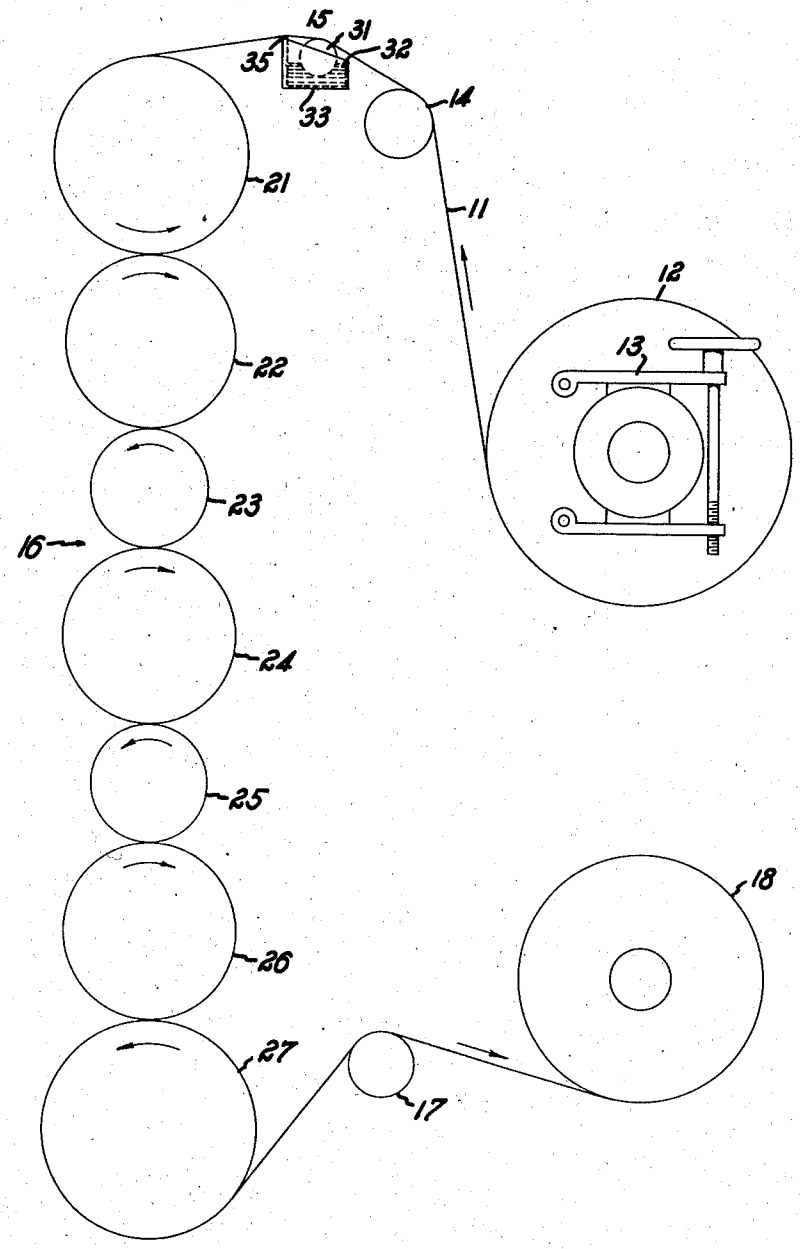
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PROCESS FOR FINISHING PAPER AND PRODUCT

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PROCESS FOR FINISHING PAPER AND PRODUCT

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This invention relates to a process of finishing paper, both coated and uncoated, in a supercalender, and aims to greatly enhance the surface density, smoothness, and gloss of the paper, and to reduce its permeability to varnish and printing ink without at the same time seriously reducing its bulk, opacity, and brightness. The process is characterized by plasticizing one surface of a paper web by the application of a relatively large amount of water, limiting the depth of plasticization to the surface only, and smoothing the plasticized surface by pressing the plasticized surface against hard surfaced supercalender rolls before harmful subsurface penetration can occur, all as hereinafter more fully set forth. Although supercalenders are sometimes composed of all metal rolls the term "supercalender" as used in the present specification and claims is to be understood to mean a calender in which the paper is pressed against hard surfaced or metallic rolls by means of relatively soft, yielding, non-metallic or compressed fibre rolls which are commonly arranged alternately in the stack and the term "calender" is used generically to designate a supercalender or a calender composed solely of hard surfaced metallic rolls.

One type of paper which may be produced by my process is the varnishing grade uncoated paper which is described in my copending application Serial No. 44,266, filed October 9, 1935, now Patent No. 2,088,893. In addition, the process may be advantageously applied to the production of many other grades of uncoated and coated papers in a simple, inexpensive manner, said papers having a combination of properties hitherto unattained in the art.

It is well recognized that paper with a very low moisture content is elastic and resilient and tends to return to its former condition when released from pressure in the calenders, and that paper which has a high moisture content is soft and plastic and tends to retain any form into which it may be pressed, and the higher the moisture content the more marked is this tendency. Thus if paper is dry when calendered the smoothing effect of the calenders is comparatively small, whereas if paper is too moist when calendered it becomes crushed, transparentized, and blackened, while being smoothed on the surface, due to a permanent closing of the interstices between the fibres, particles of coating, filler, etc. The limits within which the moisture content of paper might vary, that it might be satisfactorily smoothed and not crushed or blackened in supercalendering, as heretofore practiced, are quite narrow. The maximum tolerance of moisture content for proper finishing has been only a few percent. This is not only true of uncoated papers, but also of papers coated with mineral pigment and adhesive. It is particularly true of coatings where casein is used as the adhesive.

Broadly stated, my process consists in first temporarily softening or placticizing the surface to be finished, which is secured by a liberal moistening of this surface, while leaving the body of the paper and the other surface dry and resilient. Before the moisture has had time to penetrate into the body of the paper, the paper web is passed into a supercalender where the plasticized surface is pressed into intimate contact with hard surfaced metallic rolls by the soft surfaced non-metallic rolls which contact the dry surface of the paper web. This causes the surface to be smoothed and glazed while the body of the paper, being still dry, is not crushed, blackened, or transparentized to any greater degree than is usual in a supercalender. The heat generated in the supercalender aids in drying and rehardening of the surface of the paper before it leaves the supercalender.

The plastic condition of the surface mentioned in these specifications and claims is a condition of the surface such that applied pressure will cause it to take on permanently the approximate form into which it has been pressed. It is a condition which, if it extended throughout even a major portion of the thickness of the paper, would render even the lightest supercalendering impossible on most papers due to crushing and "cutting" of the web.

To secure the quick plasticization of the surface, I prefer to use an amount of water which would heretofore have been considered excessive and unsafe to use on a supercalender. The time from the application of the water until the application of pressure to the paper in the supercalender must never be sufficient to permit the water to soak into the paper so that crushing and consequent transparentizing or blackening of the body of the web would occur in the supercalender. Such penetration would not only soften the body of the paper so that it would be crushed and transparentized to an objectionable degree, but unless a very large amount of water remained on the sheet would also decrease the wetness and plasticity of the surface so that it would not be smoothed and compacted sufficiently to give it the desired finish.

The kind of pressure is also fundamental; it

must be between hard and soft surfaces, such as the metallic and non-metallic rolls of a supercalender, if the desired result is to be obtained. The term hard rolls as used in the specification and claims refers to rolls having smooth, relatively hard, unyielding surfaces, such as the chill-cast iron rolls used in supercalenders. The term soft rolls refers to rolls whose surfaces are sufficiently yielding to press the entire surface of a paper web against a hard roll with substantially uniform pressure, in spite of the small local variations in thickness and hardness commonly found in paper webs. The term includes the rolls made of compressed fiber (usually cotton or paper) such as commonly used in supercalenders, and equivalents for them.

The paper to be treated must be selected from a stock which will resist wetting of at least a major portion of its internal fibers long enough for the process to be preformed. For example, a stock of the nature of blotting paper would not be suitable for treatment by this process. On the other hand, the stock selected must not be so water-resistant that its surface will not be wetted and softened or plasticized to some extent in a short time when water is applied thereto. The process can, however, be advantageously applied to most grades of coated and uncoated printing papers, as well as other papers having similar properties in regard to the action of moisture and calender pressure thereon. It has been found particularly valuable as applied to coated and uncoated book and label papers, and to papers such as used for coffee bags, etc.

Due to the nature of the process as described only one surface is treated at a time. If only one surface is to be treated, the process described can be advantageously followed by a process for controlling curl such as that described in my Patent No. 2,088,893, dated August 3, 1937. Otherwise the curl will be controlled by the application of my finishing process to opposite sides in succession.

I am aware of the prior use of water or steam on webs of paper in the all metal roll "machine calenders" on paper machines, and of the use of steam on paper entering supercalenders. My results have not previously been obtained because the conditions giving adequate softening of the surface without softening the body of the paper were not present, or because the means of applying the pressure were not of the proper character to give a uniform surface. Paper makers have believed it unsafe to use water, in the quantities required in my invention, on the paper in supercalenders because of the damaging effect of water on the paper and cotton rolls of the supercalender. I have found, however, that it is possible to safely apply a comparatively large amount of water to the surface which contacts the metallic rolls, if the surface contacting the non-metallic rolls is kept dry, and so much water is not applied that the excess is pressed out beyond the edges of the web in the nip to thereby wet the non-metallic rolls.

In the prior art will be found many recommendations to moisten paper as a preparation for supercalendering. The aim is to secure uniform moistening throughout and to secure this the paper has often been "seasoned" by storing it in rolls between the wetting and supercalendering operations. In my process, on the other hand, I emphatically seek to avoid the uniform distribution of moisture through the sheet at which the prior art aimed.

In carrying out my process that surface of the paper which is to receive the finish is arranged to contact the hard surfaced metallic rolls in the supercalender. Within a few feet of its entrance into the supercalender this surface is liberally moistened.

The moisture may advantageously be applied according to the method described in the copending application of William J. Montgomery, Serial No. 150,410, entitled "Supercalendering process and apparatus" and filed concurrently herewith now Patent No. 2,251,890, dated August 5, 1941. The method there described comprises the application of a large excess of liquid water across the entire width of the surface to be treated, by means of a roll dipping into a bath and wiping against the paper surface. The excess is then immediately scraped off leaving a very thin and uniform film of moisture on the surface. Instead of removing the excess in the manner described the excess may be removed by any other suitable means, such as a high velocity air jet. Instead of applying and then removing an excess, the exact amount required may be applied by any method which will distribute this amount evenly over the entire surface of the web, for example, by spreading and applying the water by a series of rolls similar to the inking rolls in a printing press, by a properly controlled and cooled sweat roll which condenses water from steam or moisture-laden air and transfers this water uniformly to the paper, etc. It is necessary that the water be spread uniformly as otherwise the finish will show a corresponding lack of uniformity. In exceptional cases or with certain special easily softened papers a heavy steam shower may suffice. The quantity of steam ordinarily used with a steam shower of the type heretofore used on supercalenders is valueless for this purpose.

The amount of water applied to create the required plastic condition of the surface, though called a thin film, is much greater than paper makers have heretofore ventured to apply to paper in a supercalender. In most cases I prefer to have between ½ ounce and 1½ ounces of water per 100 square feet on the surface which contacts the metallic supercalender rolls. When I speak of water on the surface I mean not only liquid lying on or between the surface fibers or particles of coating, but also water which may have been absorbed into the surface fibers and filling of uncoated paper or into the surface of the coating on coated paper. In special cases, or in finishing papers of unusual properties, it may occasionally be found advantageous to use more or less water than specified, but I find that supercalendering with about 1 ounce of water per 100 square feet on the surface gives satisfactory results on a wide variety of commonly used papers.

The exact depth to which the applied water penetrates the paper surface is not known, and probably varies with different kinds of paper, different speeds of operation, etc. However, it appears probable that, at the time it passes through the first calender nip, the interior of the paper has only the moisture content (probably 2 to 4 percent) with which it is brought to the calender, while the extreme surface layer of fibers or coating contains as much as 30 percent or more of moisture. The radical departure from accepted practice can be seen when this is contrasted with the 5 or 6 percent moisture which has been considered to be the maximum that would permit the successful supercalendering of book paper.

The length of time which elapses between the time the water is applied to the paper surface and the time the wetted web first passes between the supercalender rolls may be varied in accordance with the paper being treated and the speed of operation. I find, however, that with a wide variety of papers and with normal supercalendering speeds which may vary from about 250 feet per minute up to 1200 or 1500 feet per minute it is satisfactory to wet the paper at a point within about five feet of the point where the wetted web first passes between the supercalender rolls.

The number of nips and calender pressures used are decided to fit each case in the same manner as at present, by increasing the pressure and number of nips if the finish and smoothness are too low, and reducing one or the other, or both, if the finish is too high, or blackening or crushing is apparent. In my process the pressure and number of nips required are found within the same ranges as usual in supercalendering.

In preparation for this process it is not necessary that the moisture content of the paper be held within the narrow limits required for satisfactory supercalendering. It is only necessary that the paper be dry enough to be resilient and resist crushing in the calender, and my process then supplies to the surface the moisture needed to permit the proper finishing of the surface. There is no danger of overdrying as there is when preparing paper for the usual supercalendering operation; neither is there any necessity for premoistening and "seasoning" in order to secure a good surface finish.

To illustrate the invention reference is made to the accompanying drawing in which the single figure is a diagrammatic representation of a supercalender with the necessary winder and unwinder and a wetting device associated therewith for moistening that surface of the paper which contacts the metallic rolls in the supercalender.

A paper web **11** is unwound from a roll **12** under control of a suitable brake **13** of known construction which serves to control the tension on the web. The web then passes over a guide roll **14** and a wetting device **15**, hereinafter more particularly described, into the supercalender designated as a whole by the numeral **16** and thence over another guide roll **17** and is then rewound on the roll **18** in the usual manner.

The supercalender **16** comprises a plurality of metal pressure rolls **21**, **23**, **25**, and **27** and compressed fiber rolls **22**, **24**, and **26** alternating with the metallic rolls. These rolls are carried in a suitable frame (not shown) and may be driven in the conventional manner. Pressure in addition to the weight of the rolls per se may be exerted on the journals of the top roll in the customary manner.

The wetting device **15** illustrated by way of example is similar to that more particularly described by William J. Montgomery in application, Serial No. 150,410, filed concurrently herewith and consists of a roll **31** which is positively rotated at suitable speed by driving means (not shown) and dips into a water bath **32** contained in pan **33**. Immediately adjacent roll **31** is a scraper **35** which removes the excess water applied by roll **31** before the water has had time to soak into the paper to any appreciable degree. As described in the aforesaid application this leaves a thin uniform film of water of between ½ and 1½ ounces per 100 square feet on and substantially confined to this surface of the paper at the time it is pressed against metallic roll **21** by means of the yielding, resilient, compressed fiber roll **22**. At usual supercalender speeds and temperatures the paper has passed out of the last supercalender nip before the water has had opportunity to materially penetrate and soften more than the surface layers of the paper.

Because of the high moisture content of the surface layer, the surface of the paper is pressed into unusually intimate contact with the metallic rolls **21**, **23**, **25**, and **27**, by means of the compressed fiber rolls **22**, **24**, and **26**, whereby the surface layer is compressed, smoothed, transparentized, and rendered dense to an unusual degree. However, because of its normal moisture content, which has not been increased by this treatment, the body of the paper is only affected to the usual degree by the supercalendering operation, and consequently has normal bulk, opacity and brightness. The product of this process is thus a type of paper possessing the normal bulk, opacity and brightness characteristic of paper supercalendered at normal moisture content, but having a superficial layer of the smoothness, density, and transparency characteristic of paper supercalendered while its moisture content was abnormally high.

By the term "paper" as used in these specifications and claims I mean either coated or uncoated paper and cardboard as these terms are commonly understood in the paper making and printing industries. By "coated paper" I mean papers of the types commonly so-called in the art, that is, papers carrying on one or both surfaces a coating comprising pigment such as clay, calcium carbonate, etc., bonded together and to the paper by an adhesive commonly casein or starch.

The term "varnishing grade paper" is used in the sense commonly accepted in the industry, that is, paper either coated or uncoated, the surface of which is sufficiently dense and non-absorbent that applied varnish will be held upon the surface to give a uniform gloss to the entire varnished surface. By the term "non-varnishing grade paper" is meant paper, either coated or uncoated, which does not have such a uniformly dense non-absorbent surface, and which absorbs the varnish over at least parts of the surface causing a lack of surface gloss, together with a discoloration and transparentizing of the paper due to a filling of the pores by the varnish. By the term "non-varnishing grade" of uncoated paper is meant uncoated paper which prior to treatment in the super-calendar has a formation lower than that defined in said Patent 2,088,893 as requisite for the production of varnishing grade uncoated paper.

When my process is applied to coated paper the resulting coated paper acquires certain extremely valuable properties. In the first place, it behaves on the printing press as though a higher adhesive content were present in the coating than if the same coated paper were supercalendered in the usual manner. There is less tendency for the coating to lift or pick. In other words, the effectiveness of the adhesive in the coating is increased and consequently a lower percentage is required. Since the cost of the adhesive is often the major item of coating composition cost, the importance of any savings in adhesive is obvious.

Secondly, coated papers made in accordance with my new process are much smoother than are the same papers supercalendered according to known methods. This is of particular utility in the case of papers carrying coatings which are extremely difficult to smooth out. This additional smoothness, of course, enhances the printing value.

Thirdly, coated papers made in accordance with my new process show a reduced printing ink and varnish penetrability over the same papers supercalendered in the normal manner. Thus a coated paper which would normally be highly absorptive to ink or varnish is rendered much less so when treated according to my process, and a coated paper which is fairly non-absorptive to begin with is rendered extremely so.

Although the invention serves as described to enhance the value of a large variety of coated papers normally made in the industry, it has particular value in the manufacture of varnishing grades of coated paper. For this purpose I use, as is customary, a paper carrying a coating which is relatively high in adhesive content and the pigment of which is in itself not highly receptive to printing ink. It is in general impossible to properly smooth out the surface of such coated papers by the most drastic supercalendering as carried out by the hitherto known methods, without serious damage to the bulk, brightness, and opacity of the paper. The resulting rough surface has seriously limited the quality of the printing results obtainable on these papers heretofore produced. However, when such a paper is processed according to the present invention, the resulting product has a surface smoothness equal to or greater than that previously found only in the higher grades of absorbent coated papers. It is not only possible to secure a higher finish than heretofore obtainable on coatings containing a given percentage of casein, but it is possible to secure the desired resistance to varnish penetration with a smaller percentage of casein. My invention is thus seen to reduce the casein required to produce varnish grade of coating in the same way that it has been seen to prevent picking of the more absorbent grades of coating.

This unique combination of high smoothness and low ink penetrability has not previously been obtained in single coated supercalendered papers. The surface smoothness of the product permits the faithful reproduction of fine half tone printing. By virtue of the low ink penetrability, varnish and ink dry almost entirely by oxidation or solvent evaporation, with the result that an exceptionally high gloss is imparted to the ink or varnish surface. In fact, the gloss is so high when ink alone is used that the printed portions appear to have been overprinted with varnish.

One example of a varnishing grade of coated paper which falls within the scope of the present invention is a sheet composed of a fibrous body stock having a basis weight of 48 pounds per ream (500 sheets 25 x 38 inches) coated on one side only with 12 pounds per ream of coating, composed of comparatively non-absorbent clay 90 parts, calcium carbonate 10 parts, casein 20 parts, all dry weight, and sufficient formaldehyde to harden the casein. This paper when finished according to my invention was found to have the properties indicated in the first column below and when finished by the usual supercalendering operation was found to have the properties, indicated in the second column, which are characteristic of a good grade of varnishing quality coated papers.

	New finish	Regular finish
Basis weight, pounds	60	60
Brightness	72.1	74.8
Brightness on case ink spot	52.2	45.2
Case ink test, percent loss in brightness	27.6	39.6
Bekk smoothness in seconds	975	384
Bausch and Lomb gloss in percent	48	24
Opacity (Bausch and Lomb)	96	95.2
Gurley density in seconds	3,026	1,776

The measures of density, opacity, smoothness and gloss shown in the table are made according to methods which are standard in the paper industry. Case ink has recently been standardized for testing absorbency of coated papers for printing ink and is obtainable from the Institute of Paper Chemistry. After the paper to be tested is conditioned in a standard atmospheric condition this ink is spread $\frac{1}{32}$ inch deep over a definite area of the paper surface and allowed to remain exactly two minutes. It is then removed and the spot wiped as clean as possible with a soft cloth. The brightness of the uninked paper and of the inked spot are measured with a General Electric reflectionmeter. The percentage loss in brightness due to the ink furnishes the best index now known for expressing quantitatively the absorptivity of coated paper for printing ink.

The tabulated results of these tests clearly show that varnish grade coated paper finished according to my invention shows an improvement of 70 percent in density, a decrease of 30.3 percent in absorptivity, an improvement of 154 percent in smoothness, and an improvement of 100 percent in gloss over the same paper finished in the usual manner, and that the improvements in these properties have been secured without any appreciable sacrifice in opacity or brightness, which normally show substantial decreases whenever finishing processes are modified to give increased smoothness, gloss, density, etc.

Under the microscope the difference between the two papers is readily seen. The paper made by the new method is much smoother and more nearly free from surface irregularities than the same paper finished in the usual manner; the surface appears to be to some degree transparent or glazed, showing evidence of having flowed somewhat. The paper made by the old method appears very different, the coating appears to be mashed and crushed; the high parts which carry the finish are only smoothed on their tops while the intervening low spaces remain rough and show little effect of the supercalendering. In general, varnish grades of supercalendered coated paper as heretofore known show between 30 and 40 percent loss in brightness in the Case ink test. The best of them show less than 40 percent gloss (Bausch and Lomb) and Bekk smoothness of about 600 seconds. In contrast to this, various grades of paper made according to my invention show as low as 20 percent loss in brightness in the Case ink test, Bausch and Lomb gloss running from 40 to 55 percent, and Bekk smoothness running from 600 to 1,000 seconds or more. These values of gloss and smoothness are as high as most of the heretofore known grades of supercalendered coated paper having from 60 to 80 percent loss in brightness in the Case ink test. These values are not to be regarded as the limits

obtainable with my process, but rather as typical of the papers commonly finished by my process.

Of course, there are many uses for paper in which a high absorbency is desired and my process is not adapted to those cases where this is the chief requirement. On the other hand, its ability to reduce the adhesive requirements in coated paper gives it a decided value in many cases where its abilities to enhance smoothness, gloss, and non-absorbency are not required.

It is to be understood that the particular examples cited are merely illustrative and are not intended as limiting the scope of the present invention which is applicable to a large variety of papers when one or more of the effects accomplished by the invention appear desirable. The properties of coated and uncoated paper which are desirable to adapt it for treatment according to my invention have already been mentioned. Although papers and coatings to be treated should preferably be somewhat water-resistant, I have found it possible to successfully process those containing starch or other water-soluble ingredients, by keeping the supercalender rolls cool enough to practically prevent evaporation therefrom.

It is thus impossible to state categorically what papers can and what cannot be successfully treated by my process. Anyone skilled in the art, however, who has familiarized himself with the preferred uses of my process as herein described, can, in cases where it is not apparent from these specifications, readily determine by trial whether or not any specific paper stock can be successfully treated.

My process was first disclosed in my copending application Serial No. 749,109, filed Oct. 19, 1934, of which the present application is a continuation-in-part.

I claim:

1. Process of finishing paper of the group consisting of coated and non-varnishing grades of uncoated printing papers which comprises supercalendering the paper by yieldingly and resiliently pressing the moving web against a hard, unyielding, polished surface after that side of the web which contacts said polished surface has been moistened by the substantially uniform application of between ½ and 1½ ounces of liquid water per 100 square feet and before the water has penetrated deeply enough to soften the body of the paper.

2. Process as defined in claim 1 in which the side of the paper which contacts said hard, unyielding, polished surface contains considerably in excess of six per cent of moisture and the interior of the paper contains less than five per cent of moisture.

3. Process as defined in claim 1 in which the paper is mineral coated paper.

4. Process as defined in claim 1 in which the paper is a non-varnishing grade of uncoated paper.

5. Paper of the group consisting of coated and non-varnishing grades of uncoated printing papers having a supercalendered surface of enhanced smoothness and density, characteristic of paper which has been supercalendered when the moisture content of its surface was considerably in excess of six per cent and an interior of lesser density, characteristic of paper which has been supercalendered while the moisture content of said interior was below five per cent.

6. Coated printing paper having a supercalendered surface of enhanced smoothness and density, characteristic of paper which has been supercalendered when the moisture content of its surface was considerably in excess of six per cent and an interior of lesser density, characteristic of paper which has been supercalendered while the moisture content of said interior was below five per cent.

7. Supercalendered coated printing paper as defined in claim 6, said paper being of varnishing quality and being further characterized by a smoothness of over 600 seconds as measured by the Bekk smoothness tester, a loss in brightness of less than 30% in the Case ink test, and a gloss of over 40 as measured by the Bausch and Lomb glossmeter.

8. Non-varnishing grade of uncoated printing paper having a supercalendered surface of enhanced smoothness and density, characteristic of paper which has been supercalendered when the moisture content of its surface was considerably in excess of six per cent and an interior of lesser density, characteristic of paper which has been supercalendered while the moisture content of said interior was below five per cent.

9. Supercalendered coated printing paper comprising a body portion and a coating thereon, said coating consisting essentially of mineral pigment and adhesive, the bonding strength of the adhesive and the surface smoothness, density, penetrability to printing ink, liability to pick or lift on a printing press, brightness, opacity and gloss of said paper being substantially identical with these same properties of a coated paper of the same identical composition, weight, and structure which has been supercalendered by yieldingly and resiliently pressing the coated side thereof against the hard unyielding polished surfaces of supercalender rolls after the coated surface has been moistened by the substantially uniform application thereto of from one-half to one and one-half ounces of liquid water per one hundred square feet and before the applied water has penetrated deeply enough to soften the body of the paper and which prior to said application of water had a substantially uniformly distributed moisture content of less than 5 percent, the brightness and opacity of said first named supercalendered coated paper being at least equal to and its smoothness as measured by the Bekk smoothness tester and its gloss as measured by the Bausch & Lomb glossmeter being at least double these same properties of a coated paper of the same composition, weight, structure and uniformly distributed moisture content less than 5 percent which has been finished by supercalendering under identical conditions except without said application of liquid water.

LEROY C. CATES.