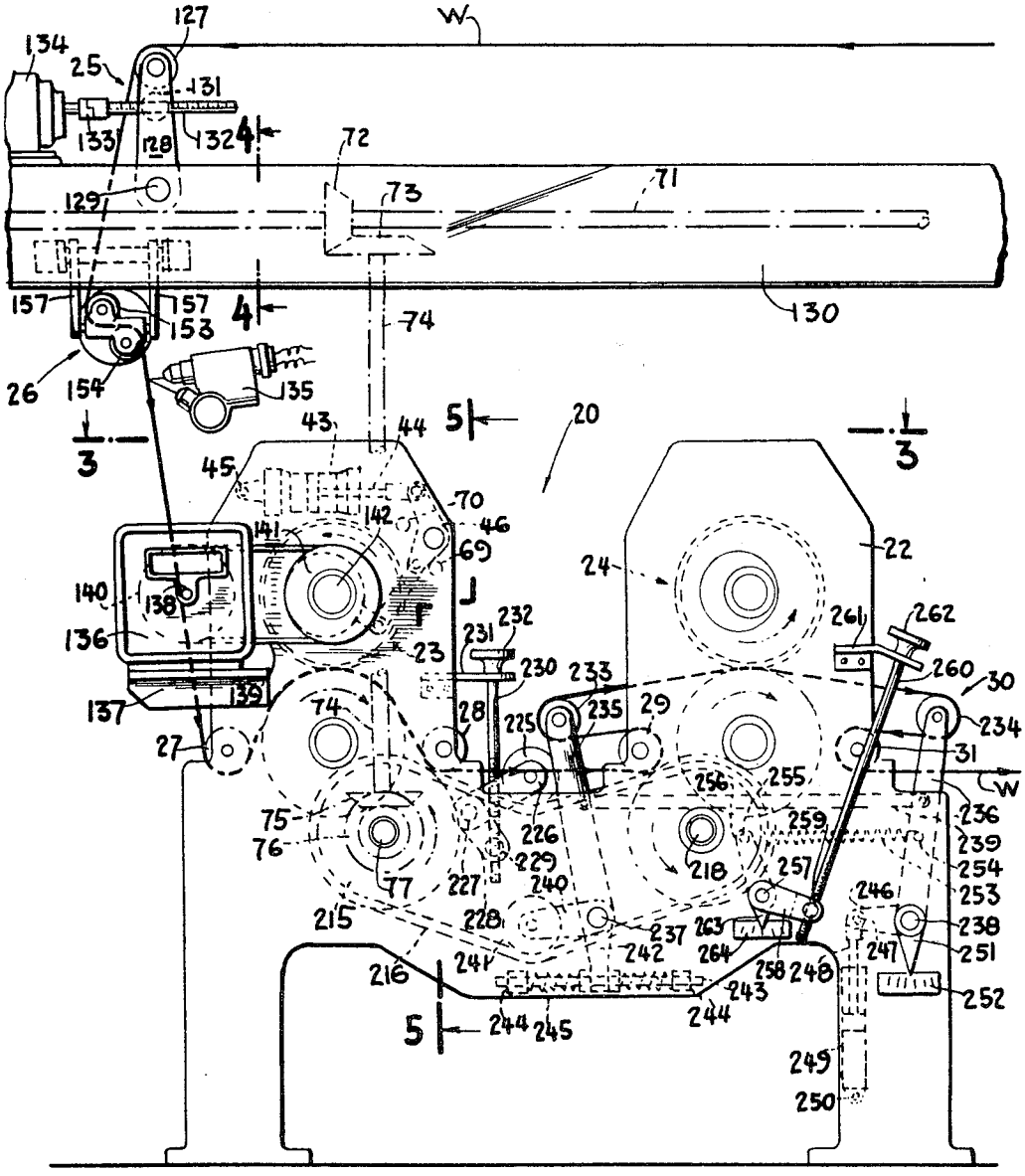
Nov. 8, 1966 W. F. HUCK 3,283,636

ROTARY PERFORATING MACHINE WITH MEANS TO CONTROL WEB MOVEMENT

Original Filed July 19, 1960 6 Sheets-Sheet 1



IIFig. 1

INVENTOR
WILLIAM F. HUCK
BY
Allen E. Johnston
ATTORNEY

Nov. 8, 1966 W. F. HUCK 3,283,636

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Original Filed July 19, 1960 6 Sheets-Sheet 2

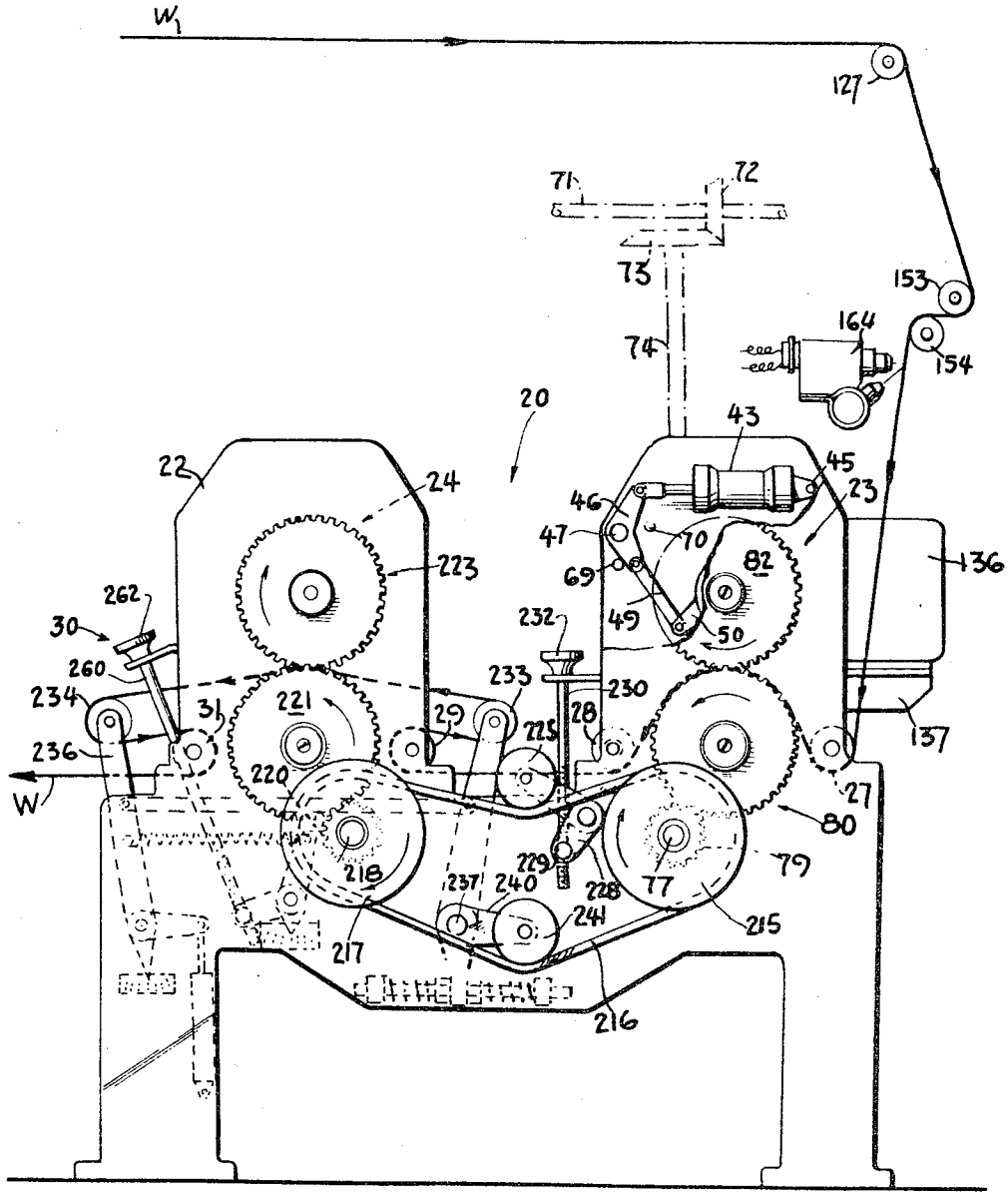


Fig. 2

INVENTOR
WILLIAM F. HUCK
BY
Albert C. Johnston
ATTORNEY

Nov. 8, 1966 W. F. HUCK 3,283,636

ROTARY PERFORATING MACHINE WITH MEANS TO CONTROL WEB MOVEMENT

Original Filed July 19, 1960 6 Sheets-Sheet 3

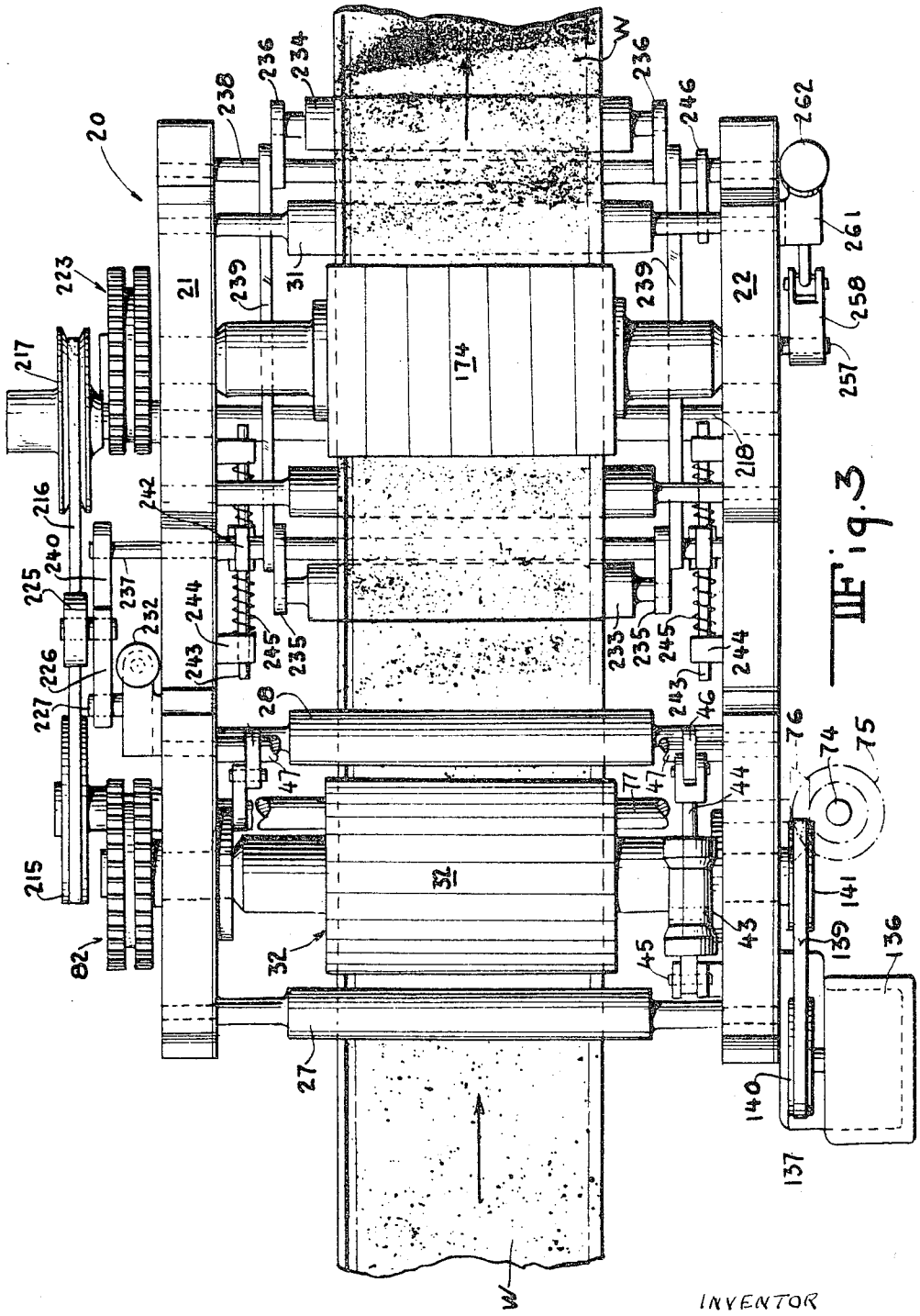


Fig. 3

INVENTOR
WILLIAM F. HUCK
BY
Albert C. Johnston
ATTORNEY

Nov. 8, 1966 W. F. HUCK 3,283,636

ROTARY PERFORATING MACHINE WITH MEANS TO CONTROL WEB MOVEMENT

Original Filed July 19, 1960 6 Sheets-Sheet 4

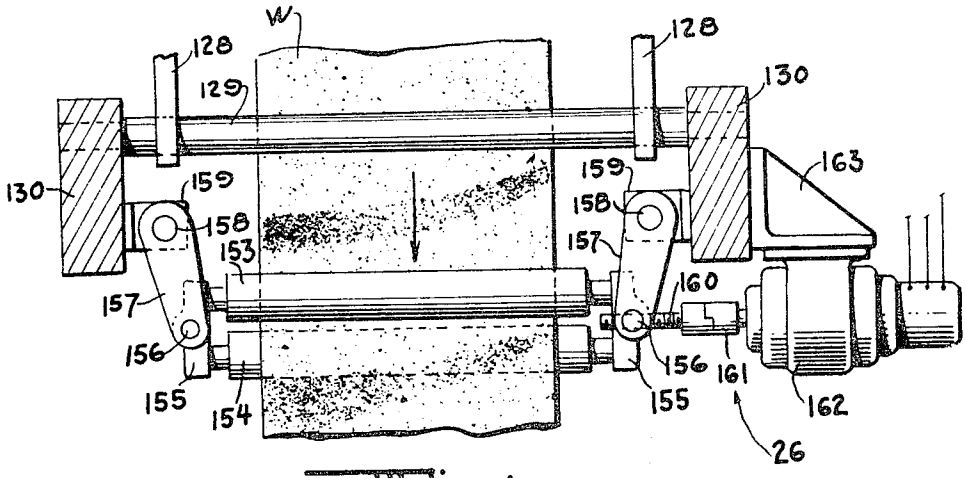


Fig. 4

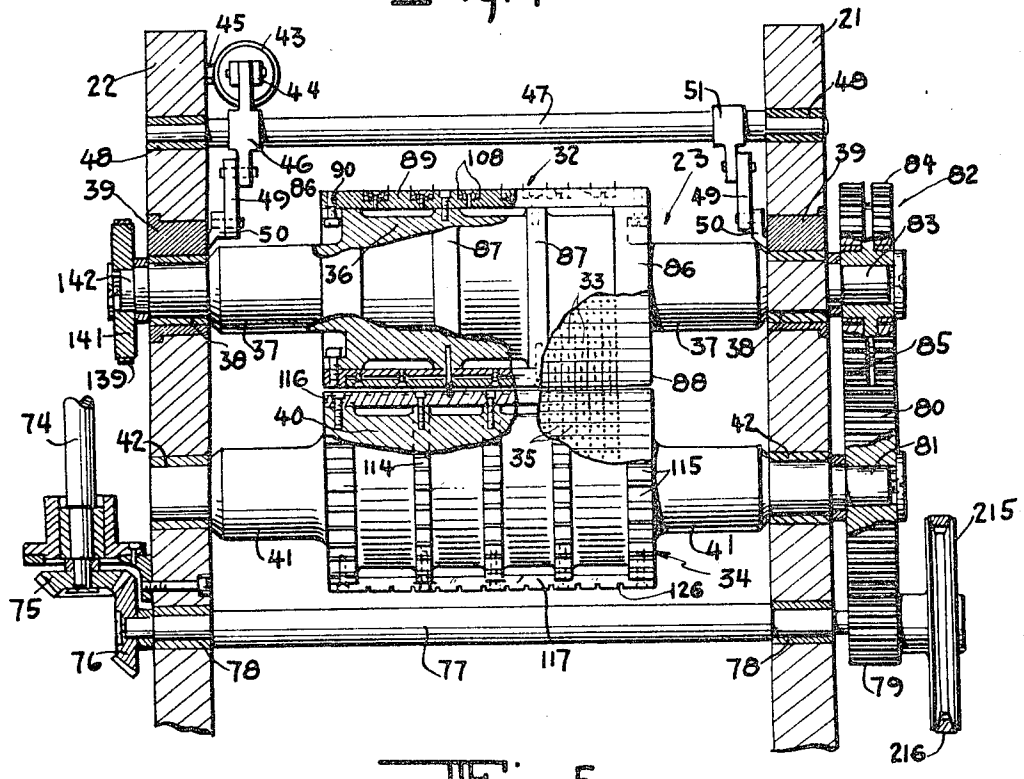


Fig. 5

INVENTOR
WILLIAM F. HUCK
BY
Albert C. Johnston
ATTORNEY

Nov. 8, 1966 W. F. HUCK 3,283,636

ROTARY PERFORATING MACHINE WITH MEANS TO CONTROL WEB MOVEMENT

Original Filed July 19, 1960 6 Sheets-Sheet 5

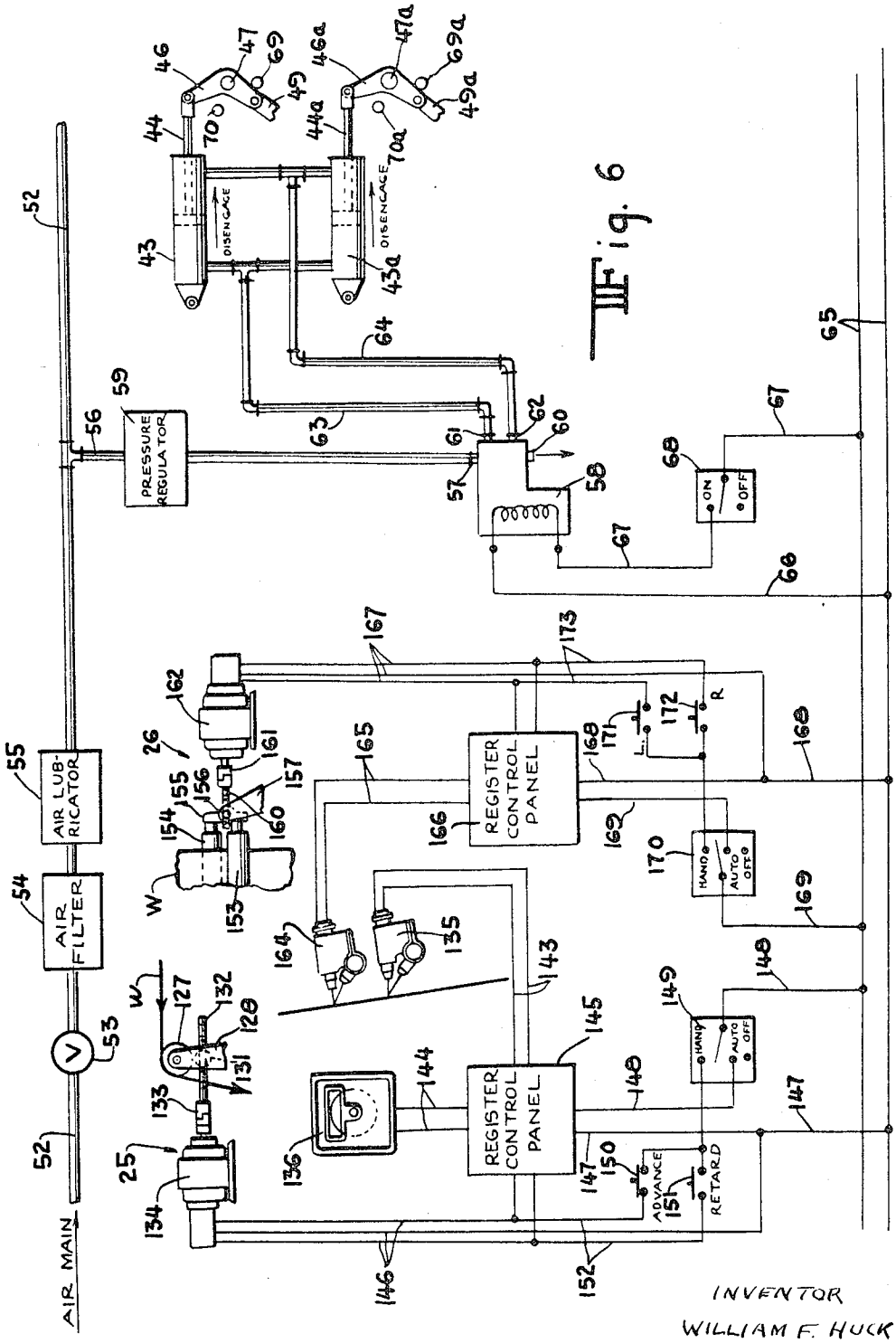


Fig. 6

INVENTOR
WILLIAM F. HUCK
BY
Albert C. Johnston
ATTORNEY

Nov. 8, 1966 W. F. HUCK 3,283,636

ROTARY PERFORATING MACHINE WITH MEANS TO CONTROL WEB MOVEMENT

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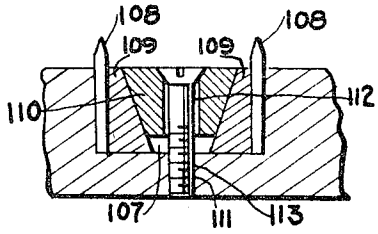


Fig. 8

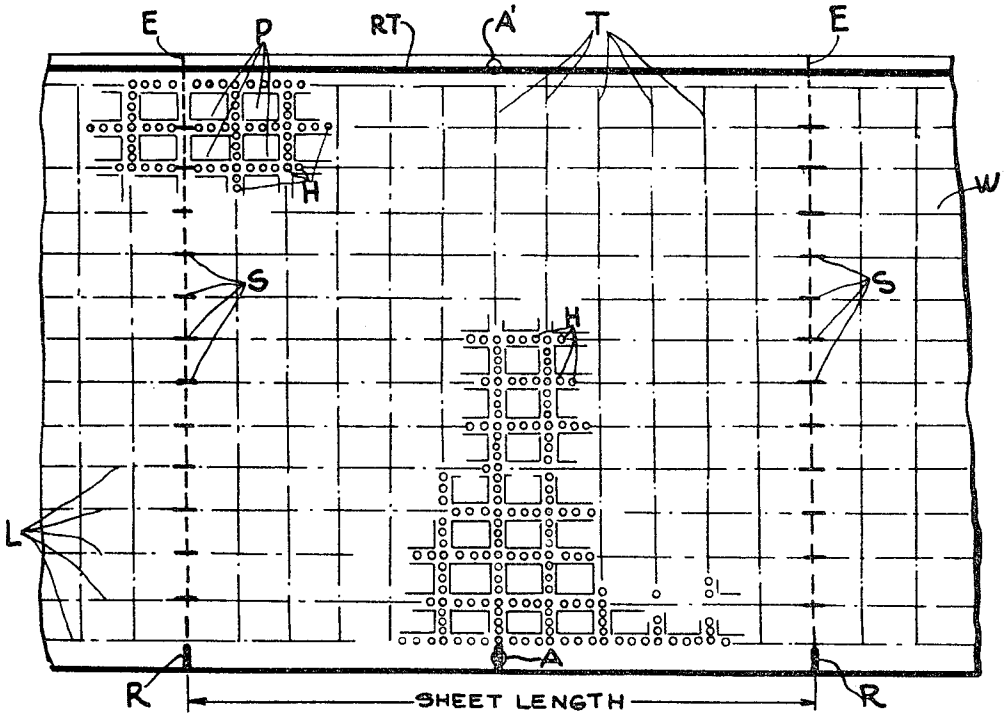


Fig. 7

INVENTOR
WILLIAM F. HUCK
BY
Albert C. Johnston
ATTORNEY

United States Patent Office

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Patented Nov. 8, 1966

3,283,636

ROTARY PERFORATING MACHINE WITH MEANS TO CONTROL WEB MOVEMENT

William F. Huck, 81 Greenway Terrace, Forest Hills, Long Island, N.Y.

Original application July 19, 1960, Ser. No. 43,839. Divided and this application Oct. 15, 1965, Ser. No. 496,488

1 Claim. (Cl. 83—365)

This application is a division of my copending application Serial No. 43,839 filed July 19, 1960.

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.

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 in 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 mainttenance 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 slight 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.

Accordingly, it is an object of this invention to provide a rotary perforating device 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 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 druing the desired high speed operation.

In accordance with the invention, a rotary perforating device having the characteristics referred to above is 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.

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 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. 7 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. 8 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** includes 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. 7, 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, rotary perforating unit **23** which is intended to form the perforations or holes H in transversely extending rows T (FIG. 7) includes a male die cylinder **32** having a suitably arranged pattern of perforating pins or punches **33** 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** 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 members **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**.

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. 6, 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 the 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 reengagement of such cylinders.

The perforating unit 23 forms the holes H in the transversely extending rows T, as previously mentioned with reference to FIG. 7, 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 perforation 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 FIG. 5, 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.

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 of the knife holding bar or bars 89 of the male die cylinder.

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 roller 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 supply 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 6. 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 Com-

pany, 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. 7, 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 illumniated 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 **37** 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 selector switch **136** are fed, by way of conductors **143** and **144**, respectively, to a register control panel **145** (FIG. 6) 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. 6, 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 journaled in bearing blocks **15** 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 6, 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 oppo-

site 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. 7, 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. 7) or the web surface which is illuminated by the bear or 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 sosrce of head **164** into the photoelectric cell of the latter, and thereby alters the voltage generated by the cell.

As shown in FIG. 6, 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. 6 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 extends 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**.

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 **27**, and a V-belt **216** which runs around pulley **215** 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**.

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 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, shafts **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 opopsite 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 radical 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 reltaively 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 coperates 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 exterted 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 balancing 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 correspondingly 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 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. 7, 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, except as defined in the appended claim.

What is claimed is:

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 pattern with respect to said perforations, thereby to restore said correct transverse registration.

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ANDREW R. JUHASZ, *Primary Examiner.*