

DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

WASHINGTON

(August 21, 1935)

PUBLICATIONS ON PAPER AND PAPER RESEARCH BY THE STAFF OF THE
NATIONAL BUREAU OF STANDARDS

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GENERAL INFORMATION

1. Character of Researches

The paper research of the National Bureau of Standards consists of studies related to the standardization of paper and the materials and processes used in its manufacture. The work on the standardization of paper leads to formulation of standards of quality, and includes, necessarily, the development of means of measuring quality. For research related to the manufacture of paper, the paper section is equipped with complete laboratory and semi-commercial papermaking facilities. This is used to obtain information which will assist the paper maker in obtaining the desired qualities in paper at a minimum of cost, in developing new or improved paper products, and in utilizing new fibrous raw materials, particularly waste materials.

2. General Scope of Bureau Work

The Bureau of Standards is charged with the development, construction, custody, and maintenance of reference and working standards, and their intercomparison, improvement, and application in science, engineering, industry, and commerce. The bureau is organized in three principal groups - research and testing; commercial standardization; administrative work, operation of plant, and construction of laboratory instruments and apparatus. The following divisions comprise the research and testing group: electricity, weights and measures, heat and power, optics, chemistry, mechanics and sound, organic and fibrous materials, metallurgy, clay and silicate products. The Commercial Standardization group consists of three divisions: simplified practice, specifications, and trade standards. The research and testing divisions are made up of 68 sections each of which deals with a particular branch of the divisional work.

3. Description of List

This list includes not only research reports of the paper section dealing primarily with paper, but also reports from other sections of work relating to paper. Publications not listed are those which have become more or less obsolete through being superseded by later publications or because they contained information of temporary value only. The publications are listed in chronological order and are arranged in groups dealing with the same general subject.

4. How to Obtain Publications

The reports of the investigations are published either in Government publications or in outside publications. The bureau usually receives reprints of the articles published outside and furnishes those available free of charge. Copies

of the publications can be consulted in many of the larger libraries. Where the price is noted, the publication may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. The prices quoted are for delivery to addresses in the United States and its possessions, and to Canada, Cuba, Mexico, Newfoundland, the Philippines, and the Republic of Panama. When remitting for delivery to countries other than those, include in your remittance one-third of the total cost of publications to cover postage. Remittances should be made payable to the "Superintendent of Documents, Government Printing Office, Washington, D. C." and sent to him with the order.

Articles marked with the asterisk (*), are out of print and reprints are no longer available. Many of the articles are published in more than one journal and references to journals in addition to those given may be found in "The Bibliography of Papermaking", by C. J. West, published by the Lockwood Trade Journal Co. and available in most libraries.

Serial letters are used to designate Bureau publications:

- RP - "Research Paper". These are reprints of articles appearing in the "Bureau of Standards Journal of Research" (BSJ. Research) and the "Journal of Research of the National Bureau of Standards" (J. Research NBS), the latter being the title of this periodical since July 1934 (volume 13, number 1).
- S - "Scientific Paper" of the National Bureau of Standards. From numbers 1 to 329, inclusive, the separate papers of this series were known as reprints from the "Bulletin of the Bureau of Standards" (Bul. BS). Subsequently, from numbers 330 to 572, the separates were known as reprints from the "Scientific Paper of the Bureau of Standards" (Sci. Pap. BS). This series superseded by the "Bureau of Standards Journal of Research" in 1928.
- T - "Technologic Paper" of the National Bureau of Standards. Numbers 1 to 202 were issued each independent of the other with individual pagination. Later they were assembled to make the first 15 volumes of this series, and subsequent separates were given volume pagination. (Tech. Paper BS). This series was superseded by the "Bureau of Standards Journal of Research" in 1928.
- C - "Circular" of the National Bureau of Standards.
- M - "Miscellaneous Publication" of the National Bureau of Standards.

For papers in other scientific or technical journals, the name of the journal or of the organization publishing the article is given in abbreviated form, together with the volume number (underscored) page, and year of publication, in the order named.

5. Outside Publications Cited

Envelope Industry (discontinued).
India Rubber World, 420 Lexington Ave., New York City.
Paper (discontinued).
Paper Industry, 333 N. Mich. Ave., Chicago, Ill.
Paper Mill, 22 E. 40th St., New York City.
Paper Trade J., Lockwood Trade Journal Co., 15 W. 47th St., New York City.
Tech. Assoc. Papers. Technical Association of the Pulp and Paper Industry, 122 E. 42nd St., New York City.

I. PAPERMAKING MATERIALS AND PROCESSES

1. Smith, W. H.
Recovery of paraffin and paper stock from waste paraffin paper*. Washington: Government Printing Office, 1916. 4 p. (U.S. Bureau of Standards, Tech. Papers No. 87).
In order to recover the paraffin and paper stock in waste paraffin paper, a process is described utilizing a vertical steam boiler, tanks for receiving the paraffin, and a beater. The waste is pulped with exhaust steam. The wax rises to the surface and the paper stock settles in the boiler. In the beater the stock is treated with an alkaline solution in hot water to remove ink. The residual wax is collected on a metal cylinder, internally water chilled, and partly submerged in the hot water of the beater. Paper prepared from the recovered stock was free from wax and entirely satisfactory. Practically all of the paper stock is recovered, but about 10 percent of the paraffin is lost.
2. Smith, W. H.
Studies on paper pulps*. Washington: Government Printing Office, 1917. 13 p. (U.S. Bureau of Standards, Tech. Papers No. 88).
Samples of paper pulps, each representing a different method of preparation and with one exception of American manufacture, have been examined to determine their chemical properties. These consist of the amount of ash, cellulose and methoxyl, the yield of furfural and methyl-furfural, and the copper number. Using the same pulps, the loss in weight produced by reagents causing oxidation and hydrolysis and the increase in weight when nitrated have been determined. The effects of sunlight, temperature, and ozonized air on the chemical constants obtained with ground wood have been ascertained.
3. Clark, F. C., and Durgin, A. G.
Couching properties of wet felts*. Paper Industry 1, No. 12; 1115-7 (March, 1920).
Addition of 10 percent of cotton to felt does not materially alter its structure or properties. A little more steam was required to dry the sheets from the cotton-wool felt. This quantity was very small. Somewhat inferior in couching properties to the wool felt. An average of 6.8 percent less water was removed by the cotton-wool felt. It appears that there were less openings through the cotton-wool felt than through the all wool felt.
4. Shaw, M. B., and Bicking, G. W.
Rubber latex in paper. The effect of adding rubber latex to the beater in the experimental manufacture of book and wrapping paper. Paper Trade J. 75, No. 26: 53-55 (Dec. 28, 1922).
This work gives first the claims made by F. Kaye, the inventor of the process of adding rubber latex to paper. This is followed by a discussion of the source, characteristics and method of analysis of the latex. Test runs were made on one and two percent rubber. The data did not show any definite improvements in paper to which latex had been added, the differences being those ordinarily found in any paper. There was a slight increase in bursting strength on book papers. The paper having latex in it

I - 4 (continued)

seemed to be better sized and to take the better finish. There was no increased retention of clay due to the addition of latex.

5. Shaw, M. B., and Carson, F. T.
Aging of rubber latex paper. India Rubber World, 63, No. 3: 561 (June 1, 1923).

Successive analyses of the same papers with increasing age indicates a comparatively rapid oxidation of the rubber retained in paper as a result of adding latex to the beater furnish. Within the limits of the investigation the oxidation was observed to be most rapid in the case of paper made of sulphite and soda pulp and least rapid in the case of rag papers. Complete oxidation in the case of the former was a matter of a few days, while in the latter case several months were required for the greater part of the rubber to oxidize.

6. Shaw, M. B., and Bicking, G. W.
A study of the experimental manufacture of condenser paper. Paper Industry, 5, No. 2: 309-311 (May, 1923).

For the manufacture of power condensers, a light weight paper approximating 0.005 inch in thickness is necessary. The requirements for this paper are that it must be free from pin holes and from conducting particles. Difficulty has been experienced in obtaining such paper since most of the commercial papers contain approximately 30 to 40 such particles per square foot. Satisfactory paper was produced in the bureau paper mill. The chief requirement in manufacturing this paper, in addition to cleanliness, is the use of a stone or composition beater roll from which metallic particles will not chip off.

7. Kellogg, E. H., Shaw, M. B., and Bicking, G. W.
Seed flax straw as papermaking material. Paper Trade J. 77, No. 5: 42-49 (Aug. 2, 1923).

Owing to the immense quantities of seed flax available, most of which is at present wasted, this material has attracted considerable attention as a source of papermaking fiber. An investigation of its use for this purpose was made, using both the whole straw and the tow. The material was pulped by the sulphate process. Pulping tests made in the experimental mill were repeated in a commercial mill to obtain reliable cost data. The pulp obtained from both sources was made into paper on the experimental paper machine.

The results indicate that there would be no difficulty in producing papers equal in quality to those obtained from wood. The cost data show, however, that at the present time both the initial cost and the cost of conversion of flax straw would be greater than that of wood.

8. Shaw, M. B., and Bicking, G. W.
Comparison of American and foreign clays as paper fillers. Washington: Government Printing Office, 1924. 44 p. 23 fig. (U.S. Bureau of Standards, Tech. Papers No. 262.) Price 15 cents. In part in Paper Trade J. 79, No. 18, 119-122; No. 22, 77-84 (Oct. 30, Nov. 27, 1924).

The purpose of this investigation was to ascertain the relative merits of American and foreign clays for use as paper fillers. The comparative

I - 8 (continued)

study included the amount of clay retained in the paper, the quality of the paper produced, and those physical properties of the clay (grit, etc.) that might affect the paper manufacturing processes. Measurements for clay retention include analyses of samples taken at 13 different positions on the paper machine. The results show that the amount of clay retained in the finished paper and the quality of the paper, in general are the same for both American and foreign clays. The color and grit tests favor very slightly the foreign clays, but not sufficiently to justify the consideration of only these properties in selecting clays.

9. Shaw, M. B., and Bicking, G. W.

Method of making uniform fiber sheets for test purposes. Paper Trade J. 79, No. 21: 51 (Nov. 20, 1924).

In investigative work of paper laboratories there is need for a method of making small sheets of fiber, uniform in quality (weight, formation, etc.) and free from the personal factor found in sheets made by hand by the usual method. A description is given of the construction and operation of a fiber sheet mould and press by means of which uniform fiber sheets can be produced.

10. Gottschalk, V. H.

Use of glue in paper coating*. Paper Trade J. 79, No. 20: 46 (Nov. 13, 1924).

Gives results of experiments on clay coating of paper using animal glues of different grades as binder. The relative amounts of glue and casein used in the coating formula are contrasted. The effect of diluting the coating mixture is discussed and a probable connection between this dilution and the mottling in the finished paper pointed out. A summary of color measurements of glue-bound coated paper is included. Some consideration is given the water-resistance and printing qualities of coated paper, and the specifications for coaters glue.

11. Shaw, M. B.

Hydrogen ion concentration in the paper mill. Paper Trade J. 81, No. 10: 59-62 (Sept. 3, 1925).

A discussion of the application of hydrogen ion concentration determinations to control of sizing and other papermaking processes. It is shown that such method of control gives superior results in respect to both quality of paper produced and economy of material.

12. Shaw, M. B., and Bicking, G. W.

A comparative study of paper fillers. Bur. Standards Tech. Paper No. 301 Price 10 cents. Dec. 5, 1925.

Commercial paper fillers consisting of asbestine, talc, clay, crown filler and gypsum, were studied to determine their comparative paper-making value, the tests being made in the semi-commercial bureau mill. The chief difference found was in degree of retention. Due to greater solubility of crown filler and gypsum, they gave lower retentions in the paper than the other materials. The papermaking processes were not adversely affected by any of the materials used. Values for chemical composition and physical characteristics are included for each material.

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13. Shaw, M. B., Bickling, G. W., and Rumsey, R. R.
Cotton stalks as papermaking material. Paper Trade J. 81, No. 5: 50-51 (July 30, 1925); World's Paper Trade Rev. 84, No. 21: 1634-1636 (Nov. 20, 1925).
Severe chemical treatment and long-cooking time were required for pulping. The yield of fiber was good but the paper had poor quality, being suitable only for low grade wrapping or board. The results indicate that this material is not commercially feasible for making paper, at least if the ordinary papermaking methods are used.
14. Shaw, M. B., Bickling, G. W., and Rumsey, R. R.
Esposito as a papermaking material. Paper Trade J. 81, No. 12: 55-56. (Sept. 17, 1925).
Papermaking tests were made on a semi-commercial scale of a partially pulped stock being offered for import from abroad. It yielded 57 to 63 percent of easy bleaching pulp suitable for book and other papers of a similar nature, a mild cooking treatment being required. The fiber was appreciably stronger than that of soda wood pulp, approaching sulphite wood fiber in strength.
15. Homill, G. K.
Consideration of glue bound coated paper. Paper Trade J. 82, No. 8: 247, 249, 251 (Feb. 25, 1926); Tech. Assocn. Papers 9: 77-79 (June, 1926).
Earlier cooperative work by the Bureau of Standards and the National Association of Glue Manufacturers has been continued to include a study of satin white and blanc fixe as coating minerals. No difficulties were encountered in using these materials with glue as the adhesive. The amounts of tanning materials which may be added to glue containing coating mixtures, to increase the water resistance of the coated papers, vary with the grade and type of glue chosen and are largely influenced by the other materials used. With coating mixtures based on medium-grade glues optimum viscosity and working life were obtained at about 85° F. Considerable attention has been paid to the problems of printing coated papers. The need for closer cooperation between paper manufacturers, ink manufacturers, and printers is stressed.
16. Shaw, M. B., and Bickling, G. W.
Research on the production of currency paper in the Bureau of Standards experimental paper mill. Bur. Standards Tech. Paper No. 329. Oct. 20, 1926. 20 p. Price 10 cents. Paper Mill 50, No. 3: 16, 35-40 (Jan. 15, 1927).
Describes some results obtained in determining the durability factors of paper suitable for currency use, with a view to increasing the wearing qualities and thereby prolonging the life of paper money. The experimental papermaking tests were made on a semi-commercial scale under practical mill conditions. The papermaking fiber was obtained from new linen and cotton rags. Various proportions of these materials were tried but best results were obtained with a mixture of 75 percent linen and 25 percent cotton. Paper of satisfactory printing quality and more than double the strength of that being supplied for currency use was produced. The increase in strength was attributable chiefly to the very gradual application of beater-roll pressure and low concentration of beater furnish.

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17. Shaw, M. B., and Bicking, G. W.

Stipa ichu grass as a papermaking material. Paper Trade J. 83, No. 18: 105-106 (Oct. 28, 1926).

Tests on stipa ichu grass from Ecuador were made to determine the value of the material as a potential source of paper pulp. The tests were limited to laboratory scale production and consisted of the usual papermaking processes. The sheets made were submitted to the various physical tests applied in evaluation of paper. Two cooking processes were included; one employing 25 percent of caustic soda; the other 25 percent of lime. The yield of unbleached pulp was 25.5 and 56.6 percent, respectively. The pulp from the caustic cook was difficult to bleach and that from the lime was deficient in strength. On account of the low yield, high chemical consumption, and lack of strength, ichu grass is not considered satisfactory papermaking material. It gives a soft and bulky sheet, and is, however, doubtless suitable for use as filler with the stronger fibered pulps.

18. Hammill, G. K., Gottschalk, V. H., and Bicking, G. W.

Surface sizing of paper with glue. Paper Trade J. 83, No. 23: 39-43 (Dec. 2, 1926.)

Growing interest among manufacturers and consumers in the permanence of paper and in improvement of strength and printing qualities of papers as related to surface sizing processes has led to a cooperative study of surface sizing by the Bureau of Standards, the Bureau of Efficiency, and the National Association of Glue Manufacturers. The results indicate that with any given paper (1) the bursting strength increases with increased retention of the glue; (2) the folding endurance increases at first with increasing glue content and then decreases; (3) the resistance to water and to wet rubbing of glue sized papers may be markedly increased by treatment with glue hardening materials such as formaldehyde; (4) the folding endurance of either unsized, rosin sized, or surface sized papers may be increased by the addition of softening agents such as glycerine; and (5) that the effects of glycerine treatment as ordinarily applied are short lived.

19. Hamill, G. K., Shaw, M. B., and Bicking, G. W.

Glue as beater sizing. Paper Trade J. 84, No. 3: 38-43 (Jan. 20, 1927); Paper Mill 50, No. 8: 44 (Feb. 19, 1927); Paper Makers' Mo. J. 65, No. 5: 179, 181 (May 16, 1927).

Because of the possibility of improving certain desirable qualities of papers, especially of those types made from the lower priced fibers and containing mineral fillers, various methods of using glue in the beater sizing of paper were studied. Optimum operating conditions and maximum retentions of glue, comparing favorably with those of the clay used, were obtained when the hydrogen-ion concentration was so controlled that the pH value approximated 4.5. In general it was found that in papers sized with glue and rosin the strength is frequently and the degree of sizing is generally improved as compared with similar papers sized with rosin alone. These improvements were most noticeable in papers containing clay filler. The chief influence of glue on the various types of papers seemed to be to enhance such intangible properties as firmness and handling qualities.

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20. Hamill, G. K.

Water resistance of mineral coated papers. Paper Trade J. 84, No. 8: 146-147, 149; 151, 153, 155 (Feb. 24, 1927); Tech. Assocn. Papers 10, No. 1: 20-25 (1927); Paper Mill 50, No. 9: 130-132, 134, 136, 138, 140 (Feb. 26, 1927).

In studying improvements in the water resistance of glue-bound papers by treatment with formaldehyde, comparisons were made of several water-resistance test methods as well as of certain empirical tests commonly applied to coated papers. There appeared to be no fixed relationship between the results of testing coated papers by several different methods. The water resistance of glue-bound coated papers may be materially increased by either applying formaldehyde to the freshly coated paper or incorporating formaldehyde in the coating mixtures. With coating mixtures based on medium-grade glues the optimum viscosity and working life occurs at about 85° F. Under these conditions from 5 to 8 percent of formaldehyde, based on the weight of glue may be added without harming the coating mixture.

21. Shaw, M. B., and Bicking, G. W.

Manila ropewaste for paper manufacture. Paper Trade J. 84, No. 18: 68-70 (May 5, 1927); World's Paper Trade Rev. 88, No. 10: 728 (Sept. 2, 1927).

Experimental papermaking tests were made to determine the suitability of manila rope waste for paper manufacture. The waste employed was the refuse fiber from the manufacture of manila cordage at the rope walk of the Boston Navy Yard. The tests were made at the request of the Bureau of Construction and repair with a view to finding a market for the rope waste of the Navy Department. The tests were on both laboratory and semi-commercial scale. Different cooking agents were employed in the pulping operation. Kraft and sulphite wood pulps and old rope stock are included for comparison. The results indicate that soda ash is the digesting agent that gives best results, both as to yield of pulp and quality of paper produced. The waste does not compare favorably with old rope stock but is considerably better than sulphite wood pulp and seems worthy of consideration as a papermaking material.

22. Shaw, M. B., and Bicking, G. W.

Waste mail pouches as papermaking material. Paper Trade J. 84, No. 19: 45-46 (May 12, 1927).

Semi-commercial tests were made to determine the papermaking value of waste mail pouches declared unserviceable for postal use. Owing to the unavoidably dirty condition of worn pouches the market price of the refuse material has been relatively low. As a result the General Supply Committee requested the tests with a view to securing for the condemned material a price commensurate with its papermaking quality. A good grade of clean half stuff was obtained from the waste by the caustic soda and the lime - soda ash processes. The paper produced was stronger than that made from sulphite wood stock and compared favorably with many of the high-grade bond and rag writing papers on the market.

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23. Shaw, M. B., and Bicking, G. W.

Caroea fiber as a papermaking material. Tech. Paper No. 340. 24 p.
May 23, 1927. Price 25 cents.

Laboratory and semi-commercial mill tests have been made to determine the papermaking qualities of caroea fiber. The tests have shown the material to be very suitable for the production of paper, especially for use with or as a substitute for rag and rope stock, of which there is a scarcity at the present time. Caroea is a South American plant now little used commercially but production and cost estimates indicate that its use for papermaking would be practical. The caustic soda process was employed in preparing the pulp. There was made unbleached paper of unusual strength suitable for bag or wrapping purposes, and bleached paper that compared favorably with papers made from rag stock. The chemical consumption and yield of pulp were satisfactory. A comparative micrographic study was included in the investigation.

24. Hamill, G. K.

The uses of glue in the paper industry*. Pub. by: The Glue Research Corp. 1928.

A hand-book published by the Glue Research Corporation. It gives a summary of the information gathered during the investigation of the uses of glue in the paper industry, by the National Association of Glue Manufacturers Fellowship at the Bureau of Standards. The publication contains an outline of papermaking processes in general, information on uses of glue in beater sizing, surface sizing and coating, and a bibliography of publications dealing with these subjects.

25. Shaw, Merle B., Bicking, George W., and Streiter, O. G.

Experimental production of roofing felts. Bureau of Standards Journal of Research 2, No. 6: 1001-1016 (June, 1929). Bureau of Standards Research Paper No. 67. Price 5 cents.

Experimental felts were made with varying proportions of the usual fibrous materials and with a high content of low-grade substitutes such as waste papers and sawdust. The waterleaf felts were made in the semi-commercial paper mill of the bureau but were saturated and coated, and thus converted into roofing, in a commercial roofing mill. The results indicate that relatively large amounts of the substitutes can be introduced into roofing felts without causing great difficulty in the manufacturing processes.

26. Shaw, Merle B.

Equipment and research work of the Bureau of Standards. Paper Trade J. 89, No. 19: 60-63 (Nov. 7, 1929).

The laboratory and semi-commercial equipment used for study of paper-making problems is described in detail and illustrated with photographs. The results obtained with the equipment are mentioned and current work is described briefly.

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27. Shaw, M. B., and Bicking, G. W.
Further experimental production of currency paper in the Bureau of Standards paper mill. Bureau of Standards Journal of Research 3, No. 3: 899-926 (Dec., 1929). Bureau of Standards Research Paper No. 121. Price, 15 cents.

The publication describes recent experimental tests to improve the durability of United States currency paper, and is supplementary to Tech. Paper No. 329, which reported the results obtained in earlier stages of the study. The subsequent work included the use of caustic soda as compared with lime for cooking the rags, the effect of variation in fiber composition, further study of the beating procedure, determination of optimum surface-sizing conditions for the best printing results, and comparative study of commercial manufacturing operations and bureau practice. As a result of the investigation, the strength of currency paper has been doubled, and paper of similar quality, superior in strength to any previously available, is being produced commercially. It is believed that the test data will be of value in the general technic of papermaking.

28. Shaw, M. B., and Bicking, G. W.
Rayon as a papermaking material. Bureau of Standards J. Research 4, No. 2: 203 (Feb. 1930) RP143. Price, 5 cents.

Laboratory tests were conducted to determine the papermaking value of rayon when treated the same as rags are in the production of fine papers. Owing to loss of strength when wet, the rayon filaments tended to break into short lengths during the preparation of the papermaking stock without the fibrillation and freying necessary for good felting properties. As a consequence the all-rayon paper lacked the strength to withstand the handling required in the pressing and drying operations, and the softness and and pliability characteristic of rag papers. Sheets made of rayon in admixture with sulphite pulp were also considerably weaker than those made from sulphite alone. The test data indicate that rayon is valueless in the rag stock for high-grade papers and may actually be detrimental to their quality.

29. Shaw, M. B., and Bicking, G., and Snyder, L. W.
Preparation of fiber test sheets. Bur. Standards J. Research 5, No. 1: 105-114 (Jan., 1930) RP190, Price 5 cents.

A laboratory method developed at the Bureau for making small sheets of fibers for evaluating the papermaking qualities of pulp is described. The method relates to the forming of the sheet of fibers on the mold and the subsequent operations of couching, pressing and drying. With the equipment and procedure described, the sheets are made of uniform quality - formation, weight, - and can be duplicated as desired. The personal equation is reduced to a minimum and truly comparable results are obtained by different operators.

30. Shaw, M. B., Bicking, G. W., and O'Leary, M. J.
Further study of paper coating minerals and adhesives. Bur. Standards J. Research 5, No. 6: 1189-1203 (Dec., 1930); Research Paper No. 254, Price 10 cents.

In view of recent developments in paper coating materials, tests were made to determine the comparative value of casein, glue and modified starch as adhesives, and of domestic and foreign clays and a commercial compound of diatomaceous earth as minerals, for coating paper. Printing tests were made on the coated papers at the Government Printing Office by the half-tone process. The diatomaceous earth compound did not adhere well to the fiber sheet. The American clay that had been refined by present methods compared favorably with the foreign clays. Equally good results were obtained with the three different kinds of adhesives, although the starch-bound coatings may possibly have absorbed somewhat more ink in the printing.

31. Shaw, M. B., Bicking, G. W., and O'Leary, M. J.
The papermaking properties of phormium tenax (New Zealand Flax), Bureau of Standards J. Research 6, No. 3: 411 (March, 1931) RP285, Price 10 cents.
Experimental laboratory and semicommercial papermaking tests were made to ascertain the suitability of phormium tenax (New Zealand flax) fiber for paper manufacture. In a number of the tests the preparation of the pulp included two successive cooking operations, fractional digestion. Either the caustic soda digestion process or two stage cooks using sodium sulphite and caustic soda, respectively, gave very good results, on the basis of both quality of fiber produced and yield obtained. The experimental data indicate that phormium tenax is a promising material for wrapping or writing papers, but that it needs to be thoroughly cleaned mechanically before being submitted to the papermaking operations.
32. Rasch, R. H., Shaw, M. B., and Bicking, G. W.
Highly purified wood fibers as papermaking material. Bureau of Standards J. Research 7, No. 5: 765 (Nov. 1931) RP372, Price, 10 cents.
Studies were made in the bureau paper mill of the papermaking qualities of highly-purified wood fibers with particular reference to their use for permanent record and currency paper. They were found to produce papers having high strength, stability, opacity and other properties necessary for such purposes. Study of the variables in the usage of the paper sizing materials showed that alum and rosin decreased the stability of the papers unless the amounts used were very carefully controlled, but that starch and glue used for surface sizing improved the stability. The fibers studied were a commercial product characterized by high alpha cellulose content, low copper number, and high strength.
33. Whittier, E. O., Gould, S. P., Bell, R. W., Shaw, M. B., and Bicking, G. W.
Commercial casein-relationship between laboratory tests and coating quality. Ind. and Eng. Chem. 25, No. 8: 904 (August, 1933).
The coating quality of commercial caseins differs considerably but the major differences can not be related to the chemical composition or to the customarily determined physical properties of the caseins. Hydrochloric acid caseins and "self-sour" caseins yield coatings differing in smoothness and surface-sizing. Both poor and good caseins were found among samples made by each of the commonly used methods. Laboratory determinations and results of coating tests are given in detail on 13 commercial caseins and on 5 caseins made by different methods from the same lot of milk. The significance and limitations of tests on casein are discussed.

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34. Rasch, R. H., Shaw, M. B., and Bickling, G. W.
A study of some factors influencing the strength and stability of experimental papers made from two different sulphite pulps. Bur. Standards J. Research, 11, No. 1: 7 (July 1933) RP 574, Price 10 cents.
A series of 43 experimental bond papers were made in study of the effect of beating treatment and sizing materials on their stability and strength. Excess alum in both beater and surface sizing adversely affected the stability of the papers, but the rosin used in beater sizing did not promote instability. Both glue and starch surface sizing had little effect on the strength and stability of the papers. The papers made with the most favorable beating and sizing treatments had only a moderate degree of stability.
35. Weber, C. G., Shaw, M. B., and C'Leary, M. J.
The papermaking quality of cornstalks. Nat. Bur. Standards Misc. Pub. M147 (Feb. 1935) Price 5 cents.
This investigation was made to determine the practical possibilities of utilizing cornstalks, a waste farm product, for paper. Pulping difficulties presented by structural characteristics of the plant were overcome by special mechanical preparation, and the material was pulped without difficulty by both the sulphate and caustic soda processes. The fibers are not strong enough for use in brown wrapping papers, but bleached pulp suitable for writing paper and greaseproof specialties was obtained by the caustic soda process. Yields were very low, making raw materials and processing costs comparatively high.
36. Bowker, R. C.
Durability of sole leather filled with sulphite cellulose extract*. Bur. Standards Tech. Paper 215 (1922).
Leathers filled with sulphite cellulose extract and with the ordinary tanning materials were prepared and tested. The data obtained from actual service tests failed to disclose any difference in quality between the two types of leather.
37. Wallace, E. L. and Bowker, R. C.
Use of sulphite cellulose extract as a tanning material*. Bur. Standards Tech. Paper 339 (1927).
Results of a study of the suitability of sulphite cellulose extracts, derived from waste sulphite liquors, for use in tanning hides. Various extracts were analyzed for tannin content in comparison with ordinary vegetable tanning materials, and information regarding the combination of tannins in these extracts with hide substance is presented. It is concluded that sulphite cellulose extracts are suitable for use in the tanning processes, and may be substituted for more costly materials.
38. Meyer, W. W.
The colloidal nature and related properties of clays. Bur. Standards J. Research 13, No. 2: 245 (Aug. 1934) RP 706, Price 5 cents.
A theory is presented on the colloidal nature and related properties of clays, based upon the findings of certain soil scientists and the existing knowledge of the phenomena of coagulation, deflocculation, plasticity, drying, shrinkage, and dry transverse strength. It is thought

I - 38 (continued)

that this paper will allay some of the present confusion of ideas concerning the subject of clay colloids by adaptation of this theory to furnish a more satisfactory explanation of the above phenomena.

39. Shaw, M. B., Bicking, G. W., and O'Leary, M. J.

A study of the relation of some properties of some cotton rags to the strength and stability of experimental papers made from them. Bur. Standards J. Research 14, No. 6, (June, 1935) RP 794, Price 10 cents.

Experimental high-grade bond papers were made in the semi-commercial paper mill of the bureau from new and from old rags to obtain information on the factors affecting the strength and stability of rag-fiber papers. The data show that high acidity resulting from excessive use of alum in rosin-sizing had a marked deteriorative effect upon these papers. The pH value for optimum results as far as stability is concerned was approximately 5.0. Of papers of the same acidity those having the lesser content of rosin were the more stable. The study shows that careful processing of raw materials in respect of active chemical components (alum, rosin, etc.) is necessary for the manufacture of stable papers.



II. PRINTING

1. Weber, C. G., and Cobb, R. M.

Register studies in offset lithography*. Bur. Standards J. Research 2, No. 3: 427 (Sept. 1932) RP 480.

Information on factors affecting the register of prints, the most serious problem encountered in offset printing has been obtained by making experimental printings in a commercial plant under routine operating conditions. The history, composition and properties of the papers used are described, the technique used in plant studies is outlined, and the effects of the important factors influencing the closeness of register, as determined by the experimental printings, are discussed in detail.

2. Weber, C. G.

Relation of paper properties to printing quality*. Paper Industry 15, No. 8 (Nov. 1933).

Information on current studies of paper problems related to the printing process requirements are presented for nontechnical readers. Some typical problems are discussed, methods of attack are mentioned, and progress is shown. The article was requested for publication in a trade journal.

3. Weber, C. G., and Snyder, L. W.

Reactions of lithographic papers to variations in humidity and temperature. Bur. Standards J. Research 12, No. 1 (Jan. 1934) RP 633, 5 cents.

The reactions of papers of known response to offset lithography to changes in relative humidity have been observed for a range of 27 to 72-1/2 percent relative humidity with constant temperature and a range of 68° to 110° F temperature with constant relative humidity. The influence of changes in relative humidity and temperature on moisture content and the effects of moisture content variations on dimensions were determined. Information on the rate of conditioning and on the hysteresis effects of adsorption, and the physical strength properties were determined at the different humidities. The reactions of the papers to atmospheric changes was correlated with the results of experimental printings previously made. Recommendations are made relative to the handling of paper in lithographic plants.

4. Weber, C. G.

Relation of paper properties to register in offset lithography. Bur. Standards J. Research 13, No. 5 (Nov. 1934) RP 730, Price 5 cents.

Papers of known history, in the manufacture of which the fiber properties were carefully controlled were tested in the laboratory and printed on a commercial press. The relationship between fiber properties and distortion of paper and misregister in offset printing was studied. Previous studies had been made using papers from one mill, of fiber from the same source. Additional information was obtained in this study. By using papers made according to recommended practice, in three different commercial mills, of pulps from widely different sources, sufficient information to permit general conclusions with respect to chemical wood offset papers was obtained.



III. PRESERVATION OF RECORDS

1. Rasch, R. H.

A study of purified wood fibers as a papermaking material. Bur. Standards J. Research 3, No. 3: 459 (Sept., 1929) RP 107, Price 15 cents.

The qualities of highly purified wood fibers and commercial papers prepared from these fibers are being investigated from the standpoint of chemical purity, color, durability and permanence; and compared with other typical papers and papermaking fibers. In order to simulate as closely as possible the deteriorating effects of natural aging, and thus determine the probable relative permanence of various types of papers and paper-making fibers; accelerated aging treatments are made and the effects measured. The results indicate that purified wood fibers are suitable for conversion into high-grade bond and permanent record papers, which have hitherto been made entirely from a high grade of rag fiber.

2. Scribner, B. W.

Permanence standards for printing and writing papers. Transactions of the A.S.M.E. 52, No. 19 (Aug. 1930).

Experience with printed and written records has shown the necessity of having adequate standards of permanency for selection of record papers. Sufficient technical knowledge is available for the formulation of such standards, and there is sufficient interest in their establishment, to make such a project feasible. This paper outlines the available information on the permanence of papers and indicates how it may be applied to formulate definite technical specifications for permanence qualities.

3. Burton, J. O.

Permanence studies of current commercial book papers. Bur. Standards J. Research 7, No. 3: 429 (Sept. 1931). RP 349, Price 5 cents.

4. Rasch, R. H.

Accelerated aging test for paper. Bur. Standards J. Research 7, No. 3: 466 (Sept. 1931). RP 352, Price 5 cents.

A series of Government bond and ledger paper was studied with reference to properties related to their permanence. They were tested for fiber purity, non-cellulosic components, and strength. The influence of the components of the papers on their stability was studied by subjecting the papers to the effects of heat and light and testing them for loss of strength and deterioration of fiber. The results indicate the feasibility of classifying papers relative to their stability by means of an accelerated aging test made by heating them for 72 hours at 100° C.

5. Kimberly, A. E., and Hicks, J. F. G.

Light sensitivity of resin paper-sizing material. Bur. Standards J. Research 6, No. 5: 819 (May 1931) RP 307, Price 5 cents.

The effect of light upon rosin, and compounds of rosin formed during the rosin sizing of paper was studied, both in air and in nitrogen. The rosin and rosin compounds were exposed to the light of an inclosed carbon arc lamp in quartz tubes. Changes of color in nitrogen, an inert gas, indicated that oxygen is not essential to the chemical alteration of rosin when exposed to light.

III -

6. Kimberly, A. E., and Hicks, J. F. G.

A survey of storage conditions in libraries relative to the preservation of records. Bur. Standards Misc. Pub. 128 (Oct. 5, 1931) Price 5 cents.

A survey of leading present-day libraries was undertaken to determine the extent to which conditions of storage may be responsible for the deterioration of records and other material stored in libraries. The inspection stressed conditions within the book stacks relative to the control of temperature, humidity, air pollution, and the exclusion of light, all of which are recognized as important factors. It was found that while the effects of light and dust were well guarded against in general, no library was able to control adequately the variation of temperature and relative humidity, and none attempted to minimize acidic pollution of the air. In view of these conditions, and of corroborating laboratory experiments, optimum conditions of air purity, temperature and illumination were formulated and means of obtaining them suggested.

7. Kimberly, A. E.

Deteriorative effect of sulphur dioxide upon paper in an atmosphere of constant humidity and temperature. Bur. of Standards J. Research 8, No. 2 (Feb. 1932) RP 407, Price 10 cents.

Fourteen different commercial book and writing papers were exposed for 240 hours to the action of an air-sulphur dioxide mixture, containing 2 - 9 parts sulphur dioxide per million parts of air, at 30° C. and 65 percent relative humidity. Comparison of the physical and chemical characteristics of the papers before and after exposure showed that the test specimens had materially deteriorated. The data obtained indicated that the modified celluloses in the papers were the main point of attack. This is one phase of research to find the effect of atmospheric components on records stored in libraries.

8. Kimberly, A. E., and Emley, A. L.

A study of the deterioration of book papers in libraries. Bur. Standards Misc. Pub. 140 (April 1933), Price 5 cents.

The paper of books stored in city libraries had uniformly deteriorated more than that of books which had been stored in country libraries. Since the paper from books in urban localities had high acid contents and showed the same type of chemical deterioration of fiber as occurs when papers are exposed to air containing small quantities of sulphur dioxide gas, it was concluded that their greater deterioration was mainly due to this fuel-combustion product. Papers containing crude straw and groundwood fibers were in poorer condition than those consisting of chemically treated rag and wood fibers. Data on kinds of fibers found as related to the dates of the books are given for their historical interest relative to usage of fibrous raw materials for book papers.

9. Kimberly, A. E., and Emley, A. L.

A study of the removal of sulphur dioxide from library air*. Bur. Standards Misc. Pub. 142 (Oct., 1933). Price 5 cents.

Tests made in the Folger Shakespeare Library, Washington, D. C. showed that sulphur dioxide, which is harmful to paper, was not completely removed from the air by washing it with untreated water in an air conditioning system of the usual type. Effective elimination was obtained, however, on

III - 9 (continued)

washing the air with water that had been treated with alkaline material at a rate sufficient to maintain the hydrogen ion concentration of the wash water within the range pH 8.5 to 9.0. The sulphur dioxide content of the washed air was found to be entirely dependent upon the hydrogen ion concentration of the wash water. The composition of a mixture of chemicals satisfactory for the treatment of the water is given.

10. Rasch, R. H., and Scribner, B. W.

Comparison of natural aging with accelerated aging by heating. Bureau of Standards J. Research 11, No. 6: 727 (Dec. 1933) RP 620, 5 cents.

Thirty-three papers ranging in fiber composition from 100 percent rag to 100 percent sulphite, including purified wood fiber papers, and book papers prepared from mixtures of sulphite and soda pulp were tested after four years of normal aging for chemical purity and strength. In most respects the papers showed little change under the tests applied. The folding endurance of the papers, however, underwent marked changes, several decreasing to less than half of the initial figure. The papers were placed in approximately the same order of stability by normal aging tests (72 hours at 100° C.) conducted four years previously. This constitutes additional evidence of the validity of the heat test as a means of estimating the relative aging quality of papers.

11. Kimberly, A. E., and Scribner, B. W.

Summary report of Bureau of Standards research on preservation of records. Bur. Standards Misc. Pub. 144 (May 1934), Price 5 cents.

A summary of research on preservation of records during the previous four years is given. A survey of conditions in libraries indicated that light, adverse temperature and humidity conditions, and particularly acid from sulphur dioxide in the air, were important causes of deterioration in addition to poor quality of some of the record papers. Each of these deteriorative agents were given exhaustive studies, which led to recommendations for overcoming them. Means of prolonging the life of records contained on impermanent paper, and of reproducing impermanent records are suggested. The usual acid writing ink was found to be deteriorative to paper but an alkaline ink appeared to be non-deteriorative. Information on protection against insects is included.

12. Scribner, B. W.

Preservation of newspaper records. Bur. Standards Misc. Pub. 145 (1934) Price 5 cents.

Contains information obtained in an examination of newspapers published in the United States as far back as 1830. Relative condition of papers of different kinds of fibers is pointed out and methods of preserving current newspaper records by retarding decay of the papers and by reproduction are suggested.

13. Scribner, B. W.

The preservation of records in libraries. Library Quarterly 4, No. 3: 317 (July 1934)

A resume of the results of research at the Bureau of Standards during the past four years. Light, adverse temperature and humidity, acidic pollution of the air, and low-grade paper were found to be largely

III - 13 (continued)

responsible for deterioration of records. Recommendations respecting protective measures are included.

14. Zimmerman, E. W., Weber, C. G., and Kimberly, A. E.
Relation of ink to the preservation of written records. Bur. Standards J. Research 14, No. 4 (April, 1935) RP 779, Price 5 cents.

Investigation of the comparative resistance of inked and uninked specimens of papers to the effects of an accelerated-aging test revealed that the rate of deterioration of writing papers was increased by the common type of writing inks. An ink made with ammonium ammonium-oxyferrigallate was found to have a minimum of deleterious effect.

IV. STANDARDIZATION OF PAPER

1. Durgin, A. G.

War time uses of paper*. Paper, 24, No. 14 (June 11, 18, 1919).

This is a discussion of the work of the Bureau of Standards on various war problems. It includes: The testing of wall board (See Clark and Conley), the production of a paper to be used in gas masks as a protection against smokes; the use of paper as a substitute for cotton and as surgical bandages (crepe paper bandages); special paper for transportation purposes, such as TNT liners; waterproof labels, etc.; paper sacking; paper for containers for powder, and for use in hand grenades and cartridge boxes; waterproof plug for shrapnell shell; airplane fabrics (a substitute for linen and cotton). The report also discusses various uses of paper by the Central Powers, especially their paper textiles.

A further discussion of some of these subjects may be found in Miscellaneous Publications of the Bureau of Standards, No. 46 (1921), entitled "War Work of the Bureau of Standards", p. 196-202, 70 cents. The topics covered are: Wall and plaster board; paper as a substitute for linen in airplane construction; paper filter for gas masks; paper containers for axle grease and saddle soap.

2. Clark, F. C., and Durgin, A. G.

Study of commercial wall board*. Paper 25, No. 23 (Feb. 11, 1920).

General discussion of classes of wall board and the tests made upon it for the War Department during the war.

3. Houston, P. L.

Suitability of paper and cotton bags in relation to burlap bags for sand*. Paper Trade J. 74, No. 21 (May 19, 1921).

According to all physical tests, as well as a weathering test, certain papers are stronger in their dry condition than either burlap or cotton and in this respect are suitable for sand bags. Paper, however, loses its strength when it is wet, and for this reason, waterproofing is necessary. It is suggested that the paper section study the waterproofing of paper and attempt to manufacture a suitable paper by the scientific control of beating and by the use of chemicals.

4. Houston, P. L.

A study of test methods for the purpose of developing standard specifications for paper bags for cement and lime*. Bur. Standards Tech. Paper 187 (1921).

In addition to the regular tests for paper, a special test is developed for giving numerically the stresses and strain that the paper of these bags undergo in service. This is called the resiliency or endurance test. A service test is given to determine the breaking strength of the paper when the bags are filled and dropped. Another service test is developed for determining the strength of the adhesive used in these bags. Special consideration is given the choice of best bags, as determined from these tests in determining the characteristics of a good quality bag and specifications are drawn up accordingly.

IV -

5. Curtis, F. C.

The standardization of paper*. Paper Trade J. 73, No. 17 (Oct. 26, 1921)

The chief functions of standardization are elimination of waste, increase in production ability and protection of general public in trade. This paper is a discussion of need of paper standardization, as refers to classification, definitions and the simplification of standards as well as the need of specifications which must be determined by the use to which the paper is to be put.

6. Committee on Simplification of Paper Sizes.

Report on simplification of paper sizes*. Paper Trade J. 75, No. 18 (Nov. 9, 1922).

Report of committee from the paper industry appointed by the Bureau of Standards to collect data and make recommendations as to the simplification of sizes of paper. The report was published by the Committee in a booklet "Suggestive Page Sizes". Numerous surveys of printed literature were made. It was found that with changes of from 1/4 to 1/2 inch, practically all literature published could be printed from four standard sheet sizes and their doubles. Recommendations are given as regards standard sizes for different kinds of paper.

7. Committee on Simplification of Paper Sizes.

Report of the Committee on the simplification of paper sizes and other data*. Booklet published by the Committee (Sept. 1923).

A resume of the work of the committees from the Paper Industry which collaborated with the Bureau of Standards in its work on simplification of paper. The results of an extensive survey of existing conditions as regards paper sizes for general commercial printing, for books and magazines, and for bond, writing, and ledger papers are given, and recommendations are made in regard to adoption of standard sizes. The reports of the committees on classification and definitions and on technical specifications are included and some additional data given.

8. Curtis, F. S., and West, C. J.

Classification and definitions of paper. Book published by Lockwood Trade J. Co. (1924) Revised by West (1928).

Report of committee appointed by the Bureau of Standards to develop a suitable classification of paper for statistical purposes and to draft tentative definitions of terms used in the manufacture and merchandising of paper. A classification of paper is given based upon the product as it leaves the mill, no attempt being made to consider the special uses of converted products. In the list of definitions which number over 800, there has been included as far as possible: (a) the basic paper terms used in the classification; (b) the names of commercial papers; (c) converted paper products; (d) standard sizes of papers; (e) special kinds of finishes; (f) miscellaneous terms.

9. Scribner, B. W., and Carson, F. T.

A study of case lining papers for the purpose of developing standard specifications. Bur. Standards Tech. Paper 312 (May, 1926) Price 5 cents.

Investigation of waterproofed case-lining papers was made at the request of the Bureau of Foreign and Domestic Commerce, in order to develop

V - 9 (continued)

information to aid overseas shippers in their selection of such papers. The type found most suitable was duplex asphalted kraft paper. As existing methods of testing the water resistance of such paper were found inadequate, research was made to find a suitable method of test. This resulted in the development of the "Ground Glass" method which is considered satisfactory for this purpose. Specifications of water resistance, strength, and weight were formulated, which are believed to define paper of suitable quality.

10. Lofton, R. E.

Study of the windows of window envelopes for the purpose of developing standard specifications. Bur. Standards Tech. Paper 343 (June 1927)
Price 5 cents.

Gives information as to the number of window envelopes used annually; defines the different types and gives the essentials in the manufacture of the windows. Describes briefly methods of testing for transparency and gloss and gives results of tests. Specifications for quality of one-piece and two-piece windows are given, and also the Post Office Departments' regulations relating to window envelopes.

Glassine and one-piece windows were found to be on the average about equal in transparency, but the latter were considerably higher in gloss. Glassine windows are more permanent in transparency than one-piece windows. Tests indicate that one-piece windows will remain practically permanent for a year or more if properly stored.

11. Carson, F. T., and Worthington, F. V.

A study of sheathing papers. Bur. Standards J. Research 3, No. 1 (July 1, 1929) Rp 85, Price 5 cents.

Thirty-six samples of sheathing paper were tested. Weight and thickness bear no definite relation to each other or to other properties except in papers of like structure. Thickness is no criterion of strength. Many of the heavier papers are comparatively weak. The papers differ greatly in strength retention after wetting. Less than a minute in some cases to several days in others were required for water to penetrate through the papers. Most of the papers were fairly impermeable to air, although some showed relatively large permeabilities. Relation of tests to service requirements is discussed.

12. Scribner, B. W.

Envelope paper qualities and their determination*. Envelope Industry 2, No. 10; 3, No. 1 (Dec. 1928; March 1929).

This article was prepared more especially for the non-technical reader. The requirements of mailing envelope papers in respect to both processing and service are discussed in detail. Simple methods of determining the paper qualities are described and references are given to information on more exact laboratory methods. The general qualities of envelope papers are indicated by the inclusion of government specifications.

13. Weber, C. G., Carson, F. T., and Snyder, L. W.

Properties of fiber building boards. Bur. Standards Misc. Pub. 132 (Dec. 1931) Price 5 cents.

IV - 13 (continued)

Various fiber building boards consisting of representative samples of wall boards and insulating boards have been studied. The composition, manufacture, and uses of the boards are discussed briefly, the results of laboratory tests of the boards are tabulated, and the different properties such as strength, density, water resistance, and expansion are discussed in detail. The test methods used are described fully and comparative properties of the two classes of boards are discussed.

14. Scribner, B. W., and Snyder, L. W.

A study of the physical properties of binders board. Paper Trade J. 95 No. 16 (Oct. 20, 1932).

Study was made in cooperation with the Binders Board Manufacturers Association of the important physical properties of binders board. The test samples used were representative commercial products. The properties tested were thickness, density, weight, bursting strength, tensile breaking strength and elongation, and behavior under flexural stresses. Uniformity of thickness and density of binding boards are both important for securing satisfactory prints on the completed book cover. The serviceability of the boards in the completed book is dependent mainly on their resistance to flexural stresses, and a simple flexural test was developed for measurement of this property.

15. Weber, C. G.

Properties of white braille papers for Library of Congress publications. Bur. Standards J. Research 12, No. 6 (June 1934) RP 690, Price 5 cents.

A study of Braille papers used in printing for blind readers was made to assist the Library of Congress in the purchase of books for the blind. Papers in use by leading commercial Braille process printers were tested; the relationship between paper properties and printing quality was determined; and requirements for satisfactory Braille paper were recommended.

16. Scribner, B. W., and Carr, R. W.

Standards for paper towels. Nat. Bur. Standards Cir. C407 (March 1935), Price 5 cents.

Contains information on quality standards of paper towels relative to their purchase. Their components and properties are discussed relative to serviceability. Tensile strength and time of absorption of water are considered to be the most important properties. Investigation disclosed that the water absorptiveness decreased greatly during six-months storage, and that the decrease can be approximated by heating the towels for 1 hour at 100° C.

17. Barrows, W. P.

The spotting of plated and finished metals. Bur. Standards J. Research 2, No. 6 (June 1929) RP 72, Price 10 cents.

The results of a study of "spotting out" of plated metal finishes are reported. The kinds of spotting defects were studied relative to the nature and causes of the defects and methods of control were investigated. Numerous protective coverings were tested, including anti-tarnish papers and cellulose laquers.

IV -

18. Codes and Specifications.

Standards and specifications in the wood-using industry. Bur. Standards Misc. Pub. M79 (1927), Price \$1.50.

Contains nationally recognized specifications and testing methods.

19. Division of Simplified Practice.

The following simplified practice recommendations are related to paper, price 5 cents each.

S.P.R. No.	Title
R10	Milk and cream bottles and bottle caps
19-28	Asbestos paper and asbestos millboard
22-33	Paper (basic sheet sizes)
31-31	Loaded paper shot shells
34	Warehouse forms
37-28	Commercial forms
42	Paper grocer's bags
44	Box board thicknesses
46	Tissue paper
50	Bank checks, notes, drafts, etc.
64-30	One-pound folding boxes for coffee
68-33	Metal and fiber flashlight cases
75-29	Composition blackboard
81-28	Binder's board
84-28	Composition books
89-32	Coated abrasive products
93-29	Paper shipping tags
98-29	Photographic paper
107-31	Glassine bags
113-30	Restaurant guest checks
114-30	No. 1 kraft paper sealing tape
120-31	Ice cream brick molds and cartons
125-31	Waxed tissue paper
126-31	Set-up boxes
127-31	Folding boxes
128-31	Corrugated boxes
129-31	Notion and millinery bags
132-32	Ice cream cups and cup caps
143-33	Paper cones and tubes
146-33	Corrugated and solid fiber boxes for canned fruits and vegetables
152-34	Basic dimensions for textile cones
153-34	Hole sizes for taper tubes for filling cop winders

20. Commercial Standards Division.

The following commercial standards are related to paper.

C.S. No.	Title
CS 16-29	Wall paper (5 cents)
CS 36-33	Fourdrinier wire cloth (10 cents)
CS 42-32	Fiber insulating board (5 cents)
CS 44-32	Apple wraps (5 cents)
CS 49-34	Chip board and miscellaneous boards for bookbinding (5 cents)
CS 50-34	Binder's board (5 cents)

V. TESTING

1. Lofton, R. E., and Merritt, M. F.
Method of differentiating and estimating unbleached sulphite and sulphate pulps in paper. Washington: Government Printing Office, 1921. 18 p. (U.S. Bur. Standards Tech. Papers No. 189) Price 5 cents.
Contains a review of methods that have been proposed for differentiating between unbleached sulphite and sulphate pulps and gives the procedure followed in developing a new and comparatively rapid method. The method of preparing the new stain and the method of procedure for differentiating between unbleached sulphite and sulphate fibers is described in detail. Tables are given showing the results of quantitative microscopical analysis of mixtures of these fibers stained by the new method.
2. Houston, P. L.
A preliminary study of tearing instruments and tearing test methods for paper testing. Washington, Government Printing Office, 1921. 18 p. (U.S. Bur. Standards, Tech. Papers No. 194) Price 5 cents.
A study is made of the relative effect of different sizes of test samples on the tearing strength of the paper. Data are reported to show that the larger the test sample the greater are the values of tearing strength. The reason for this is brought out as fabric assistance, which is of considerable importance in the textile industry. Since better comparative results are obtained by tearing paper in the machine direction it would seem that all tearing tests should be made in this direction.
3. Houston, P. L., and Ledig, R. H.
The testing of blotting paper*. Paper Trade J. 73, No. 19: 88 (Nov. 10, 1921).
Blotting papers were tested by the Klemm strip test for absorbency, by running 1 cc. of distilled water and of ink from a pipet, by the flotation test and by practical blotting tests. The results indicate that an ash test with consideration of the rag content of the paper is a satisfactory means of determining the quality and is far better than any absorbency test.
4. Houston, P. L.
Supplementary study of commercial instruments for determining the tearing strength of paper*. Paper Trade J. 74, No. 10: 43 (March 9, 1922).
Results of tests on the Elmendorf tester. This tester is built on sound principles of mechanics, is calibrated correctly and will perform satisfactorily provided certain recommendations are made mandatory in order to control test results and prevent the serious variations that different operators are very apt to obtain by using different plies in testing the same papers.
5. Carson, F. T.
The determination of sizing quality. Paper Trade J. 74, No. 14: 43-49 (April 6, 1922).
A resume is made of test methods in common use and data given showing lack of agreement among the methods. O'Kell's electrolytic method is discussed at length, a relation for the resistance within the sheet being derived and a method indicated for conversion of data to a sheet of

V - 5 (continued)

common thickness. A new test method depending upon the curling of paper when placed upon water is described.

6. Carson, F. T.

The determination of sizing quality. A supplementary report on the investigation of the electrolytic method*. Paper Trade J. 75, No. 10: 44-45 (Sept. 7, 1922).

Report of additional experimentation regarding the O'Kell electrolytic method. No definite relation was found between the data curve and the rate of absorption; therefore it was found impossible to give a satisfactory interpretation to the curve as a whole. It is concluded that despite the strong appeal made by the very positive nature of the data obtainable, the method must be considered of doubtful value.

7. Lofton, R. E.

The photomicrography of paper fibers. Washington, Government Printing Office, 1922. (U. S. Bur. Standards, Tech. Papers No. 217) Price 5 cents.

This paper reports an investigation of the efficiency of the incandescent light as a source of illumination in photomicrography, of the value of light filters, of the proper use of the substage condenser and diaphragm, of the advantages of a long bellows extension, and different types of photographic plates. A bibliography on photomicrography and related subjects is given.

8. Merritt, M. F.

Improvements in methods of making the Herzberg stain used in fiber analysis*. Paper Trade J. 75, No. 8: 43 (Aug. 24, 1922).

It is essential in using the Herzberg stain for identification of fibers, that extreme care be taken in its preparation. Variations in method of preparation that may cause poor results are cited and recommendations are given as regards procedure for the best results.

9. Houston, P. L., and Miller, D. R.

A study of commercial dial micrometers for measuring the thickness of paper. Washington, Government Printing Office, 1922. 28 p. 6 fig. (U.S. Bur. Standards Tech. Papers No. 226). Price 10 cents.

In this paper a study is made of the mechanisms, calibrations, areas, and parallelisms of contact surfaces and static contact pressures for different readings of nine commercial micrometers. A performance test is made on the nine instruments, and a new instrument is constructed to measure the compressibility of paper under different contact pressures and different size contacts. The results of the performance and compressibility tests show that different results may be expected from thickness tests on the same paper when different commercial micrometers are used because of their different contact pressures and different size contacts. In the conclusions, recommendations are made for the construction of a new standard micrometer.

10. Houston, P. L.

Effect of length and width of test specimens on the breaking strength and elongation of paper*. Paper Trade J. 76, No. 12: 54 (March 22, 1923); Tech. Assocn. Papers 6: 72-73 (1923).

V - 10 (continued)

There are a number of devices for determining the breaking strength and elongation of paper, but there is little uniformity in the procedure as to width and length of the test strip, the rate of applying the load, and the time during which the specimen is under stress. A study of these various factors indicates that there is a considerable difference in the amount of stretch when the factors are varied, but that, when only the strength is to be considered, the length of the specimen, within certain limits, is negligible and that the strength is almost proportional to the width.

11. Houston, P. L.

A quick test to determine the brittleness of paper*. Paper Trade J. 76, No. 15: 233-235 (April 12, 1923); Tech. Assocn. Papers 6: 117-118 (1923).

By means of two steel rollers, a crease is made under controlled conditions of pressure and time and the bursting strength is determined before and after such folding. The loss in strength under such conditions is an excellent indication of the brittleness of the paper. The grading of paper by this method is practically the same as that obtained by the Schopper folding endurance tester.

12. Houston, P. L., Carson, F. T., and Kirlwood, R. S.

The effect of atmospheric humidity on the physical testing of paper*. Paper Trade J. 76, No. 15: 237-251 (April 12, 1923); Tech. Assocn. Papers 6: 64-71 (1923).

The results of an extended investigation into the effect of humidity changes on the physical properties of paper are presented. Data and extracts from the literature are cited to indicate that the physical qualities are determined by relative humidity rather than by absolute humidity. The data are presented as graphs of the percent variations from values at 65 percent relative humidity, since this condition is used almost universally in the industries. Eleven grades of paper were tested for nine physical properties at eight relative humidities varying from 15 percent to 83 percent. A description of the method of procedure for each test is given and is accompanied by a discussion of results. It is shown that folding endurance, elongation and tearing resistance increase considerably with relative humidity over the observed range; tensile breaking strength and bursting strength increase up to about 40 percent relative humidity and then decrease; the increase with humidity of moisture content, ream weight and thickness is relatively small and the percent change of dimensions of the sheet is smaller still.

13. Lofton, R. E.

A measure of the color characteristics of white paper. Washington: Government Printing Office, 1923. 10 p. 6 fig. (U.S. Bur. Standards Tech. Papers No. 244). Price 5 cents.

Since the color differences between white papers are usually relatively small, it is obvious that a method capable of giving a measure of these differences must be quite sensitive to very small color increments, and that a method which makes use of the principle of multiple reflections will be much more sensitive to small color differences than any method which makes use of a single reflection. The principle of multiple reflections is employed in the Pfund colorimeter, which colorimeter was used to measure

V - 13 (continued)

the color characteristics of 21 commercial papers.

The color characteristics of each paper were determined by finding the coefficients of diffuse reflection for red (wave length 625 mu), green (wave length 550 mu), and blue (wave length 460 mu) light. It was found that none of the papers tested was truly white, but that each was more or less deficient in blue and less so in green.

14. Merritt, M. F.

Preservation of standard fiber samples. Paper Trade J. 78, No. 1: 52 (Jan. 3, 1924).

An investigation was made of the manner of preserving standard fiber samples used for reference in estimating the fiber composition of paper. Samples that had been kept for several years both in the dry state and in water, were tested with the stains commonly used in order to find if the correct color reactions were obtained. The results show that samples may be kept indefinitely in the dry state but that if kept in water, they should be renewed at least every two years. See also U. S. Bur. Standards Tech. Paper No. 250.

15. Carson, F. T.

An analysis of the strength of paper. Paper Trade J. 78, No. 12: 51 (March 20, 1924).

A discussion of the causes of the apparent anomalies in paper testing shown in a previous publication (The Effect of Atmospheric Humidity in the Physical Testing of Paper). The strength of paper is attributed to the net effect of two independent factors, the strength and flexibility of the fibers and the mutual adherence of the fibers. Both of these factors are affected by the changes in moisture content caused by variations in atmospheric humidity. The resulting effects on the different physical tests are discussed.

16. Merritt, M. F.

Pulp and paper fiber composition standards. Washington: Government Printing Office, 1924. 12 p. 9 fig. (U. S. Bur. Standards Tech. Papers No. 250). Price 15 cents.

Contains illustrations of common papermaking fibers and fiber mixtures, showing the color reactions with various stains for use as reference standards in identification and estimation of fiber composition of paper. Details are included regarding the preparation of the stains used, the water colors used to reproduce the colors of the stained fibers and the method of drawing the fibers.

17. Carson, F. T.

The detection of animal size in surface sized papers. Paper Trade J. 78, No. 15: 168 (April 10, 1924); Tech. Assocn. Papers 7: 22 (1924).

The usual tannic acid test for detection of glue cannot be relied on as some starches give a similar reaction. Attention is called to a method of removing starches by hydrolysis before applying the test. A simpler method is described which consists of adding ammonium molybdate in slightly acid solution to an aqueous extract of the paper.

V -

18. Lofton, R. E., and Costello, C. J.
Effect of weight of needle of Mullen paper tester on the bursting strength test. Paper Trade J. 78, No. 20: 58 (May 15, 1924); Tech. Assocn. Papers 7: 43 (1924).
Tests were made of a variety of papers, using three gauge needles of different weights. The results obtained with the different needles agreed closely, showing that the weight of the needle does not influence the bursting test values.
19. Carson, F. T.
Testing waterproof paper*. Paper Trade J. 79, No. 10: 43-50 (Sept. 4, 1924).
A new method for testing papers having a high degree of moisture resistance is described. This is designated as the "Ground Glass" method. The paper to be tested is folded box-shape and filled with water after being placed on a piece of ground glass lying on a dark surface. On lifting the box, if water has gone through, a film of moisture is seen, showing dark in contrast to the ground surface.
20. Carson, F. T.
A new sizing tester for paper. Paper Trade J. 79, No. 17: 44-45 (Oct. 23, 1924).
An instrument is described for applying the "Curl" method of testing paper for degree of sizing. This method has been described in previous publications. Some of the chief features of the new instrument are: means of determining more accurately the time interval of curling; means of temperature control; means of producing automatic and synchronous operations.
21. Lofton, R. E.
The glarimeter and the measurement of the finish of paper. Paper Trade J. 80, No. 7: 47-49 (Feb. 12, 1925); No. 16: 58 (April 16, 1925).
Results are given of a study of the application of the Ingersoll Glarimeter to measurement of degree of finish of paper. It is concluded that the instrument is suitable for this purpose. The method of calibrating the instrument and the procedure to follow in using it are described.
22. Carson, F. T.
An extractor and friction cleanser. Paper Trade J. 80, No. 12: 53-54 (March 19, 1925).
Description is given of an apparatus designed to remove surface coatings from carbon paper and other similar papers. This is of service where it is desired to obtain the basic paper in good condition for testing or where quantitative determination of coating and impregnating materials is desired.
23. Carson, F. T.
Testing paper for permeability to liquids*. Paper Trade J. 80, No. 10: 59-62 (March 5, 1925).
A general discussion of the testing of paper for permeability to liquids, followed by a description of such testing methods developed by the Bureau. These include a dye-sugar indicator method for degree of

V - 23 (continued)

sizing; the use of ground glass as a detector of moisture; an absorption test; and a method of testing impermeability to organic liquids.

24. Carson, F. T.

A small constant humidity testing cabinet*. Paper Trade J. 82, No. 8: 231-7 (Feb. 25, 1926); Tech. Assocn. Papers 2: 69-72 (June, 1926).

Paper is hygroscopic and as its physical properties are considerably affected by its moisture content, strength tests and other physical tests must be made under definite hygrometric conditions. As apparatus for maintaining these conditions in the usual laboratory testing room is quite expensive, most of the industrial laboratories lack such equipment. To assist in remedying this situation, an inexpensive air-conditioned testing cabinet has been developed. The testing instrument is placed inside the cabinet, and the test specimens are handled by means of long-sleeved rubber gloves fastened to apertures in the cabinet, thus obviating the necessity for exposing the interior of the cabinet to the surrounding atmosphere. A constant relative humidity is maintained in the cabinet by circulating the air through a solution of sulphuric acid, the relative vapor pressure of which is determined by its density.

25. Carson, F. T.

Measurement of the degree of sizing of the paper. Bur. Standards Tech. Paper No. 326. Sept. 11, 1926. 30 p. Price 15 cents.

Existing methods for testing the degree of sizing of paper (35 in number) are described, critically discussed and experimentally compared. Stress is laid on the essential difference between the degree of internal sizing of paper and the degree of surface sizing. The lack of concordance of the various methods has been traced to the influence of selective absorption from solution and of an extraneous resistivity. A test of the rate at which water penetrates into paper is considered the most logical and useful test of the degree of internal sizing of paper. This was confirmed by the results of tests using methods of this type developed at the Bureau of Standards compared with the other sizing tests most used.

26. Carson, F. T., and Worthington, F. V.

A wet rub tester for paper. Paper Trade J. 84, No. 2: 45-46 (Jan. 13, 1927); Tech. Assocn. Papers 10, No. 1: 116-117 (1927).

In connection with the research made to improve the quality of U. S. paper currency it was found necessary to test the resistance of the paper to abrasion. The measurement of this property is of importance in the case of most surface-treated paper. This publication describes a motor driven testing device which consists of a means of clamping the specimen firmly over a smooth surface, a weighted friction surface, an automatic counter and an automatic means of stopping the motor when a hole is rubbed through the specimen. Data are also given showing the nature of the results obtained.

27. Lofton, R. E.

Determination of the fiber composition of roofing felts. Paper Trade J. 84, No. 18: 57-58 (April 7, 1927).

Describes method used and gives results obtained in fiber determinations on six roofing felts made in the Bureau's paper mill. Fiber

V - 27 (continued)

determinations were made by the "dot-count" method. By this method, the slide is placed on the mechanical stage of the microscope, moved across the field of view, and each fiber or portion of fiber is counted as it passes under a point on the diaphragm of the eyepiece. This method eliminates errors due to estimating lengths and sizes of fibers. The results obtained by the different analysts agreed very closely and indicate that a comparatively inexperienced analyst can, by use of the dot-count method, arrive at as nearly correct determinations of the fiber composition as could be arrived at by calculations based upon the mill weights of the different constituents.

28. Scribner, B. W., and Brode, W. R.
A modified method for the determination of the copper number of paper. Tech. Paper No. 354. 6 p. Sept. 24, 1927. Price 5 cents.
A modified method particularly adapted to determination of the copper number of heavily sized rag-fiber bond paper is described. It is patterned after the method of Gault and Mukerji, and that of Staud and Gray. A variation from these methods considered of prime importance is grinding the test specimens to a finely divided condition. This was found essential for obtaining uniform and accurate test results, and such procedure shortens the time required for treatment of the paper in the various analytical manipulations.
29. Carson, F. T., and Snyder, I. W.
Calibration and adjustment of the Schopper folding tester. Tech. Paper No. 357. 16 p. Oct. 15, 1927. Price 10 cents.
The results obtained with the Schopper paper folding tester are affected to a considerable extent by relatively small errors in the adjustment of the working parts and by friction in these parts. Since most of these errors are equivalent to errors in adjusting the tension on the specimen it is necessary to calibrate the tester frequently and readjust if necessary the tension of the clamp springs. An improved device, which is essentially a balanced bell-crank lever, is described which greatly facilitates the calibration.
30. Carson, F. T., and Snyder, L. W.
Increasing the capacity of the Elmendorf tearing tester. Paper Trade J. 86, No. 13: 57-60 (March 29, 1928).
In order to make the Elmendorf tearing tester suitable for testing heavy fibrous materials such as roofing felts an auxiliary weight was designed so that it could be quickly attached to the tester and used without any other alteration in the instrument, the same scale being used either with or without the augmenting attachment. To do this it was necessary to derive an adequate calibration formula for the tester and then to set up an analogous one for the heavy-duty tester. The calibration procedure is given in some detail and a simple procedure for periodic adjustment is outlined. Some improvements are also suggested.
31. Eckhardt, H. C., and Snyder, L. W.
A study of the Thwing impact tester. Paper Trade J. 86, No. 15: 64-66 (April 12, 1928); Tech. Assocn. Papers 11, No. 1: 91-93 (June, 1928).

V - 31 (continued)

This paper presents the results of a study of the Thwing impact tester to determine its suitability for testing heavy paper and paper boards. This device appears to be capable of giving consistent results when used for testing paper boards, but the range of the instrument is not well suited to the testing of ordinary papers. A comparison is made with the hydraulic type of bursting strength tester and a fair degree of agreement with this type of tester is found. A method of calibrating the instrument is outlined.

32. Lofton, R. E., and Snyder, L. W.

Results with testers for measuring tensile strength of paper. Paper Trade J. 86, No. 24: 63-66 (June 14, 1928).

This paper gives the results of tensile strength tests as obtained with six commercial testers of various types. A description of each instrument and the method used in calibrating it are given. Seven different samples of paper, ranging in tensile strength from about six to thirty pounds, were used in this investigation. Tests were made under standard atmospheric conditions - 65 percent relative humidity and 70 degrees Fahrenheit temperature. A total of 1680 test specimens was used.

Most of the testers gave fairly uniform results, although there are a few cases of abnormally large variations.

33. Carson, F. T.

Critical study of methods of measuring the bulk of paper. Bur. Standards J. Research Paper No. 69. Price 10 cents.

A study has been made of the means of measuring the property of paper known as bulk. The factors influencing bulk tests made with the thickness gage and the pressure bulker were investigated. It was found that the amount of pressure used is the chief factor. Conditions were found for bringing the different types of instruments into substantial agreement and a standard procedure was recommended.

34. Carson, F. T., and Worthington, E. V.

Care and adjustment of folding testers of the Schopper type. Bur. Standards, Cir. No. 379. Nov. 19, 1929. Price 5 cents.

Considerable attention is required to testers of the Schopper type for measuring the folding endurance of paper, since the folding results may be affected by relatively small changes in their adjustment. Poor alignment of the rollers between which the paper is folded or excessive friction in these rollers may produce serious error in the folding results. The bell-crank lever device for adjusting the spring tension, which was described in a previous publication, has been adapted to the measurement of the friction of the rollers, and this procedure is here described. A procedure is outlined for the periodic inspection and adjustment of folding testers of the Schopper type.

35. Carson, F. T., and Snyder, L. W.

Directional designation in physical tests of paper*. Paper Trade J. 91, No. 12, p. 65 (Sept. 18, 1930).

A chart was prepared which shows how paper test strips should be cut relative to designation of the two principal directions of the paper in reporting test results, and how to obtain a maximum of the

different kinds of tests from a limited sample. In addition to explanation of the chart, a discussion of the subject is given.

36. Carson, F. T., and Worthington, F. V.

Critical study of the bursting strength test of paper. Bur. Standards J. Research 6, No. 2: 339 (Feb. 1931) RP 278, Price 10 cents.

Possible causes and alleged causes of inconsistent results in the bursting strength test for paper were investigated. The study included clamping pressure, clamping surfaces, size of bursting orifice, diaphragms, pressure gauges and speed of operation. Some were found to be without measurable effect, while others were found to affect the results more or less seriously. Recommendations are made for adequate clamping pressure and for the nature of the clamping surfaces and the size of the bursting orifice. Tensile and bursting data are correlated with the aid of a well-known engineering formula.

37. Burton, J. O., and Rasch, R. H.

The determination of alpha cellulose content and copper number of paper. Bur. Standards J. Research 6, No. 4: 603 (April, 1931) RP295, Price 10 ¢.

Modifications of the methods for determining the alpha cellulose content and copper number of cellulosic materials were made and the methods adapted to paper analysis. The modification considered of prime importance is the reduction of the paper to a cotton-like form by means of a mechanical disintegration. This was found to be essential for accurate and uniform results. It is also very important to take into account the amounts of sizing and loading materials which the paper contains. The alpha cellulose method is patterned after that of Jentgen with modifications suggested by Parsons and Ross. The copper number method is that of Braidy with a few minor modifications.

38. Carson, F. T.

Control of relative humidity in a small inclosed space. Paper Trade J. 93, No. 18: 71 (Oct. 29, 1931).

In response to a demand for information about maintaining constant humidity in a small space, especially in a small cabinet in which some testing of paper can be done, a brief description is given of suitable apparatus, together with a compilation of data for the preparation of solutions having the required relative vapor pressure. Data are given for sulphuric acid solutions, glycerine solutions, and saturated solutions of certain salts. The effects of temperature variation, the control of temperature, and the measurement of humidity are discussed.

39. Carson, F. T., and Worthington, F. V.

Hygrometry in paper testing. Paper Trade J. 94, No. 2: 34 (Jan. 14, 1932).

Many of the properties of paper are influenced to a considerable extent by the content of hygroscopic moisture. This moisture content is determined largely by the relative humidity of the surrounding atmosphere, and, therefore, it is most convenient to express hygrometric data in terms of relative humidity. The various hygrometric methods are briefly discussed and described with reference to their suitability

V - 39 (continued)

for use in the paper testing laboratory. Of the four types of methods, analytical method, dew-point method, method depending on behavior of hygroscopic substances, and wet-and-dry-bulb psychrometer, the latter is apparently best suited to the requirements of the laboratory.

40. Rasch, R. H., and Stone, G. O.
Estimating the stability of paper by heating. Paper Trade J. 95, No. 4: 28 (July 28, 1932).

For estimating the aging properties of paper, one of the most convenient tests so far devised consists of determining the loss in folding endurance after a heat treatment in air at 100° C for 72 hours. The reproducibility of results of the test is discussed in relation to: (1) the lack of homogeneity of the structure of paper, (2) possible variations between different folding machines, (3) variations in humidity during testing, and (4) variations in oven conditions. Suggestions are offered for minimizing errors resulting from these variables, and data are included to show the degree of reproducibility to be expected.

41. Carson, F. T., and Worthington, F. V.
New types of equipment for testing paper. Paper Trade J. 95, No. 16: 34 (Oct. 20, 1932).

Three paper testing devices are described. (a) A float in which the specimen is clamped under a cover glass is used in making the dry indicator test for water resistance. (b) An inclined pipette mounted on a frame and provided with a needle valve is used to deliver a very small measured drop of water onto the surface of paper in making an absorption test. (c) An extraction apparatus which combines the reflux condenser with light scrubbing is used to clean a large sheet of processed paper for the purpose of inspecting or testing it.

42. Snyder, L. W., and Carson, F. T.
A study of the MIT paper folding tester. Paper Trade J. 96, No. 22: 40 (June 1, 1933).

Measurements were made of important characteristics of a number of M.I.T. folding testers such as variation in tension, curvature of the folding surfaces, and rate of folding. Performance tests were then made, on a number of samples of paper. Some correlation was found between the variation in individual tests of paper and the measured machine variables, although the relations were not altogether conclusive. Tests were also made on the M.I.T. and Schopper folding testers. There was no correlation between the two sets of results. A proposed testing method involving the use of the M.I.T. folding tester was outlined.

43. Carson, F. T.
Effect of experimental conditions on the measurement of air permeability of paper. Bur. Standards J. Research 42, No. 5 (May 1934) RP 682
Price 10 cents.

Experimental results show that with few exceptions the flow of air through paper is proportional to the pressure difference, to the time of flow, to the effective area, and inversely proportional to the thickness.

V - 43 (continued)

With the type of measuring instrument used the results do not depend upon the viscosity of the air. The effect of relative humidity is unpredictable. Air permeability of paper was found to increase somewhat with decreasing absolute pressure. All the data agree remarkably well with the Meyer equation and indicate that the air passages in paper behave as if they were long capillary tubes.

44. Carson, F. T.

Testing the water resistance of paper and fiber board. Paper Trade J. 98, No. 21: 36 (May 24, 1934).

An attempt is made to clarify in some degree the province of water resistance tests, and developments in the technique of applying the dry-indicator test to the whole range of papers and fiber boards are described. The properties ordinarily referred to as water resistance and moisture resistance are distinguished by the phase that enters the sheet. A simple method is described for applying the dry-indicator test to all types of papers and fiber boards, and some simple pieces of apparatus are described. Some suggestions are also made toward fixing the end point more definitely.

45. Carson, F. T.

A sensitive instrument for measuring the air permeability of paper and other sheet materials. Bur. Standards J. Research 12, No. 5 (May, 1934). RP 681, Price 10 cents.

The instrument is designed to eliminate edge leakage into the test cell. An annular guard cell surrounds the test cell and the lateral pressure gradient at the boundary of the test cell is eliminated. A specially designed pressure regulator maintains a very steady pressure drop across the instrument. The air flow is measured by a capillary flow meter. The total range of the instrument is about a millionfold. Materials half an inch thick can be tested, and it is not necessary to cut the specimen. Results are reproducible to a few tenths of one percent.

46. Specifications of the transparency of paper and tracing cloth. Bur. of Standards Cir. 63 (1917) Price 5 cents.

Transparency is specified by measuring the contrast ratio, B/W, where B and W are the brightness resulting when the material is placed over black and white (MgO) surfaces, respectively.

47. Judd, Deane B.

Sources of error in measuring opacity of paper by the contrast-ratio method, BS. J. Research 12, 345 (1934); RP 660, Price 5 cents.

Contrast ratio of a paper sample is defined as the brightness of the illuminated sample when backed by a black-lined cavity divided by its brightness when backed by a surface of magnesium oxide. In practice other less fragile surfaces are substituted for the MgO surface, and to protect these substitute surfaces as well as the paper samples themselves the samples are kept from touching the surfaces. Both departures from the definition are potential sources of error. These errors have been investigated experimentally and a theoretical expression representing them is given.

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48. Judd, Deane B.
Opacity standards. J. Research NBS, 13, 221 (1934); RP 709. Price 5 cents.
Opacity of paper is commonly specified by the contrast-ratio method. According to this method the reflectance of the material backed by a perfectly absorbing surface divided by its reflectance when backed by a highly reflecting material such as magnesium oxide is taken as an index of opacity. Magnesium oxide, itself, is, however, commonly not used as the white backing because of its fragility; nor is the white backing placed in actual contact with the sample. Because of these and other sources of error, opacimeters frequently give erroneous results. Standards of opacity made of permanent material serve to check and to calibrate such instruments. Such standards made of opal glass are described, the theory of their application is given, and results of tests by their use reported. It is found that TAPPI opacity corresponds to a reflectance of white backing in contact with the sample of about 0.89.
49. McNicholas, H. J.
Reflective and transmissive properties of diffusing media. Bur. Standards J. Research 13, No. 2: 211 (Aug. 1934), RP 704, Price 5 cents.
Many problems in the textile, paper, paint, ceramic, and other industries call for optical methods in the evaluation of various properties of raw materials, intermediate, and finished products. Among such properties are the color, gloss, and surface texture of fabrics, papers, and painted or enameled surfaces, the covering and tinting powers of paints and ceramic bodies, the transparency or optical density of printing papers, tracing papers, or photographic films, and the general diffusive properties of illuminating glassware and various reflecting surfaces. To obtain fundamental data which may serve as a rational basis for the development of suitable methods and instruments for these special purposes, equipment has been designed and constructed with which a complete determination of the diffusive and absorptive properties of various materials may be made. Applications of the equipment to specific problems are not included in the scope of this paper.
50. Carson, F. T.
Maintenance, calibration, and use of paper testing instruments, Paper Industry, 16, No. 9, 621 (Dec. 1934).
This paper is a popular discussion of the chief points in the maintenance, calibration, and operation of common paper testing instruments. The instruments discussed are the psychrometer for measuring the hygro-metric condition, the room weight balance, the dial micrometer for measuring thickness, the tensile strength tester, the bursting tester, the tearing tester, and the folding endurance tester. Those phases of maintenance and calibration that can readily be attended to in any paper testing laboratory, especially those of importance most likely to be neglected are emphasized.
51. Judd, Deane B.
Method of determining the whiteness of paper. Paper Trade J. 100, No. 21, (May 23, 1935).

V - 51 (continued)

The method suggested is an extension of MacAdam's work on yellowish white textiles. It makes use of a color diagram on which equal distances in any direction refer to equally perceptible color differences. This color diagram is a transformation of the standard 1931 ICI coordinate system of colorimetry; the colors of the paper samples may be located on this diagram by any fundamental method of colorimetry using the ICI method. There remains yet to be discovered whether graders of paper use essentially the criteria used by MacAdam's observers; but preliminary results indicate that they do.

52. Judd, Deane B.

The dependence of reflectance and opacity on thickness; relation between contrast ratio and printing quality, Tech. Assocn. Papers, Series XVIII No. 1: 405, (1935).

Two families of graphs were prepared from the Kubelka-and-Munk formula. The ordinate is reflectance for black backing; the abscissa is contrast ratio for a white backing of 89 percent reflectance; this is the contrast ratio found by the official TAPPI method for measuring opacity of paper. Each curve of the first family refers to different thicknesses of the same material characterized by its reflectivity; it shows the increase in opacity and in reflectance as thickness is increased.

53. Hunter, R. S.

Reflection measurements on pulp and paper. Paper Trade J. 100, No. 26 (June 27, 1935). Tech. Assocn. Papers Series XVII, No. 1: 405, (1935).

The gloss, brightness, opacity, lightness, color, and surface texture of pulp and paper are associated with the reflection of light. It is the object of this paper to explain these factors as they are evaluated by visual observation and inspection and as they are evaluated by physical measurements of reflected light.



VI. MISCELLANEOUS

1. Publications of the Bureau of Standards 1901-1925.
Bur. Standards Cir. 24 (1925), Price 25 cents.
This circular gives a complete list of the scientific papers, circulars, handbooks, and miscellaneous publications of the Bureau to June 30, 1925.
- 1a. Supplementary list of publications of the Bureau of Standards (July 1, 1925 to Dec. 31, 1931) Price 15 cents.
This is a supplementary list of publications of the Bureau up to Dec. 31, 1931. It contains information on depository libraries and status of publication.
2. Finck, J. L.
Mechanism of heat flow in fibrous materials. Bur. Standards J. Research 5, No. 5 (Nov. 1930), Price 5 cents.
A systematic investigation of the thermal conductivities of specimens composed of fibrous materials has been made. The experiments were designed to show the effects of such factors as density of packing, arrangement of fibers, kind and size of fibers, moisture content, air convection, and radiation on the resultant conductivity of the specimens. Data on various mixtures of fibers were obtained, and it was found that in most cases the conductivity of the mixture lies between those of the constituents, taking the conductivity of each constituent which corresponds to a density equal to the density of the mixture.
3. Smith, W. C.
A method for the determination of copper, manganese, and iron in fabrics. Am. Pyestuff Reprtr. 19 (Sept. 15, 1930).
The methods described are applicable to the determination of these metals when present in textile fabrics in quantities approximately as follows: copper, 0.002%; manganese, 0.001%; and iron, 0.1%. After the organic material is destroyed, copper is determined by the potassium ethyl xanthate colorimetric method; manganese, by the potassium periodate colorimetric method of Willard, and Greathouse; and iron, by the sulphocyanate colorimetric method, aliquots from a single solution being used without separation of the metals.
4. Shiefer, H. F.
The flexometer, an instrument for evaluating the flexural properties of cloth and similar materials. Bur. Standards J. Research 10, No. 5 (May, 1933) RP 555, Price 5 cents.
An instrument is described with which the flexural work, flexural resilience, and flexural hysteresis of cloth, paper, sheet rubber, and similar materials can be evaluated. A pair of test specimens of standard dimensions are mounted in opposite angles formed by two vertical intersecting plates one of which is fixed and the other movable on a spindle. The work done in folding the specimens to various angles between the plates, the work recovered when they are allowed to unfold, and the work lost are measured. These quantities are a measure, respectively, of flexural work, flexural resilience, and flexural hysteresis of the specimens. They are related to the stiffness and creaseability of cloth and affect the sensations which contribute to the psychological qualities of "handle" or "feel" and the "drape" of fabrics. Typical results are given.

VI -

5. Schiefer, H. F.

The compressometer, an instrument for evaluating the thickness, compressibility, and compressional resilience of textiles and similar materials. Bur. Standards J. Research 10, No. 5 (June 1933) RP 561 Price 5 cents.

The instrument described in this paper provides a convenient means for measuring the thickness and the change in thickness of a textile or similar material when it is subjected to increasing or decreasing pressures. The foot of the instrument can be lowered or raised by means of a rack and pinion acting through a helical spring. The pressure applied to the specimen by the foot is indicated on a dial micrometer and the corresponding thickness of the specimen on a second dial micrometer. Readings are taken under increasing pressures and then under decreasing pressures. Curves for the compression and recovery of several materials are shown. Definitions are proposed for the terms thickness, compressibility, and compressional resilience as applied to textiles. The results of tests on rugs underlays, blankets, felts, on knit, woven, and pile fabrics, and on sheet rubber and paper are given.

6. Publications Relating to Dyes.

Bureau of Standards Letter Cir. 392 (1933). Copies may be obtained from Bureau of Standards without cost.

This letter circular lists the publications relating to dyes written by or in cooperation with members of the staff of the Bureau of Standards.

AUTHOR INDEX

Barrows, W. P.	IV - 17
Bell, R. W.	I - 33
Bicking, G. W.	I - 4, 6, 7, 8, 9, 12, 13, 14, 16, 17, 18, 19, 21, 22, 23, 25, 27, 28, 29, 30, 31, 32, 33, 34, 35
Bowker, R. C.	I - 36, 37.
Brode, W. R.	V - 28
Burton, J. O.	III - 31; V - 37
Carr, R. W.	IV - 16
Carson, F. T.	I - 5; IV - 9, 11, 13; V - 5, 6, 15, 17, 19, 20, 22, 23, 24, 25, 26, 29, 30, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 50.
Clark, F. C.	I - 3; IV - 2
Cobb, R. M.	II - 1
Costello, C. J.	V - 18
Curtis, F. A.	V - 5, 8.
Durgin, A. G.	I - 3; IV - 1, 2
Eckhardt, H. C.	V - 31
Emley, A. L.	III - 8, 9
Finck, J. L.	VI - 2
Gottschalk, V. H.	I - 16, 18
Gould, S. P.	I - 33
Hamill, G. K.	I - 15, 18, 19, 20, 24
Hicks, J. F. G.	III - 5, 6
Houston, P. L.	IV - 4; V - 2, 3, 4, 9, 10, 11, 12
Hunter, R. S.	V - 52
Judd, D. B.	V - 47, 48, 50, 51
Kellogg, E. H.	I - 7
Kimberly, A. E.	III - 5, 6, 7, 8, 9, 11, 14.
Kirkwood, R. S.	V - 12
Ledig, R. H.	V - 3
Lofton, R. E.	IV - 10; V - 1, 7, 13, 21, 27, 32
Meyer, W. W.	I - 38
Merritt, M. F.	V - 1, 8, 14, 16.
Miller, D. R.	V - 9
McNicholas, H. J.	V - 49
O'Leary, M. J.	I - 30, 31, 35
Rasch, R. H.	I - 32, 34; III - 1, 4, 10; V - 37, 40
Rumsey, R. R.	I - 13, 14
Schiefer, H. F.	VI - 4, 5
Scribner, B. W.	III - 3, 10, 11, 12, 13; IV - 9, 12, 14, 16; V - 28
Shaw, M. B.	I - 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 21, 22, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35; III - 14
Smith, W. O.	VI - 3
Smith, W. H.	I - 1, 2
Snyder, L. W.	I - 29; II - 3; IV - 9, 13, 14; V - 29, 30, 31, 32, 35, 42
Stone, G. O.	V - 40
Streiter, O. G.	I - 21
Wallace, E. L.	I - 37
Weber, C. G.	I - 35; II - 1, 2, 3, 4; III - 14; IV - 13, 15
West, C. J.	IV - 8
Whittier, E. O.	I - 33
Worthington, F. V.	IV - 11; V - 26, 34, 36, 39, 41
Zimmerman, E. W.	III - 14

SUBJECT INDEX

Adhesives, coating	I - 10, 15, 30, 33
Casein	I - 30, 33
Clays	I - 8, 30, 38
Commercial standards	IV - 20
Conditioning	II - 3; V - 12, 24, 37, 39; VI - 1, 3, 4
Cornstalks	I - 35
Cotton stalks	I - 13
Equipment of the Bureau of Standards	
Paper Section	I - 26
Esparto	I - 14
Felts, roofing	I - 25
Felts, paper machine	I - 3
Flax, seed flax straw	I - 7
Flax, New Zealand	I - 31
Glue	I - 10, 15, 18, 19, 20
Hydrogen ion control	I - 11
Minerals, coating and filler	I - 8, 30
Manila rope waste	I - 21
Paper	
Antitarnish	IV - 7
Bags	IV - 3, 4
Boards	IV - 2, 3, 14
Braille	IV - 15
Condenser	I - 6
Currency	I - 16, 27
Case lining	IV - 9
Definitions	IV - 8
Envelope	IV - 10, 12
Lithographic	II - 1, 3, 4
Offset	II - 1, 3, 4
Sheathing	IV - 11
Towels	IV - 17
Paraffin, recovery	I - 1
Permanence	III - 1, 2, 3, 4, 5, 7, 8, 10, 14
Preservation of records	III - 6, 7, 9, 11, 12, 13, 14
Printing and paper	II - 1, 2, 3, 4
Rayon as papermaking material	I - 28
Rubber latex	I - 4, 5
Simplified practice recommendations	IV - 19
Sizes, simplification	IV - 5, 6, 7
Sulphite pulp, stability	I - 34
Tanning extracts from waste liquor	I - 36, 37
Thermal conductivity	VI - 2

Testing

Absorbency	V - 3, 41
Brittleness	V - 11
Bulk	V - 33
Bursting strength	V - 18, 36
Cellulose	V - 28, 37
Chemical methods	V - 28, 37
Color	V - 13, 50
Copper number	V - 28, 37
Extractor and friction cleanser	V - 22, 41
Flexibility	V - 15, 11; VI - 4
Folding endurance	V - 29, 34, 42
Fiber analyses	V - 1, 8, 14, 16, 27
Gloss	V - 21
Instruments, calibration	V - 50
Microscopy	V - 7, 14, 16, 21
Opacity	V - 46, 47, 48
Optical	V - 21, 46, 47, 48, 49, 51, 52
Impact	V - 31
Permeability	V - 23, 45, 43
Sizing	V - 5, 6, 17, 20, 25, 41
Stability	III - 1, 3, 4, 7, 10; V - 40
Stains, fiber	V - 1, 8
Tear	V - 30
Tensile	V - 10, 15, 32
Thickness	V - 9; VI - 5
Water resistance	V - 19, 41, 44
Wet rub	V - 26