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[54] **SYSTEM FOR HIGH SPEED RETRIEVAL OF INFORMATION AND CONVERSION THEREOF TO BOOK FORM**
2 Claims, 2 Drawing Figs.

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[51] **Int. Cl.** **G03g 15/00,** G03g 15/22
[50] **Field of Search** ..... 355/3, 14, 17, 6; 315/10; 178/6.6 (A), (Inquired) 96/1

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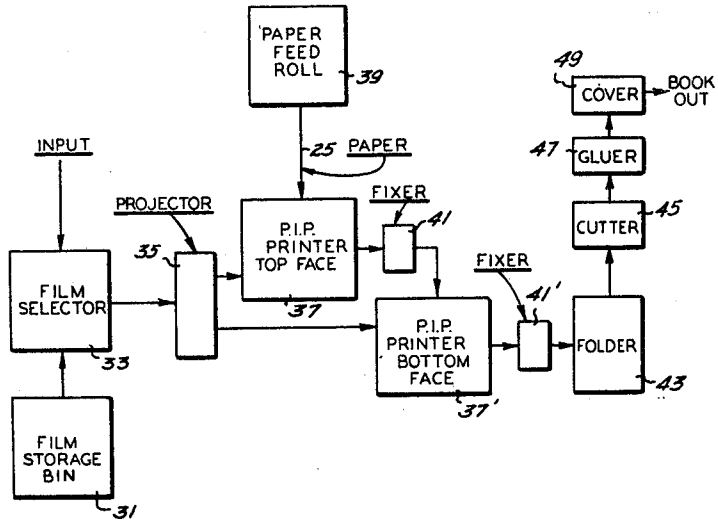
ABSTRACT: A high speed information retrieval and transfer system including an addressable information storage unit together with means for addressably selecting units of information from the storage unit. A movable image receiving web is provided for continuous, sequential recording of selected information units received from a high speed information transfer module with the rate of information selection and rate of web movement being synchronized with the communication rate of the transfer module whereby the information is sequentially imprinted in visually perceptible form onto the web, the web subsequently being cut and bound into book form.



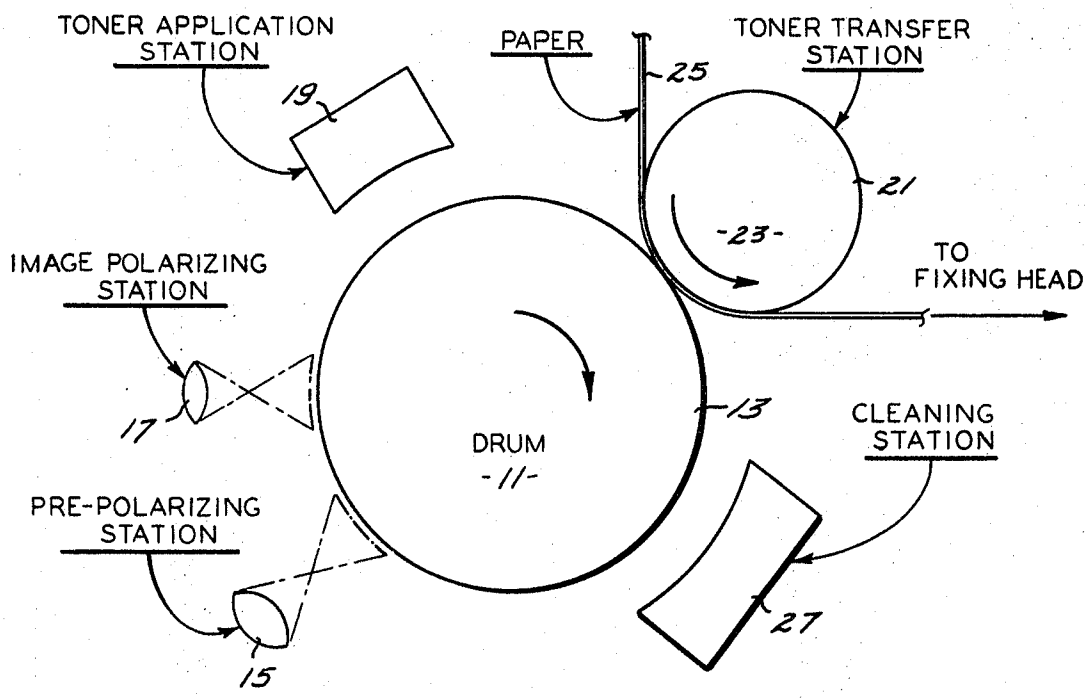


FIG. 1

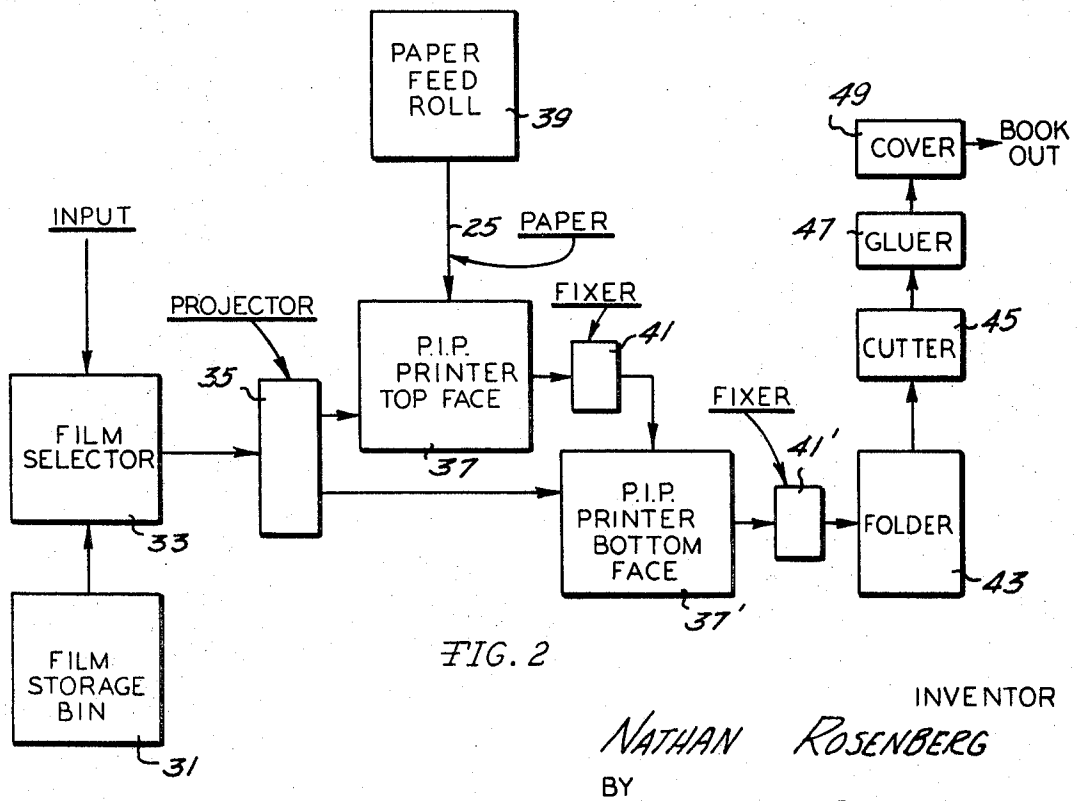


FIG. 2

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SYSTEM FOR HIGH SPEED RETRIEVAL OF INFORMATION AND CONVERSION THEREOF TO BOOK FORM

BACKGROUND OF THE INVENTION

A topic of considerable interest in the present age of exploding technology is that of (1) information retrieval, and (2) the rapid reproduction of information into various forms, documentary and otherwise. In this latter area a recent major technical innovation has established the facility to increase by many times the speed at which information has been heretofore copiable onto paper stock by electrostatic methods. This technology is the subject of U.S. Letters Pat. No. 2,972,082 to Hartmut Kallmann and Barnett Rosenberg. The invention of that patent relates to methods and apparatus for recording, storing, and recalling data of any type, by means of the persistent internal polarization of certain photoconductive materials. One of the signal characteristics of this previously patented system is its tremendous speed of transfer of recorded information from one substrate to another. The speed is substantially greater than that of any previously known methods, electrostatic or otherwise. Hereinafter the acronym PIP will be understood to refer to the phenomenon of "persistent internal polarization."

At the present time, with the almost exponential rate of increase in information, and the paper printing thereof, much attention both by government and private concerns is being given to revamping present systems of information handling. Libraries in particular have found present systems incapable of handling the ever-increasing load. In the book publishing trade the ideal approach is felt to be one which would turn out fully formed books, at a very rapid rate, from a simple input of "justified" page manuscripts. Such a system is introduced by the present invention.

SUMMARY OF INVENTION

The broadest aspect of the present invention lies in a combination of the two above-described technologies, which takes advantage of the recent advance in the high speed copy art together with techniques for the randomly accessed miniaturization of alphameric, graphic, or other information. The present invention utilizes a source of permanently recorded, indexed, eye readable information which is automatically selectable and transferable to a high speed printing apparatus. A PIP printer is presented as an exemplary means of such apparatus, and is linked to an automatic cutting and binding mechanism which fabricates books.

In its broadest sense the present invention constitutes a collection of information located in an indexed or addressable memory (e.g. magnetic core, film, tape, drum, disc, or the like) with means for selecting desired subsets of the information and transmitting the selected information to a PIP type reproducer for very high speed full size document production. The desired information is selected from the storage source by an electromechanical or electronic device and reproduced in the desired number of copies, in book form.

Two species of such a system are described:

The first is a system to eliminate the need for stacks upon stacks of volumes in libraries; it eliminates the need for the physical and clerical handling associated with locating, retrieving and checking out of volumes to library users, as well as the inverse process of book return, check-in and replacement on the shelves. In this system the volumes are preferably stored in microfilm units. The microfilm units accomplish an extreme reduction in the size of a library volume; for example an entire book can be recorded in miniature form upon a microfilm record no larger than a data processing punched card. Such miniaturization of printed matter is well within present technology and practice. A library user chooses a book by entering its call number at a keyboard unit. Almost instantly the book is called from storage and delivered therefrom in paper book form. The library user carries the book off and keeps it. No return is required. "circulation" of books is replaced by "distribution."

A second species of the invention comprises a book printing system oriented to the book publishing industry. Book images are stored much as already described, the storage source containing all those books which a publishing house intends to print. The system differs from the library concept in that, instead of a single book being produced, many copies are printed by a single command, in number sufficient to meet the current market demand. More books are printed when the demand warrants.

Accordingly, it is an object of this invention to teach a novel information system which admits of selection of information from a very large source and consequent reproduction thereof at very high speeds.

It is another object of the present invention to teach an instant library system in which the information thereof is miniaturized and mechanically selectable for documentary reproduction at very high speed, wherein the traditional library circulation is replaced by a mechanized, no-return distribution of books, at low or zero cost to the library user.

It is still another object of the present invention to introduce the means for a revolution of the book printing and publishing trade, enabling the low cost, high speed printing of books in numbers meeting the demand therefor, and to eliminate the heretofore undesirable phenomenon of books going "out of print."

Another object is to increase the availability of books of all kinds to the book reading populace at large.

Still further objects will be apparent to those skilled in the art, upon reading the present application.

DESCRIPTION OF PREFERRED EMBODIMENT

A special printing apparatus is necessary to the present invention, to enable documentary reproduction at practical speeds. Such an apparatus is one employing the electrostatic process of persistent internal polarization (PIP) which is extensively described in Kallmann and Rosenberg, "Persistent Internal Polarization," The Physical Review, Vol. 97, No. 6, 1596—1610, Mar. 15, 1955. Those authors developed specific PIP methods and apparatus for high speed recording, storing and recalling of data of any type, which methods and apparatus are described in U.S. Letters Pat. No. 2,972,082. Basically, that invention utilizes the phenomenon of persistence of internal polarization (PIP) in a broad class of photoconductive substances having a high dark resistance. By accurately controlling the intensity of the persistent internal polarization in a predetermined relation to suitable characteristics of items of data to be recorded, the characteristics are preserved in the form of variations in the degree of persistent internal polarization occurring from point to point internally of the polarized substance. Subsequently, the varying polarization may be recalled or detected by any one of several techniques, and the recorded characteristics thus reproduced. Both the recording and recall may be carried on at suitably high speeds and with a high degree of accuracy.

In the application of the PIP method to printing systems the photoconductive layer of PIP material is distributed over the surface of a rotatable drum **11**, as seen in FIG. **1**. The PIP surface layer is denoted by the numeral **13**.

Several stations along the periphery of the drum are now described, beginning with the prepolarizing station **15** and proceeding in a clockwise direction. The actual embodiment to be described is illustrative of only one of several usable PIP techniques, other examples being cited in the Kallmann, et al. patent.

The storage layer **13** is first excited at the prepolarizing station **15** by incident energy in some suitable form, e.g. visible light, X-rays, or the like, in the presence of a uniform DC electric field. This causes the material of the storage layer to become uniformly polarized in one direction. The incident energy is then turned off.

Data or information is transferred at the image polarizing station 17, which is situated clockwise of the prepolarizing station, on the periphery of the drum 11. At the image polarizing station 17, a unidirectional electric field, opposite in direction to the previous field, is applied through the layer 13. This electric field is constant across the length of the drum, over a sector of its periphery.

The optical input, concurrent with the reversed electric field, can be accomplished in various fashions. In the preferred embodiment a selected unit of data or information is scanned by a linear strip projector which proceeds across the face of the data unit at a speed equal to the linear velocity of the drum surface. Alternatively, the drum could rotate in a stepping fashion, stopping at each station; when the drum stops at the image polarizing station 17, an entire image is projected instantly onto its surface. Still another method is to step the drum and have an entire unit of data transmitted to the drum via a raster, or TV-type, scan. Hereafter, the first method, i.e., line projection with the drum in continuous motion, will be described. Whatever method of image transfer is used (the possible methods are not limited to those mentioned herein), the result is that the PIP surface, proceeding clockwise from the image polarizing station, is imbued with surface modulated internal polarization forming an image of a data unit selected from a library to be described.

Upon leaving station 17, first the incident energy, and then the electric field, is removed. The drum surface 13 proceeds to the toner application station 19. The toner consists of any medium which can be applied to the surface of the layer 13 and subsequently be transferred therefrom to a recording medium, such as sheet paper. The transfer substance is a species of polarization responsive ink, preferably an electrostatic dye of the type presently employed in electrostatic copying systems. Such a toner collects on the surface in concentrations corresponding to the local PIP density. Thus a toner image is formed on the drum surface, as a negative of the transferring data image.

The next consecutive clockwise station on the drum periphery is the toner transfer station 21. At this station the toner defined image is retrieved from the drum by a removable recording surface, i.e. the object paper. The selected unit of data is thus printed at station 21 into documentary form. The specific apparatus, represented schematically in FIG. 1, shows paper being fed in continuous web form between a drum 11 and a toner transfer roller 23 which is maintained in rolling pressure against the drum 11. Thus, as the printable sheet material, or paper, 25 feeds between the drum and roller, the toner is continuously transferred to the paper. The effectiveness of this transfer may be augmented by a simultaneous application of an electric field and/or heat.

Cleaning station 27 erases the remnant toner from the drum and prepares it for a subsequent polarization and toner application.

Referring to FIG. 2, the entire high speed information delivery system is represented schematically. A film storage bin 31 is shown which contains all the information, or the "data base," of the system. A film selector 33 is shown by which is chosen the desired unit of data from the film storage bin 31. The film selector 33 is responsive to directions received from an operator (i.e., the user of the equipment), and the instruction to the selector is labeled "input." The selector chooses the data unit in accordance with the input and places it into the projector unit 35. The projector optically transmits the data unit image to the PIP printer 37. Paper 25 is fed continuously into the PIP printer from a paper feed roll 39. The PIP printer transfers the projection image to the continuous web of paper which exits from the printer and enters the fixer unit 41. The fixer 41 stabilizes the dye image by known techniques, i.e., heat fixation, into a permanent, nonsmearing record. The paper web proceeds thence to a second PIP printer 37' and fixer 41' whereat a subsequent unit of correlated data is transferred to the reverse side of the paper sheet 25. The sheet is now printed on both sides to form a suitable book page. The web then passes consecutively through the folder 43, cutter 45, and gluer 47. The final station is the cover unit 49 from which issues a completed book.

With the intensity of incident light from presently available sources it is estimated that the PIP drum can complete a cycle in the time of about 0.2 seconds. For a book page size of 8 inches width, this implies a capability of printing at 200 feet, or 300 pages, per minute.

OPERATION

As already described, the heart of the new system is a high speed information transfer module. To achieve a practical system the rate of information transfer must be very fast. For purposes of illustrating such an operative unit the PIP printer 37 is utilized, since it represents the necessary high speed capability.

FIG. 2 represents, in schematic form, the organization of the book printing system. The film storage bin 31 contains miniaturized records stored in a form for rapid selection followed by orientation for projection by the projector 35. The storage form may constitute a microfilm reel, or microfilm cards, both presently used and understood. These records would contain pictures of "justified" book pages in appropriate sequence. In a preferred embodiment the storage cells are microfilm cards. Each card represents a rectangular unit, or matrix of information, so reduced in size that an entire book is recorded upon a single card. Thus a one-to-one correspondence exists between books and cards. Each card matrix would in turn be subdivided into submatrices, each representing one page of the book, in "justified" form. The information at any particular locality on a given page is identifiable by giving the coordinates of the particular element, in a designated submatrix. The card is selected from the bin and physically oriented with respect to the projector 35. It is then sequentially stepped through the entire array of submatrices, synchronously with the stepping rate of the drum on the PIP printer, until the entire book has been printed. Cards are purposefully utilized for their low mass and moment of inertia, which facilitates the physical movements of the cards during selection and projection.

The projector 35 casts an optical reproduction of the image, in enlarged form, onto the PIP drum in the fashion already described. The information is on the cards in visually interpretable form but of course must be magnified before printing, so as to be perceptible for reading. The embodiment of FIG. 2 shows simultaneous projection by two different PIP printers 37 and 37', the first of which prints the top side of the paper and the second of which prints the reverse side. Alternatively both sides could be printed by a single printer; this would require that first the paper web be printed with the odd numbered book pages and then rethreaded through the printer for a second pass which would print the even numbered pages on the reverse side.

The toner is fixed at 41 and 41' subsequent to leaving each printing head 37 and 37'. The fixing operation permanently bonds the toner to the paper after leaving the PIP printing head. The toner is fixed after each printing head 37 and 37'. From the fixation station the paper passes into the accordion pleater or folder 43, where it is also pressed. The pressed block of paper then has one edge removed by the cutter 45. The other edge of the paper block is coated with a rapid drying adhesive, such as "mystic" glue, or the like. At cover section 49 of the machine, a precut, prepared cover is presented to the face of the paper block and pressed thereto. The completed cover has been also printed in the PIP printer, as the first printed page. After the completed cover is pressed to the block, the book exits from the machine. It will be noted that this method of folding, cutting and binding is similar to a presently known process applied in the paper back book industry. This means for book formation also has a parallel in the output from high speed data processing printing devices.

The specific operation described offers a prodigious utility as an "instant" library system. An entire library is stored on microfilm which is accessible to a film selector, and cataloged, for example, under the Dewey Decimal System, with each book reduced to a single microfilm card. Input to the system in this case is a specific Dewey Decimal citation (call number), and the film selector is a simple card sorter or retriever, which picks out the microfilm card corresponding to the input number. The selector removes the card from the storage bin and places it in position on the projector head. Such equipment, capable of microdata recording, storage, and recall, has been in continuous and rapid development for over 20 years, and certain units (for example FOSDIC, Filmorex, Recordak, Minicard, Microcite, etc.) are presently available which are easily modified to be suitable for the library book printer purpose. An alternative system is also possible wherein the card remains stationary and the projection beam is selectably positioned at the appropriate card. A further extension of this system utilizes a selector capable of making a record of the book chosen, for accounting of pricing and royalties. The information required for this accounting is also coded onto the book card for automatic reading.

Operation of the instant library is as follows: a library user selects materials in which he is interested via an ordinary card catalog (e.g. a subject and author index). He then determines the call number of relevant materials or volumes and proceeds to a retrieving console provided with selection means, for example, a key board. He enters the call number of the appropriate volume on the key board, which causes the apparatus to search and find the designated material in storage. Before retrieving the entire opus the user may wish to make a cursory examination of its contents; this he does by pressing appropriate keys which route the selected material to a remote display device (such as those that enlarge and illuminate selected materials onto a viewing screen). Means also are provided for stepping through selected portions of the material displayed, either randomly or sequentially, so that its contents may be surveyed. If, after preliminary examination, the viewer decides to retrieve this opus in its entirety, he merely actuates a print button. This actuates the printing system which generates printed sheets and feeds them to the book making module from which issues the complete book. The user may pay a fee and take the book away as his property. There is no return of the material.

Average figures from the Michigan State University Library show that in each quarter-year approximately 15,000 books are put on reserve as required reading for courses. The average number of about 50 students per course indicates that to give each student the required reading for the course would require printing 750,000 books per quarter, or well over 2,000,000 books per year. Clearly this aspect alone, of all library services, represents a substantial use for a book printer as revealed here. Carrying this aspect to the ultimate, it is entirely possible that the herein presented system well may distribute books free of charge, yet within the present generation. The ultimate benefits of such a development are too numerous and too obvious to require explanation.

A final concept to be presented is that of integration of the presently described structure into an information retrieval system where the storage includes some description of the content of each unit of information. Such a description (or abstract) of the unit record provides a tool by which a logic or intelligence module (i.e., a computer) would search the abstract code for documents relevant to a specific inquiry. Other systems, now operating, provide a full text search as of case reports, in legal information retrieval systems, for example. Such a system produces the entire text, or selected pages thereof, at a practical speed, in a bound, inexpensive, eye readable book form. Present information retrieval systems are limited in their output by a limited printout speed. Thus, the information is stored on randomly accessible high speed memory devices, for rapid scanning. However reproduction of pertinent data is performed by relatively slow digital printing equipment at, say, 1000 lines per minute, optimum. When correlated to the system of the present invention, an entire book could be delivered from a separate, microfilm source as described, bound and covered, in about a minute.

Other advantages inhere in such a system where, for example, an attorney could retrieve the printout of a report of one judicial decision, rather than the entire volume of reports containing a superabundance of extraneous matter.

The existence of a machine capable of printing a complete book at a significantly rapid rate may also be expected to have a modifying influence on the publishing trade. A publisher will fulfill his function when he has prepared a manuscript in the form of "justified" pages of the desired print type (special typewriters are available to do this) and has produced pages with pictures in mockup form. These pages are then put on microfilm in an established sequence, and a microfilm card is prepared with accessory coded information (such as decimal call number, publisher, author, book name, pages, royalties, dates, etc.). The card is then sent to the printer. The printer is located in a central location, or in a selected city of large population. A small number of books for immediate sales are produced. No extra stock need be warehoused. As future sales requests indicate the need for further printings, they are made, as necessary, in a very short time. This eliminates the need for guessing the sales potential of a book and then being caught with an inadequate inventory during the short time a book may be in demand, or worse, having an excess stock cluttering the warehouse which will have to be sold at a loss later.

It is still true with a book printing machine that the quality of a book produced will vary depending on the quality of paper stock used and the cover material. Thus, the aesthetics of books remains unchanged. It would not be desirable for a single common format or appearance to dominate the trade, as for example with the cheapest paperback books. It may be reasonably estimated that the book printer can produce books at a rate of about one book per minute from which it follows that an average run of approximately 6,000 books can be made in 4 days running time of one printing machine. It is also clear that there will no longer be such a thing as a book the is "out of print."

The above description of several species of the preferred embodiment of my invention is intended for illustrative purposes only; modifications, extensions, substitutions and improvements will be obvious to those skilled in the art upon examination of the present disclosure. Such modifications, extensions, improvements, and substitutions are intended for inclusion within the scope of the present invention, which is to be limited only by the hereinafter appended claims.

I claim:

1. A high speed information recalling and reproducing system comprising, in combination, an ordered collection of unit records of visually interpretable information, a clockwise rotatable persistent internal polarization drum having its exterior coated with a layer of internally polarizable material, means for transferring visually interpretable information from said records to said layer of internally polarizable material on said drum, a prepolarizing station on the periphery of said drum, an image polarizing station on the periphery of said drum, clockwise of said prepolarizing station, by which an internal polarization may be induced in said layer in point-to-point correspondence with local characteristics of information on a selected unit record, a toner-application station on the periphery of said drum and clockwise of said image polarizing station, whereby said toner assumes a density of distribution over the surface thereof corresponding to the density of internal polarization therein, a toner-transfer roller situated on the periphery of said drum, clockwise of said toner application station, a source of printable sheet material, feedable between said drum and said roller, for transfer of said toner from said drum to said material, thereby to print said sheet material with an image of said originally selected unit record, a cleaning station on the periphery of said drum, clockwise of said toner transfer roller, for removal of excess

toner prior to a subsequent application thereof, said toner being an electrostatic dye, means for fixing said dye subsequent to the transfer thereof to said sheet material, said source of printable sheet material being a paper feed roll, and a second persistent internal polarization printer substantially the same as said first-mentioned persistent internal polarization printer and adapted to print onto the reverse side of a segment of said paper a unit record representing a volume page immediately subsequent to that printed on the front of said paper.

2. A high speed information recalling and reproducing system comprising, in combination, an ordered collection of unit records of visually interpretable information, a clockwise rotatable persistent internal polarization drum having its exterior coated with a layer of internally polarizable material, means for transferring visually interpretable information from said records to said layer of internally polarizable material on said drum, a prepolarizing station on the periphery of said drum, an image polarizing station on the periphery of said drum, clockwise of said prepolarizing station, by which an internal polarization may be induced in said layer in point-to-point correspondence with local characteristics of information on a selected unit record, a toner-application station on the periphery of said drum and clockwise of said image polarizing station, whereby said toner assumes a density of distribution over the surface thereof corresponding to the density of internal polarization therein, a toner-transfer roller situated on the periphery of said drum, clockwise of said toner application station, a source of printable sheet material, feedable between said drum and said roller, for transfer of said toner from said drum to said material, thereby to print said sheet material with an image of said originally selected unit record, a cleaning station on the periphery of said drum, clockwise of said toner-transfer roller for removal of excess toner prior to a subsequent application thereof, said toner being an electrostatic dye, means for fixing said dye subsequent to the transfer thereof to said sheet material, said source of printable sheet material being a paper feed roll, means for cutting said printable sheet material into segments after an image has been printed thereon, and means for binding said segments together, consecutively, into book form.