Nov. 5, 1963 L. E. WALKUP ETAL 3,109,367

METHOD FOR PATTERN REPRODUCTION

Filed Jan. 3, 1955 2 Sheets-Sheet 1

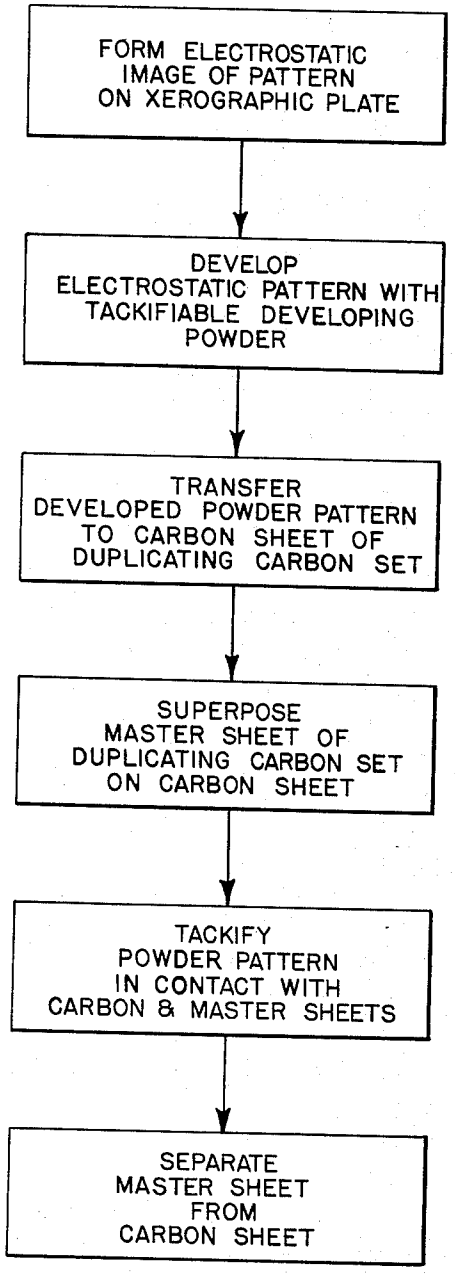


FIG. 1

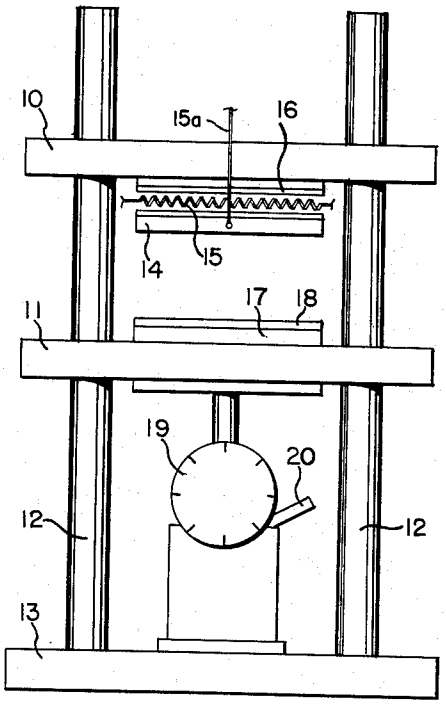


FIG. 9

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METHOD FOR PATTERN REPRODUCTION

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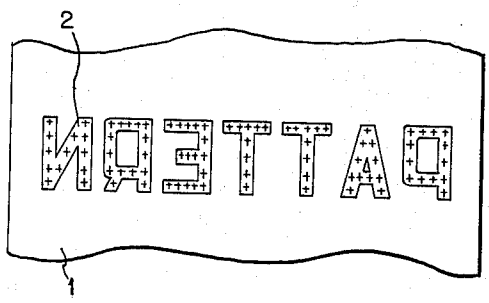


FIG. 2

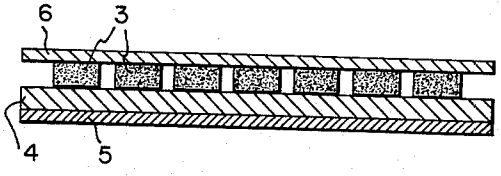


FIG. 6



FIG. 3

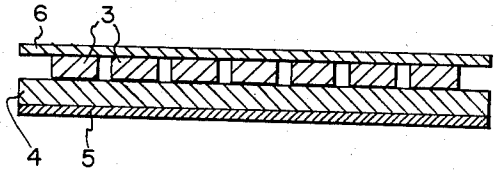


FIG. 7

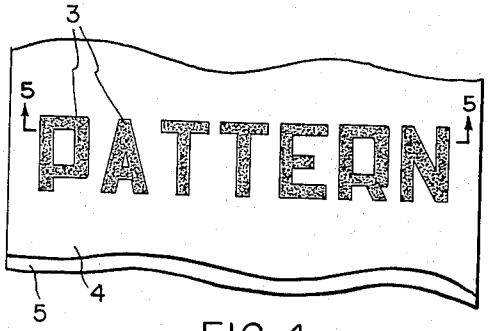


FIG. 4

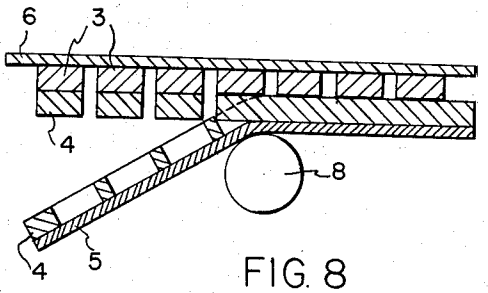


FIG. 8

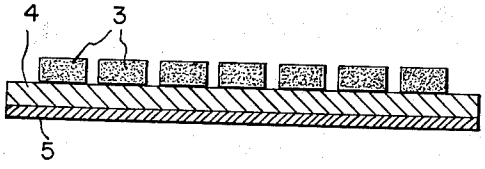


FIG. 5

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3,109,367

METHOD FOR PATTERN REPRODUCTION

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Filed Jan. 3, 1955, Ser. No. 479,453
1 Claim. (Cl. 101—149.4)

This invention relates to the field of pattern reproduction and particularly to a method of and apparatus for affixing a predetermined pattern of loosely cohesive pattern material to a firmly cohesive supporting material.

In many commercial and industrial fields, it is frequently necessary or desirable to form and/or reproduce a given pattern or outline in a specific material that does not readily lend itself to convenient or rapid methods of application. A typical example of this situation is of comon occurrence in the field of liquid or spirit duplication for the production of copies of printed material. In this process, the copy to be reproduced is typed or written on the "master" sheet of a spirit duplicating set which includes a "carbon" sheet comprising a loosely coherent layer of dye containing material mounted on a relatively smooth backing sheet so that the dye containing material may readily be stripped therefrom. The dye containing layer of the "carbon" sheet is arranged in juxtaposition to the master sheet, and the pressure of the type or writing instrument causes a quantity of dye from the carbon sheet to be deposited on the back of the master sheet in a pattern corresponding to that appearing on the front of the master sheet. When the master is completed, it is placed on the rotating drum of a duplicating machine. As copy paper is fed into the machine, it is moistened slightly, usually with an alcohol base dye solvent, as it comes in contact with either a roller or wick. Relatively little of the solvent is applied so that it evaporates quickly, but it is sufficient to pick up a thin layer of dye from the master and this dye remains on the copy paper in the form of the pattern deposited on the master sheet.

For the reproduction of typewritten copy, this process is quite adequate and is widely used, although the typist must exercise somewhat more than usual care in centering and laying out the work. A limitation of the process is that a constant typing pressure must be maintained in order to deposit a dye pattern of uniform thickness on the back of the master sheet. In the event the dye pattern is not of uniform thickness throughout, the thinner portions of dye are expended more quickly than the remainder of the dye pattern, with the result that the number of complete copies that can be made is limited by the thickness of the dye pattern in its thinnest portion. A further limitation is that the correction of typographical errors must be effected directly on the master sheet and requires substantially more time and effort than in conventional typing practice, and usually results in noticeable defects in the finished copy.

When the process is applied to the reproduction of written copy, line work, or art work, it becomes particularly cumbersome and unwieldly. In these cases, it is currently required that the desired copy be formed directly on the face of the master sheet in the exact form in which it is to be reproduced and that the writing or drawing pressure be maintained constant throughout in order to deposit a dye pattern of uniform thickness on the reverse side of the master sheet in exact correspondence with the line copy pattern formed on the front. Such practice obviously requires the services of a skilled artist or draftsman and, at best, is extremely expensive and time consuming. Furthermore, in its present form, the spirit duplicating process provides no method to make reproductions of existing copy such as prints, drawings, letterheads, or other forms of line copy, because there is no convenient method for forming a dye pattern on the master sheet that corresponds to the line copy pattern that should be reproduced.

In order to overcome the above described limitations in the spirit duplicating field and to provide a convenient process for use in other fields in which comparable problems exist, the present invention affords as its principal object a method of and apparatus for affixing a predetermined pattern of loosely cohesive pattern material to a firmly cohesive supporting material. A further object of the invention is to afford a method of and means for forming such a pattern that is of uniform thickness throughout its entire area. A further object is to improve the technique of pattern transfer wherein all pattern errors may conveniently be corrected before transfer is effected. A further object is to afford an improved method and apparatus for preparing duplicating masters for use in spirit or liquid duplicating processes.

Briefly, these and other objects of the invention are attained by an application of the art of xerography wherein a latent electrostatic image of the predetermined pattern is formed and is coated with an electroscopic powder of a type that can be caused to adhere to the supporting material on which the ultimate pattern is to be formed as well as to the material of which it is desired that such pattern be composed. Preferably, the powder image corresponding to the desired predetermined pattern is formed or or transferred to one of a pair of superposable sheets, one of which includes a firmly coherent layer of supporting material and the other of which includes a loosely coherent layer of pattern material. The sheets are then superposed with the powder image positioned therebetween and the powder image is caused to adhere to the surfaces of both sheets and bond them firmly together. When the bonding of the several materials is completed, the superposed sheets are forcibly separated whereby an area of the pattern material corresponding to the predetermined pattern is literally pulled from the layer of pattern material and is firmly affixed to the layer of supporting material.

Specifically, as the process is applied in the field of spirit duplicating, the electrostatic image of the predetermined pattern is developed with a xerographic developer including an electroscopic powdered resin which, when tackified under suitable conditions of heat and pressure, is capable of adhering firmly to the dye layer of the carbon sheet of a spirit duplicating set as well as to the surface of the master sheet thereof. After the pattern is formed and developed it is transferred electrostatically to the dye coated surface of the carbon sheet of a spirit duplicating set and the master sheet of the set is superposed thereon. The assembled set is then placed between thermostatically controlled platens of a hydraulic press wherein a predetermined pressure and temperature are applied for a sufficient period of time to tackify the powdered resin and cause it to adhere to the dye coated surface of the carbon sheet as well as to the surface of the master sheet. The sheets of the duplicating set are then forcibly separated so that a dye pattern of uniform thickness and conforming exactly to the predetermined pattern is pulled from the loosely cohesive dye layer of the carbon sheet and is firmly affixed to the master sheet, thereby forming a dye coated master sheet that may be used directly in the usual manner in a spirit duplicating machine.

The term "tackified" and the several variant forms thereof used throughout the specifications are employed to define the condition of the powder particles when treated in a manner such that the individual particles soften and coalesce and in which state they become sticky and readily adhere to other surfaces. Although this con-

dition necessarily requires a flowing together of the particles to effect a thorough fusion thereof, it is to be understood that the extent of such flowing is not sufficient to extend beyond the boundary of the pattern in which the particles are formed.

The method of the invention and a suitable device for effecting a specific application thereof are shown in the appended drawings, in which:

FIG. 1 is a flow diagram illustrating the several steps of the method of the invention, as applied in forming a predetermined pattern of dye material on a master sheet for use in a spirit duplicating process;

FIGS. 2 through 8, inclusive, are schematic illustrations of the several steps of the method of FIG. 1, wherein

FIG. 2 is a plan view of a xerographic plate bearing an electrostatic image of a predetermined pattern formed thereon;

FIG. 3 is a plan view of the xerographic plate of FIG. 2 wherein the latent image of the predetermined pattern is developed with a tackifiable developing powder;

FIG. 4 is a plan view of a portion of a carbon sheet of a carbon duplicating set to which the powder pattern of FIG. 3 has been transferred;

FIG. 5 is a sectional view of the carbon sheet and powder pattern taken on the line **5—5** of FIG. 4;

FIG. 6 is a sectional view of the elements of FIG. 4 after the master sheet is superposed thereon;

FIG. 7 is a sectional view of the elements of FIG. 6 after the powder pattern is tackified;

FIG. 8 is a sectional view illustrating the relationship of the several elements of FIG. 7 while the master and carbon sheets of the duplicating carbon set are being separated;

FIG. 9 is a schematic front elevation of a thermostatically controlled hydraulic press suitable for use in the practice of the invention.

In the practice of the method of invention, as applied in the field of spirit duplicating, the pattern to be reproduced is conveniently formed on one of the sheets of a spirit duplicating set. Such sets are in general commercial use and many types of these sets are available from various manufacturers. In general, each set comprises a master sheet and a carbon sheet attached along one edge by a suitable hinge. The set may also include a separating sheet to prevent smudging of the carbon sheet during handling but which is removed prior to the actual use of the set. The master sheet usually comprises a firmly coherent, smooth surfaced sheet of white paper that is readily receptive of impressions from typewriter type or conventional writing instruments. The carbon sheet comprises a firmly coherent, backing sheet of relatively glossy surfaced paper on which a thin layer of dye material or dye intermediate material is uniformly spread. The dye material is usually suspended in a wax coating or similar form of binder to make it adhere to the carbon sheet, and the particles of such coating are only loosely coherent with each other whereby the pressure applied by a writing instrument or type face readily detaches the impressed portion from the remainder of the dye layer. Also, since the carbon backing sheet has a smoother surface than the master sheet, the dye layer in usual practice adheres more readily to the master sheet so that impressed portions are conveniently broken away from the carbon sheet when the components of the duplicating set are separated.

By means of this application of the invention, the pattern to be reproduced may be formed in any convenient manner on any suitable type of material, and may comprise any type of copy that can be reproduced by xerographic processes. Thus, the pattern may be completed in all detail, including the correction of all typographical or other errors, before it is employed in the method of the invention.

In the process of xerography, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, a plate comprising a coating of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the light intensity which reaches them, thereby creating an electrostatic latent image on or in the plate coating. Development of the image is effected with a finely-divided material such as an electroscopic powder which is brought into contact with the coating and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image.

The developing agent employed may be of any convenient type suitable to the requirements of the particular application, the type disclosed in Patent 2,618,551, issued November 18, 1952, being illustrative of a form that may be used in most instances. As disclosed in this patent, the developer comprises a combination of coated glass bead carriers together with toner powder which comprises particles of fusible resin in which a pigment such as carbon is bonded. These components are mixed together to establish an electrostatic charge on the powder particles that is of opposite polarity to the charge comprising the latent xerographic image whereby, when the developer is cascaded over an exposed xerographic plate, the resin and carbon black particles adhere to the charged surfaces of the plate and form a powder image or pattern of the latent image previously formed thereon. In the general application of xerography the resin particles are subsequently bonded to the finished copy by the application of heat and serve to secure the carbon black particles which provide the coloring matter in the finished copy. In the present application the resin particles form the essential element of the powder mixture as the bonding agent that unites the ultimate pattern material to the supporting material. The carbon black particles serving primarily to produce a readily visible image on the xerographic plate whereby an operator may check the completeness of the copy that is formed on the plate.

Referring to the drawings the several steps of the invention outlined in FIG. 1, as applied to the formation of spirit duplicating masters, are illustrated in FIGS. 2 through 8, inclusive, wherein a xerographic plate **1** (see FIG. 2), comprising a layer of photoconductive material mounted on a conductive backing, is provided with a reverse reading electrostatic image **2** of a predetermined pattern that is formed thereon by conventional xerographic processes. In this figure, plus signs are employed to indicate the electrostatic charge forming the latent image of the pattern after the plate is exposed. After exposure, a suitable developing agent, as described above, is cascaded over the plate whereby the electrostatic image **2** is transformed to a pattern of powder particles designated by reference character **3** (see FIG. 3). Thereafter, powder pattern **3** is transferred electrostatically to the dye layer **4** of the carbon sheet **5** of a spirit duplicating set (see FIGS. 4 and 5) to form a direct reading pattern thereon. The master sheet **6** of the duplicating set is then superposed on the powder pattern on the carbon sheet (see FIG. 6) and the entire assembly is treated under suitable conditions of heat and pressure, as described below, until the powder pattern is tackified and bonded to both sheets, as in FIG. 7. When tackification and bonding is complete and the master sheet and the dye layer are firmly united by the coalesced powder particles of the predetermined pattern, the sheets are separated either by stripping in the usual manner or by sliding the carbon sheet over a rod **8** or other rounded surface (as in FIG. 8), whereby the bonded dye particles are cleanly broken from the dye layer remaining on sheet **5**. Master sheet **6**, to which a dye pattern conforming to the predetermined pattern is

firmly affixed, may now be used for producing copies in a duplicating machine in the usual manner.

The tackification of the powder pattern may be accomplished in any of a variety of devices wherein suitable conditions of temperature and pressure can be attained. A typical device for such a purpose is illustrated in FIG. 9 wherein a pair of flat pressure plates **10** and **11** are mounted on vertical guide rods **12** which are supported on a suitable base plate **13**. Preferably, upper plate **10** is fixed to the guide rods and lower plate **11** is mounted for slideable movement thereon. Supported on upper plate **10** is a rectangular steel platen **14** which is stress-relieved and surface-ground to provide a smooth flat surface against which the duplicating carbon set may be pressed. Traversing the space between plate **10** and platen **14** is a heating coil **15** which is connected to a suitable power source whereby the entire surface of plate **14** may be heated. An insulating sheet of Transite **16**, which is a product of hard pressed board of asbestos and Portland cement manufactured by Johns Manville, or other suitable material may be arranged above coil **15** to prevent undue heating of plate **10**. A thermostatic control, as schematically illustrated by thermocouple wire **15A**, may be incorporated in the power supply line to heating coil **15** to maintain the temperature of the platen within the required range.

Mounted on lower plate **11** is a layer **17** of sponge rubber or other resilient material which in turn supports a thin flexible metal sheet or platen **18**, which is preferably formed of copper to afford even distribution of heat. A hydraulic jack **19** actuated by a handle **20** is provided to elevate plate **11** to raise platen **18** into engagement with platen **14** and urge it thereagainst with any desired degree of pressure. By this arrangement of the resiliently mounted flexible platen **18**, the entire area of a spirit duplicating set placed thereon can be pressed firmly against platen **14** to establish uniform pressure between all portions of the master and carbon sheets. Although platen **18** is preferably formed of copper of .015" to .020" thickness, a wide variety of materials and gauges will obviously produce comparable results.

In general, between tackifying operations, the upper and lower platens of the press are maintained in contact so that the lower platen is heated by conduction from the upper platen. By this means the entire assembly is maintained at an even temperature to facilitate the tackification of the powder pattern.

Although various combinations of temperature and pressure may be employed, best results are obtained when platen **14** is maintained at a temperature of between 140° to 155° F. and the platens are urged together at a pressure between 10 to 15 pounds per square inch. Under these conditions tackification and bonding of the sheets is effected in a period between ½ to 5 minutes. Preferred conditions are 150±3° F. at a pressure of 10.5 to 1.4 p.s.i., and a time period of 1.5 to 4 minutes.

If desired, lower pressures may be employed for proportionately longer periods of time to produce comparable results However, in the event particles of dust or lint are present on the pattern, the range between 10 to 15 pounds per square inch is found most suitable to eliminate defects in the finished copy.

Temperatures in excess of 160° have a deleterious effect on some carbon sheet coatings, and are therefore usually avoided with such coatings. Therefore such temperatures are not recommended. At lower temperatures, pressures up to several hundred pounds per square inch may be applied with reasonably satisfactory results. However, in such cases it is found that particles of the carbon layer other than those encompassed by the pattern area sometimes adhere to the master sheet and produce undesirable background in the final copy.

Although the invnetion is described with specific reference to its applicaion to the field of spirit duplicating, it is apparent that both the method and the apparatus may readily be applied in other fields for the purpose of pattern transfer within the scope of the invention. For example, should it be desired that a direct-reading pattern be formed on the master sheet, as for use in an offset printing process, the reverse-reading powder image on the xerographic plate may be transferred directly to the master sheet instead of to the carbon sheet, as described above. Thereafter, the process is carried out in the same manner by superposing the sheets, tackifying the powder pattern, and separating the sheets to pull a direct-reading image of pattern material from the carbon sheet. Similarly, numerous other applications of the invention will be apparent to those skilled in similar or related arts whereby a desired pattern forming material that is difficult of convenient application or handling may be formed in a loosely coherent layer and bonded to a firmly coherent supporting layer by means of a common bonding agent that can be conveniently formed into the desired pattern by xerographic processes. Therefore, it is intended that all matter contained in this specification be interpreted in an illustrative sense and that the invention be limited only as defined in the appended claim.

What is claimed is:

The method of forming a predetermined dye pattern on a master sheet of a spirit duplicating set comprising the steps of:

(*a*) forming a xerographic powder resinous particle image tackifiable by heat at temperatures of 140 degrees F. and above of such predetermined pattern on the dye layer deleteriously affected at temperatures above 160 degrees F. of the carbon sheet of a spirit duplicating set;

(*b*) superposing the master sheet of said set on the dye layer of said carbon sheet supporting said powder image;

(*c*) placing said sheets in their superposed relation in a heating press to tackify and bond said powder image between the surfaces of said sheets, said press including:

(1) a pair of horizontally arranged pressure plates at least one of which is adapted to be moved vertically toward the other,

(2) a flat rigid steel platen mounted on one of said plates,

(3) a flat flexible platen mounted on the other of said plates and arranged in opposing relationship to the other platen and both being of a size to accommodate said superposed sheets, said flexible platen comprising:

(*a*) a layer of resilient material mounted on the other of said plates,

(*b*) a thin copper heat conductive sheet about .015 to about .020 inch in thickness supported on said resilient material,

(4) an electrical heating coil arranged between the rigid platen and its associated plate to heat the platen thereof,

(5) a thermostatic control connected to said coil and adapted to regulate the temperature of said rigid platen, and,

(6) jack means connected to the movable of said plates to cause engagement of the opposing faces of said platens and exert a pressure therebetween,

(*d*) operating the jack of said press to exert about 10 to about 15 p.s.i.g. on said superposed sheets for about between ½ minute to about 5 minutes while said thermostatic control maintains said rigid platen at between about 140° F. to 155° F.;

(*e*) removing the superposed sheets from said press after expiration of said time period; and,

(*f*) separating said sheets by sliding the carbon of said set over a rounded surface, whereby an area of dye layer corresponding to the area of the predeter-

mined pattern is separated from the carbon sheet and is affixed to the master sheet.

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