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728,169, May 10, 1968.

[56]

References Cited

UNITED STATES PATENTS

3,057,275	10/1962	Walkup et al.	355/4
3,148,600	9/1964	Bain	355/4
3,292,486	12/1966	Mey	355/32

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[54] COLOR COPYING APPARATUS 8 Claims, 7 Drawing Figs.

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250/65, 355/32, 355/88, 355/16, 355/84
[51] Int. Cl. G03g 15/00
[50] Field of Search 355/88, 12,
16, 27, 84, 32, 79, 103, 17, 4; 250/65

ABSTRACT: Apparatus is described for making full color copies of colored originals. Color separation, and thermally induced printing of separate colors in accurate registration, is accomplished rapidly and automatically. The apparatus employs a thermographic dry image-forming process. A powder supply unit operating at high potential applies powder to a photosensitive color transfer sheet in a pattern defined by a color separation light-image of the original. The radiation-absorptive powder pattern is heated by exposure to radiant energy to cause transfer of color to a receptor sheet.

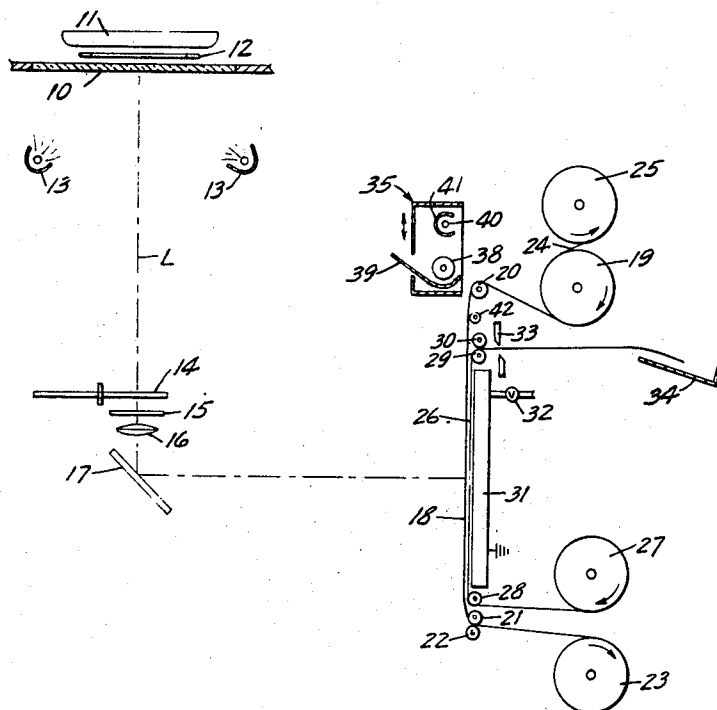


FIG. 1

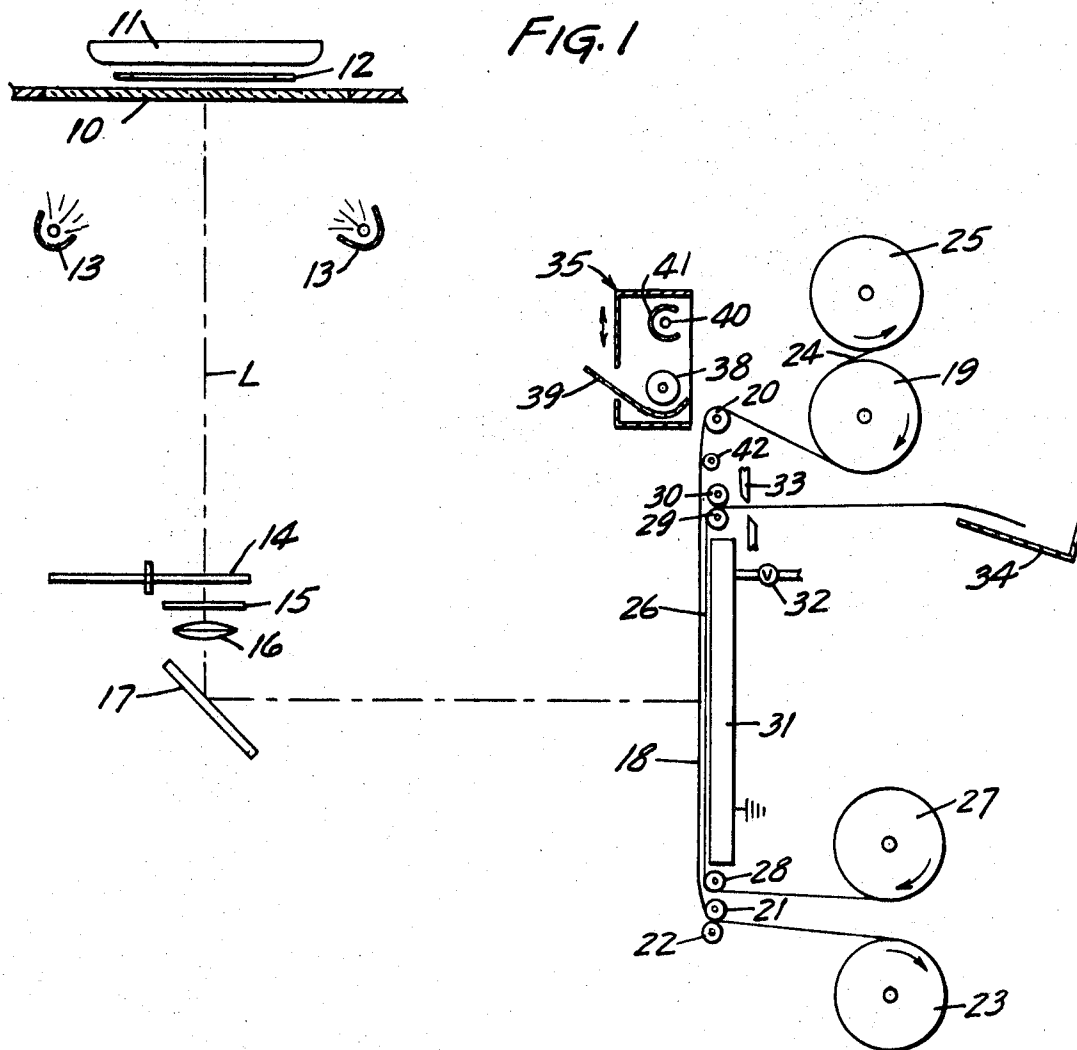
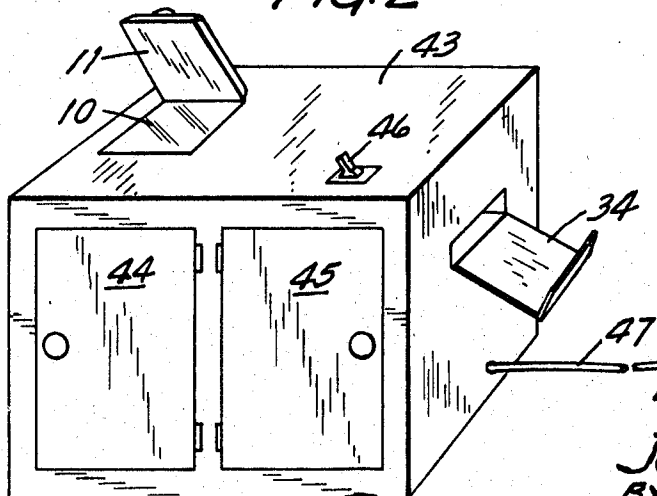


FIG. 2



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FIG. 3

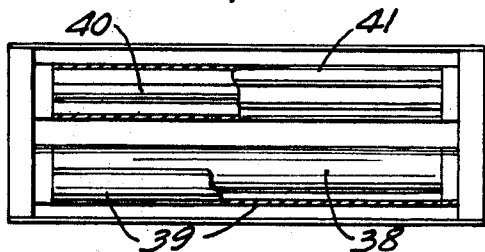


FIG. 6

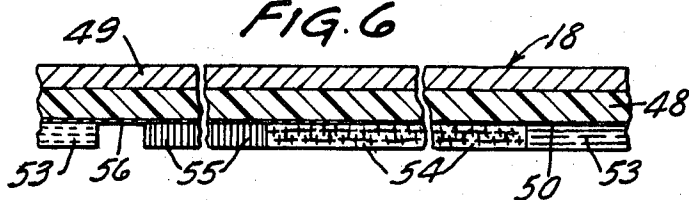


FIG. 7

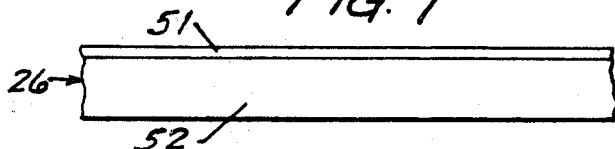


FIG. 5

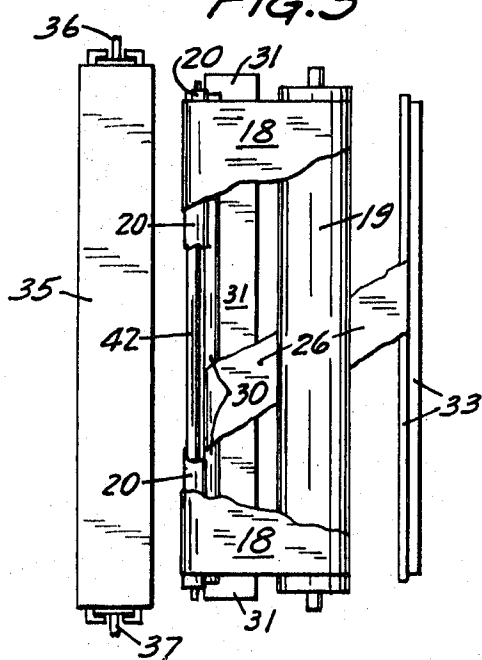
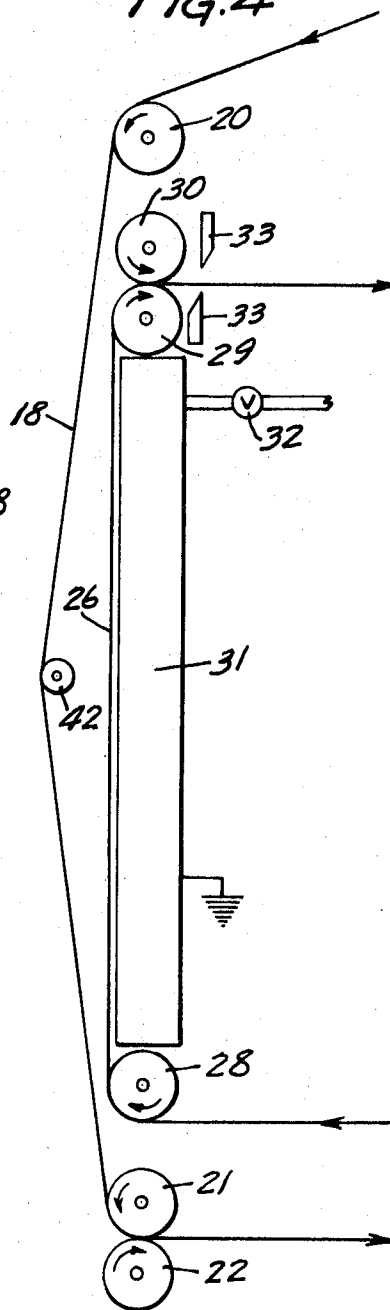


FIG. 4



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COLOR COPYING APPARATUS

This application is a continuation-in-part of our copending application Ser. No. 728,169 filed May 10, 1968.

This invention relates to the recording of colors, and in particular to apparatus useful therein. In one important aspect the invention relates to apparatus for making copies in full and true color of multicolor graphic originals. In a related aspect the invention relates to apparatus for automatically effecting color separation of a projected full-color light image, sequentially recording each separation on an intermediate, and reconstituting a full color record of the original from the several intermediates on a receptor sheet or print sheet. Exact registry of the several color separation images is maintained throughout the copying sequence.

The method of making color copies, and print sheets for use therein, are the subjects of applications Ser. No. 728,167 and Ser. No. 728,230 filed May 10, 1968.

The apparatus includes holding means for maintaining the original and the print sheet in mutually optically fixed positions throughout the copy sequence, so that registration problems are eliminated. Exposure means for directing a light-pattern of the original toward the print sheet, positioning means for placing the intermediate against the print sheet and at the focus of the light-pattern, developing means for converting the latent image to developed image-defining areas of differential radiation-absorptivity, and transfer means for transferring the color material to the print sheet, are also included. Optional removal means for separating the intermediate and print sheet assists indexing and removal operations without displacing or defacing the print. The invention, by combining these several components and functions in novel manner in a unitary apparatus, makes possible the preparation of full-color print copies of colored originals by essentially a fully automatic and completely dry procedure and in surprisingly short time.

One form of apparatus conforming to the requirements of the invention, together with intermediate and print sheets useful therein, is schematically illustrated in the accompanying drawing, wherein:

FIG. 1 illustrates in elevation the several components of the apparatus in their operating relationship;

FIG. 2 is a view in perspective of the complete color copy machine;

FIG. 3 is a partial front elevation of the intermediate or color separation image developer station;

FIG. 4 is a partial elevation on a larger scale and at a different phase of the operation of a portion of the apparatus of FIG. 1;

FIG. 5 is a partial top plan view of portions of the apparatus of FIG. 1; and

FIGS. 6 and 7 are partial sectional elevations illustrating the intermediate and print sheets respectively.

The intermediate sheet 18 is indicated in FIG. 6 as consisting of a thin supporting film 48 having over one surface a continuous photosensitive layer 49 and over the opposing surface an optional continuous conductive subcoat 50 and a repeating sequence of adjacent color transfer coatings 53, 54, 55, the several sequences being preferably separated by narrow uncoated spaces 56. The print sheet 26 of FIG. 7 consists of a paper backing 52 having a thin opaque surface coating 51.

The apparatus of FIG. 1 includes a transparent support 10 and pressure-cover 11 between which is placed the colored original 12, for example a color illustration from a magazine, of which a full-color copy is desired. Light is supplied by sources 13 and is reflected from the original along the path indicated by the broken line L. Filter 14, shutter 15, lens 16 and mirror 17 are provided for controlling and directing the light beam. The beam comes to a focus at the photosensitive surface of intermediate sheet 18 obtained from supply roll 19 and tautly supported between idler roll 20 and pull drums 21, 22. The used intermediate is wound up on drum 23; the (optional) liner 24, separating the convolutions of intermediate in the supply roll 19, is wound up on drum 25.

Print sheet 26 obtained from supply roll 27 is tautly supported between idler roll 28 and pull drums 29, 30 directly adjacent the intermediate 18 and against the porous or channeled face of a grounded vacuum platen 31, the platen being connected through a valve 32 to a vacuum pump. From the pull drums the receptor sheet is advanced past shears 33 for removing completed prints which are deposited in the tray 34.

A developing and printing station 35 is suitably supported on guides 36, 37 (FIG. 5) for reciprocating movement along the face of the supported segment of the intermediate 18, the direction of movement being as indicated by arrows in FIG. 1. The station 35 includes a conductive powder applicator roll 38 and a powder supply trough 39, and a tubular high-intensity radiation source 40 within an open-sided semielliptical reflector 41.

An optional separator bar 42 is terminally supported for similar reciprocating movement across the face of the platen 31 between the intermediate and the print sheet.

The apparatus is assembled within a cabinet 43 as indicated in FIG. 2, together with auxiliary motors, pumps, relays, switches and other operational and control components, all accessible through doors 44, 45. An external master switch 46 controls the operation. Power is supplied through cord and plug means 47.

The operation of the machine is as follows. With the intermediate 18 and print sheet 26 indexed to proper position and an original 12 in place, closing the master switch first actuates the vacuum pump to pull a vacuum on the platen 31 and thereby press the intermediate and print sheet smoothly and firmly against each other and against the platen surface. The lamps 13 are energized and the shutter 15 opened to provide the required exposure time. The light beam passes through a first color filter in the filter wheel 14 to provide a color separation and the resulting monocolored beam is focused and directed, by the lens 16 and mirror 17, onto the photosensitive surface of the intermediate.

Following the exposure, the station 35 is passed over the exposed surface and returned to position. During the forward movement the developer roll 38 is extended to make contact with the intermediate and is maintained at a high electrical potential, about 1000 volts above ground being typical. Conductive radiation-absorptive toner powder from the trough 39 is thereby selectively deposited on the unexposed areas, the remainder being retained on the roll surface. A differentially electronically conductive pattern is created in the photosensitive sheet by exposure to the light image. The developer roll serves as the cathode. Contact of the sheet with the conductive powder under the high potential results in retention of powder on the surface of the sheet. The process is described in Belgian Pat. No. 680,870 dated July 15, 1966. During the reverse movement of station 35 the roll 38 is retracted and remains at ground potential, while the lamp 40 is energized to provide brief exposure of the imaged surface. The radiant energy is absorbed at the powdered areas of the sheet and converted to heat. The resulting localized heating effect causes transfer of color material from the reverse surface of the intermediate to the coated surface of the print sheet.

The vacuum is next turned off and the separator bar 42 is caused to advance across the surface of the print sheet, thereby overcoming any slight temporary bonding between the two sheets. After completely separating the two, the bar is returned to a halfway point and somewhat removed from the print sheet, as indicated in FIG. 4, thereby holding the intermediate out of contact with any portion of the print sheet. The pull drums 21, 22 are then activated to advance the intermediate and place the second color coating in position, whereupon the bar completes its return and the intermediate is placed in pressure contact with the print sheet against the platen 31. Meanwhile the color wheel 14 has been turned to place the second color filter in the path of the image beam.

The exposure, development, transfer, separation, and reindexing steps are repeated for the second and any subsequent color separation desired. During the final sequence, and before the separator bar 42 is returned to its rest position, the

print sheet 26 is advanced by pull drums 29, 30 and the printed portion removed by shears 33 and deposited in the tray 34, leaving a fresh section in position adjacent the platen 31. Also during this period the intermediate sheet, while advancing the first of a new series of color coatings, may be more accurately repositioned through the action of sensing means in conjunction with the narrow terminal strip 56, thereby compensating for any slight changes in length within the several color supply sections.

The entire process may be repeated any desired number of times automatically, or the master switch may be automatically opened after a single sequence, e.g. by appropriate counters and shutoff relays, to permit the substitution of a different original.

In the illustrative process just described it is the nonlight-exposed areas of the intermediate which are made radiation-absorptive, and the color material is transferred from the reverse surface of the sheet at these areas. It is therefore necessary to use transfer materials which provide a color complementary to that of the filter and of the color separation image, in order to form a true color copy of the original. A typical example using conventional primary colors will employ a color transfer material producing a magenta image in conjunction with a green filter, and correspondingly a yellow image material with a blue filter and a cyan image material with a red filter. White areas are reproduced unchanged; black areas of the original are reproduced by the combination of all three color materials.

It will be understood that colors other than those complementary to those of the filter and the color separation image may be supplied as desired, e.g. by appropriate displacement of the filter 14 or of the intermediate 18 or in other ways. Again, the tonal values for specific color separations may be regulated as desired, e.g. by adjusting the intensity of the source 13 or otherwise. Monocolor prints, or black-and-white prints, are easily available.

Good results have been achieved with intermediate sheet color transfer coatings containing transferable organic dyes in polymeric binders. One specific example employs p-tricyanovinyl-N,N-dimethylaniline for magenta, duPont Oil Yellow or Sudan Yellow GR Concentrate for yellow, and duPont Oil Blue A for cyan, all in ethyl cellulose binder containing silica powder as additional filler. The photosensitive coating is a panchromatic coating comprising zinc oxide and spectral sensitizing dyes in a polymeric binder. The (optional) conductive layer is vapor-coated aluminum. One mil "Mylar" polyester film serves as an effective carrier.

Color transfer coatings containing nonvolatilizable dyes or pigments in a fusible binder may be substituted in the just-described intermediate sheets for many purposes. The color layer fuses and adheres to the print sheet at the heated areas, and when then cooled may be stripped from the carrier film by the passage of the separator bar 42.

An alternative print sheet structure omits the binder component of the dye layer and makes possible the elimination of the separator bar. In an example, thin paper is employed as the carrier, and the dye particles are uniformly rubbed or brushed into the fibrous surface. The sheet slides smoothly over the surface of the print sheet even after being locally

heated in contact therewith.

A presently preferred print sheet for use with the exemplary intermediate sheet just described consists of bond paper coated with "Vinylite VMCH" vinyl chloride-vinyl acetate copolymer containing silica powder, calcium stearate and nickel stearate. The coating absorbs and stabilizes the transferred dyes. Where the conductive coating is omitted in the intermediate, the conductivity of the print sheet is increased, for example by treating the paper base with a conductive resin impregnant.

The apparatus described, using the intermediate and print sheets above identified, has been shown to be capable of producing sharp and clear full size copies in full color of letter-size multicolor originals at a rate in excess of 1 copy per minute.

What we claim is as follows:

1. Apparatus useful in transferring color material from a photosensitive intermediate containing said material to a receptive print sheet as a colored record of a colored original, comprising, in combination: holding means for maintaining said original and said print sheet in mutually optically fixed positions; exposure means for directing a light-pattern of said original toward said print sheet; positioning means for placing said intermediate against said print sheet and at the focus of said light-pattern; developing means for forming at the surface of the intermediate a differentially radiation-absorptive pattern defined by said light-pattern; and irradiating means for briefly exposing said pattern to high intensity radiation and thereby inducing localized heating for transferring said color material from said intermediate to said print sheet in said pattern.
2. Apparatus of claim 1 including removal means for separating said intermediate and said print sheet.
3. Apparatus of claim 2 wherein said exposure means includes a series of color separation means, and including indexing means for placing a particular one of said separation means in said light-pattern and simultaneously for placing against said print sheet an intermediate containing a transferable color material appropriate to said one color separation means.
4. Apparatus of claim 3 wherein said series includes the three primary colors.
5. Apparatus of claim 4 wherein said indexing means includes control means for separately indexing each of said series of color separation means and each of a corresponding series of photosensitive intermediates in a single recording sequence.
6. Apparatus of claim 5 wherein said removal means includes separation means for maintaining separation between said intermediate and said print sheet during operation of said indexing means.
7. Apparatus of claim 1 wherein said developing means includes a source of electrically conductive radiation-absorptive toner powder and applicator means for preferentially releasing said powder at high potential to non-light-struck areas of said photosensitive surface.
8. Apparatus of claim 1 wherein said positioning means includes vacuum platen means against which both print sheet and intermediate may be held by air pressure.