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[21] Appl. No. 771,077
[22] Filed Oct. 28, 1968
[45] Patented June 22, 1971
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[54] HIGH-SPEED PRINTER 21 Claims, 10 Drawing Figs.

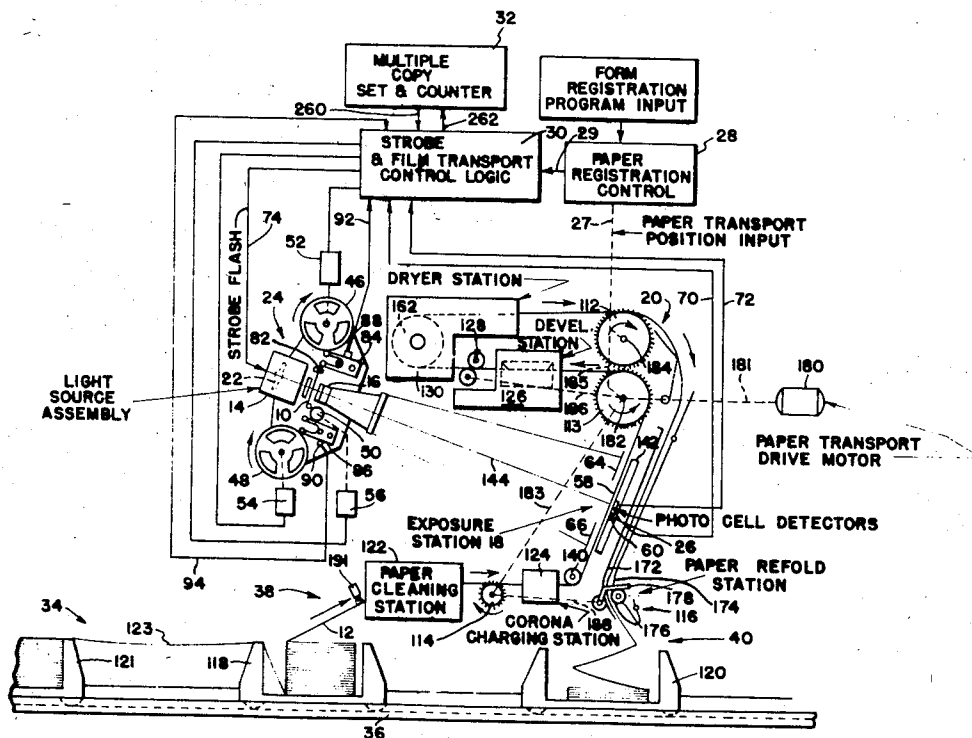
[52] U.S. Cl. 355/14,
101/228, 270/52.5, 270/61, 355/53, 355/64
[51] Int. Cl. G03b 15/00
[50] Field of Search 355/4, 14,
64, 53, 3, 17; 101/228; 197/133; 270/52.5, 61 F

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ABSTRACT: A high-speed printer makes one or more enlarged copies of image frames of a photographic medium, such as a strip of unperforated microfilm, on a photosensitive hard copy medium, such as a web of zinc-oxide-coated paper, by an electrophotographic process. Typically, a film transport moves the microfilm intermittently while a paper transport moves the paper in a continuous manner, with a high-speed flashlamp flashing images from the microfilm onto the paper. If desired, predetermined portions of the paper may contain preprinted business forms and the images from the microfilm may be registered therewith. Also, a train of carts may be provided passing under the printer, each carrying a stock of fan-folded paper to permit head-to-tail splicing of the paper so that printing may continue without interruptions for paper loading.



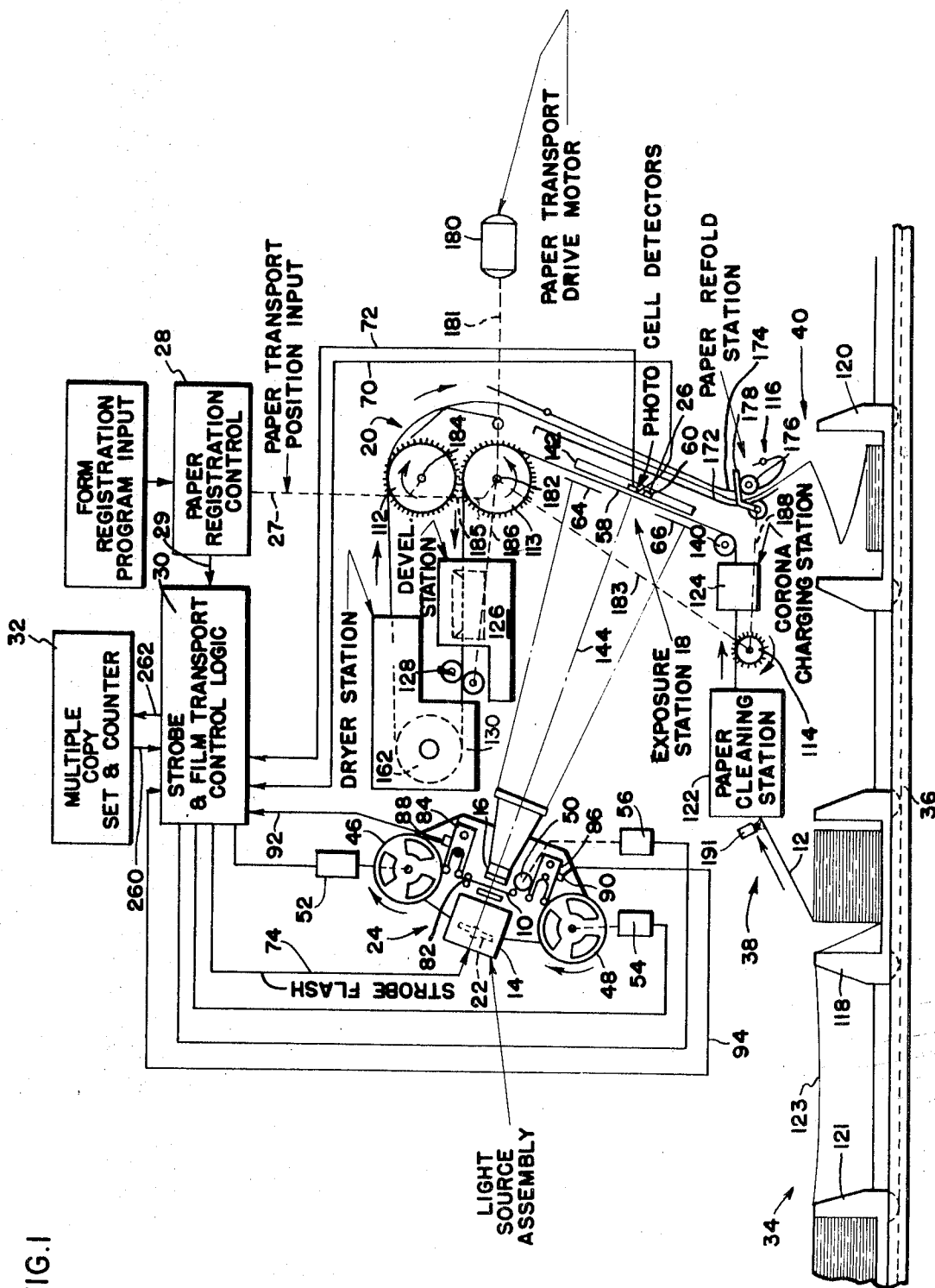


FIG. 1

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FIG. 2

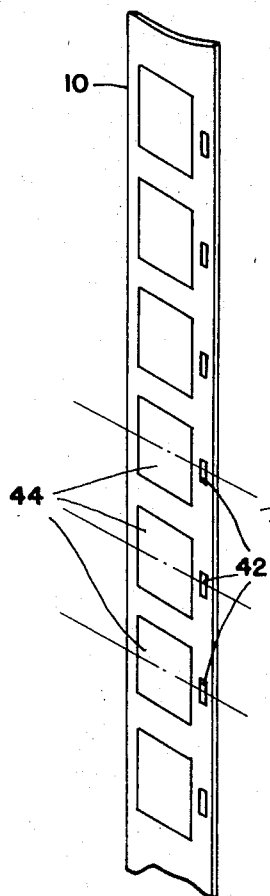


FIG. 5

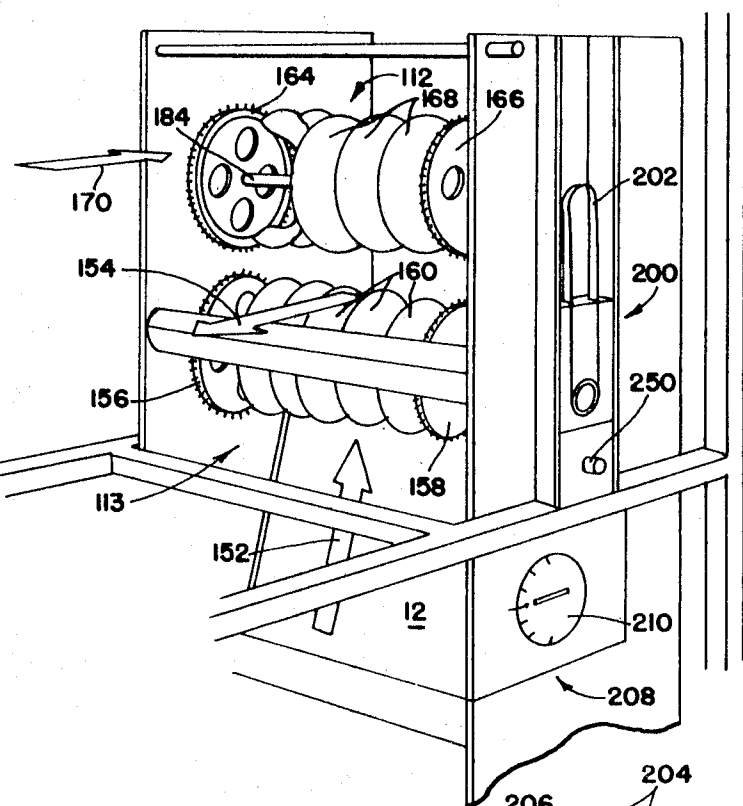


FIG. 7

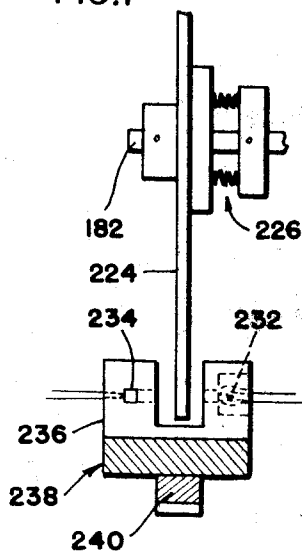
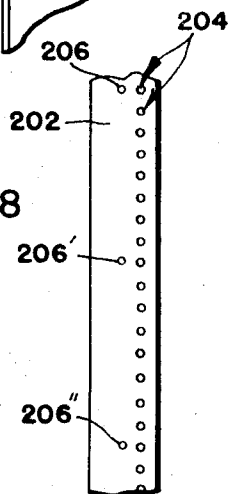


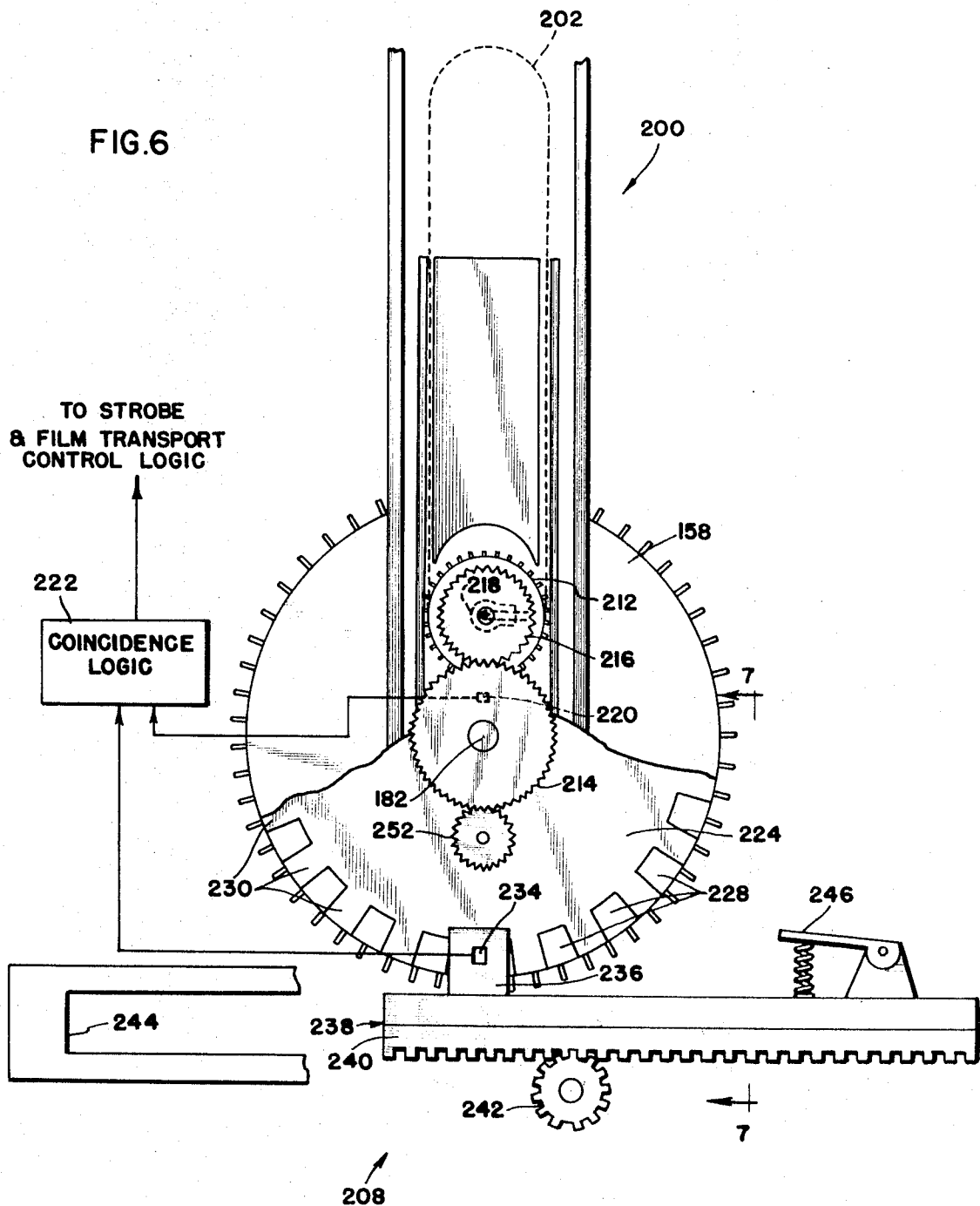
FIG. 8



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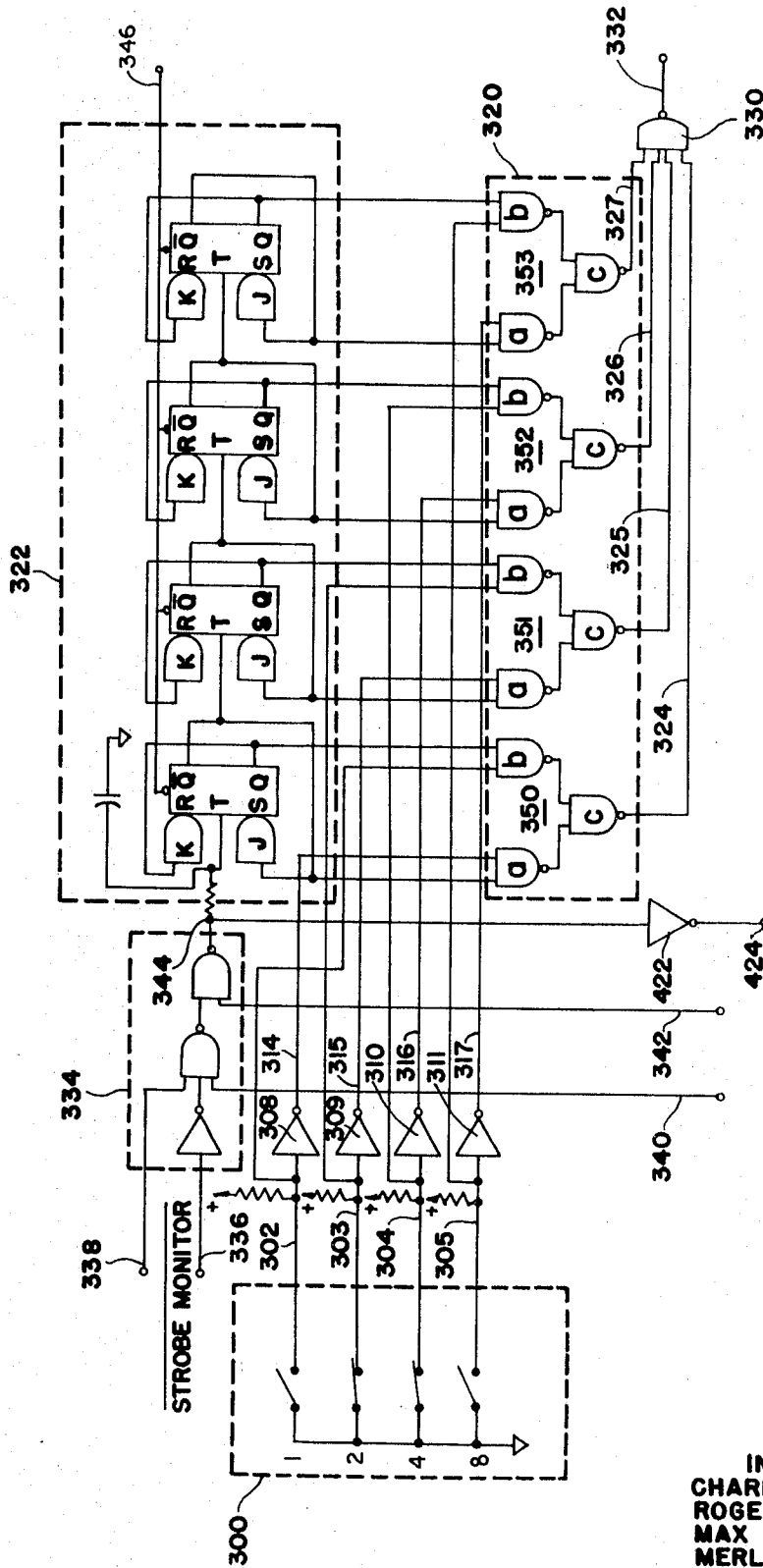
FIG.6



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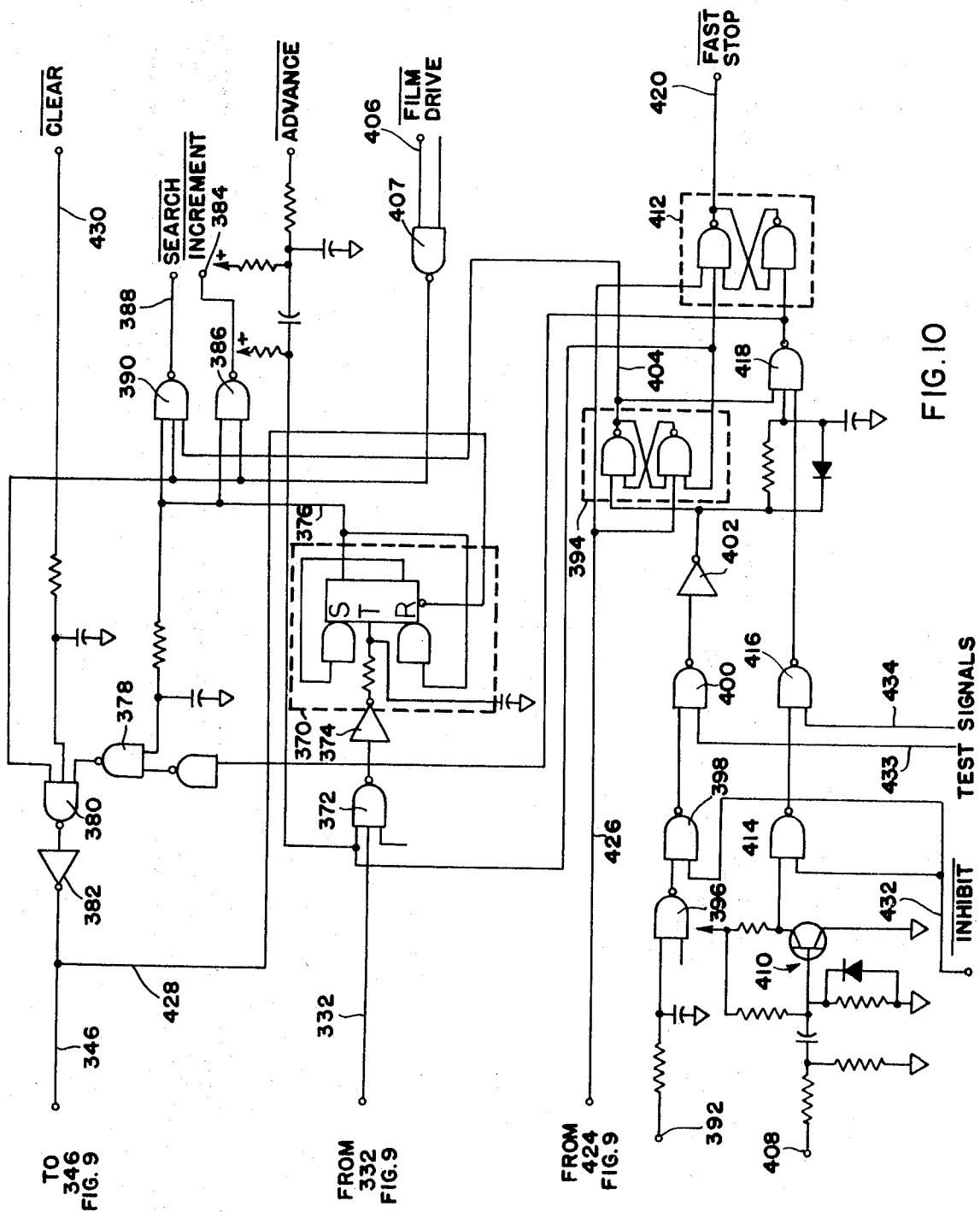
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FIG. 9



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HIGH-SPEED PRINTER

The present invention relates to the printing of images from a microimage medium onto a hard copy medium, and particularly to a high-speed automatic printer for making enlarged copies of such images from unperforated strip microfilm utilizing an electrophotographic process.

While general data and information storage techniques employing microsize photographic data, such as microfilm, are now well known, the practical use of such techniques inherently presents certain difficulties in the retrieval and reproduction of the data, as well as in the provision for data output in a form convenient and well adapted for its intended eventual use. Where there are large volumes of data to be retrieved and reproduced into a more convenient form for handling, such as by conversion to some form of hard copy or paper output, it is desirable that printing apparatus for this purpose be capable of operation at extremely high speed, while providing consistent high-quality image reproduction.

Such microfilm data storage techniques may, for example, be used for maintaining a record of customer accounts in the operation of a business concern. Each customer account may be contained on one or more frames of a microfilm reel or reels. When desired, such as for producing monthly billings, etc., each account may be printed out on paper copy, showing the transactions of each account for that billing period, and the paper copies may then be mailed directly to each respective customer. Where the number of customers involved is great, expeditious and economical handling requires that the microfilm be printed out at a very rapid rate while maintaining legibility and controlled correspondence or registration between the microfilm image and the output copy paper. The necessity for enlarging the microfilm images so as to be readily usable in the printed form, further compounds the difficulties involved in the design and operation of any such apparatus.

In certain applications it is desirable to employ a paper which is preprinted with letterheads, invoice forms, or other fixed information, and to add the variable information from the microfilm thereto so as to fill in the appropriate blanks in the preprinted forms. Various types of apparatus have heretofore been proposed for printing data on preprinted forms by using a line-by-line intermittent paper-feeding operation which necessarily results in a printing speed which is less than optimum because of the required stopping and starting of the paper. Also, such intermittent paper feeding is generally detrimental to quality image reproduction where an electrostatic process is employed for printing.

Accordingly, it is an object of the present invention to provide an improved printing apparatus for automatically printing photographic images at extremely fast speeds onto a continuously moving output medium which is in a convenient form for handling.

It is a further object of the present invention to provide an electrostatic printing apparatus for making enlarged copies of microfilm images on electrophotographic paper with good image resolution, consistent image reproducibility, and at high-volume production rates.

It is still another object of the present invention to provide such printing apparatus wherein the paper may be introduced into the apparatus and removed therefrom in a continuous and endless manner so as to provide a high-volume production rate without the necessity of stopping the printing apparatus for loading or unloading.

It is still a further object of the present invention to provide such printing apparatus having the capability of printing variable data from a microfilm strip onto preprinted forms with precise registration of both variable and fixed data, and at the aforementioned high-volume rate.

Other objects and advantages of the present invention will be apparent from the following detailed description when considered in conjunction with the accompanying drawings wherein:

1 is a schematic representation of a preferred embodiment of the apparatus of the present invention;

FIG. 2 is a perspective view of a segment of microfilm strip which may be advantageously employed in the apparatus of FIG. 1;

FIG. 3 is a perspective view of the exposure station of the apparatus of FIG. 1;

FIG. 4 is a schematic illustration of the light source and optical arrangement employed in the apparatus of FIG. 1;

FIG. 5 is a perspective view showing the upper paper transport assembly and paper registration controls employed in the apparatus of FIG. 1;

FIG. 6 is a more or less diagrammatic view in elevation of the mechanism of the paper registration controls shown in FIG. 5;

FIG. 7 is a partial view in section taken along line 7-7 of FIG. 6 in the direction of the arrows;

FIG. 8 is an elevational view of a segment of program tape which may be advantageously employed in the paper registration controls of FIGS. 5 and 6; and

FIGS. 9 and 10 are schematic diagrams showing logic circuits which may be employed in the apparatus of FIG. 1.

In general, in accordance with the present embodiment of the invention and referring to FIG. 1, apparatus is provided for printing images from a photographic film medium, such as reel-type microfilm 10, onto a photosensitive or electrophotographic hard copy medium, such as zinc-oxide-coated paper 12, at high speed by means of a fast light source 14 and an optical system 16 which projects enlarged images from the microfilm 10 to the paper 12 at an exposure station 18, and an electrostatic processing system which sensitizes the paper prior to exposure and then develops and fixes the enlarged images thereon. A hard copy or paper transport means 20 is provided for continuously moving the electrophotographic medium, in continuous web form, through the exposure station 18 at constant speed. The light source 14, which preferably comprises a strobe-type flashlamp 22, projects a short duration or "fast" image from the film medium by producing a brief high-intensity flash of actinic radiation to cause exposure thereof on the moving electrophotographic medium 12 at the exposure station 18. A film transport means 24 is also provided for moving the film medium 10 from one image to another, such as in a successive manner, intermittently, so that the exposed film image is maintained stationary during the exposure on the continuously moving paper web, and the film 10 is then moved rapidly to another image position or frame while the lamp 22 is off. The registration of each projected image in the exposure station 18 is detected by a registration photosensor 26 in a manner to be hereinafter described.

The electrophotographic paper 12 is fan folded with transverse perforations or weakened regions at each of the folds to permit easy detachment of the paper into separate or discrete segments or forms. These folds and perforations thus define a plurality of predetermined portions or sections of the paper medium which are each placed in registration with the projected image or images from the microfilm, and each of these portions of the paper may, if desired, have a preprinted form or letter format thereon; alternatively, these portions of the paper may merely be blank. Accordingly, a hard copy or paper registration control means 28 is provided for synchronously actuating or flashing the strobe 22 in normal operation only when such a predetermined portion or form of the moving electrophotographic paper 12 is registered or aligned in the exposure station 18 to properly receive the projected stationary image from the microfilm 10.

The fan-folded paper 12 preferably has marginal sprocket holes along each edge by which the paper transport means 20 moves the paper in synchronism with the mechanical rotational components thereof through sprocket or pinwheel assemblies which engage the sprocket holes in the paper. Since the sprocket holes are in fixed relation to the predetermined or form portions of the paper, they may be considered as in-

dexes of the form positions when appropriately referenced. The registration control means 28 is responsive to the positional orientation of the paper transport, and thus to the paper position, by means of a mechanical coupling to the paper transport, represented by dotted line 27, and to a form registration program input, later to be described in detail, which provides the necessary registration information to the system, corresponding to the length (in the direction of travel) of the predetermined portions or forms on the paper 12, so that the registration control 28 provides an output signal indication on lead 29 when each form portion is correctly registered in the exposure station. Registration information for various form lengths may be supplied by providing a suitable registration program corresponding to the particular paper form length used.

Logic means, shown as strobe and film transport control logic 30, is provided which is responsive to the projected image registration detecting photosensor 26 and to the output of the paper registration control means 28 for flashing the strobe 22 on the occurrence of the registration of a predetermined form portion of the continuously moving paper 12 in the exposure station 18 while the stationary projected film image is also registered therein.

One or more copies of a microfilm image may be made automatically by means of a multiple copy set and counter circuit 32 which is coupled to the control logic 30. By suitable preselection of the desired number of copies of each microfilm image frame (e.g., by means of a selector switch), the normal film transport operation is disabled until the preselected number of exposures have been completed, each on a successive form portion of the paper 12, after which the film transport 24 moves the microfilm 10 to the next image frame, and so on.

A system or train of cats 34 is provided which are guided by suitable tracks or rails 36 and are adapted to respectively deliver and receive stacks of the fan-folded electrophotographic paper at input and output stations, 38 and 40, respectively, of the apparatus, in a continuous fashion as the printing operation progresses.

Turning now to a more detailed description of the illustrated apparatus, the film transport 24 accepts 16 mm. non-perforated microfilm on standard 100, 200, or 400 foot reels. The film format is illustrated in FIG. 2, which shows a segment of the microfilm 10. As there shown, registration index marks 42 in the form of optical stripes are disposed along the edge of the film and centered on the optical axis of each image frame 44. The film may have opaque images on a transparent background with transparent optical stripes on an opaque border. Alternatively, of course, opaque stripes might be employed on a transparent border with suitable logic and photosensor circuitry for proper response. The film transport 24 has supply and takeup spindles and film reels 46 and 48, respectively, and a film-driving capstan 50, each of which are driven by a separate servomotor 52, 54 and 56 controlled by the strobe and film transport control logic 30.

A number of different data categories, classifications, jobs, etc., may be contained in a single reel of microfilm, and each of these data categories or jobs may be separated for detection by some given minimum length or gap of unexposed film not containing any images or registration marks. Thus, these gaps may be readily detected by the absence of a signal response from the registration photosensor 26 when the capstan servomotor 56 has moved the microfilm for some minimum length or time. This condition is recognized by the control logic 30, which in turn, stops the microfilm movement according to its prescribed mode of operation. The control logic 30 may provide various prescribed and controllable modes of operation, such as slew-forward and slew-reverse modes of operation wherein the film advances or rewinds at a fast speed and stops at the first record gap which is detected; a film drive mode wherein the film is driven forward until the first image frame is registered in the exposure station 18, at which time the film drive is stopped; a rewind mode wherein the film re-

winds at a fast speed and stops when the takeup reel 48 is in a given prescribed low-film condition as detected by any suitable film level-detecting means associated with the takeup reel; and a normal printing mode of operation wherein the film is intermittently advanced at a fast speed from each frame toward the next successive frame, but at a predetermined distance from the correct registration of the successive frame, the film speed is reduced to a low value and then stopped for film frame registration with the permitted tolerance within the film gate or aperture of the projector assembly and with the projected image of the frame within the exposure station. The desired operating mode is selected by suitable switches on a control panel (not shown) which are coupled to the control logic 30, described in greater detail hereinafter.

Each microfilm image is projected by the light source assembly 14 and the projection lens 16 to the exposure station 18, shown in greater detail in FIG. 3. The projected image at the exposure station 18 is inverted by the projection lens 16, so that although the film 10 travels downward on the transport 24 (FIG. 1), the images travel upward at the exposure station. Each image actually comprises two principal portions, namely, an informational portion 44 to be printed or copied and a registration indexing portion 42, as shown in FIG. 2. Both of these image portions are illuminated and projected by the light source assembly 14 in a manner to be later described. The film image registration is accomplished by imaging the registration index mark or stripe onto the paper or image plane 58 (FIG. 1) at the exposure station 18 and detecting the projected image of this mark with two photosensors 26 and 60 mounted in spaced relation a fixed distance apart along the side or lateral edge of the paper track in the exposure station 18. Registration photosensor 26 has been generally discussed above, and is disposed on or near the lateral or horizontal axis 59 of the exposure station, and the other photosensor 60 is located below the axis 59, as shown in FIG. 3. As there shown, the zinc-oxide-coated paper 12 is positioned in the exposure station with a form portion, defined by the spaced lateral perforations 62 and 62' coinciding with successive folds, equally spaced from respective upper and lower paper exposure masks 64 and 66 which, together, form the exposure window of the exposure station 18. The informational portion 44 of the microfilm image is thus exposed to the paper 12 between the lateral perforations 62 and 62' and between the marginally perforated borders 68a and 68b containing the sprocket holes, as shown. The registration indexing portion 42 is projected generally to the left of the paper 12, as illustrated in FIG. 3, so as to be imaged on the photosensors 60 and 26. The photosensor 60 is positioned below the registration photosensor 26 and serves to cause the capstan 50 to change from a high to a low film speed just prior to registration of the image. The change speed photosensor 60 receives the image of the registration index mark ahead of the registration photosensor 26 as the microfilm 10 is moved from the supply reel 46 to the takeup reel 48, and since the change speed photosensor detects the leading edge of the registration mark image first, it causes a change speed signal to be supplied to the control logic 30 via lead 70. The control logic 30 responds to this signal and slows the speed of the capstan drive servomotor 56 so that the film speed is reduced from, for example, 10 inches per second to 1 or 1/2 inch per second.

The change speed photosensor 60 is spaced ahead of the registration photosensor 26 a distance which provides an allowable slowing distance for the film, since on receiving the leading edge of the projected registration mark image, the registration photosensor 26 supplies a further signal to the control logic 30 via lead 72 which causes the film transport 24 to stop the movement of the film, and this must be within a relatively small tolerance for quality and uniform reproduction. By slowing the film speed just prior to registration of each image, the momentum of the film-driving mechanism is reduced sufficiently so that the stopping distance is maintained at an extremely low value, such as, for example, approximately 0.002 inch.

If the registration mark on the film is relatively wide, the photosensor 26 may be located above the centerline of the exposure window by one-half the width of the projected image of the mark. The image of the mark will then be on the centerline when the film is stopped.

Although the image is projected with the film 10 in a stationary or dwell condition, the paper 12 is in continuous motion, and the position of the paper represented in FIG. 3 is substantially instantaneous, the projection and exposure of the informational portion of the image being produced by the light flash of strobe 22. The stationary image registration within the exposure station 18 is accomplished prior to the strobe flash, and thus a suitable registration lamp is provided within the light source assembly 14 which continuously illuminates the microfilm so as to provide continuous projection of the registration marks 42 onto the image plane 58 at the exposure station 18 in a manner to be later described. Since the photosensors 26 and 60 are located in the image plane, they are responsive to the registration index marks as enlarged by the magnification of the projection lens 16 which produces extremely good precision in the image registration operation.

Assuming the film transport 24 is being operated in the normal mode, the microfilm 10 is accelerated to its fast speed until the registration index mark 42 of an image frame is detected by the change speed photosensor 60, at which time the control logic 30 causes the transport 24 to decelerate the microfilm 10 to its slow speed, and on detection of the index mark 42 by the registration photosensor 26, the control logic 30 causes the transport to stop the microfilm. Upon receiving a suitable signal via lead 29 from the paper registration control 28, indicating that a paper form is aligned or centered in the exposure station 18 between the masks 64 and 66, the control logic 30 generates a signal pulse on lead 74 which is fed to the light source assembly 14, causing the strobe 22 to flash. This cycle is then repeated with the transport 24 moving the microfilm to the next successive image frame, and so on. The strobe and film transport control logic 30 will not normally provide a flash signal to the strobe 22 in response to the paper registration control 28 unless it is enabled by the registration signal from the registration photosensor 26, signifying that the image frame 44 to be printed is properly registered within the exposure station 18.

More specifically, with respect to the film transport operation and construction, the capstan 50 is driven by motor 56, and the angular velocity of the capstan is sensed by a suitable tachometer generator coupled to its shaft. A DC amplifier is employed to drive the motor 56, and the amplifier is desirably driven by an electronic waveform generator to provide a signal of controlled slope for obtaining gradual, rather than abrupt, speed changes of the capstan 50 and the microfilm 10 prior to and after image registration. The waveform generator may accept inputs from the tachometer and from the control logic, and an integrating circuit may be coupled thereto and used to generate ramp signals of gradual slope, such as in response to signals from the change speed photosensor 60; but when a fast stopping action is required, such as in response to signals from the registration photosensor 26, an abrupt or square waveform signal is provided so that the image frame will be precisely registered within the exposure station. All film transport motors are substantially deenergized when the film image is registered at the exposure station 18, and each reel drive motor is equipped with a mechanical brake providing a small static friction load so that the chance of film motion from jitter, hunting, noise signals, etc., is substantially eliminated.

Vacuum loop buffering columns 84 and 86 are respectively located adjacent the supply and takeup reels 46 and 48 to isolate the inertia effects of the reels from the drive capstan 50 so as to permit high-speed, start-stop operation, and to protect the film strip 10 from abrasion. The "vacuum" or reduced pressure is provided through a vacuum or exhaust port located near the bottom of each of the columns which serves to draw the film strip into the column by the action of the atmosphere above the column, forming the respective loops, as shown.

Pressure-sensitive switches 88 and 90 are provided in operative association with each of the vacuum buffer columns, and each pressure sensitive switch is connected to a sensing aperture near the midpoint of each respective column. Pressure switches 88 and 90 provide output signals which are coupled to the control logic 30 via respective leads 92 and 94. In normal operation, the supply reel motor 52 runs forward, feeding film into the supply buffer column 84 until the film loop extends below the sensing hole therein, at which point the pressure-sensitive switch senses atmospheric pressure rather than the reduced pressure. In response to this condition, the control logic 30 causes the supply motor 52 to stop until the film loop in the supply column 84 is raised above the sensing aperture by the drive capstan 50 about which the film is wrapped. The takeup reel motor 54 also runs in the forward or takeup direction, withdrawing film from the takeup buffer column 86 until the film loop therein is withdrawn therefrom to a point above the sensing aperture connected to the takeup pressure sensing switch 90. The pressure switch 90 then detects the reduced pressure rather than atmospheric pressure and supplies a signal indicative thereof to the control logic 30 via lead 94, which in turn, causes the takeup motor 54 to stop until the takeup film loop is once again below the sensing aperture. To maintain equal tension lengths of microfilm in the two buffer columns it is desirable to position the pressure-sensing aperture in the supply vacuum column slightly above center and to position the sensing aperture in the takeup vacuum column slightly below center since the supply film loop is normally maintained just below the sensing aperture while the takeup film loop is normally maintained just above the sensing aperture. During the slow modes of operation the pressure-sensitive switches 88 and 90 may be disabled by appropriate logic circuitry, and the supply and takeup motors 52 and 54 may be driven at preset speeds. The motor driving the particular reel which may be paying out film is preferably driven in a direction to aid in paying out the film, but at a relatively low voltage so that the drag of this motor and its associated reel and brake is reduced, yet the torque produced is insufficient to pay out film without assistance from the other reel motor.

Both supply and takeup reels 46 and 48 may be equipped with low-film sensors (not shown) of any conventional or known type to indicate when a low-film condition is present on a reel by illuminating an appropriate panel indicator lamps, as well as to cause the stopping of the film. Additionally, a film-cleaning means 82 may be provided which forms an electric field in the vicinity of the film strip 10 to neutralize any static charge on the film so as to loosen and remove dirt, foreign residue, etc., by operating in conjunction with an associated vacuum cleaner.

The atmospheric pressure on the film loops in the buffer columns produce a moderate tensile force in the length of film between the columns. The tension in the film causes the film to grip the capstan so that the film can be moved by the capstan. The static friction brakes on the reel motors resist the tensile force in the film when the motors are not energized.

Turning now to the projector light source assembly and optical system of the illustrated apparatus, only a single projection lens 16 is required for projecting both the informational or data image and the registration index mark from each of the microfilm image frames. Referring to FIG. 4, the light source assembly 14 is diagrammatically illustrated to show a preferred arrangement of the principal component parts as well as their relation to the projection lens assembly 16, the film gate 96, and the image plane 58. The zinc-oxide-coated paper 12 has a response characteristic which is sensitive to ultraviolet and visible light, but not to infrared light, as the paper passes through the exposure station 18. The image of the optical stripe or registration mark on the film 10 is projected by infrared radiation from an infrared lamp 98 and the other spectral emissions therefrom are eliminated from the beam so that it does not affect the paper. The photosensors 26 and 60, located in the image plane 58, are preferably photocells of the silicon type which are substantially more sensitive or responsive to infrared than to either ultraviolet or visible light. The

infrared lamp 98 is a tungsten filament lamp and is maintained continuously illuminated for achieving change speed and image registration operations.

Strobe lamp 22 is preferably of the type filled with a gas such as xenon which emits an extremely intense flash of actinic light for an extremely short duration, such as for a period less than 100 microseconds. In the illustrated embodiment, the duration of the strobe is generally limited to the time required for the paper to move less than 0.01 inch, and preferably less than 0.001 inch. The spectral emission of the strobe 22 is primarily in the visible and ultraviolet range so as to affect the response characteristic of the paper.

The beam of ultraviolet and visible radiation and the beam of infrared radiation are combined by means of a dichroic mirror 100 which is transparent to infrared and reflective to ultraviolet and visible light. The combined beam is passed through the film gate 96, the image frame including the informational portion 44 and the registration stripe 42, and through the projection lens 16 to the image plane 58 at the exposure station 18. The flashlamp 22 is mounted in an elliptical reflector 102 which collects, redirects and focuses the light beam toward a point beyond the film gate 96 after being reflected first from a planar mirror 104 disposed at a 45° angle to the light beam, and then from the dichroic mirror 100. The planar mirror 104 reflects the beam to the front surface of the dichroic mirror 100 disposed at a 45° angle to the incident beam and 90° to the plane of the mirror 104 so that the beam of light is now folded through an angle of 180° as it is reflected from the dichroic mirror 100 to a field lens 106.

The infrared tungsten lamp 98 is located behind the dichroic mirror 100 and forms a point source of infrared radiation which is incident on a planar mirror 108 disposed in the same plane as the first planar mirror 104, being positioned at a 45° angle to the optical path from the infrared source 98, so as to reflect the incident radiation through an angle of 90° to a condenser lens 110. The condenser lens 110 then projects the radiation in the form of a parallel beam through the dichroic mirror 100, which is transmissive to infrared, and through the field lens 106 which converges the beam through the film gate 96, the microfilm image frame, and the projection lens 16 to the image plane 58. Since the dichroic mirror 100 is positioned at an angle of 45° to the infrared beam at its back surface and to the visible and ultraviolet beam at its front surface, the dichroic mirror 100 combines both the infrared registration light and the strobe light as two components into a single beam wherein the registration component is continuously present, while the strobe component is present only intermittently for image print exposure. Dichroic mirrors are generally well known, and one satisfactory dichroic mirror which may be employed is No 45-2-500, available from Bausch and Lomb, Inc.

With this optical and light source arrangement, continuous registration operation is permitted without "fogging" or discharging the electrostatic charge which has been placed on the zinc-oxide-coated paper as it passes through the exposure station 18. Additionally, with the arrangement shown in FIG. 4, ultraviolet or visible components in the radiation emission of the registration lamp 98 are reflected out of the optical path by the dichroic mirror 100 so that they cannot affect the electrophotographic paper. Likewise, any infrared component in the beam of the strobe 22 is transmitted through the dichroic mirror 100 and thus passes harmlessly out of the optical system so that the microfilm is prevented from receiving the infrared or heat energy which may be radiated by the intense flash of the strobe 22. This aids in preventing the temperature of the microfilm from becoming excessive during the exposure operation, which may be repeated at a rapid rate for printing out multiple copies of one microfilm image frame on the reel.

Turning now to the paper transport system, the general paper-handling mechanisms, and the overall electrostatic printing system, the apparatus in accordance with the illustrated embodiment of the invention accepts fan-folded paper in widths from 8½ to 18 inches, and having sprocket holes

along margins 68a and 68b, as shown in FIG. 3. The paper transport includes an upper pair of pinwheel assemblies 112 and 113 and a lower pinwheel assembly 114, all of which engage the marginal sprocket holes and move the paper through each of the various stations of the electrostatic printing system. The paper 12 is then automatically refolded at the original infold and outfold creases at the paper refold station 116.

The cart assembly 34 (FIG. 1) includes loading and receiving carts 118 and 120, respectively, which are provided at the bottom portion of the apparatus for external handling of the paper, the loading and receiving carts being desirably identical in construction and adjustable to accommodate different paper widths. Both of the carts 118 and 120, as well as additional carts such as cart 121, may be moved from the paper-loading station 38 to the paper-receiving station 40 along a fixed track or guide assembly 36 in any convenient manner, and the several carts may be connected in tandem on the track, as shown. The tracks 36 may serve to both support and guide the carts, as shown in FIG. 1, or alternately, the tracks 36 may guide the carts by slidably contacting the sides thereof, while the floor beneath the printer supports the carts. Thus, a train of carts, each containing a box of paper, may be positioned along the track portion leading to the loading station 38 to form a loading line, and the last section or form in each paper stack may be spliced to the leading section or form in the next paper stack as indicated by the spliced web portion 123. When the stack of paper in the loading cart 118, for example, is depleted, and the stack of completed printout in the receiving cart 120 is completed, the carts 118 and 120 may be moved to the right (as illustrated in FIG. 1) until the loading cart 118 is beneath the receiving station 40 to function as the new receiving cart and the next successive tandemly coupled cart 121 is placed into the loading station position. Since the trailing edge of the stack in cart 118 was spliced to the leading edge of the stack in cart 121, the paper may be supplied in a continuous manner to the printing apparatus without the necessity of stopping the operation. Thus, the employment of fan-folded paper, in conjunction with the system of carts, permits continuous printing operation at a high speed, regardless of the volume of paper involved. This is particularly advantageous as compared, for example, to the use of paper in roll form, where it would generally be necessary to stop the machine for loading at the end of each roll to permit the splicing and introduction of a new roll, or the rethreading of the apparatus, each time a new supply of paper was to be introduced. Splicing of the paper may be accomplished by any convenient means, such as, for example, strips of splicing tape transversely applied to the respective leading and trailing edges of the paper to be joined, while maintaining the marginal sprocket holes properly spaced in the direction of paper travel in the area of the splice.

The paper transport system 20 comprises those units which directly control the mechanical movement and positioning of the paper web 12 throughout its passage along the paper path of the apparatus, and through the various stations of the electrostatic processing system, from the paper supply cart 118, through a cleaning station 122, a charging station 124, a developer station 126, squeeze rollers 128, a dryer station 130, a refold station 116 and then into the receiving cart 120. The supply cart 118 is wheeled on its track below the apparatus and the leading edge of the paper is fed up and into the apparatus, as shown schematically in FIG. 1, past suitable means for holding the paper web taut such as brush 191. The paper passes through cleaning station 122 which performs the function of removing dust from the paper before it reaches the corona charge grids of the charging station 124. The paper is cleaned on both sides as it passes through the cleaning station 122 by means of a vacuum cleaner, and the dust is collected in a suitable vacuum bag.

The paper leaves the cleaning station 122 and enters the corona charging station 124 after being driven by the lower pinwheel assembly 114 which has a pair of pinwheels disposed

so that one pinwheel contacts each respective marginal portion of the paper 12, engaging the marginal sprocket holes therein, as previously mentioned. The charging station 124 may comprise any known form of corona charging structure having upper and lower corona charging grids running transverse to the paper path, and which have high-voltage potentials applied thereto which are required to produce an appropriate corona for charging the paper 12 to the proper polarity and potential for electrophotographic printing.

After the corona charge has been placed on the paper 12, the web 12 is transported from the charging station 124, over roller guide discs 140, into the exposure station 18. The exposure station 18 is formed by a smooth steel plate or platen 142 perforated with airholes through which a partial vacuum is drawn, and which holds the paper web evenly and substantially wrinkle-free over the platen surface, but permits its continuous movement thereover. Although the image plane 58 on the paper, the exposure station platen 142, and the masks 64 and 66 are shown apaced apart for the purpose of clarity of illustration, these parts are desirably closely spaced so that the paper image plane 58 is disposed on the platen 142 and the masks 64 and 66 are adjacent the surface of the paper. The platen 142 is mounted so that its flat surface slants upwardly at an angle which is perpendicular to the centerline 144 of the optical path of the projector lens 16. The width of the exposure area on the paper is substantially the same width as the charged area thereon. The length of the exposure area in the direction of paper travel corresponds to each form section of the paper and is determined by adjustment of the upper and lower masks 64 and 66 forming the exposure window, as illustrated in FIG. 3. The masks 64 and 66 are positioned by sliding them up or down on support rods 146 and 148.

Each time the strobe 22 is flashed, an enlarged image of the film strip 10 is exposed on the charge-sensitized paper form registered within the exposure window and the paper is held evenly against the platen 142 with the fold perforations 62 and 62' spaced evenly from their respective exposure masks 64 and 66. Photon bombardment discharges the paper in the exposed areas forming a latent electrostatic image. The fold perforations 62 and 62', defining the form sections of the paper 12, are desirably spaced about one-eighth inch from each respective exposure mask, and the charged area is preferably confined to the region between the marginal sprocket hole areas 68a and 68b, as shown in FIG. 3, which are longitudinal margins of approximately one-half inch in width having the sprocket holes centered therein. As previously stated, the paper 12 is not stopped in the exposure station 18 during normal printing operation, but moves continuously therethrough.

After exposure, the paper 12 travels upwardly along the paper path, around a first upper pinwheel assembly 113, and into the developer station 126. This is shown in FIG. 5 wherein arrows 152 and 154 show the direction of paper travel over the pinwheel assembly 113, which comprises marginally located pinwheels 156 and 158 for engaging the sprocket holes and a plurality of guide discs 160 mounted on a common shaft with the pinwheels and disposed therebetween.

The developer station 126 may be of any known construction and generally comprises a developer tray, liquid solution tanks and suitable pumps that provide liquids to the developer tray and maintain appropriate liquid levels for operation. After being developed, the paper 12 is fed between a pair of squeegee rollers 128 which press the excess solution from the paper web and also serve to maintain the web taut as it passes through the developer station, but of course not so taut as to cause tearing of the perforated sheets. The proper tension on the paper is maintained in the developer station by the squeegee rollers 128, the lower one of which is driven by the paper transport drive system 20 via a drive belt, through a pulley and slip clutch assembly mounted on the end of this roller. The driven pulley is driven faster than synchronous speed so that the clutch slips and the paper is kept taut. The belt is driven by a driving pulley coupled to the pinwheel shaft 182, as indicated by the dotted line 186. All of the mechanical

couplings and drives of the paper transport system 20 are indicated by dotted lines, and these parts will be discussed in greater detail hereinafter.

The paper web 12 is then fed from the squeegee rollers 128 to the dryer station 130. The dryer station 130 may comprise a dryer drum 162 over which the paper web passes, and an electric heater (not shown) placed in a stream of air directed onto the surface of the paper web as it passes over the dryer drum 162. In this manner, each image is affixed to the paper to result in permanent hard copy that can be readily handled without loss of information. The temperature of the hot air passing over the drum 162 may be controlled by any conventional thermostat coupled to the heater to continuously maintain the temperature within specified tolerances.

After the paper web 12 passes over and around the dryer drum 162 and emerges from the drying station 130, it passes over the second upper pinwheel assembly 112 of the paper transport 20, and is then directed downwardly through the paper refold assembly 116 which refolds the paper and stacks it in the receiving cart 120 located at the lower part of the apparatus under the receiving station 40. Infolds and outfolds of the paper are made at the original creases without requiring any adjustment to accommodate changes in form length. The paper enters the refold assembly immediately after leaving the upper pinwheel assembly 112 which, as shown in greater detail in FIG. 5, comprises marginally located pinwheels 164 and 166, and guide discs 168 mounted on a common shaft 184 and located therebetween. The direction of paper travel over the upper pinwheel assembly 112 is shown by the arrow 170. The paper passes down and along two metal plates 172 and 174 equipped with suitable guide wires which direct the paper into the receiving cart 120. The guide wires and plates sweep downwardly in a curve, first toward the left portion of the apparatus, and then toward the right, as shown in FIG. 1. A pair of paper drive wheels 176 are located near the lower portion of the refold station 116 which are adapted to be opened initially to permit the feeding of the paper therebetween and then to be subsequently closed to maintain driving tension of the paper web 12. A lever 178 may be provided to manually open and close the guide wheels which are mechanically coupled to the paper transport mechanism as shown by the dotted line 188 interconnecting the left drive wheel to the lower pinwheel assembly 114.

When each fan-fold crease passes out of the lower end of the refold assembly 116, beyond the paper drive wheels 176, the weight of the paper sheet, itself, causes it to bend at each fold, and in this manner the paper refolds at its original creases as it is stacked in the receiving cart 120.

Since the paper is transported, charged, developed, and dried at constant speed, the printer is capable of reliable operation at speeds up to 80 feet per minute.

Turning now more specifically to the construction of the paper transport drive 20, the upper paper transport assemblies 112 and 113 may preferably comprise two sets of pinwheels approximately 7 inches in diameter, one set above the other, and the pins on each set of pinwheels are kept in alignment with each other and with the marginal sprocket holes in the paper by suitable alignment rods inserted through holes in the pinwheels and through each set of paper support discs 160 and 168. The lower pinwheel assembly 114 has a similar structure, but with a pair of pinwheels and discs approximately 2½ inches in diameter. A single paper transport drive motor 180 may be employed to drive the entire paper transport system 20, and in a specific construction in accordance with the illustrated embodiment, the paper transport drive motor 180 is coupled directly to the upper pinwheel assembly 113 as indicated by dotted line 181, and to the lower pinwheel assembly 114 (dotted line 183) with a common drive belt. The upper pinwheel assembly 113 then drives the other upper pinwheel assembly 112 by a set of suitable transfer gears (dotted line 185) coupled to their respective shafts 182 and 184. The squeegee rollers 128 and the paper drive wheels 176 are driven by suitable belt and pulley takeoffs as indicated by the dotted lines 186 and 188.

Proper paper registration and synchronization of the strobe lamp 22 to accommodate particular form formats of various lengths is accomplished by providing suitable form registration programs as an input to the paper registration control 28, as illustrated. More particularly, the form length in the direction of travel may typically vary from $8\frac{1}{2}$ inches to 15 inches between successive folds or tear perforations. As can thus be seen, proper registration and flash synchronization for any one particular form length will be improper for another form length.

The paper registration control 28 may comprise any suitable system for this purpose, but advantageously, in the illustrated apparatus, it comprises a program tape reader employing a program loop or belt of perforated tape 202, as shown in FIG. 5. As shown in greater detail in FIG. 8, the perforated tape 202 has a series of closely spaced sprocket holes 204 disposed longitudinally along the tape and a sequence of longitudinally spaced program holes 206, 206', etc., laterally offset therefrom and located between the sprocket holes 204 and one edge of the tape. The perforated tape 202 is preferably formed from any normally opaque material, and may be composed of paper, plastic, etc. A different program tape is used for each different form length and has a different fixed spacing between successive program holes 206, 206'. A relatively long program hole spacing is used for long form lengths and a shorter program hole spacing is used for relatively shorter form lengths. The paper registration control 28 also includes a means for providing a fine adjustment of the paper form registration, generally indicated as 208 in FIG. 5, having an adjustment knob 210 for manually setting the fine adjustment provision and obtaining precise synchronization of the flash strobe with the registration of the form in the exposure station. The tape reader 200 may thus be considered as a relatively coarse paper registration control, while the adjustment provision 208 provides a fine paper registration control.

Referring now to FIG. 6, where the program tape reader 200, fine adjustment control 208, and associated mechanism, are shown in greater detail. The shaft 182 on which are mounted the upper pinwheels 156 and 158 (FIG. 5) necessarily moves in accurate synchronism with the motion of the paper web 12 and this shaft is geared to a small transparent plastic sprocket wheel 212, which drives the program loop of perforated tape 202 by engagement with the sprocket holes 204 located therein. A gear 214 is mounted on the end of the shaft 182 and drives the plastic sprocket wheel 212 through gear 216. Gear 214 is coupled to shaft 182 via a slip clutch, not shown. Thus, the program loop 202 is driven in synchronism with the movement of the paper web 12. The program loop, as previously stated, has a line or series of program holes 206 which are spaced apart a distance proportional to the length of the forms of the paper web being utilized. A lamp 218 is mounted inside the plastic sprocket 212 and directs light through the program holes 206 and onto tape reader photosensor 220 which provides a timing pulse output each time a preprinted form is approximately centered on the exposure platen 142, as indicated by the response of the photosensor 220 to the light through the program hole. Such a pulse is produced each time a successive program hole is positioned between the light source 218 and the photosensor 220, corresponding to the approximate registration or centering of the successive preprinted forms in the exposure station 18. The photosensor 220 provides, in this manner, a relatively long or coarse timing pulse signal for enabling the synchronization of the flash of the strobe 22 with registration of the paper for each exposure. These coarse timing pulses are fed to one input of a coincidence logic 222 of any conventional type.

A timing shutter wheel 224, of which only a portion is shown in FIG. 6 for the purpose of better illustration, is also driven by the same pinwheel shaft 182 via a friction slip clutch assembly 226, shown in FIG. 7. The timing wheel 224 has a multitude of alternate vanes 230 and notches 228 about its perimeter. A timing lamp 232 (FIG. 7) and a timing photosensor 234 are spaced on opposite sides of the timing wheel 224 and supported by means of a mounting bracket 236.

As the pinwheels rotate, moving the paper 12 through the apparatus, the timing wheel 224 rotates so that the vanes 230 intermittently block the light path between the timing lamp 232 and the timing photosensor 234 to generate a sequence or train of very short pulses from the latter. The number of such short pulses is relatively large during any one form length of paper travel, and these pulses are employed to achieve a fine registration adjustment of the web by permitting precise synchronization control of the web position and the strobe flash. These fine registration pulses are fed to a second input of the coincidence logic 222.

The action of the coarse and fine registration pulses produces a "vernier" control whereby only coincidence of a coarse and a fine timing pulse produces an output pulse from the coincidence logic 222, causing the strobe 22 to flash at the precise instant for exposure of the paper when it is in exact form registration. The specific phase relationship of the fine registration pulses from the timing wheel photosensor 234 and the coarse registration pulses from the program tape reader photosensor 220 may be controlled by adjusting the position of the timing wheel photosensor 234 with respect to the timing wheel 224.

In order to provide this fine adjustment of paper registration, the timing lamp 232 and photosensor 234, mounted on bracket 236, are fixed to a rack 238 having a linear gearing portion 240 disposed along its lower surface and directed downward so as to engage a pinion gear 242, as shown in FIG. 6. The pinion gear 242 is mechanically coupled to the fine registration adjustment knob 210 shown in FIG. 5, and by turning this adjustment knob, the rack 238 and the timing photosensor 234 are moved to the left or right in a plane parallel to the timing wheel, thus retarding or advancing the fine timing pulses. When a fine timing pulse and a coarse timing pulse are in coincidence, the flashlamp 22 behind the microfilm is triggered, and the paper form is exposed.

In order to set a definite relationship between the fine timing adjustment and the actual form registration, an initial adjustment may be made by moving the paper web 12 forward or backward at a slow speed until a form is centered or registered on the platen 142. While the paper is centered but not moving, the sprocket 212 driving the perforated tape loop 202 is manually rotated until one of the program holes 206 in the tape is aligned with the program reader photosensor 220. This manual rotation is made by turning a reset knob 250 (FIG. 5) which is coupled to a gear 252 (FIG. 6) which, through suitable gearing arrangements, rotates the plastic sprocket drum 212 until a program hole is aligned with the light source 218 and the photosensor 220. The gear 214 slips with respect to shaft 182 during alignment. Alignment may be indicated by a suitable control panel indicator light (not shown) for indicating the program tape reader registration. With the paper 12, loop 202, and timing wheel 224 stopped in this position, the fine timing adjustment knob 210 (FIG. 5) and pinion gear 2 (FIG. 6) are turned fully counterclockwise (as seen in FIG. 6), driving the rack 238 to the extreme left until it strikes a stop 244 which is fixed to the frame of the apparatus. During this motion, a pawl 246 near the right end of the rack 238 strikes one of the shutter vanes or teeth 230 of the timing wheel 224 and rotates the wheel 224 until the edge of the tooth is in a standard reference position, such as, for example, vertically below the center of the pinwheel shaft 182. The friction clutch assembly 226 (FIG. 7) slips as the timing wheel 224 rotates and the shaft 182 remains stationary. The fine adjustment knob 210 (FIG. 5) and consequently the pinion gear 242 are then rotated back to a position where the index mark on the knob 210 is opposite a "zero" mark on the panel, as shown in FIG. 5. With the knob index at "zero", the lamp and photosensor assembly on the rack is positioned on a vertical line or axis which extends through the pinwheel shaft 182. The paper transport motor 180 may now be turned on, and fine timing pulses will be generated as the shutter vanes or teeth on the timing wheel 224 pass the photosensor 234. The phase relationship between the leading edges of the fine timing pulses and the positions of the paper forms relative to the expo-

sure station 18 may be adjusted while the paper is moving through the apparatus at high speed in normal operation by observation of the microfilm information as it is printed out on he forms in the output and rotating the fine adjustment knob 210 slightly until the exact registration desired is obtained. Such extremely fine adjustment permits an operator to obtain the extremely precise registration which is necessary to print variable information from the microfilm onto forms which are preprinted, where any misregistration would be extremely noticeable and intolerable.

Thus, the sequence of operations of the apparatus may be summarized in that first the film is advanced rapidly until the center or axis of a film frame is near the projection aperture center and the center of the projected image is near the center of the exposure station, then it is advanced slowly until exactly at center, and then the film is stopped. The paper forms move continuously and at constant speed at all times. After the film is stopped, the center of a form reaches a position near the axis of the exposure platen and a relatively long, coarse timing pulse is generated. When the axis of the paper form reaches the exact center of the exposure platen, a fine timing pulse is generated in coincidence with the coarse pulse, which causes the strobe lamp to flash at this time. Although fine timing pulses are continuously generated before and after the form is at its center or registered position, they do not cause the strobe to flash because no coarse timing pulse is present.

Referring now to FIGS. 9 and 10, there is shown a portion of the logic circuitry which may be employed the strobe and film transport control logic 30 and the multiple copy set and counter 32, illustrated in block form in FIG. 1. However, it is of course understood that other alternative forms of logic and control circuitry may be used, such circuitry being within the skill of the art based on the teachings hereof. The illustrated apparatus employs diode-transistor logic (DTL) and is implemented with a combination of discrete components and integrated circuit modules.

Generally, the multiple copy circuit 32 comprises a multiple position selector switch by which the desired number of copies of each data frame is preselected, a counting circuit of any suitable type which is responsive to each flash of the strobe 22 to register the printing of each copy, and a comparator circuit which compares the preselected count on the selector switch with the count of the counter circuit to provide an output on lead 260 to the control logic 30 when the count of the latter has reached the preselected count. This signal indicates that the preselected number of copies of the projected image have been exposed, and the control logic 30 then causes the film transport 24 to move the microfilm 10 to the next successive image frame, in the manner previously described. Also, a reset signal is supplied to the counter circuit via lead 262 to restore the counter to zero in preparation for the printing of the next image frame.

More particularly, referring now to FIG. 9, the copy selector switch 300 has a four-digit parallel binary output on leads 302, 303, 304 and 305 formed by four single pole switches which are selectively opened and closed in the appropriate combinations to provide binary outputs corresponding to the selected number of copies to be made, as set on a suitable selection knob (not shown), coupled to the switches. The switches may thus be suitably ganged. The selector switch 300 is illustrated in position "9" for preselection of nine copies of each projected film image, and the binary parallel outputs thus form the binary number 1001. These outputs are then inverted by logic inverters 308, 309, 310 and 311 which transform the direct parallel switch outputs to the binary number 0110 which is supplied on leads 314, 315, 316 and 317 to a comparison gating circuit 320. The comparison gating circuit 320 receives inputs from both the direct and inverted outputs of the selector switch 300, as well as the output count from a counting circuit 322 to provide a parallel comparison identity indication for each respective binary digit on output leads 324, 325, 326 and 327. These leads are fed to an output NAND-gate 330 which provides a number correspondence

output at 332 which is indicative of the exact correspondence between the counter output and the preselected switch number.

A counter stepping circuit 334 is provided which is responsive to a strobe monitoring signal on its input lead 336 each time the strobe 22 is flashed. The stepping circuit input lead 336 may be coupled to any suitable circuit point for monitoring the strobe flash and may conveniently be connected to a point in the strobe power supply (not shown). Other stepping circuit input leads 338, 340 and 342 are provided to supply inhibit signals from various other portions of the logic system (not shown) so that the stepping circuit 334 and the counter 322 may be inhibited for other modes of apparatus operation, such as, for testing or initially setting up the apparatus.

The output of the stepping circuit 334 appears at lead 344, and is coupled to the input of the counter 322 through a coupling resistor, as shown. The counter 322 comprises four J-K flip-flops having their respective principal outputs (Q) connected to their K inputs, and their respective complementary outputs ($\bar{Q}$) connected to their J inputs. The stepping circuit output on lead 344 is coupled to the trigger input (T) of the first flip-flop stage, and the complementary output ($\bar{Q}$) of each stage is connected directly to the trigger input of the next succeeding stage. A reset input on lead 346 is connected to each of the flip-flop stages of the counter to restore the counter to its initial zero condition.

The comparison gating circuit 320 comprises four stages 350, 351, 352 and 353, corresponding to each of the flip-flop stages of the counter 322 and to each section of the selector switch 300. Each of these comparison gating stages comprises three two-input NAND logic gates 350a, 350b and 350c; 351a, 351b and 351c, etc., being connected so that the output terminal of the a and b gates are connected to each of the two inputs of the c gates, and the output of each c gate is connected to its respective output lead 324, 325, 326 and 327. These leads provide four inputs to the output NAND-gate 330, corresponding to the correspondence indication of each binary digit.

These circuits are interconnected so that each of the direct outputs from the selector switch 300 on leads 302, 303, 304 and 305 are respectively connected to one of the b gate inputs, while the inverted selector switch outputs on leads 314, 315, 316 and 317 are each connected to one of the respective a gate inputs. The complementary output of each J-K flip-flop stage of the counter 322 is respectively connected to the other a gate input of each corresponding stage of the comparison gating circuit 320, while the principal output of each of these flip-flops is connected to the other input of each b gate of the corresponding comparison gating circuit stage.

Thus, when the binary output count of the counter 322 has reached the preselected number count set on the selection switch 300, the output of the c gates in each of the comparison gating stages will be in the "one" stage and the output NAND-gate 330 at lead 332 will switch to its "zero" state.

Referring now to FIG. 10, the number correspondence signal on terminal 332, which indicates that the preselected number of exposures of an image frame have been completed, is fed to the toggle or complement input of multicopy-end flip-flop circuit 370 through a NAND-gate 372 and an inverter 374. The flip-flop 370 is in the cleared or zero state while the counter 322 is counting flashes, so it is switched to the one state by the number correspondence signal. When the multicopy-end flip-flop 370 is thus triggered, the complementary output on lead 376 enables gate 378. When the other input of gate 378 is subsequently enabled by the output of gate 418, as will be described later, it provides a reset signal on lead 346 by means of NAND-gate 380 and inverter 382, the reset signal on lead 346 being fed to the counter 322 (FIG. 9) which is restored to zero. The reset signal on lead 346 is also applied via lead 428 to the reset input of the multicopy-end flip-flop 370 to restore its initial state at the same time that the counter circuit 322 is restored to zero. The complementary output on lead 376 also provides an INCREMENT signal at terminal 384

by means of NAND-gate 386 and a SEARCH signal at terminal 388 by means of NAND-gate 390, when the other appropriate signal inputs are applied to these gates, as will hereinafter be described.

The INCREMENT signal at terminal 384 is supplied to a capstan drive circuit (not shown) which causes the capstan on film transport 24 (FIG. 1) to move the film toward the next successive image frame, in the manner previously described. When the change speed photosensor 60 intercepts the light from the projected film registration mark, the photosensor 60 provides a pulse to the terminal 392 which sets a stop-enable flip-flop circuit 394 comprising two cross-connected NAND gates, as shown. The flip-flop 394 is set through NAND-gates 396, 398, 400 and inverter 402, and provides a principal output on lead 404 which is coupled to a second input of the NAND-gate 390. An external FILM DRIVE signal from the apparatus control panel is provided at terminal 406 which is inverted by NAND-gate 407 and applied to the third input of the NAND-gate 390. The presence of these film drive, multicopy-end and stop-enable signals at the three inputs of the NAND-gate 390 causes this logic gate to provide the SEARCH output signal to the capstan drive circuit, causing the film capstan to move the film at a slow speed for image registration in the manner previously described.

Subsequently, then, the registration photosensor 26 intercepts the light from the projected film registration mark and provides a pulse at terminal 408, which is amplified by a transistor amplifier circuit 410. The amplified pulse triggers stop flip-flop 412 (also comprised of two cross-connected NAND gates) through NAND-gates 414, 416 and 418. The complementary output of the stop flip-flop 412 is a FAST STOP signal on terminal 420 which is applied to the capstan drive circuit, which immediately brings the film to a stop for proper registration in the exposure station 18. The signal from NAND-gate 418, which triggers the stop flip-flop 412 also is applied to NAND-gate 378. Since the other input to NAND-gate 378 is already present, a reset signal is generated on lead 346, as described before, coincident with the FAST STOP signal on lead 420.

On the occurrence of the first strobe flash after image registration, the output pulse on lead 344 (FIG. 9) from the stepping circuit 334 is supplied through an inverter 422 to terminal 424 and thence to lead 426 (FIG. 10) where it is applied to the reset input of the stop-enable flip-flop 394 and to the reset input of the stop flip-flop 412, resetting both of these flip-flops. At the same time, of course, the stepping circuit output steps the counter circuit 322 to a count of 1.

An ADVANCE signal from a control panel switch (not shown) is coupled, as shown, to the flip-flop 370 via gate 372 and to the flip-flops 394 and 412, and serves to trigger these flip-flops in the normal mode of system operation. A CLEAR signal at terminal 430 may also be supplied from a suitable control panel switch for manually resetting the counter 322 and the multicopy-end flip-flop 370. Leads 432, 433 and 434 are provided for auxiliary circuitry which may be employed for operating the system in a setup or test mode where it may be desirable to inhibit the photosensor operations and to supply simulated pulses generated by other circuits included in the apparatus for this purpose, and not shown herein.

Thus, there has been described a high-speed, hard copy printer for converting and printing out images from microfilm onto a hard copy output medium, having the capacity of producing throughputs of at least 80 feet per minute in a continuous manner, and having provisions for continuous loading and unloading of an unlimited volume of paper. The paper may be preprinted with letterheads, invoice forms or other fixed information, and variable information from the microfilm is then added to the preprinted forms with exact registration. The paper is preferably fan folded and when each form-length, or predetermined section, between the successive folds in the fan-folded paper is centered in the exposure station, the image of a microfilm frame is projected thereon by flashing a high-intensity strobe. The paper moves continuously

through the apparatus, while the microfilm is moved intermittently, so that the film is stationary during the exposure of any frame. Either one copy or a preselected number of identical copies may be made, as desired. The film is then advanced until its next frame is registered and maintained stationary for exposure.

The utilization of continuous paper movement permits the employment of a paper transport mechanism of relative simplicity, high reliability, low noise level and fast maximum paper speed. Additionally, a very high quality of electrostatic reproduction is provided by using a constant paper speed so that the charging of the paper and the development of the images are extremely uniform. By employing an intermittent film motion, any desired number of copies can readily be made from each frame of the film and the film images may be precisely registered without the necessity for complex scanning mechanisms.

Although a preferred embodiment in accordance with the present invention has been illustrated and described, various modifications will be apparent to those skilled in the art. Accordingly, the scope of the present invention should be defined only by the claims, and equivalents thereof.

Various features of the invention are set forth in the following claims.

What we claim is:

1. Apparatus for printing images from a photographic medium onto a photosensitive medium having a plurality of predetermined portions, said apparatus comprising an exposure station, first transport means for continuously moving said photosensitive medium through said exposure station, a light source for exposing an image from said photographic medium onto said photosensitive medium at said exposure station, second transport means for moving said photographic medium to position one of said images for exposure thereof on the continuously moving photosensitive medium and for maintaining said photographic medium stationary during exposure, first registration means for actuating said light source when one of said predetermined portions of the photosensitive medium is registered in said exposure station to be exposed by the stationary image from said photographic medium, second registration means for detecting registration of the photographic image in said exposure station, and logic means responsive to said second registration means and to said first registration means for actuating said light source on the registration of a predetermined portion of the continuously moving photosensitive medium in said exposure station while the stationary photographic image is registered therein.

2. The apparatus of claim 1 wherein said logic means is controllably coupled to said second transport means and causes said second transport means to move the photographic medium to a further position whereat another image thereon is then maintained stationary and in registration in said exposure station, after said light source has been actuated a preselected number of times to expose the previously positioned image, and after said first transport means has continuously moved a corresponding preselected number of said predetermined portions of the photosensitive medium through the exposure station so that each of these predetermined portions has been exposed to said previously positioned image.

3. The apparatus of claim 1 including means for operating said second transport means intermittently to position each successive image on said photographic medium for exposure, whereby each successive image is maintained stationary during its exposure to said photosensitive medium.

4. The apparatus of claim 1 further comprising means for projecting an enlarged image from said photographic medium for exposure of said photosensitive medium.

5. The apparatus of claim 4 wherein said photographic medium is in the form of microfilm, said photosensitive medium is in the form of electrophotographic paper, and said apparatus comprises means for electrophotographically copying the enlarged microfilm images onto said paper.

6. The apparatus of claim 1 wherein said light source comprises a strobe-type flashlamp for providing a high-intensity, short-duration light flash for each exposure.

7. The apparatus of claim 1 further comprising means for maintaining the movement of said photosensitive medium in synchronism with said first transport means, said first registration means comprising means responsive to the positional orientation of said transport means and to a registration information program corresponding to the length of said predetermined portions of said photosensitive medium for providing an output signal to actuate said light source upon registration of said predetermined portions in said exposure station as indicated by the transport means and registration program.

8. Apparatus for printing images from a photographic medium onto a photosensitive medium in the form of fan-folded paper, said apparatus comprising an exposure station, first transport means for continuously moving said photosensitive medium through said exposure station, a light source for exposing an image from said photographic medium onto said photosensitive medium at said exposure station, and second transport means for moving said photographic medium to position one of said images for exposure thereof on the continuously moving photosensitive medium and for maintaining said photographic medium stationary during exposure, said first transport means comprising means for moving the paper through said apparatus from a loading station to a receiving station, and said apparatus further comprising track means disposed in proximity to both loading and receiving stations, and a train of carts, each adapted to hold a stack of said fan-folded paper, movably engaged with said track means and spaced apart a distance so that one cart is in paper-loading relation to said loading station while another cart is in paper-receiving relation to said receiving station.

9. The apparatus of claim 8 wherein additional carts are movably engaged with said track means and positioned in a loading line behind the cart which is in loading relation to said loading station, all of said carts being tandemly coupled together so that the fan-folded paper may be fed through said apparatus in an endless manner by splicing the trailing edge of paper in each cart in the loading line to the leading edge of the paper in each succeeding cart and shifting each loading cart toward the receiving position as it is emptied.

10. Apparatus for printing images from a photographic medium onto a photosensitive medium having a plurality of predetermined portions, said apparatus comprising an exposure station, first transport means for continuously moving said photosensitive medium through said exposure station, a light source for exposing an image from said photographic medium onto said photosensitive medium at said exposure station, second transport means for moving said photographic medium to position one of said images for exposure thereof on the continuously moving photosensitive medium and for maintaining said photographic medium stationary during exposure, first registration means for actuating said light source when one of said predetermined portions of the photosensitive medium is registered in said exposure station to be exposed by the stationary image from said photographic medium, means for registering the photographic image in said exposure station, a source of multiple copy control signals representative of a selected number of copies to be made from the photographic image, counting means responsive to said first registration means for counting the number of predetermined portions of the photosensitive medium which pass the exposure station while the stationary image is registered therein, and control means responsive to said multiple copy control signals and to said counting means for controlling said second transport means so that said second transport means maintains the photographic medium stationary until the selected number of exposures of the image are made on a like number of predetermined portions of the photosensitive medium and advances the photographic medium upon completion of the exposure of the selected number of copies.

11. A high-speed printer for making enlarged copies of microfilm images on electrophotographic paper having a corona charging station, an exposure station, and a further processing station; first transport means for continuously moving said paper through each of said stations, a fast light source and projection means for enlarging and projecting the images of the microfilm on the paper at said exposure station, second transport means for intermittently moving said microfilm from one image to another so that the projected image is maintained stationary during exposure.

12. The printer of claim 11 wherein the electrophotographic paper is fan folded and has sprocket holes along the margins thereof, said first transport means comprising pinwheel assemblies for engaging the sprocket holes so that the paper is moved in synchronism with the rotation of the pinwheel assemblies, and registration means responsive to the rotation of said pinwheel assemblies for synchronizing the actuation of said light source with the paper movement, so that the light source momentarily projects the stationary microfilm image when a predetermined portion of the paper between successive folds is centered in said exposure station.

13. The printer of claim 12 wherein each frame of the microfilm has an optical registration mark associated therewith, said printer comprising image registration detecting means responsive to the registration mark image for providing an output indicative of image registration in said exposure station, and control means responsive to the output of said detecting means for causing said second transport means to stop the motion of the microfilm so that the projected image therefrom is maintained in registration in the exposure station.

14. The printer of claim 11 wherein the electrophotographic paper is of the fan-folded type, said first transport means comprises means for moving the paper through the printer from a loading station to a receiving station, guide means disposed in proximity to and beneath both loading and receiving stations, a train of carts movably engaged with said guide means and spaced apart a distance so that one cart is in paper loading relation beneath said loading station while another cart is in paper receiving relation beneath said receiving station, each cart being adapted to hold a stack of the fan-folded paper and, all of said carts being tandemly coupled together so that the fan-folded paper may be fed through said printer in an endless manner by splicing the trailing edge of paper in each cart beneath and behind the loading station to the leading edge of the paper in each succeeding cart and shifting each loading cart to the receiving station position after being emptied.

15. A printing apparatus for printing microfilm images onto a continuous paper web which is fan folded, said printer comprising a transport means having means for moving the paper web through the printer from a loading station to a receiving station, rail means disposed in proximity to both loading and receiving stations, a train of carts movably engaged with said rail means and spaced apart a distance so that one cart is in paper loading relation to said loading station while another cart is in paper receiving relation to said receiving station, each cart being adapted to hold a stack of the fan-folded paper, and all of said carts being tandemly coupled together so that the fan-folded paper may be fed through the printer in an endless manner by splicing the trailing edge of paper in each cart in and behind the loading station to the leading edge of the paper in each succeeding cart and shifting each cart in the loading station to the receiving station after being emptied.

16. A high speed printer for making enlarged copies of microimages on photosensitive material, comprising: a photosensitive material in elongated strip form including a plurality of predetermined portions located sequentially thereon, a microimage member in elongated strip form including a plurality of discrete microimages located sequentially thereon, an exposure station for exposing selected portions of said photosensitive material, first transport means for continuously moving said strip of photosensitive material through said exposure station, a light source for illuminating selected

microimages of said member with brief high intensity flashes of actinic radiation, optical means optically coupled to said light source for projecting enlarged images of said selected microimages onto said exposure station, and second transport means for intermittently moving said microimage member past said light source, whereby each selected microimage is held stationary proximate said light source and said optical means while at least one predetermined portion of photosensitive material is exposed to an enlarged image thereof.

17. A high-speed printer according to claim 16 further comprising: first indexes located on said photosensitive material in a fixed relation to the predetermined portions thereof, first registration means responsive to said first indexes and coupled to said light source to initiate a brief flash of actinic radiation whenever one of said predetermined portions passes a predetermined position relative to said exposure station, second indexes located on said microimage member in a fixed relation to the discrete microimages thereon, and second registration means responsive to said second indexes for stopping the motion of said microimage member when the projected image of one of said discrete microimages is at a predetermined position relative to said exposure station.

18. A printer according to claim 17 wherein, said first indexes comprise perforations in at least one margin of the strip of photosensitive material, said first registration means includes at least one sprocket wheel for engaging said perforations, said second indexes comprise one optical mark per discrete image in the margin of the microimage strip, and said microimage member is unperforated microfilm.

19. A printer according to claim 18 wherein, said first registration means further comprises program control means coupled to said sprocket wheel, said program control means including a replaceable program element having third indexes spaced in a manner representative of the lengths of said predetermined portions of the photosensitive medium, and said light source is a gas-filled flash lamp and each brief flash of actinic radiation therefrom persists for a period less than

the time required for the photosensitive material to move 0.01 inch.

20. A printer according to claim 17 further comprising: a source of multiple copy control signals representative of a selected number of copies to be made from each microimage, counting means responsive to said first registration means for counting the number of predetermined portions of photosensitive material which pass the exposure station while a projected image is registered thereon, and transport control means responsive to said multiple copy control signals and to said counting means for controlling said second transport means, whereby said second transport means holds the microimage member stationary until the selected number of exposures of the projected image are made on a like number of predetermined portions of the photosensitive material, and advances the microimage member upon completion of the exposure of the selected number of copies.

21. A printer according to claim 16 wherein, said photosensitive medium is fan-folded electrophotographic paper, said printer further comprises a loading station, a charging station, a developing station, a receiving station and guide means disposed proximate the loading and receiving stations, said first transport means is adapted to move said paper from said loading station, through said charging station, through said exposure station, through said developing station, and to said receiving station, and said printer further comprises a train of carts movably engaged with said guide means and spaced apart a distance so that one cart is in paper loading relation to said loading station while another cart is in paper receiving relation to said receiving station, each cart being adapted to hold a stack of fan-folded paper and all of said carts being tandemly coupled together so that the fan-folded paper may be fed through the printer in an endless manner by splicing the trailing edge of paper in each cart in and behind the loading station to the leading edge of the paper in each succeeding cart and shifting each cart in the loading station to the receiving station after each such cart is emptied.

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