WORLDWIDE STATUS AND PROGRESS OF LITHOGRAPHIC KEYLESS INKING TECHNOLOGIES

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Abstract: Evolution of the lithographic process towards simpler press operation using keyless inking has achieved reality. Successful field trials during the past five years in widely dispersed regions of the world have reinforced perceived customer interest in keyless lithography, particularly for newspaper publishing.

The largest number of unit orders and operating installations are for Japanese newspaper production. Two European installations have been completed and orders for keyless lithographic presses in U.S. have been announced.

Keyless lithography has been under active development for at least a decade, principally in the United States, Germany, and Japan. Although the basic lithographic process remains the same, its implementation requires new systems considerations. New materials are required. New equipment must be designed. For these reasons, development by different press manufacturers has involved distinctly different directions, a situation unlike conventional lithography.

Understanding the systems aspects of keyless lithography promises to significantly advance the industry's overall understanding and control of the lithographic process.

Product Development Status

Keyless lithography is being developed by printing press manufacturers; not by paper, ink or other consumables suppliers; not by printing and publishing companies,

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not by graphic arts technical centers. This circumstance is not surprising. Keyless inking involves significant changes to some of the lithographic printing press components. Anyone not already a press manufacturer is not likely to succeed in implementing those changes.

The active developers of keyless lithographic printing presses are beginning to learn another factor. Understanding the very nature of lithography is also required or keyless inking does not work. Hopefully, today's increased development pace infers that press manufacturers have begun to accept ownership of printing process technologies that goes beyond sideframes, bearings, rollers, nuts and bolts.

Of equal significance is the fact that virtually all of the active developments in keyless printing systems, whether letterpress, flexography or lithography, have been field-tested and marketed to or in cooperation with newspaper and insert printers. Reasons for this fact will become evident in subsequent sections of this report.

Currently there are 99 installed keyless lithographic printing units, Figure 1, most of them running in daily newspaper production, 90 in Japan and 9 in Germany. An additional 152 units are on order, 20 of which are destined for a site in the U.S.*

Mitsubishi Heavy Industries is the current market leader with a total of 126 units installed or on order, Figure 1. Ikegai-Goss (a Rockwell International joint venture) is second with 50, Koebau-Albert third with 47 and Tokyo Kikai Seisakusho is fourth with 28.

Man-Roland announced availability of a keyless lithographic product at Newstec '88 (Anon, 1988A) and Wifag infers they, too, are developing (Strickler, 1988; Gertsch, 1988). Solna and Crabtree-Vickers had keyless litho printing sites within the recent past but neither company seems to be active currently (Anon, 1982; Brown, 1986; Edgar, 1984). Publishers Equipment Corporation (PEC) were active recently, possibly related to the purchase of Print King from Solna in 1984, combined with a Warner-like technology (Anon, 1984A). At least one patent evolved from that effort (Moll, 1986). PEC product announcements have not been made.

* Half decks not included in these figures.

Advantages Expected From Keyless Inking In Lithography

A major perceived advantage is less variation in printed quality than the conventional, keyed counterpart, Figure 2. No one has yet demonstrated a vastly improved quality level by removing the ink-adjustment hardware. However, it has been amply demonstrated that once a keyed press is running at some acceptable quality level, the output from then on is more consistent when operator ink adjustments are not allowed (Fadner, 1988). So, we expect more consistent printed quality from keyless inkers and that is a quality improvement.

Another, directly-related, advantage is less manpower dependence. Not only can less manpower be used but fewer product rejects and less downtime due to human error are expected. Skilled labor is scarce and even the most skilled pressman cannot comprehend optimizing a process that none of us can yet model completely. With fewer variables to control, manpower-related costs are expected to decrease.

Most of the keyless inking technologies reach steady-state inking conditions rapidly. This translates to less start-up waste. A directly related factor is that hardware and software for adjusting ink input as a function of press speed or of image format are not required. Plate or film scanning devices for presetting of inking keys are no longer necessary.

A sometimes overlooked but distinct advantage of keyless lithography is that it retains all of the major printing advantages of conventional lithography: fast, accurate platemaking, inexpensive plates, excellent printed quality on a variety of substrates, adaptability to electronic prepress systems.

Why Keyless Lithography Is Appearing Now

A number of keyless lithographic presses seem to be available from several regions of the world simultaneously and somewhat suddenly. In reality, the specific developments from the involved companies differ considerably and some have a long history. The corresponding market entries coincide for several reasons, Figure 3:

1. Keyless letterpress operations have been successfully implemented during the past decade, particularly by Crabtree-Vickers, Koenig and Bauer, TKS and Hamada. Owners of high volume letterpress printing operations wanted to improve their production costs without making large capital investments in new printing presses. The success of hundreds of these keyless letterpress installations, including process color, have demonstrated that the operating cost savings and quality constancy are real (Verschuer, 1986; Edgar, 1986).

2. Another keyless process, flexography, has also recently been shown to be a viable option for high speed, high-volume newspaper operations (Rosenberg, 1988; Truitt, 1986).

3. Steps to reduce the dependence of print production operations on skilled manpower and to thereby reduce operator errors are generally well underway in prepress and post-press operations. The printing process itself is the obvious next target.

4. Newspaper printers and publishers are beginning to verbalize their interest in keyless inking as a means to alleviate their cost problems associated with waste, lack of skilled manpower, and for control of color printing in their operations. People in the newspaper industry communicate with their peers in other newspublishing companies at all levels of printing and publishing activities through numerous well-established media organizations. This is unlike most of the commercial printing industry. Consequently, many newspaper customers express similar needs to virtually all of their suppliers at nearly the same time. Electronic prepress conversion of newspublishing operations took only about a decade to become commonplace all over the world. It appears now that this could happen with keyless lithography.

Keyless Lithographic Technologies

Five different keyless lithographic technologies have progressed as far as field evaluations, four of them resulted in products currently being sold by four vendors. At least 25 keyless lithography U.S. patents and numerous foreign counterparts have been granted since 1977 to nine different organizations, Figure 4. Some of these

patents disclose unique product features which, if viable in the customer's hands, could create proprietary positions for the patent owners. This potentially proprietary situation is a significant departure from that for conventional lithography where anybody with machine skills and financial resources can manufacture a printing press just like his competitors, and they do.

Dahlgren Newsprinter: One of the exceptions to research on keyless lithography being the domain of press manufacturers is the Dahlgren Company. Harold Dahlgren, known primarily for his success with retrofit dampeners, was the author or coauthor of at least eight U.S. patents disclosing various elements of a rather complicated keyless inking system (Dahlgren, 1977). Public product announcements were made in 1981 (Anon, 1981). At one of the long-surviving domestic test sites, the Green Bay (WI) Post Gazette, four couples of a Goss Mark I letterpress that had been converted to Dilitho operation were further modified in 1980 to incorporate Dahlgren keyless inkers. These inkers were used for production, at least through 1985, but have since been converted back to conventional keyed inking. The system was reported to be finicky and too sensitive to control. It did produce improved quality when adjusted properly.

Dahlgren dampeners and keyless inkers had been sold to and installed at a number of other Dilitho sites, particularly in Europe. Their present fate is unknown.

As with his successful dampener, Dahlgren's approach to a new inker centered around the use of an existing form roller on an existing press. The Green Bay Post Gazette system, Figure 5, had ink input rollers 1 and 2 running at a fixed ratio to one another but at an operator-controlled variable speed relative to the press speed, which establishes a controllably-variable ink film thickness on Roller 2. Roller 3 is in contact with slow roller 2 and press-speed, ink-form roller 4 but is not driven, allowing it to slip at some intermediate speed, providing a uniform cross-press ink film to form roller 4. The form roller rotationally next encounters the slow-moving chrome roller 5 of the dampener, which also slips relative to the form roller and provides water to the ink film, like Dahlgren's well-known ink-form-roller dampeners. Vibrator roller 6, operating on the ink and water form roller film(s) probably serves to help mix the fluids so that water does not interfere with inking the plate. At Green Bay, very

high amounts of dampener concentrate were required to assure acceptable differentiation at the plate, up to seven times normal.

After simultaneous inking and dampening of the plate, the form roller encounters a press-speed, vibrated (oscillated), doctor-blade-scraped, rubber rider roller (7) that removes about half of the unused ink/water film from the form roller. Most of this split-off film is removed by the doctor blade and dropped back into the approximately one gallon ink reservoir for recirculation to input rollers 1 and 2. Fresh ink is added to the reservoir based on a signal from a level sensor.

One perceived advantage of the Dahlgren system is that much of the format and cross press dampening water variation memory is removed by the scraped rider roller, consequently a relatively uniform input ink film is continuously presented to the plate. Also, the system has some degree of overall printed shade control (ink film thickness control) by varying the speed of the two ink input rollers relative to the press speed. A practical advantage is the use of small ink volumes at the press.

An apparent disadvantage is the use of three slip nips, each of which can cause cross-press streaking, all of which need operator attention to control. Attempting to maintain control of ink film thickness without introducing streaking may be confounding factors in this system. A single inking form roller that also serves as the dampening form roller will result in form-dependent ink/water balance problems, although for many typical newspaper layouts the result is not visible in the print. At Green Bay, free water tended to appear in the ink circulation system for this reason. To help avoid the problem, the ink volume was allowed to decrease near the end of the run, using up the ink/water mixture. The next day could then begin with substantially fresh ink.

No recent Dahlgren Company development activity has been seen in trade or patent literature.

Warner Autolithography: A similar situation to that of Dahlgren Co. confronted Gordon Warner in his attempt to develop keyless lithographic inking before others did so. Warner Color Lab is not a printing press machinery supplier. In such cases, bridging the gap between proof of concept field trials and product production becomes

formidable.

Warner's preferred configuration as disclosed in two patents (15) is shown in Figure 6. He uses a slow-moving rubber ink input roller 1 running against a separately-driven and controllable copper roller 2 which, in turn, runs in a slipping relationship against an undriven rubber roller 3. Roller 3 is also in contact with dampening solution and runs in slipping contact with a special bimetal metering drum 4. In Warner's view, the ink and dampening solution input mechanisms are somewhat incidental because roller 4 takes care of any inconsistencies of water and ink input. Roller 4 has a smooth but patterned surface consisting of 25 to 50 percent chrome or other hydrophilic material regions and 75 to 50 percent copper or other oleophilic material regions. This roller is supposed to pick up ink in its oleophilic regions and water in its hydrophilic regions, then convey both to the form rollers of a conventional press. The printing plate then accepts whatever amounts of the two fluids that it needs from the ink and water portions being presented to it. Roller 4 is perceived to be continually refreshed as it rotates in contact with roller 3, thereby replacing the ink and water used up by the plate.

Warner proceeded as far as modestly successful field trials at Contra Costa Times and Santa Barbara Newspress newspaper sites in California. Activity has waned since about 1984.

Conceptually, this system has very few operator controls, most of which would be automated, according to Warner, providing advantages that the newsprinting industry desires. When combined with some of Warner's other unpublished ideas the system has greater appeal than is apparent here.

Disadvantages are rather severe. A slip nip is again utilized to introduce the slow-moving ink onto a press-speed roller, a situation not conducive to consistent, easily-controlled ink input. Also, no way is provided to independently control the relative amounts of ink and dampening solution input, assuming the bimetal roller functions as stated, except by changing to a differently-patterned roller. More seriously, Warner does not erase the format dependence and water variation memory in the film returning from the plate/form-roller nips.

Consequently, the input ink/water film reflects this return film memory, resulting in format dependent variable printed quality.

Mitsubishi Heavy Industries: Mitsubishi, a large printing press manufacturer in Japan, has marketed the largest number of keyless lithographic printing couples. Their installations at several Yomuiri Shimbun (newspaper) printing sites started in March, 1986 (Oguchi, 1988).

This technology is described in a recent MHI publication (Anon, 1988). As shown in Figure 7, it uses a slow-moving, textured oleophilic ink fountain roller 1 that is conventionally metered by a non-contacting fountain blade to produce an approximately uniform ink film that proceeds to the variable gap nip between it and the press-speed transfer roller 2. Gap adjustment and ink-input roller speed adjustment allows varying the input ink film thickness at roller 2 and therefore to the plate, providing overall shade variation control. Ink from roller 2 transfers to the plate by means of rollers 3, 4 and 5. Copper inking drum 3 has a smoothing roller 6 and rotationally subsequent to the form roller nips has a scraping blade that by removing most of the return ink film disposes of the format and water dependencies in that film. The scraped ink/water mix is dropped directly into the ink-input pan reservoir. In early versions, when the water content of the circulating ink exceeded a tolerable value, it was routed to or taken to a squeeze-roll water removal device. The resulting ink was fed back to the press.

MHI locates the dampener in the traditional direct-to-plate, water-first position, and uses non-contact water input typical of newspaper presses, here depicted as a spiral brush type.

An advantage of this approach includes the fact that much of the press is similar to conventional newspaper presses. Retrofitting is easy and evolutionary changes are modest. All but the ink removal and ink mixing-circulation portions are more-or-less standard. An essential advantage is that this system removes most of the cross-press format and water variations in the return ink film, thereby avoiding that memory showing up as printed quality variations. The system has a variable ink film input feature, allowing overall shade control, considered important in some newspaper markets.

Possible disadvantages include questionable ability to maintain small roller gaps uniformly and consistently across the press width; potential necessity for water-removal treatment of the ink; open on-press handling of relatively viscous ink that is being scraped off of an upper roller.

Mitsubishi has apparently not extensively patented their keyless lithographic inking technologies outside of Japan. They have been granted a patent covering the return ink film removal system (Sakamoto, 1986).

ANPA: The Printing Process Research Group of the American Newspaper Association designed and field-tested the anilox-metering-roller forerunner of several existing keyless letterpress and keyless lithographic inking systems. Their project, started in 1978, represents the only significant recent contribution from a non-profit industry organization to evolution of the printing processes.

As with many of the keyless lithographic systems, keyless letterpress was the basis for the ANPA litho technology (Matalia, 1983). Koenig and Bauer, Crabtree-Vickers and TKS all have marketed keyless letterpress products based essentially on the ANPA technology, probably under ANPA license.

The basic ANPA printing couple, Figure 8, involves a celled printing roller and doctor blade arrangement that is analogous to an anilox roller and blade in flexography but adapted for viscous inks by using more-appropriate metering-roller cell configurations.

Adaptation of their technology by Matalia and Navi to keyless lithography (Matalia, 1983) comprised addition of a pan roller for ink input and of dampening either direct to the plate as shown in Figure 9 or by means of one of the inking form rollers. The field prototype, running since 1982 on a Goss Metro press at Burlington County Times in Wallingboro, N. J., is still used for routine newspaper production. This configuration operates reasonably well but requires close operator attention to sporadic ink/water problems. ANPA has purposely made no major attempts to package a product. The organizational purpose has been fulfilled, namely to demonstrate that celled-roller keyless inking can be done. The technology has been licensed at a nominal fee to about 40

manufacturers (Anon, 1983).

The New York Times briefly investigated the ANPA keyless inking technology in 1984 at a field installation at their Portland, ME site (Anon, 1984B).

The major advantage of the ANPA approach clearly is the automatic, continuous ink feed provided by the metering roller. The rate of ink input increases nearly linearly with press speed, therefore no ink input controls are required. The same statement can be made about flexographic inking but until someone showed that this approach works using viscous oil inks, it remained conjecture. Another major and necessary advantage is continual erasure of most of the cross-press format and water content variations, contained in the unused ink film returning from the plate/form-roller nips, by the refilling/doctoring ink input mechanism. With this short-train inking system, ANPA has employed the closest practical location of the metering roller to the printing plate to help minimize these cross-press ink and water content variations.

Disadvantages of this system are discovered only when attempting to build press products based on the technology. Solna and Crabtree-Vickers attempted doing so and subsequently withdraw their product entries because of dampening water interference with ink input. TKS reported encountering the same problem. Although the celled metering rollers of the ANPA technology are oleophilic and will therefore accept oil-based inks, they are also hydrophilic; the same roller materials are used to meter aqueous flexographic inks. High energy materials such as chromium or nickel or ceramic particles used as the surfaces of anilox metering rollers are wetted by either water or ink. But in the presence of both, the much less viscous component, water, will displace letterpress or lithographic oil inks from the surface of these usefully wear-resistant metering roller materials. Control of inking becomes very difficult and, occasionally, impossible. In some keyless inking systems, the ink/water mixture must be removed and replaced with fresh ink.

A related disadvantage of the ANPA technology is that no means was originally provided to homogenize the scraped-off return ink/water mixture with the fresh input ink to further minimize the adverse effects of water that accumulates in the ink. At Wallingboro, free water could

be seen on top of the ink in the more-or-less static ink catch pan. Circulation was later added by the ANPA group.

TKS: The TKS keyless lithographic product is a direct hybrid of the ANPA technology, with the addition of a two-roller plus blade water removal system and a more-sophisticated ink circulation system, Figure 10. The water removal feature is required to get around the fact that the typical anilox-type metering rollers will be debonded of ink in the presence of dampening water, and a recent U.S. patent has been granted (Harada, 1988). A TKS Japanese patent covers the use of both water and ink input to the ink fountain to be certain that relative contents of the two liquids do not change, for instance, at start up (Satou, 1985). Based on patented technologies, TKS has attempted to develop oleophilic and partially hydrophobic metering rollers (Sato, 1987) but these function with only partial success based on our own early research. We have found that overall hydrophobicity is required.

Advantages are the same as for the ANPA system. Assuming that their composite tungsten carbide/copper metering roller can function without debonding of ink when used together with the mechanical water-removal system, this technology will operate better than the original ANPA system.

Two remaining disadvantages can be cited. First, an at-press or off-press water separation from the oil ink, if required, is a nuisance operation. Second, there has been no indication to date of providing for variable shade control.

TKS has eight keyless lithographic couples installed at Asahi Shimbun, another large Japanese newspaper, running black inks on a production basis with reasonable success. An order for two presses comprising 20 printing units, some of which are to be color, has been placed by the U.S. Star Ledger in Newark, N. J.

Rockwell/Goss/Ikegai: Graphic Systems Division of Rockwell International is the only press manufacturer who has patented a keyless lithographic printing system, rather than only the inker components (Fadner, 1987). Certain features, Figure 11, are of course generic with all of the other lithographic technologies, namely blanket cylinder, plate cylinder, and one or more form rollers. Although a short inking train configurationally similar to

the ANPA technology is depicted as useful (left-hand side), a longer inking train (right hand side) has certain advantages, among which are the ability to take advantage of ink-train dampening.

In this technology, a fully hydrophobic and oleophilic hard, celled metering roller is specified, together with a doctoring blade, so that a constant volume of ink is delivered by the roller regardless of how much water is in the ink. The slow-moving pan roller serves to deliver an excess amount of ink to its juncture with the metering roller. Several hydrophobic/oleophilic ink metering roller technologies have been patented (Fadner, 1986) and research continues into new materials as they are developed.

The Rockwell/Goss system has all the advantages of the ANPA system and none of the major disadvantages because of the proprietary metering roller technologies. No add-on or off-press ink-treating components are required.

A disadvantage is that no provision is made in the disclosed technologies for shade control. The metering roller delivers a fixed quantity of ink.

This technology has been successfully tested in production modes at two domestic and two foreign sites during 1986 and 1987; Memphis Commercial Appeal and New York Times, Asahi Shimbun in Japan and Aftenposten in Norway. Non-production process color printing tests were completed late in 1987 at St. Petersburg Times.

These field tests led to the sale and installation of eleven black-printing press units by Ikegai-Goss in Japan to Asahi Shimbun which have been used in daily production since 1987. Orders in hand bring the total of Ikegai-Goss keyless press units to 50.

Koebau-Albert A510X: Albert-Frankenthal (AF) and Koenig and Bauer (K & B) worked together for a number of years and have recently formed a new company, Koebau-Albert. They have delivered over 100 "short inkers" for anilox letterpress since 1982 (Anon, 1989). Their keyless lithography product development started October 1983 with an ANPA-like approach but with several modifications. K & B supplied the necessary ink chamber and doctor blade technology experience. The AF/K & B design, Figure 12, has an enclosed ink input element that

sequentially scrapes off the return film and returns that ink/water mixture to a circulation system, provides excess fresh (circulated) ink to the "anilox-offset" engraved metering roller, then scrapes off the excess ink as in flexography. The engraved or celled roller transfers the metered and refreshed ink to a single form roller of plate cylinder dimensions (Bolza-Shunemann, 1984), from there to the plate. Dampening is a typical newspaper press style, two roller direct, water-first with separated water input. The perceived requirement for different colored inks at each page position led Koebau-Albert to offer metering roller, blade and ink input elements dimensioned for use in 1, 2, or 4 page variations.

In terms of number of basic press components, this approach represents the simplest product system. The engraved roller journals and drive are designed for easy removal of the roller, allowing fast change to a roller of different cell size, to correct for differing ink characteristics. This feature is probably a carryover from conventional flexographic press features.

The system has been shown at various European Expositions, IFRA, IPEX. The first test unit in a customer's plant was installed at Druck und Verlagshaus in Neu-Isenburg in March 1985. The same location now has two four-high units for process color printing (Anon, 1987). Press orders have been taken from other customers, one each in Germany, Finland and Switzerland.

Advantages of the Koebau-Albert approach include those for the basic ANPA design; continuous metering of a uniform ink film independent of press speed; erasure of cross-press format and water content variations in the return ink film. Recirculation and mixing of the return ink helps to assure uniform ink input composition. Ability to print different colors at different page locations of the same printing couple is certainly an advantage wherever doing so is required. The manufacturer has allowed for variable density capability by designing for fast metering roller changes.

There are several perceived disadvantages. Necessity for removal of a heavy metering roller, depending upon the ink being used might not be acceptable at U.S. newspapers, even if acceptable in Europe. The metering roller technology again involves oleophilic and hydrophilic materials, not hydrophobic, and Koebau-Albert has run

across ink debonding problems. They have patented two methods to try to circumvent this problem. One involves blowing heated air on the celled roller to remove water from it. The other involves a mechanical-squeeze water removal similar to TKS' approach (Grosshauser, 1988).

Issues and Conclusions

As we have reported in previous papers (Chou, 1986; Fadner, 1987; Chou, 1988), inks for keyless lithography must exhibit properties which are different from those usually found in keyed systems. Each of the keyless configurations described in the preceding has been developed within a more or less constrained environment, so each has also been dependent upon sources of inks that were limited by geography and, in some cases, by selected partnering between the press manufacturer, the ink supplier, and the publisher whose site was being used for testing.

Ink suppliers that have not had access to the few keyless presses in operation have therefore not had the opportunity to formulate testable inks. Because of the differences in the implementations of keyless systems by the different manufacturers, it remains to be seen whether or not an ink which has been proven in one system can be equally effective in a different system. Our experience with the equipment in Japan suggests that this will not be the case.

Based on the above, we believe that one of the factors that will pace the movement of keyless lithography into the various world markets will be the rate at which suitable suppliers of ink become available.

A second issue that has the potential for pacing the keyless lithographic market is the degree to which sophisticated controls on a conventional press yield the same benefits we have ascribed to keyless systems.

In the absence of significant reductions in capital cost, which do not appear likely based on the flexographic experience, the efficacy of keyless lithography may well reside in its being able to produce absolutely better print quality rather than just better run-length consistency, Figure 2. The potential for this is present, but has not yet been proven.

A third issue, which is related to the preceding one, is the degree to which prepress work for color reproduction can be and should be modified to account for the fact that ink adjustments can no longer be used to affect color rendition changes on the press. At sites where there is no in-house color separation capability or in situations where identical separations are supplied to multiple sites without regard to the printing process, keyless lithographic reproduction cannot be expected to yield results superior to those obtainable on a conventional keyed press.

The prepress issue is also likely to be the controlling factor in relation to the penetration of keyless lithography into commercial printing. In as much as production color on keyless lithographic presses has been done only since late 1988 at one site (Neu Isenburg), the data available is not sufficient to predict what the impact of this issue might me.

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FIGURE 1

KEYLESS LITHOGRAPHY CUSTOMER BASE

JANUARY, 1989*

SUPPLIER	INSTALLED UNITS	ADDITIONAL UNITS SOLD	TOTALS	GENERAL LOCATION
MITSUBISHI JUKOGYO	71	55	126	JAPAN
IKEGAI-GOSS	11	39	50	JAPAN
KOEBAU-ALBERT	9	38	47	EUROPE
TKS	8	--	8	JAPAN
	--	20	20	U.S.
	99	152	261	

*HALF-DECKS NOT INCLUDED

FIGURE 2

ADVANTAGES OF KEYLESS LITHOGRAPHY

- o IMPROVED UNIFORMITY OF PRINTED QUALITY
- o FAST START-UP, LOW WASTE
- o LESS LABOR INTENSIVE
- o KEYLESS INKING AT LITHOGRAPHIC QUALITY

PERCEIVED REQUIREMENT

- o QUALITY BETTER THAN CONVENTIONAL

FIGURE 3

WHY KEYLESS LITHOGRAPHY IS APPEARING NOW

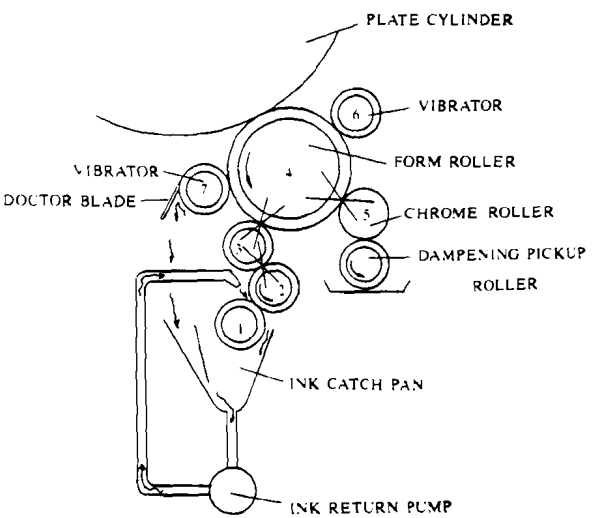
- o NEWSPAPER PUBLISHERS PERCEIVE COST ADVANTAGES.
- o KEYLESS LETTERPRESS RETROFITS HAVE BEEN SUCCESSFUL.
- o FLEXOGRAPHY RETROFITS AND NEW PRESSES HAVE BEEN SUCCESSFUL.
- o PREPRESS AND POSTPRESS OPERATIONS ARE HIGHLY AUTOMATED. THE PRESS IS NOT.

FIGURE 4

KEYLESS LITHOGRAPHY U.S. PATENTS SINCE 1977

	NO. OF U.S. PATENTS	PRODUCT MARKETED
DAHLGREN CO.	9	NO
ROCKWELL/GOSS/IKEGAI	5	YES
TKS	1 (5*)	YES
KOEBAU-ALBERT	3	YES
ANPA	2	NO
WARNER COLOR LAB	2	NO
MITSUBISHI	1	YES
PEC	1	NO
WIFAG	1 (GER)	NO
	25	4

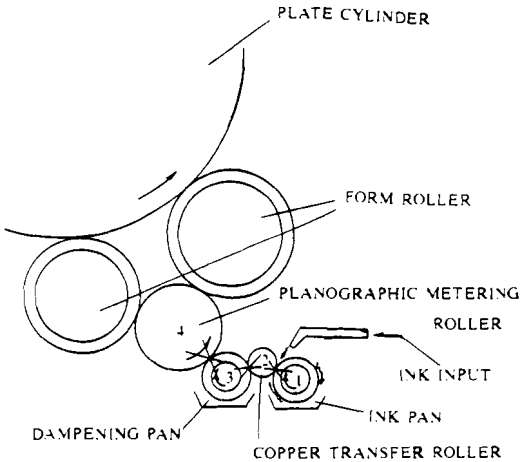
*JAPANESE PATENTS



DAHLGREN KEYLESS LITHOGRAPHY

NEWSPRINTER

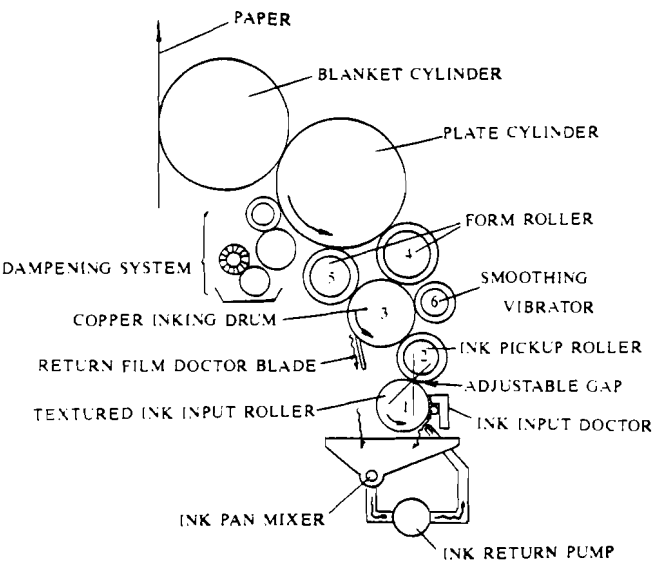
FIGURE 5



WARNER KEYLESS LITHOGRAPHY

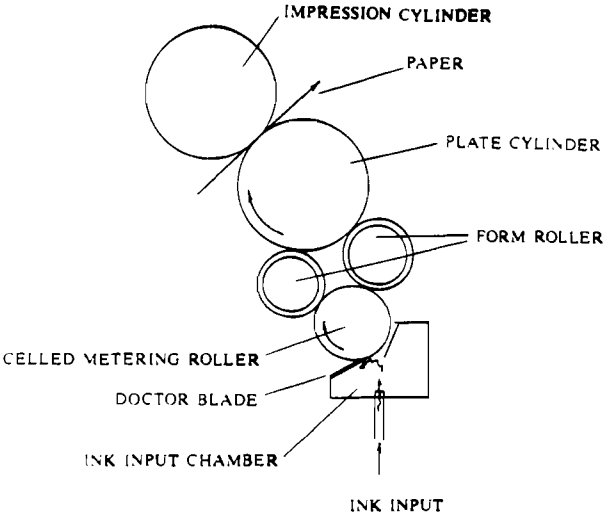
AUTOLITHOGRAPHY

FIGURE 6



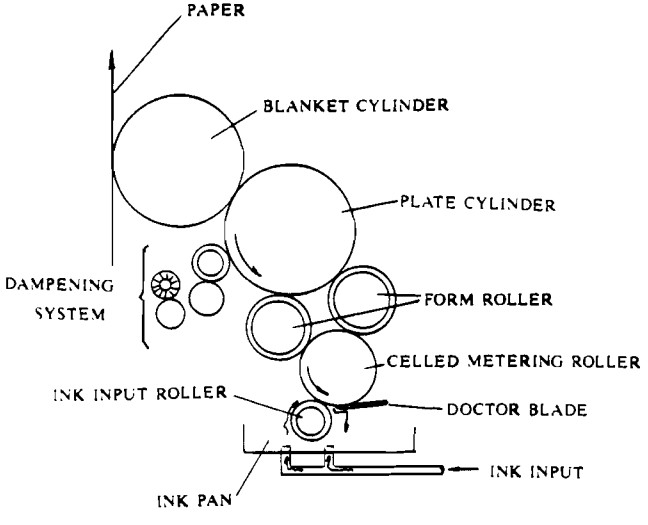
MITSUBISHI KEYLESS LITHOGRAPHY

FIGURE 7



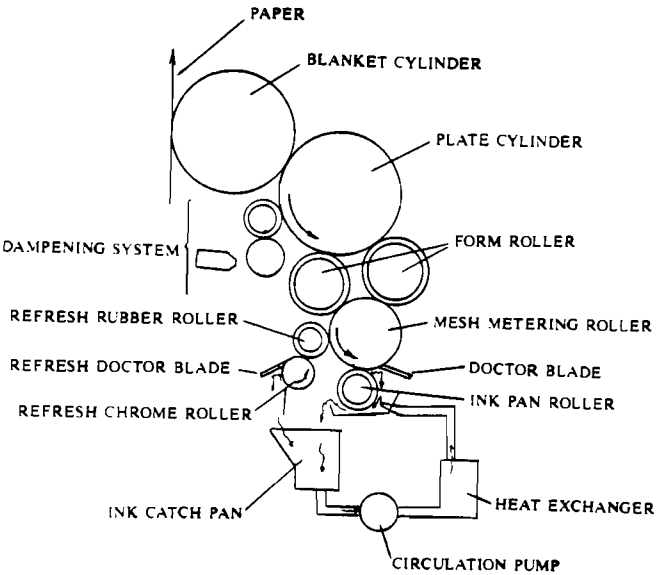
ANPA KEYLESS LETTERPRESS

FIGURE 8



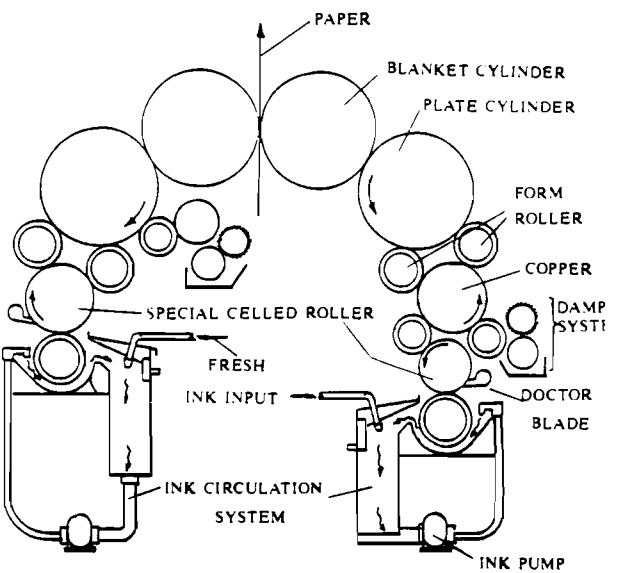
ANPA KEYLESS LITHOGRAPHY

FIGURE 9



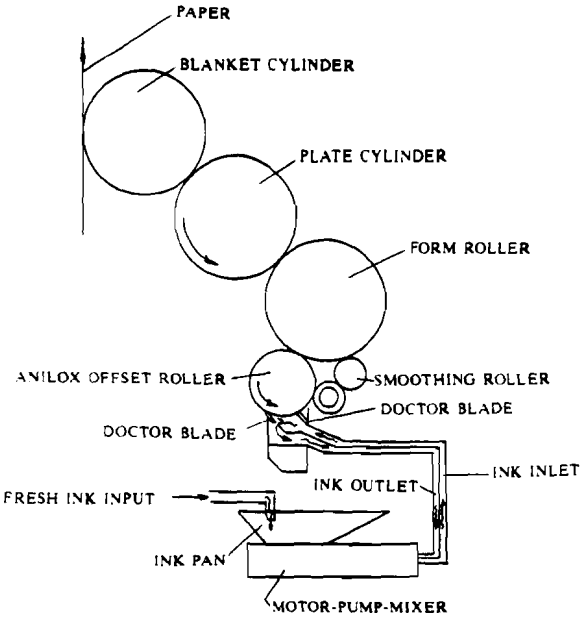
TKS KEYLESS LITHOGRAPHY

FIGURE 10



ROCKWELL-GOSS KEYLESS LITHOGRAPHY

FIGURE 11



KOEBAU-ALBERT KEYLESS LITHOGRAPHY

FIGURE 12