AUTOMATIC PRESETTING SYSTEM OF REGISTRATION ON AN OFFSET PRINTING PRESS

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Abstract: We successfully developed an ink presetting system for offset printing in 1981. This development was followed by the efforts to develop a register presetting system in order to further reduce the make-ready time and paper wastage. A new register presetting system was thus completed in August 1983. This new register presetting system operates in such a manner that a register mark written on a PS plate is read by a sensor on a plate cylinder of the printing press to attain automatic registry before starting printing. With this registration system coupled with an ink presetting system, both the adjusting time in the make-ready time and the paper wastage were reduced to one fourth for a sheet-fed offset press.

Introduction

This presentation relates to a register presetting system that is a new technology developed by us for offset printing.

The recent rapid development of the electronics and computer technologies has brought about a revolution in the industrial world, making possible an automatic system incorporating both the skill of workers and knowhow as well as mechanization of simple physical jobs. This is also true in the field of offset printing where the press speed is made faster and faster by the efforts of the printing press makers. In our printing company, on the other hand, three needs are carrying more and more importance:

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(1) Shorter make-ready time
(2) Lower paper wastage
(3) Simpler press operation

To fulfill these three needs, we developed the world's first ink presetting system in 1981 by our own technologies. This system has greatly improved ink adjustment for the make-ready work. The register adjustment that represents another major proportion of the make-ready stage, however, is still left in the hands of operator, and the necessity for its automation is urgent.

With this situation as a background, The Engineering Research Laboratory of Dai-Nippon Printing Co., Ltd. tackling the work for preset control of the printing press have set a new development target on a register presetting system, and with the cooperation of Mitsubishi Heavy Industries Co., Ltd., have completed one in August 1983.

Conventional Conditions of Registration

Conventionally, 6 or 7 trial pressworks and registration works are conducted before starting printing on the printing press. Checking the printed sheets, circumferential and lateral registration errors on the plate cylinder are corrected by inching the plate cylinder by remote control, while slew errors are rectified by use of a plate clamping device (for sheetfed press) or a cocking device (for web-fed press). If the slew error is excessive, the plate may be demounted for correction. In the case of the sheet-fed press, this job requires 30 to 40 minutes, generating paper wastage of about 700 sheets.

The primary factors of registration work are considered to exist in all processes including film stripping, press plate making and press work, and will be described sequentially below.

First, in the film stripping process, registry in maintained by a pin system and visual overlapping. This work is done manually very carefully and is rarely a cause of low accuracy. This type of work has recently been eliminated by introduction of a total scanner system. Although the total scanner system will relieve the fear of lower registration accuracy, it will not be soon before the use of this system will extend widely.

In the press plate making process, it is important to secure the positional accuracy of the screened film printed on the PS plate. The method of plate printing is of two types, one by an automatic photo composer, and the other by attaching screened film manually. The multi-face printing with automatic photo composer involves smaller cases of register troubles but lower utility rate. In the manual method, on the other hand, the practice followed in Japan on a large-sized printing press is mostly to attach and print a plurality of screened films on PS plate and it is rare to register a single sheet of full-size screened film on a pin system. More specifically, a thin template is laid on PS plate and marked off with the position reference marks by a marking-off pin. This is followed by the step of attaching, registering and printing a plurality of screened films to the position reference marks thus marked off. This method, which has so far been low in the accuracy of the reference marks, was recently improved remarkably in accuracy thanks to the successful development of an automatic marking-off machine.

Finally in the press work process, a register error may be caused by erroneous mounting of PS plate on the plate cylinder of the printing press or by phase error of the plate cylinder. In spite of the care taken on the part of operator in mounting the plate and the automatic function of printing press to return to zero point, it is a rare case that registry is attained but an error normally exists. Although the efforts to improve the plate mounting mechanism are continued, it has not yet to solve this problem. Another problem is that the chance to confirm a register error arrives only after the trial presswork.

As will be seen from the above description, it has been found that register work is not much required in the processes of film stripping or press plate making but in the press work. A measure to eliminate the register work, therefore, would be concentrated on the automatic register job on the printing press.

Concept of Register Presetting System

Methods of eliminating the register adjusting work on the printing press have so far been announced by printing press makers. But none of them has been in practical use for large-sized machine applications. Three attempts along this line will be explained below.

A first method is by a total pin system covering the entire processes from film stripping to presswork. This method is effective to some degree in small-sized printing presses, but, due to the difficult accuracy control of pin hole, cannot avoid a mounting error of the plate on a printing press large in size.

In a second method, like in gravure printing, the register mark on the printed matter is sensed by a sensor on the printing press, while at the same time effecting automatic correction. This method, though possible to automate, has the shortcomings of paper wastage and unsatisfactory mark detection accuracy.

A third method provides a base of our development of the restier presetting system in question. After the plate is mounted, a "7" register mark on the PS plate is detected by sensor, so that the plate cylinder is automatically finely adjusted before presswork. This method, developed by Mitsubishi Heavy Industries and tested by Dai-Nippon Printing in 1974, has the following three disadvantages, making it impossible to put it into practice:

(1) There is no reliable method of providing an accurate register mark which is accurate in positional relation with an image on PS plate, thus often leading to a register error. This is attributable to the conventional practice to print the plurality of screened image films and register mark films separately according to position reference marks marked manually by use of a thin template.

(2) The mark detection accuracy on the PS plate is low on the one hand and the accuracy of the correcting operation of the press is unsatisfactory on the other.

(3) There is no function to automatically correct the slew error which consumes the most correction time. (for sheet-fed press)

This third method, to the extent that the accuracy of each element is improved and the slew error correction function is added, consumes the least time of all with reduced paper wastage to achieve automatic register presetting. Therefore, we decided to develop the present register presetting system with an improvement of this third method. The sheet-fed press scheduled to be introduced into our factory was used as an object for the

development of the register presetting system.

The points stressed for development of the system under consideration were as follows:

(1) A register mark in accurate positional relation with image is to be formed on PS plate

The conventional methods free of accuracy problems include the automatic photo composer and the system of printing a full-size screened film. Both methods are accomplished by printing a screened film only with "7" mark. The problem is encountered when printing a plurality of image screened films. The register accuracy of this method has recently been remarkably improved as a result of development of a device for automatically marking off a position reference mark for application of screened film. We decided to use this automatic marking-off machine to mark a position reference mark for application of screened film and the register mark at the same time. The technological tasks to be coped with were how to beautifully mark a diagonal line of the "7" mark and to develop a sensor for detecting with high resolution the thin marking line on PS plate.

(2) Improved accuracy of mark detection and control

For mark detection, a new sensor was developed as mentioned in (1) above. To improve the control technique, on the other hand, the mechanical error of the printing press was to be eliminated by separate detection of a mark error amount and a correction operation amount and to use both of the resulting signals for feed back control.

(3) Introduction of a cocking device to obviate slew error

This mechanism was already employed in a web-fed press and could be used in a sheet-fed press any time.

(4) Improved mechanism for mounting a plate inside of the automatic correcting range

A system to automatically correct a register error on the printing press was limited in the range of correction operation. A plate clamping mechanism and

a pin system therefore were required which prevent plate displacement at least out of the such range of correcting operation.

System Configuration

This system is comprised of the following two parts:

(1) Register mark writing device (REM WRITER)

This device is intended to write the register marks "7" for register adjustment and the position reference marks for printing an image screened film at the same time on an unexposed PS plate. This system comprises a data make-up section for determining the layout for printing a screened film to prepare marking-off instruction data and a register mark writing section for marking-off the position reference marks and the register marks.

(2) Automatic register adjusting device

A device for detecting the register mark "7" from the plate surface of the printing press, and automatically registering the plate in three directions of circumference, lateral and slew.

The whole configuration is shown in Fig. 1. The system flow will be briefly explained with reference to Fig. 1.

The register mark writing device (REM WRITER) is installed in the plate-making workroom. First, with reference to the layout instructions, data for marking-off the marks is prepared at the data make-up section by entering such data as the printing press number, size of screened film, the layout and the interval of screened films through a simplified keyboard. The data thus completed are produced on the magnetic card. An unexposed PS plate is placed on the register mark writing section in registry with the pin hole and the magnetic card is read. The vacuum button and the start button are depressed, so that the position reference marks for printing the screened films and "7" register marks are automatically marked off on the PS plate. The data make-up section and the mark writing section are connectible with each other on line. In accordance with this position reference marks, the screened films are printed and developed, thus completing the plate making process. The time consumption

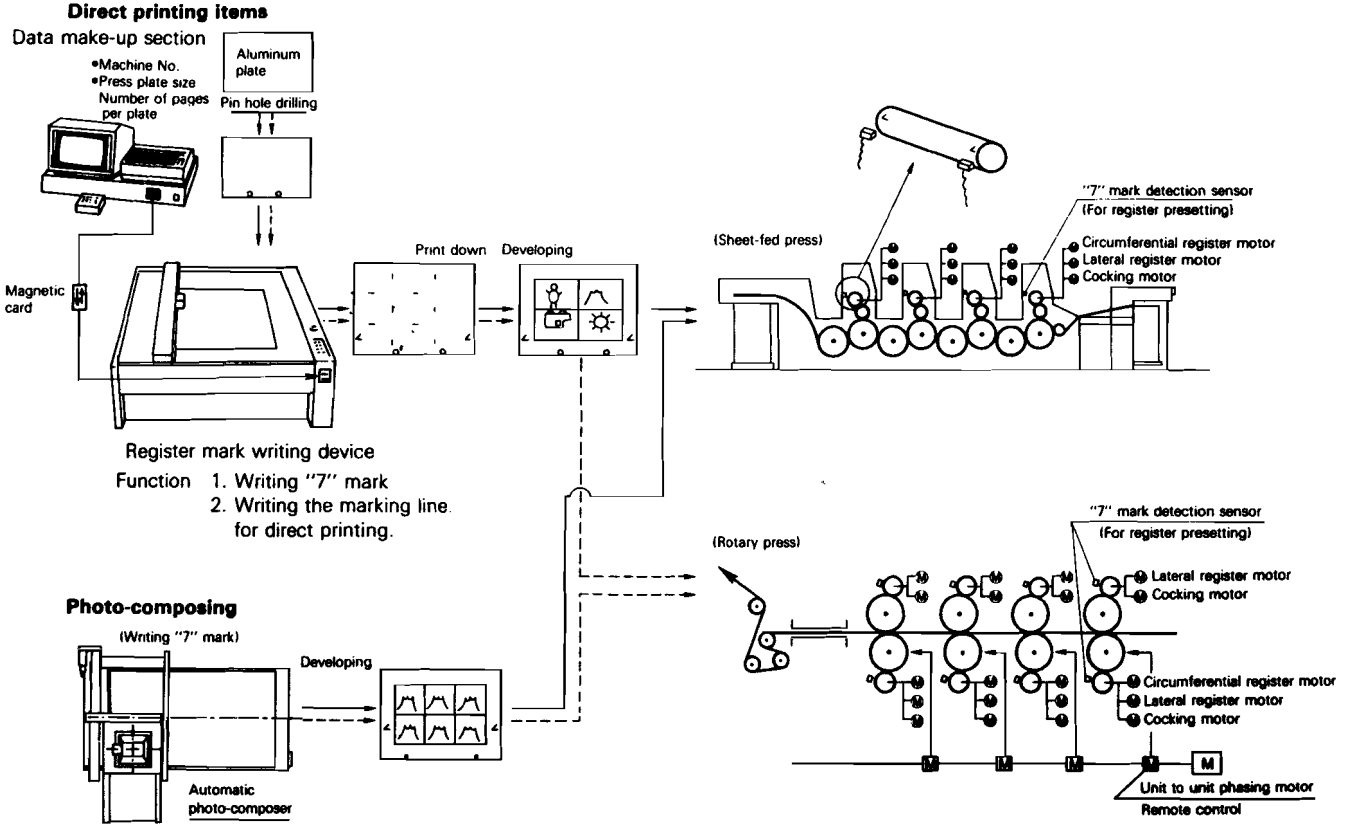

Figure 1. Register Presetting System

is so small that data making-up takes one minute or two, and the automatic mark writing only one minute or two, too. In the case of the automatic photo composer or similar method using a full-size single screened film, the "7" register mark is printed simultaneously with the image screened film.

The flow in the printing process is as described below. First, the plate is mounted on the plate cylinder having a new plate mounting device. The preset button is depressed to start the printing press slowly under no load. At the same time, the mark sensors so far kept in storage begins to move to the detection position where the "7" marks are detected, with the result that in accordance with the amount of displacement from the base position for each color, the corrections in three directions of circumference, lateral and slew are automatically effected. The correction in each of the three directions is performed by finely displacing the plate cylinder. The time from depression of the preset button to the end of correction is as short as about one minute.

Now, the register presetting is complete, making the machine ready for immediate start.

Register Mark Writing Device (REM WRITER)

The register mark writing device (REM WRITER) comprises a data make-up section shown in Fig. 2 and a register mark writing section shown in Fig. 3.

The data make-up section includes an exclusive microcomputer, a simplified keyboard, a CRT display unit, a printer, and a magnetic card writer. The data for each printing press such as plate size and register mark position are stored in advance. Up to a maximum of 32 types are registrable with the press number. The operation is performed by dialog between the simplified keyboard and the CRT display unit even by an unskilled worker. In the processes, the printing press No., screened film size, layout and interval of screened films are entered, whereby the layout size is automatically computed and produced on the magnetic card. The program can meet a wide variety of layouts, justly providing a function suitable for the web-fed press (with web width entered).

Fig. 4 shows a CRT display unit displaying the result of computation. Of all the data on display, only the "7"

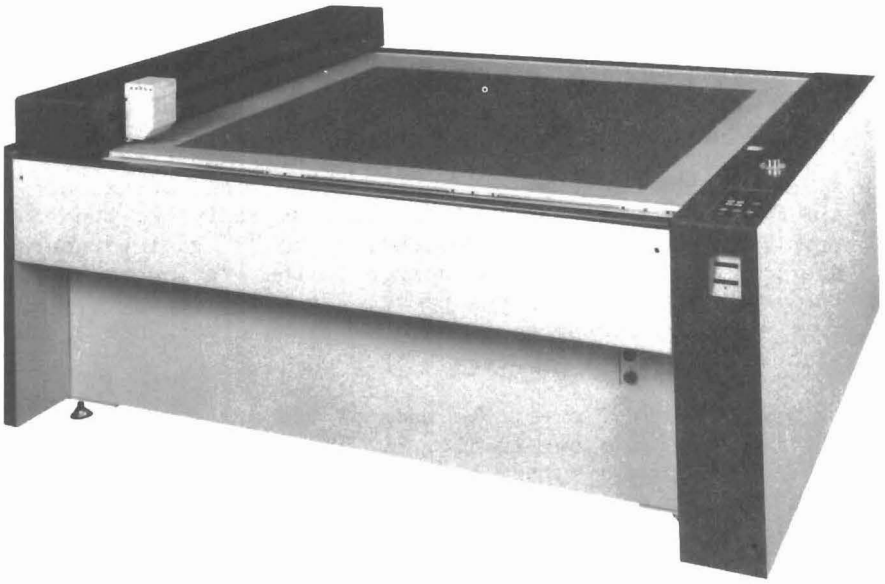

Figure 2. Data Make-up Section (REM WRITER)

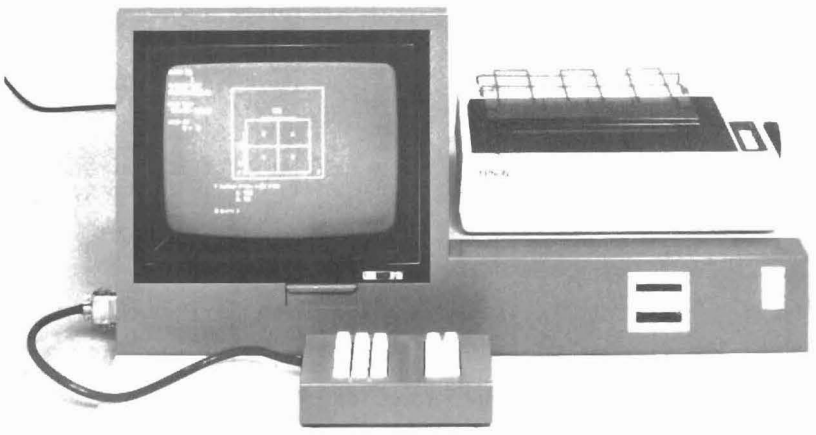

Figure 3. Register Mark Writing Section (REM WRITER)

register marks and the short lines (position reference marks for printing) crossing the rectangular sides are marked-off actually by the register mark writing section. In the display, the lower side makes up the leading side of the printing press.

The position of the "7" register marks and the mark size are shown in Fig. 5. At the lower right corner of the drawing is shown a register mark depending on the printing method (photo composing). The "7" register marks are provided at a position nearer to the leading side of the printing plate for the press. In the drawing, characters a, b, c, d represent the dimensions determined by the size of the printing press.

Now, explanation will be made of the register mark writing section shown in Fig. 3. The head of the writing section employs a cutter blade made of diamond. In order to write a beautiful and clear "7" register mark, synchronous X- and Y- drive system has been improved. This cutter blade can be easily replaced with a ball-point pen. This device enables the position reference marks for printing the screened film and the "7" register marks to be plotted at the same time, so that these two types of marks may attain the position accuracy of at least $\pm$0.02 mm. In the next printing process, the image screened films are printed along this position reference marks, maintaining a highly accurate positional relation between the register mark and the image. The operation is so simple that an unexposed PS plate is placed, the magnetic card is read, and the button is depressed. And the rest is an automatic plotting.

In this way, the most serious problem of the conventional works as to the "method of providing a register mark securing accurate positional relation with image" is resolved.

The next problem is the detection accuracy of the register mark. The line marked-off on the PS plate is thin and has sharp edges. This line remains as a very lustrous thin stripe on the non-image area lacking gloss after development of the PS plate. The mark sensor mounted on the printing press detects this thin, sharp mark optically as a gloss difference, and it has been found that the signal is very sharp. A mark sensor with satisfactory performance has been developed by improving the projection angle, shape of the projection surface and the color

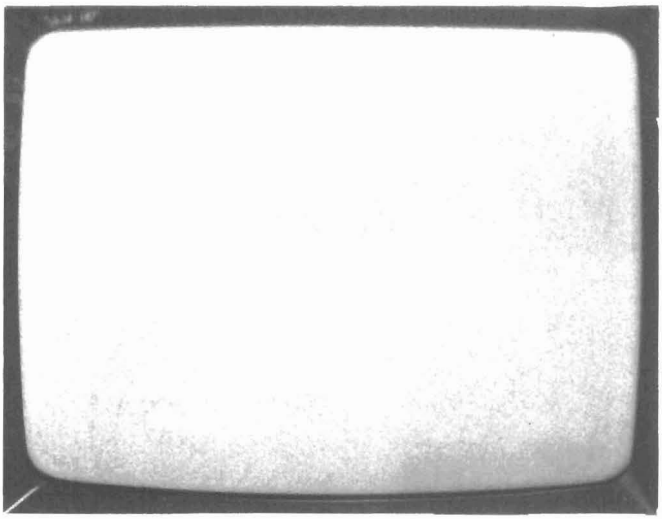

Figure 4. Example of Layout Display

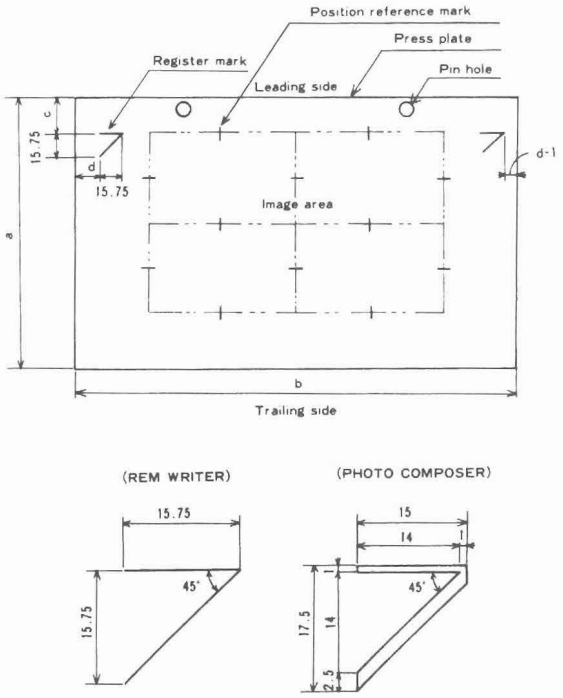

Figure 5. Example of Layout and Register Mark

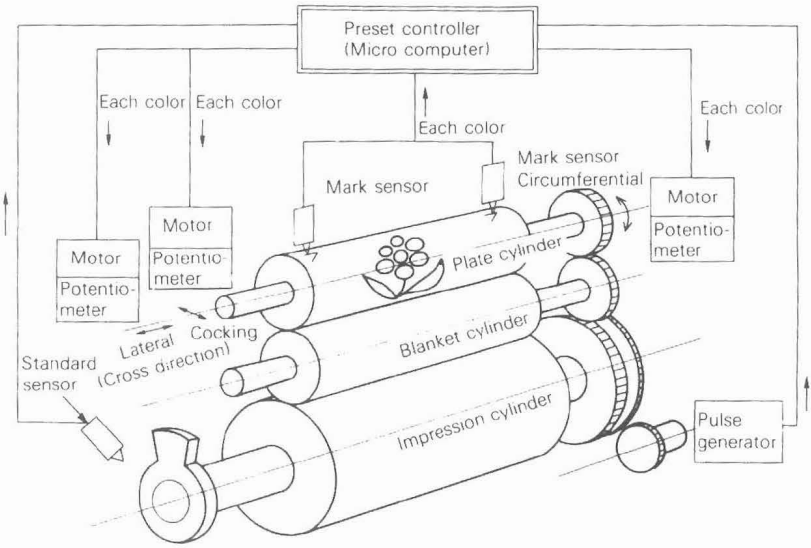

Figure 6. Configuration of Register Adjusting Device

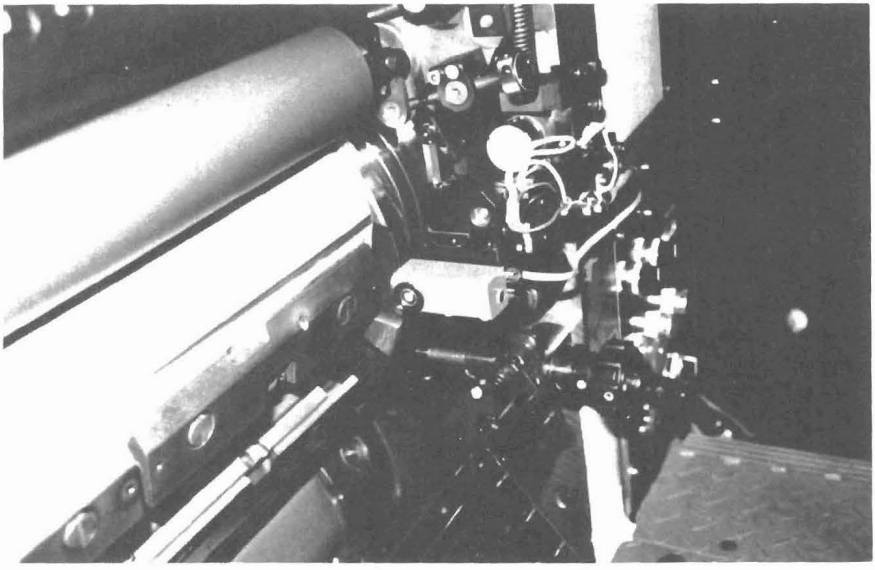

Figure 7. Mark Sensor

correction filter. This sensor is also of course capable of detecting a mark made by the photo composer.

In this manner, the problem of detection accuracy has been solved.

Automatic Register Adjusting Device for Printing Press

A configuration of the register adjusting device for the printing press is shown in Fig. 6. This device comprises the following elements: That is, register adjusting devices for adjusting the marks along three directions of circumference, lateral and slew, a sensor for detecting a "7" register mark on both sides of the plate cylinder surface, a reference sensor for generating a reference position signal in the direction of rotation of the printing press, a pulse generator for providing a measurement signal of each timing phase, and a preset controller for processing the signals of each device. The rectangular parallelopiped visible at the central portion of Fig. 7 shows a mark sensor, which is actually invisible as it is hidden under a protective cover.

The theory of register error detection will be explained with reference to Fig. 8. The circumferential length L_2 and the axial length L_4 indicating the position of "7" mark when registry is attained are stored in advance in the controller as the number of pulses from the reference position of the printing press. If the mark position detected by the sensor after the plate is mounted coincides with L_1, L_2, the amount of the register error in the three directions of circumference, lateral and slew are computed as follows:

- Circumferential error (drive side) $Q_1 = L_1 - L_2$
- Lateral error (drive side) $Q_2 = L_3 - L_4$
- Slew error $Q_3 = Q_1 - Q_1'$ (operation side)

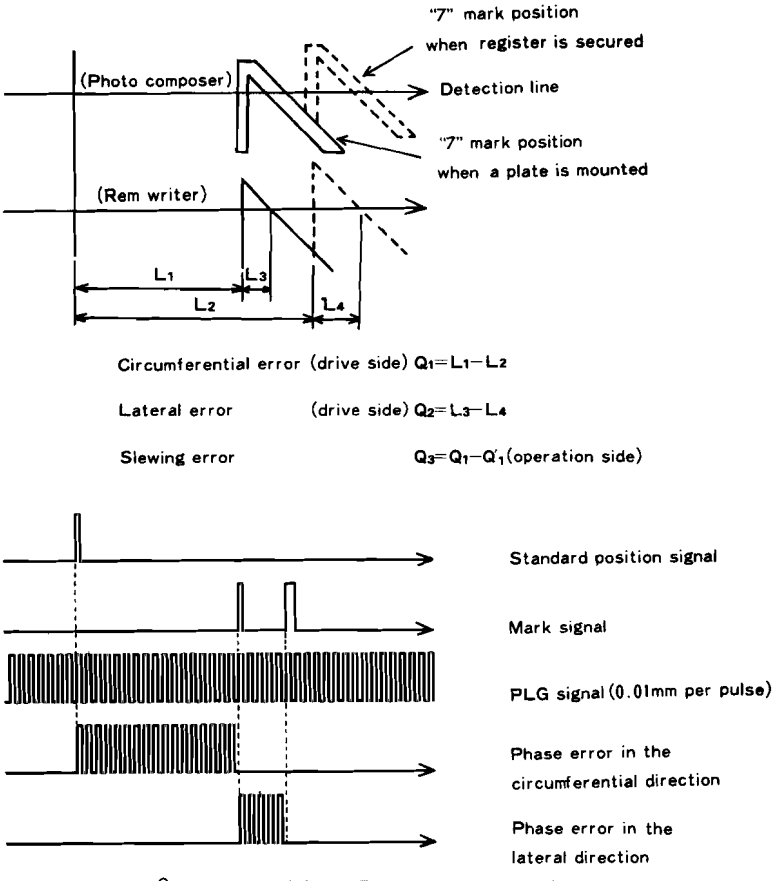

Figure 8. Detecting Theory of Register Error

The device detects and computes this register error, and drives the motors for circumferential and lateral (axial) directions and cocking respectively for each color to effect correction. The amount of the correcting operation is detected by a potentiometer installed at the drive section for each of the three directions. The error detection and the correcting operation are controlled by feedback system, thus attaining a satisfactory register adjustment accuracy of the printing press.

The operation is so simple that all that is required is to depress the preset button after mounting the plate. The printing press will start slowly under no load, and the sensor moves to the detecting position, and the register mark is detected and controlled, thus completing the presetting process. These series of operation take only about one minute and are totally controlled by program.

In order to fully display this register-presetting function, the system also incorporate means of securing the plate-mounting accuracy. The controllable range of the adjusting device of the printing press is ±1 mm for circumferential direction, ±2 mm for lateral (axial) direction, and ±0.3 mm for cocking. Unless the plate is mounted in this range, the register presetting is not achieved. Although the register for circumferential and lateral directions falls in this range by the conventional way of plate mounting, a new concept is required to secure the slew error within the limit of ±0.3 mm. In order to achieve this, the present system employs an improved pin system on the one hand and uses a newly-developed plate clamp to obviate the displacement of plate as it is clamped for sheet fed press.

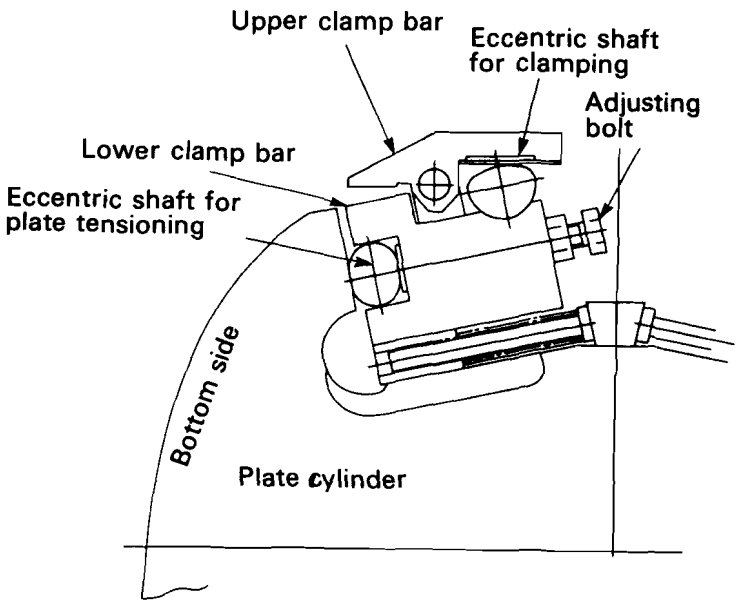

Figure 9. Plate Clamping Mechanism

The construction of this new clamp is shown in Fig. 9. For the web-fed press, on the other hand, a contrivance is taken for fixing the plate or the bending angle of the plate folding machine.

Field Test Results and Present Application

The first set of the register presetting system developed by us was installed in one of Tokyo plants of Dai-Nippon Printing in August 1983. The printing press involved was Dia V 5-color sheet-fed press of Mitsubishi Heavy Industries (plate size: 1050 x 1310 mm). This press, of course equipped with the ink presetting system (developed by us in 1981), has attained considerable achievements in the reduction of both the adjusting time in the make-ready time and the printing paper wastage which have been the objects of these two respective systems.

A register presetting test that was conducted after installation shows the register accuracy of at least $\pm$0.1 mm as expected. This accuracy figure is almost satisfactory for ordinary printing jobs. For a printing task requiring a higher figure of accuracy, fine correction is performed additionally by remote control.

On the strength of the satisfactory test results, actual printing work was immediately started, and data were collected over a couple of months on the reduction of adjusting time within the make-ready time and the paper wastage. The printing press under consideration finishes the color and register adjustments within 5 to 10 minutes. This compares with the conventional printing presses in which similar jobs required an average of 30 to 40 minutes. In the new system, both the color and register reach a substantially satisfactory stage at the end of presetting, and therefore the only requirement is its confirmation and fine correction by remote control which are repeated once or twice, as compared with the conventional printing presses requiring 6 to 7 trial printings and corrections. This reduced time consumption is mostly credited to the presetting and, to some degree, to the remote-controlled corrections of all type effected after presetting.

The paper wastage was also reduced from about 700 sheets for the conventional printing presses to about 200 sheets. This is a natural result of the reduced trial printings as mentioned above. Both time consumption and paper wastage were reduced to one fourth.

Also, the advantage attained in the plate making process was not negligible. The 1000 to 2000 sheets of thin templates which had been required for marking were eliminated, saving both the storage space and the time for searching

for appropriate templates.

In view of the great advantage thus attained, a second set of this system was introduced into the Kyoto Plant in March 1984 and is operating smoothly.

The new development has permitted us to automate the two great elements of printing adjustments. Future automation will probably be directed to the following three areas:

(1) Extension of presetting
(2) Control during running
(3) Group control

If these systems are to be realized, we think it important for us printing companies to push forward with the development efforts leading the printing press makers.

Acknowledgement

Lastly, we would like to express our deep appreciation to the staff of Mihara Plant of Mitsubishi Heavy Industries Co., Ltd. for their joining us in the development of this new system.