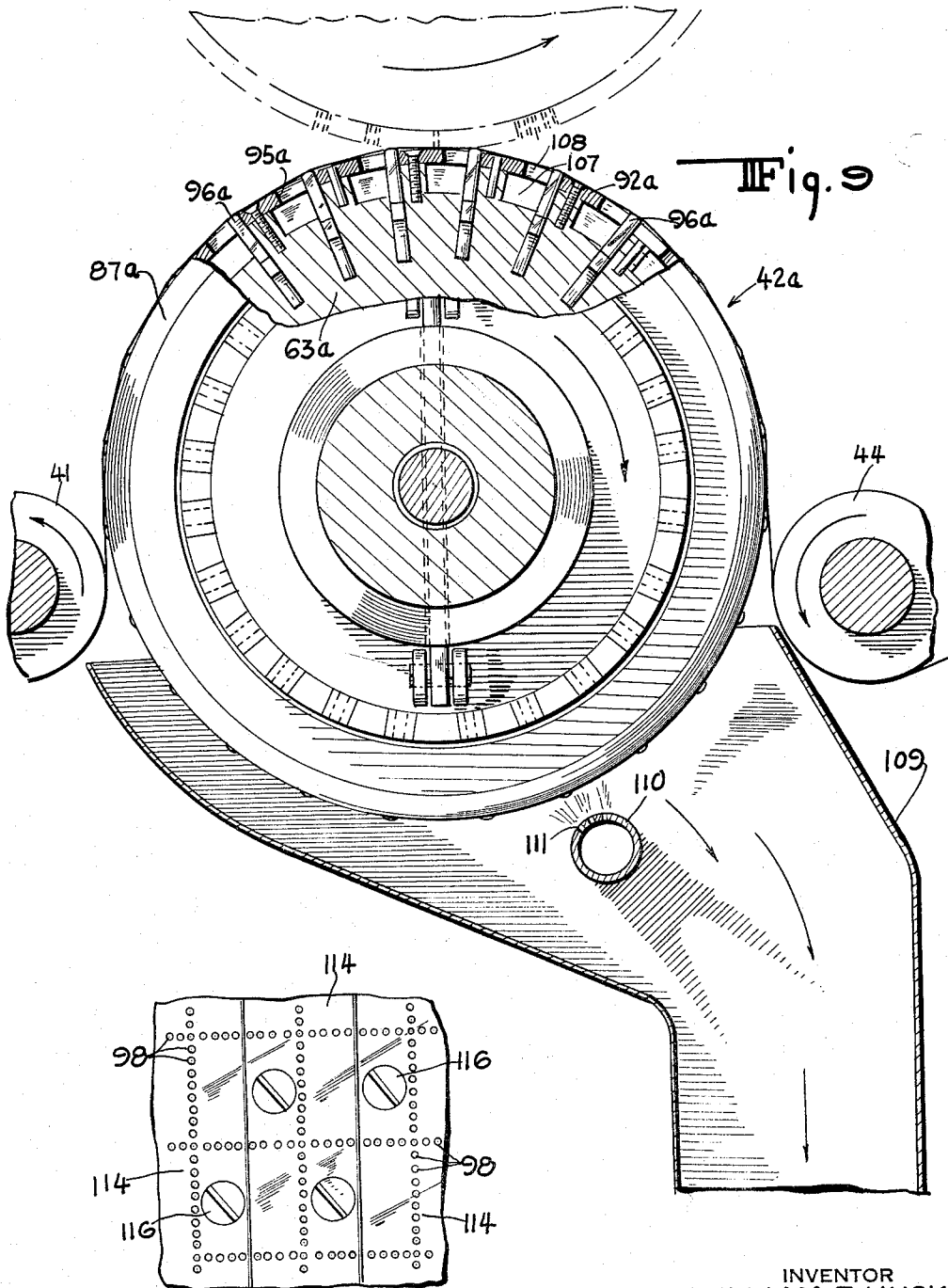


Fig. 9

Fig. 10

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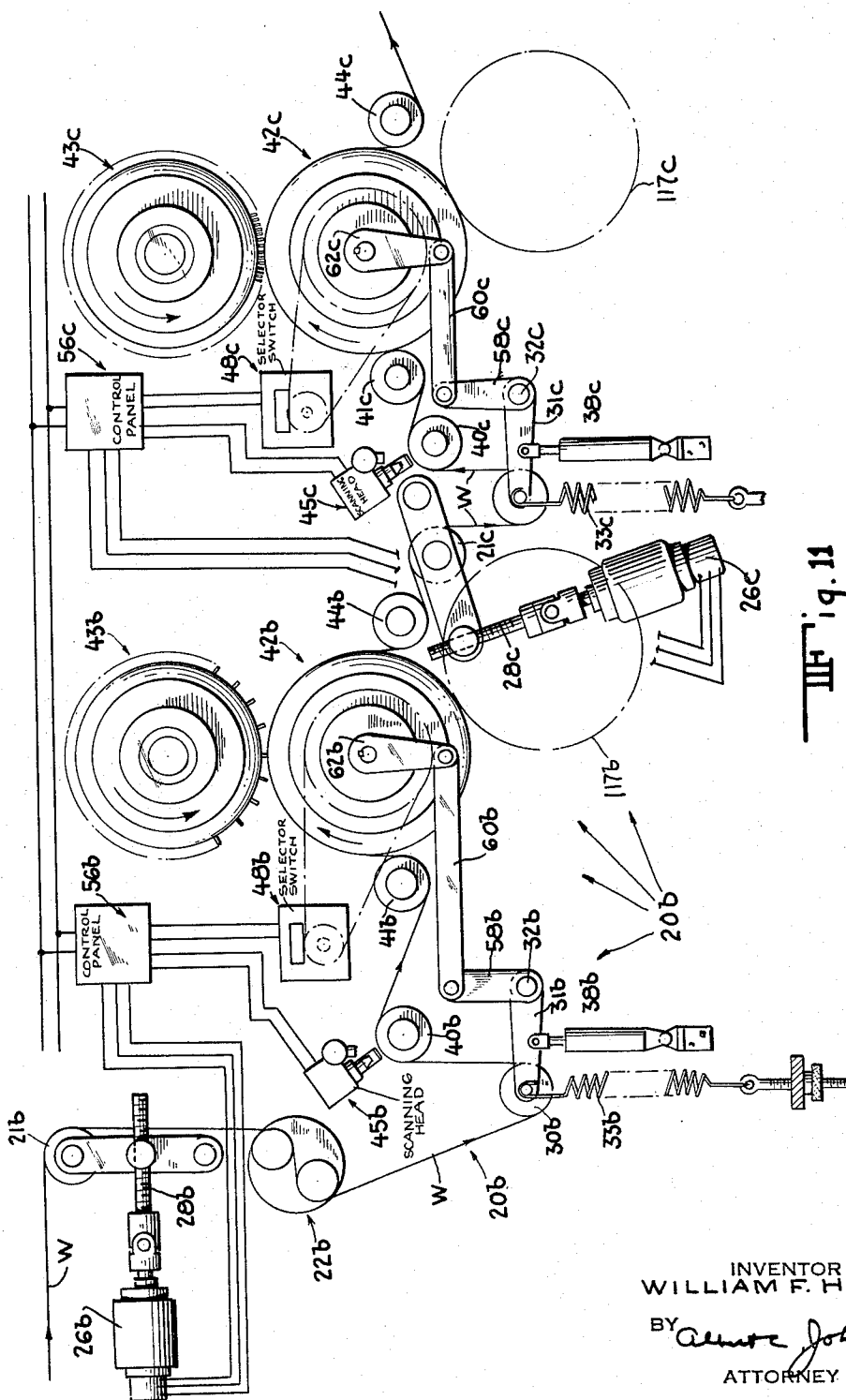
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ROTARY WEB PROCESSING APPARATUS

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8 Sheets-Sheet 8



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3,174,428
ROTARY WEB PROCESSING APPARATUS
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 Filed May 12, 1960, Ser. No. 28,609
 35 Claims. (Cl. 101—227)

This invention relates generally to rotary web processing apparatus such, for example, as mechanisms comprising devices that form cuts or holes in flexible webs such as continuous webs of paper, cloth, felt, metal sheet or foil and the like. It is more particularly directed to apparatus for perforating such webs that have been printed with multiple geometric patterns, for example, as in the case of postage and commercial stamps.

In the past, webs having postage or commercial stamps printed thereon were usually perforated by devices employing reciprocating or oscillating flat die plates. The reciprocating or oscillating flat die plates of such perforating devices simultaneously form the rows of holes extending both across and along a portion of the web representing one or more sheets of stamps to be produced. Since it is possible to obtain relatively great depth of engagement of the perforating pins in the die holes when using reciprocating or oscillating flat die plates, the clean cutting of the perforated holes can be easily accomplished. Another advantage of the use of reciprocating or oscillating flat die plates resides in the fact that in producing such die plates, the pin holding plate, stripper plate and die plate can be stacked and then drilled through in a single pass in order to economically ensure the working accuracy of all elements with respect to each other. A further important advantage of the use of flat die plates for the perforating of stamps resides in the fact that precise registration can be maintained between the perforated holes extending across and along the web and the printed areas thereon, so that the distance between adjacent holes in each of the transversely and longitudinally extending rows, and the distance between the holes at the intersections of the rows are uniform over the entire area of the web perforated during each operating stroke of the dies.

The major disadvantages of employing reciprocating or oscillating flat die plates for perforating of webs is the limitation on the speed of operation inherent in the reciprocating or oscillating of the heavy masses of such die plates while seeking to maintain the relative positional accuracy of all of the moving parts necessary for the punching of small holes.

Thus, the United States government in its production of postage stamps, and those manufacturers producing trading or other commercial stamps in great quantities, currently use rotary perforators operating at high speeds. Such rotary perforators comprise female die cylinders cooperating with male die cylinders or pin holders which are accurately geared to each other for effecting their joint rotation.

The existing rotary perforators for forming rows of holes extending both transversely and longitudinally in a web include one set of male and female die cylinders for forming the rows of holes extending longitudinally along the web and another set of male and female die cylinders for forming the rows of holes extending transversely across the web. The successive rows of holes extending transversely across the web are usually spaced apart by a sufficient distance so that the web is free to move to a limited extent between the successive rows of pins on the male cylinder provided for forming the transversely extending rows of holes. This freedom of movement of the web makes it possible to register the web so that the transversely extending rows of holes are located exactly

between the successive printed areas of the web. However, the holes of the longitudinally extending rows are so close to each other that the paper has no freedom of movement to register therebetween. For this reason, the male and female die cylinders for forming the longitudinally extending rows of holes are driven so that the surface speed thereof will be adjusted to the speed of movement of the web. As a result of this adjustment of the surface speed of the die cylinders for forming the longitudinally extending rows of holes, the locations of such holes become irregular in the longitudinal direction of the web with respect to both the transverse rows of holes and the printed areas on the web.

Such faulty or inaccurate registration of the perforations is aesthetically objectionable to many purchasers of postage and commercial stamps produced with the existing rotary perforators. Therefore, it is desirable to provide rotary perforators capable of operating at high speeds to produce longitudinally and transversely extending rows of holes in a printed web, while maintaining precise registration of the holes in the longitudinally and transversely extending rows with respect to each other and also with respect to the printed areas on the web. The difficulty in maintaining such precise registration results from the fact that the conditions of the printed web, particularly when the latter is formed of paper, are seldom, if ever, uniform, since the printing process subjects the web to moistening, varying atmospheric conditions, heavy printing pressure, and heating and cooling, with the result that slight variations occur in the lengths of the successive printed areas on the webs. While such slight variations in the lengths of the printed areas on the web are individually small, such variations accumulate over a number of the successive printed areas.

Accordingly, it is an object of the invention to provide rotary perforators which are effective to form longitudinally and transversely extending rows of holes in a printed web, while maintaining accurate register between the holes in the transversely and longitudinally extending rows and between such holes and the successive printed areas, without regard to variations that may occur in the size and spacing of the printed areas on the web.

Another object is to provide rotary perforators wherein the transversely and longitudinally extending rows of holes are formed in the printed web with a single set of male and female die cylinders while maintaining the accurate registration of the holes in the longitudinally and transversely extending rows with respect to each other and with respect to the printed areas.

A further object of the invention is to provide a rotary web processing or propelling cylinder so constructed that it will produce displacements of the portion of the web which it is propelling or processing, which displacements can be brought about, for example, in response to variations of the tension of the web or in response to variations of the registration of matter on the web with elements of the cylinder, and will enable the cylinder to be employed, for example, either for controlling the tension of the web or for keeping the web in registration.

In accordance with an aspect of the invention, the accurate registration of the longitudinally and transversely extending rows of holes with respect to each other and with respect to the successive printed areas on the web is achieved by automatically adjusting the effective diameter of the female die cylinder so that its effective circumference is kept in a desired definite relationship to the actual length of the printed areas on the web to be perforated. This feature of the invention may be employed in those cases where the web to be perforated is previously printed and is unwound from a supply roll, as well as in those cases in which the printing and perforating operations are performed successively in a single press.

In one embodiment of the invention, the effective diameter of the female die cylinder is varied in response to changes in the tension in the web resulting from changes in the length of the web between the die cylinders and a preceding web processing station, for example, a printing couple, regulated by an automatic photoelectric register control, whereas, in another embodiment of the invention, the changes in the diameter of the die cylinder may be effected directly in response to the automatic photoelectric register control.

Another object of this invention is to provide a female die cylinder for rotary perforators having efficient means for removal of the punchings or chips of web material resulting from perforation of the web.

Still another object is to provide die cylinders for rotary perforators of the described character which are constructed and arranged to ensure reasonably low production and maintenance costs.

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

FIG. 1 is a diagrammatic side elevational view of an apparatus embodying the present invention and which is operative to successively print and perforate a moving web;

FIG. 2 is a side elevational view of the perforating unit or section of the apparatus of FIG. 1, with that unit or section being shown with the frame of the apparatus removed for the purpose of clarity;

FIG. 3 is a top plan view of the perforating unit, as viewed along the plane 3—3 of FIG. 2;

FIG. 4 is a side elevational view of the die cylinders of the perforating unit, as viewed along the plane 4—4 of FIG. 3, and with the die cylinders being partly broken away and in section;

FIG. 5 is a back elevational view of the female die cylinder of the pair of cylinders shown in FIG. 4, with such female die cylinder being partly broken away and in section along the plane 5—5 of FIG. 4;

FIG. 6 is a fragmentary elevational view of the female die cylinder, but shown partly broken away and in section along the line 6—6 of FIG. 4;

FIG. 7 is a fragmentary plan view of a portion of the surface of the female die cylinder of FIGS. 4, 5 and 6;

FIG. 8 is a view similar to that of FIG. 6, but illustrating the surface of a female die cylinder constructed in accordance with another embodiment of the invention;

FIG. 9 is a side elevational view of the female die cylinder of FIG. 8, partly broken away and in section;

FIG. 10 is a fragmentary plan view of a portion of the surface of the male die cylinder included in the pair of cylinders illustrated in FIG. 4; and

FIG. 11 is a side elevational view similar to that of FIG. 2, but illustrating another embodiment of the present invention wherein separate sets of die cylinders are employed for producing the rows of perforations extending longitudinally and transversely with respect to the web.

Referring to the drawings in detail, and initially to FIG. 1 thereof, it will be seen that, in a web printing and perforating apparatus embodying the present invention, the web W is unwound from a supply roll 11 and passes through a tension control device 12 which may be of the kind disclosed in United States Letters Patent No. 7,787,463, issued April 2, 1957, to W. F. Huck. The web W travels from the tension control device 12 over an idler roller 13 and then downwardly through a side registry control device 14, which may be of the kind disclosed in United States Letters Patent No. 2,779,591, issued January 29, 1957, to W. F. Huck. From the side registry control device 14, the web W passes under an idler roller 15 and then through a printing couple 16 which applies a suitable geometric printed pattern to the web, for example, transversely and longitudinally extending rows of printed im-

pressions corresponding to the printed areas of postage or commercial stamps. The web W travels from the printing couple 16 through an oven 17 in which the printed impressions are dried. Upon emerging from the oven 17, the web W passes around cooling rollers 18 and 19 which have cold water circulated therethrough for the purpose of cooling the printed web. Following the cooling of the printed web W, the latter enters a perforating unit or section of the apparatus which is generally identified by the reference numeral 20.

As shown in detail in FIG. 2, the perforating unit 20 includes a compensating roller 21 over which the printed web W passes downwardly to a side registry control device 22 which is similar to the side registry control device 14 and, hence, may be of the kind disclosed in United States Letters Patent No. 2,779,591, which has been previously identified in detail.

The compensating roller 21 has its ends rotatably mounted in suitable bearings carried by the upper ends of arms 23 which, at their lower ends, are rockably mounted on a shaft 24 extending transversely between side frame members 25 (FIG. 3) of the apparatus. A reversible electric motor 26 is suitably mounted at the inside of one of side frame members 25 and is connected, by a universal coupling 27, to a screw 28 extending threadably through a nut member 29 secured to one of the arms 23 so that operation of motor 26 is effective to rock arms 23 for either increasing or decreasing the length of the printed web between the printing couple 16 and the perforating die cylinders hereinafter described in detail.

After passing through the side registry device 22, the printed web W passes under a floating roller 30. The floating roller 30 has the opposite ends of its shaft journalled in arms 31 extending radially from, and secured to, a shaft 32 which is rotatably mounted in the side frame members 25. A tension spring 33 is connected, at one end, to an extension 34 of the shaft of floating roller 30 and, at its other end, to an eye bolt 35 which extends through an aperture in a bracket 36 secured to the adjacent side frame member 25 (FIG. 3). A nut 37 is threaded on bolt 35 below bracket 36 in order to adjust the tension of the spring 33 which urges the floating roller 30 in the downward direction in opposition to the tension of the web W passing under the floating roller.

A dashpot assembly 38 is mounted on a bracket 39 attached to the adjacent side arm 31 for damping the angular movement of the arms 31 and thereby preventing excessive vibration of the floating roller 30 in response to variations in the web tension.

The web W runs upwardly from the floating roller 30, and then over a detection roller 40 which, at its ends, is rotatably mounted in side frame members 25. The printed web travels from the detection roller 40 under a guide roller 41, and then wraps around a female die cylinder generally identified by the reference numeral 42. The female die cylinder 42 cooperates with a male die cylinder 43 for perforating the printed web W, and the perforated web passes from cylinder 42 under a guide roller 44 prior to exit from the perforating unit or section 20.

In accordance with the present invention, the female die cylinder 42, which is hereinafter described in detail, is constructed so that its effective diameter may be varied either in direct or indirect response to the operation of a scanning head 45 disposed adjacent detection roller 40 to detect longitudinally spaced apart register marks previously applied to the web W, preferably during the printing of the latter by the printing couple 16. Such register marks may be constituted by the printed areas applied to the web or by the spaces between the printed areas, or the register marks may be in addition to the printed areas, but in a predetermined positional relationship to the latter, and may be either printed on the web or embossed therein, or in the form of slits or perforations made in the web.

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The scanning head 45 is suitably mounted on one of the side frame members 25 and may be of the type that is commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, as Item No. CR7515-P202-G4. A scanning head of the identified type generally includes a light source 46 directing a beam of light against web W on roller 40 and a photoelectric detection cell 47 disposed to scan the surface of the web at the location where the light beam from source 46 impinges thereagainst so that, when a register mark passes through the scanned region or area, such register mark changes the intensity of light reflected from the web into the photoelectric cell 47 and causes a suitable electrical signal to be emitted from the head 45.

The scanning head 45 is associated with a photoelectric selector switch 48 that is suitably mounted on a firm support, for example, on one of the side frame members 25. The photoelectric selector switch 48 may be of the type that is commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, under Item No. CR7515-P145-G4, and generally includes a slotted disc 49 mounted on a rotatable shaft 50, a light source (not shown) directing a beam of light against one side of slotted disc 49 and a photoelectric cell (not shown) at the opposite side of slotted disc 49 so as to be intermittently energized by light passing through the slots of the rotated disc and thereby produce electrical pulses or signals at regularly spaced apart intervals. Slotted disc 49 is driven by a non-slip or toothed belt 51 which runs around a pulley 52 on shaft 50 and a pulley 53 rotatable with female die cylinder 42.

The slotted disc 49 of selector switch 48 is disposed on shaft 50 so that, when the pattern of the printed areas applied by the printing couple 16 to the web W is properly registered in the longitudinal direction with respect to the pattern of the holes perforated in the web by female die cylinder 42 and the cooperating male die cylinder 43, the electrical signal resulting from the scanning of a register mark by the photoelectric scanning head 45 occurs simultaneously with an electrical signal emanating from selector switch 48. However, if the web is out of register in the longitudinal direction, the electrical pulse or signal issuing from scanning head 45 occurs either before or after the electrical pulse or signal issuing from selector switch 48.

The electrical pulses or signals issuing from scanning head 45 and selector switch 48 are fed, by way of conductors 54 and 55, respectively, to a register control panel 56 of a type that is commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, as Item No. 3S7515-CT100-A1, and which may have the assembly of electrical components as illustrated in the wiring diagram appearing between pages 9 and 10 of the Instruction Bulletin published by General Electric Company under the designation GEI-46908B.

The register control panel 56 of the above identified type is operative to amplify the signals received from scanning head 45 and selector switch 48, respectively, and to compare such signals so that any timing discrepancy between a signal resulting from a detected register mark and a related signal from selector switch 48 produces an error signal which causes energization of reversible motor 26, by way of conductors 57, and thereby effects rotation of screw 28 in one direction or the other for moving compensating roller 21 about shaft 24. Such movement of compensating roller 21 varies the length of web W between printing couple 16 and perforating die cylinders 42 and 43 for correcting any longitudinal error between the pattern of the printed areas applied by the printing couple and the pattern of the holes perforated in the web by the die cylinders.

Since an increase or decrease in the length of the web W between the printing couple 16 and the die cylinders 42 and 43 will cause an increase or decrease, respectively,

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in the web tension, the diameter of female die cylinder 42 is varied in accordance with the present embodiment of the invention so as to compensate for such changes in the length of the web in a way to avoid the exertion of an excessive pull upon the web by the cylinders 42 and 43. Changes in the web tension giving rise to the compensating action may also be caused by variations in web moistening, printing pressure, web heating and cooling and atmospheric conditions affecting the web.

In the embodiment of the invention presently being described, the effective diameter of the female die cylinder 42 is varied in response to changes in the web tension as sensed by the floating roller 30. For this purpose, a radially extending arm 58 is fixed to shaft 32 and is pivotally connected, at its free end, as at 59, to one end of a link 60 which, at its other end, is pivotally connected, as at 61, to an actuating arm 62 on cylinder 42 so that the arm 62 is angularly displaced to decrease and increase the effective diameter of female die cylinder 42 in response to upward and downward movement, respectively, of the floating roller 30 upon an increase or decrease in the web tension between the printing couple and the perforating die cylinders, as hereinafter described in detail.

Referring now to FIGS. 4 and 5 of the drawings, it will be seen that female die cylinder 42 includes a hollow body 63 having trunnions 64a and 64b at its opposite ends which are journaled in bearings 65 carried by side frame members 25. A shaft 66 is axially slidable in an axial bore 67 formed in the trunnion 64a, and the shaft 66 has its outer end secured by a screw 68 to a thrust ball-bearing 69 which has its outer race secured in a bell shaped casing 70. The casing 70 has an axial screw extension 71 which extends threadably through a tapped central bore of a housing 72 secured, as by screws 73, to the adjacent side frame member 25 (FIG. 5). The screw extension 71 of casing 70 has a smooth outer end portion on which the actuating arm 62 is mounted and secured, as by a key and slot connection 74 so that, when arm 62 is angularly displaced, as previously described, casing 70 is similarly turned, and, by reason of the threaded engagement of screw extension 71 with the tapped bore of fixed housing 72, casing 70 moves axially within housing 72 and imparts a corresponding axial displacement to shaft 66.

A bar 75 is fixed in and extends diametrically through a slot 76 in shaft 66 and passes through radially registered slots 77 in trunnion 64a, with slots 77 having dimensions in the direction of the axis of the cylinder 42 greater than the corresponding dimension of the bar 75 in order to permit movement of the latter with the shaft 66.

The opposite ends of bar 75 are connected, as by pins 78, to lugs 79 which project from a ring 80 slidable on the trunnion 64a. The body 63 of female die cylinder 42 is formed with a series of axially extending, radially outwardly opening slots 81, and bars 82 are axially slidable in slots 81 and have ends projecting axially from the latter for attachment to ring 80 by screws 83, as shown in FIG. 5. Each of the bars 82 is formed with longitudinally spaced apart, radially outwardly projecting portions 84 having edges which are inclined with respect to the axis of the die cylinder 42. Each slot 81 also accommodates a radially movable expansion bar 85 which is disposed radially outward with respect to the related bar 82 and has inclined inner edge portions 86 slidably engaging the edges 84 of the related bar 82 so that, when the latter is axially displaced within the slot 81 and the related bar 85 is held against displacement relative to the body 63 in the direction of the axis of the latter, the bar 85 is radially displaced within the slot 81.

The bars 85 are held against axial displacement with respect to body 63 by means of end rings 87 which are secured on the end portions of body 63, for example, by screws 88, and which are formed with annular lips 89 engaging against the opposite ends of the bars 85. Further, each bar 85 is formed with projections 90 at its

opposite ends, and compression springs 91 are interposed between the projections 90 and the lips 89 of the adjacent end rings 87 so that the springs 91 yieldably urge the expansion bars 85 radially inward into engagement with the related axially movable bars 82.

The female die cylinder 42 further includes female perforator plates 92 which extend axially and seat against the outer surface of body 63 between the circumferentially spaced apart slots 81 and which are located and secured on the body 63 by means of pins 93 and screws 94. As seen in FIG. 7, the successive plates 92 have their adjacent longitudinal edges in abutting relation and are formed with edge cutouts 95 which register with each other to define openings in radial alignment with slots 81. Projections 96 are formed on each of the radially movable bars 85 to extend more or less through the openings defined by cutouts 95. The plates 92 are formed with rows of die holes 97 extending both in the circumferential direction of the female die cylinder and parallel to the axis of the latter to receive correspondingly positioned perforating pins 98 provided on the surface of the male die cylinder 43 which is hereinafter described in detail.

It will be apparent that, when bars 85 are radially displaced within corresponding slots 81, in the manner previously described, projections 96 of such bars 85 will protrude by varying amounts radially beyond the outer surfaces of adjacent plates 92 thereby to increase or decrease the effective diameter of the female die cylinder 42 around which the web W is wrapped.

Thus, when female die cylinder 42 and male die cylinder 43 are rotated at a uniform angular speed, the linear speed at which the web W is pulled by the die cylinders depends upon the effective diameter of the female die cylinder 42, and it is to be understood that the thread on the screw extension 71 of the casing 70 is arranged so that, turning of arm 62 in the counterclockwise direction, as viewed in FIG. 2, in response to the upward movement of the floating roller 30 by an abnormal increase in the web tension, moves bars 82 towards the right, as viewed in FIG. 5, and the corresponding bars 85 move radially inward in order to decrease the effective diameter of the female die cylinder for reducing the linear speed of the web wrapped around the female die cylinder and thereby reduce the tension in the web between printing couple 16 and the perforating die cylinders. Conversely, a reduction in the tension of the web between the printing couple and the perforating die cylinders will be compensated for by an increase in the effective diameter of the female die cylinder, thereby increasing the linear speed of the web wrapped around the female die cylinder to compensate for such reduction in the web tension.

As the projections 96 of bars 85 protrude more or less beyond the outer surfaces of perforating plates 92, the length of the portion of web W between two adjacent bars 85 is correspondingly increased or decreased to a relatively small extent, thereby to increase or decrease to a relatively small extent the spacing between the holes of the longitudinally extending rows of perforations and the spacing between the successive transversely extending rows of perforations formed in that portion of the web, so that varying the effective diameter of female die cylinder 42 serves to maintain the proper longitudinal registration of the pattern of perforations with respect to the individual printed areas as well as to maintain a predetermined web tension.

The web tension maintained between printing couple 16 and perforating die cylinders 42 and 43 by the above described variation of the effective diameter of the female die cylinder 42 may be conveniently adjusted by manipulation of nut 37 for varying the tension of the spring 33 acting upon the floating roller 30.

It will be apparent that, as floating roller 30 moves generally vertically in response to variations in the web tension, such movement of roller 30 will affect the length of the web between printing couple 16 and die cylinders

42 and 43, and thus affect the longitudinal registry of the printed areas applied thereto by printing couple 16 with respect to the perforations formed in the web by the cooperation of die cylinders 42 and 43. However, such inaccuracies in the longitudinal registration are also sensed by the control panel 56 as a time differential between the electrical pulses or signals from scanning head 45 and selector switch 48 and the control panel 56 accordingly controls the operation of motor 26 for moving compensating roller 21 in the direction required for restoring accurate longitudinal registration of the printed areas with the pattern of perforations in the web. It is to be understood that the longitudinal register inaccuracies introduced by the movement of the roller 30 are relatively of such small magnitude that they do not prevent the photoelectric register system from acting with the other elements of the mechanism to maintain the desired accuracy or registration.

As the pins 98 of male die cylinder 43 enter the related die holes 97 of female die cylinder 42 with the web W wrapped around the latter, chips of the web are punched from the latter to form the desired perforations. In order to provide for the removal of such chips punched from the web, the body 63 of the female die cylinder has a series of circumferentially extending, axially spaced apart grooves 99 and a series of axially extending, circumferentially spaced apart grooves 100 formed in its outer surface and underlying the circumferentially and axially extending rows of die holes 97 formed in the plates 92 so that the chips punched from the web by the cooperative action of the pins 98 and die holes 97 fall into the grooves 99 and 100. The body 63 of the female die cylinder is provided with radially extending bores 101 which open, at their radially inner ends, into an interior cavity 102 extending along the entire length of the hollow body 63. One end of the cavity 102 communicates with a passage 103 extending axially through the trunnion 64b at the end of the die cylinder 42 remote from the actuating arm 62, and the outer end of the passage 103 is counter-bored, as at 104, to receive a sleeve bearing 105 which supports an end of a fixed tube 106 connected to a source of vacuum (not shown) so that a suction will be created within the cavity 102 for drawing the chips punched from the web out of the grooves 99 and 100 by way of the radial bores 101.

In an alternative construction of the female die cylinder, as illustrated in FIGS. 8 and 9, provision is made for the removal of the chips punched from the web to form the desired perforations in the latter by providing the outer surface of the body 63a of the female die cylinder 42a with cavities 107 which radially underlie the die holes 97a of the plates 92a, while the cutouts 95a of the latter are enlarged to define openings 108 next to the projections 96a of the radially movable bars which vary the effective diameter of the die cylinder. Thus, the chips punched from the web fall through the die holes 97a into the cavities 107 and are discharged from the latter through the openings 108 as the cavities occupy positions near the bottom of the female die cylinder. A chute 109 is arranged under the female die cylinder to collect the chips which fall from the cavities 107. In order to facilitate the removal of the chips from the cavities 107 under the influence of gravity, a tube 110 is connected to a suitable source (not shown) of compressed air and is arranged below the female die cylinder. The tube 110 has openings 111 through which jets of air are directed against the lower surface of the female die cylinder for agitating the chips collected within the cavities 107.

Referring now to FIGS. 4 and 10, it will be seen that the male die cylinder 43 includes a body 112 having a circumferential series of axially extending back-up bars 113 disposed around the outer surface thereof, and pin holding plates 114 resting against the radially outer surfaces of back-up bars 113 and formed with holes extending therethrough to receive the pins 98. Each of the pins

98 has a head 115 on its inner end and each hole of a plate 114 receiving a pin 98 is suitably countersunk, at its inner end, to accommodate the head 115 of the pin. Thus, the pins 98 extend radially outward through the related holes of the plates 114 and are held against outward removal by their heads 115, while radially inward movement of the pins 98 is prevented by engagement of the heads 115 of the pins with the radially outer surfaces of the back-up bars 113. Screws 116 extend through suitable openings in plates 114 and back-up bars 113 and are received in tapped bores in body 112 in order to secure the plates 114 and back-up bars 113 to the body. The holes formed in the back-up bars 113 for receiving the screws 116 are preferably oversize so that, in the event of any small misalignment between perforating pins 98 and the related die holes 97 of the female die cylinder, the plates 114 and back-up bars 113 can bend slightly about the screws 116 to compensate for such slight misalignment.

The perforating die cylinders 42 and 43 are driven by a gear 117 which may be connected to the main drive (not shown) of the printing press, and which meshes with a spur gear 118 fixed to the female die cylinder 42 at one end of the latter (FIG. 2). The gear 118 meshes, in turn, with a gear arrangement 119 (FIG. 3) which is provided on male die cylinder 43.

In order to avoid any major misalignment of perforating pins 98 with respect to the related die holes 97, the gear arrangement 119 is preferably of a type which is effective to take up any backlash between gear 118 and gear arrangement 119, particularly as the teeth of such gears become worn. The anti-backlash gear arrangement 119 may be of the kind disclosed in the United States Letters Patent No. 2,911,847, issued November 10, 1959, to W. F. Huck, and which includes two relatively narrow gears 120 and 121 mounted on a common hub and rotatable independently with respect to the latter, the teeth of the gears 120 and 121 having a combined axial dimension approximately equal to the axial length of the teeth on gear 118 of the female die cylinder. Further, the anti-backlash gear arrangement 119 includes a spring actuated linkage connected to gears 120 and 121 to urge such gears to turn in opposite directions with respect to the common hub, thereby to take up any backlash between the teeth of the gears 120 and 121 and the meshing teeth of the conventional spur gear 118.

Although the above described embodiments of the invention have the perforating section or unit 20 included in an apparatus which initially applies printed areas to the web W and then perforates the web, it is to be noted that such perforating unit embodying the invention may also be employed in the case where the web has the printed areas or patterns previously applied thereto and the preprinted web is merely unwound from a supply roll for passage through the perforating unit 20. In the last mentioned application of the invention, error signals issuing from the control panel 56 in response to the sensing of a register error between the preprinted pattern on the web and the perforations formed therein by the perforating die cylinders 42 and 43 may be made to directly control the variations of the effective diameter of the female die cylinder 43 for achieving accurate longitudinal registration between the printed areas and the pattern of perforations. In the case where the error signals directly control the variations of the effective diameter of the female die cylinder, an electric motor similar to the motor 26 actuated by the error signals may have its screw passing through a nut on the actuating arm 62, and the compensating roller 21 of the previously described embodiment of the invention may be eliminated if the type of web tension control mechanism acting on the web at a location in advance of the perforating die cylinders does not alter the longitudinal registration of the printed areas with respect to the perforated pattern, for example, as in the web tension control mechanism disclosed in the previ-

ously more fully identified United States Letters Patent No. 2,787,463.

It will also be apparent that, in the above described embodiments of the invention, the single set of perforating die cylinders 42 and 43 is effective to provide both the longitudinally and transversely extending rows of perforations in the web W. However, the invention is not limited to an arrangement having a single set of perforating cylinders and, as shown in FIG. 11 of the drawings, the transversely extending rows of perforations may be formed by a first set of perforating die cylinders 42b and 43b, while the longitudinally extending rows of perforations are formed by a second set of perforating die cylinders 42c and 43c. The perforating unit or section 20b of FIG. 11 may be employed in the printing and perforating apparatus of FIG. 1 in place of the perforating section or unit 20 and includes a compensating roller, corresponding to the roller 21 of unit 20, a floating roller, corresponding to the roller 30, and a scanning head corresponding to the head 45, for each set of perforating die cylinders. Thus, unit 20b has a compensating roller 21b which is displaced by a reversible motor 26b through a screw 28b, a side registry device 22b corresponding to the side registry device 22 of the unit in FIG. 2 and receiving the web W from the compensating roller, a floating roller 30b receiving the web from the side registry device 22b and mounted on arms 31b for movement about a shaft 32b under the opposite influences of a spring 33b and the web tension, a detection roller 40b, scanning head 45b located adjacent roller 40b to scan the register marks on the web W as the latter passes over roller 40b, a photoelectric selector switch 48b driven from the associated die cylinder 42b, a register control panel 56b receiving electrical signals from head 45b and selector switch 48b to issue error signals in the event of any defect in the synchronization of markings previously printed on the web with respect to the perforation of transversely extending rows of holes by the die cylinders 42b and 43b, and to control the motor 26b by such error signals for effecting accurate registration in the longitudinal direction of the web, rollers 41b and 44b guiding the web so that the latter wraps around the female die cylinder 42b, and a linkage 58b, 60b and 62b connecting shaft 32b with female die cylinder 42b so that the effective diameter of the latter is suitably varied, in response to changes in the web tension sensed by the roller 30b and resulting from the longitudinal registering movement of the compensating roller 21b. Further, the perforating section or unit 20b includes a compensating roller 21c receiving the web following the forming of transversely extending rows of perforations in the latter by die cylinders 42b and 43b, a reversible motor 26c for displacing a compensating roller 21c by way of a screw 28c, a floating roller 30c receiving the web from the compensating roller 21c and influenced, in opposite directions, by the web tension and by a tension spring 33c, arms 31c mounting the floating roller 30c for movement about a shaft 32c, a detection roller 40c over which the web W passes following its movement under the floating roller 30c, a scanning head 45c located adjacent roller 40c to scan the register marks on the web W as the latter passes over roller 40c, a photoelectric selector switch 48c driven from the associated female die cylinder 42c, a register control panel 56c receiving electrical signals from head 45c and selector switch 48c to issue error signals in the event of any lack of synchronization between the printed marks on the web and the operation of die cylinders 42c and 43c in producing the longitudinally extending rows of perforations, and guide rollers 41c and 44c causing the web to wrap around the female die cylinder 42c. Further, a linkage 58c, 60c and 62c is provided between shaft 32c and female die cylinder 42c to vary the effective diameter of the latter in accordance with movements of floating roller 30c caused by changes in the web tension between die

cylinders 42b and 42c as a result of the movement of compensating roller 21c.

From the above, it will be apparent that, in the embodiment of FIG. 11, each of the separate sets of die cylinders 42b and 43b, and 42c and 43c has associated therewith a mechanism for effecting longitudinal registration of the printed areas of the web with respect to the perforations formed in the web by the respective set of die cylinders and a tension sensitive arrangement for varying the effective diameter of the related female die cylinder in accordance with changes in the length of the web in advance of the female die cylinder brought about by the operation of the longitudinal registering mechanism.

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

What is claimed is:

1. In a machine for perforating sheet material, the combination of at least one set of male and female die cylinders, said male die cylinder having pins projecting radially therefrom, said female die cylinder having radial die openings in the surface thereof which are located to receive said pins as the male and female die cylinders are simultaneously rotated, so that said pins and die openings cooperate to form perforations in sheet material fed between the cylinders, said female die cylinders having internal channels near the outer surface thereof underlying and communicating with said die openings so that pieces of the sheet material removed from the latter in forming the perforations collect in said internal channels, and relatively large discharge apertures opening radially from said internal channels at said surface of the female die cylinder to permit the pieces of sheet material collected in said internal channels to fall from the latter through said discharge apertures when the latter are disposed at the bottom of the female die cylinder.

2. In a machine for perforating sheet material, the combination of at least one set of male and female die cylinders, said male die cylinder having pins projecting radially therefrom, said female die cylinder having radial die openings in the surface thereof which are located to receive said pins as the male and female die cylinders are simultaneously rotated, so that said pins and die openings cooperate to form perforations in sheet material fed between the cylinders, said female die cylinder having internal channels near the outer surface thereof underlying and communicating with said die openings so that pieces of the sheet material removed from the latter in forming the perforations collected in said internal channels, relatively large discharge apertures opening radially from said internal channels at said surface of the female die cylinder so that the pieces of sheet material collected in said internal channels tend to fall from the latter through said discharge apertures when the latter are located at the bottom of the female die cylinder, and means located externally of said female die cylinder for directing jets of air upwardly against the bottom of said female die cylinder to act through said discharge apertures on the pieces of sheet material in said internal channels, thereby to agitate said pieces and prevent their adhering within said internal channels.

3. In a machine for perforating sheet material, the combination of a male die cylinder having perforating pins projecting radially therefrom, a female die cylinder having perforating plates on its surface with radial die openings therein located to receive said pins when said male and female die cylinders are simultaneously rotated, axially extending, radially opening slots in the surface of said female die cylinder, actuating bars axially slidable in said slots, expansion bars radially movable in said slots, said actuating and expansion bars in each slot having

slidably engaging inclined surfaces effective to cause radial movement of the expansion bar in response to axial movement of the related actuating bar, said perforating plates having cutouts in radial alignment with said expansion bars and said expansion bars having radial projections adapted to extend through said cutouts radially beyond the outer surfaces of said perforating plates for varying the effective diameter of the female die cylinder upon radial movement of said expansion bars, thereby to alter the linear speed at which the die cylinders advance the sheet material fed therebetween and also to alter the distance, in the direction of movement of the sheet material, between the successive perforations formed in the latter, and means for effecting simultaneous axial movement of said actuating bars.

4. In a machine for perforating sheet material, the combination as in claim 3; wherein said surface of the female die cylinder has cavities therein communicating with said die openings to receive pieces of the sheet material removed from the latter in forming the perforations, and said cutouts of the perforating plates are substantially larger than said projections of the expansion bars to leave gaps communicating with said cavities through which the pieces of sheet material can fall when said gaps are at the bottom of the die cylinder.

5. In a machine for perforating sheet material, the combination as in claim 4; further comprising means for directing jets of air against the bottom of said female die cylinder to act through said gaps for agitating the pieces of sheet material in said cavities to ensure that said pieces fall from said cavities.

6. In a machine for perforating sheet material, the combination as in claim 3; wherein said female die cylinder is hollow and has grooves in the surface thereof communicating with said die openings and radial passages extending from said grooves to the hollow interior of the female die cylinder; and further comprising means for connecting said hollow interior with a source of vacuum so that pieces of sheet material removed from the latter in forming the perforations are exhausted from the female die cylinder by way of said grooves, passages and hollow interior.

7. A tension control mechanism for a moving tensioned web of material comprising a propelling cylinder contacting said moving web, said cylinder having axially slidable actuating bars and expansion bars adapted to project beyond the peripheral surface of said cylinder and be moved radially relative thereto to vary the effective propelling diameter of said cylinder, said actuating and expansion bars having complementary slidably engaging elements effective to cause radial movement of said expansion bars in response to axial movement of said actuating bars, and means responsive to variations in the tension of said web from a desired value to move said actuating bars axially and thereby compensatingly vary the speed at which said web is propelled so that the web tension is maintained substantially at said desired value.

8. In a machine for perforating printed sheet material having register marks thereon in predetermined positional relationship to the printing, the combination of a die cylinder having pins projecting radially therefrom and a female die cylinder over a portion of the peripheral surface of which the sheet material is trained and having radial die openings to receive said pins, means for rotating said die cylinders so that said pins successively enter the related die openings to form perforations in the sheet material fed between the die cylinders, said female die cylinder being of variable diameter, and register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the sheet material and in response to such deviations to vary the effective diameter of said female die cylinder by any amount proportional to the magnitude of, and

in either direction in compensation for the direction of, the detected deviations, so as to maintain said correct registration.

9. In a machine for perforating sheet material having register marks spaced apart and along in predetermined positional relationship thereto, the combination of at least one set of rotated male and female die cylinders respectively carrying die elements cooperating to form perforations in the sheet material continuously fed therebetween, said female die cylinder comprising expansion members forming at least part of said surface and movable radially to vary the effective diameter of said female die cylinder, and register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said die elements and the desired location of perforations in the web and in response to such deviations to vary the radial position of said expansion members, and thereby the effective diameter of said female die cylinder, by an amount proportional to the magnitude of, and in either direction in compensation for the direction of, the detected deviations, so as to maintain said correct registration.

10. In a machine for forming longitudinally and transversely extending rows of perforations in a web between longitudinally and transversely extending rows of printed areas on the web, said web having register marks thereon in predetermined positional relationship to the printed areas, the combination of a male die cylinder having radial pins projecting therefrom in rows extending circumferentially and axially on the cylinder, a female die cylinder having radial die openings in rows extending circumferentially and axially on the surface of the female die cylinder and located to receive said pins, and means for rotating said male and female die cylinders so that said pins successively enter the related die openings to form perforations between the rows of printed areas on the web fed continuously between the die cylinders, said female die cylinder being of variable diameter, and register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said rows of pins and the desired location of the rows of perforations in the web and in response to such deviations to vary the effective diameter of said female die cylinder by an amount proportional to the magnitude of, and in either direction in compensation for the direction of, the detected deviations, so as to maintain said correct registration.

11. In a machine for forming longitudinally and transversely extending rows of perforations in a web between longitudinally and transversely extending rows of printed areas on the web, said web having register marks thereon in predetermined positional relationship to the printed areas, the combination of a source of the web having the printed areas thereon, a first set of rotated male and female die cylinders having radial pins and die openings, respectively, arranged in rows extending axially on the respective cylinders and cooperating to form transversely extending rows of perforations in the web continuously fed therebetween, a second set of rotated male and female die cylinders having radial pins and die openings, respectively, arranged in rows extending circumferentially on the respective cylinders and cooperating to form longitudinally extending rows of perforations in the web continuously fed therebetween, the female die cylinder of each of said sets being of variable diameter, first register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said first set of die cylinders that corresponds to correct registration between said axially arranged rows of pins and the desired location of the transversely extending rows of perforations in the web and in response to such deviations to vary the effective diameter of the female cylinder of said first set by an amount pro-

portional to the magnitude of, and in either direction in compensation for the direction of, the detected deviations, so as to maintain said correct registration of the transversely extending rows of perforations, and second register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said second set of die cylinders that corresponds to correct registration between said circumferentially arranged rows of pins and the desired location of the longitudinally extending rows of perforations in the web and in response to such deviations to vary the effective diameter of the female cylinder of said second set by an amount proportional to the magnitude of, and in either direction in compensation for the direction of, the detected deviation, so as to maintain said correct registration of the longitudinally extending rows of perforations.

12. In a machine for perforating a printed web having register marks in predetermined positional relationship to the printing thereon, the combination of a source of the web with printing thereon, at least one set of rotated male and female die cylinders having cooperating radial pins and die openings, respectively, to form perforations in the web fed continuously between said die cylinders from said source, one of said die cylinders being of variable diameter, register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the web and in response to said deviations to vary the length of the portion of the web extending between said source and said die cylinders in the sense to restore said normal relationship, and means responsive to changes in the tension in the web resulting from varying the length of said portion to vary the effective diameter of said one die cylinder and thereby the linear speed at which said cylinders draw the web from said source so as to tend to maintain a constant web tension.

13. In a machine for perforating and printing a web, the combination of a supply roll containing the web, a printing couple applying printed impressions to the web passing therebetween from said supply roll and simultaneously defining register marks in predetermined positional relationship to the printed impressions, at least one set of rotated male and female die cylinders having cooperating radial pins and die openings, respectively, to form perforations in the printed web fed continuously between said die cylinders from said printing couple, one of said die cylinders being of variable diameter, register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the web and in response to said deviations to vary the length of the portion of the web extending between said printing couple and said die cylinders in the sense to restore said normal relationship, and means responsive to changes in the tension in the web resulting from varying the length of said portion to vary the effective diameter of said one die cylinder and thereby the linear speed at which said cylinders draw the web from said printing couple so as to tend to maintain a constant web tension.

14. In a machine for perforating a printed web having register marks in predetermined positional relationship to the printing thereon, the combination of a source of the web with printing thereon, at least one set of rotated male and female die cylinders having cooperating radial pins and die openings, respectively, to form perforations in the web fed continuously between said die cylinders from said source, one of said die cylinders being of variable diameter, a compensating roller engaging the printed web between said source and said die cylinders and being bodily movable to vary the length of the portion of the web extending between said source and said die cylinders,

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actuating means for bodily moving said compensating roller, register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the web and in response to said deviations to operate said actuating means to bodily move said compensating roller in the direction to restore said normal relationship, and means responsive to changes in the tension in the web resulting from varying the length of said portion to vary the effective diameter of said one die cylinder and thereby the linear speed at which said cylinders draw the web from said source so as to tend to maintain a constant web tension.

15. A machine for perforating a printed web having register marks in predetermined positional relationship to the printing thereon, the combination of a source of the web with printing thereon, at least one set of rotated male and female die cylinders having cooperating radial pins and die openings, respectively, to form perforations in the web fed continuously between said die cylinders from said source, said female die cylinder comprising radially movable expansion members forming at least a part of the peripheral surface thereof, register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the web and in response to said deviations to vary the length of the portion of the web extending between said source and said die cylinders in the sense to restore said normal relationship, and means responsive to changes in the tension in the web resulting from varying the length of said portion to effect radial movement of said expansion members to vary the effective diameter of said female die cylinder and thereby the linear speed at which said cylinders draw the web from said source, whereby to tend to maintain a constant web tension.

16. A machine for perforating a printed web having register marks in predetermined positional relationship to the printing thereon, the combination of a source of the web with printing thereon, at least one set of rotated male and female die cylinders having cooperating radial pins and die openings, respectively, to form perforations in the web fed continuously between said die cylinders from said source, one of said die cylinders being of variable diameter, register control means operative to detect deviations of the position of said marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the web and in response to said deviations to vary the length of the portion of the web extending between said source and said die cylinders in the sense to restore said normal relationship, a roller engaging said web portion and being bodily movable in response to changes in the tension of said web portion resulting from variations of the length thereof, and means responsive to bodily movement of said roller to vary the effective diameter of said one die cylinder and thereby the linear speed at which said cylinders draw the web from said source, so as to tend to maintain a constant web tension.

17. In a machine for forming longitudinally and transversely extending rows of perforations in a web between longitudinally and transversely extending rows of printed areas of the web, the combination of a source of the web with said printed areas thereon, a male die cylinder having radial pins projecting therefrom in rows extending circumferentially and axially on the cylinders, a female die cylinder having radial die openings in rows extending circumferentially and axially on the surface thereof, and located to receive said pins, means for rotating said die cylinders so that said pins successively enter the related die openings to form perforations between the

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row of printed areas on the web fed continuously therebetween from said source, said female die cylinder being of variable diameter, register control means operative to detect deviations of the position of said printed area from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said rows of pins and the desired location of said rows of perforations in the web and in response to said deviations to vary the length of the portion of the web extending between said source and said die cylinders in the sense to restore said normal relationship, and means responsive to changes in the tension in the web resulting from varying the length of said portion to vary the effective diameter of said female die cylinder and thereby the linear speed at which said cylinders draw the web from said source so as to tend to maintain a constant web tension.

18. In a machine for forming longitudinally and transversely extending rows of perforations in a web between longitudinally and transversely extending rows of printed areas on the web, the combination of a source of the web having the printed areas thereon, a first set of rotated male and female die cylinders having radial pins and die openings, respectively, arranged in rows extending axially on the respective cylinders and cooperating to form transversely extending rows of perforations in a web fed between said first set of die cylinders from said source, a second set of rotated male and female die cylinders having radial pins and die openings, respectively, arranged in rows extending circumferentially on the respective cylinders and cooperating to form longitudinally extending rows of perforations in the web fed between said second set of die cylinders from said first set of die cylinders, the diameter of the female die cylinder of each of said sets being variable, first and second compensating means for varying the length of the portions of said web between said source and said first set of die cylinders and between said first and second sets of die cylinders, respectively, first register control means operative to detect deviations of the position of said printed areas from a normal relationship thereof to the position of said first set of cylinders that corresponds to correct registration between said axially arranged rows of pins and the desired location of the transversely extending rows of perforation in the web and in response to such deviation to actuate said first compensating means to maintain said correct registration of the transversely extending rows of perforations, second register control means operative to detect deviations of the position of said printed areas from a normal relationship thereof to the position of said second set of cylinders that corresponds to correct registration between said circumferentially arranged rows of pins and the desired location of the longitudinally extending rows of perforations in the web and in response to such deviations to actuate said second compensating means to maintain said correct registration of the longitudinally extending rows of perforations, and first and second actuating means responsive to the tensions in the web portion between said source said first set of die cylinders and between said first and second sets of die cylinders to vary the effective diameters of the female die cylinders of said first and second sets, respectively, so that the linear speeds at which said first and second sets of die cylinders draw the web therebetween are regulated to maintain a desired tension in the web.

19. In a machine for perforating printed sheet material having register marks thereon in predetermined positional relationship to the printing thereon, the combination of at least one set of rotated male and female die cylinders respectively carrying die elements cooperating to form perforations in the printed sheet material fed therebetween, the diameter of one of said die cylinders being variable to alter the spacing between successive perforations formed along the sheet material, and register control means operative to detect deviations of the posi-

tion of said register marks from a normal relationship thereof to the position of said cylinders that correspond to correct registration between said die elements and the desired location of perforations in the sheet material and in response to such deviations to vary the effective diameter of said one cylinder in the sense to restore said normal relationship, and tension control means engaging a portion of said web extending to said cylinders from a location in advance of said cylinders and operative to vary the tension of said web portion in response to and in compensation of changes in that tension introduced by variations of said effective diameter of said one cylinder, said tension control means including means operative to prevent any change in the length of said web portion as a result of the compensating tension variation introduced by said tension control means so as not to alter the registration between said printing and said perforations.

20. In a machine for perforating sheet material having printing thereon and register marks in predetermined positional relationship to the printing, the combination of at least one set of male and female die cylinders, said male die cylinder having pins projecting radially therefrom and said female die cylinder having radial die openings at the surface thereof for receiving said pins, means for rotating said die cylinders so that said pins successively enter the related die openings to form perforations in sheet material fed between said male and female die cylinders, the effective diameter of said female die cylinder being variable to alter the spacing along the sheet material between successive perforations formed in the latter, register control means operative to detect deviations of the position of said register marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the sheet material and in response to such deviations to vary the effective diameter of said female die cylinder in the sense to restore said normal relationship, and tension control means engaging a portion of said web extending to said cylinders from a location in advance of said cylinders and operative to vary the tension of said web portion in response to and in compensation of changes in that tension introduced by variations of said effective diameter of said female cylinder, said tension control means including means operative to prevent any change in the length of said web portion as a result of the compensating tension variations introduced by said tension control means so as not to alter the registration between said printing and said perforations.

21. In a machine for perforating a printed web having register marks thereon in predetermined positional relationship to the printing thereon, the combination of at least one male die cylinder having pins projecting radially therefrom, a female die cylinder cooperating with said male die cylinder and having radial die openings at the surface thereof to receive said pins, means for rotating said cylinders so that the pins successively enter the related die openings to form perforations in a web fed between said cylinders, said female die cylinder further comprising expansion members forming at least a part of said surface and being radially movable to vary the effective diameter of the female die cylinder and thereby the spacing along the web between successive perforations formed in the latter, register control means operative to detect deviations of the position of said register marks from a normal relationship thereof to the position of said cylinders that correspond to correct registration between said pins and the desired location of perforations in the web and in response to such deviations to radially move said expansion members in the direction to vary the effective diameter of the female die cylinder in the sense to restore said normal relationship, and tension control means engaging a portion of said web extending to said cylinders from a location in advance of said cylinders and operative to vary the tension of said

web portion in response to and in compensation of changes in that tension introduced by variations of said effective diameter of said female die cylinder, said tension control means including means operative to prevent any change in the length of said web portion as a result of the compensating tension variations introduced by said tension control means so as not to alter the registration between said printing and said perforations.

22. In a machine for perforating printed sheet material having register marks thereon in predetermined positional relationship to the printing thereon, the combination of at least one male die cylinder having pins projecting radially therefrom and a female die cylinder having radial die openings to receive said pins as the male and female die cylinders are rotated, means for rotating said die cylinders including a gear transmission between said male and female die cylinders having means for taking up any backlash in said gear transmission to avoid inaccuracy in the registration of said pins with the related die openings as a result of wear in said transmission, means for guiding the printed sheet material between said die cylinders so that said pins and said die openings cooperate to form perforations in the printed sheet material, the effective diameter of one of said die cylinders being variable to alter the spacing along the sheet material between successive perforations formed in the latter, and register control means operative to detect deviations of the position of said register marks from a normal relationship thereof to the position of said cylinders that corresponds to correct registration between said pins and the desired location of perforations in the sheet material and in response to such deviations to vary the effective diameter of said one cylinder by an amount proportional to the magnitude of, and in either direction in compensation for the direction of the detected deviations, so as to maintain said correct registration.

23. In a machine for perforating a printed web having register marks thereon in predetermined positional relationship to the printing thereon, the combination of a source of said web, at least one set of rotated male and female die cylinders having cooperating radial pins and die openings, respectively, to form perforations in the web between said die cylinders from said source, means for rotating said die cylinders including a gear transmission between said male and female die cylinders having means for taking up any backlash in said gear transmission to avoid inaccuracy in the registration of said pins with the related die openings as a result of wear in said transmission, compensating means engaging the web and operative when displaced to vary the length of the portion thereof extending between said source and said die cylinders to correspondingly alter the positional relationship in the direction along the web between said printing and said perforations, register control means operative to detect deviations of the position of said register marks from a normal relationship thereof to the position of said cylinders corresponding to correct registration between said pins and the desired location of perforations in the web and in response to such deviations to displace said compensating means in the direction for restoring said normal relationship, means operative to vary the effective diameter of one of said die cylinders to correspondingly alter the linear speed at which said die cylinders draw the web from said source, and means responsive to changes in the tension of the web resulting from variations in the length of said web portion to actuate said diameter varying means so as to maintain a substantially constant web tension.

24. A tension control mechanism for a traveling tensioned flexible web, comprising a rotary web propelling cylinder of variable diameter having radially displaceable members forming parts of its peripheral surface contacting said web, and means responsive to variations of the tension of said web from a predetermined value to vary compensatingly the radial position of said members

and thereby the effective propelling diameter of said cylinder and the linear speed at which it propels said web so that the web tension is maintained substantially at said predetermined value.

25. A tension control mechanism for a traveling tensioned flexible web, comprising a rotary cylinder of variable diameter contacting and propelling said web, a floating roller engaging a portion of said web leading to said cylinder, means mounting and biasing said roller for displacement by the web in response and in proportion to variations of the tension of said web portion, and means operative in response to displacements of said roller to vary compensatingly the effective propelling diameter of said cylinder and thereby the linear speed at which it propels the web so that the tension of said portion is maintained substantially at a predetermined value determined by the force of said biasing means.

26. A tension control mechanism for a traveling tensioned flexible web, comprising a rotary web propelling cylinder, said cylinder having fixed peripheral portions and having between said fixed portions web engaging peripheral members which are displaceable radially relative thereto to vary the effective propelling diameter of said cylinder, positioning means slidable axially in said cylinder and having elements coacting with elements on said peripheral members to cause radial movement of said members in response to axial movement of said positioning means, and means responsive to variations of the tension of said web from a desired value to move said positioning means axially and thereby vary the effective diameter of said cylinder and the speed at which it propels said web.

27. A mechanism for processing a traveling flexible web, comprising a rotary cylinder, means for guiding said web over the periphery of said cylinder in wrapped relation thereto and for holding the web thereto so that it is propelled thereby at a speed determined by the action of said cylinder, said cylinder having radially displaceable members forming web engaging parts of its peripheral surface, displacement means responsive and moved in proportion to variations of a position of a portion of said web leading to said cylinder, and means positioned by said displacement means to displace said peripheral members radially through a distance proportional to the magnitude of, and in either direction in compensation for the sense of, such variations so as to vary compensatingly the web engaging circumference of said cylinder and the speed of propulsion of the web thereby.

28. A mechanism for processing a traveling flexible web, comprising a rotary cylinder, means for guiding said web over the periphery of said cylinder in wrapped relation thereto and holding the web thereto so that it is propelled thereby at a speed determined by the action of said cylinder, radially displaceable members forming web engaging parts of the peripheral surface of said cylinder, spring means in said cylinder continuously urging said members radially inward, positioning means rotated with said cylinder including a shaft slidable axially relative thereto for moving said members radially outward against the force of said spring means upon axial movement of said shaft in one direction and causing said members to be moved radially inward by said spring means upon axial movement of said shaft in the opposite direction, displacement means responsive and moved in proportion to variations of a position of a portion of said web leading to said cylinder, and means positioned by said displacement means for moving said shaft axially through a distance proportional to the magnitude of, and in either direction in compensation for the sense of, such variations so as to vary compensatingly the web engaging circumference of said cylinder and the speed of propulsion of the web thereby.

29. A mechanism for processing a traveling flexible web, comprising a rotary cylinder, means for guiding said web over the periphery of said cylinder in wrapped rela-

tion thereto and for holding the web thereto so that it is propelled thereby at a speed determined by the action of said cylinder, said cylinder having radially displaceable members forming web engaging parts of its peripheral surface, and means responsive and moved in proportion to variations of the tension of a portion of said web leading to said cylinder to displace said members radially through a distance proportional to the magnitude of, and in either direction in compensation for the sense of, such tension variations so as to vary compensatingly the web engaging circumference of said cylinder and the speed of propulsion of the web thereby.

30. A mechanism according to claim 29, the last recited means including positioning means mounted in and movable axially relative to said cylinder, a floating roller, means yieldably biasing said roller against said leading portion of the web with a predetermined force corresponding to the desired web tension, and means operated by displacement of said roller for proportionately displacing said positioning means axially and said peripheral members radially.

31. In a machine for processing a flexible web having register marks thereon at intervals corresponding to the intervals of repetitive patterns thereon, a rotary web propelling cylinder to and about the periphery of which the web is drawn continuously under tension and carrying web processing elements to act upon the web at locations in register with said patterns, said cylinder comprising radially displaceable members which form parts of its peripheral surface engaging the web, means positioning said members and movable to displace the same radially to vary proportionately the effective circumference of said cylinder and thus the speed of its propulsion of the web, and register control means including means for comparing the angular position of said cylinder with the position of register marks on the web approaching said cylinder and means responsive to variations of the relationship of these positions to displace said positioning means compensatingly.

32. In a machine for processing a flexible web having register marks thereon at regular intervals corresponding to the intervals of repetitive patterns thereon, a rotary web propelling cylinder to and about the periphery of which the web is drawn continuously under tension and carry web processing elements to act at regular intervals upon the web, said cylinder comprising radially displaceable members which form parts of its peripheral surface engaging the web, two displaceable web positioning rollers over which the web passes under tension in its travel to said cylinder, means positioning said radially displaceable members and movable with one of said rollers to displace said members radially in proportion to displacements of said one roller, so as to vary proportionately the circumference of said cylinder and thus the speed of its propulsion of the web, means biasing one of said rollers yieldably against the web under a predetermined force to tension the web, and register control means positioning the other of said rollers, said register control means including means for comparing the angular position of said cylinder with the position of register marks on the web approaching said cylinder and means responsive to variations of the relationship of these positions to displace said other roller correspondingly, whereby such variations are corrected without materially altering the length of the path or the tension of the web.

33. A machine according to claim 32, said means positioning said radially displaceable members being connected for movement with the roller biased yieldably against the web.

34. A machine according to claim 32, said means positioning said radially displaceable members including springs in said cylinder continuously urging said members radially inward, positioning elements rotated with said cylinder and movable axially relative thereto for

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moving said members radially outward against the force of said springs upon axial movement of said positioning elements in one direction, and allowing said members to move radially upon axial movement of said positioning elements in the opposite direction, and means connected with said one roller first mentioned for moving said positioning elements axially relative to said cylinder.

35. A machine according to claim 32, said cylinder being one of two coating rotary cylinders each of which has web cutting elements spaced apart thereon to coat in a zone of tangency of the two cylinders with mating web cutting elements on the other cylinder, said radially displaceable members being disposed between the web cutting elements on said one cylinder.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,174,428

March 23, 1965

William F. Huck

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 16, for "past." read -- past, --; column 3, lines 65 and 66, for "7,787,463" read -- 2,787,463 --; column 8, line 18, for "or" read -- of --; column 9, line 62, for "43" read -- 42 --; column 16, line 1, for "row" read -- rows --; line 59, for "said", second occurrence, read -- and --; column 18, line 43, after "web" insert -- fed --; column 19, line 43, for "mean" read -- means --; column 20, line 45, for "carry" read -- carrying --.

Signed and sealed this 24th day of August 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
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