Aug. 7, 1962 H. R. DALTON 3,048,515

PLURAL-PLY PAPER AND METHOD OF MANUFACTURE WITH ONE OR MORE CONDUCTIVE PLIES

Filed Jan. 11, 1960

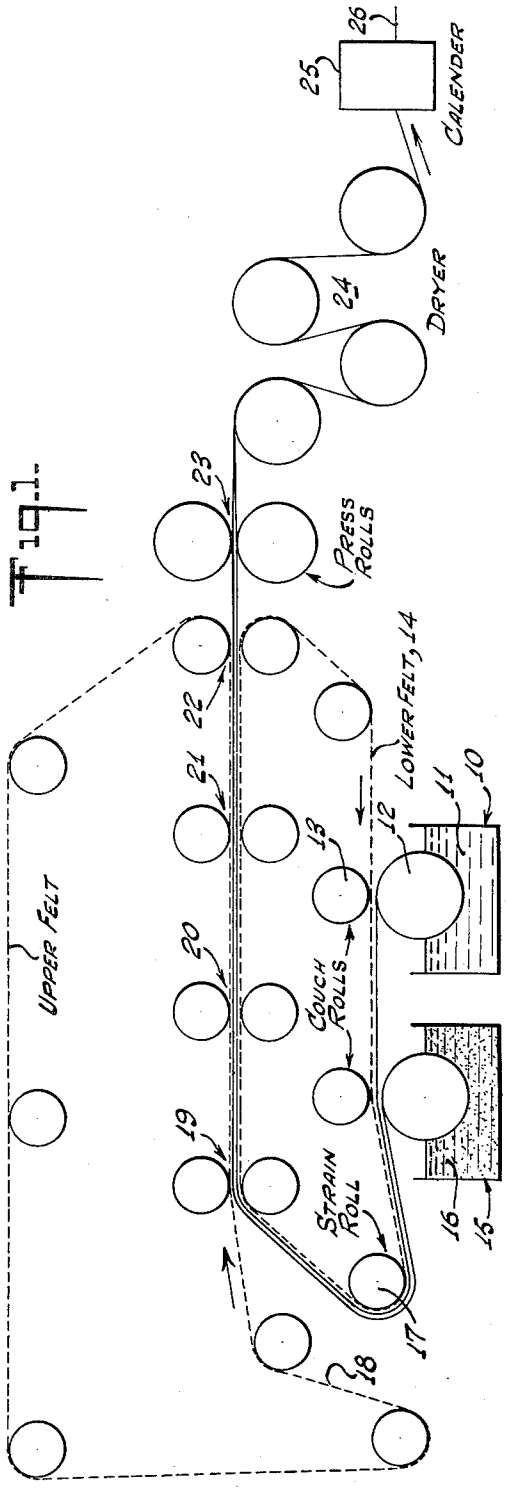


FIG. 1.

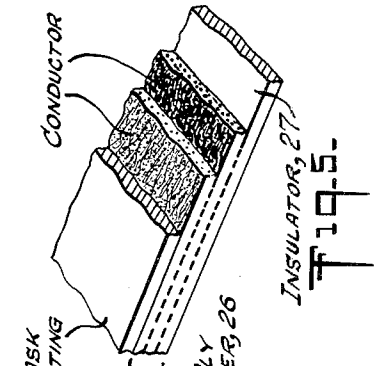


FIG. 5.

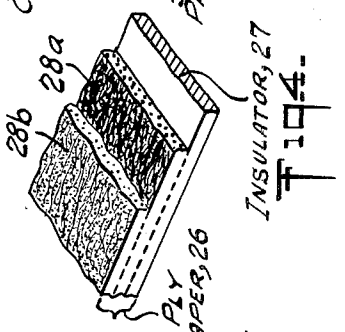


FIG. 4.

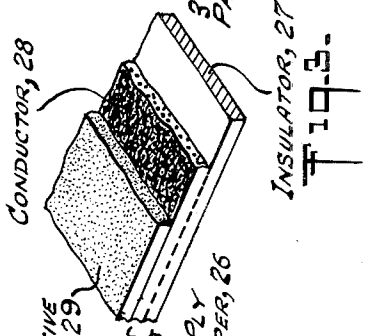


FIG. 3.

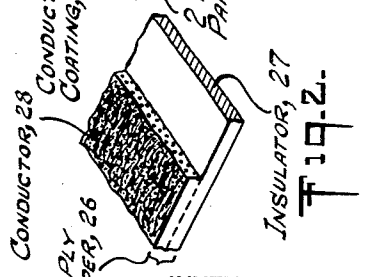


FIG. 2.

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United States Patent Office 3,048,515 Patented Aug. 7, 1962

3,048,515

PLURAL-PLY PAPER AND METHOD OF MANUFACTURE WITH ONE OR MORE CONDUCTIVE PLIES

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Filed Jan. 11, 1960, Ser. No. 1,681
14 Claims. (Cl. 162—126)

This invention relates to the art of paper making and more especially it relates to the making of paper sheets having differential electric conductivity through at least a part of the paper thickness.

A principal object of the invention relates to the making of paper wherein the back of the paper is white or light colored in itself, and the front side of the paper is dark or black, the portion of the paper adjacent the front side having precisely controlled electric conductivity.

Another object is to provide a method of making paper suitable for use in electric recorders, especially those of the electrically energized recording stylus kind, wherein the nonrecording surface of the sheet, ordinarily referred to as the back of the sheet, is of whitish hue and the front of the sheet has strata of precisely controlled electric conductivity.

A feature of the invention relates to a novel recording paper blank which has, in the fibrous body thereof, as distinguished from coatings on the paper, regions through its thickness of respectively controlled electric conductivity, whereby the paper has the normal appearance of a white backing and yet is capable of producing sharp electric recordings by visual contrast between the recorded areas and the non-recorded areas on the front of the sheet.

Another feature relates to a recording paper which has more accurately controlled electric conductivity characteristics while preserving the white back surface thereof.

Other features and advantages not specifically enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawings:

FIG. 1 is a schematic diagram of a system of apparatus for making one embodiment of the paper according to the invention;

FIG. 2 is a perspective view of a section of one of the papers according to the invention;

FIG. 3 is a modification of FIG. 2 having a separate conductive coating applied thereto;

FIG. 4 represents a modification of the paper of FIG. 2;

FIG. 5 shows the paper of FIG. 4 with a mask coating applied thereto.

In the electric recording art, numerous forms of recording papers have been proposed and used heretofore, including so-called electrosensitive papers. The present invention is in the nature of an improvement on the kind of paper disclosed in U.S. Patents No. 2,398,779 and No. 2,664,044. In general, such a paper consisted heretofore of a white or light-colored paper stock which, of course, in itself is a non-conductor. In order to achieve the required electrosensitive response for electro-recording, it has been the practice to apply one or more coatings of electrically conductive material to the normally white paper. The coating material that has been found satisfactory heretofore consisted in general of a mixture of powdered electrically conductive carbon with a suitable binder. Typical of such coatings are those referred to in said U.S. Patents No. 2,398,779 and 2,664,044. Such papers required, in addition to the paper making machines, special coating mixtures, and special coating machines to insure that the several coatings are applied in just the right

thickness, uniformity, and controlled electric conductivity. The manufacture of such papers, therefore, required extensive capital investment in the paper making machinery and the precision coating machinery. Furthermore, since the electrosensitiveness is dependent upon the coatings, there is always the possibility that the coating mechanism may become out of adjustment and may produce irregular or even minutely striated lines in the coating, which although not visible to the naked eye, may detract from the desirable surface uniform conductivity. Since such papers are usually recorded on by means of a recording stylus or by a point discharge recording electrode arrangement, the uniform electrosensitiveness of the coating must be the highest obtainable over the entire area of the blank. As disclosed in said patents, in order to render the recorded areas visible, it may be required that the paper be provided on its front face with an extremely thin masking coating of a white or light colored hue, which masking coating is physically removed by the recording currents. This removal at the recorded areas exposes the black or dark hue of the undercoating so as to produce the desired readable contrast between the recorded areas and the non-recorded areas. It is highly desirable, therefore, that during such recording only the said masking coating be removed. However, since the said masking coating is of extreme thinness and usually of such a thinness that it cannot be accurately measured by ordinary measuring instruments, and may be as thin as 0.0001 inch, there is always the likelihood that the recording current in removing the masking coating will eat into or remove some or all of the underlying conductive layer which had been applied as a separate coating as distinguished from the paper backing proper. Such a result is undesirable since any thinning or removal of the said underlying conductive black coating tends to degrade the recording by reducing the contrast at the recorded areas because the white hue of the back surface of the paper may be seen through such thinned out areas. Also it may change the otherwise uniform conductivity of the said conductive coating, which in effect changes the overall conductivity characteristics of the blank from those possessed in the absence of recording.

The present invention overcomes all the above noted objections, in that, instead of using a carbon-containing coating to impart the desired electric conductivity to the blank, the conductivity is imparted during one stage of the actual manufacture of the paper so that the conductivity does not depend upon conductive coatings, and yet the paper, considered as a whole, has its back surface of white hue and the remaining thickness of the paper adjacent the front surface is of black or dark hue. Such a paper, therefore, avoids the difficulty of the prior conductive coatings being accidentally removed by scratching or wear. The net result is that the finished paper has the normal white appearance on its back surface and it contains within itself adjacent the front surface, which is acted upon by a recording electrode, the desired conductivity. If desired, the black conductive surface of the paper proper can be provided with an additional coating of conductive carbon with a binder to form a coating which is of higher resistance than the black portion of the paper proper, thus imparting to the blank a graded or stepped conductivity through its thickness. Preferably, however, and in accordance with one aspect of the invention, the paper proper can be made so that in itself it has plies of different electric conductivity. Thus, the paper can be made in a plurality of separate passes. For example, the first pass which forms the first ply is made from white or bleached paper pulp; the second pass which forms the second ply is formed from paper pulp containing a precisely controlled amount of electrically conductive powder such

as powdered carbon or graphite; the third pass which forms the third ply is also formed from a paper pulp containing a precisely controlled amount of electrically conductive powder such as carbon or graphite, but with the amount of conductive powder in the third pass different from and preferably less than that in the second pass.

Referring to FIG. 1, there is shown one typical organization or system of apparatus for making the papers according to the invention. Since paper making machinery is well known in the art, only those parts of such machinery as are required to understand the invention are schematically shown in FIG. 1. For a more detailed description of such machinery, reference may be had to the book entitled "The Manufacture of Pulp and Paper," published by McGraw-Hill Book Company, 2nd edition, 1929, volume V, Section 1, Part 5, particularly at pages 251–282. Accordingly in FIG. 1, the numeral **10** represents the vat containing any well known pulp slurry **11**, the pulp having been beaten by any well known pulp beater mechanism. The slurry may be that used in any paper manufacturing process, such for example as ground wood pulp, sulfite pulp, soda pulp, etc., or a combination of such known pulps either bleached or unbleached. Preferably the pulp **11** is of a bleached or white hue although, if desired, any suitable coloring agent may be added to the pulp in the beater stage for example. In the well known manner the liquid or semi-liquid pulp slurry **11** is transferred by the mold roller **12** and couch roller **13**, on to the well known traveling lower felt **14**, which thereafter passes through another pulping unit **15** which may be similar to unit **10**. However, the pulp slurry **16** in unit **15**, in addition to having the usual paper pulp material, has mixed therewith in any suitable beater a precisely determined quantity of conductive powdered material such as carbon or graphite. The carbon serves the double purpose of imparting a dark or black hue to the slurry **16** and also imparting the desired electric conductivity thereto.

The conductive slurry **16** is applied over the previously formed white non-conductive pulp layer from slurry **11** with which it mates, but without materially affecting the previously formed white slurry layer on the felt **14**. These two mated layers, one of which is of whitish hue and the other black, are therefore electrically distinct but physically mated or unitized on the felt **14**. The mated layers, after leaving vat **15**, are carried by the lower felt **14** around the usual strain roll **17** and into contact with the endless upper felt **18**. The felts and the two mated paper pulps pass between a series of rolls **19**—**22** to abstract the liquid contents of the mated pulps. The mated pulps then emerge from the rolls **22** where they are separated from the felts, and they then proceed between the usual press rolls **23** to press the two-ply layers into a unitary sheet of the desired density. The two-ply sheet then passes around a series of dryer rolls **24** and thence, if desired, to any well known calendering unit **25**. The finished two-ply sheet of paper **26** emerges from the machine and is of the required thinness but with one side of the paper black and conductive, and the other side of the paper of white hue and non-conductive.

FIG. 2 shows in perspective view a section of the finished paper **26**. The two mated batches, derived respectively from the slurries **11** and **16** above described, constitute a single thickness two-ply sheet which may have a total thickness of any desired magnitude determined by the pulping consistencies and adjustments on the paper making machinery. One typical thickness for the paper **24** could be about 0.002 inch to about 0.005 inch, with a weight for example of 45 pounds (25 inches by 38 inches—500 sheets), in which case the thickness of the conductive portion, whether formed from a single pass or a multiple pass, may be for example slightly less than 0.005 inch to slightly more than 0.001 inch. In other words, the thickness of the conductive portion, whether of single or multiple pass formation, can be approximately 80 percent of the total thickness of the paper.

Merely for ease of explanation, the conductive ply and the non-conductive ply of the single thickness sheet are indicated in FIG. 2 by the separate designation numerals **27**, **28** with a dotted line therebetween. It will be understood, of course, that this dotted line is merely schematic and is not intended to indicate any physical division between the two parts of the sheet thickness except to indicate that one part (part **28**) is conductive and of black hue and the other part (part **27**) is non-conductive and of white hue. While the invention is not limited to any particular conductivity for the ply **28**, it has been found that when the paper is to be used in an electric recorder, such for example as a traveling pointed stylus recorder which is electrically energized by signals, of which U.S. Patent No. 2,860,180 is typical, the amount of carbon that is added to the slurry **16** may be such so that the ply **28** of the finished paper has a resistance of approximately 500 to 5000 ohms, as measured for example by means of a pair of electrodes as illustrated in FIG. 2 of U.S. Patent No. 2,664,044.

If it is desired to use the paper **26** to make so-called electrosensitive or facsimile recording blanks, the conductive ply **28**, as indicated in FIG. 3, may have applied thereto as by painting, spraying, knifing, etc., a coating **29** containing a powdered conductive carbon in a suitable binder. Examples of such conductive coating materials are given in said U.S. patents. Preferably the coating **29** should have a higher resistance than the conductive ply **28** so as to control the sharpness of recording.

Preferably, however, instead of using a coating to impart the desired differential or graded conductivity to the recording blank, the original paper making machinery, as disclosed for example in FIG. 1, can be arranged to make the paper itself of three plies rather than of two plies. In other words, in addition to using the two vats such as vats **10** and **15**, a third similar vat may succeed the vat **15**, and this third vat may contain a smaller amount of powdered carbon than that in vat **15**. Thus, the finished three-ply paper as shown in FIG. 4, has a white back **27** which is an insulator; a low resistance black ply **28***a*; and another higher resistance black ply **28***b*. Merely by way of example, if the amount of carbon added to the second vat **15** is such as to give the ply **28***a* a resistance of 500 to 5000 ohms, the amount of carbon that is added to the third vat to form ply **28***b* may be lower in amount so that the ply **28***b* has a high resistance. Thus, when the three-ply paper is measured for resistance at its surface, as explained in U.S. Patent No. 2,664,044, it may have a surface resistance of 1000 to 8000 ohms. It will be understood, of course, that the above figures as to resistance are merely typical and in no way limit the invention so far as the production of the differential or stepped conductivity is concerned.

The finished paper, whether of two-ply (FIG. 2), two-ply plus conductive coating (FIG. 3) or three-ply (FIG. 4), is therefore capable of being used in any electric recording equipment to produce a record by passing an electric current or discharge through the paper **26** at localized areas where the recording is to be effected. Preferably when the paper is to be used as a recording blank for facsimile or other similar electrosensitive or electro-inscribing recorders, the paper is used so that the black or dark colored conductive surface faces the recording stylus or similar inscribing electrode. Thus the ply **28***b* (FIG. 4) or the coating **29** (FIG. 3) of the higher resistance is closer to the said recording electrode than is the ply **28***a* (FIG. 4) or the corresponding ply **28** of FIG. 3. In other words, the low resistance ply **28***a* (FIG. 4) or the low resistance ply **28** (FIG. 3) acts as a common ground return for the recording currents acting on the blank.

In order to produce a desired visual contrast at the

recording areas any of the above noted papers can have its black surface provided with an extremely thin masking coating **30** (see FIG. 5) of any white or light hued pigmented material such for example as described in U.S. Patent No. 2,398,779 or No. 2,664,044. In any event the thinness of the masking layer **30** should not substantially exceed that necessary merely to mask the black hue of the conductive portion **26** of the duplex paper. Ordinarily such masking coatings are so thin that they cannot be accurately measured with ordinary thickness measuring equipment, the main requirement being that they produce a light hued surface of minimum thickness so that when the blank is acted upon by electric currents from a pointed recording stylus or electrode, the masking coating **30** is removed at the recording areas to reveal the black or dark hue of the underlying duplex paper.

One of the advantages of the duplex paper above described over the use of coated papers such as disclosed in U.S. Patent No. 2,664,044 results from the fact that more contrasting and sharper recorded copies can be obtained. Furthermore, the paper will respond to a greater range of recording currents. Both these advantages result from the fact that the fibrous conductive ply **28** or layers **28***a*, **28***b* are not destroyed as easily by the recording current used to remove the masking coating **30**. Thus the resistance of high conductive ply **28***a* remains constant. Furthermore, the contrast between the coating **30** and the non-recorded areas of the blank **27** is not reduced since the black low conductivity ply **26** is not burned up or destroyed or thinned sufficiently to reveal the white ply **27**. In the case of coated white papers, there is always the possibility that the recording currents will remove or thin the conductive coating sufficiently to enable the white hue of the paper to show through the recorded areas.

Various changes and modifications may be made in the disclosed embodiments without departing from the spirit and scope of the invention. For example, while FIG. 1 shows a typical paper making machine of the successive cylindrical type for forming the successive batches on the felt, it will be understood that the combination of a Fourdrinier unit may be used in combination with a succeeding cylinder unit so that one pass, for example the white pass, may be formed on a Fourdrinier wire and the succeeding pass or passes may be formed on cylinder paper forming units of known construction. By the expression "intimately mated plies," as used herein, is meant that the plies in the finished paper are intimately bonded throughout their entire contacting areas to form in effect a unitized single thickness sheet wherein the unitization of the plies is effected by mating them when they are in at least a semi-liquid form and then dried to form the single sheet as distinguished from separate sheets which are bonded by an intervening adhesive.

What is claimed is:

1. The method of making a duplex paper of precisely controlled transverse conductivity having superposed plies one of which is of non-conductive fibrous composition and the other of which is conductive fibrous composition, which comprises preparing two paper pulp slurries in at least semi-liquid form one of which includes a predetermined quantity of powdered electrically conductive material to impart a precisely controlled electric conductivity, forming the slurries while in said semi-liquid form into superposed mated passes, and drying the mated passes to form a single plural-ply paper sheet having one of its plies non-conductive and whitish hue on its exposed face and another ply of accurately controlled electric conductivity and of a hue contrasting with that of said exposed face, both said plies being intimately mated to form a unitized single sheet.

2. The method according to claim 1 in which the two plies are formed in successive passes, the first pass being formed from a bleached pulp first slurry and the second pass being formed from a pulped second slurry which includes powdered conductive carbon to render the second pass of blackish hue whereby the finished paper has the said non-conductive portion of whitish hue on its exposed face and the remaining conductive portion is of blackish hue.

3. The method according to claim 2 in which the first slurry has a coloring ingredient added thereto to produce a color for the first mentioned ply which is substantially contrasting in hue with said black conductive ply.

4. The method of making an electrosensitive recording blank which comprises preparing at least two paper pulp slurries, at least one of which includes powdered electrically conductive material to render it electrically conductive and of contrasting color with the next adjacent slurry, forming said slurries into a two-ply paper with one side of whitish hue and insulating and the other side electrically conducting and of contrasting color with the whitish side, the two plies being intimately and uniformly mated over their entire contacting areas but free from any intervening adhesive.

5. The method according to claim 4 in which the said conductive ply has applied thereto as a separate coating a conductive powdered material with a binder, to impart to said coating a lower conductivity than that of said conductive ply.

6. The method according to claim 4 in which a third pulp slurry is prepared, said third pulp slurry also including powdered electrically conducting material to form a three-ply paper wherein one of the plies constituting the back of the paper is of whitish hue and insulating and the remaining two plies are of respectively different electric conductivity.

7. A paper specially designed for recording in response to electric currents acting on the surface thereof in localized areas, comprising at least two fibrous paper plies one of which is of whitish hue and forms the back of the paper and the other of which is of blackish hue and is electrically conductive, and an electrically conductive coating on the said conductive ply, both said plies being intimately mated over their entire contacting surface without any intervening adhesive.

8. A paper according to claim 7 in which said coating is of higher resistance than the resistance of the said conductive ply.

9. An electro-inscribable recording blank, comprising a plural-ply single paper sheet formed of two intimately mated and bonded paper plies free from intervening adhesive and constituting a single-thickness sheet, said blank having its back surface formed of one ply which is of whitish hue and non-conducting, while its front surface is formed of another ply which is conductive, and a masking coating applied to the surface of said conductive ply and contrasting in hue therewith.

10. A plural ply paper comprised of at least two plies which constitute a single thickness fibrous sheet, wherein one ply contains electrically conductive carbon and another ply is substantially non-conductive and of contrasting color with respect to the carbon-containing ply, the two plies being intimately mated and bonded to form said single thickness sheet without any intervening adhesive.

11. A paper specially designed for recording in response to electric currents acting thereon at localized areas, comprised of successive plies of dried fibrous paper pulp and constituting a single-thickness sheet, one ply constituting the back of the paper and being non-conductive, another ply intimately mated and bonded to the non-conductive ply without any intervening adhesive, said other ply containing a predetermined amount of conductive powdered carbon to render it conductive.

12. A paper according to claim 11 in which the said one ply is constituted of bleached paper pulp to impart a whitish hue to the paper back, while the other ply constitutes the front of the paper and is of blackish hue by reason of said carbon.

13. A paper specially designed for recording in response to electric currents acting thereon at localized areas, comprised of successive plies of dried fibrous paper pulp constituting a single-thickness sheet, one ply constituting the back of the paper and being non-conductive, and at least two additional plies, all said plies being intimately mated and bonded to constitute said single-thickness sheet without any intervening adhesive, each of said additional plies having therein predetermined amounts of conductive carbon to render said additional plies of respectively different conductivities.

14. A paper according to claim 13 in which the conductive ply adjacent the non-conductive ply is of greater conductivity than the next adjacent conductive ply.

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