

Nov. 2, 1965

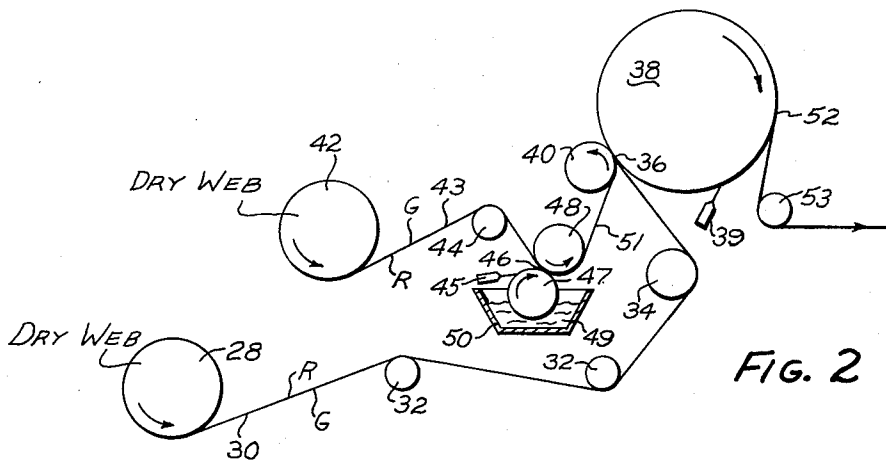
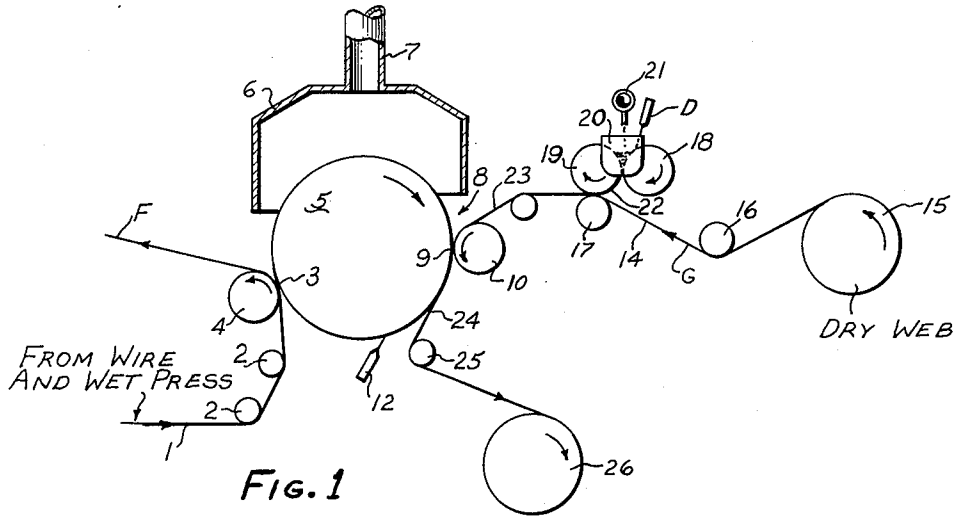
H. H. HELLER ETAL

3,215,589

TWO PLY PRINTING PAPER AND METHOD OF PRODUCING THE SAME

Filed Dec. 20, 1962

2 Sheets-Sheet 1



Nov. 2, 1965

H. H. HELLER ETAL

3,215,589

TWO PLY PRINTING PAPER AND METHOD OF PRODUCING THE SAME

Filed Dec. 20, 1962

2 Sheets-Sheet 2

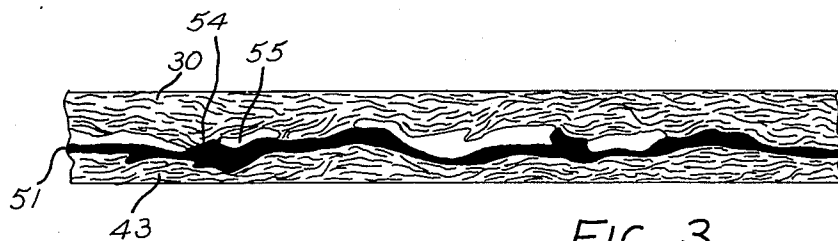


FIG. 3

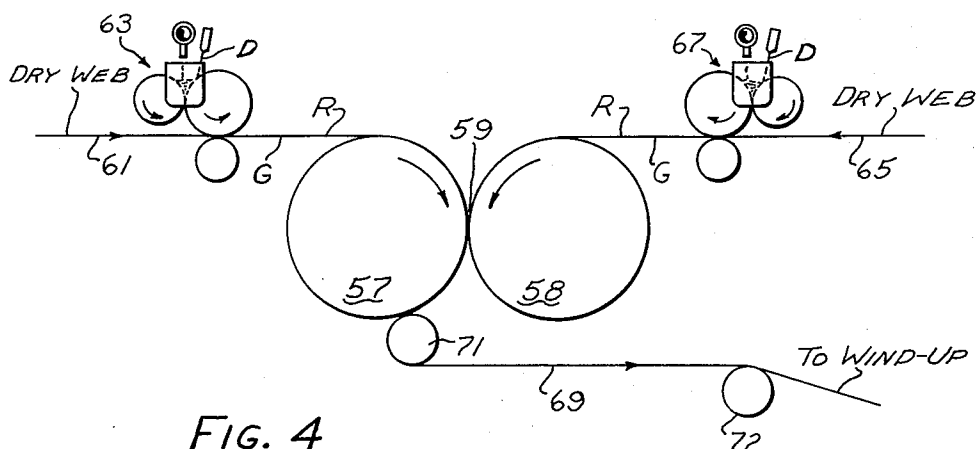


FIG. 4

1

3,215,589

TWO PLY PRINTING PAPER AND METHOD OF PRODUCING THE SAME

Harold H. Heller and Victor D. Werner, Appleton, Wis.,
assignors to Kimberly-Clark Corporation, Neenah, Wis.,
a corporation of Delaware

Filed Dec. 20, 1962, Ser. No. 246,134

3 Claims. (Cl. 162—124)

This invention relates to printing paper manufacture. More particularly, the invention is primarily concerned with printing paper for use as bookpaper, catalog paper, publication paper, newsprint, and the like, although it may be used advantageously in other paper products.

Paper adapted for high quality printing has customarily been heavily calendered or has been coated followed by supercalendering. Such treatments have been necessary to achieve the level surface required for printing and for adequate ink holdout. Coating, however, materially increases the basis weight of a paper sheet; calendering and supercalendering, in addition to reducing sheet thickness and opacity, render the sheet more brittle and harden the paper to such an extent that printing quality is affected adversely.

In the absence of a coating, and frequently with coatings, wire formed webs, as is well known in the art, tend to exhibit a definite two-sided characteristic, that is, the wire side is much rougher than the felt side. In the art the minute variations of a paper surface are commonly termed "ridges and valleys" and it is the extent of these variations in a direction perpendicular to the general plane of the sheet which is an indication of the roughness of the paper surface.

Mineral coated paper, while apparently level to the unaided eye, exhibits under the microscope zones of differing characteristics both as to levelness and gloss; the surface includes high and low spots which are rendered less prominent by supercalendering but at the expense of density and of varying density since the high spots are compressed to a greater degree than the low spots. Gloss is also affected by the distribution of pigment particles which likewise are compacted in the coating surface by supercalendering operations. While such compaction decreases the distance between individual particles of the pigment, the spread of particles still exists and contributes to nonuniform gloss characteristics.

The production of light weight webs having a level and light reflective surface on one side, commonly termed "machine glazed" paper, is well known in the paper manufacturing art. Such paper is produced commercially by pressing a wet cellulosic web against a polished drum surface and drying the web in contact with the surface; the smooth polished drier surface is reproduced on the side of the web adhering to the drier. This provides the one highly glazed surface. The side of the web opposite the drier surface is rough initially. Consequently, the dried sheet is distinctly two-sided. Accordingly, such sheets have found no utility in those applications requiring high quality printing on opposed sides of the sheet.

This present invention involves a new approach to the overcoming of prior art limitations in connection with printing paper manufacture while utilizing some of the above-noted principles of the paper art. Essentially, the invention contemplates the uniting of machine glazed webs, without loss of web glaze, into a multi-ply sheet of lighter weight than an integral sheet having corresponding printing properties. While duplex and multi-ply sheets have been proposed for newspaper and catalog printing and the like, such efforts have commonly involved lamination in the wet state and/or calendering and supercalendering operations which prevent the at-

2

tainment of bulk and other desirable properties in the finished product.

In papermaking terminology bulk or apparent density is the term applied to the paper basis weight in pounds per ream divided by the sheet caliper or thickness. In effect, this apparent density is a measure of the air content of a sheet, and it is this density or bulk which is a material factor in printing quality. The basis weight as used hereinafter is the weight of 500 sheets of 25"x38" and the caliper is that of a single sheet.

It is a primary object of the present invention to provide improved printing paper which does not require, but in some respects may advantageously employ, calendering, coating, or light supercalendering, and which paper is of low apparent density (high bulk), gloss, and delamination resistance.

It is a further object of the invention to provide an improved process for the manufacture of printing paper, in particular an improved process which may utilize and upgrade relatively inexpensive cellulose fiber furnishes.

We have found that such objects may be attained, and disadvantages of prior art methods in the production of high quality printing paper may be overcome by carrying out the following generally stated method. Initially there is applied to a machine glazed, dried, sized web on its rough surface side a thin film consisting wholly or primarily of aqueous adhesive; there is then advanced substantially immediately after the application of the adhesive a second and similar machine glazed web into contact with the first web. This second web is so presented to the first web that their rough sides are confronting. The webs are superposed within sufficient time to inhibit penetration of moisture from the adhesive to the machine glazed surfaces. The superposition step is followed or accompanied by pressing the webs together under relatively light pressure so that the webs interlock due to their roughened surfaces and contacting areas; ridge areas of the opposed rough surfaces are bonded together by the adhesive while valley areas of the surfaces are substantially unbonded. The duplex sheet is then dried as required to reduce the moisture content to that which it would normally have under the ambient conditions present. The composite sheet so formed is not densified to any material degree and, in addition, exhibits air spaces which enhance the opacity of the sheet.

In accordance with a preferred embodiment of the process of our invention, two machine-glazed webs are first formed and dried on a "Yankee" paper machine. Such machines are customarily employed in the manufacture of light weight paper, for example, tissues; a characteristic of the "Yankee" is a large drier in the form of an imperforate smooth-surfaced heated drum some 8 to 12 feet in diameter. Important considerations in connection with webs appropriately formed on such machines are that each web has one very level surface. The presence of web gloss or light reflectance capacity, desired in some printing papers, is of itself incidental. It is the levelness of the surface combined with resiliency of the web (bulk) which is of concern to the printer. The characteristics of resilience and levelness are necessary in order that skips in ink application may be avoided. While levelness may be achieved in large measure by calendering the paper or by supercalendering a coated sheet, the gain is usually accompanied by a material decrease in paper thickness (directly related to bulk). Additionally, average density and nonuniformity of density increases due to the differential compression of those incremental web surface areas having high spots relative to web surface areas having low spots. The glazed webs, in contrast, since they have a surface formed on the Yankee when the fibers of the web are wet and conformable to the smooth drier surface, are characterized by

materially less densification, are not transparentized as frequently occurs in dry calendering operations, and exhibit on the one side levelness of surface. The surface "finish" of webs produced in accordance with the invention is indicated by Ingersoll glarimeter readings of 40-42 or more and not less than 38.

The stock or furnish for the webs may be any cellulosic furnish conventionally employed in producing machine glazed webs of high quality and is suitably of a character termed a slow stock; that is, of a Canadian freeness of less than about 300. Preferably, for economical reasons the furnish for the webs in the present instance may contain a large proportion of groundwood; such groundwood inclusion is also effective in aiding attainment of a well filled surface of the sheet and in achieving resultant sheet opacity. Groundwood alone does not produce a sufficiently strong sheet and the furnish therefore includes sulfite or kraft pulp in significant quantity. Usually the groundwood percentage, to provide for opacity in the sheet as well as economy, is between about 30 to 70 percent or more by weight of the furnish.

The machine glazed surfaces of the webs are sensitive to water and suffer some loss of levelness and of gloss if wetted. The loss of levelness is occasioned by swelling of the fibers, particularly the swelling of surface fibers out of their original plane. These fibers may be dried back under some pressure to provide substantially the original level surface; the gloss characteristic is usually impaired to some extent. To assist in avoiding web penetration and material disruption of the level surface during lamination of the webs to form the printing sheet, the furnish contains a size. Sizing also strengthens the web and is employed in furnishes which form webs which are to be machine glazed to aid passage of the light weight web through lamination machine draws. In the practice of this invention the usual size treatments are effective but most suitably, the size, as noted hereinafter, is formulated to be receptive to the adhesive employed and to aid smooth spreading of the adhesive film.

The "formation" of the web, that is, the lay of the cellulosic fibers is an important consideration both as to penetration of the web by adhesive during manufacture and as to opacity of the composite sheet. If the web absorbency and porosity are not closely controlled and correlated with the fluidity of the adhesive and application nip pressure, the adhesive material, as well as the aqueous content of the adhesive composition, may be forced through the rough web surfaces to the glazed sides to impair the glaze and produce a nonuniform surface level by swelling of surface fibers. We have found that pressing of each of the webs on the Yankee drier drum and drying on the drum not only produces the desired substantially planar surface but the compaction of fibers of the sheet on the side of the web adjacent the drier during manufacture is at a maximum and the fibers, through the thickness of the web body to the opposite exposed and rough side, are less densely compacted. This provides for our purpose desirable density conditions in each web.

The bonding aqueous adhesive coating composition, however, should wet the sized web surface sufficiently to spread readily. Suitably, the adhesive, as noted, is desirably applied to the rough side of a first one of the dried webs; it is then brought into contact with the rough side of the second dried web sufficiently quickly to cause the aqueous content of the adhesive to be distributed substantially uniformly between the two webs. Alternatively, a portion of the adhesive may be applied to each web. In either event the extent to which either web must take up water from the adhesive is limited. Consequently, web wetting to a deleterious degree is avoided. If, before adhesive application, the webs are thoroughly dried, the moisture content pickup by the webs may be less than that commonly picked up by the webs under

normal ambient temperature and humidity conditions. However, some sheet drying is usually necessary.

The adhesive applied is also limited as to quantity to prevent complete filling of the spaces formed between the roughened opposed surfaces of the webs. The adhesive thus need be present only to the extent that a good bond is achieved between the webs.

Spreading of the adhesive in a thin film aids in causing the adhesive to follow primarily the ridges and valleys of the surface of the web to which it is applied and complete filling of air spaces between the webs is avoided. Suitably, the adhesive film is applied by reverse roll coater or by intaglio printing.

Thus, in effect a balance exists between the absorbency of the webs and the specific nature and quantity of coating applied. With the correct quantity of adhesive coating of a given nature and dry sized web is essentially only moistened and the web does not absorb sufficient water through the fibers to affect the glazed surfaces. Additionally, the two webs do not form a plane interface and, due to the fiber masses of the ridges and associated valleys, interlock to some degree. Nevertheless, the small size of the ridges and valleys and their close though open spacing permits a strong and satisfactory bonding action with a minimum of adhesive. The voids of spaces, being small in size and numerous, serve the dual purpose of increasing opacity and sheet bulk.

The solids content of the aqueous adhesives should be at least 30% and preferably in excess of about 50%; such solids percentage is greater than would normally be required in an adhesive used simply to bond webs together. Such solids content permits the adhesive material to enter into the fiber structure of the webs to some extent but without causing material penetration or hydration of the fibers. Such penetration is desirably avoided beyond the extent needed for permanent adhesion, not only to inhibit material fiber wetting and loss of surface smoothness, but also to prevent web brittleness, stiffness, and loss of opacity in the finished product. The amount of adhesive coating commonly applied in the practice of the invention to light weight webs should not exceed about 4 pounds in the dry state and may be as low as 1½ pounds of adhesive per ream of paper (25" x 38" x 500 sheets).

The adhesive of itself will not contribute to sheet opacity unless it is pigmented. In fact, the adhesive tends to lessen the opacity of the finished sheet. When a high groundwood content, about 50-70% or more of the furnish, is employed, there is no necessity for pigmentation. However, with webs made from conventional kraft and sulfite or even with low groundwood, some pigmentation of the adhesive may be desirable for certain printing papers. We have found that from about 5-10% by weight of pigment (based on the dry weight of the adhesive), such as calcium carbonate, TiO_2 , or the like may be employed without adversely affecting adhesion between the webs. However, since pigments tend to increase the basis weight such are generally avoided where light weight is of primary importance; in such instances it is preferable to increase the groundwood content of the webs.

The webs, to form a sheet useful in catalog, newsprint, and publication grade papers, each may have a basis weight in the range of 10 to 15 or 20 pounds per 3300 square feet (25" x 38" x 500 sheets), although for heavier printing paper the webs weights may be greater. It is not essential that each of two webs forming a duplex sheet have the same basis weight, although they should be in the same general range. Consequently, in the preferred embodiment of the invention, the web basis weights will be between about 10 and 15 pounds, and the dry adhesive weight will usually be between about 1½ and 3 pounds per ream. In general, finished duplex sheets having an uncoated basis weight in the 28 to 45 pound range are most particularly adapted for the practice of the invention since the webs for laminating may be formed readily at high speeds. Such sheets have a thickness in the range of about

0.003" to about 0.005" at an apparent density of between 8,000 and 13,000.

The sheet formed by the composite of the webs and adhesive is withdrawn through a rolling nip and dried. Such drying, as already noted, even with aqueous adhesives, need only be very slight as the aqueous content of the adhesive is not sufficient to materially raise the water content of the sheet. Thus, if two 14-pound basis weight sheets are employed with a 50% solids adhesive adapted to provide 4 pounds of adhesive dry weight on the finished sheet only about 4 pounds of water need be evaporated or taken up by the web. This is about 14% on the dry fiber weight. The amount required to be evaporated is dependent upon the initial moisture content of the web and ambient conditions. Thus, a bone dry web would normally absorb about 6% of its own weight of moisture and, in the above example, only about 8% would be required to be driven off.

While organic solvent systems rather than aqueous adhesives may be employed, these are not particularly practical or economically advantageous in the manufacture of paper on high speed machines even though wetting of the fibers is thereby inhibited. We have found that a variety of adhesives may be employed. Such include the animal glues, polyvinyl acetates, and particularly the dextrans.

The invention will be more fully understood by reference to the following detailed description and accompanying drawings wherein:

FIG. 1 is a schematic illustration of apparatus useful in one embodiment of the invention;

FIG. 2 is a schematic illustration of a preferred arrangement of apparatus in accordance with the invention;

FIG. 3 is a greatly enlarged representation of a paper web formed in accordance with the practice of a method of the invention; and

FIG. 4 illustrates a modification of the apparatus arrangement for the practice of the invention.

In the drawings corresponding numerals, where convenient, designate similar components. Also, since the web of FIG. 3 may be formed with any of the apparatus arrangements of FIGS. 1, 2 and 4, such arrangements are described first.

Referring initially to FIG. 1, the numeral 1 indicates a traveling paper web of about 13 pound basis weight (25" x 38" x 500 sheets, uncoated). This web, due to porosity, rough surface, and light weight, would not of itself provide a suitable quality printing sheet. The web, as indicated by the legend, is being passed from a wire and wet press section of a conventional Yankee drier machine on a felt F. As the web is passed over guide rolls 2 to the nip 3 it normally contains about 30% solids and 70% water.

An exemplary furnish from which the web 1 is formed contains about 60% by weight poplar groundwood refined to be free from fiber bundles; the balance of the pulp is suitably 40% bleached northern sulfite pulp refined to a Canadian freeness of about 300. Accordingly, the freeness of the total pulp is considerably less than 300. Additionally, the furnish contains about 6% by weight based on the fiber of fine white china clay as mineral filler; such serves to enhance sheet opacity. A sizing material is also incorporated with the filler on the basis of about 1% on the fiber weight of the furnish; such sizing very suitably is a rosin size containing about ¼ of 1% of ammonia cut casein (basis on fiber weight) and is in the form of an emulsion; such sizing is eminently suitable to provide a machine glazed surface at production equipment speed. This furnish additionally contains sufficient alum to provide the pH of the furnish at about 5. In the preferred embodiment described, a retention aid may also be provided to assist retention of the clay during the formation of the web. Such retention aid is a mannogalactan gum present to the extent of about ½% by weight based on the fiber weight.

The web 1 is directed to a nip 3 formed between a

pressure roll 4 and a drier drum 5 having a highly polished surface. Roll 4 and drum 5 rotate in the direction indicated by the arrows. Pressure roll 4 exerts a pressure of at least about 300 pounds per lineal inch on the web passing through the nip 3. Such pressure may vary with the nature of the web but should firmly urge the traveling web to the drier surface. The drier itself is steam heated internally and the temperature of operation is maintained to provide a completed drying of the traveling web within about 250° of the drier circumference. In the present instance the temperature of operation is about 180–200° F. drier surface temperature at a web speed of about 2000 f.p.m. As the web is dried, steam is exhausted through a hood 6 having an outlet 7.

The completely dried web designated generally at the zone 8 in FIG. 1 is directed to a nip 9 between the drier drum and a second pressure roll 10. Roll 10 is itself unheated.

Scraper blade 12, functioning in known manner, serves to maintain the surface of drum 5 clean; the scraper does not contact the traveling web or formed sheet.

A second and similar previously formed web designated at 14 is directed also at 2000 f.p.m. from a reel 15 by guide roll 16 and backing roll 17 to pressure roll 10 and to nip 9. Web 14 may be formed on the same or similar Yankee drier equipment, as described in connection with web 1. Pressure roll 10 may be driven independently of but in synchronism with drum 5 to provide the same surface speed. In the course of its travel, the web 14 is lightly coated on its upper rough side with adhesive. For this purpose rolls 18 and 19 form an applicator nip of a reverse roll coater having end dam 20. Adhesive is fed through inlet 21 and is carried in the rotation of roll 19 in the form of a thin film 22 to the web. The adhesive film on the web is designated at 23, the representation of the film being somewhat exaggerated for purposes of illustration. In essence, the coating adhesive is simply a thin sealer type of coat; too much adhesive is evidenced by the presence of a print roll type of pattern. Higher laminating speeds are desirable, not only because of economy but also because such tend to aid spreading of the adhesive into thin film form.

It is to be noted that the web 1 in the nip 9 has a smooth glossy glazed surface adjacent the drum 5 produced by drying of the web 1 on the drum. The opposite side of web 1, however, is in the present instance the felt side and rough. The web 14, having been similarly produced and appropriately reeled, has a lower glossy glazed surface designated at G, and the upper surface which carries the adhesive film 23 is a rough surface similar to the rough surface of the web 1. Thus, the webs 1 and 14 meet in the pressure nip 9 with the adhesive film 23 between the nip 9 is a relatively light pressure nip such that it does not materially densify the webs 1 and 14; about 50–100 pounds per lineal inch is satisfactory through, of course, the pressure at this zone is not particularly critical since relatively dry webs are not readily subject to fiber compression. The adhesive itself contains only a small quantity of water proportionally to web weight; accordingly, as the escaping moisture is well distributed, the glazed sides of the webs 1 and 14 as they pass through the nip formed by the smooth surfaced drum and pressure roll 10 are unaffected as to their levelness, gloss, and dimensional stability.

The adhesive is applied to the paper to the extent of 2 pounds per ream on a dry solids basis. The adhesive is a Borated Dextrin having a solids content of 50%; such adhesive is well known and commercially available. Accordingly, in the present instance only 2 pounds of water per ream are either absorbed by the moving webs or are evaporated off. If all of the water content of the adhesive is dried off, this is only about 1 pound per 1650 square feet of traveling web.

The viscosity of the 50% Borated Dextrin adhesive is about 3000 to 4000 centipoises at a temperature of 70°

F. as measured on the Brookfield Viscometer. It will be understood that it is desirable that the adhesive have little penetration but that it wet the sized web in order to secure adequate adhesion and distribution.

As will be noted from FIG. 1, the combined adhered webs forming the sheet 24 pass for a short distance on the drier 5 to permit adequate distribution and escape of moisture. The sheet 24 is then guided from the drum 5 by roll 25 and is wound at 26.

It is to be particularly noted that the adhesive in the foregoing example is applied to the preformed web; application of the adhesive to the hot web intimately adhered to the Yankee drier surface would result in immediate web penetration and would inhibit removal of the web from the surface. In all instances the adhesive should be applied to a web which is in close contact with but not adhered to the lamination roll surface.

While the apparatus of FIG. 1 may be operated in conventional manner, rolls 5, 18, 19 and 26 are usually driven and rolls 4, 10, and 17 are simply rotatably mounted and driven by pressure contact. It will be understood that all rolls may be driven if appropriately synchronized with web speed.

In the preferred embodiment illustrated in FIG. 2, both glazed webs are preformed and dried. As illustrated in FIG. 2, one dry web is fed from reel 28 as web 30 under guide rolls 32 and around roll 34 to a pressure nip 36 formed between a heated drier roll 38 and a backing roll 40. Each of these rolls 38, 40 are hard surfaced and preferably of steel, although backing roll 40 may suitably be of hard rubber. It is desirable under all pressure conditions that the rolls be sufficiently hard to prevent high spots of the webs from being pushed through to the glazed surfaces.

The second web is fed from reel 42 as web 43 over guide roll 44 and through an adhesive applicator nip 46. The adhesive applicator nip is formed by an applicator roll 47 and a backing roll 48. Roll 47 is an engraved roll, while roll 48 is hard surfaced and of rubber. A doctor blade 45 bears against the engraved roll to scrape off excess coating composition as the roll rotates. The applicator roll 47 rotates in a pond 49 of coating retained by trough 50. A print film of adhesive is carried by the roll 47 to the traveling web 43 and applied to the rough surface designated at R on the side opposite the glazed surface G. The web 43, after passing the nip 46, is directed to the nip 36 and pressed into contact with the traveling web 30. The rough side of the web 30, designated at R, is applied against the film of coating carried by the web 43. The coating film is designated at 51 and, as shown, is somewhat exaggerated in thickness for the purposes of illustration.

The web emanating from the nip 36 is carried on the polished surface of heated drum 38, and slow evaporation of any excess of moisture from the web takes place on the drum 38. The drum 38 suitably is at a surface temperature of about 200° F. The dried sheet 52 may be dried to a moisture condition in which it is in equilibrium with the surrounding atmosphere or may be completely dried as desired. It is then passed from drum 38 over the guide roll 53 and then to windup. Again, it is to be noted that the rough sides of the glazed webs have been presented to each other in a light pressure nip in such manner that there is no substantial compression of the webs and no impairment of the glazed web surfaces.

In the apparatus arrangement of FIG. 2, applicator roll 47, backing roll 48, and drying drum 38 as well as the windup (not shown) are customarily independently appropriately driven, the remaining rolls being rotatably mounted.

FIG. 4 illustrates a modification of the apparatus particularly adapted for applying a portion of the coating to the rough side of each of the dry traveling webs. As illustrated, a first pressure roll 57 and a second pressure roll 58 together form a pressure nip 59. The rolls 57,

58 are hard surfaced and are smooth. The dry preformed traveling web 61 is fed over the roll 57 through the reverse roll coater 63, the coating being applied to the rough side of the web designated at R. The glazed side designated G contacts the roll 57. Similarly, a second dry web 65 is fed through a reverse roll coater 67 to have adhesive applied to its rough side, the glazed side G of this web contacting the smooth surface of roll 58.

For the removal of the formed duplex sheet 69 from the laminating apparatus, there is positioned around the periphery of one of the nip rolls, a take-off roll 71. Thus, the sheet travels for a short distance on the roll 57 prior to its removal to windup. Suitable support means such as the carrier roll 72 provide for passage of the web to a reel (not shown).

In the arrangement of FIG. 4 the rolls 57, 58 are usually independently driven as are the rolls of the reverse roll coaters.

It is to be noted that the apparatus of FIG. 4 may be operated at any reasonable desired speed and usually will cooperate with the Yankee drier web forming equipment. Thus, the speed of the apparatus of FIG. 4 may be between 500 and 3000 f.p.m., the latter speed being useful when the apparatus of FIG. 4 cooperates with the output of 2 Yankee drier machines. On the other hand apparatus of FIG. 4 may, of course, be at a considerable distance from the Yankees which form the webs; in fact, the webs 61, 65 may be purchased, that is, they may be commercial machine glazed webs.

In connection with the apparatus of FIG. 4 it is to be particularly noted that the rolls 57, 58 may but need not be heated, and the webs, while under tension sufficient to maintain them in good contact with the rolls, are not adhered to the rolls.

Referring now to FIG. 3 and the duplex sheet in detail, there is illustrated a section of a paper web produced as by operation of the apparatus of FIGS. 1, 2 or 4. The numerals of FIG. 3, for convenience, correspond to those employed in FIG. 2. As shown in FIG. 3, the lower web 43 is bonded to the upper web 30 by a thin film of adhesive 51. The adhesive, as will be noted, tends to follow, in large measure, the web to which it is applied. However, where the rough opposed surfaces of the glazed webs are closely adjacent or are in contact, the adhesive 51 secures the ridges of the webs together as at 54 and bridges some of the spaces between the webs. Air spaces, as at 55, are defined by the opposed webs and the adhesive securing them. These air spaces are, of course, relatively minute, the illustration in FIG. 3 being about 300 times actual size. Accordingly, despite the presence of the air spaces, the webs are securely held together and resist delamination. Examination of webs produced as described indicates the presence of about 100 to 150 adhesive contact points per lineal inch or 10,000 to about 22,500 per square inch of sheet surface.

It is further to be noted that, although in large measure the adhesive exhibits a preference for the web to which it is applied, the adhesive does spread to some extent on the rough side of each web.

The greatly enlarged section (FIG. 3) clearly illustrates the numerous bonding points of the adhesive despite the presence of the multiplicity of air spaces 55. The sheet of FIG. 3 made from two webs, each having a basis weight of 13 pounds, such as previously described in connection with FIG. 1, exhibits on its outer side good machine glazed finishes. Such finish on the Ingersoll glarimeter has a value of between about 40 and 42. Additionally, such sheets have a size value of between 5 and 100 seconds based on the Tappi Standard ink flotation test. The thickness of the sheet is about 0.0034". Since the basis weight is about 28 pounds per ream, the ratio of basis weight to thickness, which ratio is a measure of apparent density, is about 8600. This compares with a value of approximately 18,000 for a single print-

ing sheet of comparable printing quality in the light weight or catalog field.

If desired, a light coating may be applied to the duplex sheet followed by a very light calendering operation, that is, a pressure of less than 300 pounds per inch of nip length. Such calendering pressure does reduce the thickness to some extent but the sheet will still exhibit more bulk than a conventional sheet of similar basis weight which is supercalendered.

With other pulps, and employing apparatus as previously described in connection with FIGS. 1, 2 or 4, the bulk is high but somewhat less than that achieved with the groundwood-sulfite combination. Thus, a semi-chemical pulp sheet having a basis weight of 36.2 pounds and a thickness of 0.0033" exhibited a density of about 10,970. An all sulfite type sheet having a basis weight of 34 pounds and a thickness of 0.0027" exhibited an apparent density of about 12,592. In contrast, commercially produced webs having a basis weight of 38-40 pounds total and coated—about 4 pounds of coat per side—exhibited apparent densities of 19,000 to 21,000. In each of the foregoing, the data taken represents an average figure over a plurality of samples. In most cases the bulk of sheets formed in accordance with the invention is very nearly twice that of comparable printing papers employed in present commercial production for bookpaper, publication grade paper, and the like. In general, the apparent density is between 8,000 and 12,000 to 13,000.

No delamination occurs in the printing operations even with tacky inks, and the sheet is thus satisfactory for the purpose for which it is designed. Of course, due to the nature of the adhesives employed, no difficulty is experienced with heat set inks.

While the printability of the described uncoated webs is excellent for many purposes, such as newsprint, catalog, and as an improvement in present uncoated bookpapers, it is frequently required that sheets for book and publication be coated. The present duplex paper requires less coating material of the usual aqueous mineral coating type—approximately $\frac{1}{3}$ to $\frac{1}{2}$ of that normally required. Further, only very light calendering is required to provide the paper on a comparable basis surface-wise with other heavily coated and calendered papers. As an illustration, the sheet produced in accordance with the example associated with FIG. 1 (60% groundwood, etc.) may be coated with the usual aqueous mineral pigment (clay, starch—55% solids) to give a dry coat weight on each side of about 4 pounds per ream.

Sheets produced in accordance with the invention compare favorably with sheets produced by conventional methods in all major respects, and particularly, the new sheets demonstrate improved printability. In one such comparison the pulp employed contained by weight 27% sulfite, 18% kraft, and 55% bleached groundwood, with minor amounts of clay and phosphoric acid. The conventional, over an average of 40 tests, had a basis weight when coated on both sides with the usual aqueous mineral pigment coating composition of 44.8 pounds. The coating was approximately 5 pounds per side. Such sheets were supercalendered after coating; the apparent density was 19,000, the thickness 0.0023, the opacity (Bausch and Lomb) 93, and the gloss (Ingersoll glarimeter) 43, while the brightness (GE) was 73. While the gloss and opacity were somewhat higher than that of the duplex sheet produced from the same pulp, the printability of the duplex sheet was superior.

The comparative duplex sheet produced from this same furnish and as described in connection with FIG. 1 had a basis weight of only 30.9 pounds, was uncoated, and had a thickness of 0.0033". The apparent density of this duplex material was only 9400—less than $\frac{1}{2}$ of that of the coated product. Opacity (Bausch and Lomb) of the duplex sheet was 84, GE brightness 71.2, and Ingersoll glarimeter value 38.6. The improved half-tone print-

ability of the uncoated sheet over the coated material is reflected by very uniform ink absorbency which is ascribed to the uniformity of formation, the levelness of surface achieved by machine glazing, and its retention throughout the described procedure, as well as the very low apparent density of the duplex sheet.

Similar comparative tests employing very high percent groundwood furnishes—as in newspaper furnishes having 75 to 80% groundwood—clearly indicate that the printability is upgraded by the use of the duplex sheet.

Single nip calendering under relative light pressure of about 200-300 pounds per lineal inch further increases printability and is useful where some loss of bulk may be tolerated.

In the procedures previously described, the wire side of the web has been the side which has been machine glazed. This is normally the rougher side of the web and in conventional machine glazing is the side presented to the Yankee drier. If desired, the felt side of the web may be the glaze side and the wire side may be the rough web side for lamination. With the conventional commercial Yankee machines, this requires turning the web prior to presentation to the Yankee. Such may be readily accomplished and some benefit results as the felt side, being somewhat more smooth initially, glazes more readily. However, either side may be utilized as the glazed side in the practice of the invention.

The tensile strength and M.I.T. fold values of the duplex sheet are improved over the corresponding single sheets produced from the same furnish; the tear strength of the duplex sheets is usually improved or at least comparable to that of a single sheet of a corresponding basis weight; these factors together with the bulky, low apparent density characteristic at good solids and half-tone printability, and Bausch and Lomb opacity values of at least 80 provide for lower basis weights in high quality paper—an important factor in publication grade and book papers. A particular advantage is that such paper permits of lower mailing costs due to improved quality with decreased weight. Also, the cost of manufacturing operations such as coating and supercalendering may be eliminated.

In the specification and appended claims, the term "dry" as applied to the webs is intended to indicate a normally dry web in equilibrium with a surrounding atmosphere, such webs normally containing 5-6% moisture; this is in contrast to the term "bone dry," which indicates a web substantially free of moisture. Also, the term "bonded areas" or "bonded contact points" is employed to designate the contacts between opposing webs, that is, the web high points which project and are secured by adhesive.

It will be understood that this invention is susceptible to modification in order to adapt to different usages and conditions and, accordingly, it is desired to comprehend such modifications within the invention as may fall within the scope of the appended claims.

What is claimed is:

1. A printing paper in which is an uncalendered sheet having a thickness in the range of about 0.003" to about 0.005" and comprising a pair of superimposed sized cellulosic paper webs, each web having a machine glazed surface and a rough surface, the rough surfaces comprising ridges and valleys and the machine glazed surfaces being substantially planar, said webs having their rough surfaces confronting, and a thin layer of adhesive bonding ridges of the rough surfaces together at their areas of contact, said sheet having a basis weight of between about 28 to 45 pounds (25" x 38" x 500 sheets) including an pounds, a proportion of the valleys of the rough surfaces being free of adhesive whereby said valleys define air spaces which contribute to the bulk of the sheet, said glazed surfaces each having an Ingersoll glarimeter value of at least 38, said sheet having an apparent density of between about 8,000 and 13,000 and a Bausch and Lomb opacity of at least 80.

11

2. Printing paper as claimed in claim 1 and wherein the bonded contact areas of the webs are in the range of 10,000 to 22,500 per square inch.

3. In the production of printing paper having a thickness in the range of 0.003" and 0.005" and an apparent density of about 8,000 to 13,000, the steps of passing a first sized cellulosic base web having rough sides and a basis weight of about 10-20 pounds per ream in the wet state to a Yankee drier, leveling one side of said base web by pressing said web while wetted against the smooth surface of a Yankee drier, drying the web on said smooth surface to provide a machine glaze surface on the web on the drier side while the other side remains rough, passing the web without removal from the drier to a nip formed between the drier and a backing roll, advancing a second and similar dry sized cellulosic paper web having one machine glaze surface and one rough surface to the nip in such manner that rough surfaces of the machine glazed webs are in confronting relation, applying a thin film of

12

an adhesive to said second web as it advances to said nip, rolling the said webs with the adhesive therebetween into a unitary sheet without impairment of the machine glaze surfaces of the webs, passing the unitary sheet on the Yankee drier for a short distance beyond the nip, and then removing the sheet in a dried condition from said drier.

References Cited by the Examiner

UNITED STATES PATENTS

1,986,961 1/35 Dodge.

FOREIGN PATENTS

1,049,224 1/59 Germany.

515,011 11/39 Great Britain.

572,944 10/45 Great Britain.

DONALL H. SYLVESTER, *Primary Examiner*.

MORRIS O. WOLK, *Examiner*.