

INTER-SOCIETY COLOR COUNCIL

NEWS LETTER NO. 12

ANNUAL MEETING

The Annual Meeting of the Inter-Society Color Council will be held in the Astor Gallery, Waldorf-Astoria Hotel, Thursday Evening, February 20, 1936 at 7:45 p.m. All delegates and members of the Council are urged to be present. Following the business meeting at which several important matters will be voted on, there will be a group of lectures on color. Members of the organizations composing the Council are invited to attend.

R. G. M.

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MESSAGE FROM THE CHAIRMAN

M. Rea Paul, National Lead Company, Brooklyn, N. Y.

As a result of a preliminary conference, held February 26, 1931, the Inter-Society Color Council came into being on September 21st of that year. Since then, the Council has closely adhered to its aims and purposes and has progressed despite conditions, adverse to its growth, that have existed since its formation.

It is the belief of your Chairman that the Council has rendered a real service to many inquirers and to certain of its member-bodies, notably, the United States Pharmacopoeia. This latter group submitted a problem that has been successfully solved through the efforts of the Council's Committee on Measurement and Specification.

The Inter-Society Color Council, shortly after its formation realized its plan of organization and procedure was inadequate. Through the efforts of Mr. L. A. Jones who was at that time Chairman, a new set of Articles of Organization and procedure were formulated. New activities could not be undertaken by the Council until this work had been concluded and the status of the member groups had been clearly defined. With the adoption of the new Articles, the opportunity has now been opened for the Council to progress along the lines for which it was originally intended - namely, "to stimulate and coordinate the work being done by various societies and associations leading to the standardization, description and specification of color, and to promote the practical application of these results to the color problems arising in science, art, and industry."

It is your Chairman's belief that the Council should not be thought of as a research group or standardizing body, but instead, an organization held together by a common interest in color, whose function is to disseminate information through publication of news letters and reports. Its second objective consists of an attempt to bring together those individuals having color problems with those who might be encouraged, through individual or cooperative researches, to provide the solution.

At the recent meeting of the Council's Executive Committee, it was decided to discontinue the Committee on Color Specifications, whose work consisted principally of the U. S. P. problem which they so satisfactorily concluded. It was also decided to discontinue the Committee on Color Names,

owing to the resignation of the individual holding the primary interest in this subject. The Committee on Membership was continued and your Chairman, with the approval of the Executive Committee, appointed Dr. W. M. Scott as Chairman. It was also decided to continue the Committee on Color Problems and your Chairman with the approval of the Executive Committee, appointed Dr. D. B. Judd as Chairman.

It was the thought of the Executive Committee that individual subcommittees to handle special problems could be set up from time to time, under the Problems Committee, and in this way function most advantageously and to the best interests of the Council.

It was the decision of the Executive Committee to hold the annual meeting of the Council in New York City during the week in February, 1936, that the Optical Society of America and the American Physical Society hold their joint meeting.

Many problems have been presented to the Executive Committee for consideration at their next meeting and it is probable that several of these will be referred as projects for study, to the Problems Committee. One, in particular that your Chairman believes would be of general interest to the various members of the Council would be the proposed attempt to assemble all of the commercial standards relating to color that have been published, and issue this information to the members of the Council.

The Inter-Society Color Council formulated at a time when depression was at its worst, and having successfully survived, leads your Chairman to believe that it will continue to progress through the combined efforts of its members, placing itself in even a better position to render a truly valuable service in the constantly broadening field of color.

Your Chairman takes this opportunity to seek your cooperation in developing the further growth of the Council, and to extend to you on his own behalf and on the behalf of the Executive Committee, best wishes for the coming year.

REPORT OF COLORISTS MEETING

Dorothy Nickerson, Color Technologist, U. S. Dept. of Agriculture, Bureau of Agricultural Economics, Washington, D. C.

The fall meeting of the third season of the Washington and Baltimore Colorists was held on Friday evening, November 22, 1935, at the Cosmos Club. Dr. K. S. Gibson, chief of the Colorimetry Section of the National Bureau of Standards, was chairman. Thirty-nine persons sat down for dinner, and about one half dozen more came later to hear the discussions.

In order that the group might become acquainted with the instruments that different members are using, the program was made up of informal talks by several members about the color measuring instruments which they are using, emphasis being placed on the way in which the instrument answers the problem rather than on a detailed description of the instrument itself.

Mr. W. N. Harrison, chief of the enameled metals section of the National Bureau of Standards discussed briefly the problem of measuring porcelain enamels and establishing standards. He described the reflectometers which they are using for this purpose and presented some of the resulting information in the form of charts. They have found that by ascertaining the reflectivity of a sample, that is, the highest reflectance obtainable by increasing thickness of layer, and the coefficient of scatter, or the ratio of reflectance over black backing to weight of enamel for very thin layers, they can calculate the reflectance for any given weight of enamel.

Dr. B. A. Brice of the Food and Drug Administration of the U. S. Department of Agriculture described the problem of grading rosins and described the photocell instrument which has been developed for use in studying problems of standardization and for use in cases of dispute. By measuring the transmission of a sample through a red filter and through a green filter (the transmission through the green filter approximating the brightness of the sample) and by taking the ratio of red to green transmissions as a measure of the chromaticity of the sample, they have found that brightness and chromaticity may be marked off on a chart in areas which represent grades with very good agreement against visual judgments. It is possible to use this red to green ratio because the spectrophotometric curves of rosin samples follow the same general shape, the curves lower in red being also lower in green. Formulas have been developed for converting the red to green ratio of a sample to a figure which represents its grade.

Mr. R. S. Hunter of the Colorimetry Section of the National Bureau of Standards described the problem of gloss measurements. Much of his time during the last two years has been spent in studying this problem, and he has developed two instruments for measuring different types of gloss. In identifying different types of gloss effects and differences, it has been necessary to establish a classification of gloss types. A classification of glossiness into at least five types of appearance effects has not previously been made although subjective and objective gloss have been differentiated by a number of workers. Mr. Hunter has listed the appearance characteristics associated with gloss under five types: objective gloss, subjective gloss, sharpness of image, bloom and smoothness. He has prepared a table containing a method of identification for each of these types, the surfaces to which each applies most generally, and the instruments by which each type of gloss may be measured. Circular No. 493 of the Scientific Section of the National Paint, Varnish and Lacquer Association at 2201 New York Avenue, contains a description of a new gloss comparator and the study of different types of gloss effects, and refers also to previous published work.

Dr. Paul E. Howe of the Bureau of Animal Industry of the Department of Agriculture outlined the problem of establishing standards for the color of egg yolks in which use is being made of the Bausch and Lomb HSB Color Analyzer. For some time it was difficult to find colors with which the strong chromas of the egg yolk colors could be matched, but special papers have been developed and that problem is now solved. The proper illumination of the glossy egg surface is still something of a problem.

Dr. C. A. Cary of the Beltsville Laboratories of the U. S. Department of Agriculture who is studying nutrition of dairy cows, discussed the problem of measuring carotin in its relation to Vitamin A, and described a spectrophotometer which they are planning to build at their laboratories at Beltsville. It is similar to one which is being used for the same purpose now at the University of Chicago.

The papers were given informally and considerable comment followed each one. The meeting seemed of enough interest to all who attended to warrant another of a similar nature at a future time, for these five problems merely scratched the surface of the many on which members of the group are working.

The next meeting will probably be held some time in February. The steering committee for the group is composed of Mr. Charles Bittinger, Dr. K. S. Gibson, Dr. Deane B. Judd, and Miss Dorothy Nickerson.

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SPINNING WEDGE COLORIMETERS

Else L. Schulze, Chemical Division Library, The Procter and Gamble Company, Ivorydale, Ohio, recently inquired for the names of manufacturers of various kinds of colorimeters of the spinning rhomb type, as exemplified by the K. & E. color comparator and the Bausch & Lomb HSR color analyzer. Information was also requested concerning the relative advantages and special characteristics of each type.

This inquiry was referred to the Council Committee on Color Problems and Dr. D. B. Judd, Chairman of that committee reported as follows:

"We know of no spinning wedge colorimeters on the market except the Keuffel & Esser and Bausch & Lomb instruments mentioned by you. For some problems and in some respects, the one instrument is preferable; for others, the other. The differences in design between the two instruments which are responsible for the important advantages are as follows:

"(1) The K & E instrument provides an illuminating system whereby both sample and standards receive light from the same lamps; its calibration therefore depends less on aging of the lamps. The adjustment of the lamps, however, is relatively inconvenient.

"(2) The B & L instrument provides a horizontal position for the sample which is an advantage in the examination of powders and liquids.

"(3) Oil from the motor in the B & L instruments some times spreads onto the glass surfaces of the optical parts which must then be cleaned.

"(4) Some of the optical parts of the K & E instrument are joined with cement which yellows with age introducing a gradual change in calibration.

"(5) The B & L instrument is somewhat more compact.

"Most of this information has been obtained from Miss Dorothy Nickerson color technologist, Bureau of Agricultural Economics, Department of Agriculture, Washington, D. C. Miss Nickerson has contributed to the design of both of these instruments, has had extensive experience with both, and has published numerous papers dealing with measurements on disc colorimeters. It is suggested that she be consulted directly if further information is desired."

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COLOR TESTS FOR WHITE PAPER

Mr. E. B. Twelker of the Scripps League of Newspapers, Seattle, Wash. asked the Technical Association of the Pulp and Paper Industry to furnish him with information as to methods and equipment available for making color tests of white paper.

This inquiry was referred to the TAPPI Paper Testing Committee, B. W. Scribner, chairman, who forwarded the following reply prepared by D. B. Judd of the National Bureau of Standards:

1. Methods of Testing There are three methods: (1) spectrophotometric, (2) abridged spectrophotometric (filter photometry), and (3) colorimetric. Detailed information on these methods may be found in papers listed in Letter Circular LC-398, Publications on Colorimetry and Spectrophotometry. For the spectrophotometric method consult references 98, 97, 91, 78, 72, 43, 31, of Part I. For filter approximations to spectrophotometry, consult references 56 and 31 of Part I and reference 52 of Part III. For colorimetric methods consult reference 31, Part I.

2. Equipment available Only a few of the available instruments are listed below. We have reason to believe that those listed will conveniently yield measurements precise enough to distinguish color differences detectable by direct visual comparison under good daylight. A fairly complete list of manufacturers of such equipment is in preparation and will be available by February of 1936; this complete list may refer to other instruments equally as satisfactory as those given in the present abridged list.

Spectrophotometers

Hardy automatic photoelectric spectrophotometer,
General Electric Co., Schenectady, New York.
Razek-Mulder photoelectric spectrophotometer,
Razek Development Lab. Inc., Llanarch, Pa.

Filter Reflectometers

General Electric Reflection Meter (Brightness tester)
General Electric Company, Schenectady, New York.
Hunter Photoelectric Reflectometer
H. A. Gardner Lab., 2201 New York Avenue, Washington, D. C.

Colorimeters

Keuffel and Esser Color Comparator,
Keuffel and Esser, Hoboken, N. J.
Bausch and Lomb HSB Color Analyzer,
Bausch and Lomb Optical Co., Rochester, N. Y.

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PRIEST-LANGE REFLECTOMETER

Irwin G. Priest (THE PRIEST-LANGE REFLECTOMETER APPLIED TO NEARLY WHITE PORCELAIN ENAMELS), J. Research NBS, 15 November, (1935); RP 847

The Priest-Lange reflectometer is described in detail and the theory of its use given for determining relative apparent reflectance for various

spectral distributions of illumination. A method for measuring spectral selectivity of reflectance is also described, together with a method for measuring diffuse-plus-specular reflectance as distinguished from diffuse reflectance alone for perfectly polished specimens. The application of the instrument to porcelain enamel samples is illustrated by a detailed account of measurements made on seven typical samples. The method for measuring diffuse-plus-specular reflectance as distinguished from diffuse reflectance is shown to be inapplicable to enamel samples because of their optical imperfections, but measurements of spectral selectivity are shown to give results in close correlation with the colors of the samples observed directly.

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LOVIBOND RED GLASSES

Roger S. Estey, Electrical Testing Laboratories, New York, N. Y. Roger S. Estey, (THE ADJUSTMENT OF LOVIBOND RED GLASSES), Oil and Soap 12, 135 (1935).

The Lovibond color system consists of red, yellow and blue sets of colored glass slides of standard size and color. These glasses are graded and numbered in terms of the intensity or depth of color on the three scales. Combinations of glasses involving one or more of the three colored sets are used to produce standard colors matching unknowns which it is desired to color grade.

These glasses are used for product control in various industries, particularly in the vegetable oil industry where it was found that the calibration of the standard glasses provided by the manufacturer was not accurate enough for the requirements of the oil chemists. The National Bureau of Standards developed an improved and more accurate color scale for the grading of the Lovibond red glasses used in combination with Lovibond 35-yellow (the set used for grading vegetable oils). Glasses regraded on this new scale received regrade numerals containing fractional components which were inconvenient to use. At the instigation of the American Oil Chemists Society the Electrical Testing Laboratories has developed a procedure whereby the grade of a glass can be reduced slightly by polishing away some of the red coloring material, thereby lightening the color. This adjustment can usually be carried to the point where the glass can be assigned an integral valued regrade numeral.

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THE CONQUEST OF COLOR

The following is a revised transcript of the comments of Dr. H. P. Gage, Chief, Optical Division, Corning Glass Works, on a paper entitled "The Conquest of Color," by H. Ketcham, delivered at the Washington, D. C. meeting of the Society of Motion Picture Engineers during the week of October 21, 1935.

"I would like to make a brief comment in addition to what Mr. Ketcham has said regarding the nomenclature of color. There is now a definite drive to do something about getting it all down to a sensible basis. Munsell has arranged one system, the International Congress on Illumination have worked on what apparently is a different system. Work is now being done under the advice of Prof. A. C. Hardy which is getting those two systems into one system so that we can express everything that Munsell expressed in the terms of the I. C. I. triangle and we will then have one system of which the Munsell samples serve as material examples.

The Colorimetry Committee of the Optical Society of America, under Dr. L. A. Jones, is doing some very good work in this matter. A report will be prepared when such a report can be prepared on account of the number of people with divergent views who have to be consulted in doing it. The Inter-Society Color Council, on which I believe the Motion Picture Engineers have representatives, is also considering this problem and as some of the members of those two organizations are identical, it is sometimes hard to tell when we have a meeting whether it is of the Inter-Society Color Council or of the Colorimetry Committee of the Optical Society, but anyway there is a definite drive to straighten out this now perplexing color nomenclature so it will be much simpler to describe colors and there will be no further excuse for doubt as to what we ought to call the color of objects.

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MERCHANDISING IMPORTANCE OF COLOR SELECTION

R. G. Macdonald, Technical Association of the Pulp and Paper Industry.

In the December, 1935 issue of the Executive Service Bulletin of the Policyholders Service Bureau, Metropolitan Life Insurance Company, there appeared an article by A. Wallace Chauncey, Vice President, The International Printing Ink Corporation, New York, N. Y. entitled "The Merchandising Importance of Color Selection."

The author points out the great lack of knowledge on the part of executives of businesses whose success depends considerably on the use of color in the product, package, advertising, etc. Color association is a tremendous force in business. The public recognizes soap by the color of its wrapper; filling stations, cigarettes, candies, by the distinctive identifications supplied through standardized coloring. The great difficulty is that color means different things to different individuals. To the chemist, color is a combination of elements in a chemical formula which in the form of a dye or pigment comes out of his test tube a certain definite hue every time he uses that formula. The physicist thinks of the terms color and light as synonymous or that color is an optical phenomenon. To the average man color is probably a sensation. He has the facility to differentiate between hues - but that is where his troubles begin. Before long it is likely that the business man will come to recognize that the proper use of color is a corporate responsibility to be exercised by management so that scientific facts may replace changeable notions.

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MORE ON EYE STRAIN

In the Inter-Society Color Council News Letter No. 11 an inquiry by Dr. G. F. Des Autels requesting information on the relationship between color and eye strain was commented on by J. E. Ives and M. Luckiesh. Since that News Letter was published, the following contributions have been received:

Miss Helen U. Kiely, Chief Chemist, American Writing Paper Company wrote as follows:

"I wonder if Dr. Des Autels is familiar with the work which Dr. C. E. Feree and Gertrude Rand did for us in 1921? Dr. Feree was connected with Bryn Mawr College at the time.

The following is an abstract from a paper that he read at a convention of the Illuminating Engineering Society of Rochester."

"It is significant to note that the retina has not only developed its greatest power to give the achromatic response to the wave-lengths in the mid-region of the spectrum, but over and above this, that is, when all are equalized in power to give the achromatic response, these wave-lengths still have a very great advantage for the three most important aspects of clear seeing, - acuity, speed of discrimination, and power to sustain acuity.

"Yellow stands at the head of the list in all the tests that have as yet been applied, - acuity, power to sustain acuity, speed of discrimination, and the tendency to produce ocular fatigue and discomfort. Yellow-green and green stand comparatively high in the first three tests, but have not ranked so well in the tests for fatigue and discomfort. Even the three-minute tests of power to sustain acuity give evidence of the inability of the retina to hold its resolving power under the action of these wave-lengths. The indications from this and the previous work are that the ruddy yellows up to and well into the orange rank comparatively high all around; while the deep reds, the blue-greens, and the blues are obviously not meant to serve as backgrounds upon which achromatic details must be discriminated with precision, ease, and speed for long periods of time."

Mr. C. R. Conquergood of the Canada Printing Ink Company furnished the following contribution by Mr. P. F. Grans, Grans and Toy Ltd.

"Mr. Charles Conquergood has asked me to forward to you information regarding our investigations in the matter of providing paper for clerical work especially designed to reduce eye strain. This I am very glad to do as I have been interested in this subject for some few years and have achieved results which I think are really worth while.

"I am in the stationery and office supply business and some few years ago became impressed with the fact that producers of accounting forms and books in their efforts to make their ruling work attractive to the eye were supplying material which subjected the user to considerable strain under constant use. Prior to the start of my investigations practically all accounting forms and books were ruled in red and purple colors as per sample "A" in the accompanying folder. My experiments led me to the conclusion that ruling colors of green and brown were much more friendly to the eyes, and in the business with which I am connected we were successful in introducing this color to our customers and providing material ruled in green and brown. Sample "B" in the folder illustrates this change in the ruling and a comparison of the two side by side will show the relief when using the new type of form. Since I have introduced this type of ruling it has been very generally copied by the entire stationery trade in Canada and substantially sold in the United States, so that today, comparatively few books or forms are offered for sale on our market in the old type of ruling.

"It was this experiment in regard to colors of ruling that led to a further consideration of the colors of paper and the matter was definitely brought to my mind as a result of a young student suffering from severe headaches through constant study. I discovered that he was working on a note book containing white paper and that while the illumination of his work was excellent, it was this very feature which increased the amount of light reflected to his eyes from the white paper. Manufacturers of paper in America particularly, have been consistent in their endeavors to provide a sheet which is brilliant in its

appearance, and to this effect have done exactly the same as the laundry people do in washing - add blueing to the pulp so that in effect the paper sold as white is really a blue-white. The jewellers tell us that the very finest diamonds are those of a blue-white color, and that diamonds of a yellowish cast are considered as seconds. The reason for this of course, is that the blue-white color has materially greater reflecting power, and for this reason it seemed obvious to me that blue-white papers were undesirable for this very reason. P

"At this time I consulted a number of oculists and other authorities in an effort to ascertain just what color might be considered neutral so far as eye strain is concerned, and one of these gentlemen explained to me that the human eye had been developed through countless ages and that resistances had been built up against various types of harmful conditions, and further, that our ancestors going back through the ages, had lived in the forests where the predominating color is green, and that if there had been any harmful effects from looking at green trees, etc. the eye had long since built up a resistance against such harmful effects.

"For this reason I experimented with various shades of green paper, having in mind the necessity for providing a contrast when the paper is written upon, and I finally arrived at the color which we now call our "sight-preserving" paper, samples of which are also in the accompanying folder. We were unable to find that any paper manufacturer produced a paper in this correct shade and it was consequently necessary for us to have it made to order. We have used a good many thousands of tons over the past two or three years, and have had almost innumerable cases brought to our attention where accountants, bookkeepers, students, etc. have eliminated headaches and eye fatigue through changing over to this color of paper. A number of very prominent business organizations such as insurance companies, banks, etc. have conducted comprehensive experiments before adopting this shade of paper; I think I am safe in saying that in no case where the paper has been tested in comparison to other colors, have they failed to adopt this new shade as standard equipment.

"I have done some slight experimenting towards the idea of producing printed books on this paper and I have included in the accompanying folder, samples of some printing for your inspection. I have concluded that it is better to use a short of bronze green printing ink in preference to black so that the general effect will be harmonious, and it is my present thought that books printed on this paper in an appropriate shade of green ink will very definitely reduce the strain and fatigue from constant reading.

"I should have mentioned above that it was also concluded that papers were very much lower in their reflecting properties if care were taken to avoid too high a finish, and I have insisted on our suppliers keeping our papers with as "flat" a surface as possible.

"Some year and a half ago so some samples of this paper and scheme of ruling was sent to Mr. Frank Towne of the National Blank Book Company of Holyoke, Mass. whose company is perhaps the largest producer of this type of equipment in America. Mr. Towne investigated the matter and his company adopted it as standard for their line of accounting and office supplies. I understand that they are greatly pleased with the reception which their new books have received and I have noticed in the November 15th issues of Forbe's magazine an article to the effect that an additional manufacturer has now adopted this new color. The opinion has been expressed to me by one of the largest paper manufacturers in the United States, that in course of time white paper will practically be eliminated from general office use.

"The success of the preceding experiment so far as we are concerned as merchandizers, may in your mind, be attributed to a large extent to the fact that we produced something different and through sales effort were able to convince the public that we had something worth while, even though the advantage was comparatively slight in actual practice. Possibly this is so to some extent but I have before me so many definite cases where clerical workers have eliminated eye troubles and consequent headaches that I am thoroughly convinced of the fact that this paper is much better than white. It is possible of course, that had I conducted my experiments with some other shade as an alternative to white, the results would have been the same or even better, but all of my experimenting pointed definitely towards greens and I feel at the moment that our present shade of paper is the best that has so far been developed."

Dr. D. B. Judd of the National Bureau of Standards supplied the following material:

COLOR AND LEGIBILITY

Some results have been obtained at this Bureau on the legibility of automobile license plates. It was found that dark letters on a light background are more legible than light letters on a dark background.

The following short bibliography lists the more important sources of information on this subject; following each title a brief summary of the several conclusions is given.

- W. D. Scott, *The Theory of Advertising*, Small-Maynard, Boston, pp. 138-139, 1903
Black letters on a white ground are more readily perceived than white letters on black.
- A. Kirschmann, *Ueber die Erkennbarkeit geometrischer Figuren und Schriftzeichen im indirekten Sehen*, *Arch. f. d. ges. Psychol.*, vol. 13, pp. 352-388, 1908. Capital letters are recognized at a greater distance in indirect vision when printed in white type on a black background than when printed in black on white.
- D. Starch, *Advertising*, Scott-Foresman, New York, pp. 189-190, 1914. Black type on white ground may be read 42 per cent faster than white type on dark gray ground.
- M. Luckiesh, *Light and Color Advertising and Merchandising*, Van Nostrand, New York, pp. 246-251, 1923. Black type on yellow background is most legible, red on green, least. The order is: black on yellow, green on white, red on white, blue on white, black on white, red on yellow, green on red, red on green.
- A. T. Poffenberger, *Psychology in Advertising*, Shaw, Chicago, pp. 262-265, 1925. Legibility depends upon the relation of color to background and the all-important factor is brightness difference. The chromaticity difference is of little importance.
- C. E. Ferec and G. Rand, *Intensity of Light and Speed of Vision Studied with Special Reference to Industrial Situations, Part II*, *Transactions Illuminating Engineering Society*, vol. 23, pp. 507-546, 1928. White letters on a black background can be seen quicker than black on white;

this superiority is particularly marked for high illuminations. For low illuminations and small letters black on white is slightly better than white on black.

W. B. Pitkin, The Art of rapid Reading, McGraw-Hill, New York, pp. 45-46, 1929. White on black, test, but not practical for books; black on white, next best; but black on lemon yellow is a close third.

D. G. Paterson and M. A. Tinker, Studies of Typographical Factors Influencing Speed of Reading, VI. Black Type versus White Type, Journal Applied Psychology, Vol. 15, pp. 241-247, 1931. Black type on a white background can be read with 10 per cent greater speed than white on black.

G. Holmes, The Relative Legibility of Black Print and White Print, Journal Applied Psychology, vol. 15, pp. 248-251, 1931. Words printed in 10-point type are 15 per cent more legible when they are black on a white background than when white on black.

M. A. Tinker and D. G. Paterson, Studies of Typographical Factors Influencing Speed of Reading, VII. Variations in Color of Print and Background, Journal Applied Psychology, vol. 15, pp. 471-479, 1931. Black type on a white background may be read most speedily; red on green, least. The order is: black on white, green on white, blue on white, black on yellow, red on white, green on red, red on green.

MEMORANDUM ON LEDGERS AND LEGIBILITY

The following factors should be considered:

- (1) The color of the paper
- (2) The color of the rulings
- (3) The color of the writing ink
- (4) The gloss of the paper
- (5) The clearness of a written ink line on the paper
- (6) The illumination.

1. The Color of the Paper. The all-important factor is that the paper color gives a high brightness contrast with the color of the writing ink. Since writing inks are usually of dark color, the paper must be of light color, the lighter the better; but small differences in reflectance are probably of no practical significance. The chromaticity of the paper probably has little effect on legibility; it may be light blue, light yellow, light green, pink, or white; pale colors are probably better than strong colors of the same brightness. It is likely that there is little justification for changing from the conventional white; on the other hand, there is no need for controlling the chromaticity accurately as far as legibility is concerned; for example, the blue dye usually added to counteract the yellowness of the stock decreases legibility somewhat by darkening the paper.

2. The Color of the Rulings. Avoid rulings of colors highly contrasting either with the paper or with other ruling colors. The ruling colors should all resemble the paper color more than the ink color. It is primarily the writing which has to be legible; hence the writing-ink color must contrast with the ruling color. Since the ink color is customarily dark, and since the paper color should be light, the ruling colors should all be light to medium. Avoid the use of both red and blue rulings; due to chromatic aberration the eye

can not focus on both of these rulings at the same time; constant changes of accommodation result in unnecessary fatigue. If differently colored rulings are used, choose colors whose hues are either the same or not much different.

3. The Color of the Writing Ink. Should be as dark as possible.

4. The Gloss of the Paper. Should be as low as possible in order to avoid the fatiguing effect of spots due to its specular reflection of the light from the illuminating source.

5. The Clearness of a Written Ink Line on the Paper. The paper should "take" ink without permitting it to spread. A paper perfect in this respect usually exhibits considerable gloss. Selection of the best compromise between absorption of ink and gloss is very important.

6. The Illumination. Many defects in legibility due to poor paper can be compensated for by appropriate illumination. The bad effects of gloss are avoided by illuminating in such a way that there are no small intense light sources that can be mirrored in the page. Faint, faded writing on dark discolored paper can be much improved in legibility by using enough favorably distributed light.

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All notices, abstracts, and requests for further information regarding any of the items appearing in this letter, should be addressed to R. G. Macdonald, Secretary, 122 East 42nd Street, New York.