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PAPER-MAKING MATERIALS.—II.*

SUGGESTIONS FOR THE MANUFACTURER.

BY F. P. VEITCH.

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CONSERVATION OF PAPER-MAKING MATERIALS.

It is evident that more attention must be given in the future to maintaining sufficient supplies of materials to meet the legitimate demands of the paper-making industry. This is an agricultural and economic problem which may be met in several different ways, the essential consideration being that it shall be solved to the greatest advantage of the country at large. It is customary to suggest that other materials than those now generally employed must be used, and particularly that some new material or process must be discovered or that a crop must be especially grown for the purpose. There are, however, a number of ways in which the materials now best known may be made to satisfy still greater demands, some of the more important of which may properly be discussed here.

Use of Larger Quantities of Scutching Wastes.

In preparing textile fibers for use, there is much waste in separating the fiber from the body of the plant tissue, and further waste in getting the fiber in proper condition for market. The fiber thus lost may be termed "scutching waste," and while no definite figures can be given as to the quantity of such waste, as most of it occurs in barbarous or semi-civilized countries, it has been variously estimated at from 25 to 50 per cent. Assuming the lower figures, the waste from the jute, manila, and sisal imported to this country would equal approximately 150,000 tons annually, and would make 120,000 tons of high-grade paper.

The scutching waste from the hemp industry, though perfectly suitable for paper, is too small in quantity to play any material part in paper making, and the growing of it primarily for this purpose is impractical, owing to the fact that hemp even at the rate of 2 cents per pound makes the paper cost as much as that made from medium-grade rags.

Larger Use of Waste Textiles and Waste Paper.

Quantity and Value of Available Wastes.—Approximately 2,030,000 tons of cotton, flax, hemp, jute, manila, sisal, and other vegetable textile fibers are made into fabrics annually in this country, and all of this sooner or later in the form of cuttings, waste from the manufacturing processes, and rags, finally finds its way into other industrial uses or is destroyed. Statistics show that approximately 400,000 tons of this kind of material, 200,000 of which are imported, ultimately reach the paper mill, leaving about 1,800,000 tons of fabrics, practically all of which is destroyed. This is sufficient to make 1,440,000 tons of the very best paper. Of course it is not possible to recover all of this material. There is some loss in the manufacturing processes through which it passes and a great loss due to wear, but it is a conservative estimate to say that 1,000,000 tons of paper stock could be secured annually from this source alone, and at 1 cent per pound (rags sell at from 1 to 6 cents per pound) would be worth \$20,000,000.

This 1,000,000 tons of waste textiles would make 800,000 tons of the strongest, most durable, and best paper, or more than enough to supply all the book, cover, plate, writing, high-grade wrapping, and blotting paper and bristol board now made in this country. There is a sufficient quantity of waste textiles to supply all demands for fine paper for years to come, and probably such papers will continue to be made from these materials, as no others which can compete with rags in cost are now known.

More than 3,000,000 tons of paper are now made annually in this country, of which fully 80 per cent, or 2,400,000 tons, becomes waste material in three or four years. Of this, about 25 per cent, or 588,000 tons, is again used in the form of new paper cuttings and trimmings and old paper for making new. Here also we estimate that fully 1,000,000 tons of raw material which would make 900,000 tons of paper could be readily saved from waste at a cost of collecting that would permit its use, as most of it is to be found in the cities and towns in the form of old books, writing paper, news paper, wrapping paper, and pasteboard. Most of this waste is not suitable for high-grade papers, but could readily be used for wrapping, cover, and blotting papers, and boards. The wholesale price of such paper ranges from \$2 per hundred pounds for new high-grade cuttings to \$1 for new white paper, and from 65 cents for folded newspaper to 20 cents per hundred for common scrap paper of any kind. Valuing the waste paper at 0.5 cent per pound, the 1,000,000

tons of paper now wasted that could be saved is worth \$10,000,000 per annum, and would make all of the building, bagging, cover, blotting, and miscellaneous papers, and all the paper board now produced. Though the cost of raw material per ton of paper is slightly greater at the above valuation than when produced from wood, the cost of manufacture from waste paper is much less, so that the product made from waste paper is fully as cheap as that from wood.

Gathering and Grading.—A more general appreciation, particularly among the country people, of the market value of rags, old rope, and waste paper of all kinds would increase largely the supply of paper stock and add considerably to the income of the people. The value for paper making of the waste textiles of the country is greater than the value of the rye crop, one-twentieth that of the wheat crop, one-third of the total value of the products of the saddlery and harness industry, half as great as that of the hardware, and as great as that of the fur goods industry. Rags to the value of \$9,000,000 annually are now used for paper making and about three times this quantity could probably be secured, which, at the same valuation, would distribute approximately \$27,000,000 among the people; \$7,000,000 worth of waste paper is used each year in paper making, but it is estimated that three times this amount can be saved, distributing \$20,000,000 per year among the people. It is evident, therefore, that the value of the waste textiles and paper annually destroyed is large and that if these can be gathered profitably, their use will serve the double purpose of producing good paper and of conserving other materials.

The various grades of rags with their current prices are shown in the following table:

Market Grades for Rags, with Current Prices.

	Cents per pound.
New shirt cuttings, No. 1.....	5½ to 6
New shirt cuttings, No. 2.....	4 to 4½
Fancy shirt cuttings.....	3½ to 4
New blue cotton.....	3 to 3½
New mixed cottons.....	1½ to 1½
Old linen:	
White.....	4½ to 5½
Gray.....	2½ to 4
Colored.....	1½ to 2½
New black cotton:	
Soft.....	1½ to 1¾
Mixed.....	1¼ to 1½
No. 1 white, old, clean.....	2½ to 3
Soiled white:	
Street.....	1¼ to 1½
House.....	1½ to 1¾
No. 2 New Yorks.....	1½ to 1¾
Street seconds.....	¾ to 1
Thirds and blues.....	1 to 1½
No. 1 satinette.....	1 to 1½
Mixed satinette.....	½ to ¾
Tailors' seconds.....	½ to ¾
Hard black carpets.....	½ to ¾

Grades of Rags.—Inspection of the preceding table shows that all rags do not sell for the same price. White rags will bring from 2 to 5 cents per pound more than colored ones, clean rags will sell from ½ to 2 cents per pound more than those that are soiled, and new rags are worth from 1 to 3 cents per pound more than old ones. The paper maker does not cook a mixture of old and new, clean and soiled, white and colored rags together, but wants them properly sorted not only according to color, cleanliness, and amount of wear, but also according to the materials from which the fabrics were made, as cotton, linen, hemp, etc. Unsorted rags, even though they consist largely of the best grades, sell at low prices, and therefore the seller, in order to secure the highest price, should carefully sort them. The higher price of clean rags may even justify washing those that are soiled.

Grades of Waste Paper.—Different kinds of waste paper also sell at different prices, and as mixed paper sells at a comparatively low price, it is profitable to grade it. The following table shows the market grades for waste paper in this country, with current prices of each:

Market Grades for Waste Paper, with Current Prices.

	Price per 100 pounds.
No. 1 hard white.....	\$2.10 to \$2.15
No. 2 hard white.....	1.80 to 1.90
No. 1 soft white.....	1.45 to 1.50
No. 1 colored.....	.65 to .70

Price per 100 pounds.

No. 2 colored.....	\$0.45 to \$0.55
Flat stock.....	.75 to .80
Crumpled sheet stock.....	.70 to .75
Book stock.....	.55 to .65
Solid ledger stock.....	1.40 to 1.50
Ledger stock.....	1.20 to 1.25
No. 1 white news.....	1.05 to 1.10
White paper.....	.90 to 1.00
Extra new manila cuttings.....	1.25 to 1.30
New manila cuttings.....	1.05 to 1.15
No. 1 old manila.....	.65 to .70
No. 2 old manila.....	.40 to .45
New box board chips.....	.35 to .40
New straw chips.....	.40 to .45
Bogus paper.....	.50 to .60
Mill wrappers.....	.50 to .60
Strictly new overissue news.....	.55 to .65
Strictly folded news.....	.40 to .45
Broken news.....	.25 to .30
No. 1 mixed news.....	.25 to .30
Straight straw and other boxes.....	.35 to .40
Mixed straw and other boxes.....	.30 to .35
No. 1 mixed papers.....	.20 to .35
Common papers.....	.15 to .20

As with rags, new, clean, white materials command higher prices than old, soiled, printed, or colored materials. The kind of fiber of which the paper was made also affects the price, as is shown by the quotation of ledger cuttings as compared with No. 1 book stock, the former as a rule being made of rags, while the latter is largely chemical wood. Therefore in order to secure the highest market price, waste paper should be graded as shown by the table.

Improvements in the Quality of Paper.

One of the most striking points brought out in the work of this laboratory in the examination of paper is that the quality of any class is seldom as good as the materials and the technical skill of the maker can produce. The several processes of paper making frequently are not conducted in such a way as to produce the strongest, most durable, and best appearing papers of a given kind. This is particularly true of papers which should have strength or durability, many of which are overloaded with clay, which weakens them, or are not properly beaten and run to give them good formation and the maximum strength of the material. This is found especially in wrapping papers and boards whose value for practical purposes depends on their strength and pliability. Thus 24 by 36 inch paper, weighing 65 pounds per ream of 500 sheets and made from chemical wood fiber, should easily have a strength of 45 pounds (Mullen), and, indeed, by proper manipulation of the processes such a paper can be made with a strength of 50 pounds. As a matter of fact, however, most 100-pound papers have a strength of only 45 pounds or less per square inch, a result due to the use of ground wood or to insufficient preparation of the stock. Again, in the case of ordinary print paper, well made from chemical wood, a 24 by 36 inch paper, weighing 39 pounds per ream, and having a strength varying from 15 to 20 pounds, is more resistant to folding, as opaque, as strong, and as desirable in every way as many 60-pound papers. Often other desirable qualities are sacrificed to secure temporary appearance and "feel," while the strength is obtained by increasing weight, instead of by a better preparation of stock, as should be the case.

Reduction of Weight and Bulk of Papers.

All classes of paper now made are almost invariably needlessly heavy and thick. The purpose for which paper is employed, whether it be for printing, writing, or wrapping, can be as well accomplished in nearly all cases, both from the utilitarian and the æsthetic point of view, by lighter and thinner paper, as suggested in the preceding section, if greater care in manufacturing is taken. The strength and quality are improved at the same time, and the consumption of paper reduced thereby from 15 to 50 per cent, to the advantage and profit of the consumer. Thus the employment of 60- and 80-pound book papers, or even of 50-pound paper, is a totally unjustified waste in most cases, as every purpose can be accomplished by 30- and 40-pound papers. Much lighter and thinner writing and wrapping papers can be employed in the vast majority of cases with quite as satisfactory results as are obtained from papers that weigh 80, 100, and 120 pounds per ream.

* A circular issued by the Bureau of Chemistry of the Department of Agriculture.

The production of lighter and thinner paper is important not only to the nation, but to the individual as well, since not only are materials thus conserved but better, and frequently cheaper, papers are secured. For example, ordinary printing paper weighs from 45 to 80 pounds per ream (24 by 36 inches), but 35- to 50-pound papers are made from the same materials, which are superior in every particular, a saving of from 22 to 40 per cent in weight. Wrapping papers are of all weights, but many 25- or 50-pound papers are stronger than 50- or 100-pound papers, so that often a saving in weight of as much as 50 per cent can be made. It is true that lighter, thinner, and better papers cost more per pound, but a pound contains more sheets. Paper is sold on the basis of weight, but is used on the basis of area, and a ream of each serves the same purpose. For example, the 35-pound paper mentioned above sells at 4.23 cents per pound, while the 45-pound paper sells at 3.7 cents. Therefore a ream of the former costs \$1.65; of the latter, \$1.77. Again, bogus manila paper made largely of ground wood (low grade) is quoted at 1.75 cents per pound; No. 1 manila (high grade) is quoted at 5.5 cents per pound, and No. 1 sulphite manila (medium) at 4.75 cents per pound. A 100-pound bogus manila has the same strength as a well-made 35-pound No. 1 manila or a 65-pound No. 1 sulphite manila. A ream of each costs, then, \$1.75, \$1.92, and \$2.92, respectively.

The paper of highest quality and price costs but little more per ream than that of the lowest quality and price and much less than the medium grade. Further, the cost of transporting, handling, and storing heavy bulky paper is greater than for the lighter ones. It is therefore believed that not only will raw materials be conserved, but the cost of the total quantity of paper used per year will be less when it is made lighter and of better quality. On the whole it is a conservative statement that the quantity of paper now used in this country can readily be reduced 25 per cent by making from the materials now employed better paper and by using no heavier paper than is required by the service to be performed.

THE NECESSITY FOR GROWING PAPER-MAKING MATERIALS.

It has frequently been suggested that materials be produced for paper making just as any other farm crop is grown, and it is worth while to inquire into the necessity for doing this. Summarizing the foregoing conservative estimates, there are annually produced in the United States agricultural and industrial wastes furnishing raw materials in much greater quantity than can be consumed in paper making for many years to come.

Estimate of Wastes Suitable for Paper Making
Produced Annually.

Material.	Waste.		Yield of Paper.
	Quantity.	Value.	
	Tons.	Dollars.	Tons.
Waste textiles suitable for papers of the highest quality and strength.	1,000,000	\$20,000,000	800,000
Flax fiber suitable for the best and strongest paper.	600,000	18,000,000	480,000
Forest waste from lumber industry suitable for medium and low grade paper.	12,000,000	60,000,000	5,000,000
Waste paper suitable for high quality and lowest quality.	1,000,000	10,000,000	900,000
Cereal straws suitable for medium quality paper and boards.	70,000,000	350,000,000	28,000,000

1 Cords.

No consideration is given here to the large quantities of marsh and other wild grasses, of bagasse, and corn and cotton stalks, which are also available, but not as desirable technically as those mentioned, nor to the bast fiber of *malbon* and other bast fibers which occur in large quantities. While it is true that not all of the above-mentioned materials could be acquired for paper making, owing, for example, to their greater value to those who produce them for other purposes, it is evident that there is no danger of the immediate exhaustion of such raw materials even on the present basis of production of paper.

The industrial conditions that have made wood the chief raw material will undoubtedly continue to encourage its extensive use for many years, so that the price of wood will largely fix the price of any competing material. Manifestly no comparisons in dollars and cents can be made, and it will probably be sufficient to say for the guidance of those interested in growing paper-making plants that the problem primarily resolves itself into a financial one. On the one hand, one must produce a material which can successfully compete in quality and cost with other available paper-making materials. On the other hand, the crop produced must be as profitable as other farm crops. If paper can not be made from the new crop as cheaply as from other materials, the mills will not buy it; and if it will not yield as large profits as other farm crops, the farmer will not raise it. It is believed that no plant so far suggested will fulfill these conditions at the present time, except as previously suggested for local consumption where transportation greatly in-

creases the cost of paper made from the commonly used materials.

CONCLUSION.

All fibrous vegetable material from whatever source derived can be used for making paper. The utility of a particular material for this purpose is governed chiefly by the cost and value of the finished paper as compared with the product made from other materials.

Without altering quality, the weights of most papers can be reduced from 10 to 20 per cent, and by decreasing weight and improving quality the amount of paper now consumed can be reduced from 10 to 50 per cent, varying with the kind of paper. It is estimated that the quantity of paper now used in this country can be reduced about 25 per cent by improving its quality and reducing its weight. In other words, 2,250,000 tons of paper will do equally well the service now performed by 3,000,000 tons.

The growing demand for paper-making materials may be supplied by the more conservative use of those which long years of practical paper making have demonstrated are well suited to the purpose. When thus used there are ample quantities to meet normal requirements for many years.

Larger quantities of waste textiles and paper should be employed for paper making. It is estimated that 2,000,000 tons of such wastes, worth approximately \$30,000,000, can be secured annually in this country. This material would produce 1,700,000 tons of paper. If this were used, the quantity of wood annually used for paper making could be reduced to about 2,000,000 cords per year.

The cheapest known raw material for medium-grade paper which can be obtained in large quantities is wood. It is highly important to practice conservative methods in its use. Therefore, the great quantity of waste from the lumber industry should be utilized for paper making wherever possible. It is probable that such "new" materials are the cheapest available.

There are large quantities of cultivated and wild straws and grasses and of flax fiber available which can be used for paper making. Economic agricultural considerations indicate that the cultivated straws should only be thus employed when the woods and textile and paper wastes can no longer supply the demand or are too costly. Flax fiber, when it can not be put to more important uses, should be employed in paper making.

Finally, when all of these supplies are no longer adequate and when economic conditions are such as to justify such innovations, there are suitable quick-growing materials which may be produced primarily for paper making.

ARTIFICIAL PLASTIC SUBSTANCES.

The manufacture of artificial plastic compositions has become an important branch of industry. These compositions include artificial caoutchouc, artificial leathers, celluloid, viscid, and other derivatives of cellulose, and plastic masses obtained from casein, maisein, gelatine, albumen and various other substances.

Artificial or Imitation Caoutchouc.—Waste scraps of vulcanized India rubber are pulverized and mixed with a solution of calcium sulphide and tar. The mixture is heated from 24 to 60 hours in a closed digester to dissolve out the sulphur added in vulcanizing, and the tar is distilled off at reduced pressure. The mass is then stirred and washed with hot water.

Neilson regenerates vulcanized rubber by treating it with oil of rosin at from 400 to 570 deg. F.

Ducastle and Alexander employ benzine and solution of soda.

Groetz employs aniline, alcohol, bisulphide of carbon, etc., and precipitates the caoutchouc from the solution of amylic alcohol (fusel oil) methyl alcohol (wood alcohol), or acetone.

Imitations of caoutchouc are also made from oils, for example, by treating a drying oil with monohydrated nitric acid and washing the resultant nitro compound, or by combining the oil with sulphur or chloride of sulphur.

Werbeck prepares a paste of gelatine, phosphate of lime, tannin and bituminous oil, and mixes it with olein soap to produce an imitation of caoutchouc.

Lesage uses gelatine coagulated in glycerine and adds a solution of genuine caoutchouc.

Lusenia di Rosa employs gelatine coagulated by tannin and mixed with castor oil, ether, and fulminating cotton. The mixture is then treated with carbon dioxide or acetylene, and finally evaporated.

Artificial or Imitation Leathers.—Planz makes a substitute for leather by combining jute, cotton, hair, glue, ceresine, lard, and water.

Brigant treats leather scraps with an alkaline solution, washes them with water and disintegrates them by passing between corrugated rollers. The shreds are then mixed with water and the resultant pulp is refined and converted into sheets by the methods employed in paper-making. The sheets are then piled together and felted to produce leather of the desired thickness.

Sylvestre treats felt with a solution of gum resins, caoutchouc, and oil.

Viscose, combined with cellulose, has been employed in the manufacture of artificial leather.

PRODUCTION OF HELIUM FROM URANIUM.

By FREDERICK SODDY.

In a paper in the October number of the Philosophical Magazine of last year I gave a preliminary account of some attempts to detect and measure the production of helium from the primary radio-elements, on which I have been engaged since 1905. The results given were few, and referred mainly to the element thorium. The following further results, obtained since the publication of the paper, with the element uranium carry the subject a stage further. The method is described in detail in the paper referred to. By special arrangements the solutions of the substances employed can be freed absolutely from air, and maintained in this condition indefinitely. After any desired period of accumulation the gases can be completely expelled by boiling the solution in a stream of gas from a voltameter. The expelled gases are freed from water by cooling, and then subjected to the action of the vapor of calcium in a special vacuum furnace, whereby all but the inert gases are perfectly absorbed. After cooling the furnace is filled with mercury, and the residual gas, if any, compressed into the smallest possible spectrum tube of lead glass. The minimum quantity of helium detectable in a successful experiment has been found by repeated trial to be 2×10^{-10} gramme. Blank tests with a similar apparatus containing sodium sulphate solution were performed, and I feel confident that the data obtained are trustworthy.

I have used two separate quantities of uranium nitrate. The first and smaller had been carefully purified by Mr. T. D. Mackenzie by extraction with ether. It contained 340 grammes of the element uranium. When it became evident that the rate of production was too slow to be conveniently estimated with this quantity, a second experiment on a much larger scale was started. The cost of this and similar other large-scale experiments was defrayed by a research grant from the Carnegie trustees. Four kilogrammes of uranium nitrate of good commercial quality, which had been re-crystallized from water, were employed. It contained 1,850 grammes of uranium. The preparation of the experiment and complete removal of air were effected by August 15 of this year. The first test for helium was performed after a period of sixty-one days. Helium in several times the minimum quantity detectable by the method employed was proved to be present in the extracted gases. The second test was performed after a period of twenty-seven days. Helium was again present, this time in quantity not much, if any, greater than the minimum detectable. The next test was performed after twelve days. No helium could be detected, although the experiment was a singularly perfect one. An experiment was then performed with the smaller quantity of uranium after a period of accumulation of 128 days. Helium was clearly detected, and its quantity estimated to be not greater than 1.5 times the minimum quantity.

The production of helium from uranium may therefore be considered to be established. With regard to the rate of production, the experiments show that this cannot be far from 2×10^{-12} (year)⁻¹. That is to say, about 2 milligrammes of helium are formed per year per million kilogrammes of uranium. The second test referred to shows that the rate is not less than 1.5. The third test shows that it is less than 3.3. The last test with the smaller quantity shows that the rate is not less than 1.7, and probably not greater than 2.5. It is of interest to note that the theoretical rate of production I recently calculated from the disintegration theory is 2×10^{-13} (year)⁻¹, on the assumption that one atom of uranium produced but one atom of helium. These measurements, therefore, lend no support to the view, discussed in the paper referred to, that uranium on disintegration expels two helium atoms.

I may mention that I have commenced the observation of a quantity of sylvine (potassium chloride), one of the minerals investigated by Strutt, and regarded by him as exceptional in containing helium which cannot be ascribed to known radio-active changes. The tests so far indicate that the rate of production of helium from this substance, if any, is below 2.5×10^{-12} (year)⁻¹.—Nature.

Freezing Salt.—Freezing salt, for the production of refrigerating mixtures, contains 20 per cent of calcium chloride, 20 per cent of magnesium chloride, 6 per cent of sodium chloride, 13 per cent of potassium chloride, and 41 per cent of water. If this salt is mixed with an equal volume of snow at 32 deg. F. we obtain a mixture of +5 deg. F. to -4 deg. F. (the latter below zero); if mixed, in equal parts, with snow or crushed ice at 23 deg. F., the temperature of the mixture will sink below -22 deg. F. (below zero).