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3,346,692

COPYING APPARATUS HAVING A HAND-HELD SCANNER SYNCHRONIZED TO THE RECORDING UNIT

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This is a continuation-in-part of application Ser. No. 301,293 filed Aug. 12, 1963 now U.S. Patent No. 3,318,996.

This invention relates to a copying and reproducing apparatus. More particularly, this invention relates to an apparatus for copying and reproducing printed or written matter such as words, phrases, sentences, symbols or the like. The apparatus is capable of reproducing entire pages of script or selected words, phrases, sentences or short paragraphs. The device is intended to be small enough to be manually portable so that it can be used wherever material is to be copied.

It is often desirable to copy and reproduce printed matter from books and the like. This is particularly desirable for professionals engaged in research, such as engineers, lawyers, and statisticians who review books, files and other literature and must copy pertinent facts therefrom. Copying by hand, particularly if there is any quantity of material to copy, is tedious and time consuming. There are presently available many types of photocopying machines. However, such machines are relatively large. Therefore, material to be copied must be taken to the machine. Further, such machines copy whole pages which is wasteful when in many instances only small portions of the page need be copied. Additionally, such machines are often constructed so as to be capable of copying loose pages and not pages from a bound volume.

In order to avoid the foregoing, copying and reproducing devices such as disclosed in U.S. Patents 3,052,755 and 3,064,078 were developed. In these devices the user would have to move the reading unit horizontally from left to right over the individual words or phrases to be copied. This would give an output, the effect of which is similar to that used in animated cartoons for "painting" words on a screen. However, there was no provision in these prior devices for synchronizing the speed of the copying unit to the speed of the reading unit. For this reason, compression or stretching out of copied letters or text resulted.

In application Ser. No. 301,293, filed Aug. 12, 1963, the foregoing difficulty and disadvantage, among others, are overcome. The present invention is a continuation-in-part of said prior application and provides an improved means for overcoming the difficulties and disadvantages of the prior art.

Therefore, it is a general object of this invention to provide a new and improved copying and reproducing apparatus.

It is another object of the present invention to provide a copying and reproducing apparatus utilizing either a fiber optic or plastic lens imaging system.

It is still another object of the present invention to provide a new and improved copying and reproducing apparatus utilizing an imaging system having only one line as an output.

It is still another object of the present invention to provide a new and improved copying and reproducing apparatus which can copy paragraphs, pictures or sentences selectively from printed matter.

Still another object of the present invention is the pro-

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vision of a new and improved copying and reproducing apparatus in which the reading head is synchronized with the recording means.

Yet another object of the present invention is to provide a new and improved reproducing and copying apparatus in which the recording means will not record unless it is moved in synchronism with the scanning head.

A further object of the present invention is to provide a new and improved copying and reproducing apparatus having means to assure movement of the recording material in proportion to movement of the reading head prior to recording on said material.

Other objects will appear hereinafter.

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIGURE 1 is a schematic representation of the apparatus illustrated partially in perspective and partially in section.

FIGURE 2 is a block diagram schematically illustrating the circuitry used with the present invention.

FIGURE 3 is a partial perspective view of a drum used with the present invention.

Referring now to the drawing in detail, wherein like numerals indicate like elements, there is shown in FIGURE 1 a copying and reproducing apparatus designated generally by the numeral 10.

In general, the apparatus includes a scanning or read head 12 and reproducing instrument 14.

The read head 12 comprises a housing 16 having an opening 18. The read head 12 is small enough to be held in the hand of the user. If desired, a handle (not shown) may be attached to the housing 16. A mask 20 is mounted inside the housing 16 adjacent the opening 18. The mask 20 defines the opening through which the material to be copied will be exposed to the interior of housing 16. Normally, the opening 18 is placed over the material to be copied so that it can be "seen" by the interior of the read head 12.

A lens 22 which may be glass or plastic is mounted adjacent the mask 20. The lens 22 transmits light to the photosensitive strip 30 and focuses an image on the surface thereof.

Photocell strip 30 is a device that segments an optical image falling on its surface and converts it into electronic form. The signal output of each segment is proportional to the light intensity on that segment. Strip 30 consists of a silicon substrate on which a linear array of switching diodes is deposited. Each switching diode is connected to the substrate at a different point so that the substrate effectively becomes a resistive bleeder network which back biases each switching diode at a slightly different level. Deposited over the switching diodes is a one-to-one corresponding linear array of photodiodes that are connected to a common buss. The construction and properties of this array of semiconductors, known as a "Scanistor," are described in detail by Horton et al. in the Proceedings of the IEEE; the composite device is available from the Semiconductor Division of the Fairchild Camera and Instrument Company, Inc. in Palo Alto, Calif.

Application of a ramp or staircase voltage to the resistive bleeder will switch successive diodes as the back-bias across a given diode is overcome. As the switching diode is switched into forward conduction, a current, proportional to the light intensity on the photodiode connected to the switched diode will flow. By means of proper circuitry, a linear image (parallel sources of light and dark areas) is converted to a serial train of electrical

pulses which may be transmitted to any other point by conventional means. The required ramp or staircase voltage is generated in scan generating device 34 which may be located in housing 16 when sufficiently miniaturized but otherwise in housing 14 for the reproducing means. The scan generator consists of well known circuitry to generate a nearly right-triangular wave whose ramp is the hypotenuse of the triangle, or a wave whose shape resembles a staircase. The use of either type of scan signal greatly simplifies the apparatus by eliminating the need for a heavy cable containing a large plurality of wires (one for each photocell); the resulting signal requires only one wire for transmission of the signal.

Cable 32, in our earlier application, consisted of a pair of wires to carry power to the lamps illuminating the material to be copied, and a large plurality of wires, as mentioned above. In this patent, the photocells are scanned serially by the ramp voltage so that only one wire (plus a line common with other signal leads) is required for the image signal. In addition to the image signal line, the cable 32 will now consist of one line for the ramp signal, one for illumination power, one for the read head synchronizing signal derived from photocell 82, and a common reference line for all signals, for a total of five (5) wires.

The output line of photo amplifier 35 is connected by conductor 36 to brush 38. Brush 38 is mounted in cantilever fashion so that its free end rides on the hub 42 of the printing unit 40. The printing unit 40 includes a printing wheel 44 supported on the hub 42 by spokes 46 which are electrically connected to and extend radially from hub 42 to wheel 44 but are only mechanically connected to wheel 44.

Wheel 44 comprises a cylindrical member made of a non-conductive material such as plastic or fiber. The circumferential spacing of the spoke ends that come through the wheel is equal to or slightly less than the width of the strip of electrostatic of electrosensitive material 50. This means that there is, at any instant, only one spoke 46 in contact with strip 50.

The hub 42 is supported for rotation about an axis parallel to the longitudinal axis of strip 50 by the motor shaft 52. Motor shaft 52 is connected to and rotatively driven by the motor 54, supported on the electrostatic paper processor 56. In the preferred embodiment, the motor 54 rotates the wheel 44 at a high velocity relative to the rate of movement of strip 50. For example, the strip 50 may be moving at 5 inches per second while the wheel 44 has a rotary velocity of 375 inches per second.

The strip 50 of recording material is drawn from a supply reel 58 across a backing plate 60 where it passes beneath the wheel 44. The backing plate 60 may be made of a conductive material and connected to ground potential so as to permit the completion of an electrical circuit between the scan ramp generator 34, conductor 36, brush 38, hub 42, spokes 46, and the electrosensitive strip 50.

The scan ramp generator 34 is triggered to begin its scanning function when one of the spokes 46 begins to sweep across the strip 50. This results in the deposition of an electrostatic charge on the strip 50 in 1:1 relationship to the signal scanned out of the photocell array by the ramp generator 34. Furthermore, the strip is continuously advanced at a rate directly proportional to the movement of the read head 12 thus enabling the wheel 44 to write the information detected by the read head 12 on the strip 50.

The strip 50 is drawn from the reel 58 across the backing plate 60 by a drive roller 62 which cooperates with a pressure roller 64. The drive roller is rotated by a stepping motor 66. The strip 50 is drawn through the electrostatic paper processor 56 by the drive roller 62. The wheel 44 rides lightly on the strip 50 which is preferably an electrostatic paper, such as A. B. Dick electrostatic paper, so that when a voltage signal is applied from the photo signal amplifier 35 to the spokes 46, a mark (sometimes called a latent image) will be formed on the strip

50. The processor 56 develops the latent image to make it visible to a naked eye.

The copying and reproducing apparatus 10 includes a circuit of which FIGURE 2 is a schematic diagram for synchronizing the movement of strip 50 with the movement of the read head 12.

The read head 12 includes a synchronizing drum 68 rotatively mounted on one side of the housing 16. As best shown in FIGURE 3, the drum 68 includes a transparent cylindrical body 70, which may be made of glass or a transparent plastic. Overlying and supported by the body 70 is a photographic emulsion 72 which is also transparent. The emulsion 72 has been developed with a plurality of black non-transparent lines 74 thereon. Thus, the overall appearance of the emulsion 72 is that of a cylindrical surface having alternating transparent and non-transparent lines thereon. The center to center distance of the non-transparent lines may be approximately .005 inch, and the spacing between such lines, which will form the transparent portion, may be .001 inch. The techniques for preparing such photographic emulsions are well known and have been used in the photographic and micro-circuit arts for a number of years.

The drum head 68 is preferably mounted to the housing 16 so that its outer periphery is flush with or slightly below the lower end of housing 16. Thus, when the end is placed adjacent the material to be copied, and the housing 16 is moved therealong, the drum 68 will be caused to rotate. Preferably, the diameter of the drum is $1/\pi$ which means that the circumference of the drum 68 is an integer of 1. Therefore, the linear speed of the read head as it is moved across the material being copied is translated directly to the drum, and is equal to the circumferential speed of the drum 68.

A light source 76 is mounted within the drum. As the drum 68 rotates, it chops the beam of light passing there-through so that the photocell 82, mounted in close proximity to the drum, receives light pulses when the drum 68 is rotated by movement of the housing 16. The rate of movement of the drum is directly proportional to the number of lines 74 moved through the beam generated by source 76. Thus, the photocell 82 receives light pulses at a rate directly proportional to the rate of translation of the housing 16. With the drum dimensional as described above, the photocell will receive 200 pulses for each inch that the drum moves.

The photocell 82 transduces the light pulses into electrical pulses, and these are conducted to the signal conditioner 86. Signal conditioner 86 may be any well known apparatus which amplifies the signal received from photocell 82 and converts it into a signal suitable for use by the rest of the circuit. Thus, the signal conditioner 86 may either provide a square pulse or a spike, depending on the type of apparatus used for the remainder of the circuit. In any case, this conditioned pulse will be referred to as a read head synchronizing pulse.

The read head synchronizing pulse is conducted from a signal conditioner 86 to an up-down bit counter 88. The up-down bit counter 88 may be any one of a number of well known types of counters which count up the bits or pulses received through one input and subtract the bits or pulses received through another input. The up-down bit counter 88 is adapted to put out a signal as long as it registers a non-zero integral number. Counter 88 puts out no signal when it registers zero.

A threshold logic 90 is connected to the output of counter 88. The threshold logic 90 may be one or several modules of circuits well known in the digital computer literature which continue to provide a pulsing output whenever the up-down bit counter 88 registers non-zero. The stepping motor 66 is connected to the output of threshold logic 90 and responds to the pulsing output thereof. For each pulse received from the threshold logic, the stepping motor 66 will rotate the drive roller a predetermined amount. This amount in turn is translated into linear movement of the strip 50 and coextensive rota-

tional movement of the pressure roller 64. When the device is operating properly, the number of pulses received from the threshold logic by the motor 66 will be equal to the number of bits counted by the up-down counter 88 which in turn is equal to the number of pulses received by the photocell 82. Thus, if the read head 12 is displaced one inch, the read head drum will generate 200 pulses, the up-down counter will count these pulses and the threshold logic 90 will apply them to the motor 66. The drive roller 62 in turn will be rotated 200 predetermined integral steps. The amount of rotation of the roller 62 for each step of the motor 66, and hence the amount of movement of the strip 50, can be adjusted to be equal to, greater than, or less than the distance travelled by the read head 12. This is accomplished by adjusting the amount of rotation delivered by the motor 66 for each pulse received.

As shown, the pressure roller 64 is below the drive roller 62 and in contact with the strip 50. As thus positioned, the pressure roller will rotate only if the strip 50 is driven forward by the roller 62. If the motor 66 fails to respond, or the roller 62 slips on the strip 50, roller 64 will not move forward.

In accordance with the principles of this invention, a paper feed synchronizing drum 92 similar in construction to the drum 68 is mounted to the axis of pressure roller 64 and rotates with it. The diameter of drum 92 and the number of lines per inch on its circumference is such that it will move one line for each stepping pulse delivered to the motor 66. Therefore, if the motor 66 receives the pulse, and rotates the drive roller 62 the requisite distance, and the strip 50 responds to such driving motion thereby rotating the pressure roller 64, the drum 92 will rotate a sufficient amount to generate one pulse of light on the photocell 98. The photocell 98 mounted in close proximity to the drum 92, receives light from the source 94. From the foregoing, it should be apparent that the drum 92 in cooperation with the source 94 and photocell 98 is generating output pulses in response to the translation of strip 50.

These pulses are transduced into electrical pulses by the photocell 98 and conducted to the signal conditioner 99 and then to the up-down bit counter 88. The conditioned electrical pulses from photocell 98 are fed into the up-down bit counter 88 so as to subtract from the count generated by the incoming read head synchronizing pulses. If the motor 66 properly responds to translate the strip 50 forward the requisite distance, then the strip feed synchronizing drum will generate feed back pulses equal to the number of input read head synchronizing pulses. These feed back pulses will cause the up-down bit counter 88 to return by steps to zero, therefore turning off the threshold logic 90 and motor 66. However, if the drive means, including motor 66 and roller 62 fails to respond, the strip feed synchronizing drum does not generate an adequate number of pulses to re-set the up-down bit counter 88 to zero. The bit counter therefore continues to develop an output which causes the threshold logic 90 to generate pulses to drive the motor 66. These pulses are applied to the motor 66 until such time as the strip 50 is moved forward the requisite amount and the strip feed synchronizing drum generates sufficient pulses to return the counter 88 to zero. This assures that the movement of the strip 50 is synchronized with the movement of the read head 12.

As shown in FIGURE 2, the occurrence of a read head synchronizing pulse (signifying that the read head has moved ahead) is remembered by flip flop memory 110 and applied to one input of nand logic circuit 112. Similarly, pulses generated by photocell 98 (signifying that the paper feed drum 92 has stepped ahead one step) are remembered by flip flop 114 and applied to the other input of nand circuit 112. Nand circuit 112 is the type of electronic circuit whose output voltage drops (to logic "0") when two conditions (both logic "1") are present at the input terminals. Thus, the nand circuit 112 will

have no output voltage (logic "0") when it has received information representing the fact that synchronizing pulses from both read head drum and strip feed drum have moved one step. The output of nand circuit 112 is applied to nor circuit 116. A nor circuit is a type of logic circuit which has an output voltage when neither condition C nor D are simultaneously present at its input. If either one or both inputs are present (logic "1") the output of the nor is no voltage (logic "0").

A light source 118 is mounted together with a lens 120 so as to pass light through the spokes 46 of wheel 44. The lens 120 focuses the light on a photocell 122. As the wheel 44 rotates, the spokes 46 interrupt the light from source 118, and photocell 122 responds by producing a pulsing output. This pulsing output is amplified by the amplifier 124 and applied to the other input of the "nor" circuit 116. Light source 118 and photocell 122 are aligned so that spoke 46 will interrupt the light beam whenever one of the spokes 46 is adjacent the edge of strip 50. This absence of a voltage output from the amplifier 124, coupled with the absence of voltage output from nand 112 (signifying that both a read head synchronizing pulse and strip feed drum pulse have occurred) triggers or initiates the beginning of a scan ramp in scan generator 34 upon the rise of voltage output from nor 116. Thus, the spoke 46 coming into the correct position to begin writing, triggers the scanning of a vertical line of information in the read head provided the read head has moved to a new position from its previous scan and the strip feed drum have moved to a new position. Rewriting or overwriting of old information is thus prevented and read and write scan operations are synchronized.

The nand circuit 112 and the nor circuit 116 described above, are well known logic circuits and need not be described in detail.

The person utilizing the copying and reproducing apparatus 10 places the read head 12 on the printed matter to be copied. He can see what he is copying merely by looking through an opening in the housing. As he moves the read head 12 along the printed page, the synchronizing drum 68 turns, causing the stepping motor 66 to rotate drive roller 62 to pull the strip 50 beneath the rotating wheel 44. The wheel 44 prints in the manner described above.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

We claim:

1. Copying and reproducing apparatus comprising a scanning head having an outer housing with a scanning opening in said housing, means within said housing for sensing light transmitted into said opening and producing electrical signals proportional thereto, recording means for receiving said signals and recording a pattern corresponding to the pattern of light transmitted into said opening, said recording means including a recording head and an electro-sensitive strip; drive means for moving said strip past said recording head; scanning head movement sensing means for sensing the movement of said scanning head, said scanning head movement sensing means including a light source; a light sensing transducer for transducing light received from said light source into electrical signals; and a displaceable light interrupter, intermediate said source and said transducer, for sequentially interrupting the passage of light to said transducer in proportion to the movement of said scanning head; and synchronizing means for controlling said drive means in accordance with signals received from said transducer, whereby the movement of said strip will be directly proportional to the movement of said scanning head.

2. Copying and reproducing apparatus in accordance with claim 1 wherein said displaceable light interrupter

includes a light transparent rotatable drum having a non-transparent grid fixed thereon, said drum being rotatably mounted to said scanning head for rotation in proportion to the movement of said housing.

3. Copying and reproducing apparatus in accordance with claim 2 wherein said synchronizing means include a counter for counting the number of interruptions by said interrupter, a threshold logic for generating an output when said counter registers more than zero, and a stepping motor for said strip drive means, means connecting said stepping motor to said threshold logic, and means for reducing the count in counter to zero when said strip has moved a distance proportional to the movement of said scanning head.

4. Copying and reproducing apparatus in accordance with claim 1 wherein said synchronizing means include a counter for counting the number of interruptions by said interrupter, a threshold logic for generating a signal when the count on said counter is greater than zero, a stepping motor connected to said threshold logic for mechanically driving said strip, and a count reducing means for diminishing the count to zero when said strip has been moved a distance proportional to the displacement of said scanning head.

5. Copying and reproducing apparatus in accordance with claim 1 wherein said synchronizing means includes an up-down bit counter responsive to the output of said light sensing transducer for mounting the number of interruptions by said light interrupter, a threshold logic connected to said up-down bit counter for generating a signal when said up-down bit counter registers greater than zero, a stepping motor responsive to said threshold logic, said stepping motor being mechanically connected to said strip drive, and means for detecting movement of said strip, said means including a second light source, a second light sensing transducer, and a second displaceable light interrupter intermediate said second source and said second transducer for sequentially interrupting the passage of light to said second transducer in proportion to the movement of said strip, the output of said second transducer being connected to said up-down bit counter for diminishing said counter to zero, said second light interrupter being adapted to sequentially interrupt the passage of light to said second transducer in proportion to the movement of said strip.

6. Copying and reproducing apparatus in accordance with claim 1 including second sensing means for sensing the movement of said strip, said second sensing means including a light source, a light sensing transducer, and a displaceable light interrupter intermediate said source and said transducer for sequentially interrupting passage of light to said transducer in proportion to the movement of said strip, means connecting said first and second sensing means to a logic circuit, said logic circuit including

means for producing an electrical output only when said first sensing means senses movement of said scanning head and second sensing means senses movement of said strip.

7. Copying and reproducing apparatus in accordance with claim 6 wherein said recording means includes a spoked wheel rotatable about an axis parallel to the direction of movement of said strip, the spokes being made of an electrically conductive material, said spokes equally spaced about the circumference thereof, and circumferential distance between said spoke and rim connections being equal to or slightly less than the width of said strip, means for rotatively driving said wheel, means for sensing that one of said spokes is adjacent a side edge of said strip, said last mentioned sensing means being connected to a second logic circuit, said first mentioned logic circuit being connected to said second logic circuit, said second mentioned logic circuit including means for producing an output signal only when it simultaneously receives a signal from said first mentioned logic circuit and said wheel position sensing means.

8. Copying and reproducing apparatus in accordance with claim 7 wherein said scanning head includes a lens, a trigger scan ramp for scanning the light output adjacent the other end of said lens for producing an electrical signal in accordance with the light transmitted by said lens, and means connecting the trigger circuit of said ramp to the output of said second logic, whereby said lens is scanned when said strip has advanced in proportion to the movement of said scanning head and a spoke end is adjacent the edge of said paper.

9. Copying and reproducing apparatus in accordance with claim 7 wherein said scanning head movement sensing means includes a cylinder mounted for rotation about its axis, means connecting said cylinder to said outer housing for rotating said cylinder at a rate proportional to the displacement of said scanning head, the surface of said cylinder including a grid of alternating transparent and non-transparent lines, light sensing means for sensing the movement of said strip including a rotatable cylinder mounted for rotation about its axis, means for rotating said cylinder in response to movement of said strip, at least a portion of the surface of said cylinder including a grid of alternating transparent and non-transparent lines, a light source and a second light sensing transducer, to sense chopped light emitted by a light source through said drum.

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