

CTP Productivity and Recorder Design

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Abstract

The first drum recorders and scanners appeared in the 1920's. These devices, built on a lathe bed, imaged manually loaded films. The imaging sources were glow modulator tubes and incandescent lamps with mechanical modulators. During the intervening decades semiconductors, lasers, air bearings, brushless motors, and computers have been used to improve the image quality and productivity of various output devices. In the 1960’s and 70’s, visionaries foresaw the day when lithographic printing plates would be imaged by laser energy modulated by computer generated data. That day has arrived.

Today, newspapers and commercial printers employ automated CTP (Computer To Plate) devices to image metal and plastic printing plates. Several system approaches have been developed, each exploits the characteristics of one of the several plate types that have been introduced. Systems are available that use, UV, visible or IR lasers.

This paper reviews some of the CTP innovations that have evolved to meet the demands for image quality, productivity, reduced cost and environmentally benign operation.

Offset Lithography

Offset Lithography, is a printing process in which the image to be printed is rendered on a flat surface, such as aluminum sheet and treated to repel ink when wetted with a fountain solution. The plate is coated with an ink accepting layer which can be imaged and then developed to selectively reveal the ink repelling surface in the non-image areas. An image is created on the plate by contact printing with a film negative; or plates can be exposed by direct laser imaging.

A film negative containing the image of a pasteup, a representation of the page to be printed is used to contact print a plate. The pasteup is manually assembled from typeset galleys and graphics and then photographed with a process camera to obtain the film. The plate is developed and prepared for press after contact printing.

When computer typesetters were developed in the 1960’s it became possible to create low cost pasteups. These in turn, enabled economic offset printing. Offset lithography and computer typesetting essentially displaced hot metal which had been employed since the time of Gutenberg.

With the development of digital outline fonts, electronic halftoning techniques and pagination software, the labor intensive pasteup is being supplanted by digitally imaged films and plates.

The rule for printing a quality image is hard against soft and soft against hard. An inked image is first offset from the hard printing plate to a compliant blanket and then transferred, or offset, to the sheet. This procedure reduces noise in solid image areas due to paper and plate surface irregularities.

Lithographic Plates

Among the lithographic plates that have been introduced are those with photosensitive, thermal, waterless and ablation coatings. Plates can also be prepared with thermal ablation transfer sheets. Systems that employ ablation plates and thermal ablation transfer sheets are the most environmentally benign. They do not require silver film, and they do not require film and plate processing. However, to date, ablation systems have not gained favor. Ablation systems are expensive, exhibit poor productivity and because of their limited use, the ablation plates are costly.

Plates with photosensitive coatings generally respond to UV radiation. These plates can be handled in a yellow or red safe light and are typically exposed in a vacuum exposure frame. They can also be exposed in a CTP system with a UV laser.

Plates with orthochromatic coatings can be exposed with a FD YAG laser. These plates, which are generally more expensive than photosensitive plates, can be handled in a red safe light.
Plate coatings sensitive to visible light can be exposed with less expensive imaging systems employing HeNe or laser diodes. However, while the imaging systems are less expensive these plates are expensive. Most photosensitive plates require chemical processing after exposure.

The Laser Thermal Printing [1] process consists of focusing the beam of an infrared laser onto a plate coating containing an absorber and a thermally sensitive reagent. The coating absorbs the laser energy and converts it to heat which causes a chemical reaction in the coating. The plate is then processed prior to going to press. Such plates, which can be handled in daylight, exhibit exceptional image quality and can achieve long press runs when baked.

Ablation plates consist of lithographic metal coated with an ink receptive coating that is ablated by a high power laser. These plates have exceptional shelf life and can be handled in daylight. After imaging, the plate is heated to set the residual image layer. Potentially, such plates are economical as no intermediate film or chemical processing is required.

The thermal ablation transfer process involves a plastic film coated with an infra red absorber, a binder and a UV or thermosetting resin. The film with the coating held in intimate contact with the plate by vacuum is then imaged with a high power laser. An energy density of some ten megawatts/cm^2 propels the image coating into the metal. The plate is then heated or exposed to UV radiation to fuse the image.

Waterless plates are coated with an ink repelling silicone coating which is ablated to reveal an ink absorbent layer. After the silicone debris is removed, the plate can be used on press without further processing and without fountain solution.

Productivity

The hour before press start a metropolitan newspaper will typically close 60 to 80 pages. Newspapers are printed on parallel press lines to deliver all the papers in time. Since each page may require four to twenty duplicate plates, a capability must exist to prepare about 1,000 plates an hour. Several automatic plate exposure systems that expose and develop 250 plates/hour are used with the duplicate plates made from one film negative.

Early CTP systems could image but 45 to 60 expensive newspaper plates/hour. Because of the high cost of these devices and the limited production rate, it was thought that CTP was only suitable for the smaller newspapers. These papers use one to four plates per page. As the imaging time for a newspaper page approaches 15 seconds larger newspapers are investigating the economics and benefits of CTP. Figure 1 shows that as the image time decreases, media load/unload time becomes the significant factor limiting productivity. Further, in those systems which employ thermal media, scan efficiency is a major contributor to productivity.

Commercial printers do not require the plate quantity, or duplicate plates required by newspapers. They generally use larger, long run plates with high resolution images. In commercial CTP systems, the load/unload time is less critical than in newspaper systems, but while less critical it can be a significant competitive item.

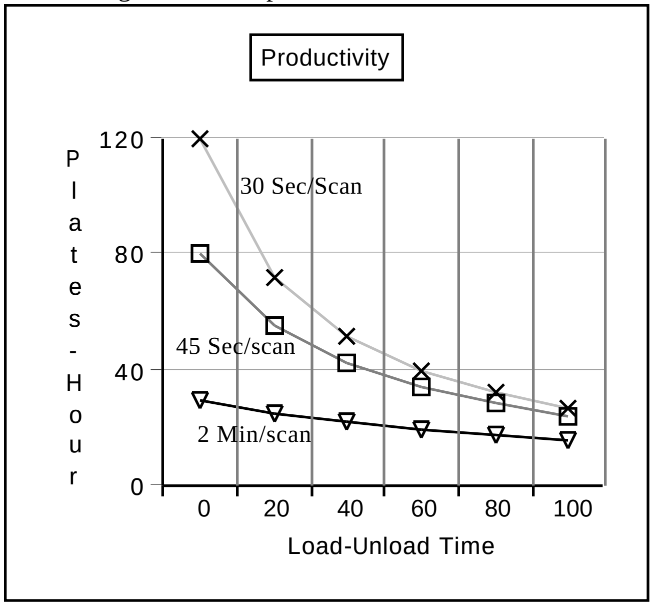

Figure 1. Productivity vs Load/Unload Time

The challenge to the designer of a CTP system is to economically match or exceed the productivity set by the automated plate exposure systems. As one might expect, the challenge has been met by several design approaches.

Recorder History

Phototypesetters which produced pasteup galleys were constructed with glass disks that carried font images. The disks were rotated and translated orthogonal to a capstan driven film transport. At the right positions a xenon lamp flashed a selected font image to the photographic film or paper.

With the development of the laser, the computer and digital type there was a surge of activity leading to the introduction of low cost, small format capstan, line scan recorders for preparing photographic films, paper and plates. These flatbed device employed galvanometer, holographic and multifaceted spinners to generate the scan line. Many sophisticated units used F-theta lenses to linearize the scan. The smaller, low cost, long focal length units with limited scan angles lived with the pixel errors.

In these systems, the film is often backed into the supply cassette or taken up by a loop. It is given a running start before imaging to minimize film waste.

Early imagesetters were plagued by pixel position errors because of motor hunting and bearing noise. Some designs employed hysteresis motors [2] to drive the spinner and achieve constant speed at low cost. Unfortunately, these motors exhibit hunting because of small, random voltage and torque disturbances.

Motor bearings are a significant source of torque disturbance. The balls in a ball bearing are separated by a retainer which over time change contact position with the balls. This in turn introduced the small torque disturbances which lead to pixel position errors.

The maximum line to line position error of an imagesetter is typically specified at an eighth of a pixel. To meet this specification, the velocity error while scanning a 20 line in a 1270 dpi imagesetter must be less than one part in 200,000.

The productivity of a single beam laser recorder improves as spinner speed increases. While early spinners ran at some 3,600 rpm the spinners in new machines run at 30,000 to 60,000 rpm. At these high speeds, optics should be small, symmetrical and balanced so they are not distorted by rotational forces.

The high speed spinner has been made possible by new magnetic materials, short wavelength lasers, small optics, solid state controls and self-generating air bearings.

Solutions to the ball bearing and hysteresis motor problems are non-cogging, brushless DC motors and self-generating air bearings. However, in these bearings, the inner and outer races contact each other as the spinner stops. If the residual momentum during contact is high and debris generated, the bearing will eventually fail.

Many film systems have automated conveyors which cut and deliver exposed film to a processor to improve productivity. Automated plate systems remove the slip sheet between plates. The plates are then transported under the scan line on a platen driven by a linear motor or lead screw. After imaging the plate is ejected and the platen returned to the load position.

System Design

The design of a laser system for a given market usually involves a trade off analysis that includes the performance objectives as well as projections of capital and operating costs. Generally, expensive sensitive plates can be imaged by inexpensive low power HeNe or diode lasers. The designer trades off optical and scan efficiency for system simplicity and reduced cost. In turn, the user compares high capital cost, low consumable cost systems with a low capital cost, high consumable cost systems.

For the preparation of large format, accurate, high resolution films and plates, it is the drum recorder that sets the standard. Drum machines are used for the production of films and directly imaged printing plates. Systems are available with resolutions to 4,000 dpi and a 5 to 15 µm spot. Drum systems come in two flavors, external and internal. These are further distinguished by whether they use a single laser beam or array imaging.

There are thus, four drum recorders, two external and two internal. The external drum with one image source has poor productivity. The drum speed is limited by centrifugal forces which can distort the attached media. Productivity is further influenced by the drum start/stop and media loading times.

The external drum recorder with array imaging is a significant technical innovation. Productivity is high as array imaging is fast and drum speeds are low which reduces the media loading time. Drum arrays can be created with a modified Scophony modulator illuminated by a pulsed laser [3] or constructed as a laser diode array.

The Internal Drum Recorder With One Laser

In an internal drum recorder, the media are stationary while the spinner continually rotates. This arrangement simplifies the load/unload mechanism which improves both productivity and reliability.

Figure 2 shows an unusual internal drum recorder [4] developed in the early 1970’s to image a thermal ablation film with a receptor. The system produced a dry film with a plate or a film and proof. The single spinner created a two dimensional scan which could simultaneously expose two different pages.

The scanning element is a hollow shaft with a deflecting mirror at each end. The shaft, with a piston at its center, is supported by air journal bearings. The bearings are mounted in a stationary cylindrical member with air inlets at each end. Air turbines located near each deflector rotate the shaft. Turbine air enters the shaft through inlets at each side of the piston. The shaft angular rate is determined by its average pressure, while linear acceleration and position are a function of the piston differential pressure. Both the linear position and angular rate are controlled by electro-pneumatic servos.

While the system had a very high scan efficiency, it had poor productivity because of manual loading. Further, as with all traditional internal drum recorders, vibration errors are exacerbated by the long focal length and doubled by the reflecting spinner.

Laser power was delivered to the shaft by collimated optics which were designed to minimize spot size variation with shaft position.

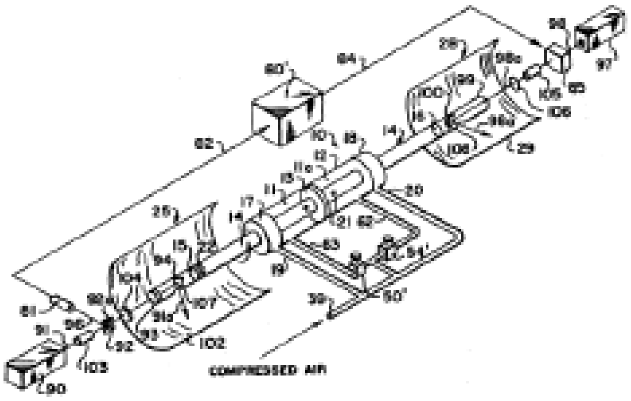

Figure 2 Pneumatic Internal Drum

The spot size and focal tolerance of an optical system are a function of laser characteristics, beam truncation and F#. Compared with an external drum recorder, the traditional single beam, internal drum recorder requires larger more expensive optics. Further, system sensitivity, defined as $f/\partial f$, is greater. Thus, because of this increased sensitivity, the traditional internal drum recorder requires more attention to the control of vibration, assembly and thermal errors.

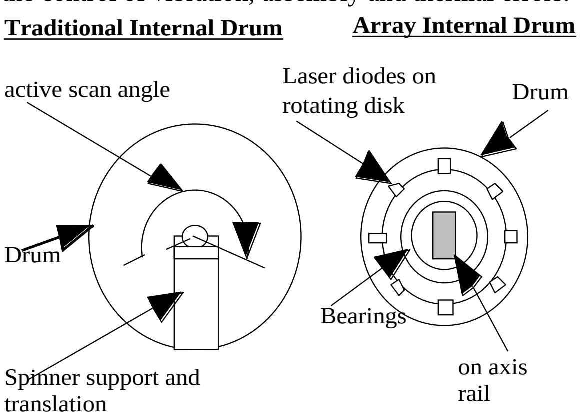

Figure 3 Traditional and Array Internal Drum Recorders

Figure 3, shows a sketch of a traditional internal drum recorder. The focal point of a laser beam rotated by a spinner traces the locus of a circle coincident with the drum. The spinner is mounted on a carriage and translated along the axis of the cylinder. Unfortunately, scan efficiency is limited by the rail and carriage which obscure a significant portion of the drum.

An internal drum recorder with array imaging has been a goal for over twenty-five years. These efforts were foiled by image rotation as illustrated in figure 4. Several complex solutions have been patented but none appear to have been implemented.

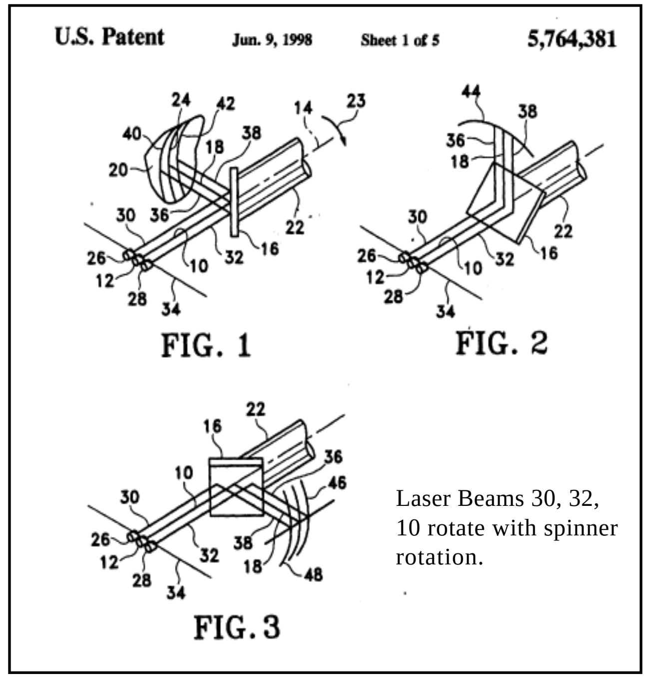

Figure 4. Array Image Rotation in a Traditional Internal Drum

Recently however, several practical approaches have appeared. In a solution commercialized by Fuji [5] a two or three beam array is incorporated into an otherwise, traditional internal drum recorder. Fuji analytically determined the instantaneous position error of each beam as a function of spinner rotation. Based on this analysis, they created a design that corrects the errors with AO deflectors. The initial Fuji product is a film recorder that images sensitive films with inexpensive lasers and a two or three beam array. With array imaging and a high speed spinner, the Fuji machine is very productive.

An interesting thermal array recorder, has been introduced by the Swiss company [9] Lüscher. This internal drum recorder utilizes only half the available scan angle. By limiting the duty cycle, plate handling and linear transport design are simplified. But, the drum is twice the size and productivity is halved.

The internal drum recorder with array imaging [11] shown schematically in figure 3, achieves full scan efficiency. The rail and carriage assembly are encircled by bearings centered within the drum. The bearings support a rotating disk driven by a DC motor. The disk receives electrical power for the lasers and controls from an alternator. The alternator has its magnets fixed to the carriage while the motor has its magnets attached to the disk. This arrangement drives and delivers power to the disk without brushes. A coaxial capacitive or optical transducer transmits data between the the rotating spinner and translating carriage assembly.

Thermal Imaging In Array Drum Recorders

Because of their lower rotational speeds, pixel dwell time in drum recorders with array imaging is long. The long exposure time allows the absorbed energy to diffuse through the pixel periphery which significantly reduces the exposure rate. Dan Gelbart [8] has described a beam shaping method to compensate this array imaging effect.

Virtual Drum Machines

Early imagesetter drums were fabricated with expensive, machined castings. These were often aged before machining to minimize stress relaxation distortion. Today, some vendors are using drums cast from epoxy concrete, a stable material with improved stability and reduced cost. It has excellent thermal properties and its damping characteristics reduce vibration.

In some traditional internal drum systems the film vacuum clamp has been eliminated. This is accomplished by driving the film into the drum until the leading edge engages spring loaded end stops. This action places the film in compression and forces the film base to conform to the drum surface. Advantage can be taken of the film stiffness by replacing the drum with end rings to further reduce cost.

A most dramatic cost reduction has been achieved by [10] Exxtra. The Exxtra imagesetter creates a virtual drum when the film is lightly tensioned after it has been transported over a pair of end rings. During a scan, clamshell baffles engage the film surface as the spinner is transported along the drum center. The baffles eliminate film fogging laser reflections, and help to stabilize the film surface.

An alternative virtual internal drum design [6] places a plate in compression forcing it into a cylindrical shape while it is constrained by longitudinal stringers. In the later version [11] of this technique, each stringer is adjusted under closed loop control by actuators at the end of each stringer to compensate drum radius, taper, and cylindricity. The actuators are driven by a focus sensor in the rotating disk which detects the radial difference between the plate surface and a reference. This assures a fixed image length, independent of plate thickness, without changing the pixel clock as required with other approaches.

Residual high frequency radial errors can be sensed and corrected by individual auto focus units associated with each laser. Feed forward techniques, can ensure a fast accurate response to local errors.

This internal drum recorder with array imaging [13] has high scan efficiency and a very fast, efficient load/unload mechanization. The clamp arm securing the plate during the load/unload sequence is on the drum center line. This arrangement, in concert with the available space between stringers and a drum that is a continuous cylinder, allows the load/unloaded mechanism to rotate in one direction without a time wasting direction change.

Conclusions

The successful large format CTP system will be characterized by excellent image quality, high resolution, and high productivity. Thermal CTP systems will assume a more prominent market position with the continued development of cost effective plates and new more productive, high duty cycle recorders.

References:

1. Charles DeBoer Graphic Art Applications of Laser Thermal Printing” 1995 TAGA Proceedings, pp 29
2. Thomas D. Hayosh, Motors And Control Systems for Rotating Mirror Deflectors, Proc. SPIE Vol 84, 1976
3. US Patent 4,577,932 Multi-spot Modulator Using A Laser Diode, D. Gelbart
4. US Patent 4,131,916 Pneumatically Actuated Image Scanning Reader/Writer
5. US Patent 5,502,709 Apparatus for Recording Images on Interior Surface of Cylinder
6. US Patent 4,262,594 Method and Apparatus for Manipulating and Transporting Image Media
6. US Patent 5,589,900 Virtual Drum Imagesetter
7. US Patent 5,835,686 Electronic Prepress System Having a Capstan Driven Virtual Internal Drum Imagesetter
8. Dan Gelbart Thermal Imaging Outside the Law of Reciprocity, Presented at the 1999 TAGA Conference
9. www.luescher.com
10. www.exxtra.com
11. US Patent 5,764,381 Internal Drum Recorder With Array Imaging