United States Patent [19]

Dahlgren

[11] **3,847,079**

[45] **Nov. 12, 1974**

[54] **METHOD OF PRINTING SHEETS**

[76] Inventor: **Harold P. Dahlgren,** 726 Regal Row, Dallas, Tex. 75247

[22] Filed: **Sept. 10, 1973**

[21] Appl. No.: **395,808**

Related U.S. Application Data

[63] Continuation of Ser. No. 250,143, May 4, 1972, abandoned, which is a continuation-in-part of Ser. No. 737,521, June 17, 1968, Pat. No. 3,664,261.

[52] **U.S. Cl.** **101/426,** 101/174, 101/216, 101/232

[51] **Int. Cl.** **B41f 5/08**

[58] **Field of Search** 101/183–184, 101/174–177, 136, 216–218, 146–148, 231–234; 271/79, 82, 50

[56] **References Cited**

UNITED STATES PATENTS

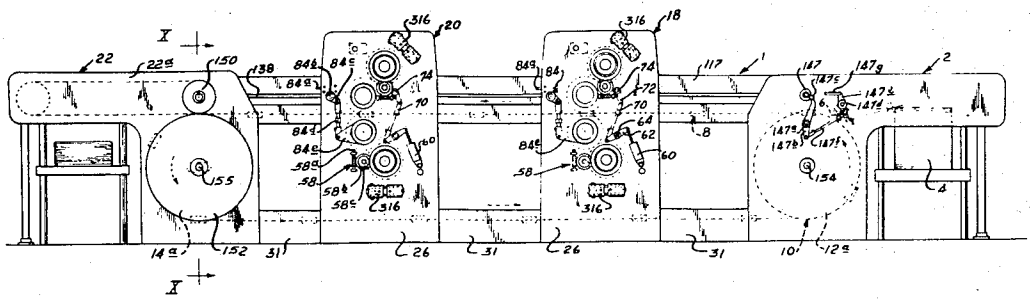
522,128	6/1894	Toye	101/183
534,298	2/1895	Toye	101/184
2,366,335	1/1945	Hucks	101/137
2,551,060	5/1951	Simmons	101/232
2,753,798	7/1956	Babst	101/232
2,794,390	6/1957	Burke	101/232
2,911,907	11/1959	Davidson	101/137
3,422,757	1/1969	Grabman et al.	101/232

Primary Examiner—Robert E. Pulfrey
Assistant Examiner—Edward M. Coven
Attorney, Agent, or Firm—Howard E. Moore; Gerald G. Crutsinger

[57] **ABSTRACT**

A method of printing in which sheets are aerodynamically supported and directed along a path having no abrupt changes in direction to and through individually driven and mechanically synchronized multi-color perfecting towers while the sheet is continuously gripped and moved by a single set of grippers so that only printing cylinders touch the sheet, eliminating sheet transfer between the time the sheet leaves the feeder and the time it reaches the delivery. The sheet and printing cylinders are maintained in a constantly registered condition as the sheet is moved from the feeder to the delivery.

5 Claims, 34 Drawing Figures



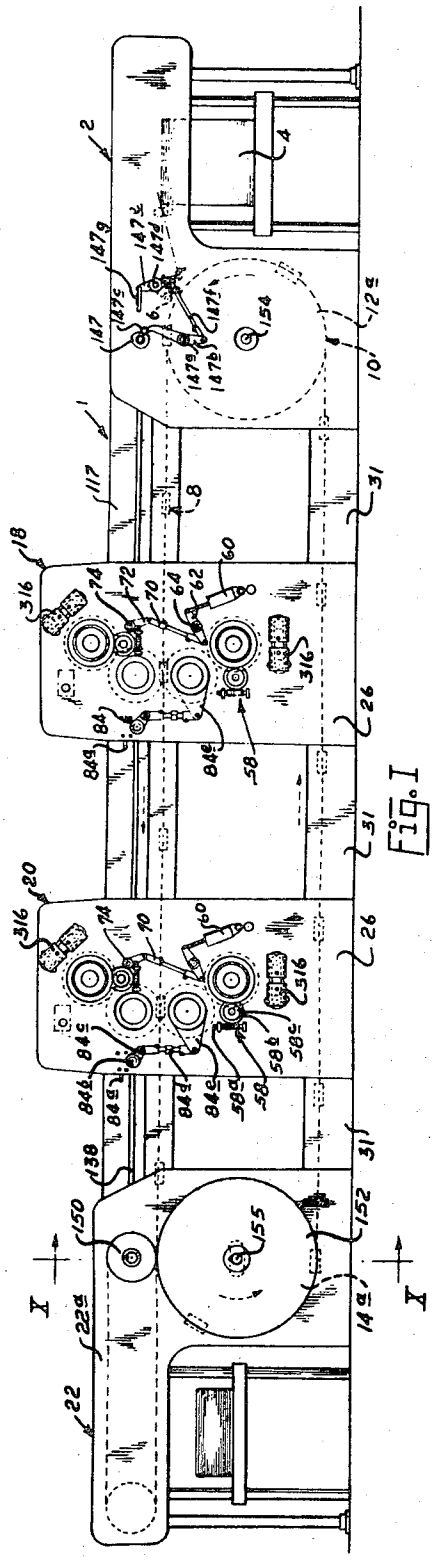


Fig. I

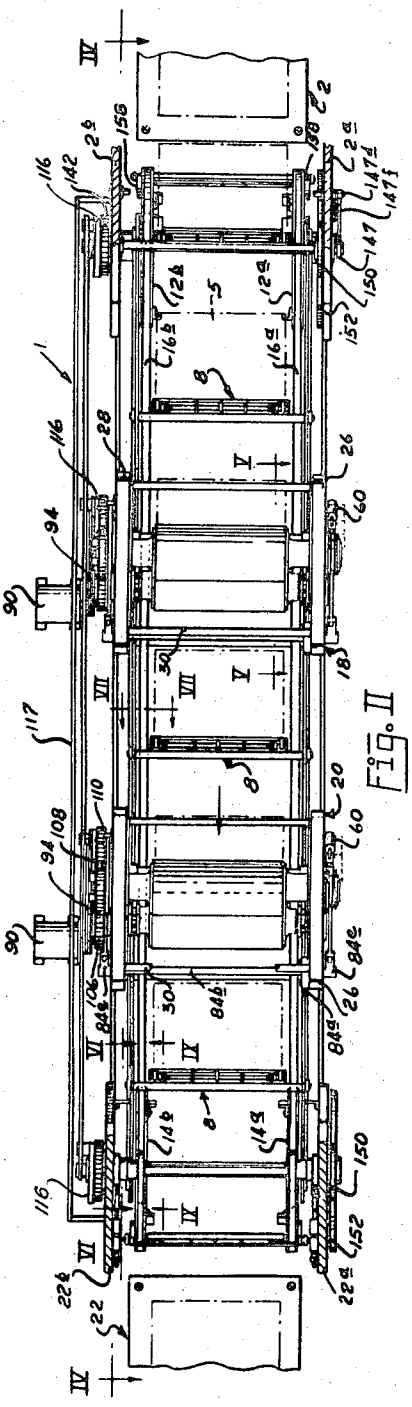


Fig. II

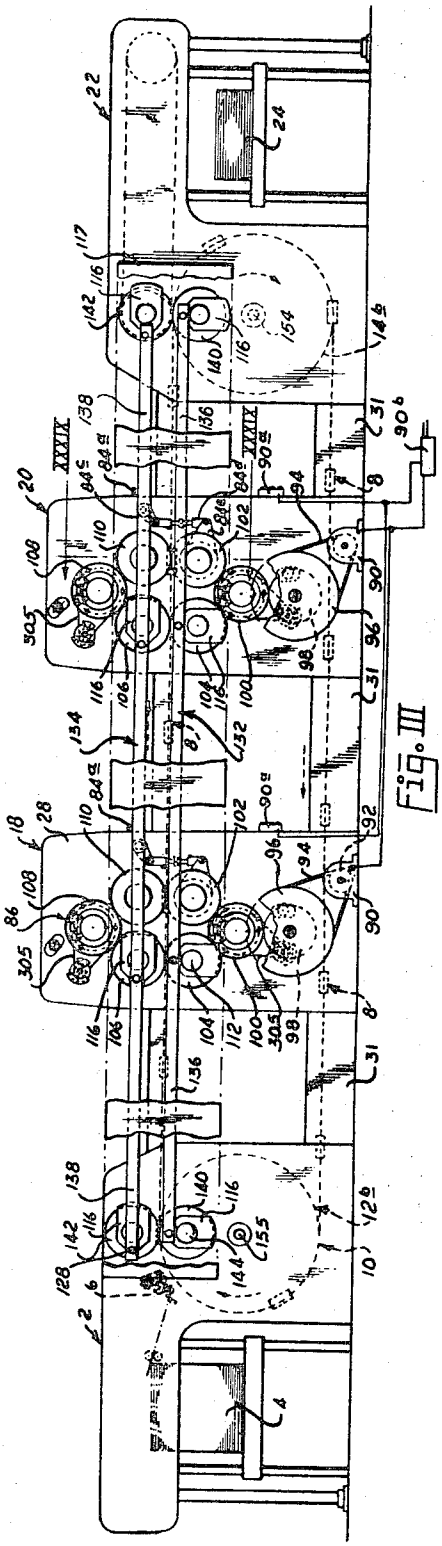


Fig. III

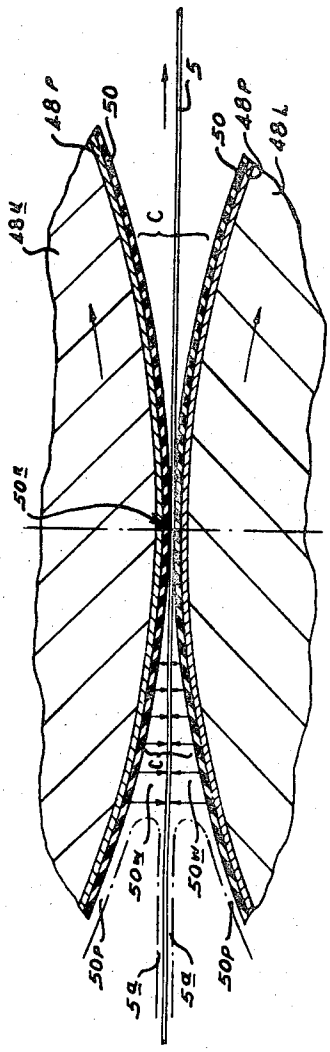


Fig. XX

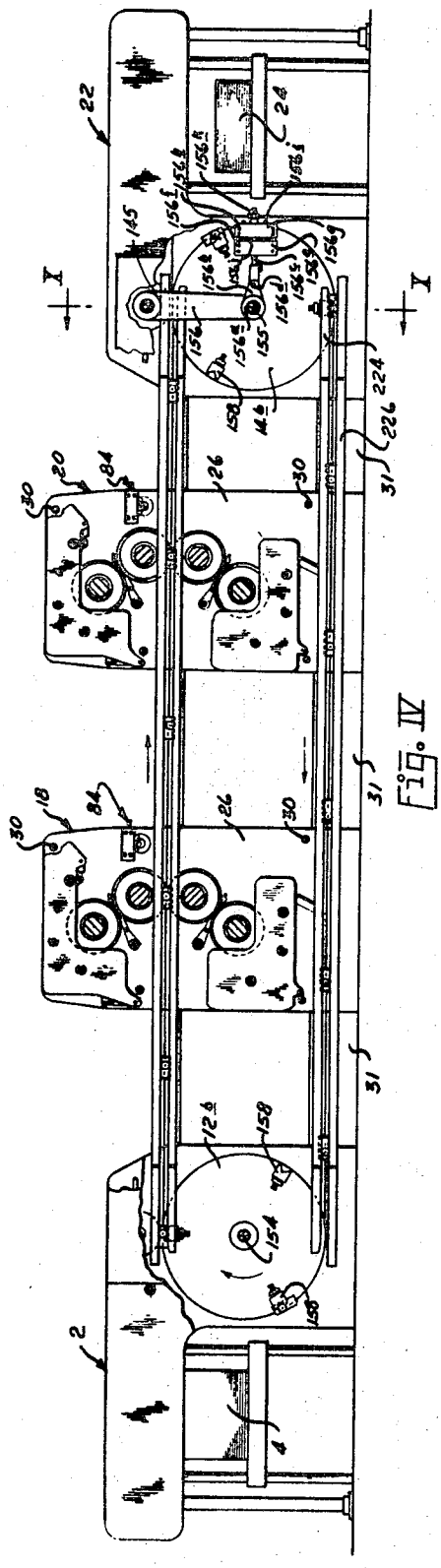


Fig. IV

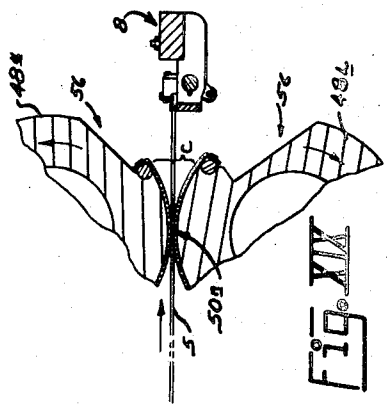


Fig. XIX

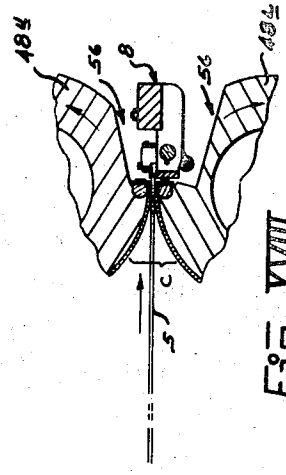


Fig. XVIII

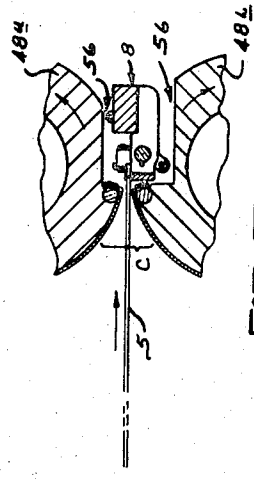


Fig. XVII

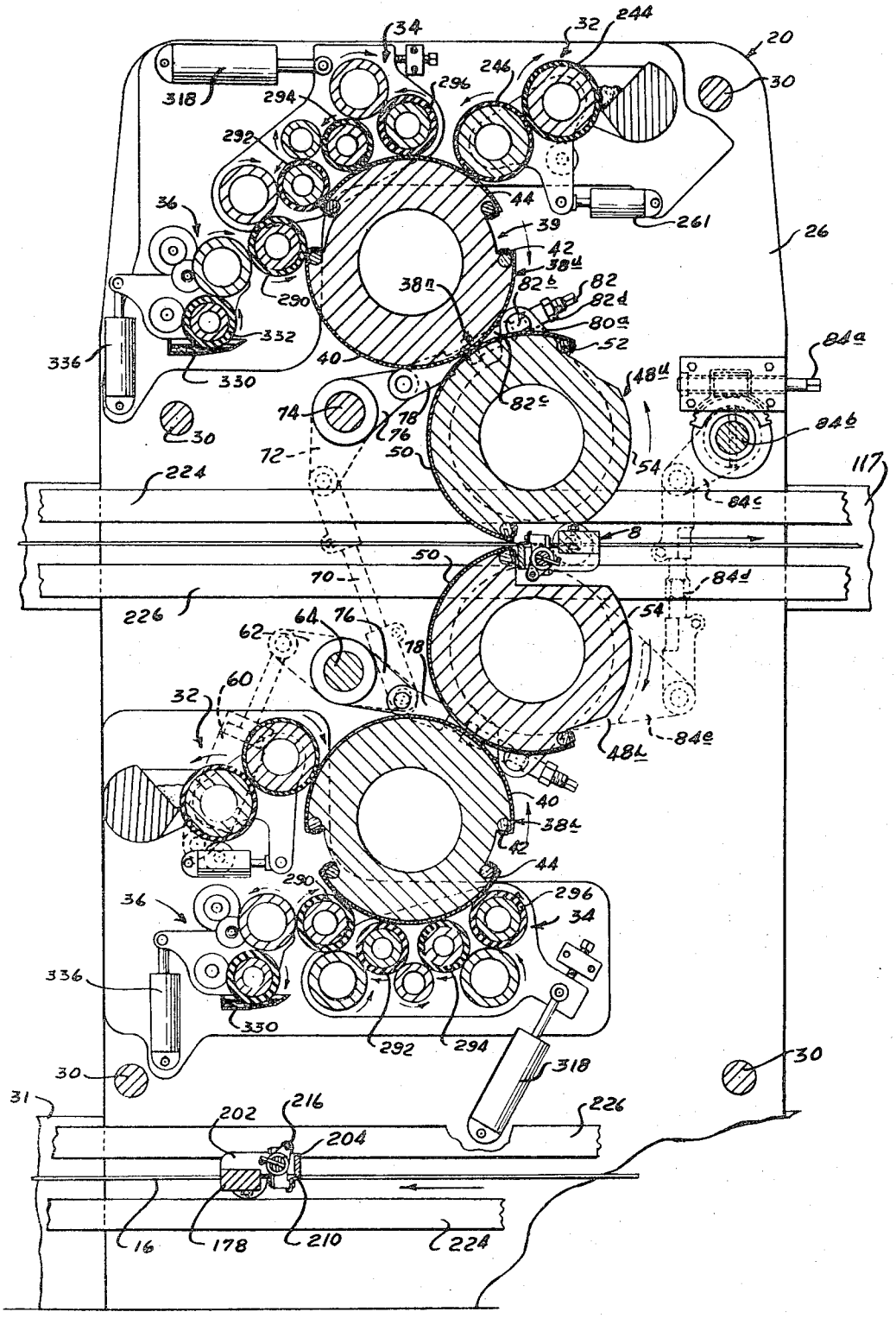

34
32
244
20
318
294
296
246
30
292
36
44
261
39
26
42
38u
38n
82b
82
82d
290
80a
332
52
84a
336
40
48u
330
74
78
82c
84b
30
76
72
50
54
117
224
84c
8
50
84d
70
226
54
62
64
76
78
60
32
84e
48L
40
38L
42
44
290
296
36
34
336
330
292
294
318
30
30
31
202
216
226
204
16
178
210
224

Fig. V

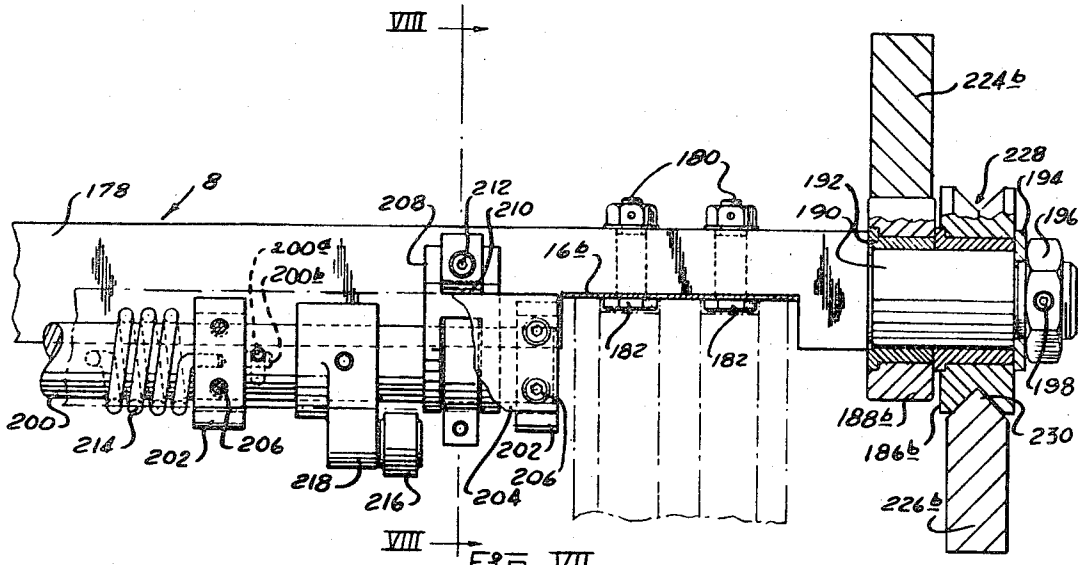


Fig. VII

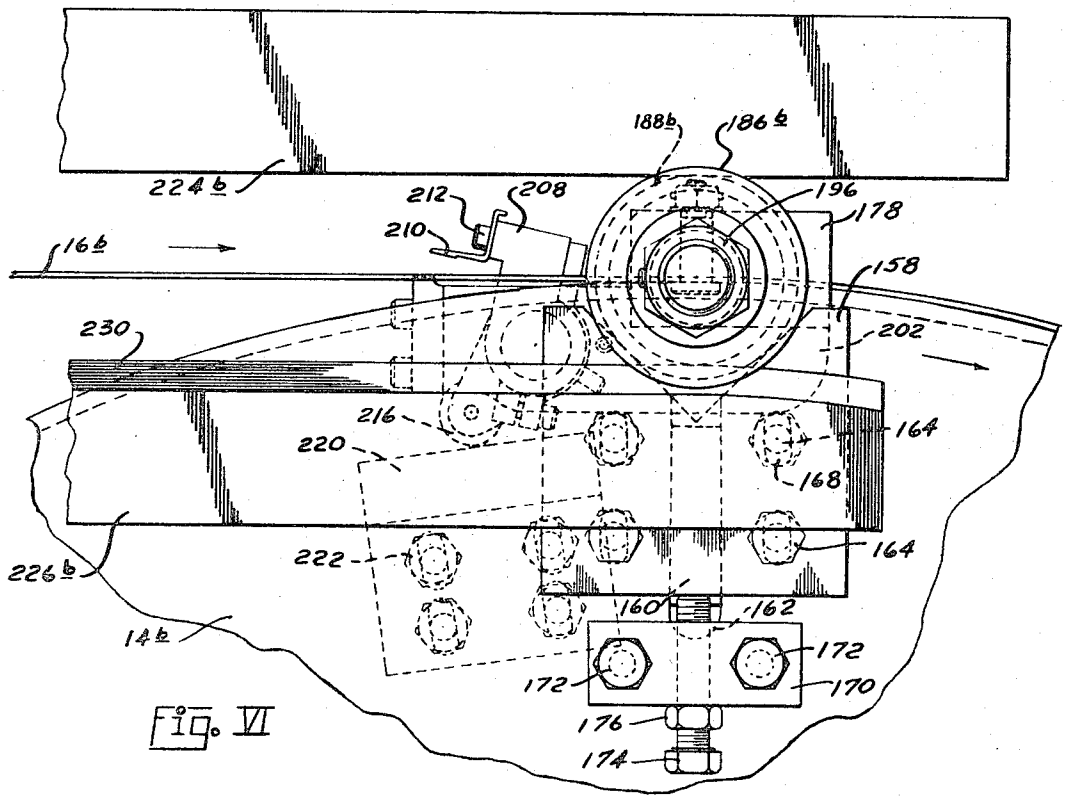


Fig. VI

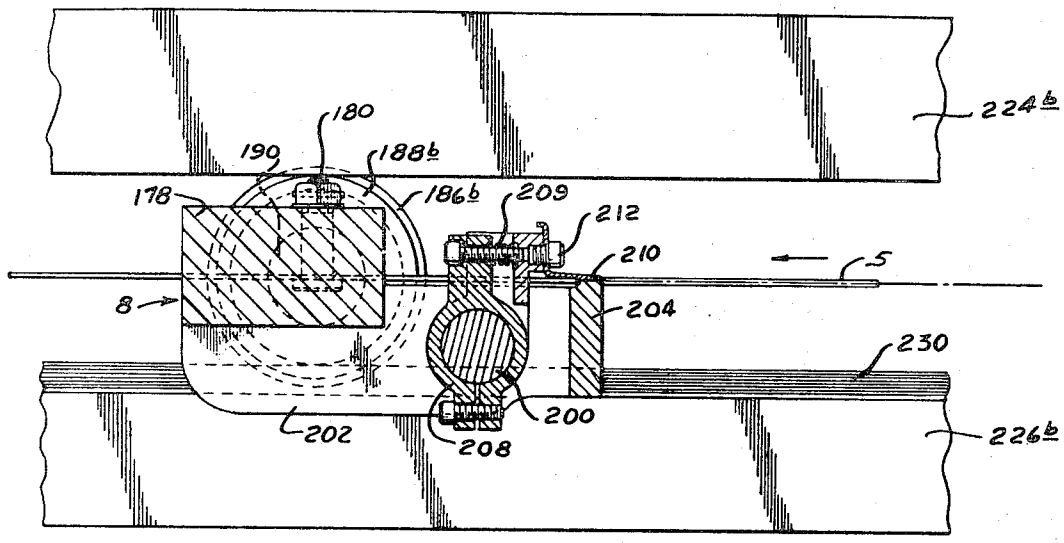


Fig. VIII

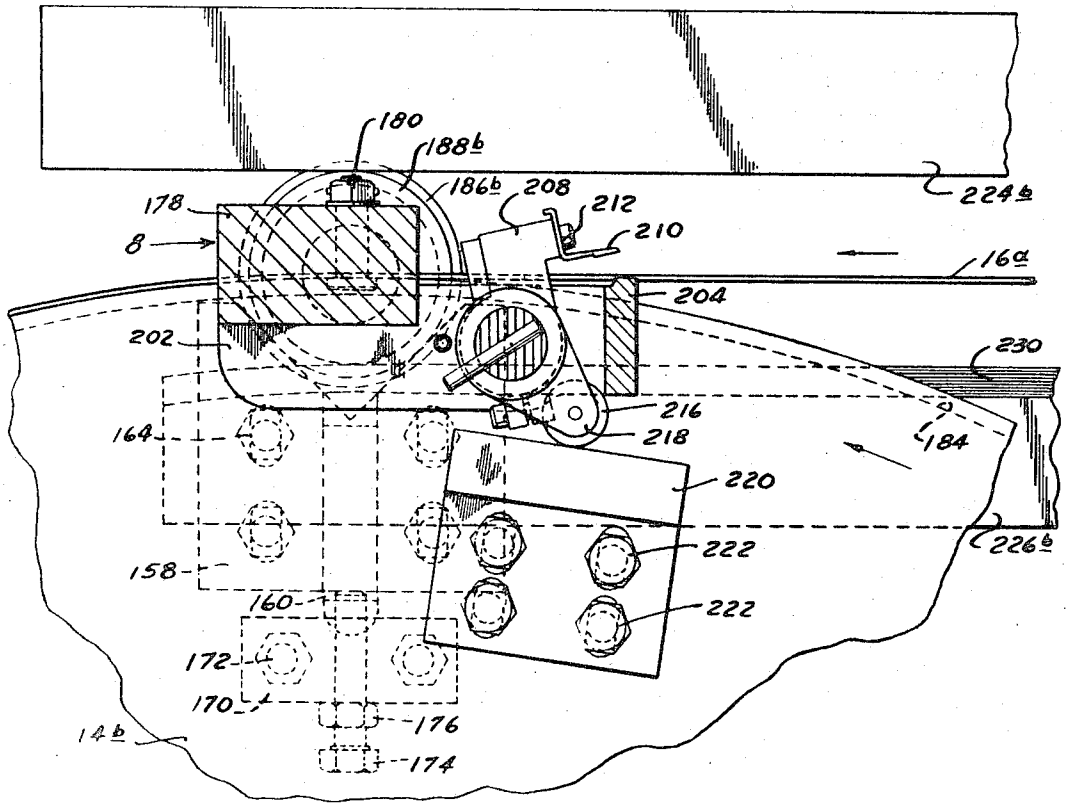


Fig. IX

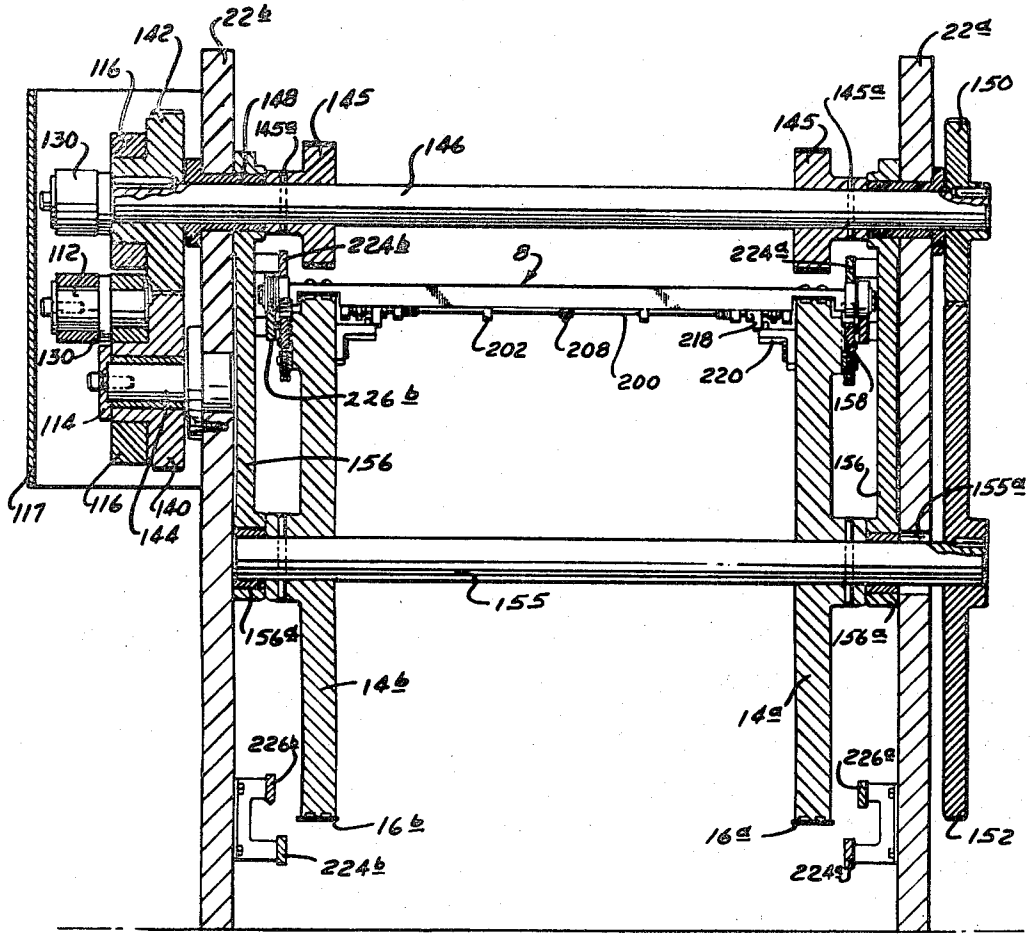


Fig. X

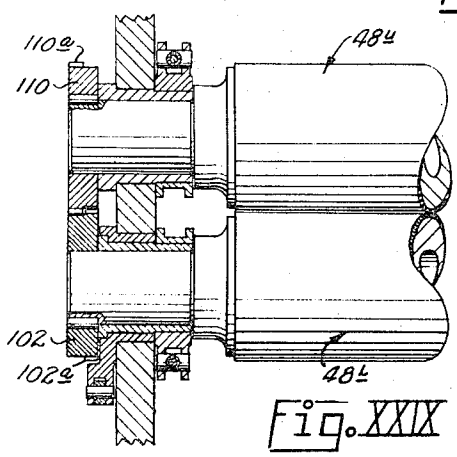


Fig. XXIX

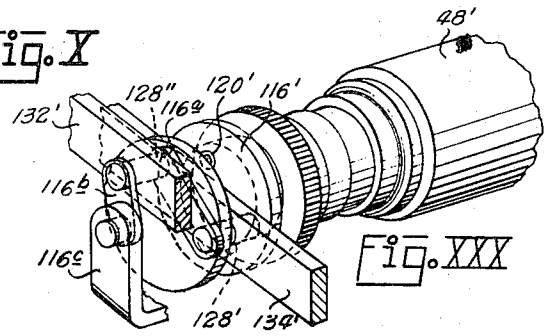


Fig. XXX

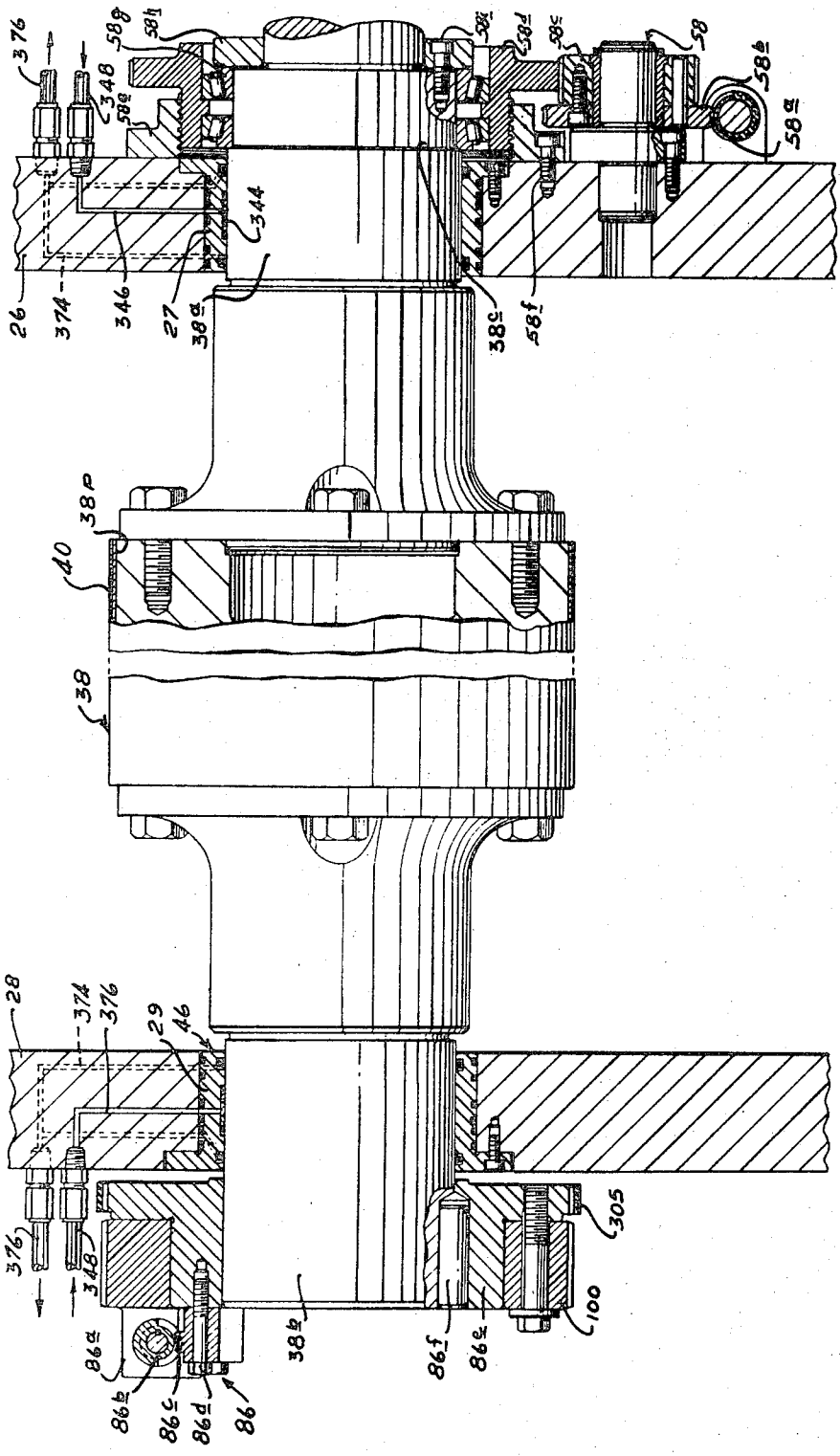

376
348
58g
58h
58
58a
344
346
374
26
27
38a
38c
58f
38p
40
38
28
29
46
305
100
86a
86b
86c
86d
86
38b
86f
86e

Fig. XI

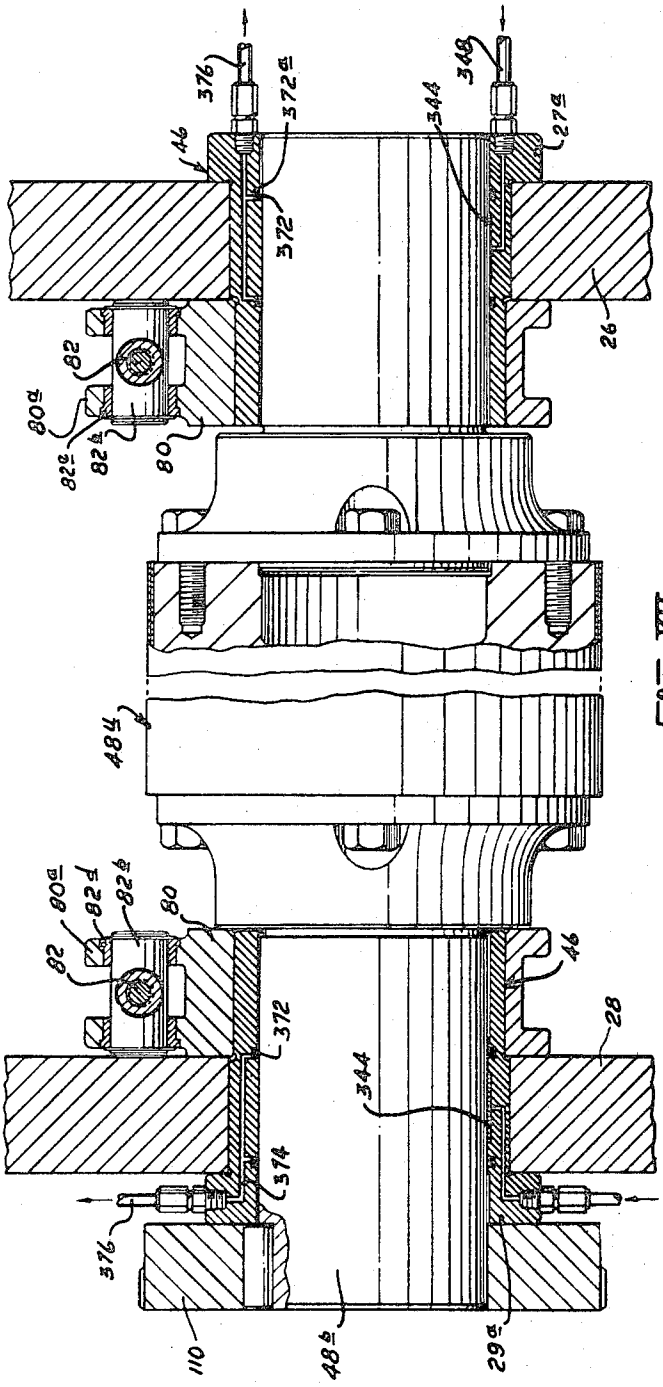


Fig. XII

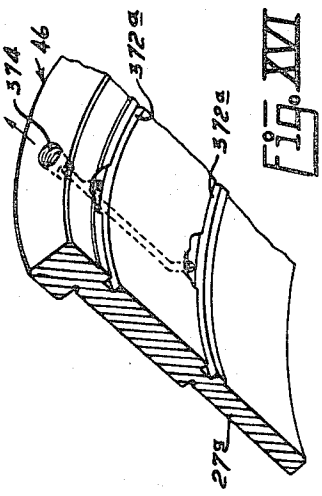


Fig. XVI

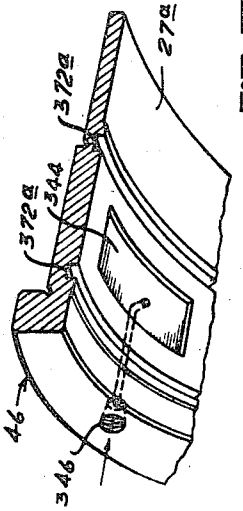


Fig. XV

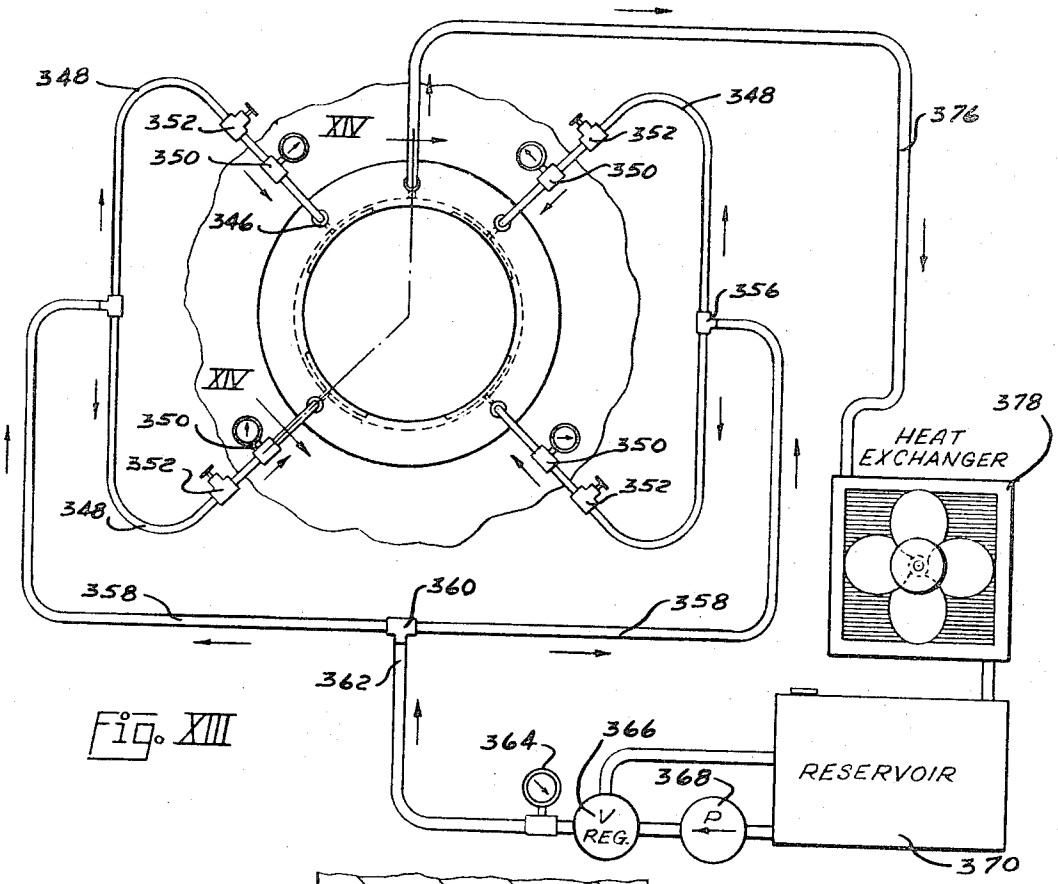


Fig. XIII

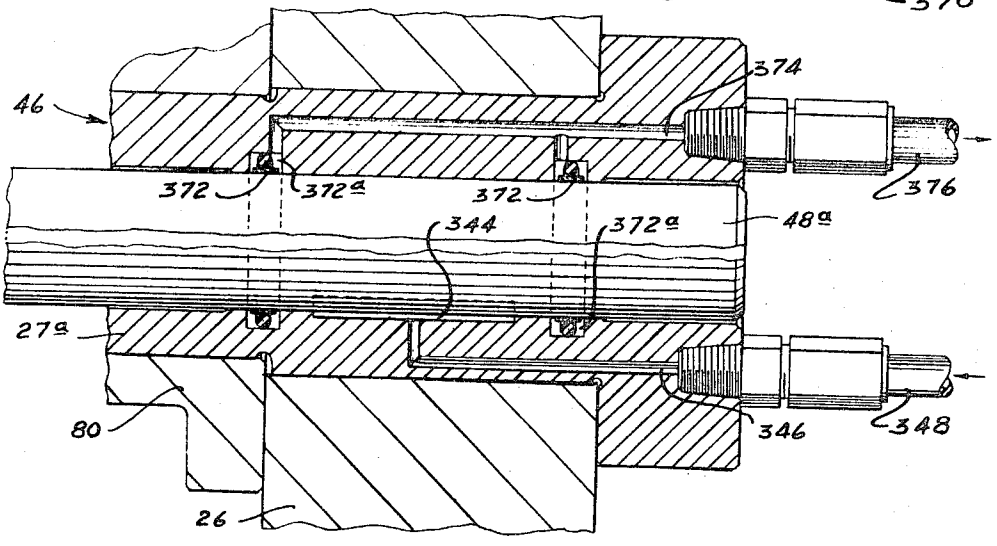


Fig. XIV

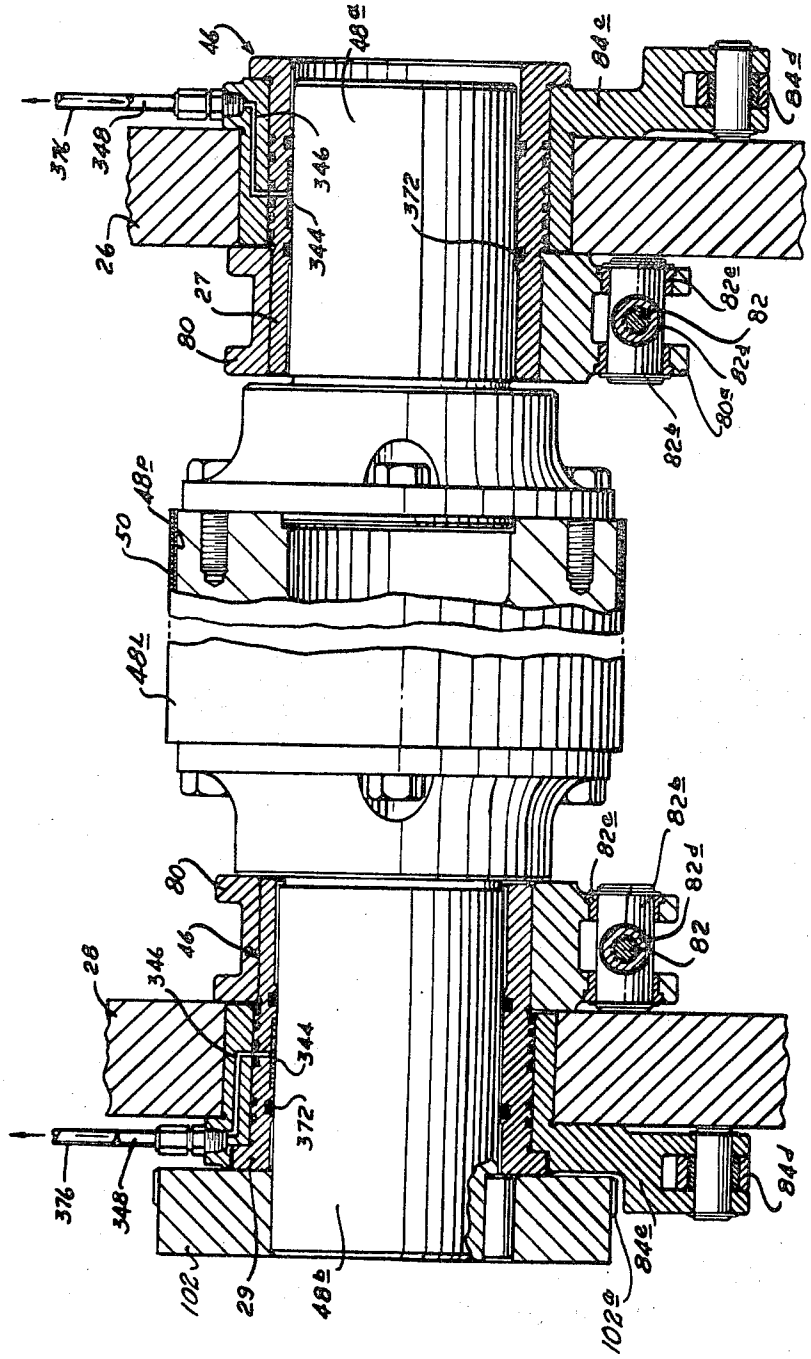

46
48a
84c
84d
37b
34b
26
346
344
372
27
80
82e
82
82d
82b
80a
48c
50
48L
82c
82b
82d
82
80
28
46
346
344
372
376
348
102
29
48b
84e
84d
102a

Fig. XII

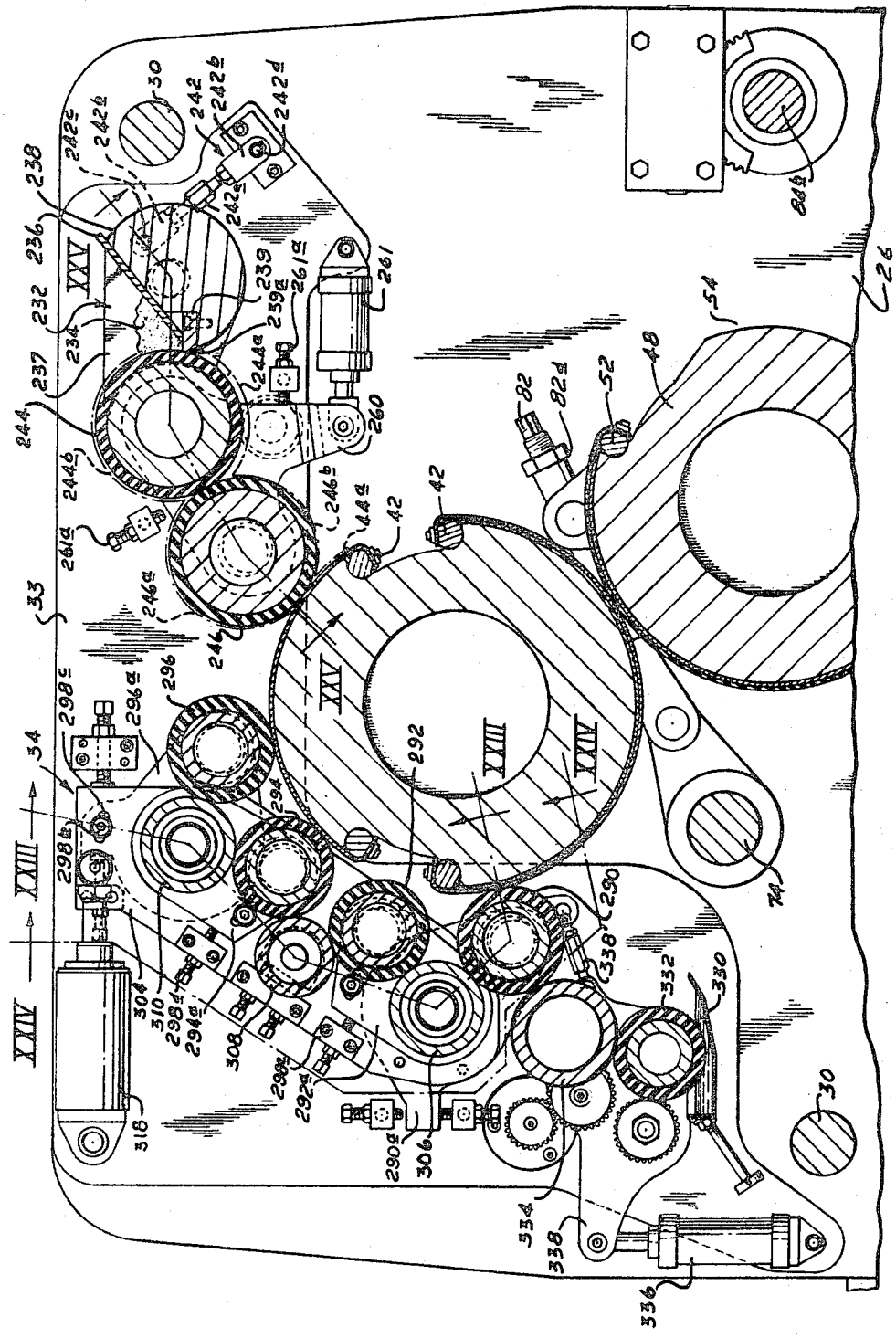

XXV
XXIII
XXIV
XXV
XXIII
XXIV
30
242
242b
242c
242d
242e
238
236
232
234
237
244
239
239a
261a
261
244a
260
246b
246a
246
42
82
82a
52
48
54
26
33
34
296
296a
298c
298b
298a
294
292
290
74
304
310
308
294a
294c
298d
292a
290a
306
318
332
330
334
338
336
30

FIG. XII

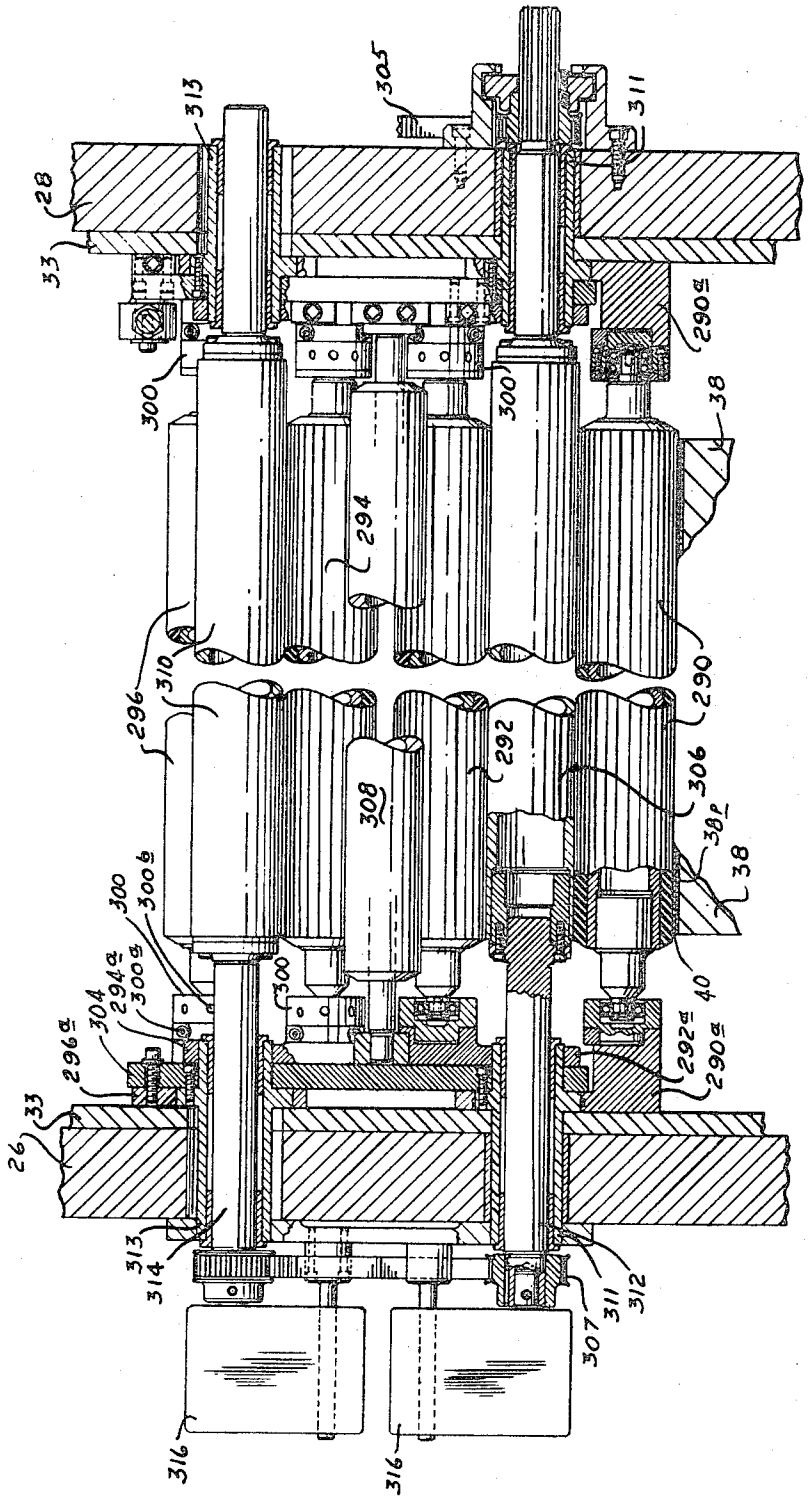


Fig. XXV

Fig. XXIII

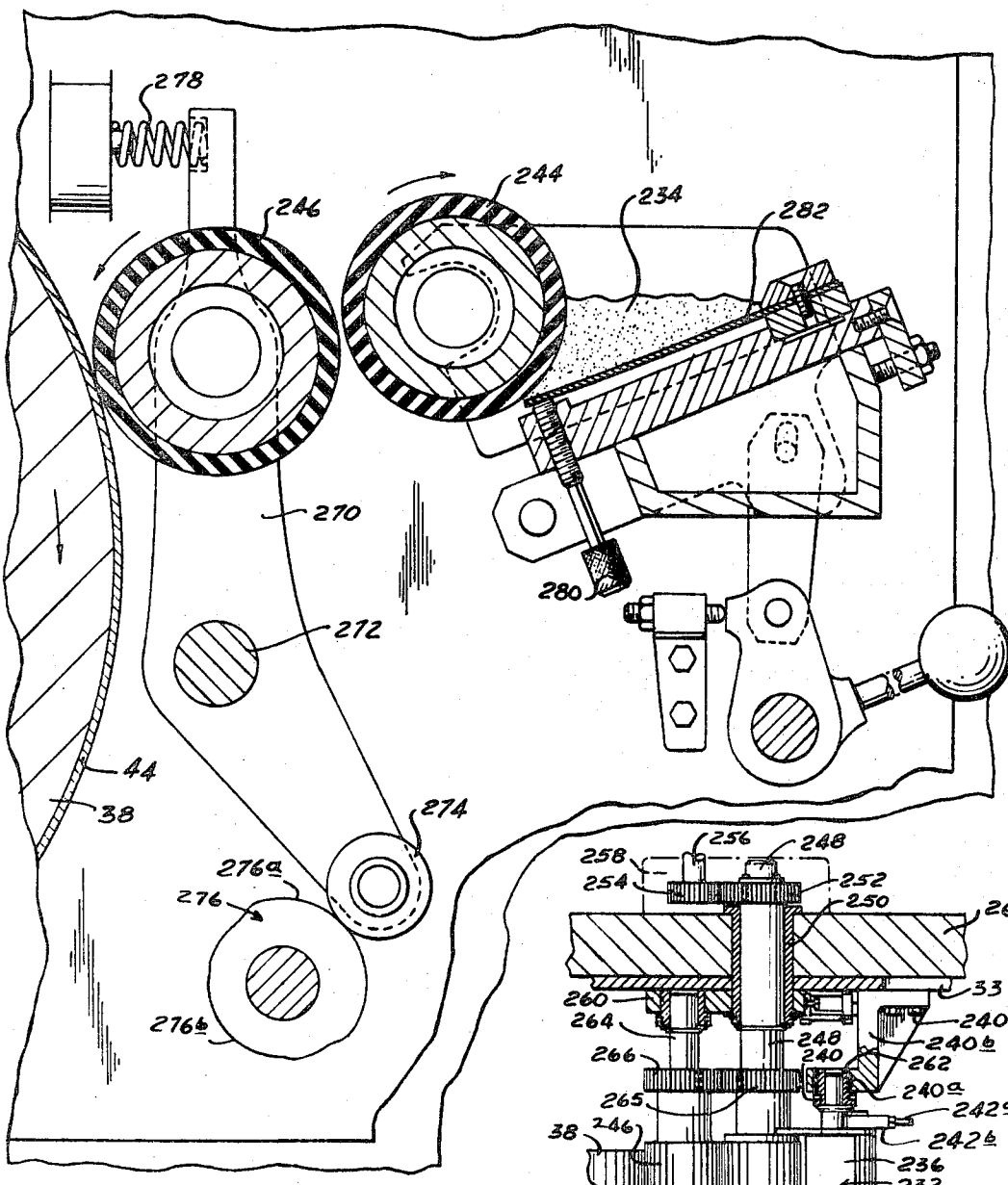


Fig. XXVI

Fig. XXV

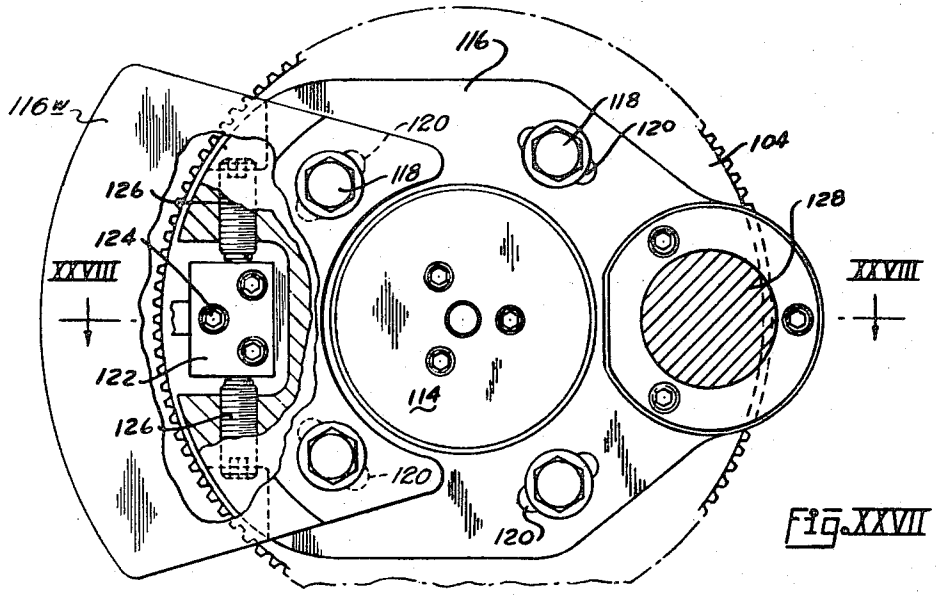


Fig. XXVII

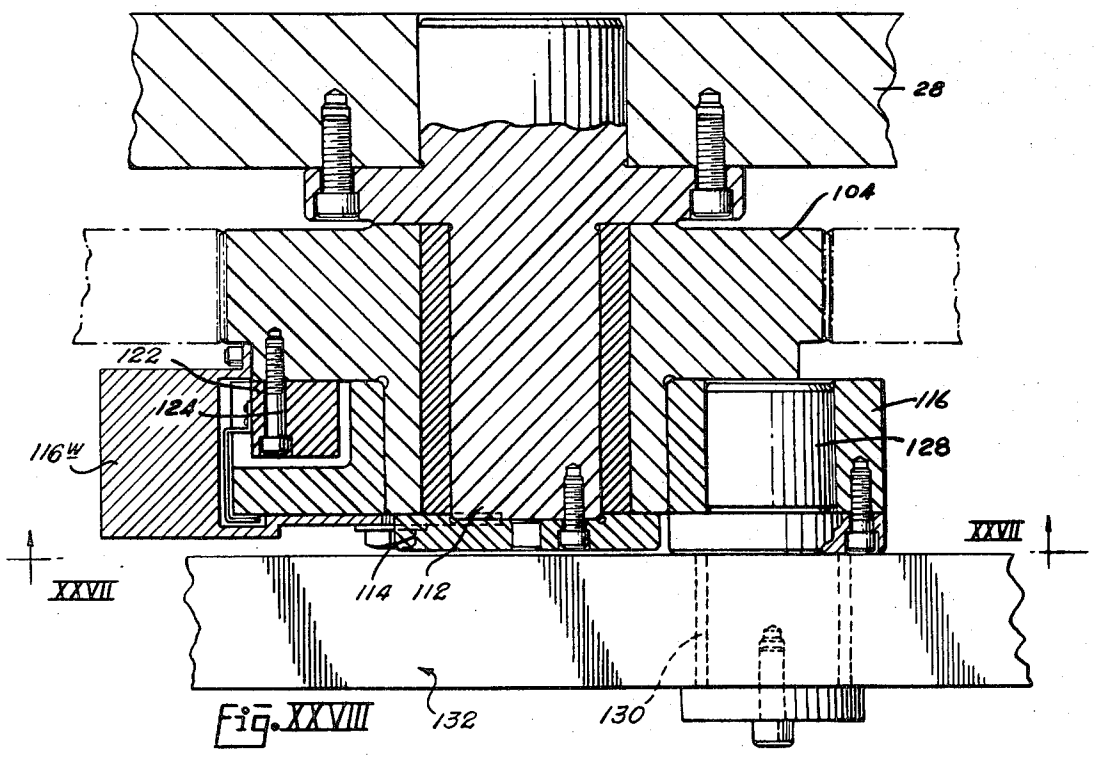


Fig. XXVIII

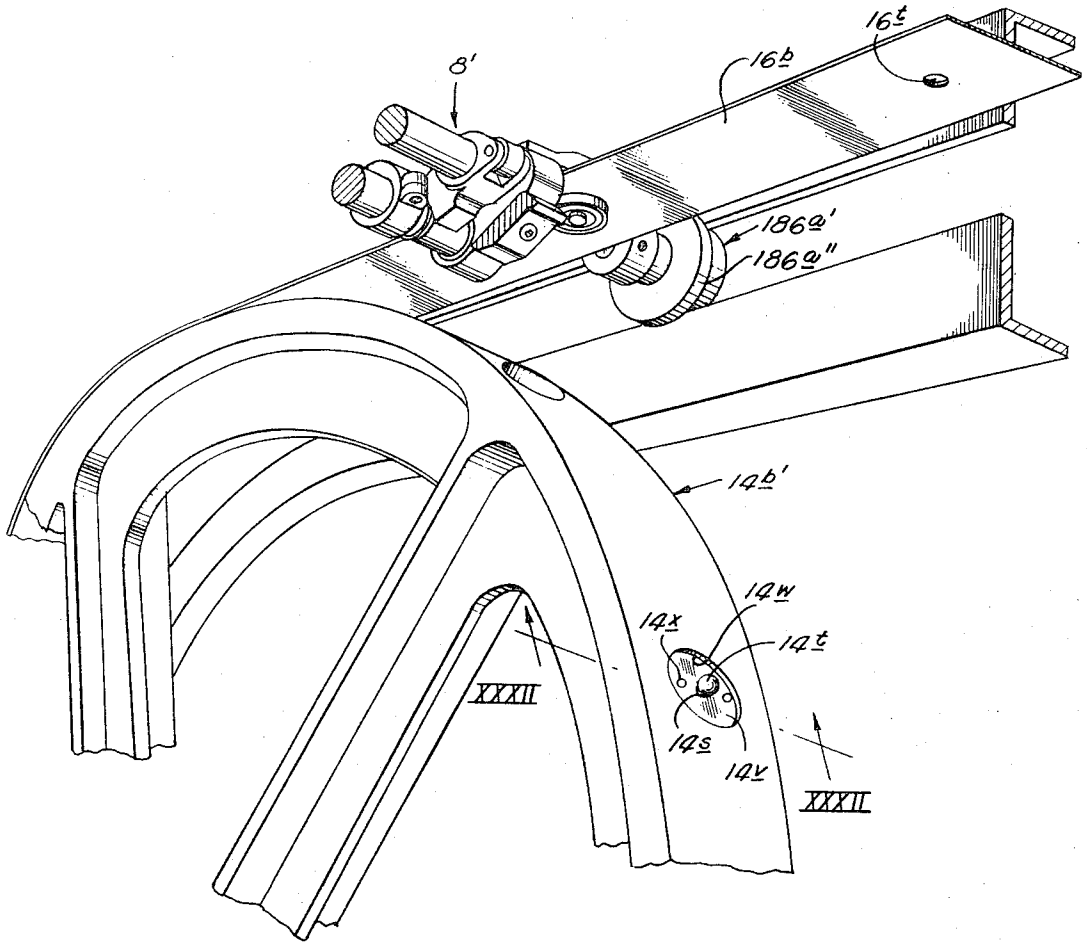


Fig. XXXI

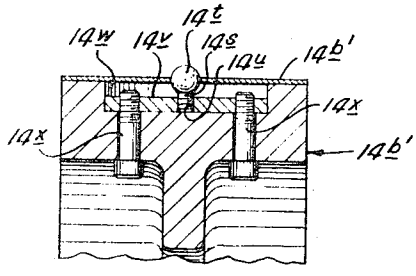


Fig. XXXII

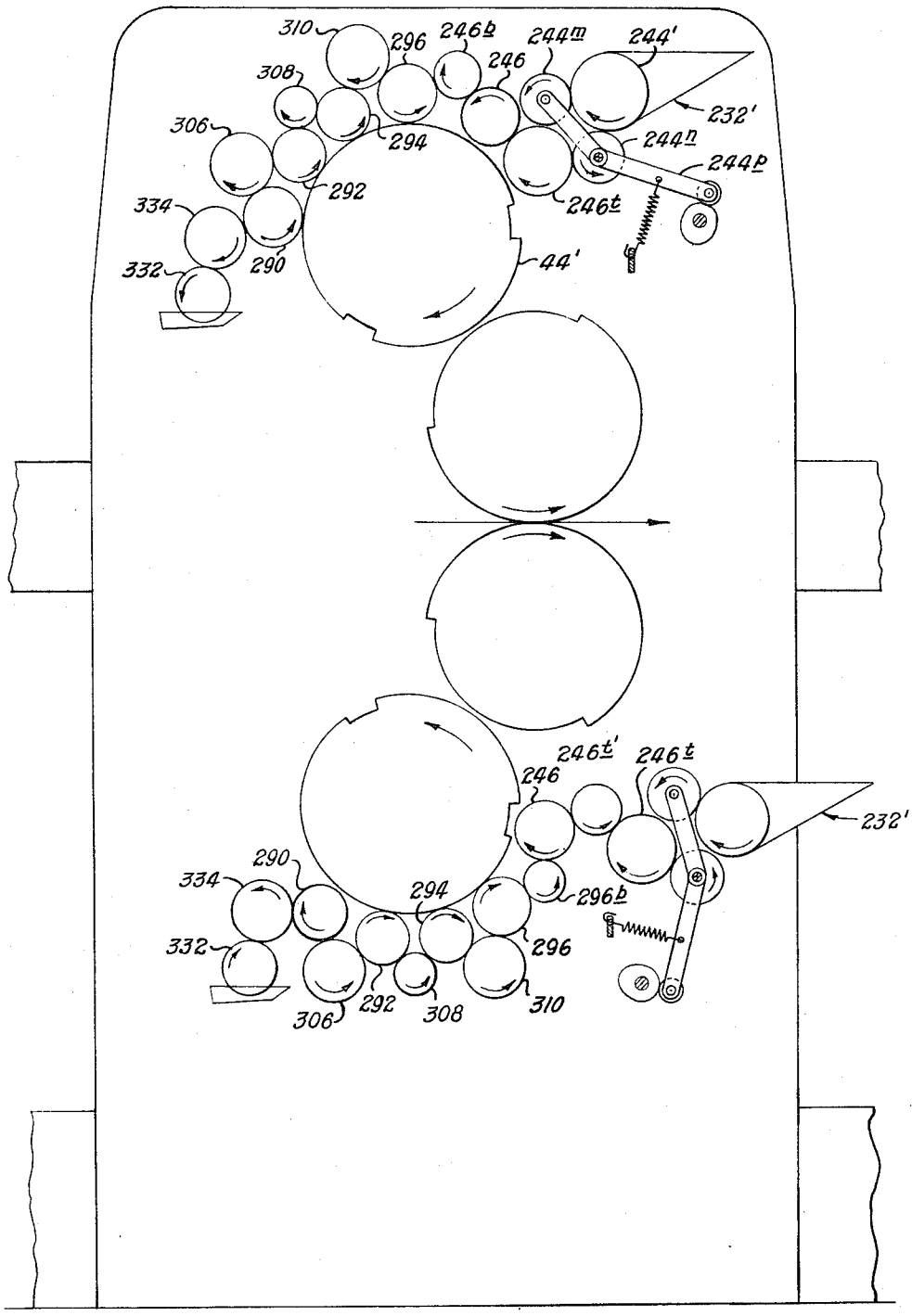

310
296
246b
244m
244'
308
246
232'
306
294
244n
244p
292
246t
334
44'
290
332
246t'
246t
246
232'
290
334
294
296b
296
332
292
308
310
306

Fig. XXXIII

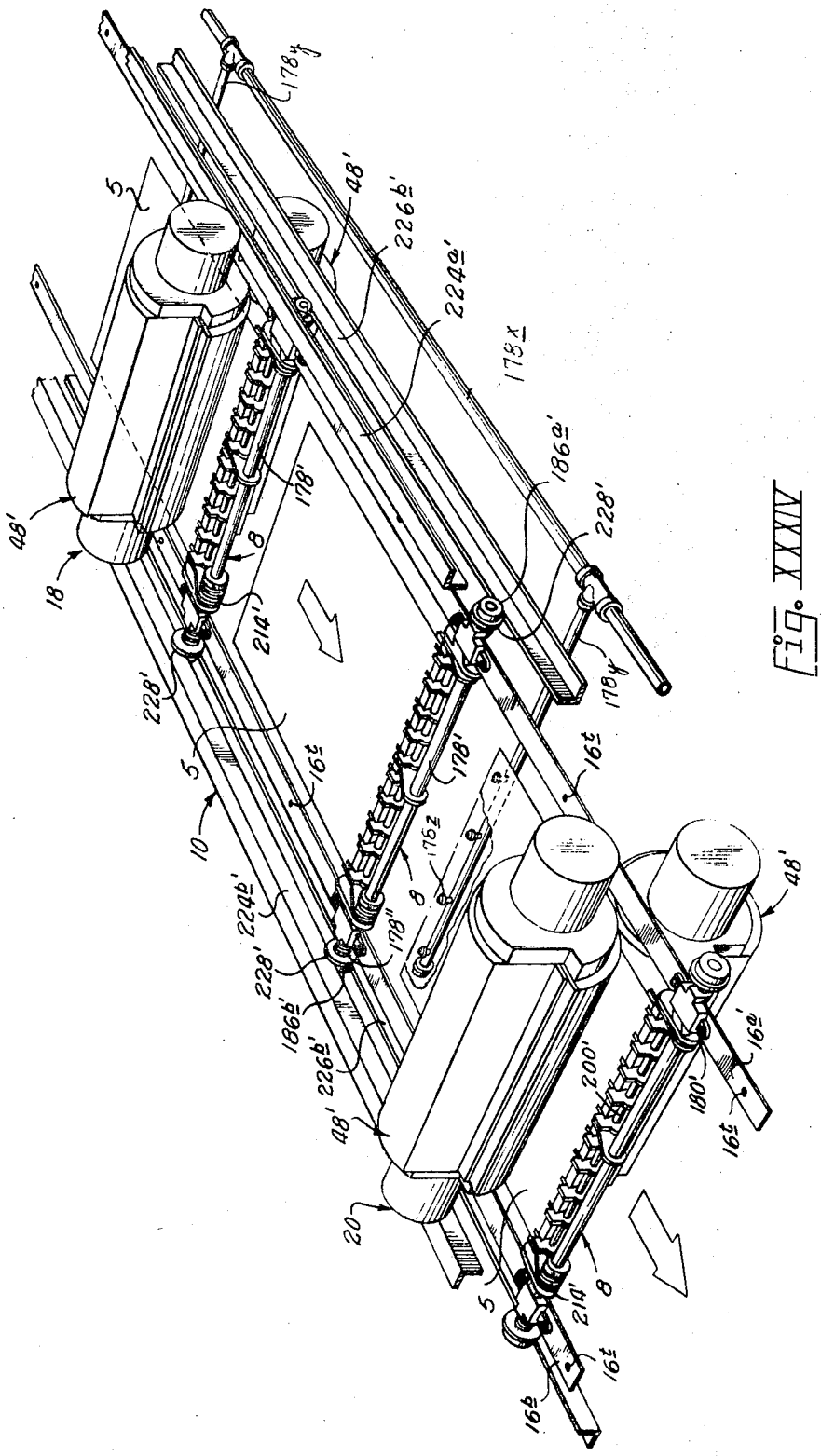

178y
48'
226b'
224a'
175x
186a'
228'
178'
214'
8
5
18
16c'
16b'
16a'
10
224a'
228'
186b'
226b'
175z
178"
48'
200'
180'
20

FIG. XXIV

METHOD OF PRINTING SHEETS

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation of application Ser. No. 250,143, filed May 4, 1972 now abandoned which was a continuation-in-part of my co-pending Application Ser. No. 737,521, filed June 17, 1968, entitled STRAIGHT FEED PRESS, now U.S. Pat. No. 3,664,261.

BACKGROUND OF THE INVENTION

No significant advances have been made presenting new concepts in sheet-fed printing systems for decades. Printing systems designed for the sheet-fed printer are basically the same and allow printing on one side of the sheet at a time, requiring sheets to be turned over and rerouted through the press for single or multi-color perfecting. Sheets are progressively and meticulously transferred in serpentine fashion about transfer and impression cylinders and hopefully registered from one cylinder to another and from one printing unit to another until finally they emerge as a printed product. Printing units must be synchronized for color register through numerous drive and idler gears and consequently presses are extremely complex, massive units which are very expensive to manufacture because of numerous transfer and printing cylinders and mechanisms related thereto.

One or two color sheet-fed perfectors have been developed heretofore. However, these machines were specifically designed for specific jobs, such as mass production of paperback books, and are totally unsuitable for high speed production of four folor process printing on both sides of the paper.

Heretofore no commerically successful sheet-fed press had the capability of printing on two sides of a sheet in as many as four colors by passing the paper through the press one time.

It is the common and accepted practice in the printing industry to run a sheet to be printed through the sheet-fed press a multiplicity of times to attain multicolor printing on two sides of a sheet. After each pass of the sheet through the press, the plates must be changed and the press made ready for the next pass to apply other colors or to print on the back of the sheet. It is readily apparent to those skilled in the printing art that a considerable amount of time is spent making sheet-fed presses ready to print and in attaining proper registry of the numerous components of the press.

In a typical four-color one-side printing press a sheet delivered from the feeder is caught by the gripper bars of a first transfer cylinder. The sheet is folded around the transfer cylinder and carried to the grippers on the first impression cylinder where the grippers of the transfer cylinder release the paper and it is caught by the grippers of the impression cylinder. The grippers on the impression cylinder rotate the paper into contact with thh blanket cylinder where printing is accomplished in one color on one side of the sheet. When the grippers on the impression cylinder release the sheet, grippers on a second transfer cylinder grasp the sheet, causing the printed surface to be in contact with the transfer cylinder while it is rotated to the grippers of a second impression cylinder. The grippers of the second transfer cylinder release the sheet as it is caught by the grippers of the second impression cylinder which rotates the sheet into contact with a second blanket where a second color is applied to the same side of the sheet. Grippers on a third transfer roller catch the sheet as it is released by the grippers of the second impression cylinder and the printed surface is again brought into contact with a transfer cylinder while it is being delivered to the grippers of a third impression cylinder. This process is continued until the sheet passes to delivery. When one side of the sheet is completed, the press is replated the sheets are turned and re-fed through the press to print the other side of the sheet.

Virtually all sheet-fed printing presses heretofore developed have the characteristic of feeding the sheet serpentine fashion through the press while the grippers associated with each cylinder catch the sheet as it is being released by the grippers of the previous cylinder.

One of the major problems encountered by the printing industry lies in synchronizing the various cylinders whereby the sheet will be grasped and released at the proper moment for maintaining registry between the cylinders of successive towers so that colors do not overlap or separate.

Chains have been used in the past with limited success to transfer sheets from one printing station to another. However, grippers supported by the chain were positively indexed to the printing station cylinders in an attempt to regain register which was periodically lost between printing stations.

A chain has inherent limitations as a smooth transfer media because chordal motion of the links limit smooth flow; linear deformation of the chain results from numerous pivot joints. Lubrication requirements at joints, to help prevent wear, noise, shock and vibration, present maintenance problems.

The gripper and chain transfer media could not, by itself, register the sheet between printing stations, even with the chain travelling precisely at cylinder speeds. As a compromise, grippers had to be loosely supported on the chain, moved from normal position, and indexed to printing station cylinders prior to actual sheet transfer at the cylinder. As soon as sheet transfer was accomplished and the gripper became separated from index with the cylinder, the gripper jumped or jerked back into its normal relation with the chain.

In the transfer system employed and disclosed herein, there is no contact between tape directed gripper bars and the printing cylinders thereby eliminating shock, vibration, wear, noise, mis-register and other apparent problems accompanied by chain supported grippers being indexed to cylinders. The printing cylinders are entirely independent of the sheet transfer mechanism and vice versa except for speed synchronization of cylinder surface speed with that of the tape.

Another problem has been the offsetting of wet ink on transfer cylinders from the freshly printed surface on the paper and consequently back on to the next sheet that is passed through the press. Heretofore, presses with a multiplicity of towers for applying more than one color of ink to the sheet were driven by a common drive through a complex gear train or through long shafts which have inherent distortion thereby increasing the problem of synchronizing components of the press thereby making precision registry more difficult.

Typical four-color one-side printing presses have an average of about 20 cylinders including the plate cylin-

ders, blanket cylinders, impression cylinders, transfer cylinders and skeleton wheels.

Sheet-fed printing presses heretofore used have relatively low production speeds which never exceed 8,000 impressions per hour.

All sheet-fed presses heretofore used have basically the same complex ink foutain with keys to vary the ink flow and an ink train consisting on an average of about twenty rollers for smoothing and distributing the ink to the plate cylinder.

A universal characteristic of sheet-fed printing presses heretofore used has been the employment of massive bearers on each end of the plate and blanket cylinders to assure rotation of the cylinders without vibration when the cylinder load is reduced because of gaps in the cylinders. The use of bearers has been necessitated by limitations of bearings heretofore incorporated into the design of presses for journaling the cylinders.

Apart from the equipment design being basically the same, one only has to be briefly associated with problems in the industry to see that printing problems, too, are the same for the similarly designed presses; namely, extensive time and effort are required for make-ready; extreme difficulty in obtaining and maintaining register between colors; streaking and slur caused by gear lash and deformation or by vibration and shock of complex mechanism movements; offsetting caused by the printed side of the sheet being in contact with transfer cylinder and skeleton wheel surfaces; sheet or board fatigue; considerable downtime for maintenance caused by breakdown of the complex mechanical systems; problems relating to ghosting on certain printing layouts; problems relating to control of ink-water balance and sometimes the most neglected problem of all, that of requiring personnel having special skills, talents, experience and perseverance to "get the job done" with the above mentioned type of printing systems.

All the above problems are related basically to problems involving lack of versatility, quality, economy and ease of operation, and are largely caused by the stereotype conventional design of the present day printing system.

Since the problems for the sheet-fed printer are not being readily solved by "updating and face-lifting" of the old concepts of printing, the only apparent alternative has been to switch to web-offset lithography. Here the printer can print several colors on two sides of the sheet at the same time with increased production. In addition to the multi-color prefecting capability the web-press is superior to the sheet-fed press in specific situations because higher production rates and lower break-even points are possible.

This at first would seem to be the answer, except for the fact that many of the problems existing in sheet-fed printing also exist in web-offset; namely, lack of color register caused by deformation of long drive shafts; basically the same kind of ink fountain with keys used in sheet-fed presses; a complicated train of rollers and conventional water foutain system; common drive for the entire press; rollers or ball-bearing with massive cylinder bearers on the plate and blanket cylinders; and printing cylinders are universally the same circumference as the finished sheet cut-off length, allowing absolutely no time for recovery of the inking form rollers after they finish a printing cycle.

Apart from problems common to the conventional sheet-fed operation, switching from sheet-fed to web-offset lithography presents other distinct disadvantages.

A web-offset press is limited to one sheet length equal to the circumference of the plate cylinder. When shorter sheet lengths are required excessive waste results from non-use of the unprinted web portion. Another complete press system must be designed, manufactured, purchased and used for printing different sheet sizes to avoid excessive waste of paper. Web presses are generally more expensive because of complex folders, dryers, chill devices, etc., necessary. More time is usually required for make-ready and more waste is encountered since the web must be running through the press and desirably at production speeds while registering and while color correction changes are being made because it is difficult to compensate for wind-up of the drive system when the press is stopped. Crews trained for printing on sheet-fed equipment find that they must learn new skills when using web equipment.

The printing industry is faced with a dilemna of the sheet-fed and web-fed printing operations, each having decided advantages over the other, while sharing common problems which are inherent in the stereotyped press design which has been virtually unchanged for decades.

SUMMARY OF THE INVENTION

I have developed a novel sheer-fed offset lithographic printing press which incorporates the advantages of sheet-fed equipment heretofore employed and the advantages of the web-press, while eliminating deficiencies of each.

By eliminating elements which did not contribute to the success of the lighographic printing press but which prevented or defeated it, I have developed a sheet-fed printing press which has the capability of perfecting, i.e., printing on both sides of the sheet at the same time, in any desired number of colors while the sheet is passed one time through the printing press.

I have eliminated all transfer cylinders, impression cylinders and skeleton wheels which have been used heretofore for feeding a sheet through the press serpentine fashion.

I have developed a sheet-fed printing press which incorporates a straight through and continuous sheet transfer principle similar to the feeding style of web presses whereby the sheet is grasped by a gripper bar after being delivered to the sheet transfer mechanism by a conventional feeder and the sheet is directed along an uninterrupted path-having no abrupt changes in direction to and through one or a plurality of printing towers where printing is accomplished selectively on one side; or, on both sides of the sheet at the same instant, or any combination thereof in any desired number of colors. This eliminates turning the sheet over after printing on one side and re-feeding it through the printing system. This also eliminates the necessity for numerous cylinders, constantly gripping and releasing the sheet as has been required heretofore.

Eliminating the complex ink fountain used on conventional presses, I have developed a press with a novel ink fountain, having a rigid doctor blade and a minimum number of rollers in the ink train for applying ink to the plate cylinder.

I have eliminated the need for bearers on the blanket and plate cylinders by the use of a novel journal, which has not been used heretofore in printing presses, which operates on hydrostatic principles offering a new and unexpected result, in that it eliminates the need for bearers.

I have eliminated the common drive system and have incorporated a novel system for driving the printing towers by individual drive motors while maintaining register for multi-color printing by the use of synchronizing links for maintaining critical elements of each printing tower and the sheet transfer system in synchronization at all times.

It is a primary object of the invention to provide a sheet-fed printing press which incorporates a sheet transfer system which moves the sheet in virtually a straight horizontal line, eliminating transfer and impression cylinders, in which the sheet length is unrelated to and may be variably less than the circumference of the printing cylinder, thereby incorporating the straight feed characteristic of the web press with the variable cut-off characteristic of the sheet-fed press.

Another object of the invention is to provide a sheet-fed press in which the sheet is continuously gripped by a single set of grippers from the time the sheet enters the press until delivery, offering the ultimate in register for multi-color printing.

Another object of the invention is to provide a printing press in which the sheet is grasped at the leading edge by a set of grippers and aerodynamically supported and directed to and through one or more printing towers.

A further object of the invention is to provide a sheet-fed printing press which may be used as a perfector to print any desired number of colors on both sides of the sheet, eliminating the need for a second pass through the press.

A still further object of the invention is to provide a sheet transfer sytem capable of gripping and registering two sheets simultaneously in a single set of grippers to move the sheets through perfecting printing towers to print on one side of each sheet.

A further object of the invention is to provide a printing press in which the only cylinders which touch the paper are the printing cylinders, thereby eliminating all costly transfer cylinders, impression cylinders, skeleton wheels, and related complex gripper mechanisms commonly used in sheet-fed presses.

A further object of the present invention is to eliminate marking caused by the offsetting of wet ink on sheets exposed to transfer cylinders and subsequent offsetting of the ink to subsequent sheets.

A still further object of the invention is to provide a sheet-fed printing press having a sheet gripping mechanism carried by an endless flexible conveyor having an in-line feeder and delivery, allowing fast but accurate control of the speed of the paper through the press.

A still further object of the invention is to provide a sheet-fed printing press in which the sheet travels through the path of least resistance thereby utilizing natural phenomena such as the cantilever effect on the sheet as it is grasped in the nip between the blanket cylinders, causing the sheet to lie tangent to the blanket cylinders due to its modulus of elasticity and also phenomena involving boundary layers of air and air pressure at the nip between opposing blanket cylinders.

A still further object of the invention is to provide a printing press having a simplified continuous inking and dampening system, eliminating problems relating to ink-water balance, emulsification, ghosting, one turn roller streaks and "hickies."

A still further object of the invention is to provide a printing press having a novel plate cylinder having a printing plate covering approximately one-half of the circumference thereof and an ink receptive recovery plate covering substantially the other half thereof associated with the ink train, allowing recovery time for redistribution of the ink on the form rollers of the ink train to eliminate ghosting.

Another object is to provide a printing press having an ink fountain which does not supply an overabundance of ink to the inking form rollers while the form rollers are in the plate cylinder gap, thereby eliminating one turn roller streak.

A still further object of the invention is to provide a printing press having an ink fountain utilizing a rigid doctor blade in contact with a resilient roller wherein the thickness of the ink film to be applied may be metered continuously and applied at a controlled, uniform rate in regulated quantities and demanded by the printing layout.

A still further object of the invention is to provide a sheet-fed printing press which may serve as a perfector in which printing is achieved on both sides of the sheet at precisely the same moment as the sheet is drawn between adjacent blanket cylinders and touches the cylinders only at the printing nip.

A still further object of the invention is to provide a sheet-fed printing press in which each blanket cylinder serves the dual purpose of a blanket cylinder for offsetting ink to the sheet and simultaneously as an impression cylinder for the blanket which is offsetting ink to the opposite side of the sheet.

These and other objects are effected by my invention as will be apparent in the following description taken in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrating the present invention are provided so that the invention may be better and more fully understood, in which:

FIG. 1 is a side elevation view of the operator side of the printing press;

FIG. II is a top plan view of the printing press having the inker broken away;

FIG. III is a side elevational view of the drive side of the printing press;

FIG. IV is a cross sectional view taken along lines IV—IV of FIG. II;

FIG. V is a sectional view through a typical printing tower taken along lines V—V of FIG. II;

FIG. VI is a cross sectional view taken along lines VI—VI of FIG. II showing a typical tape wheel in the delivery station;

FIG. VII is a enlarged elevational view of a typical gripper bar looking in the direction indicated by the arrows along lines VII—VII of FIG. II;

FIG. VIII is a cross sectional view taken along lines VIII—VIII of FIG. VII through a typical gripper bar with the gripper in closed position;

FIG. IX is a cross sectional view taken along lines IX—IX of FIG. II through a typical gripper bar with the gripper in the open position at the delivery station;

FIG. X is a cross sectional view taken along lines X—X of FIG. I showing the details of construction of the sheet transfer mechanism at the delivery station;

FIG. XI is a partially sectionalized fragmentary view illustrating the details of construction and mounting of a typical plate cylinder;

FIG. XII is a partially sectionalized fragmentary view illustrating details of construction and mounting of the upper blanket cylinder;

FIG. XIII is a diagrammatic view illustrating a suitable hydraulic circuit for providing lubrication to the hydrostatic bearing bearers utilized for journaling the plate and blanket cylinders;

FIG. XIV is an enlarged cross sectional view taken along lines XIV—XIV of FIG. XIII;

FIG. XV is a perspective view of a portion of a hydrostatic bearer illustrating a suitable configuration of a recess utilized for receiving lubricant for the bearing;

FIG. XVI is a perspective view of a portion of a hydrostatic bearer illustrating a suitable configuration of the annular rings utilized for draining lubricant from the bearing;

FIGS. XVII, XVIII and XIX illustrate the relationship between the blanket cylinders and the gripper bar assembly which continuously grips the sheet as the gripper bar assembly and sheet enter (FIG. XVII), pass through (FIG. XVIII) and leave FIG. XIX) the cutaway portion of respective blanket cylinders;

FIG. XX is an enlarged cross sectional view illustrating the nip between opposing blanket cylinders while printing is being accomplished on a sheet;

FIG. XXI is a partially sectionalized fragmentary view illustrating details of construction and mounting of the lower blanket cylinder;

FIG. XXII is an enlarged cross sectional elevational view cut transversely through the rollers of the upper ink train;

FIG. XXIII is a cross sectional view taken along lines XXIII—XXIII of FIG. XXII;

FIG. XXIV is a cross sectional view taken along lines XXIV—XXIV of FIG. XXII;

FIG. XXV is a cross sectional view taken along lines XXV—XXV of FIG. XXII illustrating details of construction of the primary inker;

FIG. XXVI is an enlarged cross sectional view, similar to FIG. XXII, of a second embodiment of the primary inker;

FIG. XXVII is an elevational view, with parts broken away, of a crankplate in the synchronizing system;

FIG. XXVIII is a cross sectional view taken along lines XXVIII—XXVIII of FIG. XXVII;

FIG. XXIX is a cross sectional view taken along line XXIX—XXIX of FIG. III;

FIG. XXX is a fragmentary perspective view of a modified form of synchronizing apparatus;

FIG. XXXI is a fragmentary persective view of a modified form of a tape wheel;

FIG. XXXII is a cross sectional view taken along line XXXII of FIG. XXXI;

FIG. XXXIII is a diagramatic view of a modified form of the inker; and

FIG. XXXIV is a diagramatic view illustrating sheet flow. Numeral references are employed to indicate the various parts as shown in the drawings and like numerals indicate like parts throughout the various figures of the drawing.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIGS. I and XXXIV of the drawings the numeral **1** generally designates a sheet-fed multi-color perfecting litho-graphic printing press.

A feeder mechanism **2** feeds sheets of unprinted paper from a stack **4** by suitable means to a swing gripper **6.** The swing gripper **6** accelerates individual sheets **5** to the velocity of gripper bars **8** carried by the sheet transfer mechanism, generally designated by the numeral **10.** Sheet transfer mechanism **10** comprises tape wheels **12***a*, **12***b* and **14***a*, **14***b* which carry tapes **16***a* and **16***b*, having gripper bars **8** mounted therebetween for moving individual sheets **5** through the printing press, as will be hereinafter more fully described.

A plurality of printing towers **18** and **20** is provided, giving the released a multi-color prefecting capability. Conventional leveling devices such as jack screws (not shown) may be utilized for tower leveling.

A delivery mechanism **22** grips the individual sheets **5** as they are relased by gripper bars **8** of the sheet transfer mechanism **10** and positions the sheets by suitable means in a stack of printed sheets **24.**

Referring to FIGS. II and V of the drawing, each printing tower **18** and **20** has a side frame **26** on the operator side and side frame **28** on the drive side of the printing press joined by tie bars **30** forming a strong rigid structure upon which various components of the press are mounted. Feeder **2** and delivery **22** have operator side side frames **2***a* and **22***a* and drive side side frames **2***b* and **22***b*, respectively. Structural ties **31** join the side frames of individual towers **18** and **20** and side frames of the feeder **2** and delivery **22.**

Primary inkers **32** and secondary inkers **23** cooperate with dampeners **36** to provide a proper balance of ink and dampening fluid to the plate cylinders **38,** which are duplicated at the upper and lower ends of the tower.

PLATE CYLINDER

Plate cylinders **38,** FIGS. V and XI, are rotatably journaled at opposite ends thereof in side frames **26** and **28** in bearings **27** and **29.** It should be noted that plate cylinders **38** differ from conventional plate cylinders in two very important aspects.

First, the printing plate **40** does not cover substantially all of the circumference of plate cylinder **38,** FIG. V. Printing plate **40** wraps around substantially one-half of the circumference of plate cylinder **38.**

Both web and sheet-fed presses heretofore developed have covered as much of the surface of the plate cylinder as possible with the plate. This has been necessitated in web presses to reduce waste of paper and in the sheet-fed presses to make a more compact press.

Plate **40** is detachably secured to plate cylinder **38** by conventional plate clamps **42** conventionally positioned in gap **39.** An ink pad **44** is mounted in a similar manner as plate **40** and covers substantially the remaining circumference of plate cylinder **38.**

Ink pad **44** is an ink receptive plate having an effective diameter slightly greater than that of the effective diameter of the plate **40.** In view of the fact that the surface of the ink pad **44** is of greater radial distance from the center of the plate cylinder **38** than the radial distance from the center of the plate cylinder to the surface of plate **40,** ink is distributed over ink pad **44** by

primary inker 32 and the ink is spread over the form rollers by the secondary inker 34 from pad 44, while plate 40 does not contact rollers of the primary inker but receives ink only from the form rollers of the secondary inker.

Utilization of the ink pad 44 allows great simplification of the conventional ink train, while overcoming ghosting problems often encountered by lithographers using conventional inking systems. Since plate 40 does not cover the substantial circumference of plate cylinder 38, form rollers in the ink fountain have sufficient time to recover, eliminating ghosting as will be hereinafter described.

The second important deviation of plate cylinder 38 from the conventional plate cylinder is the elimination of bearers. Bearers have been universally used on plate cylinders and blanket cylinders to prevent vibration when cutaway portions of the plate cylinder and blanket cylinder come into rolling contact.

Plate cylinder 38 has reduced diameters at opposite ends thereof, forming journals 38a and 38b which are supported by bearings 27 and 29 respectively in the side frames 26 and 28. One end 38a of plate cylinder 38 is captured by the lateral register adjustment 58, as will be hereinafter explained, while the other end 38*b* is free to slide axially through bearing 29. This construction provides automatic compensation for thermal expansion of plate cylinder 38.

I have eliminated the need for bearers by replacing conventional ball, sleeve and roller bearings with a hydrostatic bearer 46, FIGS. XI–XVI, which is machined to very close tolerance between bearing sleeve 27 and 29 and journals 38*a* and 38*b* on the plate cylinders 38 blanket journals 48*a* and 48*b* on blanket cylinders 48, allowing virtually no vibration of the plate cylinder as will be hereinafter more fully explained.

BLANKET CYLINDER

When printing is being accomplished blanket cylinders 48 are in rolling contact with plates 40 on plate cylinders 38, FIG. V. On each upper and lower unit, blanket 50 is detachably secured to blanket cylinder 48 by conventional blanket clamps 52 and is of substantially the same length as plate 40, thereby covering the same proportion of the circumference of blanket cylinder 48 as plate 40 covers on plate cylinder 48 which is equal in diameter to blanket cylinder 48. Each blanket cylinder 48 has a recessed area 54 on the outer surface, providing clearance for the ink pad 44 on plate cylinder 38 to prevent contact between the blanket cylinder 48 and the ink pad 44.

It should be noted that as hereinbefore explained that blanket cylinders 48 do not have conventional bearers on each end thereof, but each blanket cylinder 48 has a journal 48*a* and 48*b* at opposite ends thereof supported in hydrostatic bearings 46 which will be described in detail hereinafter.

Each blanket cylinder 48 has a gap or cutaway portion 46 on the outer surface, FIGS. V, XVII, XVIII and XIX, allowing gripper bars 8 to move therebetween as they rotate.

ADJUSTMENT AND THROW OFF

Each plate cylinder 38 has suitable lateral color registering adjustment mechanism 53, FIG. I and XI. A suitable means for establishing and maintaining lateral register comprises a worm 58a and a worm gear 58*b* for driving a spur gear 58*c* which in turn meshes with gear teeth on a threaded adjustment screw 58*d* whereby rotation of the worm 58*a* will cause the threaded adjustment screw 58*d* to be moved laterally, thereby moving plate cylinder 38 laterally with respect to the side frames 26 and 28. Adjusting screw 58d threadedly engages collar 58e, rigidly connected to the operator-side side frame 26 by bolts 58*f*. Adjusting screw 58*d* has annular thrust bearing 58*g* mounted therein which is captured between shoulders 38*c* on cylinder 38 and plate 58*h* secured by bolts 58*i* to the end of plate cylinder journal 38*a*.

A suitable throw-off mechanism is utilized to separate the blanket cylinders 48U and 48L from plate cylinders 38U and 38L respectively and to separate the upper blanket cylinder 48U from lower blanket cylinder 48L when the last sheet passes from the feeder or when a sheet 5 fails to feed. A suitable mechanism, FIGS. I and V, comprises a throw-off hydraulic cylinder 60 actuated by an electric eye or other suitable means (not shown), pivotally connected to a crank 62 wherein actuation of throw-off cylinder 60 causes crank 62, which is rigidly connected to cross shaft 64, to rotate shaft 64. Crank 62, rigidly connected to shaft 64, also moves adjustable link 70 to rotate a second crank 72 rigidly secured to a second cross shaft 74. Rotation of the first and second cross shafts 64 and 74 respectively results in rotation of cranks 76 which are rigidly secured to each of said cross shafts. A rod eye 78 is pivotally connected to each crank 76 and has an adjustment screw 82 threadedly engaged therein. Screw 82 extends through and threadedly engages pin 82*b* and is secured relative thereto by lock nuts 82*c* and 82*d* threadedly engaging adjustment screw 82. Pin 82*b*, FIGS. XII and XXI, is rotatably journaled in bushings 82*e*, rigidly connected to outwardly extending lugs 80*a* on throw-off crank 80. Throw-off crank 80 is rigidly connected to eccentric bushing 27*a* and 29*a* of hydrostatic bearing 46. The eccentricity of bushings 27*a* and 29*a* causes opposing blanket cylinders 48L and 48U to move to an off impression position when throw-off cylinder 60 is actuated. It should be apparent that actuation of throw-off cylinder 60 results in rotation of throw-off crank 80 and eccentric bushings 27*a* and 29*a*, causing each blanket cylinder 48U and 48L to move from contact with plate cylinders 38U and 38L respectively and causes blanket cylinders 48U and 48L to be separated

Paper pressure adjustment 84, FIGS. I, V and XXI, consists of a worm 84*a* rotatably mounted on the operator-side side frame 26, which rotates a worm gear segment rigidly connected to cross shaft 84*b*, transmitting rotation to lever arm 84*c* rigidly connected to cross shaft 84*b*. An adjustable rod 84*d* is pivotally connected between lever arm 84*c* and the paper pressure eccentric 84*e*.

It should be noted that paper pressure eccentric 84*e* is provided on lower blanket cylinders 48L only. Paper pressure eccentric 84*e*, FIG. XXI, is rotatably journaled in the operator-side side frame 26 and the drive-side side frame 28, having eccentric bushings 27*a* and 29*a* of hydrostatic bearer 46 rotatably journaled therein. It should be readily apparent that rotation of worm 84*a* results in rotation of paper pressure eccentric 84*e*, causing the lower blanket cylinder 48L to be moved relative to upper blanket cylinder 48U, thereby providing means for adjusting the paper pressure between adjacent blanket cylinders.

Circumferential register adjustment **86,** FIGS. III and XI, provide a means for rotating the upper plate cylinder **38U** or the lower plate cylinder **38L** relative to plate cylinder gears **108** and **100** respectively, and allows rotation of one plate cylinder relative to the other. Adjustment **86** includes an outwardly extending lug **86a** on each plate cylinder gear **100** and **108,** having a worm gear **86*b*** rotatably journaled therein meshing with gear segment **86*c*** connected by bolts **86*d*** to bushing **86*e*** pinned at **86*f*** to journal **38*b*** of each plate cylinder **38U** and **38L**. It should be apparent that rotation of worm **86*b*** associated with the plate cylinder in one tower will impart rotation thereto, providing circumferential adjustment thereof relative to the corresponding plate cylinders of other printing towers for color register. The blanket cylinders **48U** and **48L** may be adjusted circumferentially relative to each other, utilizing set screws **126** in crank plates **116,** FIGS. XXVII and XXVIII, as will be hereinafter more fully explained.

Utilizing set screws **126,** the blanket cylinder gaps **56** may be positioned to begin printing at the desired location on each side of sheet **5** and will allow gripper bars **8** to pass through blanket gaps **56.**

Referring to FIG. III of the drawing, each printing tower **18** and **20** has an individual drive consisting of a variable speed motor **90** having a drive sheave **92** mounted on the shaft thereof. Belts **94** are carried on drive sheave **92** and driven sheave **96** rotatably journaled on side frame **28** of the drive side of each tower **18** and **20.** Driven sheave **96** is rigidly connected to a lower plate cylinder drive gear **98** which meshes with the lower plate cylinder gear **100.** Rotation of the lower plate cylinder gear **100** imparts rotation to lower plate cylinder **38L**. Lower blanket cylinder **48L** has a gear **102,** having interrupted teeth **102*a***, (FIG. XXIX), rigidly connected thereto which meshes with lower plate cylinder gear **100** imparting rotation to lower blanket cylinder **48L**.

A lower idler gear **104** meshes with the lower plate cylinder gear **100** and with an upper idler gear **106** which in turn meshes with upper plate cylinder drive gear **108,** rigidly connected to upper plate cylinder **38U**. The upper plate cylinder gear **108** meshes with the upper blanket cylinder gear **110,** having interrupted teeth **110*a***, rigidly connected to the upper blanket cylinder **48U**.

From the foregoing it should be readily apparent that motor **90** drives the lower plate cylinder and the lower blanket cylinder while transmitting power through idler gears **104** and **106** to drive the upper plate and blanket cylinders.

The pitch diameters of plate cylinder gears **100** and **108** and blanket cylinder gears **102** and **110** coincide with the peripheral surfaces of plate cylinders **38L** and **38U** and blanket cylinders **48L** and **48U** respectively, such that no slippage occurs at the plate and blanket nip **38*n*** when the cylinders are in pressure contact.

Plate cylinder gears **100** and **108** are identical. Blanket cylinder gears **102** and **110** are identical except that teeth **102*a*** on gear **102** and teeth **110*a*** on gear **110** are interrupted or offset in opposite directions to prevent driving or interference there-between. The surface speed of each cylinder is the same. Exact surface speed relationship is obtained between the plate cylinder, blanket cylinder and paper by placing packing **38*p*** and **48*p*** under the plates **40** and blankets **50,** thereby packing same relative to the pitch diameters of the gears **100, 108, 102** and **110**; by adjusting the pressure between adjacent plate and blanket cylinders (screw **82**); by adjusting the paper pressure (adjustment **84**); and by synchronization (links **132** and **134**) of individual towers **18** and **20.**

Idler gears **104** and **106** are mounted on stub shafts **112,** FIG. XXVIII, which are rigidly secured to the side frame **28.** A retainer plate **114** is bolted or otherwise rigidly secured to the end of each stub shaft **112** to prevent axial movement of the idler gears **104** and **106** relative to the stub shafts **112.**

A crankplate **116** and counterbalance **116*w*** are rigidly connected to each idler gear **104** and **106** by bolts **118** which pass through elongated openings **120** in the crankplate **116.** The elongated openings **120** allow circumferential adjustment between the crankplate **116** and the idler gear.

A stop block **122** is securely attached as by cap screws **124** to the idler gear **104.** Set screws **126** in crankplate **116** may be adjusted with relation to stop block **122,** thereby causing crankplate **116** and counterbalance **116**w to rotate relative to the idler gear **104.**

Crankplate **116** may be adjusted or rotated with respect to idler gear **104** by loosening bolts **118** and adjusting set screws **126** relative to stop block **122,** causing crankplate **116** to rotate to the desired position and then tightening bolts **118** through elongated holes **120** to secure the crankplate **116** and counterbalance **116*w*** to idler gear **104.** Each crankplate **116** has an outwardly extending crankpin **128** thereon upon which a bearing **130** is pivotally mounted. Crankplate **116** on idler gear **104** of printing tower **18** is connected through a lower synchronizing link **132** to crank-plate **116** on idler gear **104** of printing tower **20,** best illustrated in FIG. III, forming a rigid mechanical linkage, causing idler gear **104** of each printing tower to rotate in synchronization.

The upper idler gears **106** of each printing tower **18** and **20** are similarly connected by an upper synchronizing link **134.**

It should be noted that the printing stations are self-contained units powered by individual motors **90.** Synchronization of multiple printing stations is accomplished by mechanical linkages **132** and **234** indirectly connecting the rotating cylinders. Load sharing is accomplished by mechanical linkages **132** and **134** so that each motor carries its portion of the load of all stations. Loads will be normally equal at each tower.

Individual drive motors **90** at each printing station are driven in unison by one central control **90*b***. This provides speed synchronization and load sharing. Controls **90*a*** are located at each printing tower for necessary maintenance and operation from that point. Printing tower controls **90*a*** shall consist of: jog forward; jog reverse; emergency stop; and warning. The jogging operations will be performed at low speeds which can be adjusted for optimum convenience. The emergency stop will shut down the press in minimum time. The warning operation must be energized before any jogging may be performed. These controls are conventional and well known to persons skilled in the art.

A drive motor **90** may also be provided for the sheet transfer mechanism as hereinafter explained wherein all drive motors (connected thru the synchronizing linkages between each station and between the last station and the transfer mechanism) share the total load

imposed by the printing stations **18** and **20** plus the sheet transfer mechanism **10.** One control **90***b* furnishes power to all main drive motors **90.**

Motors **90** are all connected in parallel so that one common field voltage from the control **90***b* supplies all motors **90,** and one common armature voltage from the control also supplies all motors. Field supplies to each motor may be individually trimmed to balance electrical speed.

The dampener **36** is independently driven and controlled as fully explained in U.S. Pat. No. 3,168,037. The dampener drive will be variable speed with controls at each station and remote controls at a console or master station and speed indication and trim controls at the delivery end of the printing system.

Printing presses heretofore developed have utilized a common drive system consisting of a single motor and long shafts and complicated gear trains for delivering power to the individual printing towers. When a long bar or shaft is subjected to a torque the cross section at one end rotates with respect to the cross section at the other end, resulting in twist or angular displacement of one end of the shaft with respect to the other end. Deflection of drive shafts causes the printing towers to get out of register which results in poor printing quality. Likewise presses utilizing complicated gear trains experience gear lash with the same accompanying register problems.

Synchonizing links **132** and **134** will be subjected to slight differential loading and therefore the deflection problem heretofore experienced will be non-existent.

While the feeder **2** and delivery mechanism **22** may be driven by individual drive motors in the same manner as heretofore described with respect to printing towers, the particular embodiment shown in the drawing utilizes sections **136** and **138** of links **132** and **134** to transmit power from motor **90** of printing tower **18** and **20** through idler gears **104** and **106** to drive gears **140** and **142** rotatably journaled on the drive-side frame **2***b* and **22***b* of the feeder mechanism **2** and the delivery mechanism **22,** FIG. X. The end section **136** of lower synchronizing link **132** is pivotally connected to crankpins **128** on crankplates **116,** one of which is secured to lower idler gear **104** and the other to lower idler gear **140.** Gear **140** is rotatably journaled on stub shaft **144** rigidly connected to the drive-side frame **2***b* and **22***b* of the feeder station **2** and delivery station **22.** Lower gear **140** meshes with upper gear **142** rigidly mounted on one end of cross-shaft **146,** rotatably journaled in side frames **22***a* and **22***b* in bearings **148,** having a drive gear **150** rigidly mounted on the opposite end thereof. Drive gear **150** meshes with tape wheel gear **152** rigidly connected to the tape wheel axle **155.**

From the foregoing it is readily apparent that power from motor **90** of printing tower **20** provides power through synchronizing links **136** and **138** to the tape wheel axle **155** of the delivery mechanism **22.** Power is supplied to the tape wheel axle **154** of feeder mechanism **2** in substantially the same manner as will be hereinafter explained.

It should be noted that crankplate **116** on the upper idle gear **106** is rotated 90° with reference to crankplate **116** on lower idler gear **104.** The particular configuration causes lower link **132** to be most efficient as a torque transmitting member at the instant that upper link **134** is least efficient and vice versa.

A modified form of means for connecting the synchronizing links to synchronize rotation of printing cylinders is illustrated in FIG. XXX.

Links **132′** and **134′** are pivotally connected to crankpins **128′** and **128″** which are circumferentially spaced 90° apart about the axis of printing cylinder **48′.** Crankpins **128′** and **128″** are secured relative to a crankplate **116′** by crankarms **116***a* and **116***b.* The crankplate **116′** is secured by suitable means such as bolts **120′** to the cylinder **48′.** A support arm **116***c* secured to a side frame is employed to support the outer end of the crankshaft assembly.

The gearing is such that the speed of sheet **5,** carried by gripper bar **8** of sheet transfer mechanism **10,** is equal to the surface speed of the blanket cylinders **48** so that no slippage occurs as sheet **5** passes through the printing nip **50***n.*

A cover **117** is bolted or otherwise rigidly secured at its opposite ends to the drive side **2***b* and **22***b* of the printing press and extends longitudinally thereof. Cover **117** extends outwardly from the press, forming a protective guard around links **132–138,** crankplates **116** and gears **100, 102–110.** Additional covers **31***a* serve as windshields for sheets **5,** preventing movement of air currents about the sheet which could cause the sheet to wrinkle or flutter as it passes through the system.

SHEET TRANSFER MECHANISM

The sheet transfer mechanism, hereinbefore briefly described, includes tape wheels **12** and **12***b* rigidly connected to tape wheel axles **154** rotatably journaled in the side walls **2***a* and **2***b* of feeder station **2** and tape wheels **14***a* and **14***b* rigidly connected to tape wheel axle **155** rotatably journaled in tape wheel hangers **156** adjustably secured to side walls **22***a* and **22***b* of delivery station **2.**

Referring to FIG. X of the drawing, it should be noted that tape wheel hangers **156** are rotatably secured to bearings **148** in which cross shaft **146** is journaled. Hangers **156** allow the distance between the tape wheel shafts **154** in the feeder station **2** and tape wheel shaft **155** in the delivery station **22** to be adjusted for regulating the tension in tapes **16***a* and **16***b.*

Hangers **156** are provided in the delivery station only. However, it should be readily apparent that tape wheel axle **154** or **155** could be supported in hangers **156** as desired.

As illustrated in FIG. IV, tape wheel axle **155** has a bushing **156***a* rotatably journaled thereon, having outwardly extending lug **156***b* rigidly connected thereto. A pre-load adjusting screw **156***c* is hingedly connected to a lug **156***b* by a pin **156***d.* A stationary block **156***e* is rigidly secured to the side wall **22***b* of delivery station **22** by bolts **156***f* while sliding block **156***g* is adjustably secured to the side walls by bolts **156***h* through elongated holes. Guide pins **156***i* extend through blocks **156***f* and **156***g* having springs **156***j* therearound between said blocks. An adjusting nut **156***k* threadedly engages adjusting screw **156***c.*

It should be readily apparent that tension in tapes **16***a* and **16***b* may be adjusted or pre-loaded by rotating preload adjustment nut **156***k* relative to block **156***g.* While it is contemplated that tapes **16***a* and **16***b* will move in a smooth uniform fashion, springs **156***j* on guide pins **156***i* are provided for absorbing excessive shock and to

prevent breaking of parts of the sheet transfer mechanism **10.**

Springs **156***j* also serve as an expansion joint for the tapes **16***a* and **16***b*, elminating thermal stresses which would result in the tapes if axle **155** were rigidly anchored.

The distance between gripper bars **8** will ordinarily be equal to the circumference of plate cylinders **38U** and **38L**. However, the gripper bars may be positioned at distances equal to multiples of the circumference of the plate cylinders if it is deemed expedient to do so.

Tapes **16***a* and **16***b* may be of any length as long as the length of each tape is equal to a multiple of the circumference of plate cylinders **38U** and **38L**.

It should be noted that the use of the straight line sheet transfer mechanism **10** allows individual printing towers **18** and **20** to be unevenly spaced if it is deemed expedient to do so. Therefore, a multi-color press could have individual printing towers arranged with varying spaces therebetween providing great flexibility, allowing the printing press to be installed in a building without modification where it might be necessary to modify the building for installation of a conventional printing press.

Referring to FIG. X, tape wheel axle **155** extends through slot **155***a* in the operator-side side frame **22***a* of the delivery station **22** having tape wheel gear **152** mounted on the outside of the side frame, allowing tape wheel axle **155** to be adjusted by the tape pre-load adjustment nut **156***k*. Gear **150** on crankshaft **146** is also mounted on the outside of the side frame meshing with tape wheel gear **152.**

It should be noted that adjustment of the position of axle **155** causes gear **152** to be moved about the center of shaft **146** thereby maintaining gears **150** and **152** in meshing relation.

Delivery wheels **145** are rigidly connected to cross-shaft **146** by a pin **145***a*, providing power for delivery station **22.**

Tape wheel axle **154** in the feeder station is journaled in side walls **2***a* and **2***b* thereof. Tape wheel gear **152,** FIG. II, is mounted on the inside of the side frame **2***a* of feeder station **2.** Gear **150,** mounted on cross-shaft **146** of the feeder station, is also mounted on the inside of the operator-side frame **2***a* in driving relation with tape wheel gear **152.**

Cross-shaft **146** on the feeder station **2** extends through the side frame **2***a* of said feeder station **2** and has a cam plate **147** rigidly secured to cross-shaft **146** outside of the side frame **2***a*, FIG. I. A stub shaft **147***a* is mounted on the outside of the side frame **2***a* of feeder station **2** which has a bell crank **147***b* rotatably mounted thereon. Cam follower **147***c* is rotatably journaled on bell crank **147***b* in rolling contact with cam plate **147.** A second bell crank **147***e* is rigidly connected to actuator shaft **147***d* of swing gripper mechanism **6** of feeder tation **2.** An adjustable link **147***f* connects the lower ends of first bell crank **147***b* and second bell crank **147***e* while a spring **147***g*, connected to the upper end of bell crank **147***e*, urges said bell crank in a counter clockwise direction. It will be apparent that spring **147***g* acting through bell crank **147***e*, link **147***f* and bell crank **147***b* urges cam follower **147***c* toward the face of cam plate **147.** Cam **147** and related linkage is a means for delivering power to feeder station **2** from drive motor **90** of printing towers **18** and **20.**

As hereinbefore pointed out, feeder station **2** and delivery station **22** may be individually powered, if it is deemed desirable to do so. Synchronizing links **136** and **138** would then function in exactly the same manner as synchronizing links **132** and **134** for maintaining individual components of the sheet transfer mechanism **10** in synchronization with the components of individual printing towers **18** and **20.**

As best seen in FIG. I and II of the drawing, each tape **16***a* and **16***b* is an endless flexible conveyor having sufficient tensile strength so that no appreciable stretch or lineal deformation results within the range of forces applied thereto in its present application. Tapes **16** may be constructed of any suitable material such as a single strand steel tape, a multiple strand cable, or belt. However, a steel tape is utilized in the particular embodiment shown in the drawing. Tape **16a** is carried about tape wheels **12***a* and **14***a* journaled on one side of the printing press while a second tape **16***b* is carried about tape wheels **12***b* and **14***b* journaled on the other side of the printing press.

Each tape wheel **12***a*, **12***b*, **14***a* and **14***b* has V-blocks **158,** FIGS. VI, IX and X, radially spaced adjacent the circumference thereof. Each V-block **158** has a key **160** extending outwardly from one face thereof which is complementarily received by key way **162** in the tape transfer wheel **14***b* in FIG. VI. V-block **158** is adjustably secured to the tape transfer wheel by bolts **164** extending through elongated holes **168** in V-block **158** to threadedly engage the transfer wheels. A support block **170** is secured to the tape wheels adjacent V-blocks **158** by bolts **172** and has an adjusting screw **174** extending therethrough. V-blocks **158** may be adjusted on the tape transfer wheels by loosening bolts **164,** allowing movement of the V-blocks **158** by rotation of adjusting screw **174.** When the desired position is attained bolts **164** and jam nut **176** on adjusting screw **174** are tightened, thereby rigidly connecting the V-block to tape transfer wheels. V-blocks **158** are mounted on tape transfer wheels **12***a*, **12***b*, **14***a* and **14***b* in the same manner.

Each gripper bar assembly **8** includes a support bar **178** rigidly connected to tapes **16***a* and **16***b* by any suitable means such as locating pins **180,** FIG. VII. Heads **182** of locating pins **180** are received by peripheral recesses **184** in each tape wheel **12***a*, **12***b*, **14***a* and **14***b*. Each support bar **178** has outer guide rollers **186***a* and **186***b* and inner guide rollers **188***a* and **188***b* rotatably mounted on each end thereof. Each guide roller is mounted on axle **190** of support bar **178** which has a bushing **192** rotatably mounted thereon held in proper position by thrust washer **194** and a jam nut **196.** A set screw **198** is provided in jam nut **196** to prevent loosening of jam nut **196.**

An actuator shaft **200** is rotatably mounted in backup plate supports **202** which are welded or otherwise rigidly connected to the support bar **178.**

A backup plate **204** is rigidly connected by bolts **206** to backup plate supports **202** and extends transversely between tapes **16***a* and **16***b*, which are spaced apart, in substantially parallel relationship to support bar **178** and actuator shaft **200.**

A plurality of conventional gripper finger support assemblies **208** are rigidly connected to actuator shaft **200** in spaced apart relation throughout the length thereof. A gripper finger **210** is rigidly connected to

each gripper finger support assembly **208** by a cap screw **212.**

A torsion spring **214** is positioned about and connected between actuator shaft **200** and the backup plate support **202,** applying torque to actuator shaft **200** to provide a substantial force, causing pin **200***a* on shaft **200** to be maintained in engagement with actuator shaft stop **200***b* extending outwardly from backup plate support **202** to grip a sheet of paper **5** between gripper fingers **210** and backup plate **204.** As best seen in FIG. VIII, compression spring **209** urges the gripper finger support assembly **208** and shaft **200** in a counter clockwise direction. Torsion spring **214** overcomes the forces exerted by compression springs **209** and urges pin **200***a* in a clockwise direction into contact with stop **200***b*.

It is very important that sheet **5** not slip relative to gripper fingers **210** and backup plate **204** after the sheet has been gripped. The spring constant of the torsion spring **214** and the number of gripper fingers **210** necessary to accomplish this result may vary depending upon the size and weight of the sheet **5** for specific printing operations.

Cam followers **216** are rotatably journaled on actuator arms **218** adjacent tape wheels **12***a*, **12***b*, **14***a* and **14***b*. Arms **218** are rigidly connected to actuator shaft **200.** Cams **220** are fixedly secured by bolts **222** to the tape wheel in such a relationship to the cam followers **216** that rotation of the tape wheel will bring the cams **220** into contact with the followers **216,** thereby rotating actuator arms **218** and actuator shafts **200** against force exerted by the torsion spring **214,** causing gripper fingers **210** to rotate away from backup plate **204.** The exact position and configuration of the cams **220** may be varied in a specific operation whereby the gripper fingers **210** will be rotated relative to backup plate **204** to grip a sheet at the precise moment it is swung into proper position by swing gripper **6** from the feeder mechanism **2** and to release the sheet after printing has been accomplished thereon when the sheet has been conveyed to the delivery mechanism **22.**

While the specific description has been directed to tape wheel **14***a* and **14***b* (FIGS. VI–X), it should be noted that tape wheels **12***a*, **12***b* and grippers associated therewith have the same general configuration and operate in substantially the same manner. The tape carried gripper assemblies **8,** rigidly connected to the endless flexible conveyor tapes **16***a* and **16***b* by locating pins **180,** grasp a sheet of paper **5** from the swing gripper assembly **6** of the feeding mechanism **2,** move the sheet in a straight horizontal line to and through the printing towers **18** and **20,** release the sheet when it is gripped by the delivery mechanism **22** and the gripper assemblies **8** return to the feeder mechanism **2** to pick up another sheet.

As best illustrated in FIG. IX of the drawing V-blocks **158** receive the inner guide rollers **188** as tape wheels **12***a*, **12***b*, **14***a* and **14***b* rotate, causing the tapes **16**a and **16***b* and the gripper assemblies **8** to rotate therewith.

Inner tracks **224***a* and **224***b* and outer tracks **226***a* and **226***b* extend longitudinally throughout the printing press at the upper and lower ends thereof and are positioned to receive and guide the inner and outer guide rollers **188***a*, **188***b* and **186***a* and **186***b* respectively, thereby supporting the weight of each gripper bar **8** as it travels between tape wheels **12***a*, **12***b* and **14***a*, **14***b*. As best seen in FIG. VI of the drawing, the path of travel of the gripper bars **8** are defined by the configuration of the opening between the inner track **224** and the outer track **226.** One of the outer guide rollers **186***b* on each support bar **178** has a groove **228** therein which receives and rolls along an upwardly extending portion **230** of the outer track **226** on one side of the press. It should be readily apparent that the gripper bars **8** will be guided by the outer track **226***b* because lateral alignment is maintained by the groove **228** on the outer guide wheel **186***b* while the inner track **224**b above the inner guide roller **188***b* prevents disengagement of the groove **228** from the upwardly extending portion **230** of the outer track **226***b*.

As best illustrated in FIG. X, the other outer guide roller **186***a* on each support bar **178** does not have a groove **228** thereabout. This provides means for automatically compensating for thermal expansion of support bar **178** because the guide roller **186***a* is free to move laterally relative to the outer track **226***a*.

While guide tracks **224** and **226** are shown to be straight and horizontal in FIG. IV, it should be readily apparent that the tracks may be inclined or curved to conform with any desired configuration if it is deemed expedient to do so. I anticipate the use of the above described continuous gripping tape controlled gripper bar **8** with tracks curved or inclined in a vertical or horizontal plane for controlling the path of a sheet through a printing press regardless of the geometric configuration of individual printing towers and the components thereof.

Sheet **5,** accelerated by conventional swing gripper assembly **6,** is gripped firmly along its leading edge by the tape carried gripper bar assemblies **8** while the remainder of the sheet is aerodynamically supported and floated on air to the first printing tower **18.**

Sheet transfer mechanism **10** hereinbefore described causes the sheet **5** to travel along the path of least resistance, thereby causing the sheet to attain a position in a plane parallel with its direction of travel.

Shaping of the outside of an object to provide as little air resistance as possible is desirable in the design of objects which are to travel fluently through the air. However, even well-designed streamlined objects have drag caused by skin friction, causing a boundary layer of air adjacent the surface of the object to move with the object.

Moving air pushes up against flat surfaces held at an angle to the direction of air flow and therefore surfaces moved through the air are pushed upward by the force of air against their under surfaces. The sheet being held along its leading edge, with the remaining portion unsupported, is curved progressively downwardly due to the weight of the unsupported length of the sheet. This shape produces an air foil and consequently when the sheet is pulled forward along its leading edge the air moves faster across the top of the sheet than beneath it. The pressure of the fast moving air is, therefore, less above the sheet than beneath it and accordingly the sheet will be lifted along its unsupported length. It should be apparent that the flexible sheet, suspended at its leading edge in gripper bar assemblies **8,** will attempt to achieve an equilibrium position due to the upward force of air on the lower portion of the sheet and also because of the low pressure air above the sheet, resulting from the air foil when the sheet is curved.

It should be noted that lift of an air foil is proportional to the square of the air speed. Therefore, even at

relatively low printing speeds adequate lift is provided for positioning the sheet in a plane parallel to its direction of travel. The air pressure acting upon the sheet lifts the unsupported surface of the sheet, coupled with laminar flow of air along its surfaces, allows the sheet to glide swiftly and smoothly from one printing station to another.

The leading edges of the support bar **178** may be of any configuration deemed expedient for reducing air turbulence along the sheet or to increase lift if sufficient lift is not accomplished at very low air speeds for heavy weight sheets. Slots or openings in the support bar near the leading edge of the sheet may be incorporated into the gripper bar assembly for directing air currents across the sheet **5.**

In the form of the device illustrated in FIG. XXXIV a pipe **178***x* is connected to a suitable source of pressurized fluid, such as an air compressor (not shown). Pipe **178***x* communicates with lines **178***y* having outlet nozzles **178***z* positioned to direct air upwardly against lower surfaces of sheets **5.** The velocity of air jets is controllable by suitable valving (not shown) to exert lifting force upon the sheets and to minimize sheet flutter.

In FIG. XVII of the drawing, the sheet **5** is shown as the gripper bar assembly directs the sheet into relation with the blanket cylinders **48**U and **48**L for beginning the printing cycle.

Referring to FIG. XVIII of the drawing, the sheet is shown in position just as the blanket cylinders **48**U and **48**L contact the sheet. It should be noted that as the blanket cylinders contact the sheet **5,** additional forces are exerted upon the sheet, tending to cause the sheet to lie in a plane perpendicular to the center line between the opposing blanket cylinders. The sheet gripped at the nip **59***n* between the blanket cylinders acts as a uniformly loaded cantilever beam. The equation for the elastic curve of a uniformly loaded cantilever beam is $y = -w/24EI\ (x^4 - 4L^3 x + 3L^4)$ where y equals the deflection of the beam, w equals the unit weight of the material, E equals modulus of elasticity, x equals the distance from the unsupported end of the beam, and L equals the length of the beam. Obviously, where x is equal to L at the supported end of the beam, the deflection of the beam is zero.

As best seen in FIG. XX of the drawing, the boundary layers of air **50***p* adjacent the surfaces of the blanket cylinders **48**U and **48**L and the boundary layer of air **5***a* adjacent each side of the sheet **5** are compressed as any given portion of the sheet approaches the nip **50**n between the blanket cylinders. Pressure wedges **50**w are formed above and below the sheet **5,** also contributing to hold the sheet straight out and away from the printing cylinders in an equilibrium position, substantially bisecting the cusp area C formed by the converging curved surfaces of the opposing blanket cylinders, immediately prior to entering the nip **50***n* where printing is accomplished.

As best seen in FIG. XIX, after printing has been accomplished at the nip between the blanket cylinders the gripper bars **8** strip the paper from the surfaces of the inked blanket cylinders **48**U and **48**L, causing the sheet **5** to bisect the cusp C, and carries and directs the sheets to the next printing tower.

From the foregoing it should be apparent that I have developed a novel sheet transfer mechanism which utilizes natural phenomena for aerodynamically supporting a sheet to and through successive printing towers wherein the sheet travels aong the line of least resistance.

In view of the fact that sheets **5** are continuously bar **8** from the moment the sheet leaves feeder mechanism **2** until the moment it is released at delivery mechanism **22.** I anticipate the use of the above described sheet transfer mechanism with a feeder which feeds two sheets of paper simultaneously whereby the two sheets may be gripped and carried through through the successive printing towers wherein printing will be accomplished on one side of each sheet simultaneously or printing may be accomplished on both sides of a single sheet simultaneously. Operation of the sheet transfer mechanism in this manner will allow the printer who does not wish to print on both sides of the sheet to run two sheets simultaneously through the perfecting printing towers, thereby utilizing the perfecting advantage while printing on one side of the sheet, thereby doubling production for a job requiring the printing on one side of a sheet.

A modified form of apparatus employed for indexing tapes **16***a'* and **16***b'* relative to tape wheels **14***a'* and **14***b'* and guide tracks **224'** and **226'** is illustrated in FIGS. XXXI and XXXII.

Tape wheels **14***a'* and **14***b'* have projections, such as tooling balls **14***t*, secured in spaced apart relation about the periphery thereof. As best illustrated in FIG. XXXII, tooling ball **14***t* has a threaded shank **14***s* secured in a threaded aperture **14***u* through disc **14***v*. Disc **14***v* is secured in socket **14***w*, formed in the periphery of wheel **14***b*, by bolts **14***x*.

Tapes **16***a'* and **16***b'* have spaced apertures **16**t formed to receive tooling balls **14***t* for positively indexing the gripper assembly **8'** relative to wheel **14***b'*.

As best illustrated in the form of the device illustrated in FIGS. XXXI and XXXIV guide rollers **186***a'* and **186***b'* rotatably secured to support bar **178'** of gripper assembly **8'**, have flanges **228'** formed adjacent the inner edge thereof to engage tracks **224***a'*, **224***b'*, **226***a'* and **226***b'*. Rollers **186***b'* are mounted to permit movement thereof longitudinally of support bar **178'** and are urged outwardly by springs **178''**. It should be apparent that flanges **228'** are urged into engagement with the respective guide tracks maintaining lateral register of sheets **5** while permitting thermal expansion of the gripper bar assembly **8'**.

Printing cylinders **48'**, illustrated in FIG. XXXIV, of each printing couple **18** and **20** are adapted to form an unobstructed passage permitting movement of gripper assemblies **8'** from the feeder station to the delivery station without engagement with structural members other than tracks **224***a'*, **224***b'*, **226***a'* and **226***b'*, said tracks directing the gripper assemblies **8'** along a path having no abrupt changes in direction. The tracks are preferably substantially straight or uniformly curved to minimize abrupt changes in speed and direction of the mass of the gripper assemblies **8'**. Changes in speed or direction would impart periodic changes in the tension in tapes **16***a'* and **16***b'* and consequently disturb register since exact correspondence of images printed at each printing tower **18** and **20** must be constantly maintained for quality multicolor printing.

The above description of a sheet transfer mechanism and the mechanism for individually driving printing towers **18** and **20** has been limited to printing towers capable of printing on both sides of a sheet simulta-

neously. It should be noted, however, that the above description is intended only to illustrate one-suitable embodiment of the invention. Obviously, the use of perfecting printing towers is not a prerequisite to success of the sheet transfer mechanism **10** or the drive mechanism which I have developed.

The perfecting printing towers, which have been described and illustrated in the drawing, may be utilized for printing on one side of a sheet, if it is desirable to do so, by simply removing the plate **40** from one of the plate cylinders **38.**

Individual printing towers **18** and **20** may be adapted to print on one side of a sheet by merely eliminating one of the plate cylinders **38** and substituting an impression cylinder for one of the blanket cylinders.

The straight through and continuous sheet transfer concept of offset printing hereinbefore described does not require that the sheet remain in a plane perpendicular to a line between the centers of the printing cylinders. Likewise, it is not necessary that the center of opposing blanket cylinders be vertically one above the other. The term "straight through" merely distinguishes the concept of the present invention from a sheet transfer mechanism of conventional printing presses wherein a sheet is fed serpentine fashion through the press.

Although multiple printing towers have been shown and described, the concept of the present invention may be utilized with a press having a single station for printing on one side or on both sides of a sheet.

PRIMARY INKER

Primary inker **32,** best seen in FIGS. V, XXII and XXV, includes an ink reservoir **232** which forms a receptacle for ink **234.** The ink reservoir **232** is defined by a plate **236** extending between side plates **237.** Plate **236** is detachably secured to a substantially semicircular shaft **238** which is rotatably journaled adjacent its opposite ends in adjustment eccentric **240** in self-aligning bushing **240***a* carried in bracket **240***b*, secured by bolts **240***c* to mounting plate **33,** detachably secured to side frames **26** and **28.** A doctor blade **239** is bolted, or otherwise detachably secured, on the shaft **238** adjacent a lower edge of the plate **236.**

Adjustment **242,** consisting of a screw **242***a*, having right-hand threads at one end thereof and left-hand threads at the other end thereof, threadedly engages rod eyes **242***b* at each end thereof. One rod eye **242***b* is pivotally connected to shaft **238** by pin **242***c*, while the other rod eye **242***b* is pivotally connected to the mounting plate **33** by pin **242***d.*

A resilient surfaced ink transfer roller **244** is rotatably journaled in bushings **250** extending through side frames **26** and **28** in a position adjacent the ink reservoir **232** and defines one side thereof. Doctor blade **239** extends outwardly from the surface of shaft **238** whereby the radius from the center of the shaft **238** to the edge **239***a* of the doctor blade **239** is greater than the radius of the shaft **238.** It should be readily apparent in FIG. XXII of the drawing that the adjustment screw **242** may be rotated for adjusting the pressure between the edge **239***a* of the doctor blade **239** and the surface of the ink transfer roller **244.**

As ink transfer roller **244** rotates through the ink **234** downwardly toward the doctor blade **239** a metered film of ink **244***a* adheres to the surface thereof. The function of the adjustable doctor blade is to meter or regulate the ink film thickness. Therefore, the doctor blade **239** is a coarse metering device for measuring ink distribution to the transfer roller **244.**

Eccentric **240** is a means for adjusting the distance between the center of shaft **238** and the center of ink transfer roller **244**; and, therefore, is also a means for adjusting the pressure between the edge **239***a* of doctor blade **239** and the surface of transfer roller **244.** Uneven adjustment of eccentrics **240** at opposite ends of shaft **238** adjusts the thickness of ink film **244***a* laterally along the length of roller **244.** After lateral distribution has been attained, adjustment screw **242** is utilized to vary the thickness of film **244***a* while leaving lateral distribution undisturbed.

Applicator roller **246** is in rolling pressure contact with transfer roller **244.** Consequently, the ink film **244***a* will be split, according to the theory commonly referred to as the equal split theory, whereby ink film **244***b* on the ink transfer roller **244** and the ink film **246***a* on the applicator roller **246** will be of substantially the same thickness.

Applicator roller **246** is also in rolling contact with the raised ink pad **44** on the plate cylinder **38,** thereby resulting in a split of the ink film **246***a* into film **246***b* on the applicator roller **246** and a film **44***a* on the ink pad **44.** It should be noted, as heretofore pointed out in the description of the plate cylinder **38,** that applicator roller **246** applies ink to the raised ink pad **44;** however, plate **40** which is not raised does not contact applicator roller **246.** Consequently the primary inker **32** is in contact with and applies ink only to the raised ink pad **44** and not to the plate **40.**

The applicator roller **246** and transfer roller **244** are geared together, as will be hereinafter explained and consequently rotate at the same speed while the gearing is such that plate cylinder **38** may rotate at a different speed. By increasing or decreasing sped of rotation of the applicator roller **246,** the thickness of the ink film **44***a* may be varied. The thickness of the ink film-**44***a*, therefore, regulated through a coarse adjustment by varying the pressure of doctor blade **239** on the transfer roller **244** while fine regulation is achieved by varying the surface speed of the applicator roller **246** relative to the surface speed of ink pad **44.**

As best seen in FIG. XXV, ink transfer roller **244** is rigidly mounted on shaft **248** which is journaled in bushing **250** in the side frames **26** and **28** of each printing tower **18** and **20.** Shaft **248** extends through the operator-side side frame **26** and has a gear **252** rigidly connected thereto which meshes with and is driven by gear **254** rigidly secured to the shaft **256** of a variable ratio gear box **258** which is driven by conventional power take-off means synchronized to press speed.

From the foregoing it should be apparent that while speed of transfer roller **244** is variable, once a desired ratio of speed of the transfer roller **244** relative to the speed of the plate cylinder has been established, thereby regulating the ink film **44***a* at a desired thickness, changes in the speed of the plate cylinder **38** will result in a corresponding change in the speed of the ink transfer roller **244** and applicator roller **246,** thereby maintaining a desired thickness of the ink film **44***a.*

A hanger **260** is pivotally mounted on bushing **250** and supports an eccentric bushing **262** in the opposite end thereof, having a shaft **264** on which the applicator roller **246** is mounted. Hanger **260** is rotated by an actuating cylinder **261** against a positive adjustable stop

261*a*, thereby controlling contacting pressure between the ink pad and applicator roller **246.** Timing gears **265** and **266** are mounted on shafts **248** and **264** respectively whereby rotation of the applicator roller **246** is imparted by rotation of the transfer roller **244.**

The particular modification of the primary inker allows the transfer roller **244** and the applicator roller **246** to rotate in a driving relationship at substantially the same surface speed, having a speed determined by the variable ratio drive gear box **258.** This allows applicator roller **246** to slip relative to ink pad **44,** furnishing a fine metering device for precisely regulating the thickness of the ink film **44***a*.

If it is deemed more desirable to do so, timing gear **265** may be placed on the plate cylinder **38** thereby causing the applicator roller **246** and the plate cylinder **38** to rotate in a driving relationship. This also allows a fine regulation of the film thickness **44***a* by slipping transfer roller **244** relative to applicator roller **246.** In this case the applicator merely serves as an idler.

Although the transfer roller is shown and described with applicator roller between it and the plate cylinder **38,** it should be understood that if the primary inker were placed on the other side of the plate cylinder, an applicator roller **246** would be unnecessary and transfer roller **244** would directly contact the raised ink pad **44.**

Utilization of the ink pad **44,** the surface of which is raised above the plate surface **40,** eliminates the requirement for oscillating the applicator roller away from the plate as the plate approaches this roller. Oscillation would necessarily be required if ink pad and plate were on the same level so that only the applicator roller contacts the ink pad surface.

As best illustrated in FIG. XXXIII, a bridge roller **246***b*, positioned to transfer ink from the ink coated applicator roller **246** to form roller **296** of the secondary inker, is employed if insufficient ink is delivered to the form rollers **290–296** by ink pad **44** to prevent one turn roller streaks.

In the form of primary inker illustrated in FIG. XXXIII, a roller **246***t* is employed in rolling contact with applicator roller **246.** Dual ductor rollers **244***m* and **244***n* are rotatably secured to an oscillating arm **244***p* which is moved by a cam **244***r* causing surfaces of ductor rollers **244***m* and **244***n* to alternately contact surfaces of transfer roller **244** and roller **246***t*. The rate of rotation of cam **244***r*, preferably driven by the press determines the rate of oscillation of rollers **244***m* and **244***n*. Transfer roller **244** is driven by a variable ratio gear box as hereinbefore described such that the speed of applicator roller **244** is changed linearly or nonlinearly with changes in press speed. The speed ratio may be manually adjusted to provide optimum ink coverage at any press speed.

In the lower primary inker an additional roller **246***t* is positioned between roller **246***t* and applicator roller **246** to maintain directional rotation of the rollers.

Instances in which it is not deemed expedient to utilize the raised ink pad, ink pad **44** may be lowered thereby causing the outer surface of the ink pad to be the same radial distance from the center of plate cylinder **38** as the radial distance from the center of the plate cylinder to the outer surface of the plate **40.** If the ink pad **44** is not raised, applicator roller **246** may be mounted on a shaft **272,** thereby then acting as an oscillating roller, as shown in the modified form of FIG. XXVI. A rotatable cam **276,** geared to the press drive, is provided for alternately shifting the applicator roller **246** between the transfer roller **244** and the ink pad **44.** Bell crank **270** carries a cam follower **274** on the lower end thereof and such follower is spring urged into contact with the surface of a cam **276** by spring **278.** It will be apparent that as the larger radius **276***a* of the cam **276** contacts the cam follower **274** the applicator roller **246** will be pushed into pressure contact with the ink pad **44** and that when the cam follower **274** engages the reduced radius **276***b* of the cam **276,** the spring **278** will push the applicator roller **246** into contact with the transfer roller **244.** Thereby the applicator roller **246** alternately contacts the ink pad **44** and the transfer roller **244** to transfer ink from the transfer roller **244** to the ink pad **44.**

The applicator roller **246** is in pressure contact with transfer roller **244** when the plate **40** is in a position adjacent applicator roller **246.** As the ink pad **44** is rotated adjacent applicator roller **246,** the said roller will oscillate onto the ink pad **44** to replenish ink thereto.

The purpose of the ink pad **44** is to facilitate even distribution of the ink film over form rollers of the secondary inker and to allow time for recovery of the ink film on the forms after they have been partially depleted of ink by the passing of the plate **40** thereover. The ink pad acts as a ductor which is partially depleted of ink by the passing of the forms, the ink being replenished by the primary inker. The use of conventional keys on the rigid doctor blade **239** is not necessary under normal operating conditions. However, it may be deemed expedient, without deterring from the plate cylinder and secondary inker arrangement, to utilize conventional keys or adjusting screws **280** which are positioed in spaced apart relation along the length of a conventional ink fountain doctor blade **282** for varying the pressure at particular locations along the length of the blade with respect to transfer roller **244.** Such a result may be accomplished utilizing a conventional blade support assembly of the type shown in FIG. XXVI for distributing ink over ink pad **44.**

SECONDARY INKER

Referring to FIGS. V, XXII, XXIII and XXIV of the drawing, the secondary inker, generally designated by numeral **34,** includes a plurality of form rollers **290, 292, 294** and **296** rotatably journaled in eccentric **300** adjustably secured to from roll hangers **290***a*, **292***a*, **294***a* and **296***a*. Cap screws **300***a*, extending through a threaded opening in an outwardly extending portion of each form roll hanger **290***a*, **292***a*, **294***a* and **296***a*, may be loosened, allowing rotation of the eccentrics **300** by inserting a pin wrench into holes **300***b* in each eccentric bearing **300,** thereby adjusting pressure between each form roller **290** through **296** and vibrator rollers **306** and **310.** Eccentric bushings **262** in the primary inker are similar in construction to bearings **300** in the secondary inker.

Ink is fed to the ink pad **44,** as hereinbefore described, by the primary inker **32.** The ink film **44***a* on the ink pad **44** is distributed over form rollers **290** through **296,** each having a resilient ink receptive surface. The vibrator rollers **306, 308** and **310,** usually metal, and having a smooth ink receptive surface, impart a smooth, churning action to the ink film on the said form rollers to minimize irregularities that may

form in the ink film thereon. The ink film transferred from the pad **44** to the forms must go through this experience prior to being applied to the plate **40.** Vibrator rollers serve not only to laterally smooth ink films on the form rolls but also serve as momentary storage rolls replenishing form rolls of ink removed therefrom until the ink storage pad can fully recharge the form roll at the beginning of the inking cycle. They also serve to drive form rollers at press speed, especially when forms are in plate gap areas.

Vibrator rollers **306** and **310** are mounted on shafts **312** and **314** respectively and when rotated are translated axially by conventional vibrator boxes **316** which use a worm, worm gear and cam linked to the inker or press frame for providing translating motion.

Each form roll **290** through **296** is rotatably journaled on separate form roll hangers **290***a*, **292***a*, **294***a* and **296***a* respectively which are rotatably journaled on sleeves **311** and **313** around the shafts **312** and **314** of vibrator rollers **306** and **310.** Each form roll hanger **292***a*–**296***a* is adjustably secured to actuator plate **304** by bolt **298***b* in an elongated slot **298***c* whereby pressure between each form roller and the plate cylinder **38** may be adjusted. To vary the pressure, bolt **298***b* may be loosened whereby the form roller hangers **292***a*–**296***a* may be pivoted by turning adjusting screws **298***d* rigidly secured to the actuator plate **304** and block **298***e*. From FIG. XXII of the drawing, it is apparent that tightening adjustment screw **298***d* will rotate form roller hanger **292***a*–**196***a* and consequently the form roller toward plate cylinder **38.** When proper pressure is achieved, bolt **298***b* may be tightened, locking the form roller in the desired position.

Actuator plate **304** is pivotally mounted and rotates about shaft **312.** Actuator cylinder **318** may be utilized for throwing the secondary inker **34** on or off. In FIG. XXII of the drawing it should be apparent that retraction of the piston rod of cylinder **318** will rotate actuator plate **304,** causing form rollers **292, 294** and **296** to be separated from the surface of plate cylinder **38.**

Multiple form rollers serve to smooth out the layer of ink to the plate **40** and multiple diameters serve to minimize any visible trace of one revolution pattern between the robles and the place.

Vibrator roller **306** is driven by timing belt **305** on thb drive side of the press and timing belt **307** on the end of shaft **312,** connected to vibrator roller **306,** transmits motion to vibrator roller **310.** Roller **308** is a self-actuating vibrator and serves to connect roller **292** to **294.** Gearing is selected so that all rolls of the secondary inker travel at substantially the same surface speed as the plate surface.

From the foregoing it should be readily apparent that I have developed a new and novel inking system comprising a primary inker which delivers a regulated ink film **44***a* to ink pad **44** of plate cylinder **38,** which in turn is transmitted to form rollers **290–296** and subsequently to plate **40** attached to plate cylinder **38.** Because the length of the ink pad is made equal to, or greater than, the circumference of the largest form roll, all form rolls turn at least one revolution on the pad and become fully replenished of ink after contact with the plate.

DAMPENER

Dampener **36** includes a reservoir **330** for dampening fluid having a resilient covered metering roll **332** rotatably submerged therein which is in rolling pressure contact with a chrome-plated hydrophilic transfer roll **334** which is also in rolling pressure contact with form roll **290** for providing dampening fluid thereto. Dampener **36** is preferably of the typh disclosed in my U.S. Pat. No. 3,168,037, issued Feb. 2, 1965, entitled "Means for Dampening Lithographic Offset Printing Plates."

Dampener actuator cylinder **336** is connected to the metering and transfer roller hanger **338** which is pivotally mounted at the centerline of metering roller **332.** The form roll hanger **290***a* which supports form roll **290** is connected to the hanger **228,** supporting chrome-plated transfer roller **334** by turnbuckle **338.** Referring to FIG. XXII, it should be apparent that actuation of cylinder **336** rotates hanger **338** and hanger **290***a*, thereby separating form roller **290** from plate cylinder **38.** The link is so positioned that the transfer roller **334** also separates from form roller **290** as cylinder **336** is actuated.

The dampener drive is individually driven and controlled. The drive is variable speed with controls at each station and remote controls at a console or master station, and speed indication (which indicates) moisture transfer) and trim controls at the delivery end of the printing system. However, other types of conventional dampeners could be employed.

HYDROSTATIC BEARER

As hereinbefore pointed out in the description of the plate cylinders **38** and the blanket cylinders **48,** the massive bearers which are universally used to prevent vibration of the plate cylinders and the blanket cylinders when the cutaway portions wherein come into rolling contact have been eliminated. As best seen in FIGS. XI–XVI of the drawing, a hydrostatic bearer bearing **46** is utilized for radially encompassing the shaft **38***a* at each end of each plate cylinder **38** and each blanket cylinder **48** in the side walls **26** and **28** of each printing tower **18** and **20.**

Each hydrostatic bearer bearing **46** consists of a bushing **27, 27***a*, **29** and **29***a* which may have inside and outside diameters either concentric or eccentric, depending upon which cylinder is journaled therein. Bushing **27***a* and **29***a*, in which the upper and lower blanket cylinders **48U** and **48L** are journaled, are eccentric as hereinbefore described and are rotated by the throw-orf mechanism.

Each bushing **27, 27***a*, **29** and **29***a* has a multipli-city of recessed areas **344** cut away from the inner surface thereof as best seen in FIGS. XIII–XVI. While any number and any configuration of recesses may be utilized which provides the best result for a specific situation, depending upon the size and loading of the cylinders, the particular embodiment illustrated in the drawing consists of four substantially rectangular indentions in the inner face of each bushing **27, 27***a*, **29** and **29***a* which are equally spaced and diametrically opposed. Each recessed area **344** has an inlet port **346** centrally located therein which communicates with a flexible branch line **348.** Each branch line **348** has a pressure gauge **350** and a valve **352** mounted therein, whereby the pressure and flow rate of oil to each recessed area **344** may be closely regulated. Branch lines **348** communicate through a suitable connection **356** with a trunk line **358** which in turn communicates through a suitable connection **360** with a supply line **362.** A pres-

sure gauge **364** and valve **366** are positioned in supply line **362** for regulating pressure and flow rate of oil delivered by pump **368** from reservoir **370** through the supply line **362.**

A modified form of the hydrostatic bearer is illustrated in FIGS. XXIX and XXX wherein each bushing **27, 27***a*, **29** and **29***a* has a smooth bore **372***d* formed in the outer end thereof. Each bore **372***d* has a shoulder **372***e* at the inner end thereof against which a sleeve **372***f* is positioned in abutting relation. Spaced recessed areas **344'** extend through walls of sleeve **372***f* and are positionable relative to fluid inlet ports **346***p* to permit circulation of fluid as heeinbefore described toward outlet ports **347***p*.

Provision of sleeves **372***f* allows fabrication of bushings **27, 27***a*, **29** and **29***a* in segments which can be modified or replaced without replacing the entire assembly.

Sleeves **372***f* are secured in position by any suitable means. However, in the preferred form the sleee is secured by a shrink fit.

From the foregoing it should be readily apparent that the pump **368** provides oil or other suitable hydraulic fluid under pressure in regulated quantities through supply line **362** to trunk line **358** through the flexible branch line **348** to inlet port **346** of the recesses **344.**

Seals **372** are positioned in spaced apart relation in annular grooves **372***a*, whereby oil delivered to recesses **344** is captured therebetween. Outlet ports **374** are positioned in communication with annular grooves **372***a* for removing low pressure oil from each bushing through return line **376** communicating therewith. A heat exchanger **378** is provided in return line **376** for cooling the oil which has been circulated through each bearing **27, 27***a*, **29** and **29***a*. Oil from the heat exchanger **378** is returned to reservoir **370,** thereby completing the cycle through the hydraulic system.

Additional check valves, pressure gauges, filters and the like may be provided to solve problems encountered in specific situations.

Inlet port **346** and outlet port **374** may be positioned in any suitable configuration depending upon space requirements.

In view of the fact that the loading on the plate cylinders and blanket cylinders is small compared to pressure maintained in the vicinity of recesses **344,** the hydrostatic bearer, hereinbefore described, provides a very stiff bearing which is virtually free from wear, having a starting torque which is negligible. Virtually friction free rotation may be achieved, although the difference in the outside diamenter of the journal of the shaft and the inside diameter of each bushing **46** is very slight, having clearances of a few thousandths of an inch which results in a cylinder without wobble and having sufficient stiffness to eliminate bearers heretofore employed.

Bushings **27, 27***a*, **29** and **29***a* are very short in length relative to the distance between side frames **26** and **28** relative to the journal diameter of the cylinder ends. Therefore, exact alignment of said bushings in opposite side frames is not necessary to prevent binding between the journal and the bushing. Also closer fit of bearing to journal can be accomplished, thereby increasing stiffness, when narrow bearings are used because deflection of journals **38***a*, **38***b*, **48***a* and **48***b*, when loaded, is negligible.

By utilzing large rigid journals on the ends of the printing cylinders, by minimizing long widths, by using materials for both journal and bearing having nearly equal thermal expansion coefficients, and by preloading the journal in the center of the bearing with a controlled pressure, oil flow rate, and temperature, I have achieved virtually the ultimate in obtaining a very stiff, long life, low starting torque self-aligning, totally enclosed bearing which serves also as a hydro-bearer. I have disproved that the rule of thumb used by the industry for determining bearing clearances (0.001 inches/inch diameter) can be reduced substantially to one-fourth (0.00025 inches/inch diameter) without causing any adverse affects whatsoever.

I have eliminated not only bearers, but also problems relating thereto, such as setting bearer presures and forcing conventional bearings and cylinder journals into an abnormal position which contributes to cylinder fatigue, short bearing life and costly maintenance.

Utlization of materials having equal coefficients of thermal expansion, such as cast iron for bushings **27, 27***a*, **29** and **29***a* and steel for journals **38***a*, **38***b*, **48***a* and **48***b*, results in expansion of the hole in said bushings at the same rate of expansion as the journals, thereby resulting in uniformity of allowance between journal and bushing regardless of temperature increase or decrease of the members.

The use of the hydrostatic bearers is especially important in the press described herein, because it is important that wobble and drag be reduced to a minimum in order to effect perfect registry, controlled cutoff and inter-unit synchronization provided by this improved press.

From the foregoing it should be readily apparent that I have developed an improved printing press which is simple in design and operation and offers high speed production while simultaneously achieving the high quality. I have developed a multicolor perfecting capability which includes a new combination of improved components comprising a hydrostatic bearing, a load sharing and inter-unit synchronizing system plus a new and improved ink fountain, a novel plate cylinder and blanket cylinder having a cooperative relationship for providing a uniform distribution of the ink film for replenishing the ink, after each printing cycle, in accordance with demands of the blanket cylinder where printing is accomplished. A novel sheet transfer mechanism incorporated herein eleiminates numerous printing problems heretofore encountered, while providing a sheet-fed printing press having all the advantages of a sheetfed press and of a web-fed press in a single unit which most effectively utilizes the improved inker in the lithographic process.

The press is versatile in that it may be adapted for perfecting, single side printing, or two sheets may be printed simultaneously.

While any one of the improved components which I have developed may be used individually or in combination for improving printing presses heretofore developed, best results are accomplished by combining the aforesaid improvements in a single printing press of the type hereinbefore described.

OPERATION

Having described a suitable embodiment of my invention, a mode of operation is as follows:

The sequence of operation will be described in five steps comprising:

Step 1 - make ready,
Step 2 - primary inker "on,"
Step 3 - dampener "on,"
Step 4 - secondary inker form rollers "on," and
Step 5 -impression "on."

Make ready procedure is substantially the same as that required in the operation of conventional printing presses. Plates **40** must be installed on plate cylinders **38** and blankets **50** must be installed on blanket cylinders **48** with proper packing **38**p and **48**p under each plate **40** and each blanket **50.**

The reservoir of the primary inker **32** and dampener **36** must be filled.

Certain initial adjustments must be made. The pressure between metering roll **332,** chrome transfer roll **334** and form roll **290** must be adjusted to regulate the supply of dampening fluid to the plate, providing uniformly distributed and regulated amounts of moisture to the plate. The approximate speed ratio between transfer roll **334** and form roll **290** must be established for regulating the proper dampening fluid film thickness to the plate.

The pressure between doctor blade **239** and transfer roller **244** of the primary inker **32** must be adjusted for regulating the thickness of film **244***a*. The approximate speed ratio between roller **246** and plate cylinder **38** must be established for regulating the thickness of ink film **44***a* on ink pad **44.**

The pressure between form rolls **290** and **292** and vibrator roller **306** and form rollers **294** and **296** with vibrator roller **310** may be adjusted for providing smooth distribution of ink film **44***a* over said form rollers. Form rolls **290–296** and applicator roll **246** should be properly set to plate and ink pad respectively.

Printing impression pressure may be adjusted by varying the pressure between each blanket cylinder **48** and its adjacent plate cylinder **38,** utilizing adjustment screw **82.**

Sheet pressure may be adjusted for the specific thickness of stock to be run, utilizing paper pressure adjustment **84.**

A stack of sheets **4** is placed upon the skid of feeder mechanism **2.** Make ready is completed by starting the printing units, thereby starting the sheet transfer mechanism **10** synchronized through links **136** and **138** with the individual printing towers **18** and **20,** thereby starting feeder **2** and delivery **22.** When the printing units are started all cylinders, the plate cylinders **38** and blanket cylinders **48,** all form rolls, all vibrator rollers and the sheet transfer mechanism are traveling at reservoirs the same surface speed. When the inker and dampener reserviors are full and the rollers are rotating, step **1,** make ready, is completed.

Step 2 of the operation, primary inker "on," is initiated by actuating cylinder **261,** causing roller **246** to be pivoted in contact with ink pads **44** on plate cylinders **38.** Ink film **44***a* builds up to an equilibrium thickness according to the adjustment of ink fountain doctor blade **239** and according to the speed of transfer roller **246** relative to the speed of plate cylinder **38.**

It should be noted that ink pad **44** is slightly raised relative to plate **40** and consequently the primary inking transfer roller **246** contacts only the ink receptive storage pad **44** while clearing the plate **40** as the respective cylinders rotate. Therefore, the plate **40** does not receive ink from the primary inker **32.**

Step 3, dampener and first form roller of secondary inker "on," is initiated by actuating cylinder **336,** causing form rolls **290** to be pivoted into contact with plates **40** on plate cylinders **38.** The fountain solution is now being distributed to the first inker form rollers **290** and thence to the plate **40** and builds up an equilibrium on the plate **40** according to the dampening metering roll setting to the transfer roll and according to transfer roll's surface speed relative to that of form roll **290.**

It should be noted that form roll **290** contacts the ink pad **44** as well as dampener transfer roll **334** and plate **40,** thereby starting the supply of ink to the remaining secondary inker rollers **292, 294** and **296** and to the plate **40.** Fountain solution and ink is now on the plate where lithography occurs. Plate **40** is cleaned in the non-image areas and inked up in image areas. The remaining form rolls of the secondary inker **34** are now ready to engage plate **40.**

Step 4 of the operation operating secondary inker forms "on," is initiated by actuating cylinder **318,** causing form rollers **292, 294** and **296** to be pivoted into contact with plate **40.** Each form roll **290–296** turns at least one complete revolution on the ink pad **44** prior to engagement with plate **40.**

Multiple form rolls serve to smooth out the layer of ink to the plate and multiple diameters serve to minimize any visible trace of one revolution pattern between the rollers and the plate. Vibrators **306, 308** and **310** serve to laterally smooth ink films on the form rolls and serve as momentary storage rolls, replenishing the form rolls of ink removed therefrom until the ink storage pad **44** can fully recharge the form roll at the beginning of the inking cycle.

As hereinbefore explained, form rolls **292–296** are disengaged from plate **40** and ink storage pad **44** when the secondary inker is off. When the secondary inker forms are on they engage plate **40** and ink storage pad **44.** When the individual printing tower is off impression, the blanket and plate cylinders are separated and the blanket cylinders are separated. After a few revolutions of the plate an equilibrium of ink and water is reached, keeping the non-image area clean and maintaining a fixed quantity of ink on the plate ready for transfer to the blanket **50** when the tower is placed on impression for the printing cycle.

Step 5 of the cycle of operation is impression "on." A sheet from stack **4** in feeder station **2** will be started through the press manually. Blanket cylinders **48** go on automatically and progressively when a sheet is detected at the proper place prior to entering the first printing station. Absence of a sheet at a proper place will stop the feeders and sequentially and progressively throw off the blanket cylinders at each printing station as the last sheet to be printed progresses through the system.

The first sheet **5** is detected by an electrical limit switch (not shown). The electrical limit switch actuates throw-off cylinder **60** simultaneously moving the upper blanket cylinder **48**U and the lower blanket cylinder **48**L into contact with plates **40** on the upper and lower plate cylinders **38**U and **38**L and into contact with sheet **5** as it moves between the blanket cylinders **48**U and **48**L. As the sheet progresses to subsequent printing towers, the blanket cylinders will be engaged in precise synchronization so that the blanket cylinders are

engaged to opposing blankets and their adjacent plate cylinders at the proper time.

Absence of a sheet in its proper place prior to entering the first printing station will cause the first printing station opposing blanket cylinders to separate immediately after the last sheet leaves the blanket nip **50**n. Through synchronization, the following printing stations blanket cylinders separate as this same last sheet leaves the blanket cylinder nip of the respective towers. All units will remain off until the feeding problem is corrected and the feeder is manually started.

After the presence or absence of a sheet is detected the method of blanket cylinder actuation is performed by electrical limit switches, operating by cams synchronized with the system, which operate selector valves, which in turn route oil or air pressure to hydraulic or pneumatic cylinders **60.** The cylinders operate a mechanical linkage, hereinbefore described, which engages the blanket cylinders when a sheet **5** is present or disengages the blanket cylinders when a sheet is not present.

As blanket **50** is moved into contact with plate **40** and sheet **5,** ink is transferred from plate **40** to blanket **50** and offset to sheet **5.** The cycle of inking, dampening and printing with a continuous duty inker and dampener now begins.

After an equilibrium of ink and water is reached on the plate **40** and, therefore, throughout the inking and dampening system, it should be noted that upon going "on impression" any ink or water quantity removed from the plate **40,** caused by transfer to the blanket **50** and thence to the sheet **5,** is immediately replenished by the continuous duty aspects of the inking and dampening system.

It should also be noted that ink removed from blanket **50** by the sheet **5** is replenished by plate **40** while plate **40** is replenished by form rolls **290–296** of the secondary inker **34.** Ink or water removed from forms **290–296** is replenished by the continuous duty dampening system **36,** ink vibrator storage rolls **306, 308** and **310** and ink storage pad **44.** Ink removed from storage pad **44** is replenished by the continuous primary inker **32.**

Form rolls **290–296** of secondary inker **34** are replenished by the ink pad **44,** presenting a fully recovered ink surface to the plate **40** after it has been depleted of ink by blanket **50.** With each cycle of plate cylinder **38,** exactly the same amount of ink which is removed from form rolls **290–296** is replenished.

Minute adjustments may be made at the beginning or during the production run.

As the last sheet from stack **4** leaves feeder station **2** the electrical limit switch will actuate throw-off cylinder **60,** causing the blanket cylinders of the first printing station to separate immediately after the last sheet leaves the blanket nip. Subsequent printing towers will be thrown off impression as the last sheet passes therethrough.

As many towers may be added as may be desired, the two illustrated being simply for illustration purposes. Therefore, as many colors may be printed on one or both sides of the sheet as may be desired, depending upon the number of towers.

Furthermore, any tower or the upper or lower section of any tower may be rendered inoperative for printing simply by leaving the plate off of the selected plate cylinder, in which instance the blanket cylinder associated therewith would serve as an impression cylinder only. Therefore the press may be selectively utilized for printing on one or both sides of the sheet. Perfect registry and cutoff is accomplished by virtue of the continuous sheet conveyor system hereinbefore described.

It will be understood that other and further embodiments of the invention may be devised without departing from the spirit and scope of the appended claims.

I claim:

1. A method of sheet-fed printing comprising, providing a sheet; providing a printing press having at least two adjacent rotatable printing cylinders; positioning the leading edge of a sheet in a gripper element; moving the gripper element toward and between the printing cylinders in a straight line substantially normal to a line intersecting the tangent point of the cylinders and the longitudinal axes thereof; printing on both sides of the sheet carried by the gripper element at substantially the same instant; and moving the gripper element away from the printing cylinders in a substantially straight line to disengage the sheet from surfaces of each of the printing cylinders whereby the sheet when passing between the cylinders is maintained in substantial line contact with the cylinders.

2. The method of claim **1** with the addition of the step of shielding the sheet adjacent opposite sides of the path along which the gripper element is moved to prevent movement of air currents transversely of the direction of travel of the sheet.

3. A method of printing on a sheet as said sheet is moved between adjacent rotating printing and impression cylinders comprisng steps of, providing a sheet having a length which is less than the circumference of the printing cylinder; attaching the sheet in a gripper element adjacent the leading edge of the sheet; moving a conveyor at a uniform speed in non-driving relation to printing and impression cylinders to move the gripper element; guiding the gripper element toward, between and away from the printing cylinder and the impression cylinder such that the sheet substantially bisects the cusp area formed by adjacent converging surfaces of the printing and impression cylinders; and printing on the sheet as it is moved between the printing cylinder and the impression cylinder.

4. A method of printing comprising the steps of: positioning the leading edge of a sheet in a gripper element; moving the gripper element along a substantially straight path toward, through and away from a plurality of printing stations whereby the sheet when passing between adjacent cylinders in thh printing station is maintained substantially in line contact with the cylinders; urging the gripper element laterally across the path into engagement with an indexing surface adjacent each printing station; and disengaging the leading edge of the sheet from the gripper element after the sheet has been moved through each of the printing stations.

5. A method of transferring sheets to, through and out of a printing nip between a pair of adjacent cylinders, at least one of which has a longitudinally extending gap formed therein comprising the steps of: rotating an endless flexible tape having spaced gripper elements secured thereto such that each gripper element moves along substantially straight tracks passing adjacent opposite ends of the printing nip; restraining each gripper element against longitudinal movement transversally of one of the tracks; rotating the cylinders such that each

gripper element passing therebetween will be positioned in a longitudinally extending gap; positioning the leading edge of a sheet in a gripper element such that movement of the gripper element will transfer the sheet to, through and out of the printing nip; and disengaging the leading edge of a sheet from the gripper element after the sheet has moved out of the printing nip.

* * * * *