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SYNTHETIC FIBER PAPER

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The present invention relates to the art of paper making and is more particularly concerned with the manufacture of specialty papers having physical characteristics and properties closely resembling the light-weight, long-fibered, porous, tissue papers disclosed and claimed in my prior United States Patents Nos. 2,045,095 and 2,045,096. In a sense, the present invention may be said to be an outgrowth or continuation of the development set forth in these prior patents for the purpose of manufacturing paper for specialty requirements.

The light-weight, long-fibered, porous, tissue paper manufactured in accordance with the aforesaid patents has attained wide-spread use in industry for various purposes. For instance, a large proportion of the tea bags now on the market is made up of paper of this character. Also, this type of paper has found considerable use as a base for stencils and for packing and cleaning lenses.

While these papers serve very well for the indicated and other uses, there is one inherent drawback which, up to the present time, has not been solved. Since these light-weight papers are made up of natural fibers, particularly fibers of *Musa textilis*, the characteristics of the finished paper are dictated more or less by the physical characteristics of the original fibers. In other words, in many cases the natural fiber may be either too short or too wide, or both, for some uses.

It is the primary object of the present invention to provide a process for the manufacture of paper, particularly paper of the foregoing type, wherein many variations in the paper characteristics may be adjusted at will.

Having the foregoing in mind, I have been able, after considerable research, to prepare a light-weight, long-fibered, porous paper composed substantially entirely of synthetic, artificially formed fibers. Insofar as I am aware, the production of finished paper sheets composed substantially entirely of synthetic, artificially formed fibers and having substantial strength has heretofore been considered impossible. This is probably due to the fact that ordinary or conventional, non-fibrous binders, bonding agents or cements, such as glues, starches, sodium silicate, etc., which are applied in solution form and then dried, do not possess sufficient binding strength to cause the synthetic fibers to entangle or bond together to give the resultant sheet sufficient strength. As a matter of fact, I have actually found that these con-

ventional bonding agents are so lacking in binding strength for this purpose that a synthetic fiber web employing such binders is so weak structurally that it cannot be removed from the paper making wire as a sheet.

Some attempts have been made to prepare paper from a mixture of natural fibers and varying amounts (up to 50%) of a soluble synthetic fiber, such as cellulose acetate fiber. Papers made up of such a fiber mix are then treated with a solvent or heat, or in some cases both, to cause the acetate fibers to coalesce or congeal. This after-treatment, which serves to "fix" the acetate fiber is costly and requires the use of solvents, usually inflammable. Furthermore, it is very difficult to control the "fixing" so that the fiber will not be completely melted or dissolved.

It has now been found that paper of the foregoing characteristics can be manufactured from synthetic fibers, in which the synthetic fibers may be used in amounts up to 98% and wherein such a good fiber bond is obtained that the paper possesses sufficient strength for the specialty purposes indicated.

The terms "synthetic fiber" or "synthetic, artificially formed fiber" as employed herein refer only to those fibers which are manufactured by truly synthetic or "reforming" methods wherein a solution of the fiber is extruded through very small orifices (spinnerettes) and then the extruded solution allowed to congeal either in a precipitating bath or by evaporation of the solvent or by temperature changes, thereby forming continuous filaments of any desired diameter which can later be cut into any desired length. The invention is definitely limited to the use of synthetic fibers of the foregoing character and does not contemplate the use of chemically treated or modified natural cellulose fiber, such as nitrated cellulose and the like.

Dimensions of these synthetic fibers useful in the practice of the invention vary in accordance with the type of paper produced. In general, however, fiber lengths of from $\frac{1}{8}$ inch to 1 inch and fiber diameter of 12-80 microns, corresponding to $\frac{3}{4}$ to 5 denier, are recommended for the type of tissue contemplated.

A great variety of synthetic fibers may be employed for the purpose of the present invention, and I have found that synthetic fibers such as cellulose acetate, cellulose nitrate, regenerated cellulose from viscose, Vinylite (a synthetic resin made by polymerization of vinyl compounds), Aralac (a fibrous product made from skim milk

casein), and spun glass; may be used in amounts as high as 98% of the basic raw material.

A very important feature of the present invention resides in the use of a specially prepared, fibrous binding or bonding agent capable of causing the synthetic fibers to adhere one to the other to such a degree as to provide sufficient strength in the finished paper sheet. Fibrous binders found useful for the purpose under consideration are derived from two sources:

When some natural fibers are digested and subsequently washed, there is washed away a material which is made up of very small fibrillae having dimensions in the magnitude of 0.002 inch long and 0.000035 inch wide, and which may be reclaimed and used as a binding flock. Some fibers are especially rich in this material. I have found, for instance, that the inner section of the *Musa textilis* leaf has an abundance of this material.

I have also found that a suitable binding flock can be produced by taking natural fibers and hydrating them in a beater to an extent much beyond the hydration usually employed in highly beaten papers. In fact, the fibers should be beaten to a point where their dimensions approximate those of the natural fibrillae described in the foregoing paragraph, and where the hydrated cellulose has the color, appearance and consistency of heavy cream. Under a high-power microscope one can observe that the natural fibers have lost most of their original fiber structure and have been broken down into countless, very short and very fine microscopical filaments. If one studies the surface of natural paper making fibers, such as *Musa textilis*, under the electron microscope and compares it with the surface of synthetic fibers, the function of the present binding flock becomes apparent. Under the electron microscope with up to 10,000 diameter magnification the surface of the *Musa textilis* unbeaten fiber has countless tiny fibrillae extending from the central fiber. These fibrillae are responsible for giving the paper formed by these fibers its physical strength. They interlock the main fibers thereby holding them together. The electron microscope shows the synthetic fiber to be absolutely smooth with no fibrillae extending from its central fiber. For this reason there is no interlocking of the fibers in the paper mat and they pull apart very easily, thereby giving no strength to the paper sheet. The discovery has been made, in accordance with this invention, that fibrillae may be supplied through the use of the binding flock so that the synthetic fibers may be held together in matted form.

The size of the fibrillae of the binding flock is microscopical and a comparison of the size of one with the average size of fibers in ordinary papers should be considered.

The following table illustrates a comparison, generally, of average fiber dimensions of the synthetic fiber employed in the invention, the average fiber found in ordinary papers such as tissues, news and writing, as compared to the dimensions of the fine filaments or fibrillae which are employed in the binding flock for the synthetic fibers.

	Synthetic fiber	Ordinary fiber	Binding flock
Length.....inches..	.31	.071	.002
Width.....do.....	.001	.002	.000035
Projected area.....sq. in..	.00031	.000142	.000,000,070

It will be understood that all the fiber dimensions in the foregoing table are determined by those dimensions appearing in the finished paper, having all the beating necessary for that particular type of paper. It will be observed that the projected fiber area of fibers in the usual papers is more than 2,000 times as large as the projected area of the fiber making up the binding flock and the synthetic fiber projected area is approximately 4000 times the projected area of the microscopical binding flock fibrillae.

It should be further understood that in producing these microscopical fibrillae, not all of the original flock-producing fibers get broken down to the dimensions shown in the table under the term "binding flock." Some fibers will escape complete reduction in spite of long continued beating action. However, substantially all the fibers must be broken down to these small fibrillae to get good results. Unless at least 90% of the total flock-forming fiber is broken down to within plus or minus 25% of the above fiber dimensions, weak synthetic fiber paper will be formed with great difficulty in handling on the paper machine. Stated differently, at least 90% of the fibrillae in the flock are .0015 to .0025 inch in length and .000027 to .000044 inch in width.

It is important, in selecting a fiber for the preparation of this type of binding flock, that it be one which will take a good hard beating action and produce hydration rather than pulverization. At the end of the beating the freeness, as registered on the Gurley freeness tester, should be near zero contrasted to a freeness of 50 to 500 for usual paper manufacture. Different fibers produce binding flocks of varying characteristics but I prefer the flock derivable from such fibers as flax, Manila hemp, caroa, and hemp, although I have made an acceptable flock from bleached kraft pulp.

The binding flock may be used in proportions such that the fibrillae make up 2 to 10% of the finished paper product based on dry weight. Paper containing even as little as 2% by weight of the binding flock possesses sufficient strength to give good machine operation and good use characteristics. Additional strength can be realized if more flock is used and I have found that if 10% of flock is employed a stronger paper results than that prepared from natural fibers of the same length.

The papers of the present invention, being made up of long synthetic fibers are very porous due to the fact that many interstices are left between the fibers. Examination under a powerful microscope discloses that at each crossing of the synthetic fibers there will be a discernable bond caused by the extremely fine filaments of the binding flock.

It is obvious from the above that many variations in the paper characteristics can be achieved due to the fact that one is able to use any predetermined fiber length, any predetermined fiber width, and various small amounts of binding flock to vary the strength. As pointed out hereinbefore, accurate operating conditions such as these have never been possible when using natural fibers.

The actual paper making steps are quite simple. The stock is made up by first providing a mixing vat to which is added the required amount of water. The desired synthetic fibers of predetermined diameter are then cut to the length desired in the finished paper and added to the vat. After the fibers and water have been added to

the vat and well mixed, the desired amount of previously prepared binding flock is added. It should be pointed out that this mixing operation is in no way comparable to the action obtaining in an ordinary paper making beater. The action is purely and simply a mixing one and the fibers remain in substantially their original form. After thorough mixing the stock is fed onto the inclined Fourdrinier wire of the paper making apparatus disclosed in my prior United States Patent No. 2,045,095.

Exemplary of the make-up and characteristics of specialty papers manufactured in accordance with the present invention the following may be mentioned:

Stencil paper—6¼#—base weight:

Fiber length—¾ to ¾ inch

Denier—¾ to 1½

Binding flock—2 to 8%

Bursting strength—¾ to 5½# per square inch

Tea bag paper—8½#—base weight:

Fiber length—¾ to ¾ inch

Denier—½ to 5

Binding flock—4 to 8%

Bursting strength—3 to 12# per square inch

In connection with that type of paper useful in the making up of tea bags, it might be mentioned that by suitable choice of synthetic fiber a thermoplastic tea bag paper could be made by the process of the invention. In other words, the edges of two superimposed sheets enveloping a charge of tea may be heat-sealed in machinery provided for this purpose to form the finished tea bag. This obviates any after-treatment of natural fiber papers heretofore used for this purpose to render them thermoplastic and heat-sealable.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of my invention.

This is a continuation-in-part of application Serial No. 470,637, filed December 30, 1942, now abandoned.

What is claimed is:

1. A thin, porous, light-weight, finished tissue paper of substantial strength comprising about 98% unbeaten, synthetic, artificially formed, extruded fibers ⅛–1 inch in length and 12–80 microns in diameter matted and firmly held together in sheet paper form with about 2% of a fibrous cellulosic flock binder composed of microscopical fibrillae at least 90% of which are .0015 to .0025 inch in length and .000027 to .000044 inch in width, said synthetic fibers being uniformly distributed throughout the sheet in substantially their original, fibrous, ungelatinous, uncoalesced form but being spaced to present many interstices.

2. A thin, porous, light-weight, finished tissue paper of substantial strength comprising at least 90% unbeaten, synthetic, artificially formed, extruded fibers ⅛–1 inch in length and 12–80 microns in diameter matted and firmly held together in sheet paper form with 2 to 10% of a fibrous cellulosic flock binder composed of microscopical fibrillae at least 90% of which are .0015 to .0025 inch in length and .000027 to .000044 inch in width and which are derived from plants and leaves, said synthetic fibers being uniformly distributed throughout the sheet in

substantially their original, fibrous, ungelatinous, uncoalesced form but being spaced to present many interstices.

3. A thin, porous, light-weight, finished tissue paper of substantial strength comprising at least 90% unbeaten, synthetic, artificially formed, extruded fibers ⅛–1 inch in length and 12–80 microns in diameter matted and firmly held together in sheet paper form with 2 to 10% of a fibrous cellulosic flock binder composed of microscopical fibrillae at least 90% of which are .0015 to .0025 inch in length and .000027 to .000044 inch in width and which are obtained by highly hydrating natural fibers in water suspension, said synthetic fibers being uniformly distributed throughout the sheet in substantially their original, fibrous, ungelatinous, uncoalesced form but being spaced to present many interstices.

4. A thin, porous, light-weight, finished tissue paper of substantial strength comprising at least 90% unbeaten viscose fibers ⅛–1 inch in length and 12–80 microns in diameter matted and firmly held together in sheet paper form with 2 to 10% of a fibrous cellulosic flock binder composed of microscopical fibrillae at least 90% of which are .0015 to .0025 inch in length and .000027 to .000044 inch in width and which are obtained by highly hydrating natural fibers in water suspension, said viscose fibers being uniformly distributed throughout the sheet in substantially their original, fibrous, ungelatinous, uncoalesced form but being spaced to present many interstices.

5. A thin, porous, light-weight, finished tissue paper having a bursting strength of more than ¾ lb. per square inch comprising at least 90% unbeaten synthetic, artificially formed, extruded fibers ⅛–1 inch in length and 12–80 microns in diameter matted and firmly held together in sheet paper form with 2 to 10% of a fibrous cellulosic flock binder composed of microscopical fibrillae at least 90% of which are .0015 to .0025 inch in length and .000027 to .000044 inch in width and which are obtained by highly hydrating natural fibers in water suspension, said synthetic fibers being uniformly distributed throughout the sheet in substantially their original, fibrous ungelatinous, uncoalesced form but being spaced to present many interstices.

6. A thin, porous, light-weight, finished tissue paper of substantial strength comprising essentially unbeaten, synthetic, artificially formed, extruded fibers ⅛–1 inch in length and 12–80 microns in diameter matted and firmly held together in sheet paper form with a fibrous cellulosic flock binder composed of microscopical fibrillae at least 90% of which are .0015 to .0025 inch in length and .000027 to .000044 inch in width, said synthetic fibers being uniformly distributed throughout the sheet in substantially their original, fibrous, ungelatinous, uncoalesced form but being spaced to present many interstices, said binder comprising 2 to 10% of the weight of the finished paper.

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REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
1,790,839	Richter	Feb. 3, 1931

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