

Feb. 9, 1960

H. S. GLEASON
PRINTING APPARATUS

2,924,646

Filed April 23, 1953

3 Sheets-Sheet 1

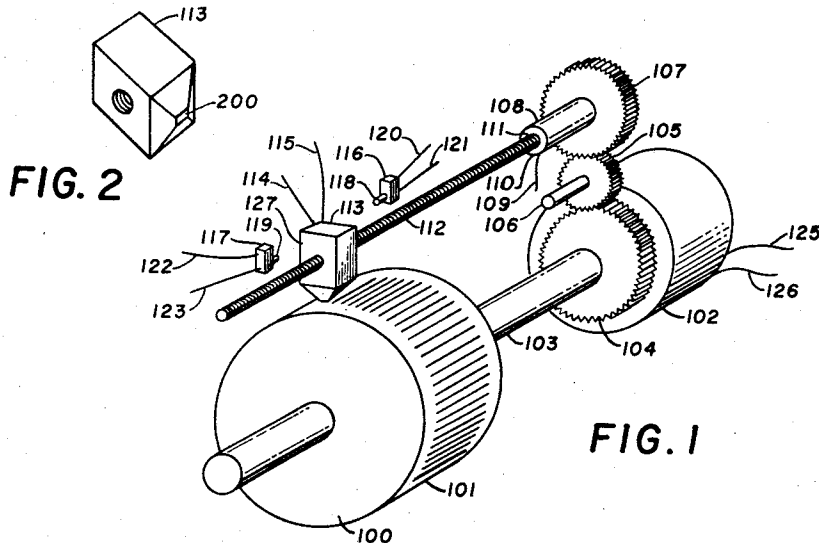
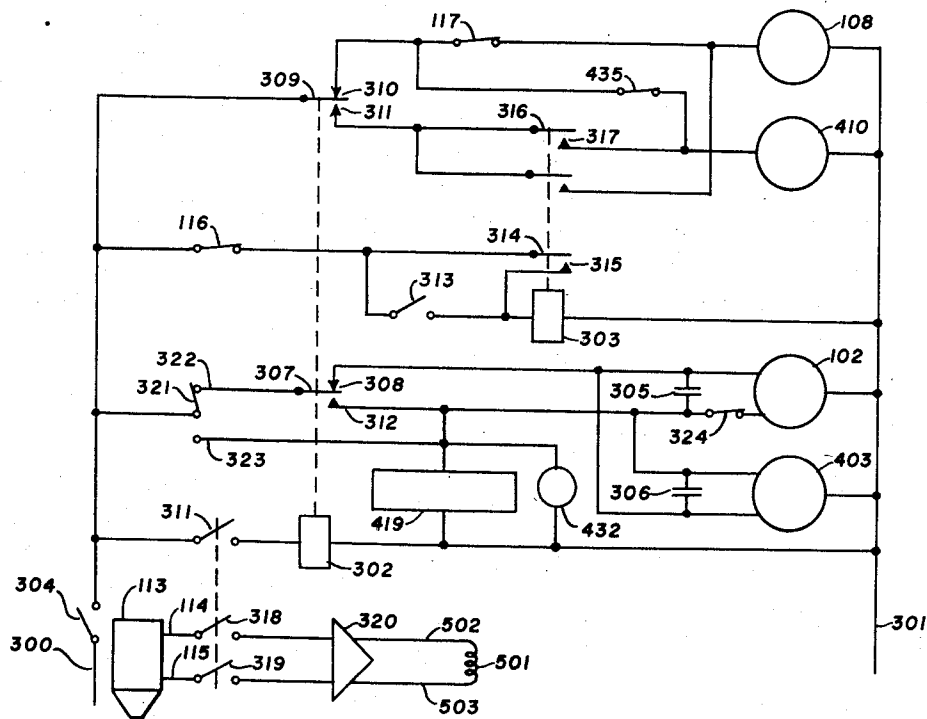


FIG. 3

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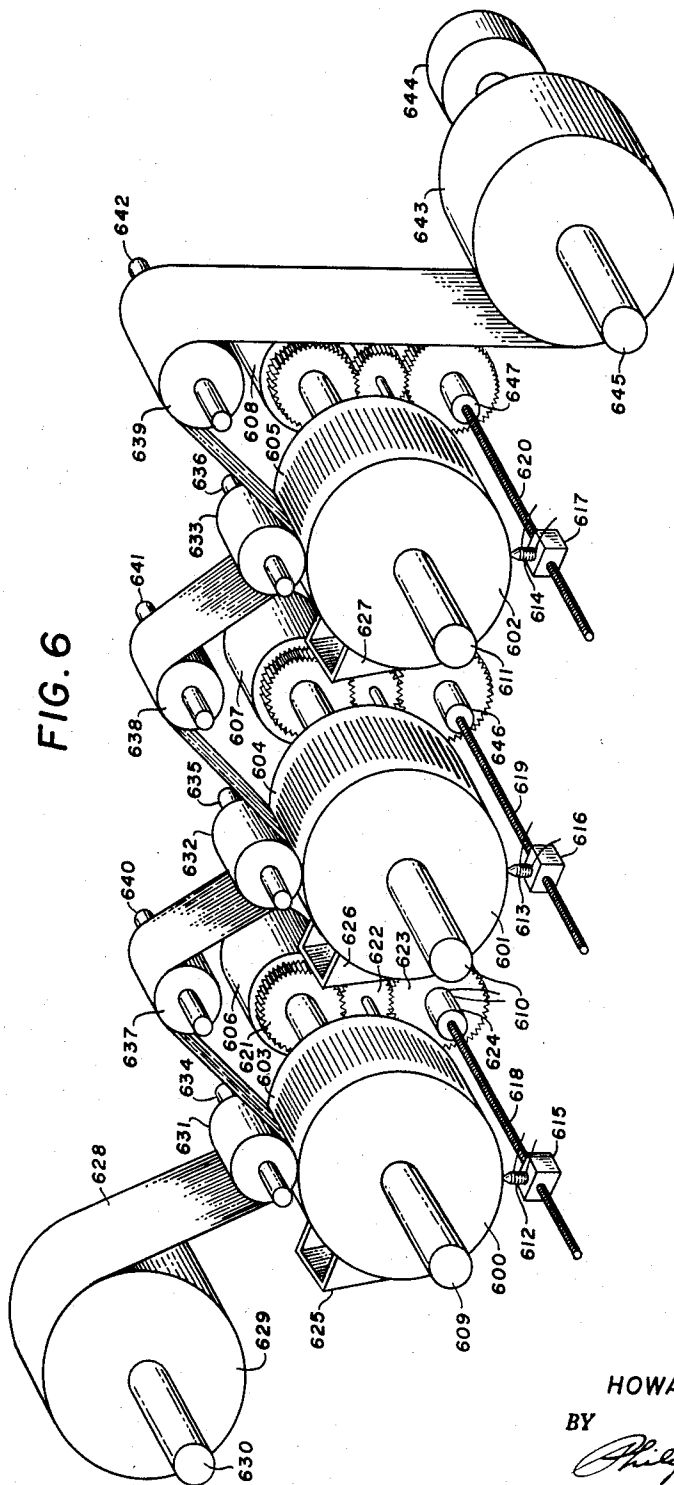
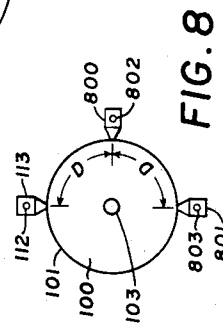
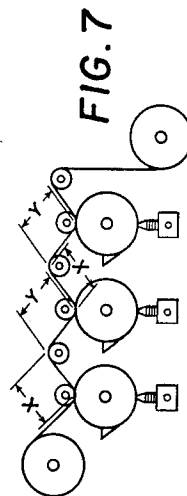
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3 Sheets-Sheet 2



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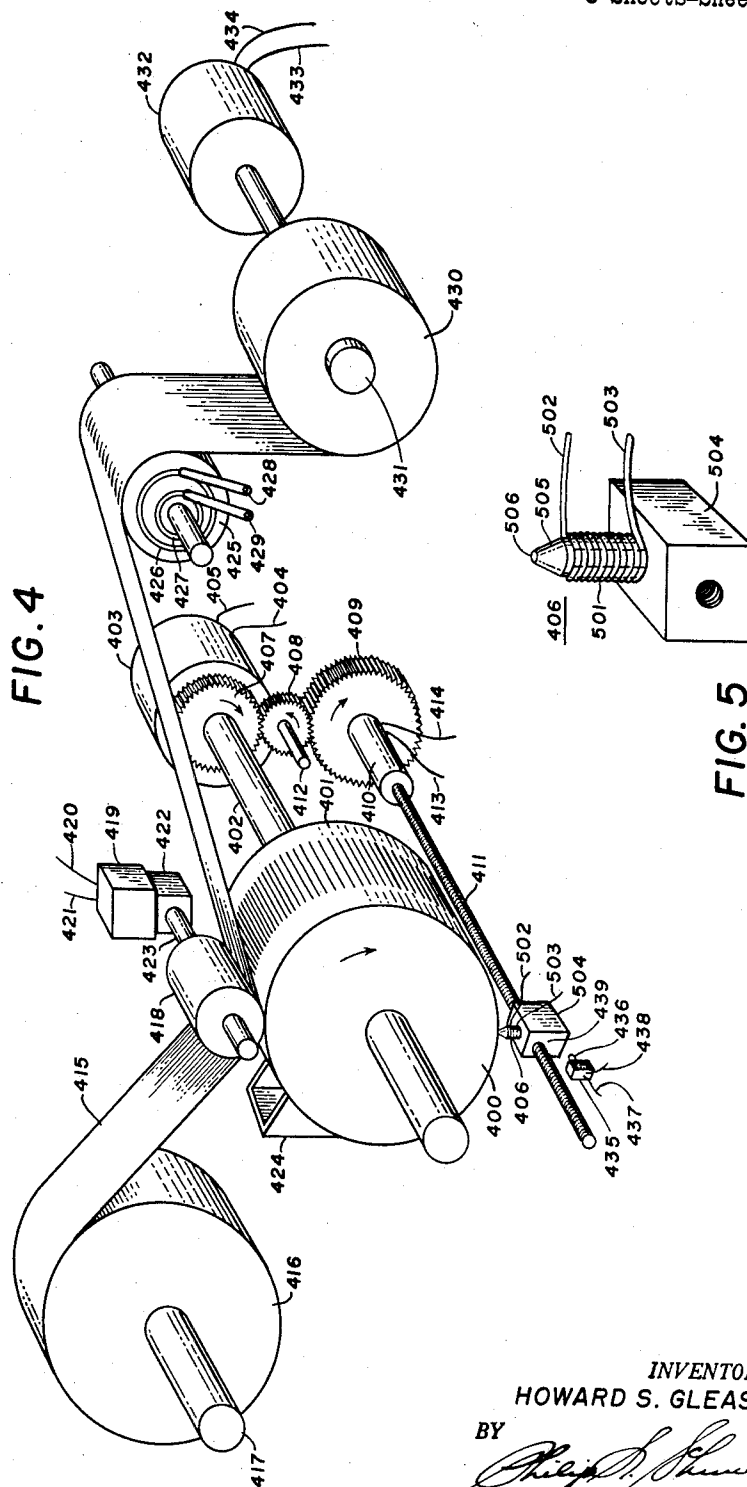
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3 Sheets-Sheet 3



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2,924,646

PRINTING APPARATUS

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Application April 23, 1953, Serial No. 350,680

6 Claims. (Cl. 178—5.2)

My invention relates to printing apparatus and more particularly to printing apparatus of the type based on the transfer of a layer of comminuted magnetic material from the surface of a magnetic medium to the material to be printed. Apparatus of this type is disclosed and claimed in my copending application Serial Number 301,103, filed July 26, 1952, now U.S. Patent No. 2,841,461, and assigned to the assignee of the present application.

It is an object of my invention to provide an apparatus for printing copies of a pattern wherein the pattern and a magnetic recording medium are synchronously scanned on an elemental-portion basis, and a magnetic image of the pattern is recorded on the medium for subsequent printing through the transfer of comminuted magnetic material to the material to be printed.

It is also an object of my invention to provide an apparatus of this sort which is capable of printing copies of the pattern in color.

It is another object of my invention to provide a printing apparatus of the type mentioned wherein scanning of the pattern may occur at a first point and recording of the medium may occur at a second point remote from the first.

In general, I accomplish these and other objects of my invention by providing a pickup unit and a printing unit. Since the pickup unit and the printing unit may be situated in locations remote from each other, I term the former unit a transmitter and the latter unit a receiver. The pickup unit, or transmitter, has means for scanning the pattern to be copied on an elemental-portion, or elemental-area, basis. Means are also provided for converting a predetermined type of information in elemental areas of the pattern into an electrical quantity.

This electrical quantity is conveyed by suitable means to the printing unit. This means may be a radio link or a wire communication line, for example, and a quantity may be sent as a continuous waveform or a series of discrete pulses, or in any other form well known to those skilled in the communication art which will yield the desired transfer of information from the transmitter, or pickup unit, to the printing unit, or receiver.

The printing unit has a magnetic recording head with a flux-emitting area of substantially elemental dimensions. The printing unit has means for causing the magnetic recording head to scan a magnetic recording medium in the same order as the scanning at the transmitter, and consequently to impress a magnetic image of the pattern on the magnetic recording medium. The printing of copies from this magnetic image may be in accordance with the principles laid down in my above-identified copending application.

I employ the terms "elemental area," "elemental portion," and "elemental dimension" in a sense analogous to that employed in the television and half-tone engraving arts, for example. As is well known in those arts, a picture or image may be considered as a group of adjacent areas of small, or elemental, dimensions, each of

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these elemental areas having a light-emitting factor (or light-reflecting factor, as the case may be) which is proportional to the average density of the image over that area. Since these elemental areas are closely adjacent each other, the discrete degrees of density blend into an overall pattern of varying density, provided the eye of the observer is sufficiently far away that it cannot perceive the character of the individual elemental areas. This circumstance, of course, applies to visible patterns, such as drawings, photographs, etc. Those skilled in the art can readily appreciate, however, that my invention is capable of printing visible copies of other patterns, such as magnetic, electrostatic, or heat radiation fields, for example. While I have chosen to explain below an embodiment of my invention which handles visible patterns, it is to be understood that other patterns (including three-dimensional, for example) may be copied according to my invention through the use of an appropriate transducer for converting a predetermined type of information about the pattern into an electric quantity.

I employ the term "scanning" through analogy with the television and facsimile arts, for example. This refers to the consideration of one elemental area of a pattern after another, in an orderly and predetermined sequence.

It is also to be understood that I employ the term "printing" in its broadest sense, that is, as meaning the fixing, or impression, of a stamp, mark or character upon something. I refer in this specification to the "something" as the "material to be printed."

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawings in which

Fig. 1 is an isometric view, in simplified form, of one embodiment of a printing unit according to my invention;

Fig. 2 is a detail of Fig. 1;

Fig. 3 is a schematic wiring diagram of a control circuit useful in my invention;

Fig. 4 is an isometric view, in simplified form, of a printing unit suitable for use in my invention;

Fig. 5 is a detail of Fig. 4;

Fig. 6 is an isometric view, also in simplified form, of a multi-color printing unit for use in my invention;

Fig. 7 is a schematic end view of the arrangement of Fig. 6 which is useful in explaining the arrangement thereof; and

Fig. 8 is a schematic end view of one embodiment of my invention for use with the printing unit of Fig. 6.

In this specification, a block of reference numerals has been reserved for each figure, with the initial digit of each reference numeral being the number of the figure to which it is assigned. Thus, reference numerals 100-199 are assigned to Fig. 1, 200-299 to Fig. 2, etc. The system enables the reader, when he sees a given reference numeral in the text, to go directly to the particular figure in the drawings where the numeral first appears.

Fig. 1 shows, in simplified form, an isometric view of a transmitter, or pickup unit, useful in carrying out my invention. A drum 100 carries the image to be copied around its circumference 101. Drum 100 is coupled for rotation to motor 102 by means of shaft 103. Shaft 103, as with other shafts illustrated in this specification, has been shown without means of support for maximum clarity of explanation. A variety of support means is well known to those skilled in the art, and in any event may be arranged in any suitable manner to provide a spatial arrangement equivalent to that indicated. Shaft

103 carries a gear 104 which meshes with idler gear 105. Gear 105 is mounted on shaft 106 which may be supported in any convenient manner, as just mentioned.

Gear 105 meshes with gear 107, which is in turn coupled to clutch 108, which is preferably electrically actuated. Leads 109 and 110 may be connected to a suitable source of energy for the actuating circuit of clutch 108. Clutch 108 is indicated in semi-schematic form; that it, its external appearance is pictured, with the understanding that its inner arrangement may be that of any suitable clutching device which, when energized, couples its input side (in this case, gear 107) to its output side 111.

The output side 111 of clutch 108 is coupled for rotation to threaded shaft 112. The latter is oriented parallel to the axis of drum 100. A threaded carriage 113 is mounted on threaded shaft 112 for progressive movement therealong. Threaded carriage 113 is shown in greater detail in Fig. 2. A window 200 is provided in that portion of threaded carriage 113 which is nearest to the circumferential surface of drum 100. This window is dimensioned to receive light only from an elemental area of the image on circumferential surface 101. The pitch of threaded shaft 112 and the ratios of gears 104, 105 and 107 are chosen such that window 200 scans over a spiral path around circumferential surface 101 of drum 100; that is, drum 100 rotates many times during a single traverse of window 200 across surface 101 in a direction parallel to the axis of rotation of drum 100.

Threaded carriage 113 is provided with a transducer, not shown, for converting the intensity of light received through window 200 into an electrical quantity, such as an electrical current. The transducer in carriage 113 is preferably a photoelectric cell. The electrical quantity is taken from carriage 113 via leads 114 and 115.

The pickup unit of Fig. 1 is provided with limit switches 116 and 117 having actuating plungers 118 and 119, respectively. Limit switches 116 and 117 are fixed in position relative to drum 100, in any suitable manner, not shown, and are normally closed, that is, they open when plungers 118 and 119, as the case may be, are depressed. Leads 120 and 121 are the connections for the limit switch 116, while leads 122 and 123 are the connections for limit switch 117. Limit switches 116 and 117 are so located relative to drum 100 that plungers 118 and 119 are actuated by the sides of carriage 113 when window 200 reaches the edges of the circumferential surface 101 of drum 100. Limit switches 116 and 117 may be supported by any means, not shown, since such means are well within the skill of those experienced in the art, and, in any event, the exact nature of the supporting means is not essential to an understanding of my invention.

Motor 102 obtains power over leads 125 and 126. A suitable control circuit involving motor 102 and limit switches 116 and 117 will be explained below in connection with Fig. 3.

The receiver, or pickup unit, shown in Fig. 4 is based on a drum 400 having a circumferential surface comprising a magnetic recording medium. The arrangement of Fig. 4 includes means for impressing a magnetic image of the pattern to be printed on circumferential surface 401, and also includes apparatus for producing printed copies of that pattern.

The drum 400 is coupled for rotation by means of shaft 402 to motor 403. Power is supplied to motor 403 over leads 404 and 405. The magnetic image of the pattern is impressed on circumferential surface 401 by means of a magnetic recording head 406 which has a flux-emitting area of elemental dimensions.

A preferred construction of magnetic recording head 406 is shown in greater detail in Fig. 5. Here it may be seen that magnetic recording head 406 comprises a magnetic core around a smaller-diameter central portion (in-

dedicated in dashed lines) on which is wound a coil 501 of wire. The ends of this coil are brought out as leads 502 and 503. The lower end of coil 505 is secured in threaded carriage 504 by any convenient means, such as a force fit in a mating hole. The upper end of core 505 preferably comprises a truncated cone-shaped portion whose apex, or flux-emitting area, 506 may have elemental dimensions closely approximating those of window 200 in threaded carriage 113 (Fig. 1).

Flux-emitting area 506 of magnetic recording head 406 is oriented for recording on magnetic recording medium 401. Area 506 is carried in a direction parallel to the axis of drum 400 by means of threaded shaft 411, which is likewise oriented parallel to the axis of drum 400, and which carries threaded carriage 504. The motion of threaded shaft 411 is imparted by a gear train including gears 407, 408 and 409 and clutch 410. Gear 407 rotates with shaft 402. Gear 408 is carried on stub axle 412. Gear 409 is coupled for rotation to the input side of clutch 410, while threaded shaft 411 is coupled to the output side. Threaded shaft 411 has the same pitch as threaded shaft 112 at the transmitter. Through synchronous operation of motors 102 and 403, carriage 504 is carried across the face of circumferential surface 401 in synchronism with the scanning of surface 101 by carriage 113. It will be noted that scanning of drum 400 is 180° displaced from the scanning of drum 100, but this does not affect the operation of the apparatus. Clutch 410 may have the same characteristics as clutch 108 at the transmitter. Its actuating energy is received over leads 413 and 414.

The apparatus shown in Fig. 4 which is used to print copies of the pattern from the magnetic image impressed on the circumferential surface 401 of drum 400 by magnetic recording head 504 is substantially the same as that used in my above-identified copending application. As explained in that application, the material to be printed may comprise a strip of paper 415 which is derived from a source of paper such as paper roll 416 wound around shaft 417. The paper is preferably impregnated with a very light sizing of wax.

Paper strip 415 is brought into intimate contact with the circumferential surface of drum 400 by means of pressure roller 418. An electrical actuator 419, obtaining its power over leads 420 and 421, depresses its plunger 422 when energized. Plunger 422 carries axle 423 downward, and roller 418 is consequently pressed down against strip of paper 415. This brings the under-surface of paper 415 into intimate contact with the circumferential surface 401 of drum 400.

Circumferential surface 401 is covered with a layer of comminuted magnetic material. The elemental-area density of this layer is proportional to the corresponding elemental-area magnetic density of the magnetic image on surface 401. The comminuted magnetic material is derived from hopper 424. As explained in my above-identified copending application, the comminuted magnetic material may be carbonyl iron particles about 8 microns in diameter. In passing between roller 418 and drum 400 a substantial portion of the comminuted material is transferred to paper 415.

Next paper 415 is passed over a heated drum 425. Drum 425 may be heated in any suitable manner, as by an interior heating element, not shown, to which power is conveyed by means of slip rings 426 and 427. Contact may be made to rings 416 and 417 by brushes 428 and 429, respectively. The heating means preferably is so arranged that heat from drum 425 slightly melts the wax impregnation of paper 415 and so embeds the comminuted particles in the paper and prevents subsequent dislodgement. As those skilled in the art can readily appreciate, a heated, stationary, paper guide may be substituted for drum 425.

After passing over the heated drum 425, the paper may be wound onto roll 430 carried on axle 431. The roll is

kept taut by motor 432 which obtains its power over leads 433 and 434.

After the circumferential surface 401 of drum 400 has passed out of contact with the paper, any comminuted magnetic material remaining on the surface may be removed, by a vacuum cleaner or other suitable means, not shown, as explained in my above-identified copending application. Copy after copy of the pattern to be printed may be made on paper strip 415 through successive rotations of drum 400. In each rotation, the spreading of a layer of comminuted material on surface 401, the transfer of a substantial portion of the material to the paper, and the removal of surplus material on the drum may be repeated in turn without any action by magnetic recording head 406.

The copies printed on strip 415 may be cut apart to provide individual copies, just as is done in rotary printing press work. Those skilled in the art will realize, of course, that sheets of paper could be substituted for continuous strip 415 and that the material to be printed need not be paper but may be an other suitable substance.

When all the desired number of copies has been printed by rotation of circumferential surface 401 against paper 415, the magnetic image of the pattern to be printed may be erased by any suitable means, such as a conventional magnetic erase head. This procedure is fully explained in my above-identified copending application, and hence it is not felt necessary to repeat the explanation here. The erase head has not been shown in Fig. 4 because it is preferably located just below hopper 424 and hence would not be sufficiently visible to convey useful information to the reader.

A limit switch 435 having actuating plunger 436 and leads 437 and 438 is supported by any suitable means, not shown, such that side 439 of threaded carriage 504 actuates plunger 436 when side 127 of carriage 113 actuates plunger 119 of limit switch 117.

A suitable interconnection of transmitter and receiver is indicated schematically in Fig. 3. Leads 300 and 301 are connected to a source of power (not shown because of its conventional nature) capable of operating motors 102 and 403. Motors 102 and 403 are preferably of the synchronous type. Clutches 108 and 410, as well as actuator 419 and takeup motor 432, are arranged for operation from this source of power. Relays 302 and 303 are likewise arranged for operation on this voltage and frequency.

To form a magnetic image of the pattern on circumferential surface 101 of drum 100, power switch 304 is first closed. Motors 102 and 403 have two windings in phase quadrature. Capacitors 305 and 306 are used to produce a 90° phase shift in one or the other of these windings as required for forward or reverse motion of the motor.

Upon closure of power switch 304, motors 102 and 403 each rotate in the reverse direction, voltage being applied to them through back contacts 307, 308 of relay 302. Clutches 108 and 410 are likewise energized through back contacts 309, 310 of relay 302 and through the normally closed contacts of limit switches 117 and 435. As a result of the operation of clutches 108 and 410, motors 102 and 403 drive threaded carriages 113 and 504 to the left, as viewed in Figs. 1 and 4, respectively. This leftward motion continues in the case of carriage 113 until its left side 127 depresses plunger 119, thereby opening limit switch 117 and so deenergizing clutch 108; in the case of carriage 504, motion continues until limit switch 435 is opened and clutch 410 is deenergized.

As soon as threaded carriages 113 and 504 reach their left-hand travel limits and stop moving, the operator may close direction switch 311. The closed position of switch 311 is the "forward" position, that is, the position in which carriages 113 and 504 travel to the right. Closure of switch 311 energizes relay 302. Closure of front contacts 309, 311 of relay 302 has no effect at this time

on clutches 108 and 410, but the making of front contacts 307, 312 causes motors 102 and 403 to operate in the forward direction.

After direction switch 311 has been placed in the forward, or closed, position, the operator may momentarily close "send" switch 313. This causes operation of relay 303 over a circuit including send switch 313 and the normally closed contacts of limit switch 116. Operation of relay 303 causes this relay to lock up at its contacts 314, 315, whereupon send switch 313 may be released to its open position.

The operation of relay 303 closes a circuit through its make contacts 316, 317 to clutches 108 and 410, this circuit extending through make contacts 309, 311 of relay 302. Since motors 102 and 403 are operating in the forward direction at this time, engagement of the clutches causes carriages 113 and 504 to move to the right as viewed in Figs. 1 and 4. When threaded carriage 113 reaches the right-hand limit of its travel, plunger 118 is depressed and normally-closed switch 116 breaks the circuit to relay 303. The release of relay 303 causes the deenergization of clutches 108 and 410 at make contacts 316, 317, and carriages 113 and 504 thereupon stop their movement.

As indicated in Fig. 3, switch 311 may have switches 318 and 319 ganged therewith. Leads 114 and 115 may be connected via these switches to a suitable amplifier 320. Leads 502 and 503 of recording head winding 501 are connected to the output of amplifier 320. Thus, whenever carriages 113 and 504 are moving to the right, i.e., in the recording direction, the output signals from the transducer in carriage 113 reach recording head 406; but when movement is to the left, or in the reset direction, no signals from carriage 113 reach amplifier 320. Those skilled in the art can readily appreciate, of course, that amplifier 320 may be dispensed with if signals of sufficient intensity are available on leads 114 and 115.

When the scanning is finished and the magnetic image is complete on circumferential surface 401 of drum 400, printing may take place. To initiate printing action, switch 321 is thrown from the "record" side 322 to the "print" side 323. This energizes actuator 419, take-up reel motor 432, and drum motors 102 and 403. The printing process then proceeds as previously described. Motor 102 need not run during printing if it is desired to save power. In that case, normally closed switch 324 may be opened.

I am able, in accordance with my invention, to print copies in color of a varicolored pattern through the use of colored comminuted magnetic material, or of comminuted magnetic material which imparts a color to the material to be printed. I first obtain information regarding one color component of the pattern at a time. I then form a magnetic image of that color component of the pattern and print that color on the material to be printed. I subsequently add other color components of the pattern to the printing process.

The embodiment of my invention shown in Fig. 6 is particularly useful in printing copies in color of varicolored patterns. When used with a transmitter of the type shown in Fig. 1, the apparatus of Fig. 6 enables the color component images to be transferred to the material to be printed in rapid succession.

The apparatus shown in Fig. 6 prints three color components and comprises three printing units of the type shown in Fig. 4. Other numbers of color components can be printed in succession by using a different number of printing units. Each of the printing units has a printing drum with a circumferential surface comprising a magnetic recording medium. These drums are 600, 601 and 602, with corresponding circumferential surfaces 603, 604 and 605.

The drums are respectively rotated by motors 606, 607 and 608 which are connected in parallel and are respectively coupled to shafts 609, 610 and 611. Mag-

netic recording heads 612, 613 and 614 are respectively positioned for recording on circumferential surface 603, 604 and 605. These heads are mounted on corresponding threaded carriages 615, 616 and 617 which are in turn carried by threaded shafts 618, 619 and 620, respectively.

Power is transmitted to threaded shaft 618 from motor 606 by a gear train including gears 621, 622 and 623. Clutch 624 disconnects power from threaded shaft 618 when energized. Similar gear trains and clutches are employed between motor 607 and threaded shaft 619 and between motor 608 and threaded shaft 620. The clutches may be connected in parallel.

Each of drums 600, 601 and 602 has a hopper full of comminuted magnetic material of a color corresponding to the particular color component that that particular drum is to print. Thus, drum 600 may have hopper 625 filled with, say, red comminuted magnetic material; drum 601 may have hopper 626 filled with blue comminuted magnetic material; and drum 602 may have hopper 627 filled with magenta comminuted magnetic material.

To form magnetic images of the color components of the pattern to be copied on the circumferential surfaces of 603, 604 and 605, the transmitter of Fig. 1 may be employed. In this case, the output of amplifier 320 may be connected in turn to magnetic recording heads 612, 613 and 614 during three successive scanings by window 200 of the pattern on surface 101. If desired, the connection of the amplifier to the individual heads may be changed with a switch, not shown. During the first scanning, where the red component of the pattern is to be picked up and its magnetic image recorded on surface 603, a red filter may be placed over window 200 so that only red light can reach the transducer inside threaded carriage 113. Similarly, the red filter may be removed and a blue filter substituted when the photoelectric transducer is connected to magnetic recording head 613. And again, the blue filter may be removed and a magenta filter placed over window 200 when the photoelectric transducer in threaded carriage 113 is connected to magnetic recording head 614. Of course, those skilled in the art can readily appreciate that color components other than those mentioned may be used, and the number may be greater or smaller than three, or in general, n components. Thus for n color components, n transducers pick up n types of information regarding pattern density and convey it to n recording heads, respectively, which in turn record it on n corresponding recording media. N sources of comminuted magnetic material distribute correspondingly colored particles over each of the n media, whereby a substantial portion of the magnetic material is transferred from the n individual media to the material to be printed. It is furthermore apparent that the color of comminuted magnetic material used with a given printing unit drum may or may not correspond to the color component image recorded on that drum.

The material to be printed is illustrated in Fig. 6 as a strip of paper 628 derived from roll 629 on axle 630. Paper strip 628 is successively brought into intimate contact with circumferential surface 603 of drum 600, circumferential surface 604 of drum 601, and circumferential surface 605 of drum 602 by rollers 631, 632 and 633, respectively, which are respectively supported by axles 635 and 636. The paper is guided by rollers 637, 638 and 639 which are respectively supported on axles 640, 641 and 642. These rollers may be heated, as explained in connection with roller 425 in Fig. 4, to fix the comminuted magnetic material to the paper when a wax-impregnated paper is used. After printing, paper 628 is rolled up on roll 643, which is maintained taut by motor 644 rotating shaft 645. The individual colored copies of the original pattern may subsequently be cut apart.

As pointed out above, motors 606, 607 and 608 may be connected in parallel, as may be clutches 624, 646 and 647. The wiring diagram shown in Fig. 3 is thus ap-

plicable with this modification and the understanding that the three recording heads are individually connected to the output of amplifier 320 during successive scanings of the pattern.

Fig. 7 shows an end view of the apparatus of Fig. 6. Dimensions X and Y must equal the circumference of drum 100 in order for the images to be printed superimposed, or in registration. Means, not shown, may be provided for raising or lowering axles 640, 641 and 642 individually to change dimensions X and Y and so adjust the registration of the three color component images on the paper.

Fig. 8 shows another embodiment of the transmitter of Fig. 1 in schematic form. Fig. 8 constitutes an end view of the arrangement of Fig. 1 to which have been added threaded carriages 800 and 801, which are respectively carried on threaded shafts 802 and 803. Each threaded carriage has a transducer (not shown), and each transducer is permanently connected through an individual amplifier (not shown) reserved to the corresponding one of recording heads 612, 613 and 614 in the receiver, or printing unit. This avoids the plural scanings encountered with the embodiment of Fig. 1, but is obviously more complex.

Threaded shafts 802 and 803 may be driven by gear trains identical with that used for threaded shaft 112, but angularly displaced around the circumference of drum 100 by a distance D , as indicated. In this event, the sum of distances X and Y in Fig. 7 must total D to provide proper registration. In Fig. 8, each of the windows of threaded carriages 112, 800 and 801 must have filters for different color components of the pattern to be copied; for example, a red filter may be placed over the window of threaded carriage 113, a blue filter over the window of threaded carriage 800, and a magenta filter over the window of threaded carriage 801. In the event these colors are used, powders of corresponding colors would ordinarily be used in hoppers 625, 626 and 627.

While I have shown and described my invention as applied to a specific embodiment thereof, other modifications will readily occur to those skilled in the art. I do not, therefore, desire my invention to be limited to the specific arrangement shown and described, and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim is:

1. In an apparatus for printing copies in color of a varicolored pattern of varying density, the combination of means for scanning said pattern on an elemental-area basis to derive information on the density of each of a plurality of colored components of said pattern; a plurality of magnetic recording media respectively corresponding to said color components; means for recording said information regarding each of said color component densities on the corresponding ones of said media in the same order as said information occurs in said pattern, thereby to form magnetic images of said densities on the corresponding ones of said media; a plurality of sources of comminuted magnetic material respectively associated with said magnetic recording media, the comminuted magnetic material of each source having substantially the same color as the color component whose magnetic image is present on the corresponding magnetic recording medium; means for distributing said comminuted magnetic material from each said source over the surfaces of the corresponding magnetic recording media; and means for bringing a given area of the surface of the material to be printed successively into intimate contact with comminuted magnetic material on the surfaces of said magnetic recording media, whereby a substantial portion of said comminuted magnetic material on said media is transferred to said material to be printed, and means for registering the comminuted magnetic material images transferred from said magnetic recording media, one upon another, on said material to be printed.

2. In an apparatus for printing copies in color of a varicolored pattern of varying density, the combination of a plurality of transducers for converting the intensity of light from an elemental area of said pattern into an electrical quantity; means for admitting only light of a particular color to each said transducer, the particular color of light admitted to each said transducer being different from the colors of light admitted to others of said transducers; a plurality of magnetic recording media; a plurality of magnetic recording heads respectively corresponding in number to said transducers, each one of said heads being positioned for recording a magnetic image on one of said media, and each one of said heads having a flux emitting area of substantially elemental area dimensions; means for energizing each said magnetic recording head in accordance with said electrical quantity from tone of said transducers; means for causing each said head to scan its corresponding magnetic recording medium at the same speed and with the same motion as a corresponding one of said transducers, whereby magnetic images of particular color components of said image to be printed are formed on the various ones of said media; a plurality of sources of comminuted magnetic material respectively associated with said magnetic recording media, the comminuted magnetic material of each source having substantially the same printing color as the color component whose magnetic image is impressed on the corresponding magnetic recording medium; means for distributing said comminuted magnetic material from each source over the surface of the corresponding magnetic recording medium; and means for bringing an elemental area of the surface of the material to be printed successively into intimate contact with the comminuted magnetic material on the surfaces of said magnetic recording media, whereby a substantial portion of said comminuted magnetic material on said media is transferred to said material to be printed, and means for registering the comminuted magnetic material images transferred from said magnetic recording media, one upon another, on said material to be printed.

3. In an apparatus for printing copies in color of a varicolored pattern of varying density, the combination of a plurality of transmitters of a plurality of nonchromatic signals, respectively, corresponding to different color components of the pattern to be printed, a plurality of monochrome printing units, each unit including a printing drum having a circumferential surface of magnetically-retentive characteristics and a of comminuted magnetic material of distinctive color; means for rotating said printing drums; a printing-drum threaded shaft oriented parallel to the axis of rotation of each drum, a printing-drum threaded carriage mounted on each printing drum threaded shaft, a magnetic recording head having a flux-emitting area of elemental dimensions mounted on each carriage and positioned for magnetic recording on the circumferential surfaces of said printing drums; means for applying said signals respectively to the magnetic recording heads; means for distributing said comminuted magnetic material from said source of each printing unit over the circumferential surface of the corresponding printing drum; means for bringing the surface of the material to be printed into intimate contact with the comminuted magnetic material on the surfaces of said printing drums in succession, whereby a substantial portion of said comminuted magnetic material on said drums is transferred to said material to be printed, and means for registering the comminuted magnetic material images transferred from said printing drum, one upon another, on said material to be printed.

4. In an apparatus for printing copies in color of a varicolored pattern of varying density, the combination of a pickup unit including a pickup drum carrying said pattern to be copied around its circumference, means for rotating said pickup drum, a plurality of threaded shafts coupled for rotation to said rotating means, each said

threaded shaft being oriented parallel to the axis of rotation of said pickup drum, a threaded carriage mounted on each said threaded shaft, a photoelectric transducer having a light-receiving aperture of elemental-area dimensions mounted on each said threaded carriage, each said transducer being positioned for light pickup from elemental areas of said image on said pickup drum, and means for admitting light of one distinctive color to each transducer; a plurality of monochrome printing units, each printing unit including a printing drum having a circumferential surface of magnetically-retentive characteristics, a source of comminuted magnetic material of a color different from that in the others of said printing units, means for rotating said printing drums synchronously with said pickup drum; a threaded shaft oriented parallel to the axis of rotation of each drum, a printing-drum threaded carriage mounted on each printing drum threaded shaft, a magnetic recording head having a flux-emitting area of elemental dimensions mounted on said printing-drum threaded carriage and positioned for magnetic recording on the circumferential surface of said printing drum; means for impressing signals derived from said transducers, respectively, to the magnetic recording heads; means for distributing said comminuted magnetic material from said sources over the surfaces, respectively, of the printing drums; and a plurality of first idling rollers rolling, respectively, against said drums, and a plurality of second idling rollers adjustably spaced from said drums for bringing each elemental area of the surface of the material to be printed successively into intimate contact with the different-colored comminuted magnetic materials on the corresponding elemental surfaces of said printing drums.

5. Apparatus for reproducing on paper a colored picture from a plurality of separate signals characteristic of selected color components of the picture to be reproduced, comprising printing apparatus having a plurality of printing drums of extended surface area of magnetizable material, a plurality of magnetic recording heads associated, respectively, with the printing drums, each recording head being responsive to one of said signals, means for systematically scanning each printing drum with the associated recording head for tracing a magnetic image of one color component of said color picture; and means for sprinkling powder of magnetizable material respectively over the magnetic image of each printing drum, each powder being of a distinctive color; and means for rolling a strip of paper successively against each printing drum to transfer the powder of each image to the paper, and means for adjusting the length of the paper strip between drums so as to adjust to coincidence on the paper of the powdered images of the several drums.

6. Printing apparatus comprising a plurality of rotatable drums, the surface of said drums being of magnetizable material, a recording head associated with each drum, each recording head being responsive to monochromatic signals and having a constricted pole face of elemental area and having means for systematically scanning said pole face over the surface of the rotating drum to write a magnetic image on said surface corresponding to said signals, means for dusting the magnetic image on each drum with a magnetizable powder of distinctive color; a pressure roller idling against each drum, the drums and rollers being so disposed that a strip of paper threaded successively between each drum and its roller will be impressed with the images of different colors, and idling rollers between the drums, the positions of the idling rollers being separately adjustable to vary the length of the paper strip between drums to establish coincidence of the separate color images on the strip.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 23,113 Tandler et al. ----- May 10, 1949
(Other references on following page)

UNITED STATES PATENTS

1,116,949	Stille	Nov. 10, 1914
1,817,098	Ranger et al.	Aug. 4, 1931
1,917,509	De Ybarrondo	July 11, 1934
1,924,911	Buecker et al.	Sept. 25, 1934
2,035,475	Hay	Mar. 31, 1936
2,179,002	Washington	Nov. 7, 1939
2,185,806	Finch	Apr. 15, 1941
2,238,601	Reynolds	Apr. 15, 1941
2,357,809	Carlson	Sept. 12, 1944
2,428,945	Singer	Oct. 14, 1947

2,584,695

2,657,932

Good

Blaney

Feb. 5, 1952

Nov. 3, 1953

OTHER REFERENCES

Atkinson et al.: Ferrography, published November 1951 in Journal of the Franklin Institute, vol. 252, No. 5, at pages 373 to 381. (Copy available in Div. 17.)

Berry et al.: Ferromagnetography, General Electric Review for July 1952, pages 20, 21, 22 and 61. (Copy available in Div. 16.)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,924,646

February 9, 1960

Howard S. Gleason

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 58, for "rfeerence" read -- reference --;
column 4, line 48, for "againstristrip" read -- against strip --;
column 5, line 21, for "be an" read -- be any --; column 7, line
63, for "axles 635 and 636." read -- axles 634, 635 and 636. --;
column 9, line 17, for "tone" read -- one --; line 48, for "and
a of" read -- and a source of --.

Signed and sealed this 2nd day of August 1960.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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