June 14, 1966 W. F. HUCK 3,255,651

ROTARY PERFORATING DEVICE

Filed July 19, 1960 8 Sheets-Sheet 1

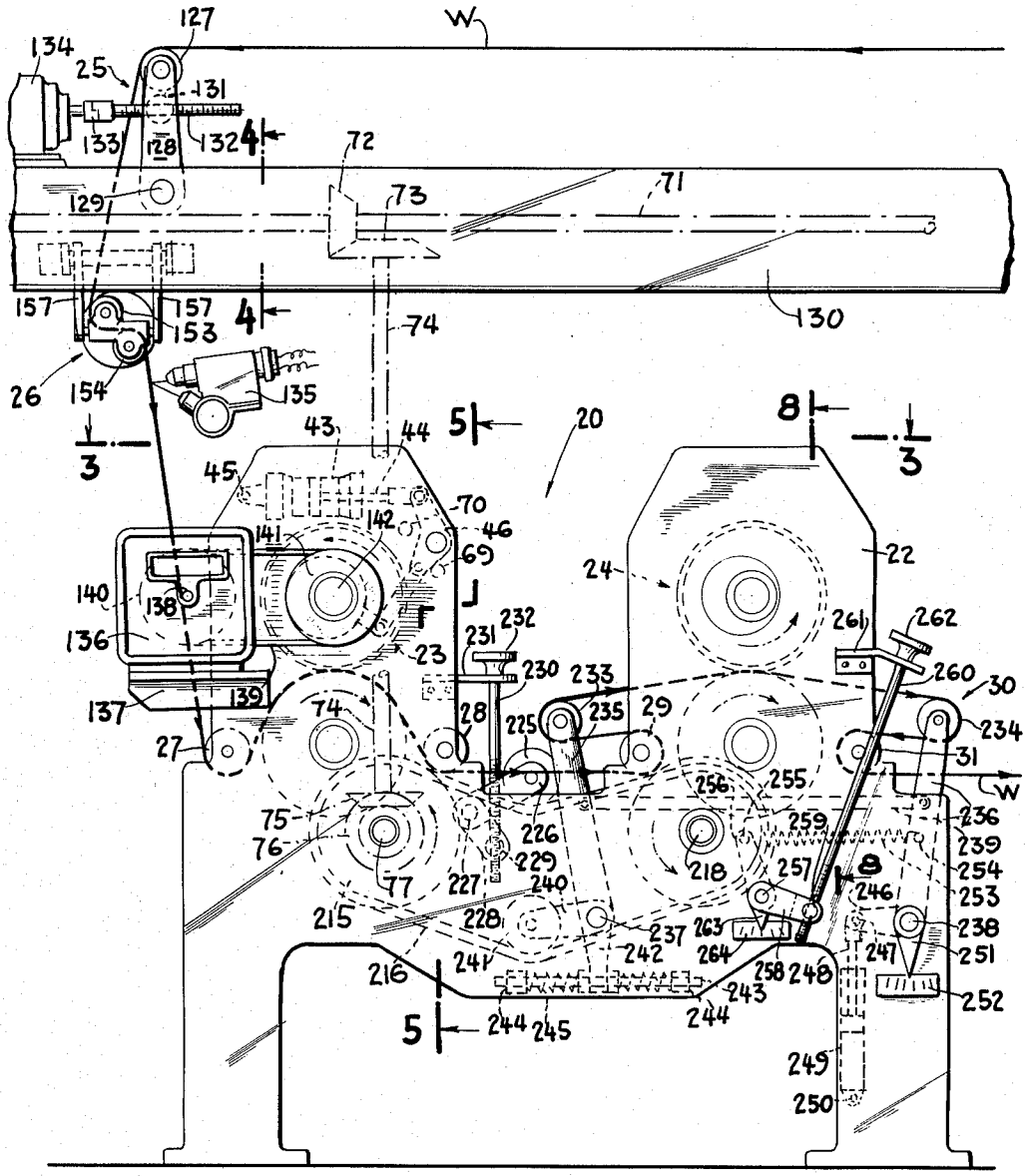


Fig. 1

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ROTARY PERFORATING DEVICE

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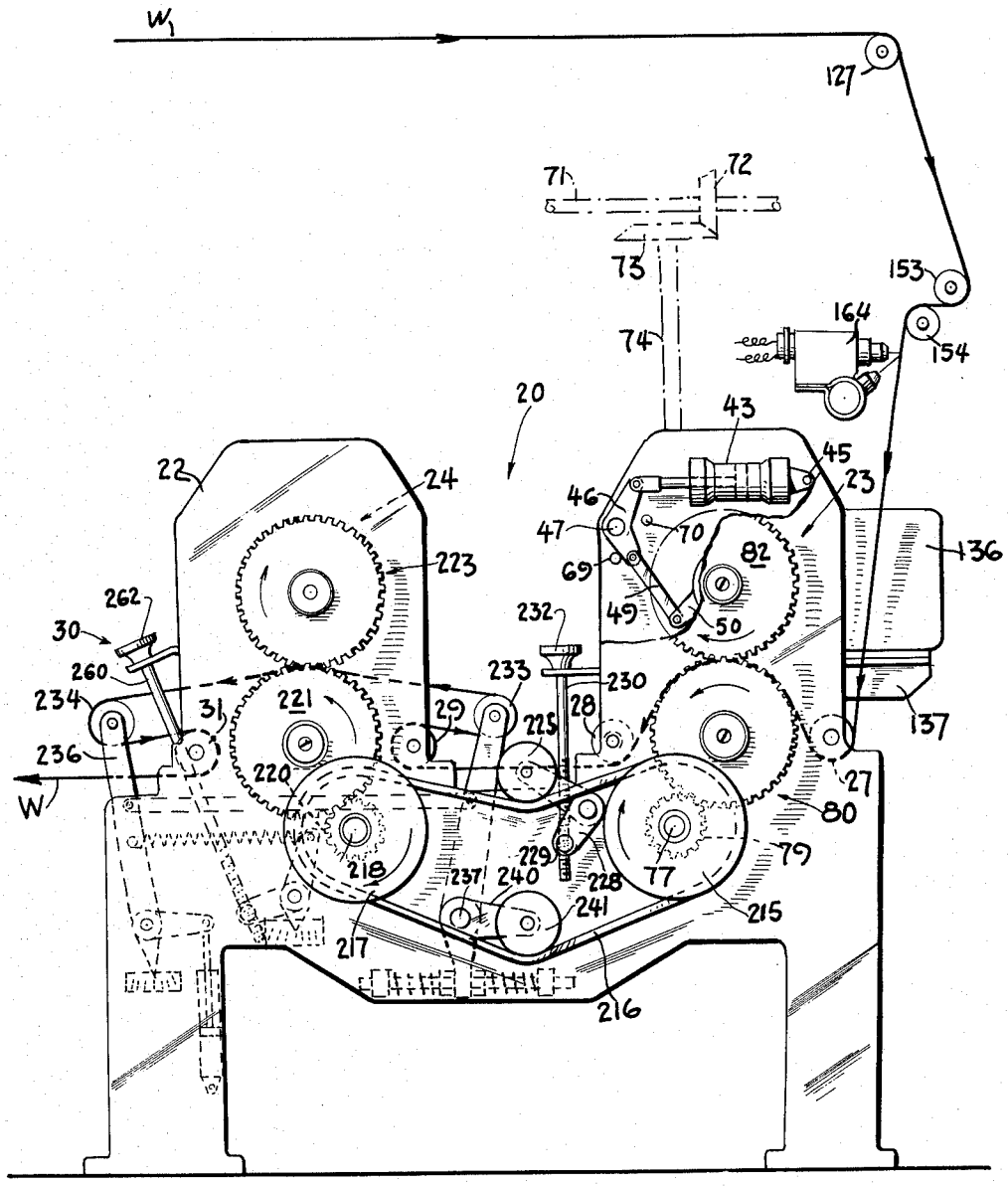


Fig. 2

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ROTARY PERFORATING DEVICE

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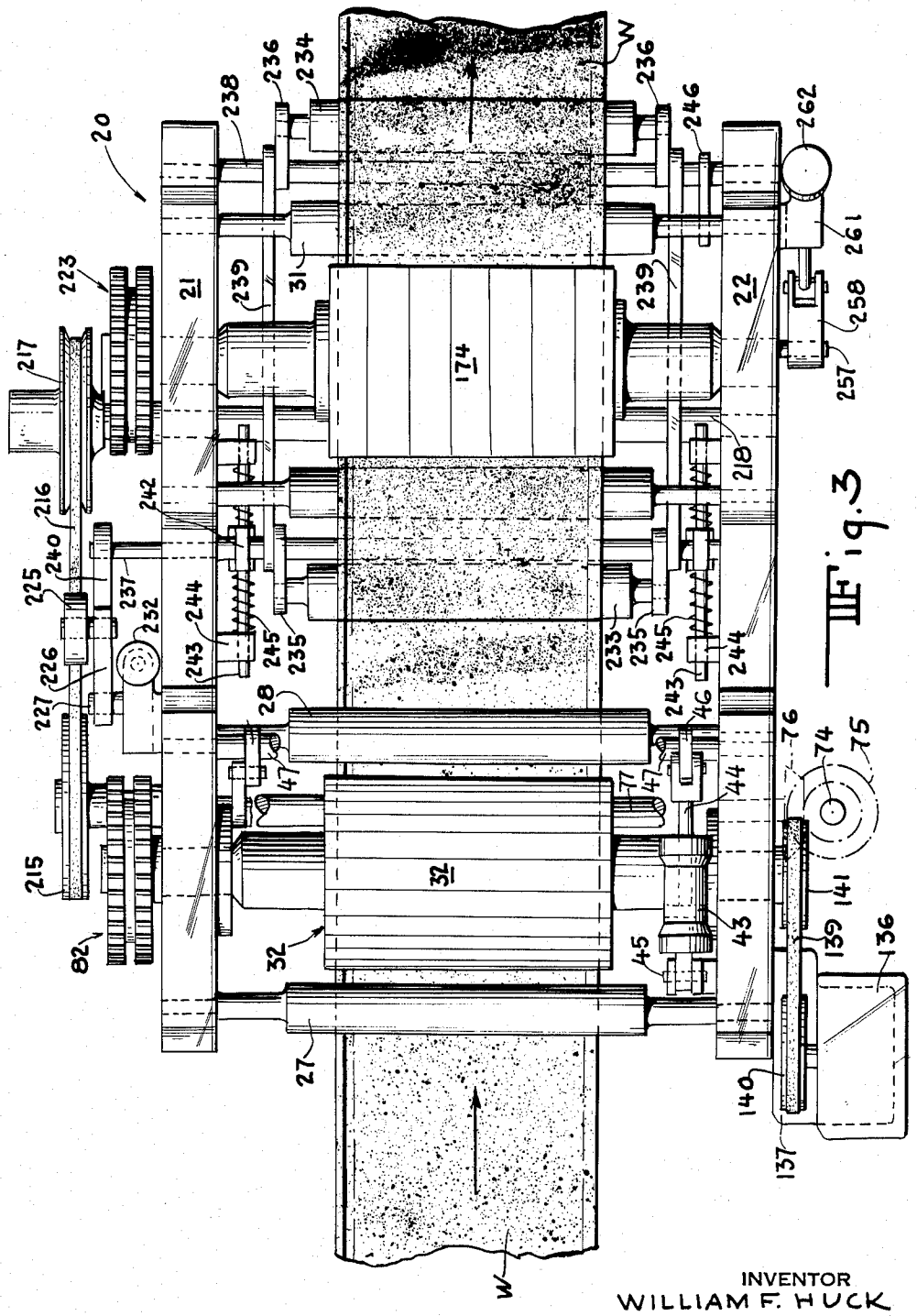


Fig. 3

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ROTARY PERFORATING DEVICE

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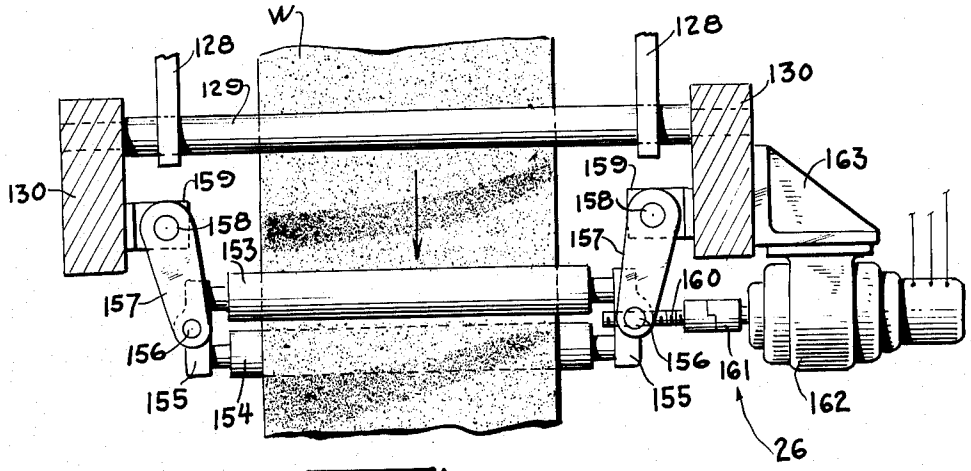


Fig. 4

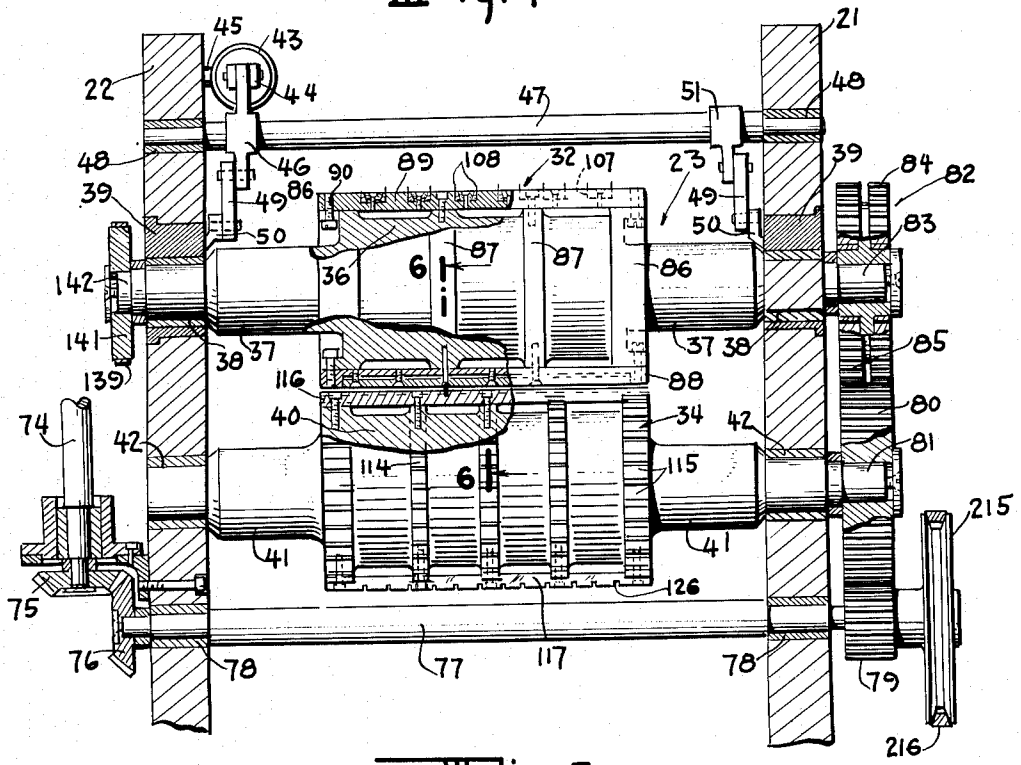


Fig. 5

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ROTARY PERFORATING DEVICE

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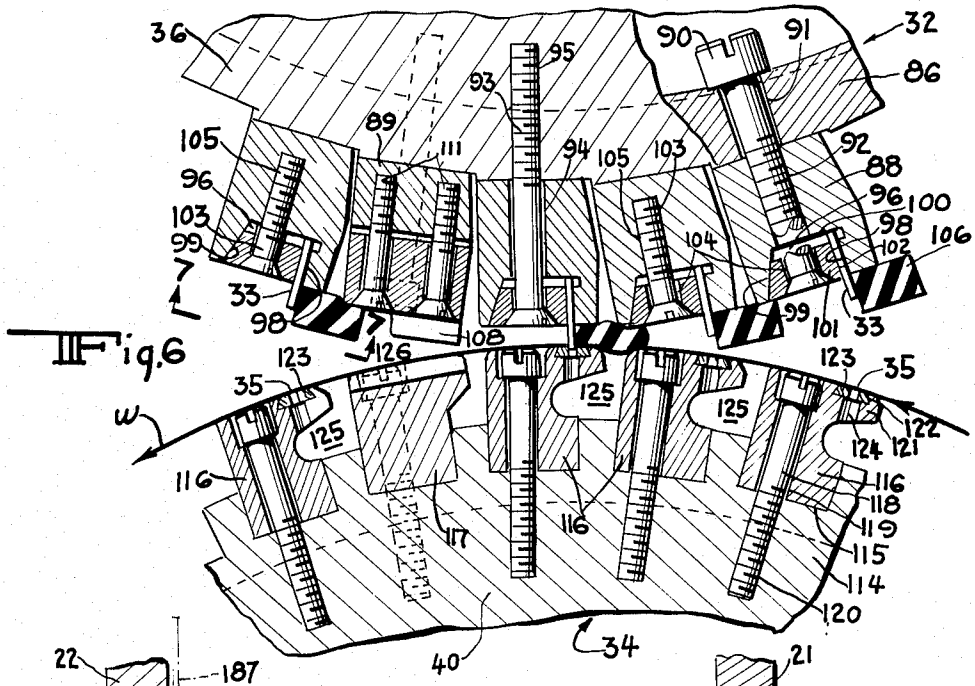


Fig. 6

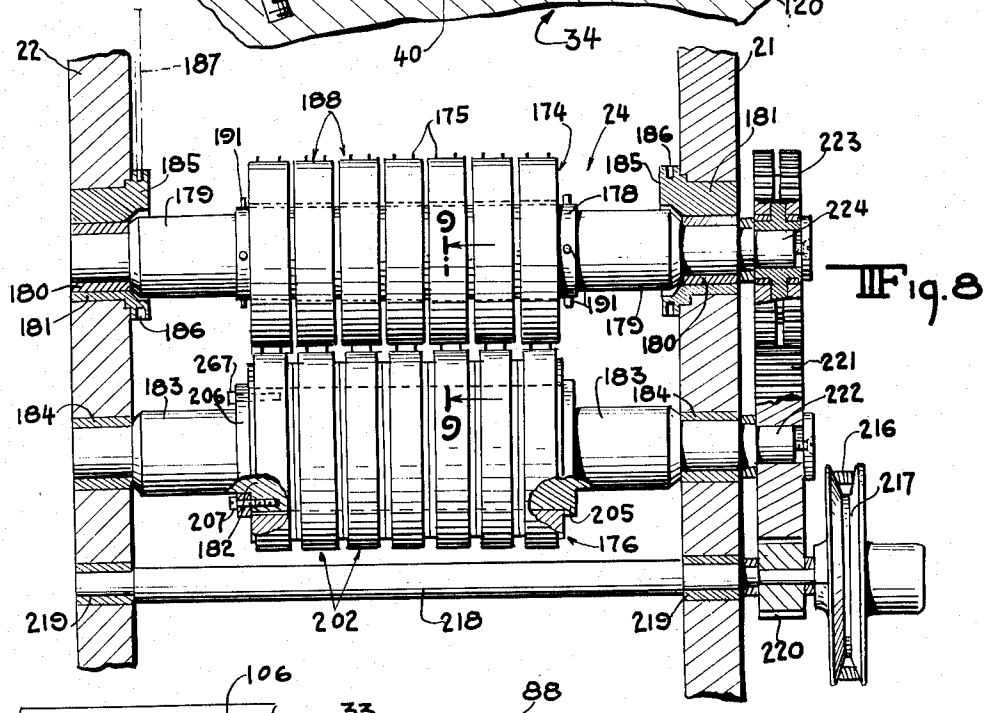


Fig. 8

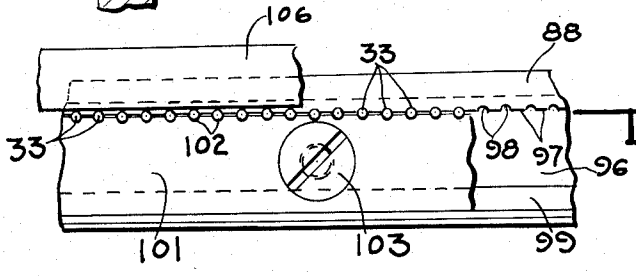


Fig. 7

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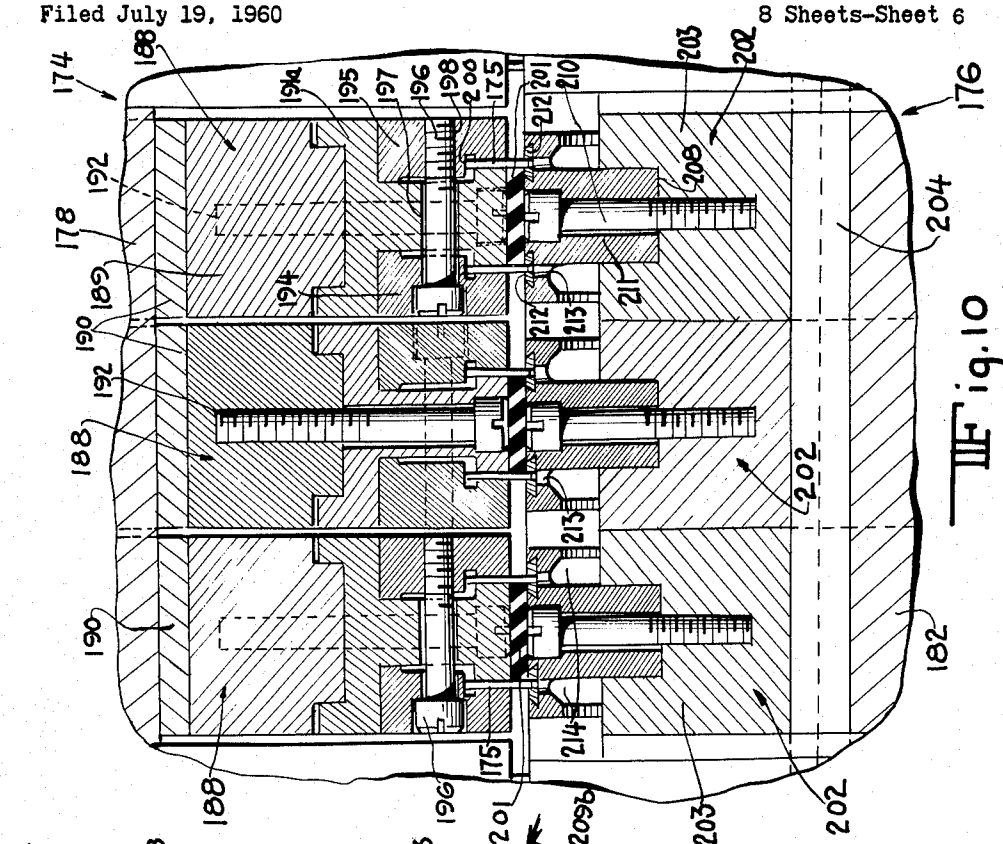


Fig. 10

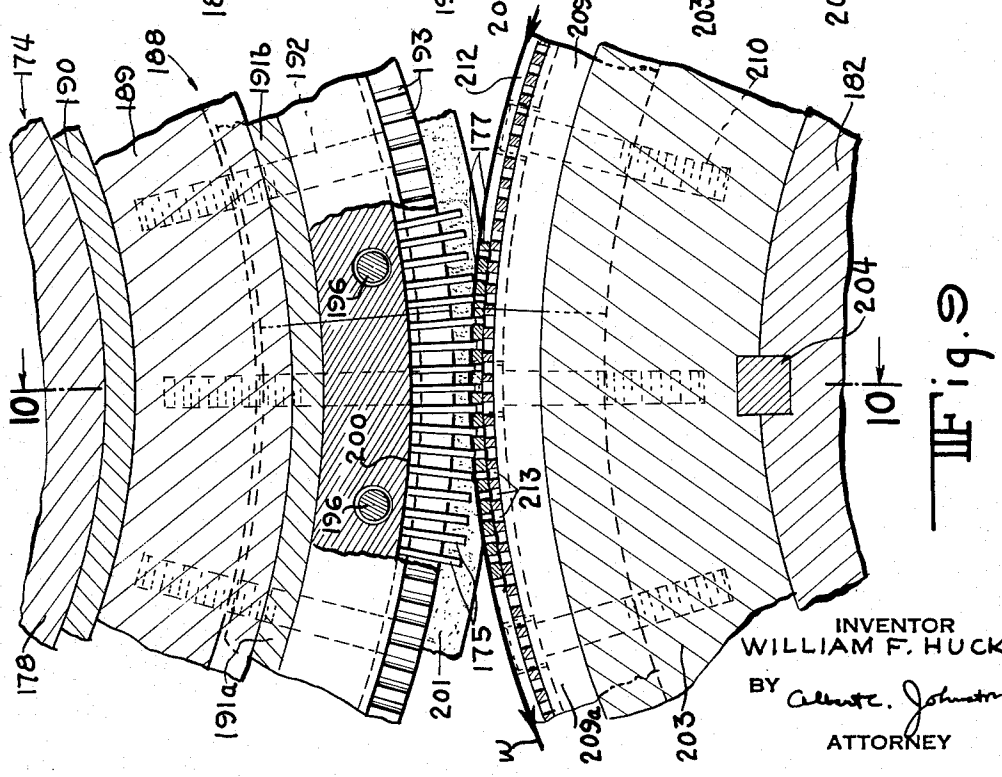


Fig. 9

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ROTARY PERFORATING DEVICE

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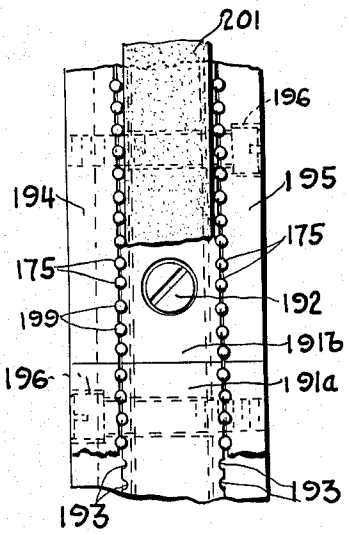


Fig. 11

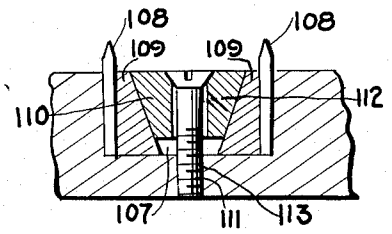


Fig. 14

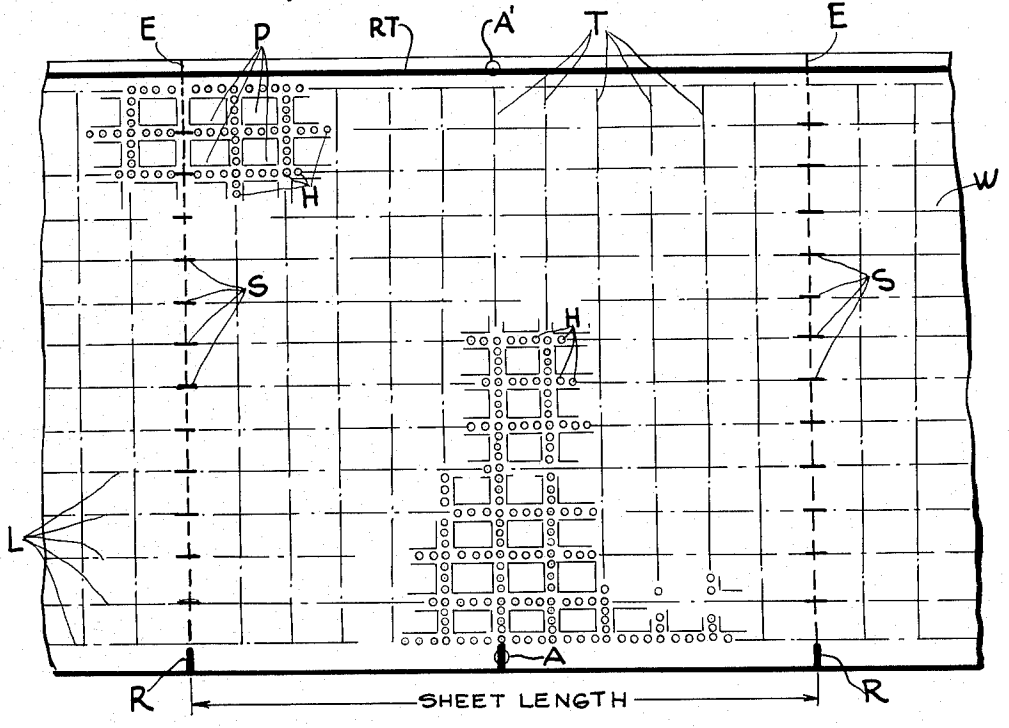


Fig. 13

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ROTARY PERFORATING DEVICE

Filed July 19, 1960 8 Sheets-Sheet 8

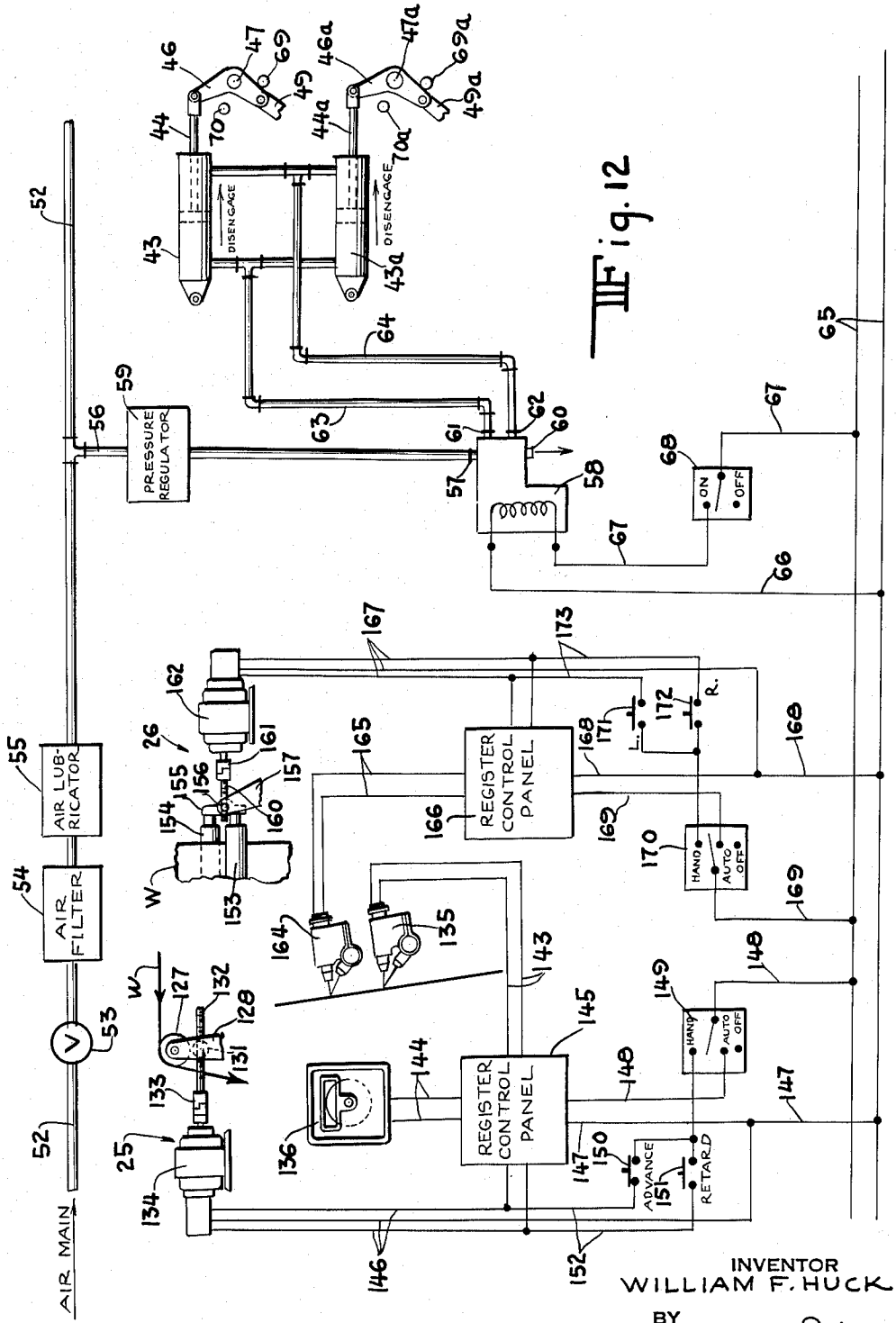


Fig. 12

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United States Patent Office 3,255,651 Patented June 14, 1966

3,255,651

ROTARY PERFORATING DEVICE

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Filed July 19, 1960, Ser. No. 43,839
9 Claims. (Cl. 83—76)

This invention relates generally to perforating devices that form patterns of holes in webs of paper, cloth, felt, metal sheet or foil and the like, and is particularly directed to devices 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. During each operating stroke, the reciprocating or oscillating flat die plates of such perforating devices simultaneously form the rows of holes extending both transversely and longitudinally in a portion of the web representing one or more sheets of the 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 plate for holding the perforating pins, the stripper plate and the plate intended to have the die holes can be stacked and then drilled through in a single pass in order to economically ensure the working accuracy of the perforating pins with respect to the holes in the stripper plate and the female die plate.

The major disadvantage of employing reciprocating or oscillating flat die plates for the perforating of webs is the limitation on the speed of operation inherent in the reciprocation or oscillation 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 perforation of small and closely spaced apart 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 perforating devices operating at as high speeds as practicable. Such rotary perforating devices generally comprise cylindrical male dies or perforating pin holders cooperating with cylindrical female dies and being accurately geared to each other for effecting their joint rotation with the perforating pins of the male die successively entering the related die holes of the cylindrical female die to form corresponding perforations in the web fed between the cooperating cylindrical male and female dies. However, in the existing rotary perforating devices, the perforating pins may enter the die holes only to a relatively small depth because of the relative angular motion between the axes of the pins and holes, respectively, during their mutual engagement, and this limitation on the depth to which the perforating pins may enter the die holes adversely affects the clean cutting of the perforated holes, particularly during high speed operation. The existing rotary perforating devices further present difficulties in accurately aligning the perforating pins or male punches with the female die holes, and in rapidly separating and accurately reengaging the perforating pins and die holes of the cooperating male and female die cylinders, for example, when it becomes necessary to repair or replace worn or otherwise defective parts thereof, or during the initial threading of the leading end of a web through the device prior to the commencement of normal operation.

The existing rotary perforating devices are further disadvantageously characterized by an undesirably high noise level during operation, and are deficient in effecting the stripping of the perforated web from the male punches or perforating pins immediately after the formation of the perforated holes. These existing devices also encounter difficulties in attaining a sufficiently rapid rate of disposal of the chips which are punched from the web during the perforation of the latter, so that the female die holes often become jammed or clogged with such chips which then cause breakage of the perforating pins unless operation of the device is immediately halted for correction of the jammed or clogged condition. The general effect of the above mentioned disadvantages of the existing rotary perforating devices is to substantially limit the operating speeds thereof.

Most of the existing rotary perforating devices producing holes in rows extending transversely and longitudinally with respect to the web employ two pairs of male and female die cylinders, with one of such pairs of die cylinders forming holes in rows which extend transversely across the web, while the other pair of die cylinders produces holes in rows extending longitudinally along the web. Since the rows of holes extending transversely across the web are usually spaced substantially apart in the direction of movement of the web, there is some freedom of movement for the web between the successive transversely extending rows of perforating pins. This freedom of movement helps to register the position of the web relative to the die cylinders so that the holes in the transversely extending rows are located exactly between the transversely extending rows of printed areas. However, the holes or perforations included in the rows extending longitudinally with respect to the web are very closely spaced apart so that the web has no freedom of movement between the successive perforating pins forming such holes, and registration of the holes in the longitudinally extending rows with respect to the printed areas requires that the die cylinders for producing such holes or perforations be driven at varying speeds which are adjusted to the speed of the web. Such varying speeds of the die cylinders have a tendency to cause tearing or rupture of the web, and the perforating of the web noticeably weakens the latter and may also result in its elongation, but the tension controls employed in the existing rotary perforating devices have been ineffective for firmly and precisely regulating web tension and have been lacking in sensitivity to tension variations so that tearing or rupture of the web occurs quite frequently, particularly when operating at high speeds.

Although it is known that the faulty or inaccurate registration of the rows of perforations with respect to each other and with respect to the printed areas is aesthetically objectionable to many purchasers of postage and commercial stamps, the maintenance of precise registration during the operation of rotary perforating devices is made difficult by reason of 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, heating and cooling, with the result that slight variations occur in the lengths of the successive printed areas on the web. While such light variations in the lengths of the printed areas on the web are individually small, the individual variations may accumulate over a number of the successive printed areas and produce a substantial error in registration. While the existing rotary perforating devices employ register controls which seek to compensate for the web variations, these register controls have not proved to be reliable or completely effective at high operating speeds.

Rotary perforating devices for producing transversely and longitudinally extending rows of relatively small, closely spaced apart holes in webs must be complex,

precise and relatively expensive assemblies of cooperating components, and it is inherent, in such rotary perforating devices, that the perforating pins and die holes of the male and female die cylinders are subjected to a high degree of wear. However, the existing rotary perforating devices have proved to be extremely expensive to manufacture and to maintain, particularly during high speed operation.

Accordingly, it is an object of this invention to provide a rotary perforating device of the kind having two pairs of cooperating perforating cylinders operating consecutively on a printed web to form transversely and longitudinally extending rows of holes or perforations, and which is capable of successfully operating at a substantially higher speed than that possible with the existing rotary perforating devices.

Another object is to provide a rotary perforating device of the described character which is capable of maintaining accurate registration of the rows of perforations with respect to the printed areas on the web, and which automatically and instantaneously adjusts to accommodate variations in the size and spacing of the printed areas on the web, even during the desired high speed operation.

A further object is to provide a rotary perforating device of the described character having two sets or pairs of male and female die cylinder acting successively on the printed web to form rows of perforations extending transversely and longitudinally with respect to the web, respectively, and further having tension controls which are effective, even when operating at high speeds, to firmly and precisely regulate the web tension and to be sensitive to relatively small tension variations in order to avoid tearing or rupture of the web.

In accordance with an aspect of the invention, one of the pairs of male and female die cylinders is operated at a substantially constant speed and functions as a propelling means for the web to be perforated, while the other pair of male and female die cylinders is driven at a variable speed which is automatically adjusted in accordance with the tension in the web in order to maintain a desired tension in the web between the two pairs of die cylinders and also at the output of the perforating device.

In accordance with a further aspect of the invention, a rotary perforating device having the characteristics referred to above is additionally provided with photoelectric scanning means cooperating with register marks previously applied to the printed web in order to sense any error in either longitudinal or lateral registration of the printed areas on the web with respect to the perforating die cylinders and, in the event of a sensed error, to suitably actuate longitudinal and lateral registering means so as to effect the necessary corrections.

Another object of the invention is to provide a rotary perforating device of the described character wherein the male and female die cylinders thereof may be rapidly disengaged from each other and then reengaged for example, when it becomes necessary to repair or replace worn or otherwise defective parts of the cylinders, or during the initial threading of the leading end of a web through the device prior to the commencement of normal operation, and wherein such disengagement and reengagement may be effected without loss of driving synchronism, alignment of the perforating pins and die holes, or registration of the web with respect to the die cylinders.

A further object is to provide a rotary perforating device of the described character wherein the male and female die cylinders are provided with readily and individually removable and easily replaceable perforating pin and female die units, respectively.

Still another object is to provide a rotary perforating device of the described character wherein each pair of male and female die units is constructed in a manner to permit the initial accurate alignment of the perforating pin and female die units thereof prior to the commencement of normal operation, and then to rigidly maintain such accurate alignment during normal high speed operation.

A still further object is to provide a rotary perforating device of the described character in which the female die cylinders are designed for rapid and efficient removal of the chips which are punched from the web during the perforation of the latter, and wherein each male die cylinder is provided with improved means effective to strip the web from the perforating pins or punches immediately after the perforating action, and further to absorb most of the noise of the perforating action.

A still further object of the invention is to provide a rotary perforating device of the described character having male and female die cylinders which are designed and constructed so as 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 an illustrative embodiment thereof which is to be read in connection with the accompanying drawings forming a part hereof, and wherein:

FIG. 1 is a side elevational view of a rotary perforating device embodying the invention;

FIG. 2 is another side elevational view of the rotary perforating device of FIG. 1, but as viewed from the opposite side thereof and with the side frame of the device being partly broken away;

FIG. 3 is a top plan view of a major portion of the rotary perforating device of FIGS. 1 and 2, as viewed along the line **3—3** of FIG. 1;

FIG. 4 is a transverse sectional view taken along the line **4—4** of FIG. 1, and showing a lateral registration mechanism included in the rotary perforating device embodying the invention;

FIG. 5 is an enlarged vertical sectional view taken along the line **5—5** of FIG. 1;

FIG. 6 is an enlarged fragmentary sectional view taken along the line **6—6** of FIG. 5 and showing the structural details of the male and female die cylinders provided in the rotary perforating device embodying the invention for forming the perforations in transversely extending rows;

FIG. 7 is a fragmentary detail view of the surface of the male die cylinder in FIGS. 5 and 6, as viewed in the direction of the arrows **7—7** on FIG. 6;

FIG. 8 is an enlarged transverse sectional view taken along the line **8—8** of FIG. 1, and showing the male and female die cylinders provided in the rotary perforating device embodying the invention for forming the perforations in rows which extend longitudinally with respect to the web;

FIG. 9 is an enlarged fragmentary sectional view taken along the line **9—9** of FIG. 8 to show the structural details of the male and female die cylinders of that view;

FIG. 10 is a sectional view taken along the line **10—10** of FIG. 9;

FIG. 11 is a fragmentary detail view of a portion of the surface of the male die cylinder of FIGS. 8, 9 and 10;

FIG. 12 is a schematic diagram of the controls included in the rotary perforating device embodying the invention for maintaining longitudinal and lateral registration of the printed web with respect to the perforating cylinders, and for engaging and disengaging the cooperating perforating cylinders;

FIG. 13 is a fragmentary plan view of a portion of a printed web which has been perforated in a rotary perforating device embodying the present invention; and

FIG. 14 is an enlarged detail view of a portion of the male die cylinder structure appearing in FIG. 5.

Referring to the drawings in detail, and initially to FIGS. 1, 2 and 3 thereof, it will be seen that a rotary perforating device embodying the present invention and there generally identified by the reference numeral **20** in-

cludes spaced apart side frame members 21 and 22 between which there are mounted a rotary perforating unit 23 adapted to form perforations in rows extending transversely with respect to the web W, and a rotary perforating unit 24 which acts on the web following the formation of the transversely extending rows of perforations therein by the unit 23, and which is adapted to form longitudinally extending rows of perforations in the web.

The web W, which has been previously printed with small repetitive patterns P arranged in transversely and longitudinally extending rows, as shown in FIG. 13, enters the rotary perforating device 20 from the top, as shown in FIG. 1, and is initially acted upon by a longitudinal register control mechanism 25 and then by a transverse register control mechanism 26, which mechanisms are arranged in succession and hereinafter described in detail. After being acted upon by the transverse register control mechanism 26, the web W passes under an idler roller 27 arranged in front of the perforating unit 23 and having its opposite ends rotatably journaled in suitable fixed bearings carried by side frame members 21 and 22. After passing through the perforating unit 23, the web travels under idler rollers 28 and 29 which are respectively arranged in back of perforating unit 23 and in front of perforating unit 24, and which have their opposite ends rotatably journaled in fixed bearings carried by side frame members 21 and 22.

After running around the idler roller 29, the web W passes through perforating unit 24 and is acted upon by a web tension control mechanism which is generally identified by the reference numeral 30 and which comprises rollers 233 and 234 engaging the web W at locations in front of perforating unit 24 and in back of the latter, respectively. Following engagement of the web by roller 234 of the tension control mechanism 30 at the location in back of perforating unit 24, the web passes around an idler roller 31 which is disposed in back of perforating unit 24 and has its opposite ends rotatably journaled in fixed bearings carried by side frame members 21 and 22.

As shown in FIG. 5 and FIG. 6, rotary perforating unit 23 which is intended to form the perforations or holes H in transversely extending rows T (FIG. 13) includes a male die cylinder 32 having a suitably arranged pattern of perforating pins or punches 33 (FIG. 6) projecting radially therefrom, and a female die cylinder 34 disposed below the cylinder 32 and having a correspondingly arranged pattern of female die holes 35 (FIG. 6) in its surface to receive the perforating pins 33 as the cylinders 32 and 34 are jointly rotated with the web W passing therebetween, whereby the perforating pins 33 and female die holes 35, cooperate to form the desired holes or perforations in the web.

The male die cylinder 32 includes a body 36 having trunnions 37 projecting axially from the opposite ends thereof and rotatably journaled in bearings 38 which are mounted in eccentric bearing housings 39 rotatably supported by side frame member 21 and 22.

The female die cylinder 34 also includes a cylindrical body 40 having trunnions 41 projecting axially from its opposite ends and being rotatably journaled in bearings 42 which are mounted in side frame members 21 and 22. It will be apparent that rotation of eccentric bearing housings 39 is effective to displace the axis of rotation of male die cylinder 32 with respect to the axis of rotation of female die cylinder 34. When the eccentric bearing housings are rotatably disposed to provide a relatively small distance between the axes of the male and female die cylinders, the perforating pins or punches 33 of cylinder 32 are engageable in the corresponding female die holes 35 of cylinder 34. However, when eccentric bearing housings 39 are turned to positions which space the axis of cylinder 32 a relatively large distance from the axis of cylinder 34, the perforating pins are disengaged from the female die holes, thereby to facilitate initial threading of the web through the rotary perforating device, or the replacement or repair of the removable elements included in the cylinders 32 and 34, as hereinafter described in detail.

Although eccentric bearing housings 39 may be manually turned to effect the engagement and disengagement of the die cylinders 32 and 34, the rotary perforating device 20 embodying this invention preferably includes a pneumatically operated system for imparting the necessary turning movements to the eccentric bearing housings. Thus, as shown in FIGS. 1, 3 and 5, a pneumatic pressure cylinder 43 having a ram or piston rod 44 projecting from one end is pivotally mounted, at its opposite end, on a pin 45 projecting inwardly from side frame member 22, and the free end of the piston rod 44 is pivotally connected to one end of a bell crank 46 which is fixed to a shaft 47 disposed above cylinder 32 and having its opposite ends rotatably journaled in bearings 48 carried by side frame members 21 and 22 (FIG. 5). The opposite end of bell crank 46 is pivotally connected to a link 49 which is, in turn, pivotally connected to an extension 50 projecting from the eccentric bearing housing 39 mounted in the adjacent side frame member 22. A radial arm 51 is also fixed to the shaft 47 adjacent side frame member 21 and has its end pivotally connected to a link 49 which is, in turn, pivotally connected to an extension 50 projecting from the eccentric bearing housing 39 carried by side frame member 21. Thus, stroking of the piston rod 44 of cylinder 43 causes turning of shaft 47, and the bell crank 46 and arm 51 cooperate with the links 49 and extension 50 to transmit the turning movement of shaft 47 to the eccentric bearing housings 39.

As shown in FIG. 12, the engagement and disengagement of cylinders 32 and 34 is preferably controlled by an electro-pneumatic circuit that includes a compressed air supply conduit 52 having the usual flow control valve 53, air filter 54 and air lubricator 55 interposed therein in close proximity to the perforating device 20. A branch conduit 56 extends from the compressed air supply conduit 52 to the inlet port 57 of a solenoid controlled valve 58, and a conventional pressure regulator 59 is interposed in branch conduit 56. The valve 58 is provided with an exhaust port 60 and with two exit ports 61 and 62 which are respectively connected by pipes 63 and 64 to the opposite ends of the cylinder 43. The coil of solenoid operated valve 58 is connected to the usual electrical supply lines 65 by way of conductors 66 and 67, and the latter has an on-off switch 68 interposed therein. The valve 58 is arranged so that, when its coil or solenoid is energized by movement of switch 68 to its on position, compressed air flows through exit port 62 and pipe 64 to the right hand end of cylinder 43 while the left hand end of cylinder 43 is connected to exhaust port 60 by way of pipe 63 and exit port 61, so that the piston rod 44 is retracted and causes turning of bell crank 46 and shaft 47 in the counterclockwise direction, as viewed in FIG. 12, to the extent permitted by engagement of the lower arm of the bell crank with a stop pin 69 projecting from the adjacent side frame member 22 into the path of movement of the bell crank. Engagement of the bell crank 46 with stop pin 69 corresponds to the position of eccentric bearing housings 39 for effecting engagement of cylinders 32 and 34. On the other hand, when the solenoid or coil of valve 58 is de-energized, by movement of switch 68 to its "off" position, valve 58 connects the left hand end of cylinder 43 to the source of compressed air, by way of the pipe 63 and exit port 61, while the right hand end of cylinder 43 is connected to the exhaust port 60 by way of pipe 64 and exit port 62, thereby to permit the elastic expansion of the compressed air in cylinder 43 at the left hand side of the piston which causes extension of piston rod 44 and clockwise turning of bell crank 46 and shaft 47 to the extent permitted by the engagement of the bell

crank with a stop pin 70 which also projects from the adjacent side frame member 22 into the path of movement of the bell crank. Engagement of the bell crank 46 with stop pin 70 corresponds to the disengaged position of the male die cylinder 32 with respect to female die cylinder 34.

The rotary perforating device 20 is driven in synchronism with an associated web processing machine (not shown), for example, a printing press for applying the repetitive printed patterns P to the web prior to the perforating of the latter in the device 20, or a cutting and stacking machine which receives the perforated web from the device 20 and cuts the web into sheets of predetermined size which are then suitably stacked, the desired synchronous drive of the rotary perforating device 20 being derived from a suitably rotated main drive shaft 71 (FIG. 1) running horizontally above the perforating device and carrying a bevel gear 72 meshing with a bevel gear 73 at the upper end of a vertical transmission shaft 74. The lower end of transmission shaft 74 carries a bevel gear 75 meshing with a bevel gear 76 secured to one end of a cross shaft 77 disposed below female die cylinder 34 and having its opposite end portions rotatably journaled in bearings 78 carried by side frame members 21 and 22. As shown in FIG. 5, the end of cross shaft 77 remote from bevel gear 76, that is, the end of the cross shaft projecting outside of side frame member 21, has a pinion 79 fixed thereon and meshing with a spur gear 80 which is secured to an extension 81 of the adjacent trunnion 41 of female die cylinder 34. Thus, female die cylinder 34 is rotated from cross shaft 77 by way of the meshing pinion 79 and gear 80, and the male die cylinder 32 is driven from the gear 80, preferably by way of a backlash take-up gear 82 which is mounted on an extension 83 of the adjacent trunnion 37 of the male die cylinder and which is of the type disclosed in detail in U.S. Letters Patent No. 2,911,847 issued November 10, 1959 to W. F. Huck. Such a backlash take-up gear generally includes two relatively narrow gears 84 and 85 mounted on a common hub and rotatable independently with respect to the latter, and a spring actuated linkage connected to gears 84 and 85 to urge the gears to turn equal distances in opposite directions with respect to the common hub, thereby to take up any backlash between the teeth of the gears 84 and 85 and the meshing teeth of the conventional spur gear 80. Thus, the backlash take-up gear 82 is effective to maintain precise rotational alignment between the bodies of cylinders 32 and 34 despite changes in the contours of the gear teeth produced by wear. Further, the teeth of gears 82 and 80 are dimensioned so that meshing engagement therebetween will be maintained even when the eccentric bearing housings 39 are turned to effect disengagement of cylinder 32 from cylinder 34, thereby to ensure that the rotational alignment of the bodies of the cylinders 32 and 34 will not be disturbed during disengagement and re-engagement of such cylinders.

The perforating unit 23 forms the holes H in the transversely extending rows T, as previously mentioned with reference to FIG. 13, and also is intended to form slits S which are longitudinally aligned with the longitudinally extending rows L of holes or perforations formed by the perforating unit 24, as hereinafter described in detail, and which are arranged in transversely extending rows E corresponding to the opposite end edges of sheets to be cut from the printed web W following the perforations thereof in the device embodying the invention. The slits S facilitate the tearing of the individual sheets into strips along the longitudinal rows L of perforations.

The male and female die cylinders of perforating unit 23 have circumferences that are equal to a whole number multiple of the sheet length to be cut from the perforated preprinted web, that is, the distance between the successive rows E of slits S.

As shown in FIG. 5, the body 36 of male die cylinder 32 has radially raised, axially directed, circumferential flanges 86 at its opposite ends, and a plurality of circumferential, radially raised ribs 87 at axially spaced apart locations between flanges 86.

As shown in FIGS. 5, 6 and 7, male die cylinder 32 of perforating unit 23 further includes a circumferentially arranged series of axially extending pin holding bars 88 corresponding to the transversely extending rows T of holes or perforations to be formed in the web W, and one or more knife holding bars 89 carrying knives 108 in a pattern corresponding to the transversely extending rows E of slits S to be formed in the web. The opposite ends of the bars 88 and 89 are secured to the flanges 86 by means of mounting screws 90 which are loosely received in radial bores 91 (FIG. 6) formed in the end flanges 86 and which threadably engage in tapped bores 92 provided in the end portions of the bars 88 and 89. The central portions of the bars 88 and 89 are further secured to body 36 at the locations of the ribs 87 by means of mounting screws 93 which are loosely received in bores 94 of the bars 88 and 89 and which threadably engage in tapped bores 95 formed in the body 36 and having counterbored outer end portions.

As shown in FIGS. 6 and 7, each of the pin holding bars 88 has a longitudinally extending groove 96 in its outer surface, with one side wall 97 of groove 96 having spaced apart, semicircular recesses 98 machined therein while the opposite side wall 99 of groove 96 converges towards side wall 97 in the direction toward the bottom 100 of the groove. A wedge bar 101 is received in groove 96 and, along one side edge, is provided with semicircular recesses 102 matching the recesses 98, while the other side edge is inclined or undercut at the same angle as the side wall 99 of the groove.

The perforating pins 33 are received in the matching semicircular recesses 98 and 102 of each pin holding bar 88 and the related wedge bar 101 and are clamped tightly in such recesses when wedge bar 101 is drawn radially into groove 96 by clamping screws 103 which pass through clearance holes 104 in the wedge bar and threadably engage in tapped bores 105 formed in pin holding bar 88.

It will be seen that the radially projecting height of perforating pins 33 is exactly controlled by abutting the radially inner ends of such pins against a seat formed by the bottom 100 of the related groove 96, while each wedge bar 101 having the recesses 102 matching the recesses 98 of the related pin holding bar 88 serves to rigidly clamp the perforating pins both axially and laterally with respect to the male die cylinder.

Compressible rectangular pieces 106 of rubber or other similar resilient material are cemented to the radially outer surfaces of pin holding bars 88 adjacent the pins 33 and are dimensioned to normally project radially beyond the outer ends of the perforating pins. The purpose of the resiliently compressible pieces 106 is to strip the perforated web W from the pins 33 while the latter are withdrawing from the female die holes 35 immediately after the perforating of the web. The resiliently compressible pieces 106 have the added advantage of substantilly reducing the high level of noise otherwise associated with the formation of the perforations in the transverse rows T. Each of the knife holding bars 89 is formed with a number of rectangular cutouts 107 which are spaced apart therealong and, as shown in detail in FIG. 14, knives 108 are disposed against the opposite side walls of each cutout 107 and project radially beyond the radially outer surface of the bar 89. Tapered clamping blocks 109 are disposed within the cutout 107 against the knives 108, and a central wedge member 110 is drawn radially inward between the clamping blocks 109 by clamping screws 111 which pass through clearance holes 112 in the central wedge member 110 and are received in tapped bores 113 formed in the bar 89 at the bottom of the cutout 107. Thus, the central wedge member 110 spreads the clamping blocks 109 apart so as

to securely clamp the knives **108** between blocks **109** and the adjacent side walls of cutout **107**.

As shown in FIG. 5, body **40** of female die cylinder **34** has radially raised, circumferentially extending ribs **114** at the opposite ends thereof and also at axially spaced apart locations therebetween, and the ribs **114** are formed with axially aligned cutouts **115** at circumferentially spaced apart locations to receive female die bars **116** which correspond, in number and location, to the pin holding bars **88** of male die cylinder **32**, and one or more female die bars **117** which contain narrow grooves **126** that correspond, in number and location, to the knives **108** of the knife holding bar or bars **89** of the male die cylinder.

The female die bars **116** and **117** are secured to body **40** by means of mounting screws **118** which extend through clearance holes **119** in the female die bars and threadably engage in tapped bores **120** formed in body **40** at the location of ribs **114**. Each of the female die bars **116** projects radially outward beyond ribs **114** and, as shown in FIG. 6, the radially outer portion of each die bar **116** has a lateral extension or flange **121** extending along one side edge of the die bar and having its outer face formed with a dovetail slot **122** extending longitudinally along die bar **116** and receiving a die insert **123** of similar cross-sectional shape which is formed with the female die holes **35** corresponding to the perforating pins **33** of the male die cylinder. Further, the flange **121** is formed with enlarged or clearance holes **124** extending radially inward from the die holes **35** and opening into an axially extending cavity **125** which radially underlies the flange **121** and which opens radially outward between the flange **121** and the next adjacent female die bar **116**.

When the perforating pins **33** enter the die holes **35** of each die insert **123**, the chips punched from web W passing between the male and female die cylinders are easily propelled through the enlarged clearance holes **124** into the related cavity **125** which is relatively voluminous so as to easily accommodate the chips without jamming of the die holes, and the collected chips fall from each cavity **125** as the latter reaches the bottom of female die cylinder **34**, at which point, the surface of the female die cylinder is no longer covered by the web.

Each female die bar **117** also projects radially outward beyond the ribs **114** of body **40**, and the radially outer surface of die bar **117** is formed with narrow grooves **126** (FIG. 6) which are adapted to receive knives **108** of the related die bar **89** so as to cooperate with such knives in cutting the slits S into the web W.

Further, as shown in FIG. 6, the resiliently compressible pieces **106** of male die cylinder **32** are located so as to span the opening of a cavity **125** of female die cylinder **34** when the adjacent perforating pins **33** enter the female die holes **35** of the die insert carried by the female die bar **116** adjacent the spanned cavity. Thus, each resiliently compressible piece **106** can bulge out into the opening of the corresponding cavity **125** to take up small amounts of slack that may occur in the web W in the vicinity of the female die cylinder **34** as a result of humidity changes, varying amounts of ink application, varying web drying conditions, or any other influence affecting the pitch of the repetitive printed patterns P applied to the web. Since female die cylinder **34** has a fixed effective diameter and a fixed pitch between the rows of female die holes **35** of the successive bars **116**, the above mentioned tension variations in web W in the vicinity of the female die cylinder would cause the web to be either too loose or too tight along the periphery of the female die cylinder. However, the bulging action of resiliently compressible pieces **106** serves to maintain, within small limits, correct register between perforating pins **33** and the repetitive printed patterns P, even though small variations exist in the pitch of these repetitive printed patterns.

It is to be noted that the above described structural details of die cylinders **32** and **34** make it possible to obtain and maintain precise alignment of perforating pins **33** with the related die holes **35**. In initially obtaining the desired precise alignment, each female die bar **116** is securely fastened to body **40** of the female die cylinder by tightening the related screws **118**. The corresponding pin holding bar **88** of male die cylinder **32** is initially secured to body **36** by only partially tightening the screws **90** and **93**. Cylinders **32** and **34** are then simultaneously turned until the perforating pins **33** of bar **88** undergoing adjustment are located in precise alignment with die holes **35** of the related female die bar. Then the mounting screws **90** which engage the opposite end portions of the adjusted bar **88** are tightened, such screws being accessible while the pins **33** engage in the related die holes **35**, and serving to maintain the desired position of the adjusted bar **88** relative to body **36** during further turning of the die cylinders to a position where the pins **33** of the adjusted bar **88** no longer engage in the related die holes **35** and the mounting screws **93** are thus accessible and can be tightened for rigidly holding the bar **88** in its adjusted position during normal high speed operation. Further, it will be noted that, by reason of the clearance between each mounting screw **93** and the related bore **94** of bar **88** and also the enlarged or counterbored outer end portion of the related tapped bore **95**, each mounting screw **93**, which is smaller in diameter and tightening capacity than each of the mounting screws **90**, can deflect slightly in a manner similar to a cantilevered beam, so as to permit a certain small amount of freedom of movement of perforating pins **33** relative to the corresponding die holes **35** for ensuring precise alignment with the latter during the perforating operation.

Referring again to FIG. 1, it will be seen that the longitudinal register control mechanism **25** includes a movable roller **127** over which the web W travels and being rotatably supported, at its opposite ends, in arms **128** which extend radially upward from a shaft **129**. The opposite ends of shaft **129** are rotatably mounted in suitable bearings carried by upper frame members **130** so that arms **128** and **127** can rock, as a unit, about a horizontal axis defined by the shaft **129**. A nut **131** is pivotally supported by one of arms **128** and threadably receives an adjusting screw **132** which is connected by a universal joint **133** to the shaft of a reversible electric motor **134** mounted on the adjacent upper frame member **130**.

It will be apparent that, when electric motor **134** is rotated in one direction, for example, to effect swinging of arms **128** in the clockwise direction, as viewed in FIG. 1, the corresponding movement of roller **127** will decrease the length of printed web W between the source thereof, for example, a suply roll of the printed web, or a printing couple for applying the desired repetitive printed patterns to the web, and the perforating unit **23**, thereby to longitudinally advance the printed patterns P with respect to the transverse rows T of perforations formed by perforating unit **23**, whereas, when motor **134** is rotated in the opposite direction, roller **127** is displaced to increase the length of the printed web between the source thereof and perforating unit **23**, thereby to longitudinally retard the printed patterns P with respect to the transverse rows T of perforations.

The reversible electric motor **134** is actuated in response to detected longitudinal register errors by a photoelectric control system shown in FIGS. 1 and 12. Such a control system includes a photoelectric scanning head **135** which may be of the type commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, under items No. CR7515–P202–G4. A scanning head of the identified type generally includes a light source directing a beam of light against an edge portion of the web W at a location between roller **127** of longitudinal register control mechanism **25** and idler roller **27**, and a photoelectric detection cell disposed to scan the surface of the web at

the location where the light beam impinges thereagainst. As shown in FIG. 13, the edge portion of web W to be scanned by the head **135** has spaced apart register marks R applied thereto. Such register marks are preferably applied to the web during the printing thereof and may be either printed on the web or embossed in the web, or in the form of slits or perforations made in the web. It will be apparent that, when a register mark R passes through the illuminated region or area A scanned by the photoelectric detection cell of head **135**, such register mark changes the intensity of light reflected from the web into the photoelectric detection cell and causes a suitable electrical signal to be emitted from head **135**.

The photoelectric control system for the motor **134** further includes a photoelectric selector switch **136** which is suitably mounted, for example, on a bracket **137** secured to side frame member **22** adjacent perforating unit **23** (FIG .1). The photoelectric selector switch **136** may be of the type which is commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, as item No. CR7515–P145–G4, and generally includes a slotted disk mounted on a rotatable shaft **138**, a light source (not shown) directing a beam of light against one side of the slotted disk and a photoelectric cell (not shown) at the opposite side of the slotted disk so as to be intermittently energized by light passing through the slots of the rotated disk and thereby produce electrical pulses or signals at regularly spaced apart intervals. Shaft **138** of selector switch **136** is driven from perforating unit **23** by means of a belt **139** running around pulleys **140** and **141** which are respectively secured to shaft **138** and to an axial extension **142** of the trunnion **137** of male die cylinder **32** which is rotatably mounted in side frame member **22** (FIGS. 1, 3 and 5).

The slotted disk of selector switch **136** is disposed on shaft **138** so that, when the printed patterns P of web W are properly registered in the longitudinal direction with respect to the transverse rows T of perforations to be formed by perforating unit **23**, the electrical signal resulting from the scanning of a register mark R by the photoelectric scanning head **135** occurs simultaneously with an electrical signal emanating from selector switch **136**. However, if there is a longitudinal register error, the electrical pulse or signal issuing from the scanning head **135** occurs either before or after the corresponding electrical pulse or signal issuing from selector switch **136**.

The electrical pulses or signals issuing from scanning head **135** and seelctor switch **136** are fed, by way of conductors **143** and **144**, respectively, to a register control panel **145** (FIG. 12) which 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 **145** of the above identified type is operative to amplify the signals received from scanning head **135** and selector switch **136**, respectively, and to compare such signals so that any timing discrepancy between a signal resulting from a detected register mark R and a related signal from selector switch **136** produces an error signal which is transmitted to motor **134**, by way of conductors **146**, and thereby causes rotation of reversible correction motor **134** in the direction for displacing roller **127** so as to overcome the detected register error. Thus, if the detected register mark R arrives too soon at the scanned region or area and therefore gives rise to a signal emanating from head **135** prior to the corresponding signal from selector switch **136**, motor **134** is rotated in the direction for swinging arms **128** in the counterclockwise direction, as viewed in FIG. 1, whereas, if the detected register mark lags behind its correct or registered position, the resulting error signal transmitted from control panel **145** to motor **134** produces rotation of the latter in the direction for causing clockwise turning of the arms **128**.

As shown in FIG. 12, register control panel **145** draws its power from electrical supply lines **65** by way of conductors **147** and **148**, and the latter has a switch **149** interposed therein and provided with three positions in which motor **134** of longitudinal register control mechanism **25** is rendered inoperative, is automatically operated in response to register errors detected in the manner indicated above, or is operated by manual controls, respectively. Such manual controls are in the form of an "advance" push-button switch **150** and a "retard" push-button switch **151** interposed in conductors **152** which extend from switch **149** and from conductor **147** to the conductors **146** so that, when switch **149** is in its position for hand or manual control, visually detected, relatively large longitudinal register errors may be corrected by depressing either one or the other of the switches **150** and **151**.

The transverse register control mechanism **26** is intended to maintain accurate transverse registration between the printed patterns P on the web W and the longitudinal rows L of perforations formed in the web by unit **24** of perforating device **20**. As shown in FIGS. 1 and 4, transverse register control mechanism **26** includes parallel upper and lower web contacting rollers **153** and **154** having their opposite ends rotatably journalled in bearing blocks **155** which are centrally pivoted on axles **156** carried by the lower ends of arms **157**. The arms **157** are suspended from shafts **158** which are rockably supported in brackets **159** carried by the upper frame members **130**. As is apparent in FIG. 4, the lateral distance between the axes of shafts **158** is greater than the distance between the shafts or axles **156** measured in the direction parallel to the axes of the rollers **153** and **154** so that, when the latter are in their central position, as shown in FIG. 4, the arms **157** at the opposite sides of the path of travel of web W converge downwardly.

One of the bearing blocks **155** carries a centrally located nut (not shown) which threadably receives an adjustment screw **160** connected by a universal joint **161** to a reversible electric motor **162** which is suitably suspended from a bracket **163** carried by the adjacent upper frame member **130**. Thus, when the reversible motor **162** is rotated in one direction or the other, adjustment screw **160** causes corresponding lateral displacement of rollers **153** and **154** which, by reason of the previously mentioned downward convergence of the arms **157** in the neutral or central position of the rollers, are also tilted or inclined from the horizontal to an extent dependent upon their lateral displacement.

As shown in FIG. 1, the web W passes in front of and then under roller **153** before passing over and in back of the roller **154** so that the tilting action of rollers **153** and **154** that accompanies the lateral displacement thereof is effective to urge the web laterally in the same direction as the lateral displacement of rollers **153** and **154**.

In the rotary perforating device **20** embodying the present invention, the reversible correction motor **162** of transverse register control mechanism **26** is energized by means of a photoelectric control system which, as shown in FIGS. 2 and 12, includes a photoelectric scanning head **164** that may be of the type commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, as item No. 3S7515PS102. The scanning head **164** is suitably mounted so that a light source therein will direct a beam of light against the edge portion of web W at the opposite side of the latter from the register marks R and at a location along the web that is intermediate roller **154** and idler roller **27**.

As shown in FIG. 13, the edge portion of web W against which scanning head **164** directs a beam of light is preprinted with a transverse register line RT which is

in a fixed transverse position with respect to the printed patterns P of the web. The scanning head **164** is laterally located so that, when there is correct transverse registration between the web and perforating device **20**, particularly, perforating unit **24** of the latter, the area or region A' (FIG. 13) of the web surface which is illuminated by the beam of light from scanning head **164** is exactly bisected by one longitudinal edge of register line RT, and thereby establishes the normal intensity of light reflected from the web to a photoelectric cell included in scanning head **164** during correct transverse register. It will be apparent that any deviation of the transverse position of the web, toward one side or the other, from this correct transverse register position causes a change in the intensity of light reflected by the web from the light source of head **164** into the photoelectric cell of the latter, and thereby alters the voltage generated by the cell.

As shown in FIG. 12, the voltage generated by the photoelectric cell of head **164** is led, by conductors **165** to a register control panel **166** which may be of the type that is commercially available from the Specialty Control Department of General Electric Company, Waynesboro, Virginia, as item No. 3S7515SR100 and which, as shown in the wiring diagram thereof appearing between pages 18 and 19 of the instruction bulletin published by General Electric Company under the designation GEH–2121A, generally includes a Wheatstone bridge network that is balanced when the strength of the electrical signal from scanning head **164** corresponds to correct transverse register of the web. Any deviation in the strength of the electrical signal received from scanning head **164** serves to unbalance the Wheatstone bridge which thereby generates an error signal which is sufficiently amplified by a conventional amplifier included in panel **166** and which is led from the latter to motor **162** by way of conductors **167** for energizing the correction motor of transverse register control **26**. The resulting rotation of motor **162** is converted by the previously described combined lateral displacement and tilting of the web contacting rollers **153** and **154** into a proportional lateral displacement of the web W tending to restore the desired accurate transverse registration of the web.

As further shown in FIG. 12, register control panel **166** draws its power from electrical supply lines **65** by way of conductors **168** and **169**, and the latter has a switch **170** interposed therein and provided with three positions in which motor **162** of transverse register control mechanism **26** is rendered inoperative, is automatically operated in response to register errors detected in the manner indicated above, or is operated by manual controls, respectively. Such manual controls are in the form of a "left" push-button switch **171** and a "right" push-button switch **172** interposed in conductors **173** which extend from the position of switch **170** for manual or hand control to the conductors **167** so that, when switch **170** is in its position for hand or manual control, visually detected, relatively large transverse register errors may be corrected by depressing either one or the other of the switches **171** and **172**.

As shown in FIG. 8, rotary perforating unit **24** which is intended to form the perforations or holes H in longitudinally extending rows L (FIG. 13) includes a male die cylinder **174** having a suitably arranged pattern of perforating pins or punches **175** projecting radially therefrom, and a female die cylinder **176** disposed below the cylinder **174** and having a correspondingly arranged pattern of female die holes **177** (FIG. 9) to receive the perforating pins **175** as the cylinders **174** and **176** are jointly rotated with the web W passing therebetween, whereby the perforating pins **175** and female die holes **177** cooperate to form the desired holes or perforations in the web.

The male die cylinder **174** includes a body **178** having trunnions **179** projecting axially from the opposite ends thereof and rotatably journaled in bearings **180** which are mounted in eccentric bearing housings **181** rotatably supported by side frame members **21** and **22** (FIG. 8).

The female die cylinder **176** also includes a cylindrical body **182** having trunnions **183** projecting axially from its opposite ends and being rotatably journaled in bearings **184** mounted in side frame members **21** and **22**. It will be apparent that rotation of eccentric bearing housings **181** is effective to displace the axis of rotation of male die cylinder **174** with respect to the axis of rotation of female die cylinder **176**, whereby the perforating pins **175** may be successively engaged in the related female die holes **177**, as during normal operation of the perforating device, or the perforating pins may be withdrawn from the die holes to facilitate initial threading of the web through perforating unit **24** or the replacement or repair of the removable elements included in the cylinders **174** and **176**, as hereinafter described in detail.

Although eccentric bearing housings **181** are shown in FIG. 8 to be provided with flanges **185** at their inner ends having radially opening sockets **186** adapted to receive removable handles, for example, the handle **187** appearing in broken lines on FIG. 8, whereby the eccentric bearing housings may be manually turned to effect the engagement and disengagement of die cylinders **174** and **176**, it is to be understood that the eccentric bearing housings **181** may also be actuated by a pneumatically operated system of the kind previously described with reference to the eccentric bearing housings **39** of the male die cylinder **32** of the perforating unit **23**. Thus, as shown in FIG. 12, the pneumatically operated system for imparting the necessary turning movements to the eccentric bearing housings **181** may include a pneumatic pressure cylinder **43***a* having a ram or piston rod **44***a* projecting from one end and being pivotally mounted, at its opposite end, on a pin projecting from one of the side frame members **21** or **22** adjacent male die cylinder **174**, with the free end of piston rod **44***a* being pivotally connected to one of a bell crank **46***a* which is fixed to a shaft **47***a* disposed above cylinder **174** and having its opposite ends journaled in bearings carried by the side frame members. The opposite end of bell crank **46***a* is pivotally connected to a link **49***a* which is, in turn, pivotally connected to a radial extension projecting from the eccentric bearing housing **181** mounted in the adjacent side frame member. A radial arm (not shown) is also fixed to the shaft **47***a* adjacent the other side frame member and has its end pivotally connected to a link which is, in turn, pivotally connected to an extension projecting from the eccentric bearing housing **181** carried by that other side frame member. Thus, stroking of the piston rod **44***a* causes turning of shaft **47***a*, and this turning movement of the shaft is transmitted to the eccentric bearing housings **181** in the same way as in the pneumatically operated system for turning the eccentric bearing housings **39**.

If desired, the switch **68** which controls the engagement and disengagement of cylinders **32** and **34** of perforating unit **23** can also be employed for controlling the engagement and disengagement of cylinders **174** and **176** of perforating unit **24** by selectively connecting the opposite ends of cylinder **43***a* to the supply of compressed air and to the exhaust port **60** by way of the pipes **63** and **64** which extend from exit ports **61** and **62**, respectively, of solenoid controlled valve **58**.

As shown in FIGS. 9 and 10, male die cylinder **174** of the longitudinal perforating unit **24** further preferably includes an axially arranged series of male ring assemblies each generally identified by the reference numeral **188** and each including a mounting ring **189** having a force fit on an antifriction bearing **190** which is rotatable on the cylindrical surface of body **178**. As shown in FIG. 8, removable radial pins **191** project from the opposite ends of body **178** and serve to confine male ring assemblies **188** therebetween, while permitting small axial

movements of ring assemblies **188** for alignment purposes.

Each of ring assemblies **188** further includes a mating pair of semi-circular pin holding ring sections **191***a* and **191***b* (FIG. 9) each having a substantially T-shaped cross section with the cap of the T being directed radially inward. The pin holding ring sections **191***a* and **191***b* are secured to the related mounting ring **188** by mounting screws **192** passing through radial holes in ring sections **191***a* and **191***b* and threadably engaging in tapped holes provided in mounting ring **189**. As shown particularly in FIG. 11, the opposite side edges of the outer peripheries of ring sections **191***a* and **191***b* are formed with spaced apart semi-circular recesses **193** for receiving and locating perforating pins **175**, and pins **175** are securely clamped in recesses **193** by means of opposed clamping rings **194** and **195** which are secured against the opposite sides of the stem of the T-shaped cross section of ring sections **191***a* and **191***b* by means of clamping screws **196** which pass through axially directed clearance holes **197** in clamping ring **194** and the related ring sections **191***a* and **191***b* and threadably engage in tapped axial holes **198** in clamping ring **195** (FIG. 10).

The clamping rings **194** and **195** of each ring assembly **188** have annular, radially directed surfaces confronting the opposite side edges of the outer peripheries of ring sections **191***a* and **191***b* and being formed with semi-circular recesses **199** (FIG. 11) matching the previously described recesses **193** so that the perforating pins **175** are rigidly clamped in the matching recesses to prevent either radial or lateral movement of the pins **175** relative to the mounting ring **189** of the respective ring assembly **188**. As shown in FIGS. 9 and 10, each of clamping rings **194** and **195** is formed with a cylindrical, outwardly facing shoulder **200** against which the inner ends of perforating pins **175** are abutted in order to ensure that perforating pins **175** will project uniformly from the surface of male die cylinder **174**.

Resiliently compressible ring pieces **201** formed of rubber or other similar material are cemented to the radially outer surface of each of the pin holding ring sections **191***a* and **191***b* and are dimensioned so as to normally project beyond the outer ends of the adjacent pins **175**, as is apparent in FIG. 9. The resiliently compressible ring pieces **201** are effective to remove the perforated web W from the pins **175** as the latter retract from the female die holes **177** immediately after the longitudinal perforating operation, and ring pieces **201** have the further advantage of substantially reducing the high level of noise that would otherwise be associated with that perforating operation.

As shown in FIGS. 9 and 10, female die cylinder **176** of perforating unit **24** further preferably includes an axially arranged series of ring assemblies each generally identified by the reference numeral **202** and including a mounting ring **203** which is slidable on body **182** and held against rotation relative to the latter by a key **204**. A radial flange **205** is provided at one end of the body **182**, and a clamping ring **206** having an outer diameter greater than that of body **182** is secured to the opposite end of the latter, as by screws **207**, so that the mounting rings **203** of the several ring assemblies **202** are axially clamped between flange **205** and ring **206**.

As shown in FIG. 10, the outer periphery of each mounting ring **203** has a radially opening circumferential groove **208** for accommodating and accurately locating a pair of semi-circular die ring sections **209***a* and **209***b* having generally T-shaped cross sections with their stems extending into the groove **208**. The ring sections **209***a* and **209***b* are secured to the related mounting ring **203** by means of mounting screws **210** passing through radial clearance holes **211** in ring sections **209***a* and **209***b* and threadably engaging in tapped holes formed in mounting ring **203** and opening at the bottom of groove **208**. The outer peripheral surfaces of the mating die rings **209***a* and **209***b* of each ring assembly **202** carry two circumferentially extending, removable circular die inserts **212** of dovetail cross section and having the female die holes **177** formed therein. The die inserts **212** are also preferably formed in semi-circular halves, and ring sections **209***a* and **209***b* are formed with clearance holes **213** in radical alignment with the female die holes **177** to facilitate removal of chips from the holes **177** of die inserts **212**.

As shown in FIG. 10, the caps of the T-shaped cross-sections of ring sections **209***a* and **209***b* of adjacent ring assemblies **202** are spaced apart axially and relatively voluminous cavities **214** are defined between such caps and the outer peripheral surfaces of the related mounting rings **203** so that the removed chips can easily collect in the cavities **214** during the perforating operation, and can fall from the cavities **214** through the axial spaces between the adjacent ring sections **209***a* and **209***b* at the bottom of female die cylinder **176**.

It is to be understood that the previously described, relatively complex constructions of male and female die cylinders **32** and **34** of perforating unit **23** and of male and female die cylinders **174** and **176** of perforating unit **24** have been employed in order to greatly reduce maintenance time and costs. Each of male die cylinders **32** and **174** has individually removable perforating pins **33** and **175** rigidly clamped to pin holding bars **88** or ring sections **191***a* and **191***b*, and such pin holding bars and ring sections are also individually removable from the respective bodies **36** and **178**. Therefore, if any single perforating pin is defective, it may be readily removed and replaced merely by releasing, and subsequently retightening the nearest clamping screw **103** or **196** without removing the related pin holding bar **88** or pin holding ring section **191***a* or **191***b* and without the necessity of disengaging the male and female die cylinders. Similarly, if any one of the pin holding bars **88** or the pin holding ring sections **191***a* or **191***b* is defective, it may be readily removed and replaced merely by releasing and subsequently reengaging the related mounting screws **90** and **93** or **192** without affecting the adjacent pin holding bars or ring sections, and without disengaging the male and female die cylinders or bodily removing the same from the frame of the perforating device.

Similarly, each of the female die cylinders **34** and **176** has individually removable die inserts **123** or **212** having the female die holes **35** and **177**, respectively formed therein and being rigidly clamped in bars **116** and ring sections **209***a* and **209***b*, respectively which are, in turn, individually removable from the bodies **40** and **182**. Hence, if one or more of the die holes **35** or **177** is defective, the die insert containing such defective hole or holes may be readily removed and replaced without removing the bar **116** or the ring sections **209***a* and **209***b* from the related cylinder body, and without the necessity of disengaging the cooperating male and female die cylinders. Further, if any one of the female die bars **116** or the ring sections **209***a* or **209***b* is defective, it may be readily removed and replaced by releasing and subsequently reengaging the releated mounting screws **118** or **210** without affecting the adjacent bars or ring sections, and without disengaging the cooperating male and female die cylinders or bodily removing the same from the frame of the perforating device.

It will also be seen that, by reason of the fact that the ring assemblies **188** of male die cylinder **174** are free to turn and to move axially through small distances relative to the body **178**, the perforating pins **175** carried by such ring assemblies can seek their own accurate alignment with the female die holes **177** of the related ring assemblies **202** of female die cylinder **176**.

In accordance with the present invention, cylinders **174** and **176** of perforating unit **24** are driven at a variable speed which is automatically adjusted in accordance with the tension in web W in order to maintain a desired

tension in the web between perforating units 23 and 24 and also at the output of perforating device 20.

As shown in FIGS. 2 and 3, the variable speed drive for the die cylinders of perforating unit 24 includes a pulley 215 secured on the end of cross shaft 77 which projects through side frame member 21, and a V-belt 216 which runs around pulley 215 and around a variable diameter pulley 217 which is preferably of the kind disclosed in U.S. Letters Patent No. 2,812,666, issued November 12, 1957, to W. F. Huck, and which is mounted on a projecting end or extension of a shaft 218 extending laterally below perforating unit 24 and having its opposite end portions rotatably journaled in bearings 219 carried by side frame members 21 and 22. In a variable diameter pulley of the identified type, the radius of contact of belt 216 with variable diameter pulley 217, and hence the transmission ratio between shafts 77 and 218, depends upon the tension in belt 216 and, as will hereinafter be described in detail, the tension in belt 216 is made dependent upon the relative tensions in web W before and after perforating unit 24.

As shown in FIG. 8, cylinders 174 and 176 of perforating unit 24 are driven from shaft 218 by means of a pinion 220 secured on shaft 218 adjacent pulley 217 and meshing with a spur gear 221 secured on a projecting end 222 of the trunnion 183 of cylinder 176 which is supported in a bearing carried by side frame member 21. Spur gear 221 meshes, in turn, with a backlash take-up gear 223 mounted on an extension 224 of the trunnion 179 of die cylinder 174 which is supported in side frame member 21. Backlash take-up gear 223 is preferably similar to previously described backlash take-up gear 82, that is, of the type disclosed in detail in U.S. Letters Patent No. 2,911,847, issued November 10, 1959, to W. F. Huck, and is effective to maintain precise rotational alignment between the bodies of cylinders 174 and 176 despite changes in the contours of the gear teeth produced by wear. Further, the teeth of gears 221 and 223 are dimensioned so that meshing engagement therebetween will be maintained even when the eccentric bearing housings 181 are turned to effect disengagement of cylinder 174 from cylinder 176, thereby to ensure that the rotational alignment of the bodies of such cylinders will not be disturbed during disengagement and reengagement thereof.

The initial tension in V-belt 216, and the resulting initial transmission ratio between shafts 77 and 218 is determined by the position of an idler pulley 225 engaging the top run of belt 216 and being rotatably supported on an arm 226 extending radially from a pivot shaft 227 which is rotatably supported in the adjacent side frame 21. A radial arm 228 is also fixed to pivot shaft 227 and, at its free end, carries a nut 229 which is threadably engaged by the lower end of a generally vertically directed screw 230 which is rotatably supported in a bracket 231 carried by side frame member 21 and which has a hand wheel or knob 232 secured to its upper end so as to facilitate manual rotation of screw 230. It will be apparent that rotation of screw 230 causes turning movement of pivot shaft 227 and corresponding rocking of arm 226, whereby idler pulley 225 either increases or decreases the initial tension in belt 216.

In order to make the tension in belt 216 responsive to the tension in web W, the perforating device 20 further includes floating rollers 233 and 234 respectively disposed in front and in back of perforating unit 24 so that web W travels forwardly from fixed idler roller 29 before passing around floating roller 233 on its way to the perforating unit 24, and so that the perforated web travels forwardly from floating roller 234 before passing around fixed idler roller 31 at the exit or outlet of perforating device 20. The opposite ends of floating rollers 233 and 234 are rotatably mounted in the upper end portions of pairs of arms 235 and 236, respectively, and the pairs of arms 235 and 236 are secured, adjacent their lower ends, to laterally extending shafts 237 and 238, respectively, which have their opposite end portions rotatably journaled in side frame members 21 and 22. Links 239 are pivotally connected, at their opposite ends, to arms 235 and 236, respectively, in order to ensure that floating rollers 233 and 234 will have equal displacements at all times.

As shown in FIGS. 2 and 3, shaft 237 projects laterally beyond side frame member 21 and, at its projecting end, carries a radial arm 240 having a take-up pulley 241 rotatably mounted at its free end and engaging the lower run of V-belt 216 from above. Thus, rocking or turning of shaft 237 will cause corresponding displacement of take-up pulley 241 for either increasing or decreasing the tension in belt 216. Downwardly projecting arms 242 are also secured to shaft 237 adjacent the inside surfaces of side frame members 21 and 22, and the lower end of each downwardly projecting arm 242 is secured to a rod 243 which extends substantially horizontally. The opposite end portions of each rod 243 extend loosely through blocks 244 which are suitably secured to the inside surface of the adjacent side frame member 21 or 22, and compression springs 245 extend around each rod 243 between the opposite sides of the related downwardly projecting arm 242 and the stationary blocks 244.

A radial arm 246 is secured to shaft 238 adjacent the inside surface of side frame member 22 and, at its free end, is pivotally connected, as at 247, to the upper end of a rod 248 which is secured to a piston slidable within a cylinder 249 having its lower end pivotally mounted, as at 250, on the adjacent side frame member 22. Cylinder 249 is filled with a relatively viscous fluid which acts on the piston of rod 248 to effectively dampen relatively high frequency reciprocations of the piston, and hence the corresponding high frequency oscillations or "hunting" of shaft 238, arms 235 and 236 and floating rollers 233 and 234. An end of shaft 238 projects laterally beyond side frame member 22 and carries a pointer arm 251 which cooperates with a dial or scale 252 secured to the side frame member to indicate the positions of floating rollers 233 and 234 at any instant.

The initial positions of floating rollers 233 and 234 are determined by at least one tension spring 253 which is connected, at its opposite ends, to a pin 254 on the arm 236 adjacent side frame member 22 and to a pin 255 carried by an arm 256 which extends radially from the inner end of a pivot shaft 257 rotatably carried by the adjacent side frame member 22. The outer end of pivot shaft 257 has a radial arm 258 secured thereto and carrying a nut 259 which is threadably engaged by a screw 260 rotatably mounted in a bracket 261 secured to side frame member 22. A hand wheel or knob 262 is secured to the upper end of screw 260 in order to permit manual rotation of the latter which effects turning movement of pivot shaft 257 and of the arm 256, whereby the initial tension in spring 253 can be adjusted. Further, the outer end of shaft 257 carries a pointer 263 cooperating with a dial or scale 264 secured to side frame member 22 in order to indicate the position of arm 256, and hence the initial tension in spring 253.

It will be appreciated that the arms 235 and 236 and the links 239, considered as a unit, are maintained in equilibrium by a balancing of the forces resulting from the web tension in advance of perforating unit 24, as sensed by floating roller 233, the web tension following the perforating unit 24, as sensed by floating roller 234, the tension in V-belt 216 which acts on take-up pulley 241, the tension in spring 253 connected to one of the arms 236, and the equal and opposite forces exerted by springs 245 against the arm 242 extending downwardly from shaft 237. When the adjustable hand wheels 232 and 262 are manipulated to adjust the position of pulley 225 and the tension in spring 253, respectively, so that pointers 251 and 263 register with the centers of dials 252 and 264, respectively, the tension control mechanism is set for bal-

ancing the web tensions before and after perforating unit 24. However, when either of the hand wheels 232 or 262 is manipulated from the position corresponding to the balanced setting, the equilibrium of the forces acting on arms 235 and 236 and links 239, considered as a unit, is upset and such unit is displaced a small angular extent about shafts 237 and 238 to assume a new equilibrium position which corresponds to a tension differential which is maintained between the web sections before and after perforating unit 24.

When hand wheels 232 and 262 are set so as to obtain an equilibrium of forces with balanced web tensions before and after perforating unit 24, the described tension control mechanism will operate to maintain the desired balanced tension condition. Thus, if an abnormal reduction or slackening in web tension develops after perforating unit 24, that is, to the right of unit 24, as viewed in FIG. 1, the resulting inequality in the tensions before and after perforating unit 24 will cause arms 235 and 236 to pivot clockwise about the axes of shafts 237 and 238 so as to tend to equalize the web tensions before and after the perforating unit. Such pivoting of arms 235 and 236 connected by links 239 causes corresponding turning of shaft 237 which results in proportional upward movement of take-up pulley 241, thereby decreasing the tension in belt 216 and corsespondingly increasing the contact radius of belt 216 with variable diameter pulley 217 and correspondingly decreasing the rotational speed of pulley 217 and shaft 218, and hence of cylinders 174 and 176 of perforating unit 24. This decrease in rotational speed of cylinders 174 and 176, and the resulting decrease in the speed of travel of web W through perforating unit 24 is proportional to the initially assumed abnormal reduction in web tension after the perforating unit and is sufficient to restore the tension after perforating unit 24 to its desired value, that is, to a value equal to the tension in the web in advance of perforating unit 24.

Similarly, if there is an abnormal reduction or slackening in the web tension in advance of perforating unit 24, the resulting inequality between the web tensions before and after perforating unit 24 causes arms 235 and 236 to pivot, as a unit, in the counterclockwise direction about shafts 237 and 238, respectively, so as to tend to balance the unequal web tensions, and such pivotal movement produces a proportional downward movement of take-up pulley 241. The downward movement of take-up pulley 241 increases the tension in V-belt 216 and proportionately decreases the contact radius of that belt with variable diameter pulley 217, whereby there is a proportional increase in the rotational speed of pulley 217 and shaft 218, and hence in the rotational speed of cylinders 174 and 176 of perforating unit 24. This increase in the rotational speed of cylinders 174 and 176 results in an increase in the speed of travel of web W through perforating unit 24 which is proportional to the initially assumed abnormal decrease in web tension between perforating units 23 and 24 and is sufficient to restore the web tension to its desired value.

In view of the previously described balancing of the forces which act on the unit consisting of arms 235 and 236 and links 239 in the equilibrium position of that unit, it will be apparent that the adjustment of hand wheel 232 in the direction for causing downward movement of pulley 225, and hence an increase in the initial tension in V-belt 216 would cause a corresponding increase in the force acting upwardly on take-up pulley 241, and which tends to pivot arms 235 and 236 in the clockwise direction, as viewed in FIG. 1, but this tendency can be overcome by manipulating hand wheel 262 so as to cause a corresponding increase in the tension in spring 253 which tends to pivot arms 235 and 236 in the counterclockwise direction. Since the increase in tension in V-belt 216 reduces the radius of contact of that belt with variable diameter pulley 217, and thereby increases the rotational speed of cylinders 174 and 176 of perforating unit 24, with a corresponding increase in the web tension between units 23 and 24, the increase effected in the tension of spring 253 would establish an equilibrium position for the arms 235 and 236 at which the tension in web W after perforating unit 24 is equal to the increased value of web tension in advance of the perforating unit. Thus, even when it is desired to maintain equal web tensions before and after perforating unit 24, hand wheels 232 and 262 can be manipulated to either increase or decrease the equal web tensions which are to be maintained.

Further, when the position of pulley 225 or the tension in spring 253 is altered so as to cause a shifting of the equilibrium position of arms 235 and 236 in the direction causing downward displacement of take-up pulley 241, the corresponding increase in the tension of belt 216 causes reduction in the radius of contact of that belt with variable diameter pulley 217 and thereby proportionally increases the rotational speed of cylinders 174 and 176 of perforating unit 24, so as to increase the web tension before the perforating unit and decrease the web tension after the perforating unit, and to subsequently maintain this differential in the web tensions. Similarly, if the tension in spring 253 is reduced below the setting for the balanced web tension condition, arms 235 and 236 move to a new equilibrium position and, during such movement, take-up pulley 241 is moved upwardly to decrease the tension in V-belt 216 and thereby increase the radius of contact of such belt with variable diameter pulley 217 causing a corresponding decrease in the rotational speed of cylinders 174 and 176 of perforating unit 24. Such decrease in the rotational speed of cylinders 174 and 176 tends to increase the tension in the web after perforating unit 24 with respect to the tension in the web in front of the perforating unit, and the differential in the web tensions thus created is subsequently maintained.

From the above detailed description of an illustrative embodiment of the invention, it will be apparent that a rotary perforating device has been provided that can be easily maintained, and that is effective to maintain accurate longitudinal and transverse registration of perforations formed in the web with respect to preprinted patterns on the web, while accurately establishing and maintaining desired tension conditions in the web, even during high speed operation.

It is to be understood that the transverse perforating unit 23 and the longitudinal perforating unit 24 are adapted to be used individually when it is required to perforate the web W only along transversely extending rows or along longitudinally extending rows, respectively. Further, although the perforating units 23 and 24 of the illustrated embodiment cooperate to form rectangular patterns of holes in the web, as is apparent in FIG. 13, rotary perforating devices embodying the invention may be designed to form differently shaped and dimensioned patterns of holes or perforations in the web.

Although an illustrative embodiment of the invention has been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to that precise embodiment, and that various changes and modifications may be effected therein without departing from the scope or spirit of the invention, which is intended to be defined in the appended claims.

What is claimed is:

1. A rotary perforating device for forming holes in a web having repetitive printed patterns thereon; said device comprising a first perforating unit having male and female die cylinders cooperating to form holes in rows in the web as the latter passes therebetween, registration means acting on the web in advance of said first perforating unit and operative to maintain a predetermined positional relationship between the printed patterns on the web and the rows of holes formed in the web by said first perforating unit, a second perforating

unit having male and female die cylinders between which the web passes following the forming of said rows of holes in the web, said cylinders of the second perforating unit cooperating to form holes in the web in rows at predetermined positions with respect to those formed in the web by said first perforating unit, means driving the cylinders of said first perforating unit at a predetermined rotational speed so as to propel the web therebetween, adjustable means driving the cylinders of said second perforating unit at a rotational speed which is variable with respect to the rotational speed of the cylinders of said first perforating unit so as to change the relationship between the tensions in the web at locations between said first and second perforating units and after said second perforating unit, respectively, and control means responsive to variations in the relationship of the tensions in the web at said locations to vary the speed at which said cylinders of the second perforating unit are driven in the sense for maintaining a predetermined relationship between said tensions.

2. A rotary perforating device for forming holes in a web having repetitive printed patterns thereon; said device comprising a first perforating unit having male and female die cylinders cooperating to form holes in rows in the web as the latter passes therebetween, registration means acting on the web in advance of said first perforating unit and operative to maintain a predetermined positioned relationship between the printed patterns on the web and the rows of holes formed in the web by said first perforating unit, a second perforating unit having male and female die cylinders between which the web passes following the forming of said rows of holes in the web, said cylinders of the second perforating unit cooperating to form holes in the web in rows at predetermined positions with respect to those formed in the web by said first perforating unit, means driving the cylinders of said first perforating unit at a predetermined rotational speed so as to propel the web therebetween, adjustable means driving the cylinders of said second perforating unit at a rotational speed which is variable with respect to the rotational speed of the cylinders of said first perforating unit so as to change the relationship between the tensions in the web at locations between said first and second perforating units and after said second perforating unit, respectively, floating rollers movable as a unit and respectively contacting the web before and after said second perforating unit so as to be urged in opposite directions by the web tensions at said locations, adjustable means establishing a position of equilibrium of said floating rollers for a predetermined relationship between the web tensions at said locations so that any deviation from said predetermined relationship causes movement of said floating rollers as a unit, and control means for said adjustable means driving the cylinders of said second perforating unit responding to said movement of the floating rollers to vary the rotational speed of said cylinders of the second perforating unit for restoring said predetermined relationship between the web tensions at said locations.

3. A rotary perforating device for forming holes in a web having repetitive printed patterns thereon; said device comprising a first perforating unit having male and female die cylinders cooperating to form holes in rows in the web as the latter passes therebetween, registration means acting on the web in advance of said first perforating unit and operative to maintain a predetermined positional relationship between the printed patterns on the web and the rows of holes formed in the web by said first perforating unit, a second perforating unit having male and female die cylinders between which the web passes following the forming of said rows of holes in the web, said cylinders of the second perforating unit cooperating to form holes in the web in rows at predetermined positions with respect to those formed in the web by said first perforating unit, means driving the cylinders of said first perforating unit at a predetermined rotational speed so as to propel the web therebetween, means for driving the cylinders of said second perforating unit from said driving means for the cylinders of the first perforating unit and including a variable ratio transmission device, floating rollers movable as a unit and respectively contacting the web before and after said second perforating unit so as to be urged in opposite directions by the web tensions at locations before and after said second perforating unit, adjustable means establishing a position of equilibrium of said floating rollers for a predetermined relationship between the web tensions at said locations so that any deviation from said predetermined relationship causes movement of said floating rollers as a unit, and control means changing the transmission ratio of said transmission device in response to said movement of the floating rollers, thereby to vary the rotational speed of the cylinders of said second perforating unit relative to the rotational speed of the cylinders of the first perforating unit for restoring said predetermined relationship between the web tensions at said locations.

4. A rotary perforating device as in claim 3; wherein said transmission device includes driving and driven pulleys, one of said pulleys being of the variable diameter type, and a belt running around said pulleys and having a radius of contact with said one pulley which is dependent on the tension in said belt; and wherein said control means for changing the transmission ratio includes a take-up pulley engaging said belt and being movable to vary the tension in the belt, and means coupling said take-up pulley to said floating rollers to effect movement of said take-up pulley in accordance with said movement of the floating rollers as a unit.

5. A rotary perforating device as in claim 4; wherein the tension in said belt causes the latter to urge said take-up pulley and said floating rollers to move in one direction; and further comprising spring means operative to urge said floating rollers to move in the opposite direction so that the influence of the tension in said belt, the force of said spring means and the web tensions at said locations are in balance in said position of equilibrium of the floating rollers.

6. A rotary perforating device as in claim 5; wherein said adjustable means establishing the position of equilibrium comprise manipulatable means operative to vary the force of said spring means and manipulatable means operative to vary the initial tension in said belt of the transmission device, so that the values of the web tensions at said locations can be jointly increased and decreased by simultaneously operating both of said manipulatable means for varying the force of said spring means and said initial tension of the belt, while the relationship between said web tensions can be changed by operating only one of said manipulatable means.

7. A rotary perforating device for forming holes in a web having repetitive printed patterns thereon and transverse and longitudinal register marks in predetermined positional relationship to the printed patterns said device comprising a first perforating unit having male and female die cylinders cooperating to form holes in rows in the web passing between said cylinders, a second perforating unit having male and female die cylinders cooperating to form holes in rows in the web passing therebetween following passage of the web between said die cylinders of said first perforating unit, longitudinal and transverse register correcting means contacting the web in advance of said first perforating unit, photoelectric means scanning the transverse and longitudinal register marks of the web and detecting any error in the registration of the marks with respect to said cylinders of the first perforating unit, means driving said cylinders of the first perforating unit at a predetermined rotational speed so as to propel the web therebetween, means driving said cylinders of the second perforating unit at a variable rotational speed, and control means responsive to variations in the tensions

in the web before and after said second perforating unit to vary the speed at which said cylinders of the second perforating unit are driven so as to maintain an adjustably predetermined relationship betwen said tensions.

8. A rotary perforating device for forming holes in a printed web having repetitive printed patterns thereon and transverse and longitudinal register marks in predetermined positional relationship to the printed patterns; said device comprising a set of rotated male and female die cylinders having perforating pins and die holes, respectively, cooperating to form perforations in the printed web as the latter passes between said rotated cylinders; a longitudinal register control mechanism including a roller contacting the printed web before said cylinders and being movable to advance and retard the web with respect to said cylinders, and motor means operative to effect the web advancing and retarding movements of said roller; a transverse register control mechanism including roller means contacting the printed web before said cylinders and being movable axially and in a tilting sense to transversely displace the web with respect to said cylinders, and motor means operative to effect the movements of said roller means for transversely displacing the web; first photoelectric web scanning means actuated by the longitudinal register marks of the web to emit register signals representing the longitudinal position of the web as a function of time; selector switch means driven in synchronism with said cylinders and emitting uniformly intermittent signals representing the rotational positions of said cylinders as a function of time and which occur simultaneously with said register signals upon correct longitudinal registration of the printed patterns of the web with respect to the perforations formed in the web by said cylinders; control means operating said motor means of the longitudinal register control mechanism in response to any deviation between the occurrence of said register signals and the corresponding signals from said selector switch means to move said roller in the direction for restoring said correct longitudinal registration; second photoelectric web scanning means actuated by the transverse register mark of the web to emit a signal having an amplitude corresponding to the transverse position of the web relative to said cylinders; and control means operating said motor means of the transverse register control mechanism in response to the deviation of the amplitude of the signal from said second web scanning means from a predetermined value corresponding to correct transverse registration of said printed patterns with respect to said perforations, thereby to restore said correct transverse registration; said device further comprising a second set of male and female die cylinders having perforating pins and die holes, respectively, cooperating to form perforations in the printed web as the later passes therebetween after passing between the first mentioned set of die cylinders, said pins and die holes of the first set of die cylinders being arranged in spaced apart rows extending in one direction relative to the web and said pins and die holes of the second set of die cylinders being arranged in spaced apart rows extending in another direction relative to the web, so that the formed perforations are in rows extending transversely and longitudinally with respect to the web; adjustable means driving said second set of cylinders at a rotational speed which is variable with respect to the rotational speed of said first set of cylinders so as to change the relationship between the tensions in the web at locations before and after said second set, and control means responsive to variations in the relationship betwen the web tensions at said locations to vary the speed at which said second set of cylinders is driven in the sense for maintaining a predetermined relationship between said tensions.

9. A rotary perforating device as in claim 8; wherein said adjustable means driving the second set of cylinders includes variable ratio transmission means, and said control means includes floating rollers movable as a unit and respectively contacted by the web before and after said second set of cylinders so as to be urged in opposite directions by the web tensions at said locations, adjustable means establishing a position of equilibrium of said floating rollers for said predetermined relationship between the web tensions at said locations so that any deviation from said predetermined relationship causes movement of said floating rollers as a unit, and means varying the transmission ratio of said transmission means in response to said movement of the floating rollers, thereby to vary the rotational speed of said second set of cylinders for restoring said predetermined relationship between said tensions.

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