Oct. 14, 1969 W. L. KITE, JR 3,472,674

PRESSURE SENSITIVE PAPER AND METHOD OF PRODUCING SAME

Filed July 13, 1966

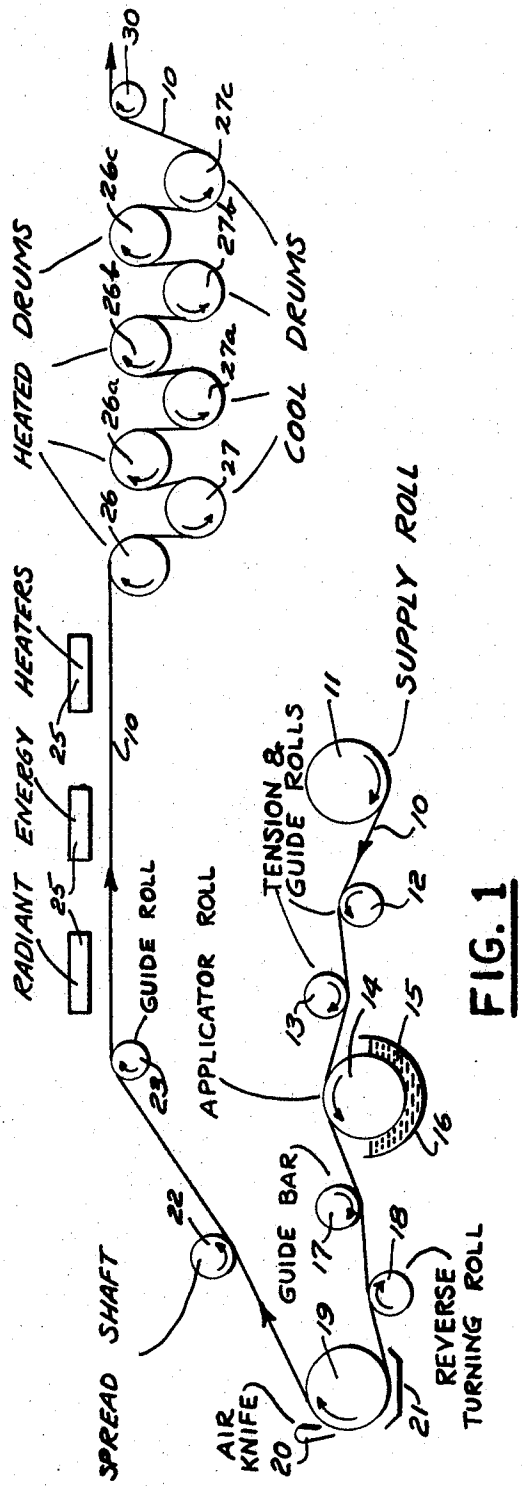


FIG. 1

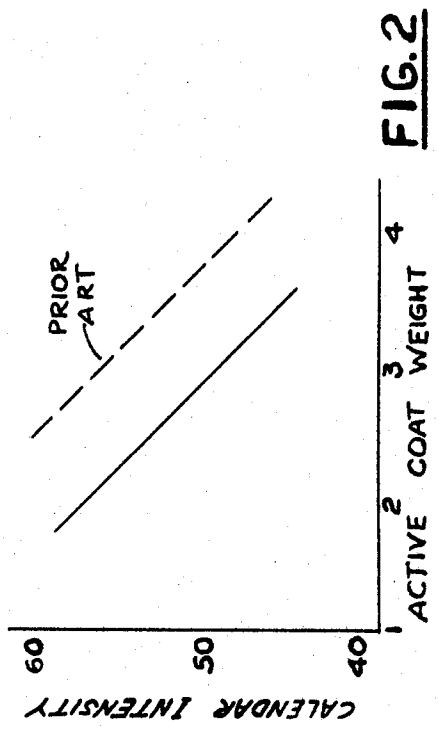


FIG. 2

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United States Patent Office 3,472,674 Patented Oct. 14, 1969

3,472,674

PRESSURE SENSITIVE PAPER AND METHOD OF PRODUCING SAME

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Filed July 13, 1966, Ser. No. 564,936
Int. Cl. B41l 1/00; B44d 1/46; D21h 1/22
U.S. Cl. 117—36.1 10 Claims

ABSTRACT OF THE DISCLOSURE

The present invention relates to the method of increasing the pressure-sensitivity of paper coated with pressure-rupturable marking fluid-containing microscopic capsules by heating the applied coating containing said capsules in a manner such that all portions of said coating except the exposed surface thereof are heated to evaporate the water content from said coating before any substantial portion of the liquid water reaches the exposed surface of said coating.

This invention relates to methods of producing pressure sensitive paper such as described in U.S. Patent No. 2,711,375 granted to Robert W. Sandberg on June 21, 1955.

As recognized in said patent, and also in U.S. Patent No. 3,186,861 granted to John W. Smith et al. on June 1, 1965, the production of such paper presents major problems major problems, particularly at relatively high speed operations. In general, prior art methods of producing such pressure sensitive paper have applied to a web of paper a fluid coating composition including marking fluid containing microscopic capsules rupturable by marking or printing pressures to release the marking fluid and thus produce a pressure sensitive sheet and also including a relatively coarse material, such as cellulose fibers, to provide smudge resistance. Following application of the coating to a paper web, it was smoothed and the coating was distributed and thereafter dried.

Because of the pressure sensitive character of the marking fluid containing capsules, such coating compositions have generally been applied by an air-knife coating method wherein an excess of coating material is applied to a moving web of paper and the excess is then removed by a stream or jet of air. Other coating methods have been unsuccessful generally in that they apply forces sufficient to cause rupture of the marking fluid containing capsules, or have resulted in the removal of the fiber content from the coating film so that the resultant paper product was deficient in smudge resistance. Additionally, it was found desirable to include in such coating compositions a substantial amount of such fiber material to provide adequate smudge resistance. However, it was found that, while an increase in fiber content provided increased smudge resistance, such increase decreased the sensitivity characteristics of the coating. Thus, as fiber content was increased to provide adequate smudge resistance, heretofore it was necessary to provide an increased amount or coat weight of marking fluid containing capsules, hereinafter referred to as active coating, in order to obtain or maintain the desired sensitivity.

As noted in the aforesaid Sandberg Patent No. 2,711,375, starch was employed as a binder material and the coating composition was air-dried at normal temperature or by a hot-air blast. With the advent of high speed coater equipment, it has been found that the above described prior art methods are not desirable for the high speed production of pressure sensitive paper because they produce a resultant paper product having inadequate sensitivity and/or smudge resistance. Originally, using the

prior art methods for producing pressure sensitive paper, it was determined that adequate sensitivity and adequate resistance to smudge could be obtained if the weight of active coating was maintained in the range of about 3.0 to 3.5 dry pounds (25 x 38—500). Following the advent of high speed coating equipment and prior to making of the present invention, attempts were made to obtain pressure sensitive paper having improved sensitivity and smudge resistance by re-formulation of the coating composition, primarily by a reduction in starch or binder content, with the active coating weight remaining in the above noted range. Of course, if the starch or binder content is reduced too much, the coating will not adhere to the paper web and will dust off.

Accordingly, a primary object of the present invention is to provide an improved process for producing a pressure sensitive paper product.

Another object is to provide such a process which includes control of the distribution and disposition of constituents of marking fluid containing microscopic capsule type coating compositions whereby a pressure sensitive product having requisite sensitivity and smudge resistance characteristics can be produced economically and at high speeds.

Still another object is to provide such a process which includes control of constituents and their distribution and disposition in marking fluid containing microscopic rupturable capsule type coating compositions whereby substantial economies in manufacture are effected through substantial reduction in active coating weight while maintaining desired sensitivity and smudge resistance characteristics of the product resulting from such process.

These and other objects will be apparent from the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a diagrammatic view illustrating one embodiment of the process used in practicing this invention;

FIGURE 2 is a graphic illustration of the comparative relationships between active coating weight and sensitivity in accordance with the invention and according to the prior art.

Generally, the present invention comprises applying a desired amount of fluid coating mixture containing a binder, rupturable microscopic capsules and coarse solid materials such as cellulose fibers to a web, distributing the coating, and subsequently drying the coated paper until the liquid parting of the coating composition is immobilized, said drying being in a manner such that the binder does not migrate and become concentrated at the exposed surface of the coating composition. It is, of course, for ecoonmic reasons, desirable to dry the coating as rapidly as possible. In accordance with the invention, this may be accomplished conveniently by using known heating and/or drying means. However, the successful production at high speeds of a pressure sensitive paper product coated with a coating composition containing rupturable marking fluid containing microscopic capsules and having the characteristics of adequate sensitivity as well as smudge resistance involves the control of the migration of the binder material so that the binder material does not move toward the exposed coated surface. This control is accomplished by evaporating the water within the body of the coating and away from the exposed surface thereof.

Unexpectedly, it has been found that when proper control is exercised through the use of the process in accordance with this invention, the active coating weight can be substantially reduced below prior requirements while still maintaining a desired level of sensitivity characteristic and that, contrary to known prior art, the fiber content of the coating composition can be increased to

provide additional smudge resistance without sacrificing the desired level of sensitivity.

Substantially no binder migration to the exposed coated surface is obtained by drying the coated base from the uncoated side with either (1) direct or (2) indirect driers, by (3) radiant energy driers from either or both sides of the coated base, by (4) dielectric heat energy (high frequency) driers or by (5) any combination of (1), (2), (3) and (4).

For purposes of explanation, direct drying is accomplished by convection heat transfer between the wet coating composition and a hot gas, the latter removing the vaporied liquid as well as supplying the heat needed for evaporation. Commonly used driers of this type use a warm or hot blast of air directed at or across the material being dried. In contrast, indirect drying is accomplished through transfer of heat by conduction to the wet coating. Drying drums or cylinders are widely used driers of this type.

The use of radiant energy driers, such as for example, infra-red driers, either alone or in combination with heated drum driers on the uncoated side are preferred for the method of this invention.

In FIGURE 1, there is illustrated an embodiment of the process utilized in practicing the present invention. A web of paper **10** is unwound from a supply roll **11** and passed over tension roll **12** and under tension roll **13** to an applicator roll **14**. A coating composition **15**, such as disclosed in above noted Patent No. 2,711,375, containing the rupturable microscopic capsules and cellulose fiber material, is picked up from supply pan **16** by applicator roll **14** which applies said coating, in excess of the amount finally desired, to the bottom side of the moving web of paper **10**. Coated paper **10** then passes under a guide bar **17** and over a reverse turning roll **18** which operates to remove gross surface tension patterns from the film of wet coating. The coated paper then passes around a backing roll **19** and is acted upon by an air knife means **20** which removes the excess coating which, in turn, collects in pan **21** from whence it can be recycled into supply pan **16**. After passing backing roll **19** and air knife **20**, the coated side of the paper web passes beneath the spread shaft **22** which smooths and uniformly distributes the wet coating over the surface of paper web **10**. The coated web then passes upwardly over guide roll **23**. After web **10** passes guide roll **23**, it is subjected to an initial drying action provided by heat supplied by a plurality of radiant energy heaters **25**.

Following the initial heating action provided by heaters **25**, paper web **10** passes to a second drying means comprising a plurality of heated dryer drums **26**, **26***a*, **26***b*, **26***c* and a plurality of non-heated dryer drums **27**, **27***a*, **27***c*, **27***b*. As is clearly shown in FIGURE 1, the coated side of the paper web **10** does not contact the heated drums **26**, **26***a*, **27***c* and coated side of the web does contact the non-heated drums **27**, **27***a*, **27***b*, **27***c*. Thus, the uncoated side of web **10** passes around heated drum **26** and the passes around non-heated drum **27** with the coated side of the paper in contact therewith. After leaving the last dryer roll, the paper web **10** passes upwardly and over a guide roll **30**, following which it may be wound on a take-up roll (not shown) or passes to any desired location for any additional manufacturing steps that may be desired.

In carrying out the process in accordance with the invention, a coating composition is first prepared. The coating composition consists basically of marking fluid containing capsules (active coating) such as that disclosed in above noted Patent No. 2,711,375, material including cellulose fibers to provide smudge resistance and binder material. In addition to the basic composition, minor proportions of other ingredients such as surfactant and/or pH modifiers may also be employed. In general, the active coating will constitute from about 65 to 75%, by weight, of the coating composition, the starch or binder content will be in the range of about 6 to 16½%, by weight, with the remainder being the material added to provide smudge resistance except for the minor ingredients. For example, a minor amount of a high-molecular weight non-ionic surfactant was employed in an amount not exceeding 2/10 of 1%, by weight, of the coating composition to wet out the ingredients utilized for the purpose of providing smudge resistance. An example of such a surfactant is sold under the trade name of Pluronic L–62 by the J. B. Ford division of Wyandotte Chemical Corp., Wyandotte, Mich. In addition, soda ash was employed as a pH modifier in minor amounts less than ½ of 1%, by weight. The coating composition has sufficient water added thereto so that it is applied to the paper web at about 18–22%, by weight, total solids and at a viscosity of about 20–40 cps. as measured by a Brookfield viscosimeter at 60 r.p.m. and at room temperature (75°).

The coating composition was applied to a paper web at an active coating weight of 3.35 pounds per 3300 square feet and the sensitivity of the resulting product compared when drying was accomplished by four different means. The results are set forth in the following table:

Drying method	Side dried	Sensitivity
Heat gun	Coated	51.9
Heat lamp	Uncoated	44.4
Do	Coated	45.7
Do	Both	45.7
Quartz lamp	Coated	45.7

The heat gun referred to in the above example is one known as Masters Heat Gun Model HGX301. The particular heat gun employed in the conduct of the above test produced at air temperature of 400° F. when the gun nozzle was held one inch from the coated side of the paper when drying by this method. Radiant energy drying achieved by means of a heat lamp refers to a 375 watt infra-red heat lamp held one inch from the coated side of the paper during the drying operation; and radiant energy drying achieved by means of a quartz lamp refers to 1000 watt-240 volt quartz lamp held two inches from the coated side of the paper during the drying operation.

As used herein, the term sensitivity refers to calender intensity after 30 seconds and is a contrast ratio method wherein the lower the numerical value, the greater the sensitivity. Sensitivity is determined by placing a coated paper to be tested in contact with a standardized transfer receiving paper and printing thereon by a calender machine. Sensitivity is determined by contrasting the reflectance of the printed and non-printed areas.

More specifically, a coated paper sample to be tested and a standard transfer receiving paper are superimposed with the coated side of each paper in contact with the coated side of the other paper. The superimposed papers are then run through a calender machine, the rolls of which are subjected to a known standard load. A Bausch & Lomb Opacimeter is employed to obtain at least three measurements of the percent reflectance of the printed and unprinted areas of the standard receiving paper 30 seconds after calendering and the results of such measurements are averaged. The calender intensity ratio in percent is then calculated according to the formula:

$$\text{Percent calender intensity} = \frac{\text{average printed area reflectance}}{\text{average non-printed area reflectance}} \times 100$$

Again referring to the table of results set forth above, it is apparent that in terms of sensitivity, the coated paper product that was dried by the heat lamp method had the best sensitivity characteristics, while that dried by the heat gun method had the poorest sensitivity characteristics. Those products that were dried by radiant energy means had substantially equal sensitivity charac-

teristics regardless of whether the drying was accomplished by means of an infra-red heat lamp or by means of a quartz lamp and, furthermore, regardless of whether drying was accomplished from the coated or uncoated or both sides of the coated paper product.

Using the same coating composition and coat weights as set forth in the preceding example, the coating composition was applied to a paper web and the resulting paper products dried by additional means in order to further evaluate the effect of the various drying methods on the sensitivity properties of the resultant paper product. The results obtained were as follows:

Drying method	Side dried	Calender sensitivity
Heat gun	Uncoated	47.9
Do	Coated	51.4
Steam drum	Uncoated	46.7
Steam drum plus cold air from heat gun applied to coated side.	do	51.6
Steam drum plus heated air from heat gun applied to coated side.	do	52.2
Steam drum	Coated	54.9
Steam drum plus cold air from heat gun applied to uncoated side.	do	52.3
Steam drum plus heated air from heat gun applied to uncoated side.	do	54.5

The above tabulation clearly demonstrates that the application of a hot surface (indirect drying means) and/or hot or cold moving air (direct drying means) to the coated side has a detrimental effect on the sensitivity properties of the coated paper product. Where steam drum was employed as a drying method in the above example, the drum was heated to a surface temperature of 225° F.

Additional comparisons were made on commercial coating and drying equipment, some of which included a drying tunnel in which air is applied to the coated side of the sheet as well as equipment where no drying tunnel was employed and wherein radiant energy drying means other than heat lamps or quartz lamps were employed. Such additional radiant energy drying means included the use of Red-Ray and Infra-Red equipment which are gas burners manufactured, respectively, by Red-Ray Manufacturing Co. and by Bryant Industrial Processing Corp.

From the results of the comparisons set forth in the two preceding examples, it was expected that sensitivity could be improved by reducing the air velocity and/or temperature in the drying tunnel since the tunnel applied the air from the coated side. This was confirmed and it was found that sensitivity was somewhat improved upon a reduction in air velocity and/or temperature in the tunnel. However, such improved sensitivity characteristics required that the coating equipment be operated at substantially reduced speeds. Also, coated paper produced on a coater employing radiant heating means with no drying tunnel, at similar coat weights, was substantially more sensitive than paper produced on equipment employing a drying tunnel with air directed at the coated side of the paper. It was also found that if paper coated with marking fluid containing capsules is dried essentially from the uncoated side, a very substantial reduction (about 20–35%) is effected in the active coat weight required to produce comparable sensitivity characteristics as compared to the coat weight required when drying is accomplished by prior art methods. As used herein, dried essentially from the the uncoated side means either blowing heated air against the uncoated side of the sheet or contacting the uncoated side of the sheet against a heated surface. For example, it has been found that emulsion coated paper dried essentially from the uncoated side with a weight of active coating (oil containing capsules) as low as 2.2 pounds per 3300 square feet will have a sensitivity equivalent to that obtained with the 3.0 to 3.5 pounds per 3300 square feet coat weight heretofore required. Additionally, it has been found that drying by radiant energy or high frequency dielectric means will also allow the application of such low coat weights without a sacrifice in the sensitivity of the coated paper. Furthermore, when radiant energy drying methods are employed, the radiant energy can be applied to either the coated or the uncoated side of the sheet. And, if either uncoated side drying or drying by radiant energy means are used alone or together, they produce a sheet having greater sensitivity, with comparable weight of active coating and coating composition, than a sheet dried by the heretofore conventional means of drying from the coated side, although with some loss in smudge resistance characteristics. Unexpectedly, it has been found that by increasing the content of the cellulose fibers in the coating formulation, this smudge resistance loss can be overcome without an accompanying decrease in sensitivity characteristics, and the resulting coating will maintain its superior sensitivity characteristics at a given coat weight. Equally important, the coating composition has been applied to a paper web and dried at speeds up to 800 feet per minute and there appears to be no limit to the speed at which the coating equipment can be operated due to the drying methods of the present invention.

While particular embodiments of the invention have been illustrated and described for the purpose of illustration only, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from the spirit of the invention, and it is to be understood that the present invention includes all such modifications and equivalents which fall within the scope of the invention which is defined by the appended claims.

What is claimed is:

1. In a process of manufacturing a pressure-sensitive manifold sheet comprising the steps of applying to a web of paper an aqueous coating composition containing rupturable marking fluid containing microscopic capsules and sufficient binder to secure said microscopic capsules to said paper web, and thereafter drying the coated paper, the improvement which comprises increasing the pressure sensitivity of said dried coated paper by heating said applied coating in a manner such that all portions of said coating except the exposed surface thereof are heated to evaporate the water content from said coating before any substantial portion of the liquid water reaches the exposed surface of said coating.

2. The process of claim 1 wherein said evaporation is effected by radiant energy driers.

3. The process of claim 1 wherein said evaporation is effected by dielectric heat driers.

4. The process of claim 1 wherein said evaporation is effected by direct driers on the uncoated side of said coated paper web.

5. The process of claim 1 wherein said coating composition additionally contains cellulose fibers to provide smudge resistance.

6. The process of claim 1 wherein said drying is effected by evaporating water within the body of said coating away from the exposed surface thereof until at least the binder of said coating is immobilized and then completing the drying of said coating by conventional means.

7. The process of claim 6 wherein said coating is applied to one side of said paper web and wherein the initial drying is effected by radiant energy applied to either side of said paper web and said drying is completed by heating means applied from the uncoated side of said paper web.

8. A pressure sensitive manifold sheet produced in accordance with the process of claim 1.

9. A pressure sensitive manifold sheet in accordance with claim 8 wherein the active coat weight of the dried coating is of the order of 2.2 pounds per 3300 square feet of dried sheet.

10. The pressure sensitive sheet in accordance with claim **16** wherein said dried coating contains about 16%, by weight, of cellulose fibers and the weight of said dried coating is of the order of 2.2 pounds per 3300 square feet.

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U.S. Cl. X.R.

117—36.2, 119.6, 156