This invention relates to the manufacture of wet-strengthened paper, that is, paper of markedly higher wet-strength than ordinarily. While not restricted thereto, it deals especially with wet-strengthened paper of substantially unimpaired absorptivity and hence of particular value for those uses for which it is important that a paper possess an absorptivity comparable to that of waterleaf paper and yet be of markedly higher wet-strength than that of waterleaf paper.

While it has been found that specific substances, notably regenerated cellulose and gelatin, can be incorporated into paper in controlled amount conducive to a wet-strengthened absorptive paper product, yet a long-continued quest for other agents capable of wet-strengthening paper while substantially preserving its absorptivity has shown what was to be anticipated, namely, that numerous binders or sizes capable of increasing the wet-strength of paper to a significant extent are so water-repellent as to destroy in effect the absorptivity of the paper and that water-soluble or water-absorbing binders, although capable of enhancing the dry strength of the paper and preserving to a noteworthy degree the absorptivity of the paper, are generally of little value in improving the wet-strength of the paper.

I have discovered that locust bean gum can be made to function exceedingly well as a wet-strengthening agent in paper-making without detracting unduly from the absorptivity of the paper, provided that the gum is properly alkalinized or activated with an alkaline solution. It is preferable to alkalinize the gum in situ in the paper-making machine, and, to this end, an alkaline solution may be applied to the gum-containing paper web while the web is still on the papermaking machine, for instance, on its way to the drier, or it may be applied to the predried, gum-containing paper web and the web redried. While aqueous solutions of various alkaline compounds, including caustic soda, caustic potash, and similar hydroxides, are effective and can be used as activating media for the gum, it is considered preferable at the present time to use solutions of comparatively mildly alkaline compounds, such as borax and sodium carbonate, for it has been found that a paper product of the desired high wet-strength and other qualities is realized with a pH value little greater than 7 in the finished paper product and that it is easy to obtain such desired slight alkalinity even with dilute alkaline solutions of such comparatively mild alkaline compounds as have no appreciable effect on the skin. Thus, when the finished paper product is to serve as towels, paper handkerchiefs or other skin wipes, the presence therein of borax or similar mildly alkaline compound in amount to impart suitable alkalinity thereto has no noteworthy effect on the skin.

The locust bean gum useful for the purposes hereof is available on the market as a fine white powder that lends itself readily to incorporation into papermaking stock without any conditioning treatment whatever and is well retained by the stock. This is evidently attributable to the fact that the powder particles swell promptly in cold water and hence become intimately attached to and/or enmeshed in the fibers of the papermaking stock while in aqueous suspension and while the water of suspension is being drained from the thin web of stock on the papermaking machine. It thus becomes possible to add the powdered gum to the papermaking stock in the beater engine, in the head box, or at any other convenient place in the course of papermaking and thus, while otherwise pursuing essentially a conventional papermaking practice, to produce a paper sheet throughout which the gum is substantially uniformly distributed.

Because the gum can be dissolved in weakly alkaline water, it is most surprising that a weakly alkaline solution activates the gum so that it exerts extraordinary wet-strengthening effect on paper. The fact is, however, that mere spraying of weakly alkaline solution on the wet, gum-containing web on its way to the dry end of the papermaking machine or mere dipping of the predried, gum-containing paper web in weakly alkaline solution followed by redrying yields a finished paper product whose wet-strength is vastly greater than that of a similar paper product lacking the activated gum. While the present invention comprehends the impregnation of a paper web in dried or moist condition with an aqueous solution of the gum, yet solutions of the gum are highly viscous even at very low gum content so that they do not ordinarily lend themselves very well to use in uniformly impregnating the web; and it is, moreover, more expedient from the standpoint of a papermaker to add the powdered gum as such to the papermaking stock, particularly as the powdered gum can be quickly and uniformly dispersed throughout the stock with excellent retention by the stock of the water-swollen gum particles throughout subsequent stock manipulation.
papermaking operations and alkalinizing treatment.

For making papers of high absorbency as well as markedly supernormal wet-strength, as little as 1% to 1½% or even less of the locust bean gum, based on the dry weight of the papermaking stock, may be used pursuant to the present invention. If desired, however, the gum may be used for the purposes hereof in amount up to about 5% or in even greater amount, although it is usually preferable to stay within an upper limit of gum usage of about 5%, based on the dry weight of the papermaking stock, in producing paper products of the absorptivity desired for such an article as paper toweling.

The papermaking stock used for the purposes hereof may comprise any one or a mixture of various cellulose fibers, such as sulphite pulp, kraft pulp, wood pulp refined to high alpha cellulose content, cotton, etc. The pulp may be of unbleached, semi-bleached, or bleached character; and it is to be observed that, because of the whiteness of the locust bean gum, it does not detract from the whiteness of bleached papermaking stock into which it is incorporated. When a paper product of highest absorbency is desired and the papermaking stock is being suspended in water in a beater engine, the beater roll is operated in such a way and for such a period of time as to do little more than individualize the fibers or smooth out the stock sufficiently to enable the formation therefrom of a uniformly textured sheet on the papermaking machine. In other words, the stock is not beaten or hydrated with a view toward developing a paper sheet of the relatively high density requirements of board, writing, or ledger papers. On the contrary, the beater engine is operated essentially as a mixer to bring about uniform suspension of the pulp fibers in the water and uniform dispersion of the gum particles throughout the suspension, assuming that the powdered gum is added to the stock while in the beater engine rather than at a later stage of paper making, say, while it is flowing as a stream to the papermaking machine.

Typical procedures carried out accordant with the present invention involved the use of a mixture of equal parts by weight of bleached sulphite and bleached kraft wood pulps. After the mixed pulps were suspended in water with very little hydration thereof to produce a uniform pulp suspension of appropriate consistency for paper making, namely, of about 1% fiber content, locust bean gum was added as a fine powder to the suspension in amount to yield a paper sheet containing ½% gum, based on the dry weight of the pulp. Specifically, the powdered gum was dispersed uniformly in the dilute pulp suspension at the head box of the papermaking machine. The sheet produced on the papermaking machine, which had a basis weight of about 22 pounds, was pressed and dried in the usual way on the papermaking machine.

The dried paper sheet containing ½% locust bean gum, based on the dry weight of fiber, was dipped into an aqueous borax solution of 1% strength and then redried. Tests showed that the dried, weakly alkalinized product had a wet-tensile-strength of 1.4 pounds. When a solution of 1% borax was sprayed onto a similar predried, gum-containing paper sheet in an amount of 300%, based on the weight of the dried gum, and the sprayed sheet redried, it was found that the dried, weakly alkalinized product had a wet-tensile strength of 1.8 pounds. Since it appeared that the use of excessive borax solution might have the effect of leaching out some of the gum, a similar predried, gum-containing paper sheet was sprayed with borax solution of 1% strength in the amount of only 150%, based on the weight of the dry gum, and the sprayed sheet redried, in which latter case it was found that the wet-tensile strength of the dried product had risen to 2.0 pounds. All of the dried, mildly alkalinized gum-containing paper products were, however, characterized by a wet-strength much greater than that of a paper sheet similarly made but of waterleaf character, that is, containing no gum. Indeed, the similar waterleaf paper sheet had a wet-tensile strength of only 0.20 pound. It might be noted that the dried, mildly alkalinized, gum containing paper products hereof were of substantially unimpaired water absorbency in the sense that they imbibe water practically as freely and practically to the same extent as the similar waterleaf paper sheet. Their excellence for such purposes as towelin need hence hardly be stressed.

In testing the paper products hereof for their wet-tensile-strength, the method is to moisten a strip of½" inch width by means of a pulp brush dipped into water and subjecting the strip thus moistened or brushed transversely at the appropriate zone to the tensile-strength-testing machine. The wet-tensile-strength recorded by the machine represents the load in pounds which the moistened strip of ½" inch width can support at the rupture or breaking point.

It is to be understood that the exemplary procedures hereinbefore given are subject to wide variation without departing from the spirit or scope of the invention hereof as defined by the appended claims. Thus, it is possible to apply the inventive principles hereof in making paper products of widely varying basis weight and compactness and adapted for many uses besides that of taking up water while resisting disintegration. For instance, a wet-strengthened, absorbent paper product hereof containing locust bean gum as the wet-strengthening agent may undergo a secondary impregnation with water-repellent materials of oleaginous, resinous, or waxy nature. Thus, it may be impregnated with paraffin, or the like to produce a water-repellent paper sheet suitable for use as a lettuce crate-liner, for wrapping celery, etc. In such latter spheres of use, it is desirable that the water coming from the melted ice in which the heads of lettuce or bundles of celery are packed be repelled by the paper-liner or wrapper.

So far as concerns the alkalinization of a predried paper web containing the locust bean gum, it is possible, as already indicated, to use any alkaline solution capable of imparting to the paper a pH value greater than 7. It is thus seen that alkaline solutions of widely varying alkalinity or strength are useful for the purposes hereof and that the alkalinity of such solutions may be afforded with alkalis or alkaline compounds of many different kinds, even though for some purposes, such as towelin, it is preferable to work with dilute alkaline solutions whose alkalinity is provided by such mildly alkaline compounds as borax. The amount of alkaline solution used to alkalinize the gum in situ in the gum-containing paper web is also subject to wide variation, but it is generally preferable to apply no more alkaline solution to the web than is necessary to wet or alkalinize the web substantially uniformly throughout while avoiding dripping or drainage.
of solution from the web in such amount as might be attended by undesirable extraction or loss of gum from the web. In usual commercial practice, the gum-containing paper web after its alkalization or treatment with alkaline solution is dried or redried at elevated temperature, as on the steam-heated drier drums of a paper-making machine. It is thus seen that the process hereof can be practiced while a sheet of paper is being made at the customary high papermaking speeds and the resulting continuous sheet of paper containing the gum can be activated or brought to the desired high wet-strength by alkalization while such sheet is pursuing its high speed continuous course from the station of alkalization, through the drier, and thence to the reel.

I claim:

1. A method of making a paper product of high wet-strength, which comprises forming paper from paper-making stock containing powdered locust bean gum in an amount not more than about 5%, based on the dry weight of the stock; and alkalizing the resulting paper with an aqueous solution of an alkaline compound.

2. A method of making a paper product of high wet-strength, which comprises forming paper from paper-making stock containing powdered locust bean gum substantially uniformly dispersed throughout in an amount not more than about 5%, based on the dry weight of the stock, wetting the resulting paper with an alkaline solution of sufficient alkalinity to impart thereto a pH value greater than 7, and drying the alkalinized paper.

3. A method of making an absorptive paper product of high wet-strength, which comprises incorporating into substantially unhydrated papermaking stock not more than about 5% of powdered locust bean gum, based on the dry weight of the stock, forming paper from the resulting stock, alkalining the paper substantially uniformly with an aqueous solution of a mildly alkaline compound, and drying the paper.

4. A method of making an absorptive paper product of high wet-strength, which comprises incorporating into substantially unhydrated papermaking stock about ¼% to 1% of powdered locust bean gum, based on the dry weight of the stock, forming paper from the resulting stock, wetting the paper substantially uniformly with a solution of borax, and drying the paper.

5. A method of making a paper product of high wet-strength, which comprises incorporating into papermaking stock powdered locust bean gum in an amount not more than about 5%, based on the dry weight of the stock, forming paper from the resulting stock, spraying the paper with a solution of mildly alkaline compound in amount to wet the paper substantially uniformly throughout while substantially avoiding the extraction of the gum therefrom, and drying the paper at elevated temperature.

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