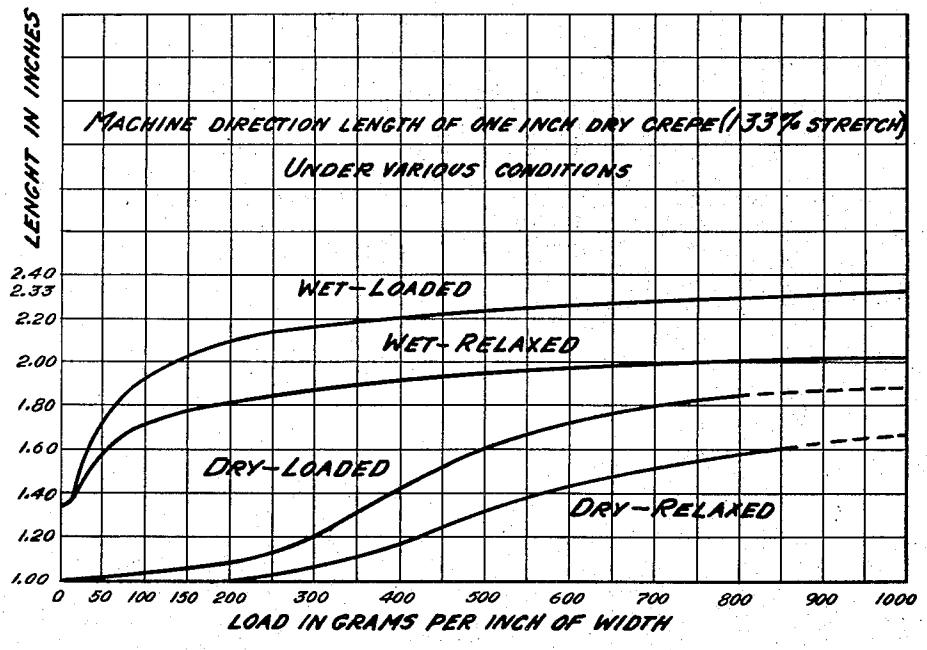
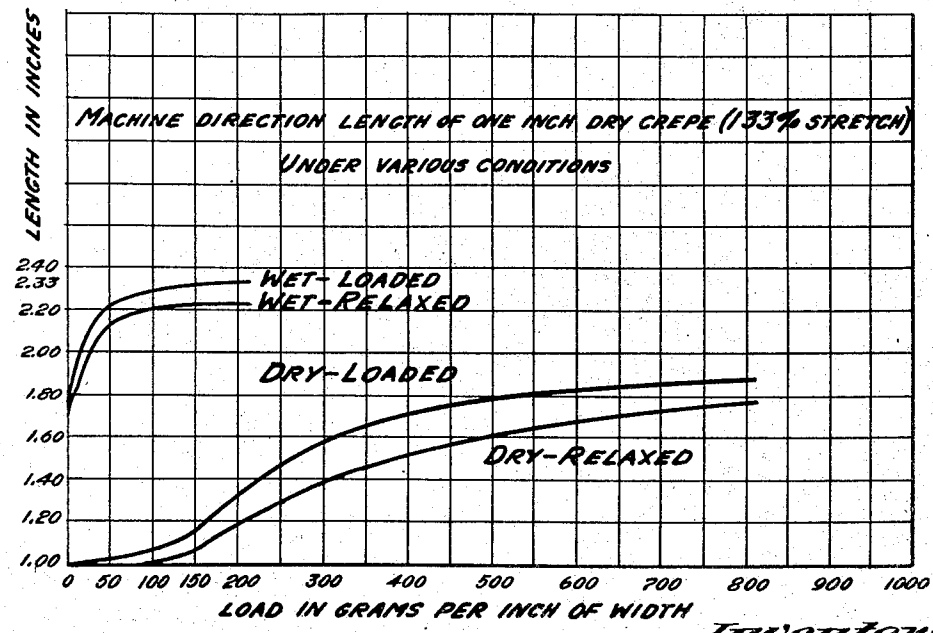
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CREPED PAPER AND METHOD OF MAKING

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CREPED PAPER AND METHOD OF MAKING

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This invention relates to a method of creping paper and to the resulting creped paper product.

In the art of making crepe paper it is a well known and accepted characteristic property of the product that upon becoming wet with water it loses its crepe structure—and especially so if it is also stretched while wet. For most of the purposes for which crepe paper is made, it consequently loses its suitability.

A crumpled paper, sometimes called crepe paper, such as paper towels, has been made in the course of paper manufacture by creping the freshly formed sheet before it has been fully dried and while it is in the form of a wet or but partially de-watered pulp. The creping knife forces such a sheet back upon itself and crumples and compacts the sheet. The resulting sheet becomes thicker and more bulky, and may also be pulled out to a slightly greater length, upon subjecting it to tension.

Such papers, however, being formed from thoroughly saturated and water-swollen pulps from the beater are more hydrated and more plastic than pre-formed paper sheets, upon wetting—they possess low adhesion to the creping roll and consequently come from the creping roll in the form of a coarse and non-uniform crepe structure. Moreover, such processes are usually run for economical reasons at a faster rate (e. g., that of paper formation) than is practiced for the production of a high crepe ratio. The resulting sheet of paper produced in this way is therefore of a coarse and non-uniform creped texture, low crepe ratio, and of little elasticity or resiliency.

In contradistinction to the foregoing type of paper which is crumpled in the process of manufacture, the present invention relates to crepe papers which are made from a completely preformed paper sheet, with or without sizing, calendering, or the like, which is relatively smooth and flat. Such a sheet is moistened and applied to a smooth surface, such as a creping roll, to which it is made to adhere with an adhesive or film-forming agent, and from which it is then creped by forcing it into sharply folded ridges, as it is separated from the creping surface. Crepe papers formed in this way are characteristically composed of paper with parallel sides to which is imparted a sharply folded or plaited structure, each plait being separate from adjacent plaits except for its continuity of union along the lines of fold.

Such papers are characterized in general by possessing a high crepe ratio, which is the ratio

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of the original length of the paper sheet to the apparent length of the sheet after the crepe structure has been imparted to it. They are further characterized in that the actual thickness of the paper sheet is of substantial uniformity throughout—both throughout the plaits and throughout the lines of fold. Of course the outer surfaces of the folds are stretched and the inner surfaces of the fold lines are wrinkled. It is a further comparison of these properties that the plaits are comparatively uniform.

In these respects crepe paper made from preformed paper sheets differ distinctly from sheets of pulp which are crumpled in the formation of the sheet while in the course of manufacture. Such crumpling of the paper pulp forces the softened fibers of the sheet upon themselves, into thicker masses in the lines along which the paper yields to the crumpling force, before it is forced away from the creping surface. In this way the resulting sheet is made thicker in such crumpled areas or lines.

In accordance with the present invention, it is found that a pre-formed sheet of paper, preferably smooth-surfaced, as by machine glazing, may be creped and not only be given substantially any crepe ratio desired, but also such resiliency that it will retain that crepe ratio or a considerable proportion of it after stretching, and not only while dry but also while wet with water. That is, the crepe paper will yield to stretching out to a length substantially equal to its length before creping, and whether such stretching is done while the paper is dry or while the paper is completely wetted with water, it will return considerably toward its creped length upon releasing the stretching tension.

The paper, therefore, exhibits an enhanced dry resiliency and what constitutes practically a new characteristic for crepe papers and especially for crepe papers of high crepe ratio—a wet resiliency or elasticity.

A further characteristic is likewise discovered in papers treated in accordance with the invention, which is manifested by a marked increased resistance to the initial extension or expansion of the creped paper. Moreover, its stability is also manifested by a resistance to stretching of such papers, especially when stretched into the range which approaches complete extension, whether they be wet or dry, and a proportionate tendency to return to their original creped dimensions and shape.

Many procedures and many compositions have

heretofore been proposed for application to paper in order to increase its strength and to increase its resistance to water, and also to increase both properties so that it should be strong when wet. It has also been proposed to treat fabrics so that they should be resistant to the formation of creases.

In the present case, however, it is desired to impart a crepe or sharply folded structure to the paper sheet. It is not an object to render a flat sheet stiff and resistant to deformation or to elongation. On the contrary, it is desirable that the sheet be creped and that the creped sheet may be readily folded or crumpled, or that it may be stretched out to the full original length of the sheet of paper from which it was made. But it is an object that when thus stretched out—whether the sheet be dry or wet—it will spontaneously resume approximately or as nearly as possible its original creped dimensions, as soon as the stretching force is removed.

It is an object and an accomplishment of the present invention to produce crepe paper of the type having a high crepe ratio (e. g., above 1½:1) which strongly tends to retain its creped conformation even when wet, which will readily permit stretching from this conformation, substantially to the original dimensions of the uncreped sheet, but which will retract the folds, considerably towards their originally creped conformation, spontaneously upon release of such stretching, so that the sheet will preserve considerable crepe ratio. It is also an object and accomplishment of the invention that the treated creped sheet shall be protected against the softening effects of water, so that it shall manifest such elasticity or resiliency of the creped structure, even while it is immersed in or wet by water.

In accordance with this invention, the crepe paper is preferably given a high crepe ratio and, either during the creping operation or in an after treatment of the preliminary creped sheet, the whole sheet is treated with a composition which is capable of causing the creping to be stable against relaxation with water, to resist distortion in response to stretching forces, and to resume its former shape and disposition after the distorting or stretching forces are removed.

The compositions with which the invention may be carried into actual practice are limited, but comprise in general resin-forming materials which are capable of wetting paper fibers and adhering firmly thereto or reacting with the fiber and which preferably are capable of polymerization, which cause the paper to have a sharp, elastic resistance or resiliency with respect to even slight distortion of shape, as well as throughout the complete opening out of the folds of the crepe, and which preferably, though not necessarily, are both water resistant, per se, and are capable of forming resins-cellulose compositions whose sensitivity to water is considerably reduced.

Such resins include the urea formaldehyde resins, melamine resins, and phenol formaldehyde resins.

The preferred composition, which has been found especially useful for such application to crepe paper, is of the urea formaldehyde type resin, such as dimethylol urea, and accordingly a typical and representative example of the practical utilization of the invention will be described with reference to this compound.

For example: 6 grams of dimethylol urea is mixed with 0.18 gram aluminum sulphate and the whole made up to a total of 100 cc. with water.

In one form of procedure for carrying out the invention, a sheet of water-leaf or previously sized or machine glazed paper (or one treated with a film-forming agent as hereinafter set forth and described) may be wetted as by passing through a creping bath containing dimethylol urea, and thence upon a creping roll. The creping roll may be heated, in accordance with usual practice, but not sufficiently to develop or cure the resin appreciably while thereon. The wet, adherent sheet is then creped off from the creping roll, by contact with a doctor blade, thus acquiring the "creped structure" characteristic of creped paper. It may be made of whatever crepe ratio is desired, inter alia, by regulating the relative rates at which the paper is applied to and withdrawn from the creping roll, its adhesiveness to the creping roll, stiffness, sizing and other characteristics of the paper, the character and set of the doctor blade to the creping roll, etc. The sheet is then dried and heated to a sufficient degree (without injury to the paper) and for a sufficient time to polymerize the resin to a practically complete stage of cure.

By such procedure, which is representative of the general procedure of this invention, a sheet of creped paper is obtained which exhibits a marked increase in elasticity or resiliency upon being subjected to stretching forces. Not only does it require a greater force or load to stretch it out to various degrees, including the ultimate, original uncreped length of the paper sheet, but upon release from the stretching force or load, it will return considerably towards its unstretched shape and dimensions.

This elasticity or resiliency is attributed to the elasticity or resiliency which is developed by the curing of the resinous material incorporated in the sheet, where it imparts to the fold of the creped paper a spring-hinge effect, permitting complete unfolding of the crepe structure, but resisting it continuously and until the creped paper is completely extended to its original, uncreped length. Since the resin-paper composition is strong and also elastic and resilient within this range of distortion (which may be further promoted or assisted by the incorporation of plasticizers)—after such extension, the spring-hinges which they form in the crepe folds retract, when released from the stretching force, and draw the creped paper back into its original creped conformation.

A further feature of the product is that the resinous compounds are also characteristically inert to water. Consequently, if the paper is impregnated with large amounts of resin, the crepe paper so treated will be water-resistant also. Such paper will have substantially complete resistance to water, but its properties will become less like paper and more like the resin, particularly with respect to stiffness and brittleness. It is, therefore, usually preferable to use a less complete impregnation of the paper with the resin. In this case, water may permeate the treated and creped sheet and tend to soften and relax the fibers and cause expansion of the crepe. But this tendency is limited, and it may be offset by imparting a higher crepe ratio to the treated sheet than is required, and thereafter moistening the creped sheet. Thereupon the moistened sheet will expand slightly, with corresponding loss of a portion of the high crepe ratio—but the remaining crepe ratio of the sheet

will be permanently preserved or stabilized as against further loss of crepe by subsequent wetting.

As indicated above, the creping bath may have an adhesive or film-forming agent added thereto, such as (3%) hydroxy ethyl Cellosolve, polyvinyl alcohol, or animal glue. These promote adhesion of the sheet to the creping roll, resisting its removal from the roll by the doctor blade and thus permitting high crepe ratios to be formed. Their use also increases the degree of wet strength obtained by the resin.

A catalyst for controlling or promoting the subsequent polymerization of the resin, such as paper-makers' alum, may also be added to the creping bath, in suitable quantities.

An alternative procedure for carrying out the invention consists in the preliminary creping of the pre-formed paper sheet (which may be a water-leaf sheet, but is preferably sized and machine glazed, etc., as above noted) in the usual way, followed by treating the creped sheet with a fine dispersion or solution of the resin, such as dimethylol urea. For example, the creped sheet may be immersed in a suspension or solution (preferably of low water content or non-aqueous) of such polymerizable resin reagents.

A solution suitable for this treatment, in which the water content is preferably low, may be prepared as follows:

Dimethylol urea	grams	6.25
Aluminum sulphate	do	0.1875
Water	cc	25
Methyl Cellosolve (monomethyl ether of ethylene glycol)		75

Or a wholly non-aqueous solution of the resin might advantageously be employed, to avoid softening and consequent loss of crepe ratio—especially until the resinous component becomes effective to impart water resistance and wet-resiliency to the sheet. The sheet is then dried and cured at room temperature, or it may be subjected to elevated temperatures. This causes the resinous solution to set and the sheet to acquire its elastic, form-restoring characteristics.

If the resin is so applied (either from the creping bath or in the immersion procedure) and is inert to water, the resulting sheet will be substantially unaffected by wetting; and upon immersing the sheet in water it will manifest the very unusual property of being stretchable under water and of elastic return considerably toward its previous shape and dimensions upon release.

In view of the tendency for the polymerized resin to produce stiffening and embrittlement, it is advantageous to soften the resin-paper composition by the addition of a small amount of plasticizer or softening agent, such as glycol, sugar, urea, or glycerine, etc., to the finished sheet.

When a sufficiently high concentration of resin is used, a paper can be produced which will not expand at all when wet with water. Such a sheet, however, is too brittle for most practical uses. To get a crepe which is flexible, less than this maximum amount of resin must be used. Crepes containing less than the maximum amount of resin expand somewhat when wet with water. In practice, this initial expansion can be compensated for by making the initial crepe in a higher ratio than the finished product requires. After the resin has been cured, the sheet is wetted with water, the initial expansion allowed to take place, whereby the crepe is reduced to the ratio desired in the final product and dried. This crepe is now fully stabilized; that is, a further wetting with water does not produce a dimensional change.

If, in such process of taking up the initial expansion the crepe should be stretched considerably beyond the limits of the initial expansion, and then dried, this crepe will actually contract when further wetter with water.

Furthermore, one may replace the water used in the second operation with a solution containing paper softening agents. Amounts of resin may then be used in the creping solution in excess of that normally used to avoid brittleness because the softener reduces brittleness. This results in a net gain of greater wet resilience. Example of a softening solution which might be used in this treatment is as follows:

Glycerine	grams	15
Total with water	cc	100

Instead of or in addition to the softening solution used in the second operation, it may be desirable to use materials for the purpose of imparting other specific characteristics to the finished crepe. For example, water repellency may be attained by including Aridex WP of Du Pont or other water-proofing solutions. On the other hand, an absorbent sheet may be produced by including re-wetting agents such as Aerosol OT of American Cyanamid. Examples of such modifications follow:

1. Water-repellent finish:

Glycerine	grams	20
Aridex WP	cc	20
Total with water	cc	100

2. Absorbent finish:

Glycerine	grams	15
Aerosol OT 10%	cc	0.5
Total with water	cc	100

The resulting properties developed in crepe paper treated in accordance with the present invention are graphically represented in the accompanying charts, in which:

Chart I, the upper chart for treated crepe, plots the amount of stretch in inches of 1'' strips of crepe paper treated or made in accordance with the invention, 1'' wide, against a load in grams in respect of (*a*) a strip loaded while dry, and (*b*) a dry strip, loaded and relaxed, and of (*c*) a strip wetted, then loaded while wet, and (*d*) a strip, loaded while wet and relaxed from such load.

Chart II, the lower chart, for untreated crepe, plots the amount of stretch in inches of 1'' strips of regular crepe paper, made in accordance with procedures of the prior art, 1'' wide, against a load in grams, in respect of (*a*) a strip loaded while dry, and (*b*) relaxed, and of (*c*) a strip wetted, then loaded while wet, and (*d*) relaxed from such load.

It should be noted that the present disclosure is for the purpose of illustration only, and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

Another demonstration of the unique properties of paper creped in accordance with the present invention may be made by drawing a sheet of the creped paper taut (but not taut enough to flatten all the creping) and, while fixedly held in this taut condition, submitting it to high relative humidities of the surrounding

atmosphere. Under these conditions the paper remains taut, instead of softening and relaxing.

We claim:

1. The method of making crepe paper which comprises impregnating a sheet of paper with an aqueous solution of a polymerizable synthetic resin selected from the group consisting of aldehyde condensation products of urea, phenol and melamine, said resin capable of wetting paper fibres, of adhering firmly thereto, and of imparting to the paper a sharp elasticity with respect to even slight distortion of shape as well as throughout the complete opening out of the folds of the crepe, creping to produce a high ratio crepe above 1½:1 and heating the paper to polymerize the resin, the amount of the resin in the paper being sufficient to impart elastic return thereto when both wet and dry but insufficient to produce brittleness and stiffness whereby the flexible crepe paper may be stretched when both wet and dry and will return considerably to its original crepe length upon release of such stretching tension.

2. The method according to claim 1 wherein the resin is dimethylol urea.

3. The method according to claim 1 wherein the paper is creped in the presence of a creping adhesive.

4. The method according to claim 1 wherein a creping adhesive is included in the impregnating solution.

5. The method according to claim 1 wherein after the resin is polymerized, the sheet is remoistened with water and dried whereby the crepe sheet is stabilized against subsequent wetting with water.

6. The method according to claim 1 wherein the sheet is creped to a ratio higher than that desired in the finished sheet, and after polymerization of the resin, remoistening the sheet with water to cause initial expansion of the sheet to the desired crepe ratio and drying the sheet.

7. Flexible crepe paper prepared by the method of claim 1 having a high crepe ratio above 1½:1, characterized by having the polymerized resin distributed throughout the crepe paper structure, and further characterized by yielding to stretching when both wet and dry and of returning considerably toward its crepe length upon releasing such stretching tension.

8. The method according to claim 1 wherein the resin solution contains about six percent of the resin by weight.

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