Dec. 14, 1965 I. TORNBERG ETAL 3,222,966

HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 1

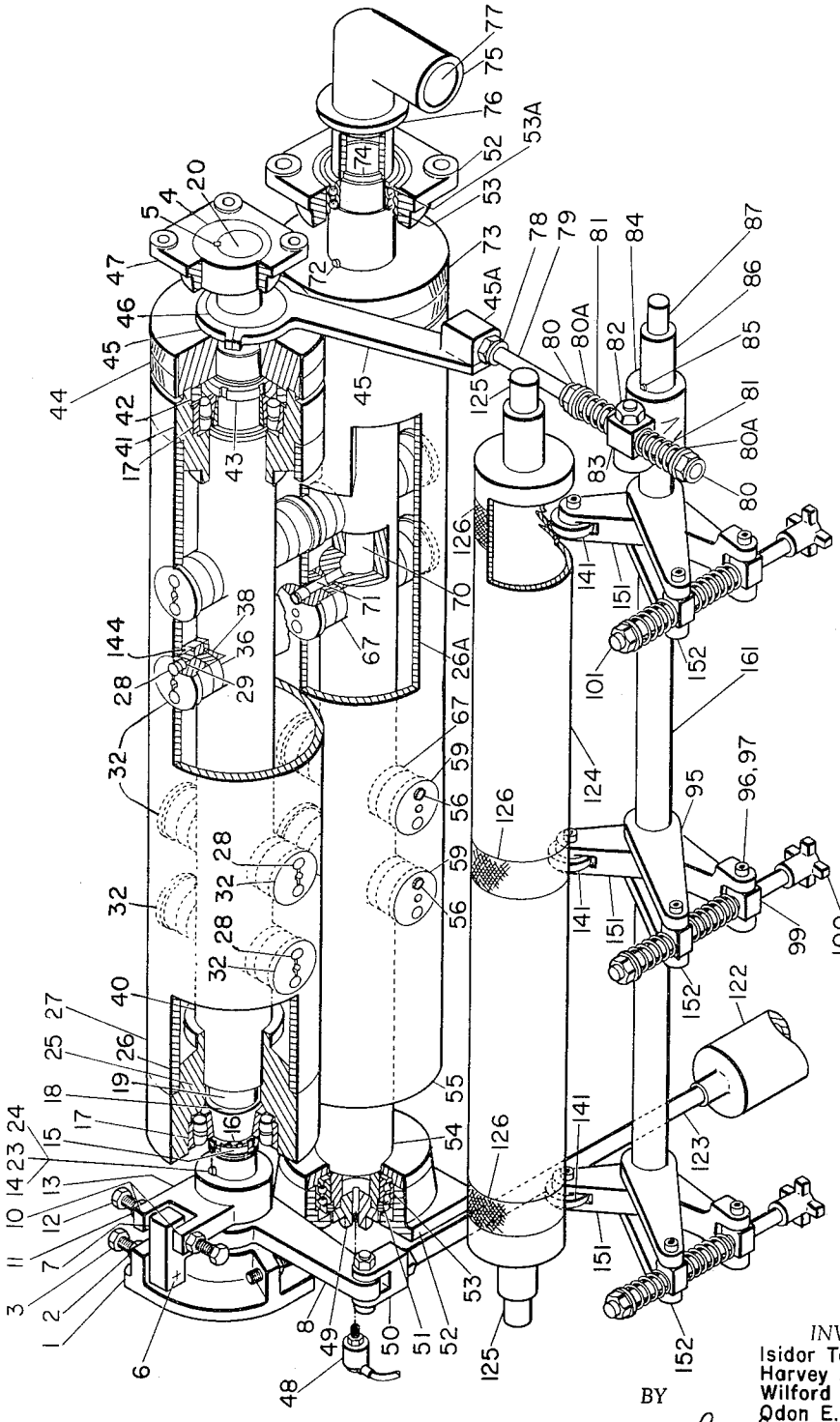


FIGURE 1

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HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 2

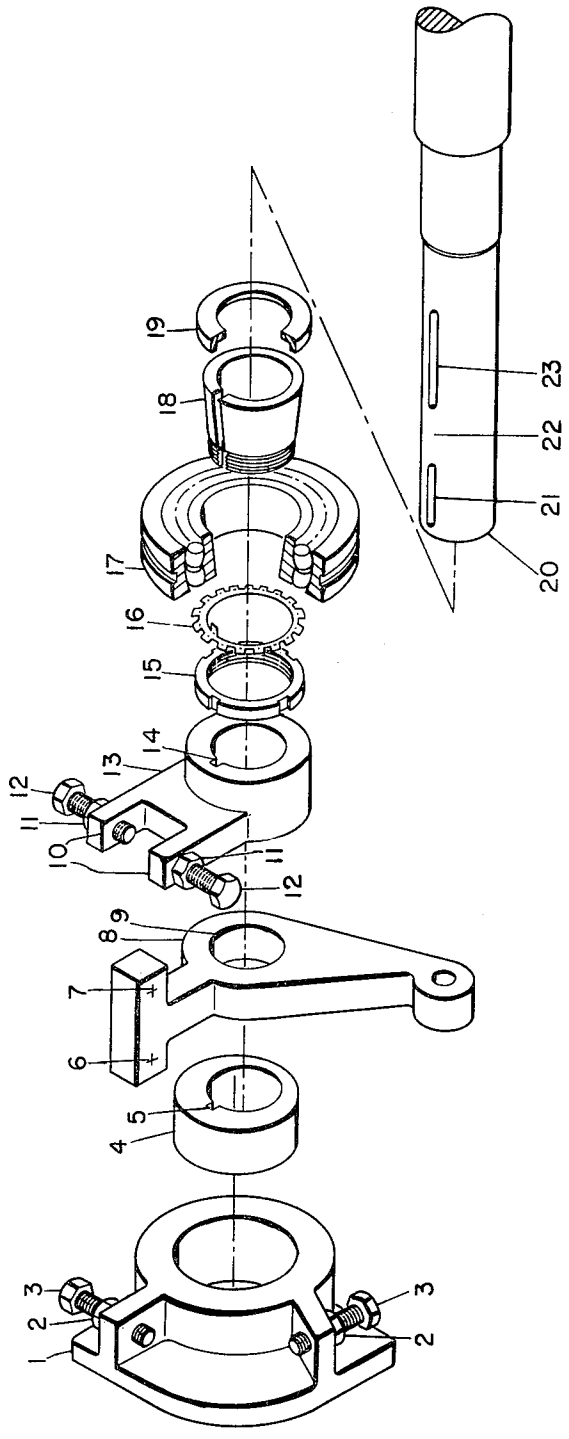


FIGURE 2

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HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 3

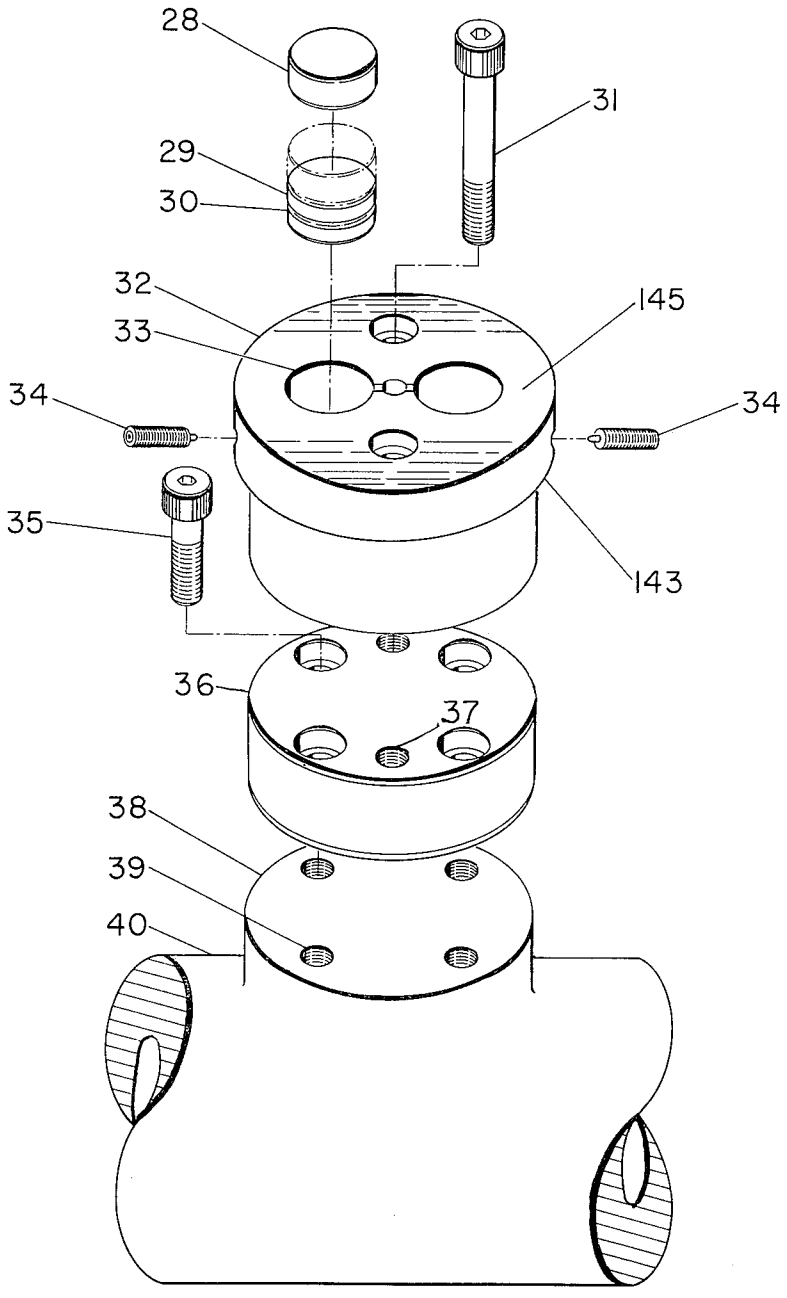


FIGURE 3

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HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 4

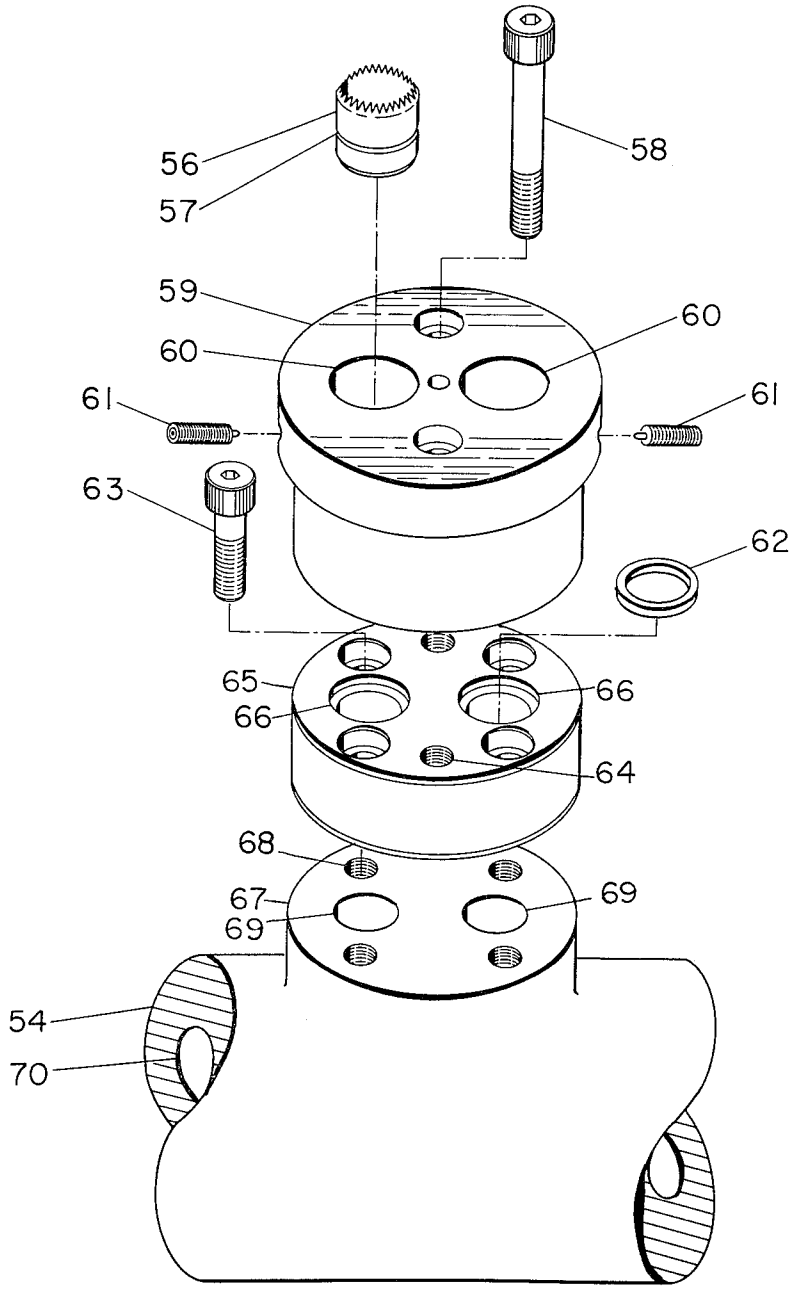


FIGURE 4

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HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 5

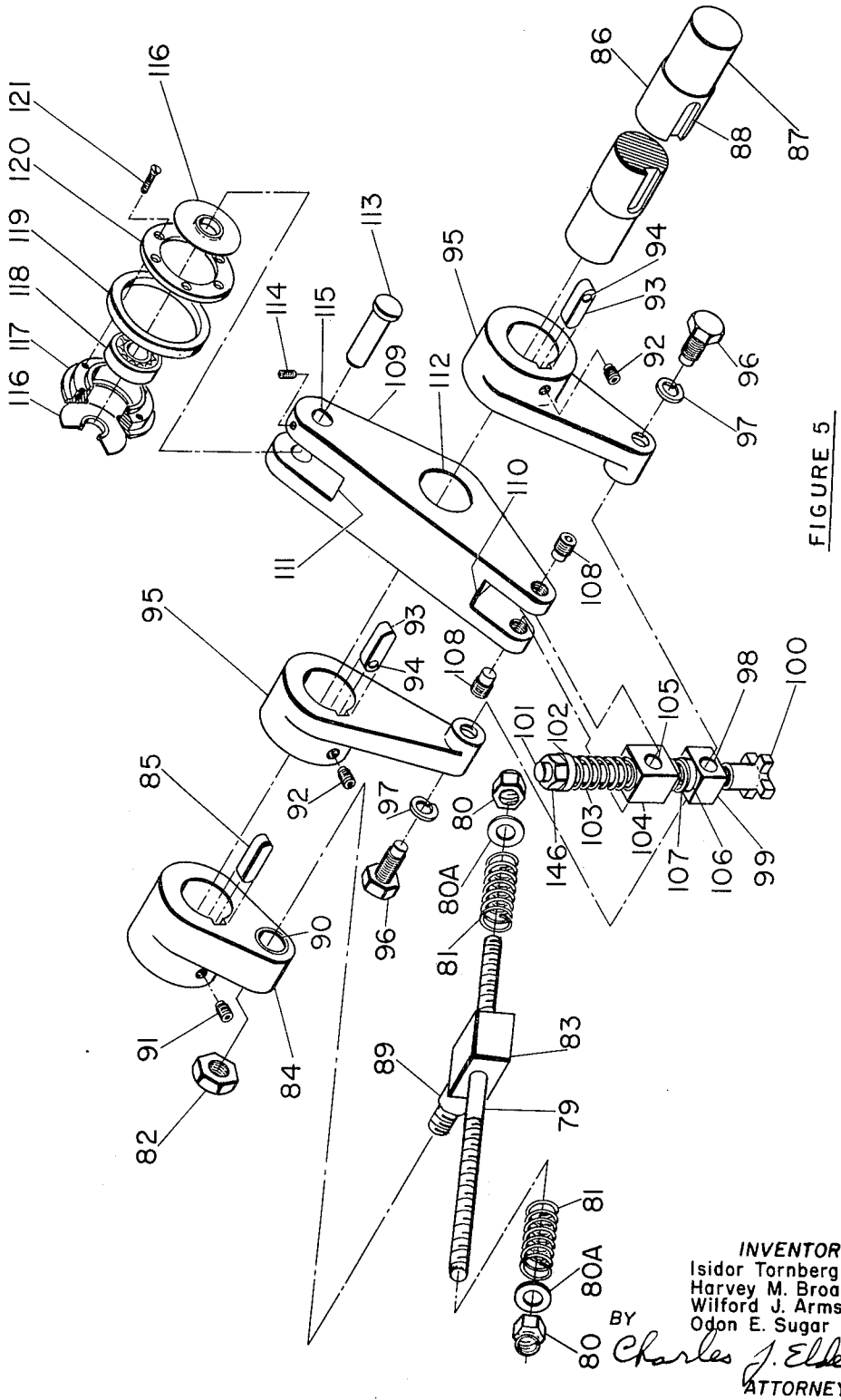


FIGURE 5

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HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 6

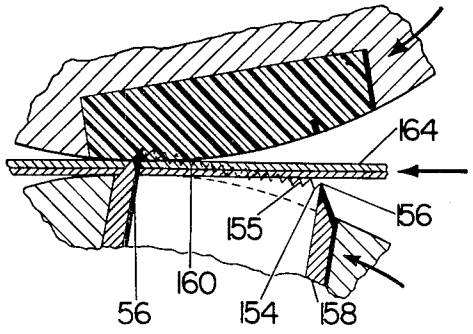


FIGURE 6

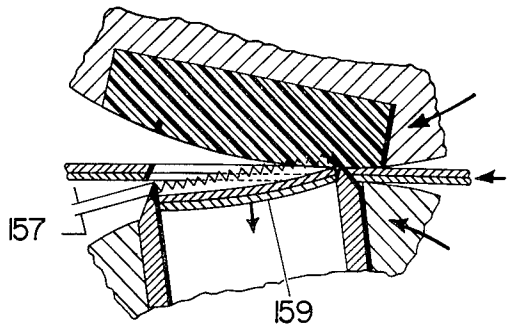


FIGURE 6A

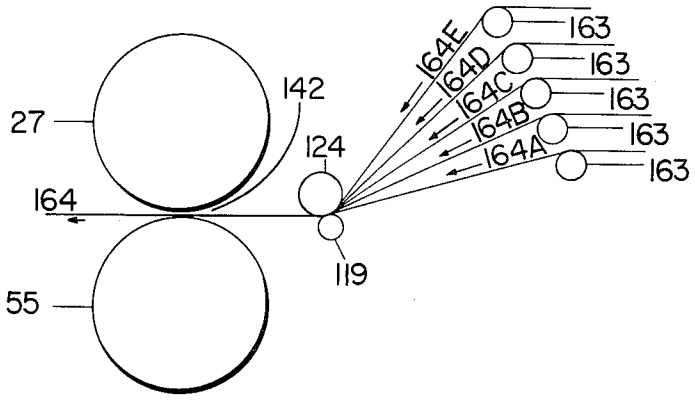


FIGURE 9

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HIGH SPEED WEB PUNCHING DEVICE

Filed March 19, 1963 7 Sheets-Sheet 7

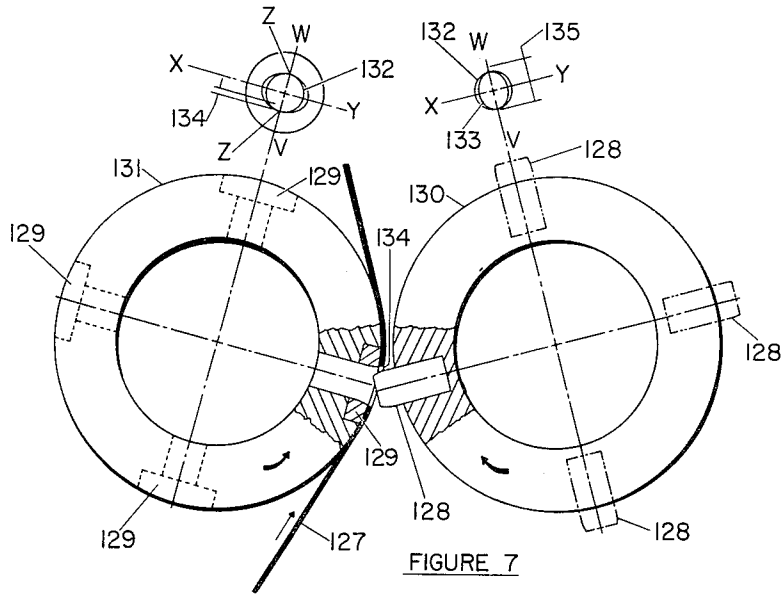


FIGURE 7

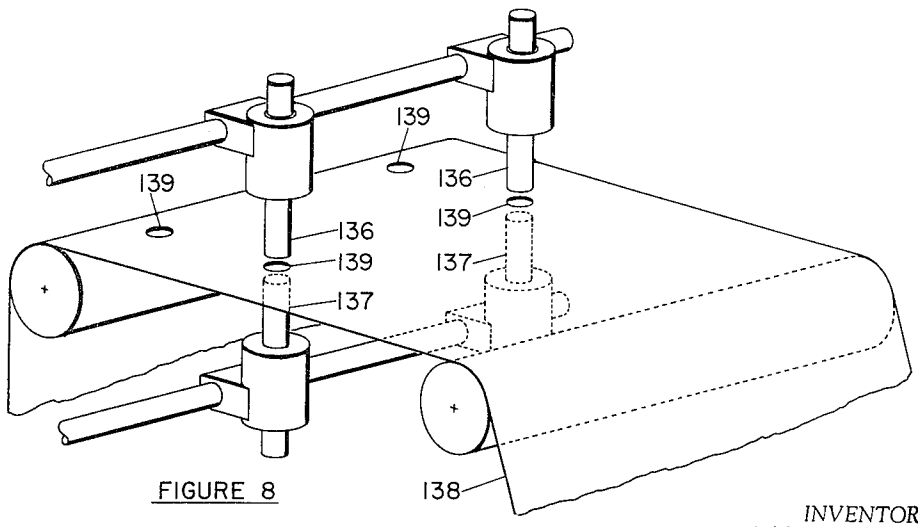


FIGURE 8

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United States Patent Office 3,222,966 Patented Dec. 14, 1965

3,222,966

HIGH SPEED WEB PUNCHING DEVICE

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Filed Mar. 19, 1963, Ser. No. 266,300
7 Claims. (Cl. 83—98)

This invention relates in general to web-handling and converting machinery, and more specifically to the methods and machines used to produce perforations or punched holes of any shape in a rapidly moving web of paper, plastic, textiles, and similar materials. The apparatus of the invention readily applicable, for example, to providing a thumb index for a newspaper.

A proper understanding of the details and manner of operation of both the present invention and some of the more common prior art proposals will be gained by referring to the following description thereof, taken in conjunction with the accompanying drawings and in which:

FIGURE 1 is a stylized isometric view of the invention, wherein various components have been sectioned and cut-away in order to clarify the description of the construction and workings thereof;

FIGURE 2 is an isometric view of certain components of the invention which serve to control it during operation, and which have been shown in an exploded relationship to assist in a clear description;

FIGURE 3 is an isometric view of certain additional components of the invention, namely the pad holder assembly, which serves to facilitate the fabrication and assist in the economical operation of the invention, and which has been shown in an exploded relationship to assist in a clear description;

FIGURE 4 is an isometric view of certain additional components of the invention, namely the punch holder assembly, which serves to facilitate the fabrication and assist in the economical operation of the invention, and which has been shown in an exploded relationship to assist in a clear description;

FIGURE 5 is an isometric view of certain additional components of the invention, namely the trolley and trolley control assembly, which serves to control the invention during its operation, and which has been shown in an exploded relationship to assist in a clear description;

FIGURES 6 and 6A are stylized cross-sectional views which illustrate the action of the punch and the pad components of the invention;

FIGURE 7 is a stylized schematic view of the essential components in an existing method of web-punching;

FIGURE 8 is a stylized isometric view of the essential components in another existing method of web-punching; and

FIGURE 9 is a stylized schematic view showing the method of gathering webs to lead through punching cylinders.

Prior to considering the present invention in detail, it will be advantageous to consider two of the prior devices used in punching moving webs.

As shown schematically in FIGURE 7, a moving web **127** can be punched at a reasonable speed by a system wherein a number of identical sets of punches **128** and dies **129** are mounted on drums or wheels **130, 131**, with the surface speed of the die drum **131** synchronized to match that of the web **127** which passes between it and the punch drum **130**.

Even though this method of web-punching embodies several distinct limitations and disadvantages, it has been rather widely employed in a variety of applications be-

the equipment which this system requires is relatively inexpensive to build and to operate where high speeds are not required.

The punch and die sets are round **132** when new but, because they pass into and out of mesh in much the same manner as do gear teeth, the punches and dies tend through wearing action to gradually shape themselves into a complex elliptical configuration **133** and therefore to punch elliptical holes in the web.

Punch and die clearances are critical, particularly when running thin webs. Therefore, periodic reductions in punch and die clearances must be made in order to compensate for wear.

Normal practice is to fix the punch pins **128** and the dies **129** rigidly in their respective drums, and to adjust the punch and die clearance when necessary by reducing the center to center distance between the rolls. This method is advantageous in that it provides a uniform reduction in clearance on all punches and dies across axis *x–y*, it is relatively easy to do, and it provides reasonable die life when running thin stock.

Unfortunately, when the wear on the dies at points *z* has increased the effective punch and die clearance **134** across axis *v–w* beyond the original outside diameter **135** of the punch, the punch and die sets must be discarded because they will no longer punch clean in the area of points *z*.

A majority deficiency inherent in this system is that, due to the critical nature of the punch and die clearances, the maximum speed at which the system can be operated is generally well below the most profitable operating speed for the equipment on which it is installed. Appreciable quantities of lint are produced in paper punching operations, particularly with this system, and the abraiding action of this lint is tolerably low at moderate web speeds. However, at the higher surface speeds employed in modern web-handling equipment, generally upwards of 800 to 1,000 feet per minute, the abraiding action of the lint becomes destructive to a degree where the operation of this system is no longer practical or profitable.

In another and more recently developed web-punching system, as shown in FIGURE 8, by positioning two spark-gap electrodes **136, 137**, opposite each other and feeding the moving web **138** between the faces of the electrodes, it is possible to burn or, literally, to "blow" a hole **139** in the moving web **138** by passing a high energy electrical discharge from the face of the one electrode and through the web to the face of the other electrode.

The power consumption of any such spark-gap system is generally high, because most papers, plastics, and textiles are good electrical insulators. Therefore, such systems are usually limited to the punching of relatively thin webs. Any increase in the thickness and/or the dielectric strength of the web will require a proportionate increase in the power output of the system, and a disproportionately greater increase in the system's total overload capacity. These requirements make it prohibitively expensive to build, install and operate a spark-gap system for the punching or perforating of any but the thinnest web materials.

Waste punch-out material disposal is another facet of the spark-gap system which can at once be both an advantage and a problem, depending upon the requirements of the finished product. The spark-gap system is advantageous in that it does not produce "confetti," and thereby eliminates the confetti collecting and disposal nuisance common to most rotating punch and die systems. The spark discharge causes the punched-out material to disintegrate, so to speak, into very small particles which can be collected almost completely with exhaust ducts.

A disadvantage of the system is that, under some frequently encountered combinations of humidity and temperature, and depending upon various common characteristics of web materials, small but nonetheless troublesome bits and pieces of the incompletely disintegrated waste punch-outs tend to cling to the moving web, being attracted thereto by residual static charges on the web's surface.

Ozone produced by the potential across the spark-gap can cause a continuing corrosion problem in the operation of this system. The corrosion can be negligible or serious by degrees, depending upon an infinitely variable interaction of many factors, the more important of which are web material, electrode material, intensity, duration, and frequency of the spark discharge, humidity and temperature; and the physical characteristics of the equipment upon which the spark-gap system is installed.

Corrosion is not confined to the immediate area of the spark-gap installation. Ozone (O_3) is an allotropic form of oxygen which readily decomposes ($O_3 \rightarrow O_2 + O$) in the presence of heat and/or humidity. While very active chemically, the ozone and its decomposition products are for the most part collected by the exhaust system, and the chemical corrosion is thereby confined almost completely to the exhaust system components. However, the balance of the interconnected pressroom equipment is placed in an anodic condition by the minute but nonetheless continuous concentration of oxygen in the immediate area of the spark-gap installation. Electrochemical corrosion is thereby accelerated throughout the equipment upon which the spark-gap system is installed.

In view of the above-enumerated deficiencies in prior art web-punching machines, it is accordingly an object of the present invention to provide a machine which will punch one or several webs moving at high speed, so that the equipment on which it is installed can be run at full speed.

A further object of the invention is to provide a web-punching machine which is economical to operate, which is substantially automatic, and has a durability at least equal to the equipment on which it is installed.

A still further object of the invention is to provide a web-punching machine which is sufficiently versatile to punch a variety of web materials and thicknesses, either single or multiple webs, and at varying rates of speed, all without affecting the quality of the punch.

Yet another object of the invention is to provide a web-punching machine in which punch and die clearances are not critical, and in which punch-outs are quickly and economically removed.

Yet another object of the invention is to provide a web-punching machine which can either be installed as a modification of or accessory to existing web-treating machines or which will function as a self-contained punching machine.

Various other objects and advantages will appear from the following description of one embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

With reference to FIGURE 1, the basic components of the invention are first, two cylinders, namely a punch cylinder **55** and a pad cylinder **27**, which are positioned with their axes parallel to each other and their faces separated by an air gap which may, for illustration, be about .010 inch. A drag roller **124** and a trolley assembly indicated generally at **161** and shown in detail in FIGURE 5 are positioned adjacent to the punch cylinder **55** and pad cylinder **27**. In operation, the web is led from the last idler rolls in the printing equipment, over the trolley wheels **141**, under the drag roller **124**, and into the nip **142** (FIGURE 9) between the punch cylinder **55** and the pad cylinder **27**.

The operation of this machine which implements our invention can be best explained by first describing its construction. As shown in FIGURE 1, the pad cylinder **27** is constructed with an outer shell **26** into which, on the control end, is fitted a shoulder spacer **19**. A similar spacer designated as a cylinder cap and bearing housing **41** is fitted into the shell **26** on its opposite or "drive" end. A hollow inner shell **40** connects and is tightly fitted into the shoulder spacer **19** and the bearing housing and cylinder cap **41**. Bosses **38** are welded or otherwise affixed to the inner shell **40**. These bosses **38** are shown positioned in FIGURE 1 as they would be on a machine designed specifically to punch thumb-indexing notches in a tabloid newspaper. Other requirements may dictate that a greater or lesser number of bosses be located on the shell, or that they be located in different positions, in any required arrangement.

As shown assembled in FIGURE 1 and exploded for the sake of clarity in FIGURE 3, the faces of the bosses **38** are machined flat and normal to the center line of the inner shell **40**. Holes **39** (FIGURE 3) are drilled and tapped in the face of each boss. Spacers **36** are affixed to the bosses **38** with socket head cap screws **35**. The clearance holes in the spacers **36** are counterbored so that at assembly, the heads of the socket head cap screws are fully recessed into the face of the spacers **36**.

Again referring to FIGURE 3, two holes **37** are drilled and tapped into the face of the spacers **36**. These tapped holes **37** accept the socket head cap screws **31** which lock the pad holder body **32** into the pad cylinder shell **26**. The pad holder body is machined and fashioned with a shoulder **143** which mates with matching shoulders **144** (FIGURE 1) machined in the face of the pad cylinder's outer shell **26**. The face of the pad holder body **145** is machined on a radius which matches the radius of the outer shell **26**, so that when assembled, the face of the pad holder body **145** and the face of the outer shell **26** match to form a smooth, uninterrupted surface.

Two holes **33** are bored in the pad holder body **32**. Pads **28** made of polyurethane or another suitable resilient material are cemented or otherwise secured to pad mounting plugs **29**, and these assembled components slip-fit into the holes **33** in the pad holder body **32**. The pad and mounting plug assemblies **28**, **29** are retained in the pad holder body **32** by means of spring loaded pins **34** whose heads snap lightly into matching retaining grooves **30** which are machined into the walls of the pad mounting plugs **29**. Alternatively, steel balls held by set screws can be used in place of pins **34**, provided groove **30** is made to match the ball.

In normal operation, the pad holder body **32** remains more or less permanently in the pad cylinder **27**. The pad and pad mounting plug assemblies **28**, **29** are removed by means of an "L" shaped steel hook which slips into the slot shown in FIGURE 3, interconnecting the two holes **33** in the face of the body **32**.

The punch cylinder **55** is assembled in much the same manner as is the pad cylinder **27**. An outer shell **26***a* is affixed to a hollow inner journal **54** by means of spacers (not shown) on the control and drive ends. As shown assembled and cut-away in FIGURE 1 and exploded for the sake of clarity in FIGURE 4, bosses **67** are welded or otherwise affixed to the hollow journal **54**. The faces of these bosses **67** are machined flat and normal to the center line of the journal **54**. Holes **68** (FIGURE 4) are drilled and tapped into the face of the bosses **67** to accept the socket head cap screws **63** which fasten the spacers **65** to the bosses **67**. The face of the spacers **65** are counterbored so that at assembly the heads of the socket head cap screws **63** are fully recessed. The face of the spacers **65** are drilled and tapped **64** to accept the socket head cap screws **58** which fasten the punch holder body **59** and lock it into the punch cylinder shell.

Again referring to FIGURE 4, holes **60** are bored into the face of the punch holder body **59** to accommodate the punches **56**. The holes **60** are bored with their inside diameter matching the outside diameter of the punches, to a predetermined depth and there necked down with a

square shoulder to a diameter matching the inside diameter of the punches. The base of the punches 56 rests on this shoulder. Spring loaded set screws 61 are located in the punch holder body 59. The heads of these spring loaded set screws 61 snap into retaining grooves 57 which are machined in the wall of punches 56, and the punches are thus retained in the punch holder body 59.

Holes 66 matching the inside diameter of the punches 56 are bored in the spacer 65, and are counterbored to accept and retain the sealing rings 62. The sealing rings 62 protrude slightly above the surface of the spacer 65 when the two are assembled, and serve to seal the bores 66 and 60 in order to prevent the escape of lint and paper punches during the operation of the machine, as will be explained later. Holes 69 matching the inside diameter of the punches 56 are bored through the bosses 67 and the wall of the hollow journal 54. When the spacer 65, the punch body 59, and the punch 56 are assembled in line with the boss 67, the bores 69, 66 and 60, and the inside bore of the punch 56 form a smooth, continuous walled bore which is broken only by slight irregularities in the rubber seal ring 62. It is through this bore that the waste punch-outs are packed and transported into the hollow journal 54 and thus transported through its bore 70 to the waste disposal elbow 75 (FIGURE 1), as is fully described hereinbelow.

Referring again to FIGURE 1, the punch cylinder journal 54 is supported on main bearings 53 on both ends. The inner race of these bearings 53 is force fitted on the gudgeons 53*a* on both ends of the journal 54. On the control end of the journal 54 the inner race is locked securely by the bearing lock nut 51. The outer race of the main bearings 53 is supported in cast steel bearing housings 52, which are flanged and bolted to the side frames of the punching machines. The side frames are fabricated from steel plate which has been suitably machined and finished to accept the various components which are affixed to it. The side frames have been omitted from the drawings for the sake of clarity, since construction thereof is obvious to those skilled in the art.

The end of the bore 70 in the pad cylinder's hollow journal 54 is machined on the drive side to accommodate the sealing ring 74 and on the control side to accept the end plug 49.

A herringbone drive gear 73 is fitted onto the drive end of the punch cylinder journal 54, and the gear 73 and journal 54 are keyed together with a fitted key 72. Lateral motion or slippage of the gear 73 is prevented by cap screwing it to the drive side end plug of the punch cylinder 55.

In operation, and with particular reference to FIGURES 1 and 2, the axis of the punch cylinder 55 remains in a fixed location, and the nip opening 142 (FIGURE 9) is increased or decreased by manipulating the eccentrics 4 which support the stationary eccentric journal 20 of the pad cylinder 27. As partially described previously, the pad cylinder 27 is comprised of an outer shell 26, two end cylinder cap and bearing housings 25, 41, and a hollow inner journal or shell 40. These are assembled as a unit 27, and supported on each end by main bearings 17, whose outer races are locked into the cylinder cap and bearing housing 41 on the drive end by means of the lock nut 42, and allowed to float freely in the shoulder spacer 19 on the control end to permit expansion and contraction of the cylinder during operation. The inner races of the main bearings 17 are locked in place on the eccentric journal 20 (FIGURE 2) by means of the tapered bore adapters 18, locknuts 15, and lockwashers 16. The eccentric journal 20 does not rotate.

A herringbone gear 44 is affixed to the pad cylinder's drive and cylinder cap and bearing housing 41. The bore in this herringbone gear 44 is sufficiently large to allow the gear to rotate freely without contacting the eccentric journal 20.

Eccentrics 4 are affixed and keyed 5 to the eccentric journal 20 with keys 5'. The eccentrics are supported in a cast steel housing 47 on the drive end and housing 1 on the control end.

As shown assembled in FIGURE 1 and exploded for the sake of clarity in FIGURE 2, on the control end the eccentric journal 20 and the eccentric 4 are supported in the cast steel housing 1. The housing 1 embodies two cast steel bosses as shown. In each of the bosses a limit screw 3 is located and locked with a jam nut 2. The eccentric 4, as mentioned previously, is keyed to the journal 20 through a key 5' (FIGURE 1) and keyway 5 and the keyway 21.

A cast steel drive arm 8 is located on the journal 20 immediately adjacent to the housing and eccentric 1, 4. The bore 9 in the drive arm 8 is smooth, and is dimensioned to a slip fit on the smooth section 22 of the journal 20. The nip limit lug 6 is trapped between the nip limit screws 3 at assembly.

A cast steel yoke 13 is affixed to the journal 20 immediately adjacent to the drive arm 8, by means of keyways 14 and 23 and key 24 (FIGURE 1). The lugs 10 on the yoke 13 straddle the nip control lug 7 on the arm 8 at assembly. The operating nip control screws 12 are jammed tightly against the nip control lug 7 at assembly, and the drive arm 8 and yoke 13 operate as a unit, as will be more fully explained hereinbelow.

A clevis 50 and air cylinder 122 are linked to the drive arm 8 as shown in FIGURE 1. In operation, when the piston rod 123 is fully extended as shown in FIGURE 1, the drive arm is in its uppermost position, and the nip 142 (FIGURE 9) is open to its widest limit. The nip control and adjustment will be more fully explained hereinbelow.

Referring to FIGURE 1, a trolley control cam 46 is affixed to the eccentric journal 20 immediately adjacent to the herringbone gear 44, on the drive end of the pad cylinder 27. A connecting rod assembly 45 is clamped to the cam 46, and is fitted with adequate clearance to permit free rotation of the cam 46 within the connecting rod clamp 45. The connecting rod 45 is fabricated from plate steel, and a drilled and tapped steel boss 45*a* is welded or otherwise affixed to its one end. A connecting rod 79 is fabricated from round steel bar stock, threaded in from the one end for approximately half its length, and for a shorter distance from the opposite end. The short threaded end is screwed into the boss 45*a* on the connecting rod 45, and the long threaded end is assembled as shown in FIGURE 1, and exploded for the sake of clarity in FIGURE 5.

The short threaded end is locked into the boss 45*a* with jam nut 78. On the long threaded end, wrist pin block 83 is trapped and centered between the balanced springs 81 which are retained by the elastic tensioning nuts 80 and washers 80*a*. The turned trunnion 89 (FIGURE 5) on the wrist pin block 83 is fitted into the bushed bore 90 in the crank arm 84. The wrist pin block 83 is retained in the crank arm by the elastic stop nut 82.

The crank arm 84 is positioned near one end of the trolley control shaft 86, and is retained in position by key 85 and set screw 91. Trolley wheel support and pressure-loading assemblies indicated generally at 151 and 152, respectively, are positioned at intervals on the trolley control shaft as shown in FIGURE 1. These assemblies are located in positions which permit the trolley wheel assemblies to run in contact with the web in portions of the printed page commonly called "gutters" in printing terminology. These gutters are unprinted areas where the page will later be folded or cut.

As shown assembled in FIGURE 1 and exploded in FIGURE 5, the rocker arm assemblies 151 and pressure-loading assemblies 152 are each comprised as follows. A rocker arm 109 is positioned on the trolley control shaft 86, and its smooth bore 112 is slip-fitted to permit free rotation about the trolley control shaft 86.

Referring to FIGURE 5, two control arms **95** are locked onto the trolley control shaft **86** and secured with keys **93** and set screws **92**. The keys **93** are machined with a shallow pocket **94** which accepts the dog-point on set screw **92**. This permits set screw **92** to be loosened sufficiently to free its locking force on shaft **86**, while retaining its engagement in pocket **94**. This permits the complete trolley wheel support and pressure control assembly to be moved on the shaft **86** while at the same time retaining the keys **93** in their respective keyways in the control arms **95**. The keyway **88** in the trolley control shaft **86** is cut the full length of the shaft with the exception of the trunnions **87** on each end of the shaft, which are not keyed.

A floating nut **99** is slip-fitted into the space between the machined faces of the bosses on the ends of the control arms **95**, and is secured in this position by the hex-head dog-pointed wrist-pin screws **96** and the lock washers **97**. The dog points on wrist-pin screws **96** engage the shallow bores **98** in the floating nut **99**.

A threaded adjustment shaft **101** is backed through the threaded hole in the center of the floating nut **99**. A drilled and tapped hand knob **100** is threaded into place on the end of shaft **101** as shown, and is secured by "staking." A balance and return spring **107** is slipped onto shaft **101** on the end opposite hand knob **100**, and is brought to rest against the shoulder or step collar **106** on the shaft **101**. A pressure block **104** is then slipped onto shaft **101** and trapped in place by the compression spring **103**, washer **102**, and elastic stop nut **146**.

The pressure block **104** is then positioned in the slot **110** in rocker arm **109**, and the rocker arm is rotated slightly until the shallow bores **105** on each side of the pressure block are engaged by the headless wrist-pin screws **108**.

The trolley wheels (indicated generally in FIGURE 1 at **141**) are assembled as follows. The tire **119**, which may variously be fabricated of steel, brass, rubber, or plastic, is press-fitted onto the rim of the wheel body and bearing housing **117**. Roller bearing **118** is fitted into the bore of the body **117**. The outer race of the roller bearing **118** is retained in the body **117** by a shoulder on the one side of the bore in the body **117**, as shown, and by the retaining rim **120** on the opposite side. The retaining rim **120** also serves to hold the tire **119** against the retaining rim on the body **117**. The retaining rim is secured to the body **117** with six flat head machine screws **121** (one shown).

The assembled wheels are positioned in the slots **111** in the rocker arms **109**, and centered between two spacing washers **116**. Axle pin **113** is inserted in the bores **115** in the walls of slot **111**, through the bore in the bearings **118** and the bores in the spacers **116**. Axle pin **113** is locked in position with socket head set screw **114**.

The drag roller **124** (FIGURE 1) is constructed as a steel shell with gudgeons **125** press-fitted and welded in each end. The shell and the gudgeons are rough-machined before assembly and welding, and are then finish machined as a unit. The gudgeons **125** are supported on each side in flanged cartridge ball bearings which are bolted to the inside of the side frames. The side frames have been omitted from the drawings for purposes of clarity, as previously noted.

The trolley control shaft **86** is positioned in the machine relative to the axis of the drag roller **124** in such a manner as to permit the trolley wheels **141** to contact the face of the drag roller **124** at approximately the mid-point in the web's total "wrap" on the face of the drag roller.

As shown in FIGURE 1, knurled sections **126** in the shape of rings have been machined on the face of the drag roller **124**. These overlap the center line of each trolley wheel by approximately one inch laterally in both directions.

These knurled segments **126** are found to be helpful in controlling the web under certain conditions of press-

room temperature and humidity when running various classes of web materials, notably newsprint. These factors will be more fully explained in the description of the operation of the machine, immediately hereinbelow.

As shown in FIGURE 1, and schematically in FIGURE 9, the basic components of the machine are arranged as follows. The pad cylinder **27** and punch cylinder **55** are positioned so that a vertical centerline drawn through their axis (FIGURE 9) would be nearly normal to web line **164** when the web is drawn in a straight line tangentially from the face of the drag roller **124** and through the nip **142** between the punch cylinder **55** and the pad cylinder **27**.

When set for the simultaneous punching of five webs, the webs **164***a*, *b*, *c*, *d* and *e* are drawn over a rack of five idler rolls **163** and are brought together when wrapped slightly or "broken under" the drag roller **124**. The combined or unitized webs **164** are led from the drag roller **124** and through the nip **142** between the pad cylinder **27** and the punch cylinder **55**. The webs **164** may then be led as desired to subsequent stations in the converting apparatus, such as slitters, folders, sheeters, or the like. The converting operations which conceivably may precede or follow the punching work performed by the punching apparatus are so numerous and varied as to permit only a passing mention in this application.

The pads **28** are located as desired in their holders in the pad cylinder **27**, and the punches are snapped into their holders in the punch cylinder **55** in positions which correspond with the pad locations in the pad cylinder. In that particular embodiment of the invention which is being described in this specification, the punch and pad cylinders are geared together as shown in FIGURE 1, and are driven by an intermediate herringbone gear which takes its power from the main drive shaft of the printing equipment on which the invention is installed. This is done in order that the punching done by the apparatus may be continuously and exactly registered in the desired places on the finished printed pages which comprise the webs **164** that are fed through the apparatus. The webs **164** are comprised of pages when they reach the apparatus of the invention in the sense that they are printed and numbered as "pages" by the printing stations which precede the punching apparatus in the conversion of the blank webs. In this particular application they will, following the punching by the apparatus of the invention, be formed, slit, cut, collected or collated, and folded into the more commonly accepted sense of the word "pages," which will in fact then be the pages of a tabloid newspaper. These operations are in such common usage and so well known to those familiar with high speed web newspaper printing presses as to make their explanation and/or description here unnecessary.

An arrangement of automatic controls in the nature of relays, solenoid valves, timing devices, and switches is interlocked with the controls on the printing press on which the invention is installed. This control system is so arranged as to hold the nip **142** between the pad cylinder **27** and punch cylinder **55** open to its widest limit when the press run commences.

The cam **46** (FIGURE 1), control arm **45**, and connected components of the trolley and trolley control apparatus shown in FIGURES 1 and 5, are arranged and adjusted so that as the nip **142** opens when the arm **8** is raised by the air cylinder **122**, the trolley wheels remain engaged in contact with the drag roller **124** until the nip **142** is opened to approximately two-thirds of its maximum limits. At that point in the pad cylinder's travel, the trolley wheels begin to move out of contact with the drag roller **124**, and because of differences in the effective moments in eccentrics **4**, cam **46**, and arm **84**, the trolley wheels move away from the drag roller **124** more rapidly and therefore farther than does the pad cylinder **27** move from the punch cylinder **55** during the remainder of its travel. The net effect of this multiplying linkage is that,

when the nip 142 is fully open, the trolley wheel tires 119 are actually farther from the drag roller 124 than is the pad cylinder 27 from the punch cylinder 55. This action is provided to permit rapid clearing and rethreading of the complete converting apparatus in the event of a high speed web breakage.

When the press run commences, the nip 142 is wide open as described previously. After the initial press adjustments such as those governing ink coverage and registration have been made, and while the press is being brought up to normal operating speed, air is introduced to the opposite or "nip closing" side of cylinder 122, and the nip 142 begins to close. The trolley wheel tires 119 begin at the same time moving rapidly toward the drag roller 124, and when the nip 142 has closed approximately one-third of its total travel, and before the points of the teeth in the punches 56 contact the webs 164, the trolley wheel tires 119 have contacted and will begin to exert pressure upon the webs 164 which are wrapped around the drag roller 124.

The nip 142 continues closing at a rate determined by the adjustment of a needle valve in the exhaust port on the "opening end" of cylinder 122. The closing rate can be controlled in any of a multitude of different ways. The method just described has proved to be convenient in this application.

As can be seen, with the multiplication of forces provided by the linkage between the nip closing eccentrics 4 and the trolley control system, by the time the nip 142 has closed fully the rocker arms 109 have long since reached the limit of their travel, and the spring 81 on the cam 46 side of the wrist pin block 83 has been forced into considerable compression between the wrist pin block 83 and the washer and stop nut 80*a*, 80. This compressive force is converted to torque by the wrist pin block 83 and applied through arm 84 as a moment about the axis of the trolley control shaft 86. This torque is transmitted through shaft 86, and acting through arms 95 and floating nuts 99, it draws shaft 101 downward. Shaft 101, as mentioned previously, is slip-fitted through pressure block 104. Therefore, since rocker arm 109 has reached the limit of its travel, pressure block 104 is for all practical purposes stationary, and when shaft 101 is drawn forcibly downward through pressure block 104, the washer 102 and stop nut 146 transmit considerable compressive force to spring 103. This compressive force is transmitted by pressure blocks 104 to the rocker arms 109, which in turn press the trolley wheels 119 against the webs 164 on drag roller 124 with greater force.

The pressure exerted on the webs 164 by the trollley wheels 119 can be adjusted during operation by the use of hand knobs 100 which control the pressures exerted by the individual trolley wheels. The total pressure exerted by all of the trolley wheels can be increased or decreased by adjusting nuts 80 on the connecting rod 79.

The nip opening 142 is universally adjustable. As a "rule of thumb," the nip opening when punching five webs would, before beginning the press run, be adjusted to clear six thicknesses of the same web material when fully closed against the closed limit stop screw, 3 in the eccentric housing support 1. Before making this adjustment, the operating nip control lug 7 would have been centered and secured between lugs 10 and operating nip adjustment screws 12.

After the press run commences, and the nip 142 has been closed to its tightest limit, as previously preset, the nip opening can be increased or decreased by adjusting the screws 12 and jam nuts 11, which are readily accessible from the top of the apparatus.

A greatly enlarged cross-section of the action of our punch and pad combination is illustrated in FIGURE 6. As shown, the punches have on their cutting edge a complete circle of teeth 155, which are shaped with various tooth forms depending upon the material to be punched, but always with approximately 72 teeth spaced evenly about the circumference of a punch which can be one inch in inside diameter. The teeth are always cut so that the diameter of a circle drawn through the root 154 of the teeth will be roughly 3% to 5% larger than the circle formed by the points 156 of the teeth. The teeth have been determined through extensive experimentation to be most effective when they are shaped in such manner that the depth of the tooth from point to effective root 157 is approximately equal to the total thickness of the web to be punched. In operation it has been found that the root of the tooth 154 must normally penetrate into the pad 28 to a depth equal to at least one and one-half web thicknesses.

As shown in FIGURE 6, the punch 56 is just entering the web for its first punch. The bore of the punch 158 is open. The punch continues to roll in contact with the pad, penetrating the web, punching the hole, and removing the waste punch-outs 159, as illustrated in FIGURE 6A. While this action is seemingly very simple, it is not a complete cutting action in the strict sense of the word, and neither is it a tearing, shearing, or blanking action. Rather, the action of the punch is a complex combination of pin-point perforation followed by shearing to a depth where, in each web, the minuscule tabs which, at that instant in space and time when the foot of the tooth has penetrated to a point roughly approximate to 160 in FIGURE 6, that is, about half-way thru the web, the minuscule tabs which continue to connect the waste punch-out 159 to the main body of the web 164 do not have sufficient strength to resist the ripping and tearing pressure being exerted by the pad 28.

Because the effective outside diameter of the waste punch-outs 159 is equal to the root diameter of the punches, and larger than the bore 158 of the punches (due to curvature of the cylinder), an action occurs during the punching in which the waste punch-outs 159 are packed against each other quite solidly into the bore 158 of the punch 56. This packing action continues to repeat itself with each succeeding revolution of the punch and pad cylinders 27, 55 until the bore of the punch 158, and the bore behind it in the punch holder body, spacer, boss, and hollow journal, collectively designated "waste disposal passage" 71 (FIGURE 1) is packed full of waste punch-outs and continues packing. An action is then initiated in which, as each succeeding layer of five, or whatever number of waste punch-outs 159 is punched and packed into the mouth of the bore 158 in the punch, the waste punch-outs in the disposal passage 71 advance toward the hollow journal a distance equivalent to the thickness of the total just punched, and an equivalent number of waste punch-outs are discharged from the disposal passage and into the bore 70 of the punch cylinder's hollow journal 54.

It is worthy of emphasis to note that, during punching, pad 28 is pierced by the teeth of punch 56, but this does not result in any permanent circular groove in the pad. Rather, there appears a hair-line crack where each tooth penetrates the pad, the resiliency of the pad material acting to effectively open and close as the punch goes in and out. This results in a "wiping" action which is believed to be responsible, at least in part, for the greatly improved punching of which the present invention is capable.

As shown in FIGURE 1, rotary union 48 is screwed and secured into the journal end plug 49. Compressed air, in pressures which vary from low for light web materials to high for heavy web materials, is introduced into the bore 70 through this rotary union and end plug. The air flows through the hollow bore from the end plug 49 to the elbow 75 and through the bore 77 of elbow 75, pushing the waste punch-outs 159 along with it, and out through the waste disposal elbow to a suitable container. Elbow 75 is connected to the hollow bore through a suitable mounting flange 76. In flowing through bore 70, it is to be noted that the air reduces the pressure in disposal

passage **71** by a Venturi effect, with the result that air will not blow out of disposal passage **71** even when it is empty of punch-outs **159**.

The web is thus punched, the waste punch-outs are collected, and the waste punch-outs are neatly and efficiently carried through the side frames of the apparatus in waste disposal elbow **75**.

It is to be understood that various changes in the details, materials, steps and arrangements of parts, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

Having thus described the subject matter of the invention, what it is desired to secure by Letters Patent is:

1. Device for simultaneously punching a plurality of flexible moving webs that comprises,

a rotatable punching cylinder;

a rotatable pad cylinder in spaced parallel relationship to said punching cylinder;

hollow punch means the inner surface of which define a passage therethrough and having a toothed cutting edge, said punch means being radially mounted in said punching cylinder with said cutting edge extending beyond the surface thereof;

resilient pad means mounted in said pad cylinder and located therein so as to be directly exposed to said punching cylinder only near and at the point of closest approach between said pad means and said punch means, the surface of said pad means being flush with the surface of said pad cylinder;

means capable of controlling the spaced relation between said cylinders to a distance slightly in excess of the thickness of said webs during operation of said device;

the extension of said cutting edge beyond the surface of said punching cylinder being such as to penetrate said pad means at the point of closest approach between said cylinders;

means capable of removing punch-outs through the passage in said punch means;

drive means capable of rotating said cylinders at a predetermined speed; and

means capable of transporting webs under a predetermined tension between said cylinders at the point of closest approach therebetween and in a direction

normal to the centerline between the axes of said punching cylinder and said pad cylinder.

2. The devices as claimed in claim **1**, wherein said punch means comprise a hollow cylinder, the outer surface of said toothed cutting edge is beveled, the inside diameter of said cylinder is slightly larger at the root of the teeth of said cutting edge than at the points of said teeth, and the depth of said teeth is at least equal to the thickness of the webs to be punched.

3. The device as claimed in claim **1**, wherein a plurality of said punch means and a plurality of said pad means are mounted in said respective cylinders.

4. The device as claimed in claim **1**, wherein said controlling means are actuated through an eccentric mounting on one of said cylinders.

5. The device as claimed in claim **1**, wherein said punch-out removing means comprise hollow journal means located about the axis of said punching cylinder and connecting with the passage in said punch means, and means capable of creating a flowing stream of gas through said hollow journal, whereby punch-outs entering said journal from said passages are removed from the device.

6. The device as claimed in claim **1**, wherein said web transporting means comprise in part a drag roller and tensioning wheels between which said webs pass prior to passing between said punching and pad cylinders.

7. The device as claimed in claim **1**, wherein said pad means are made of a polyurethane material.

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