#1912 THE INSTITUTE OF PAPER CHEMISTRY
(Permanence of Paper for "Committee on Materials of Research") Reports

PROJECT REPORT FORM

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Humidity Room

PROJECT NO. 1912
COOPERATOR IPC
REPORT NO. 1
DATE May 4, 1956
NOTE BOOK 1464
PAGE 7 TO 50
SIGNED John I. Mollen
John I. Mollen

THE PHYSICAL EVALUATION OF NATURALLY AGED PAPERS CONTAINED IN VOLUME XIII OF THE DICTIONARY OF AMERICAN BIOGRAPHY

This report presents the data obtained in the evaluation of basis weight, Schopper folding endurance, Schopper tensile strength and zero span tensile strength for three different kinds of paper contained in Volume XIII of the Dictionary of American Biography, printed and edited in 1934. Each copy of this volume was one of twenty five run off as a test to determine how the various kinds of paper stand up under actual storage and use conditions.

Copies of these test volumes were sent to various libraries, distributed widely as to city and country location, sea level and higher elevation, cold and warm and temperate climate. The locations for the various copies are given in Table I.

TABLE I

Copy No.	Location
1	Dartmouth College, Hanover, New Hampshire
2*	Boston Public Library, Boston, Massachusetts
3	Columbia University, New York City
4	The New York Public Library, New York City
5*	The New York Public Library, New York City
6	St. Lawrence University, Canton, New York
7	Library of Congress, Washington, D. C.
8	University of North Carolina, Chapel Hill, North Carolina
9	Public Library, Jacksonville, Florida
10	Howard Memorial Library, New Orleans, Louisiana
11	St. Louis Public Library, St. Louis, Missouri
12	Cincinnati Public Library, Cincinnati, Ohio
13*	Cleveland Public Library, Cleveland, Ohio
14	Carnegie Library, Pittsburgh, Pennsylvania

TABLE I (continued)

Copy No.	Location
15*	John Crerar Library, Chicago, Illinois
16	Iowa State College Library, Ames, Iowa
17	Butte Public Library, Butte, Montana
18	Colorado College Library, Colorado Springs, Colorado
19*	University of Arizona Library, Tucson, Arizona
20	University of Southern California Library, Los Angeles, California
21*	University of California Library, Berkeley, California
22	Seattle Public Library, Seattle, Washington
23*	Toronto Public Library, Toronto, Ontario
24	McGill University Library, Montreal, Quebec, Canada
25	Dalhousie University Library, Halifax, New Brunswick

*Not received by Paper Evaluation Section for testing.

The first section of each book was printed on the same stock as used for the regular trade edition, namely "American Writing Paper," 100% rag, a stock weighing on the basis of a 25" x 38" sheet, 60 lbs. to 500 sheets, made by the American Writing Paper Company, Holyoke, Massachusetts. This is sample A.

The second section was printed on Worthy Permanent Book, 100% rag, white, a stock weighing, on the basis of a 25" x 38" sheet, 70 lbs. to 500 sheets, made by the Worthy Paper Company Association of West Springfield, Massachusetts. This is sample B.

The third section was printed on "Special Alpha Natural 60 lbs. run d-27139, 100% Solka," purified cellulose made by the Brown Company, Portland, Maine, a paper weighing, on the basis of a 25" x 38" sheet, 60 lbs. to 500 sheets made by the Dill & Collins Paper Company, Philadelphia, Pennsylvania. This is sample C.

The above information on the history of the samples was taken from a memorandum which was found in the front of each book.

A description of the three papers is given on the memorandum page reproduced herein as Table II. The sample identification letters A, B, and C which appear on this page were assigned by us for reporting purposes.

TABLE II

MEMORANDUM ABOUT THE PAPER STOCK OF THIS VOLUME
OF THE DICTIONARY OF AMERICAN BIOGRAPHY

This copy of Volume XIII of the Dictionary of American Biography is one of twenty-five run off as a test to determine how various kinds of paper stand up under actual working conditions.

Front matter and pages 1-198 are printed on the same stock as used for the regular trade edition, namely "American Writing Paper," 100% rag, a stock weighing on the basis of a 25" x 38" sheet, 60 lbs. to 500 sheets, made by the American Writing Paper Company, Holyoke, Massachusetts. The chemical tests of this paper give the following results:

Sample A

Alpha content--before aging		95%
after aging		91.8%
Copper number--before aging		.32%
after aging		.73%
Rosin content		.97%
Total acidity		.018%
pH		6.4
Fold--before aging	*M	74.7
	C	48.5
after aging	M	49.0
	C	39.5

*M--Strips cut with the machine.
C--Strips cut against the machine.

Pages 199-358 are printed on "Worthy Permanent Book, 100% rag, white," a stock weighing, on the basis of a 25" x 38" sheet, 70 lbs. to 500 sheets, made by the Worthy Paper Company Association of West Springfield, Massachusetts. The chemical tests of this paper show the following results:

TABLE II (continued)

Sample B	Alpha content--before aging	95.41%
	after aging	94.2%
	Copper number	.456
	Copper number, increase in oven	.0201
	pH	6.3
	Rosin content	.596%
	Folding endurance--not specified loss in oven	5.8%

Pages 359 to the end of volume are printed on "Special Alpha Natural 60# run d-27139, 100% Solka," purified cellulose made by the Brown Company, Portland, Maine, a paper weighing, on the basis of a 25" x 38" sheet, 60 lbs. to 500 sheets, and made by Dill & Collins Paper Company, Philadelphia, Pennsylvania. Chemical tests of this paper show the following results:

Sample C	Alpha content--before aging	90.7%
	after aging	87.25%
	Copper number--before aging	.92
	after aging	.98
	pH	5.7
	Rosin content	.2%
	Folding--before aging	5.5
	after aging	4.7
	Loss in folding after aging	.8 or 85.5%

In addition to the sheets specified above two sample sheets of each stock are bound at the end of the volume to permit later checking or testing without harming the text.

Copies of these test volumes are sent to the following libraries, distributed widely as to city and country location, sea level and higher elevation, cold and warm and temperate climate:

1. Dartmouth College, Hanover, New Hampshire
2. Boston Public Library, Boston, Massachusetts
3. Columbia University, New York City
4, 5. The New York Public Library, New York City
6. St. Lawrence University, Canton, New York
7. Library of Congress, Washington, D. C.
8. University of North Carolina, Chapel Hill, North Carolina
9. Public Library, Jacksonville, Florida
10. Howard Memorial Library, New Orleans, Louisiana
11. St. Louis Public Library, St. Louis Missouri
12. Cincinnati Public Library, Cincinnati, Ohio
13. Cleveland Public Library, Cleveland, Ohio

TABLE II (continued)

14. Carnegie Library, Pittsburgh, Pennsylvania
15. John Crerar Library, Chicago, Illinois
16. Iowa State College Library, Ames, Iowa
17. Butte Public Library, Butte, Montana
18. Colorado College Library, Colorado Springs, Colorado
19. University of Arizona Library, Tucson, Arizona
20. University of Southern California Library, Los Angeles, California
21. University of California Library, Berkeley, California
22. Seattle Public Library, Seattle, Washington
23. Toronto Public Library, Toronto, Ontario
24. McGill University Library, Montreal, Quebec
25. Dalhousie University Library, Halifax, New Brunswick

The basis weight was determined on samples taken from copy nos. 1, 9, 10, 16, 20, 22 and 25. Schopper fold and Schopper tensile were determined on samples taken from copy nos. 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 18, 20, 22, 24 and 25. The latter includes samples from all books received by the Paper Evaluation Section for testing. Zero span tensile was determined only on samples taken from copy no. 1. The results for these determinations are shown in Table III. The basis weight determinations were made on unprinted sheets taken from the back of each book. The fold and tensile determinations were made on the printed pages. Ten pages for each sample were used and these were selected at regular page intervals from the various copies. Ten specimens, one from each page, were tested for both directions of the paper. The Zero span tensile specimens were selected and placed in the zero span jaws in such a way that failure took place on an unprinted section. The specimens which were used to make the zero span tensile determinations were taken from the same 10 sheets that provided the fold and regular tensile specimens.

An average of all the fold data of each sample for the two directions reveals that the folding endurance of Sample A (American Writing Paper, a 100% rag) was 62 and now is 10. The folding endurance of Sample B (Worthy Permanent Book, 100% rag) for which no original value was given, now is 9. The folding endurance of Sample C (Special Alpha Natural purified cellulose) was 6 and now is 3. It will be noted that the Special Alpha Natural retained 50% of its folding endurance over a period of about 22 years. The American Writing Paper retained 17% of its original folding endurance. However the folding endurance of the American Writing Paper is better now than the original folding endurance of the Special Alpha Natural. The same is true when comparing the Worthy Permanent Book paper with the Special Alpha Natural purified cellulose.

Inasmuch as the original tensile strength values were not given there is no way of telling how much the samples deteriorated with regard to this property over the past 22 years.

TABLE III

Copy No.	Sample		Basis Weight In Pounds 25x38--500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
1	A	Max.		19	11	17.6	10.7	48.7	36.5
		Min.		10	6	13.7	7.8	40.6	29.0
		Av.	56.1	14	8	16.1	9.1	44.0	32.1
	B	Max.		12	12	17.9	13.4	55.0	46.1
		Min.		7	6	15.4	10.0	47.0	36.5
		Av.	71.2	9	9	16.5	11.6	51.5	40.6
	C	Max.		5	2	13.4	6.1	43.5	30.2
		Min.		3	1	9.0	5.1	35.0	23.8
		Av.	60.8	4	2	11.5	5.6	39.7	26.1
3	A	Max.		13	11	17.1	9.8		
		Min.		7	5	14.9	8.1		
		Av.		10	8	15.9	9.2		
	B	Max.		9	8	17.4	12.7		
		Min.		6	6	15.7	9.3		
		Av.		7	7	16.7	10.6		
	C	Max.		4	2	12.5	5.8		
		Min.		3	1	8.6	3.7		
		Av.		3	2	11.1	5.1		
4	A	Max.		13	9	16.9	9.1		
		Min.		5	5	14.6	6.6		
		Av.		9	6	15.9	8.2		
	B	Max.		11	10	16.9	11.2		
		Min.		5	6	15.4	9.3		
		Av.		7	7	16.0	10.4		

TABLE III(Continued)

Copy No.	Sample		Basis Weight In Pounds 25x38--500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
	C	Max.		4	2	11.2	5.9		
		Min.		2	1	8.8	4.7		
		Av.		3	2	10.0	5.4		
6	A	Max.		18	11	17.9	10.5		
		Min.		7	5	14.7	8.6		
		Av.		14	8	16.7	9.5		
	B	Max.		12	12	18.1	13.4		
		Min.		7	7	16.4	8.3		
		Av.		9	9	17.3	12.0		
	C	Max.		4	2	13.2	6.1		
		Min.		2	1	11.3	5.4		
		Av.		3	2	12.4	5.8		
7	A	Max.		14	11	17.9	9.8		
		Min.		8	5	14.6	9.0		
		Av.		11	7	16.4	9.4		
	B	Max.		10	11	19.6	13.0		
		Min.		7	6	16.4	10.7		
		Av.		8	8	17.4	11.6		
	C	Max.		5	2	12.2	6.1		
		Min.		2	1	9.7	4.7		
		Av.		3	2	11.1	5.5		
8	A	Max.		14	9	18.3	10.0		
		Min.		5	3	14.4	8.8		
		Av.		9	6	16.4	9.5		

TABLE III (Continued)

Copy No.	Sample		Basis Weight In Pounds 25x38--500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
	B	Max.		10	10	17.9	13.0		
		Min.		5	4	16.4	10.0		
		Av.		7	7	17.2	11.5		
	C	Max.		4	3	12.4	6.1		
		Min.		2	1	10.3	5.1		
		Av.		3	2	11.5	5.6		
9	A	Max.		17	12	16.9	9.8		
		Min.		7	7	14.6	8.5		
		Av.	57.3	12	9	15.8	8.8		
	B	Max.		9	11	17.4	12.5		
		Min.		6	7	15.6	10.2		
		Av.	71.2	8	9	16.5	11.6		
	C	Max.		4	2	12.9	6.1		
		Min.		2	1	11.0	5.2		
		Av.	61.6	3	2	12.1	5.7		
10	A	Max.		18	11	18.3	10.3		
		Min.		7	5	14.7	8.8		
		Av.	56.5	12	7	16.9	9.5		
	B	Max.		12	13	18.5	13.5		
		Min.		7	6	16.6	10.3		
		Av.	72.5	9	9	17.4	11.9		
	C	Max.		6	3	13.4	6.1		
		Min.		2	2	11.3	5.1		
		Av.	61.5	4	2	12.5	5.8		

TABLE III (Continued)

Copy No.	Sample		Basis Weight In Pounds 25x38--500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
11	A	Max.		13	12	17.1	10.3		
		Min.		3	4	13.7	7.3		
		Av.		8	8	15.6	9.1		
	B	Max.		10	11	18.3	13.2		
		Min.		4	7	15.6	10.7		
		Av.		7	8	17.0	11.9		
	C	Max.		4	2	13.2	5.8		
		Min.		2	1	10.5	4.1		
		Av.		3	2	11.7	5.3		
12	A	Max.		17	11	18.8	11.2		
		Min.		5	6	14.7	8.3		
		Av.		12	8	16.6	9.7		
	B	Max.		11	12	17.3	13.2		
		Min.		7	6	15.7	10.7		
		Av.		9	9	16.7	11.7		
	C	Max.		4	2	13.4	6.1		
		Min.		2	1	10.3	5.1		
		Av.		3	2	11.9	5.7		
14	A	Max.		14	11	17.6	11.2		
		Min.		4	4	13.2	9.0		
		Av.		8	8	15.4	9.8		
	B	Max.		11	11	18.3	12.9		
		Min.		6	6	15.4	11.0		
		Av.		8	9	17.0	12.0		
	C	Max.		4	2	13.5	5.9		
		Min.		3	1	11.0	3.7		
		Av.		3	1	12.4	5.4		

TABLE III (Continued)

Copy No.	Sample		Basis Weight In Pounds 25x38--500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
16	A	Max.		16	10	19.1	10.5		
		Min.		6	5	15.6	8.8		
		Av.	57.3	12	7	17.0	9.6		
	B	Max.		9	11	18.3	12.9		
		Min.		6	6	16.4	10.7		
		Av.	70.8	8	8	17.3	11.7		
	C	Max.		4	2	13.4	6.3		
		Min.		3	2	11.2	5.4		
		Av.	57.7	3	2	12.0	5.8		
17	A	Max.		18	12	18.5	10.5		
		Min.		9	5	14.9	8.6		
		Av.		13	9	17.0	9.7		
	B	Max.		16	12	18.8	13.0		
		Min.		6	6	16.8	10.2		
		Av.		10	9	17.4	11.8		
	C	Max.		6	4	13.2	6.1		
		Min.		4	2	11.7	5.4		
		Av.		5	2	12.5	5.8		
18	A	Max.		19	13	18.3	10.3		
		Min.		11	5	14.6	7.6		
		Av.		14	9	16.6	9.5		
	B	Max.		13	13	19.6	13.7		
		Min.		9	6	15.2	10.2		
		Av.		11	10	17.5	12.2		

TABLE III (Continued)

Copy No.	Sample		Basis Weight In Pounds 25x38—500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
	C	Max.		5	2	13.5	6.4		
		Min.		3	2	11.8	5.6		
		Av.		4	2	12.7	6.0		
20	A	Max.		15	10	18.6	10.7		
		Min.		7	6	14.6	9.1		
		Av.	55.4	10	8	16.6	9.8		
	B	Max.		12	12	19.0	12.9		
		Min.		7	7	16.6	9.3		
		Av.	70.2	9	9	17.7	11.8		
	C	Max.		5	2	13.9	6.1		
		Min.		3	2	11.5	5.6		
		Av.	61.5	4	2	12.4	5.8		
22	A	Max.		27	11	18.3	10.5		
		Min.		8	6	14.9	7.8		
		Av.	57.5	14	8	16.9	9.7		
	B	Max.		12	12	18.6	13.4		
		Min.		9	5	16.3	10.3		
		Av.	71.2	10	9	17.3	12.0		
	C	Max.		7	3	13.5	6.1		
		Min.		3	2	10.8	5.2		
		Av.	58.3	5	2	12.3	5.8		
24	A	Max.		19	14	19.0	10.7		
		Min.		8	5	15.2	9.5		
		Av.		13	9	16.9	10.0		

TABLE III (Continued)

Copy No.	Sample		Basis Weight In Pounds 25x38--500	Schopper Fold No. of Double Folds In	Schopper Fold No. of Double Folds Across	Schopper Tensile Pounds Per Inch In	Schopper Tensile Pounds Per Inch Across	Zero Span Tensile Pounds Per Inch In	Zero Span Tensile Pounds Per Inch Across
	B	Max.		11	11	18.6	13.0		
		Min.		7	7	16.3	10.2		
		Av.		9	9	17.5	12.1		
	C	Max.		5	3	14.2	16.1		
		Min.		3	2	10.2	5.6		
		Av.		4	2	13.0	5.9		
25	A	Max.		25	11	18.6	10.2		
		Min.		7	6	14.6	9.5		
		Av.	55.4	15	8	16.8	9.8		
	B	Max.		12	14	18.6	13.0		
		Min.		7	7	15.9	10.7		
		Av.	68.8	9	9	17.0	12.0		
	C	Max.		6	2	13.5	6.3		
		Min.		3	2	10.2	5.1		
		Av.	60.4	4	2	12.2	5.8		

PROJECT REPORT FORM

PROJECT NO. 1912
COOPERATOR I.P.C.
REPORT NO. 2
DATE August 24, 1956
NOTE BOOK 1464
PAGE 122 TO 127
SIGNED Roger Van Eperen
Roger Van Eperen

Copies to: Files
Lewis
Wink
Van Eperen

The M.I.T. Folding Endurance at Zero Tension of Naturally Aged Papers Contained in Volume XIII of the Dictionary of American Biography.

This report presents the M.I.T. folding endurance of copies 4 and 18 of Volume XIII of the Dictionary of American Biography. The tests were made on each of the three different kinds of paper contained in the volume. The three different kinds of paper are identified as samples A, B, and C and are defined in Report No. 1.

The M.I.T. folding endurance was obtained for three different tensions, 1 kilogram, 500 grams, and 200 grams. The values obtained are plotted on semilog paper and the extracalculated values for zero tension are presented in the table.

TABLE I

M.I.T. FOLDING ENDURANCE AT VARIOUS TENSIONS

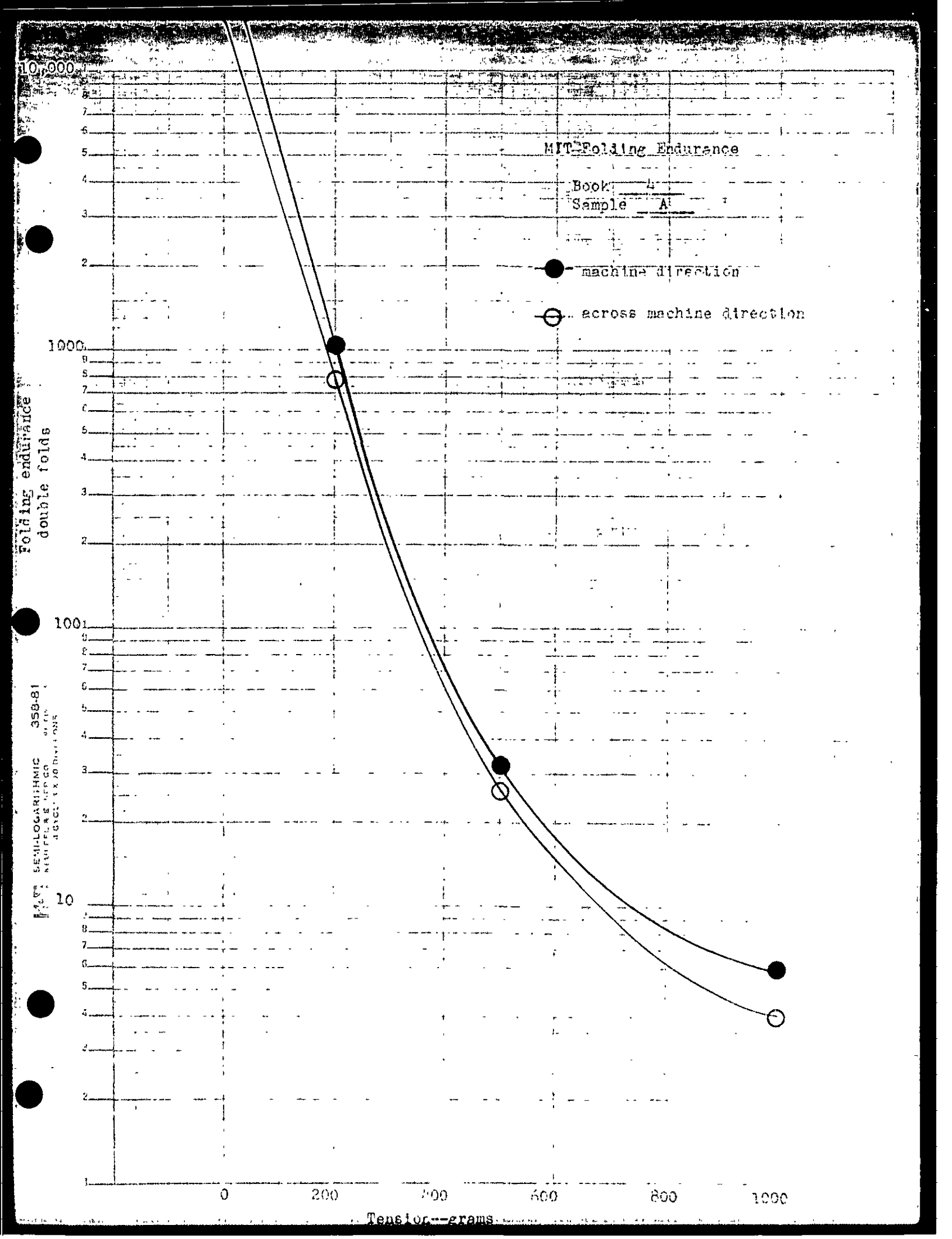
	1 kg. Tension	500 g. Tension	200 g. Tension	0 Tension Extracalculated
Book 4				
Sample A				
Machine direction	6	32	1031	22,700
Cross direction	4	31	774	14,600
Sample B				
Machine direction	4	19	394	7,300
Cross direction	4	24	290	2,200
Sample C				
Machine direction	2	8	70	450
Cross direction	1	5	42	260

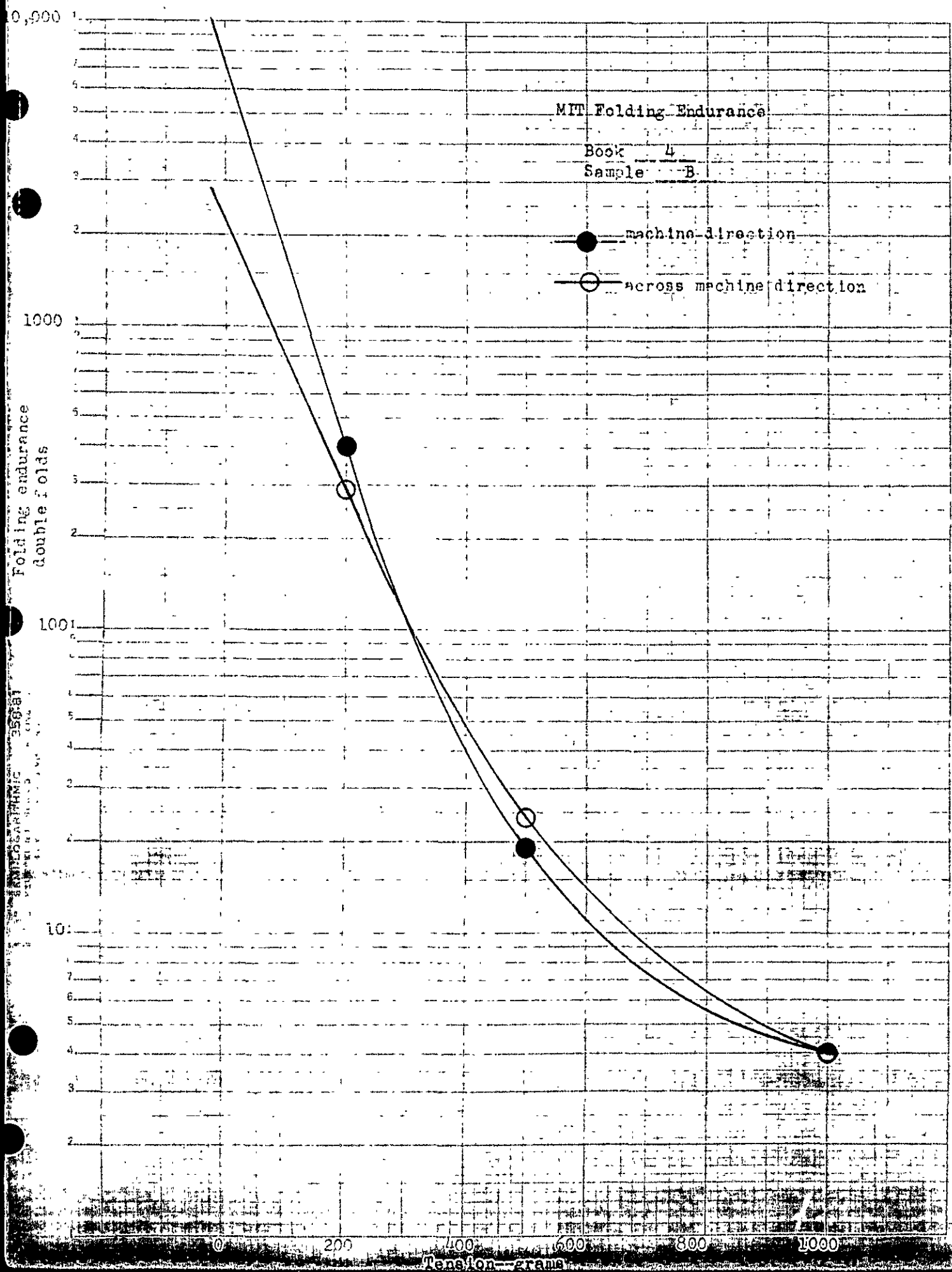
TABLE I (Continued)

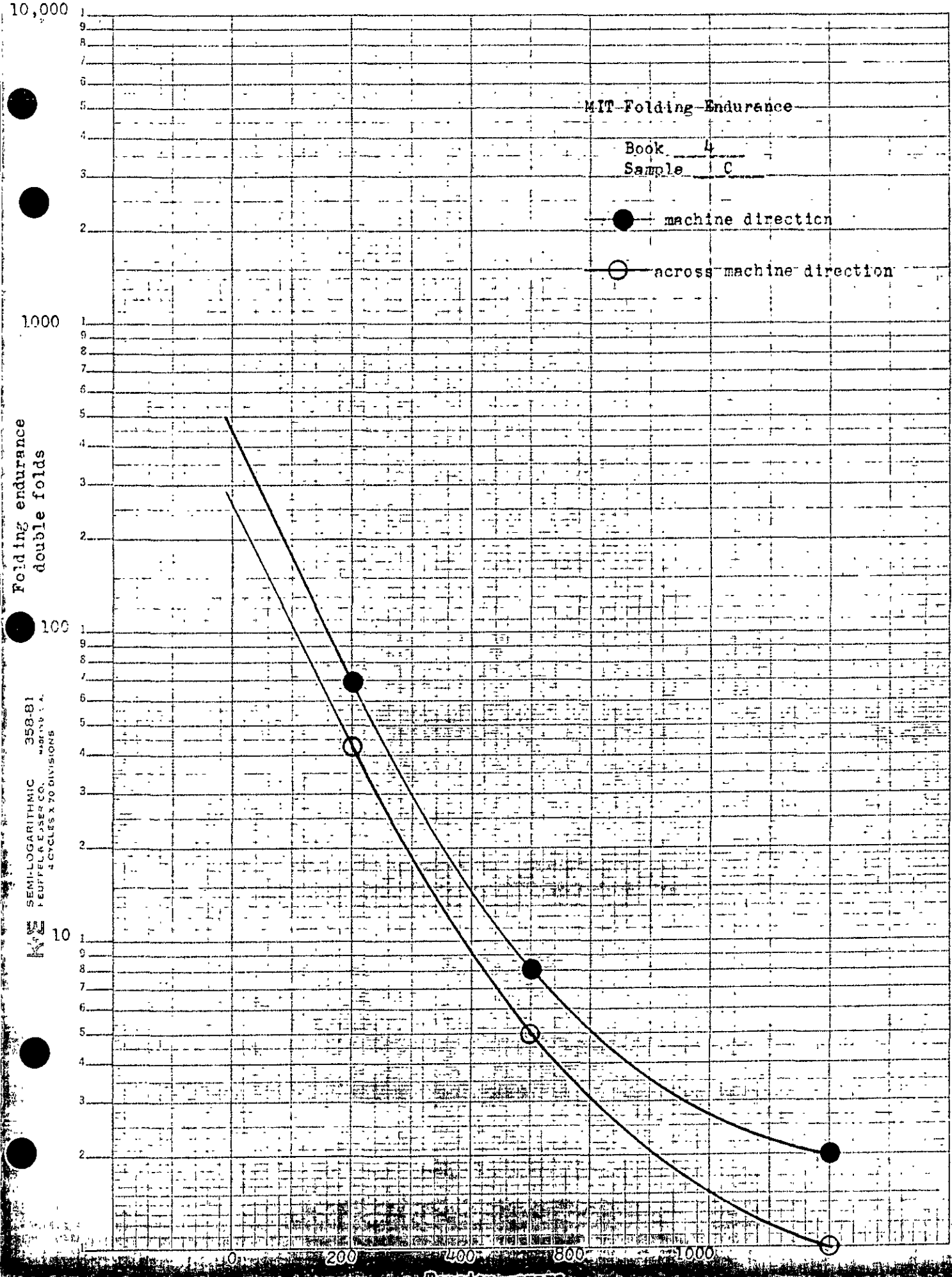
M.I.T. FOLDING ENDURANCE AT VARIOUS TENSIONS

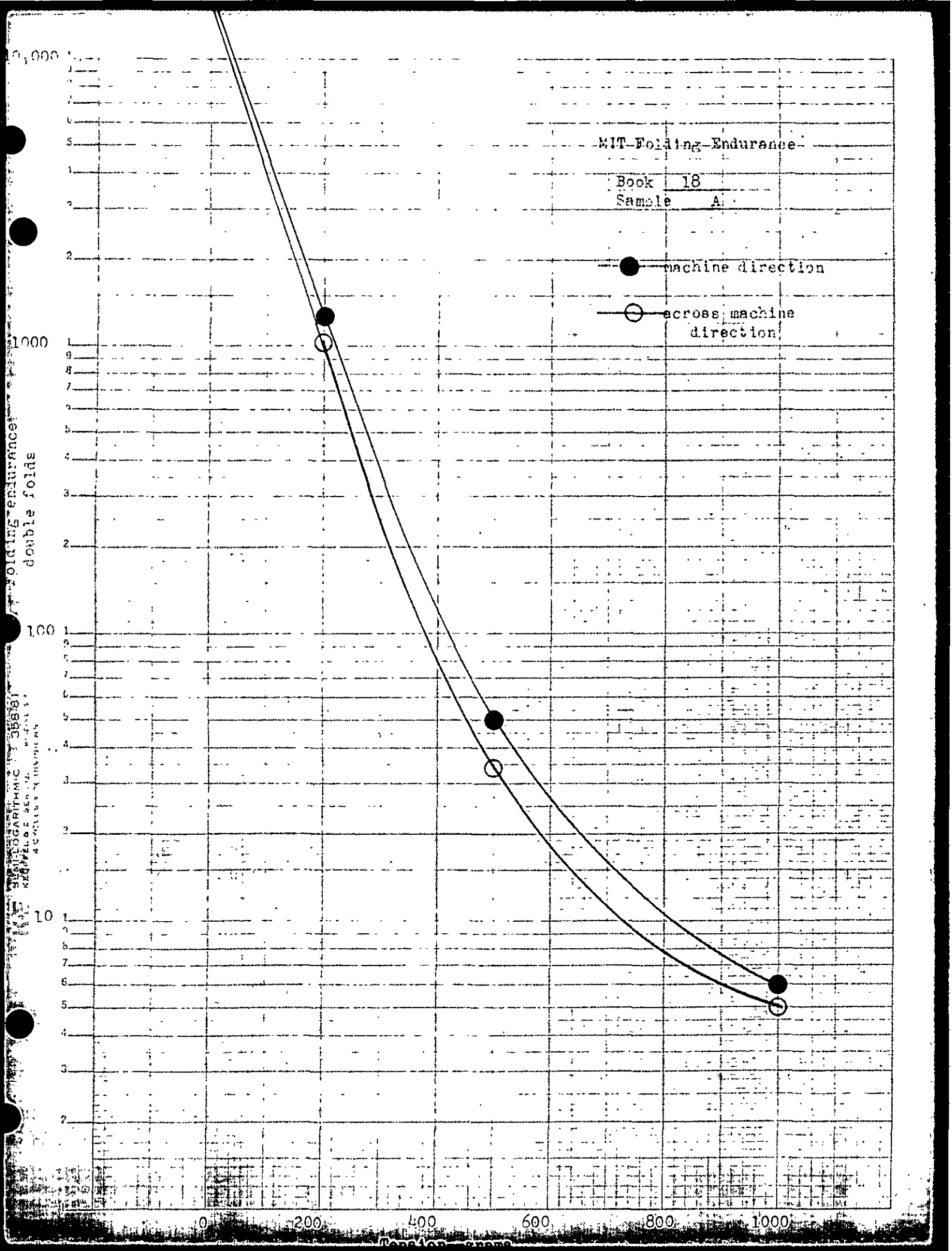
	1 kg. Tension	500 g. Tension	200 g. Tension	0 Tension Extracalculated
Book 18				
Sample A				
Machine direction	6	50	1283	17,400
Cross direction	5	34	1032	16,000
Sample B				
Machine direction	5	25	684	17,900
Cross direction	5	28	935	22,000
Sample C				
Machine direction	2	9	148	2,000
Cross direction	1	5	76	910

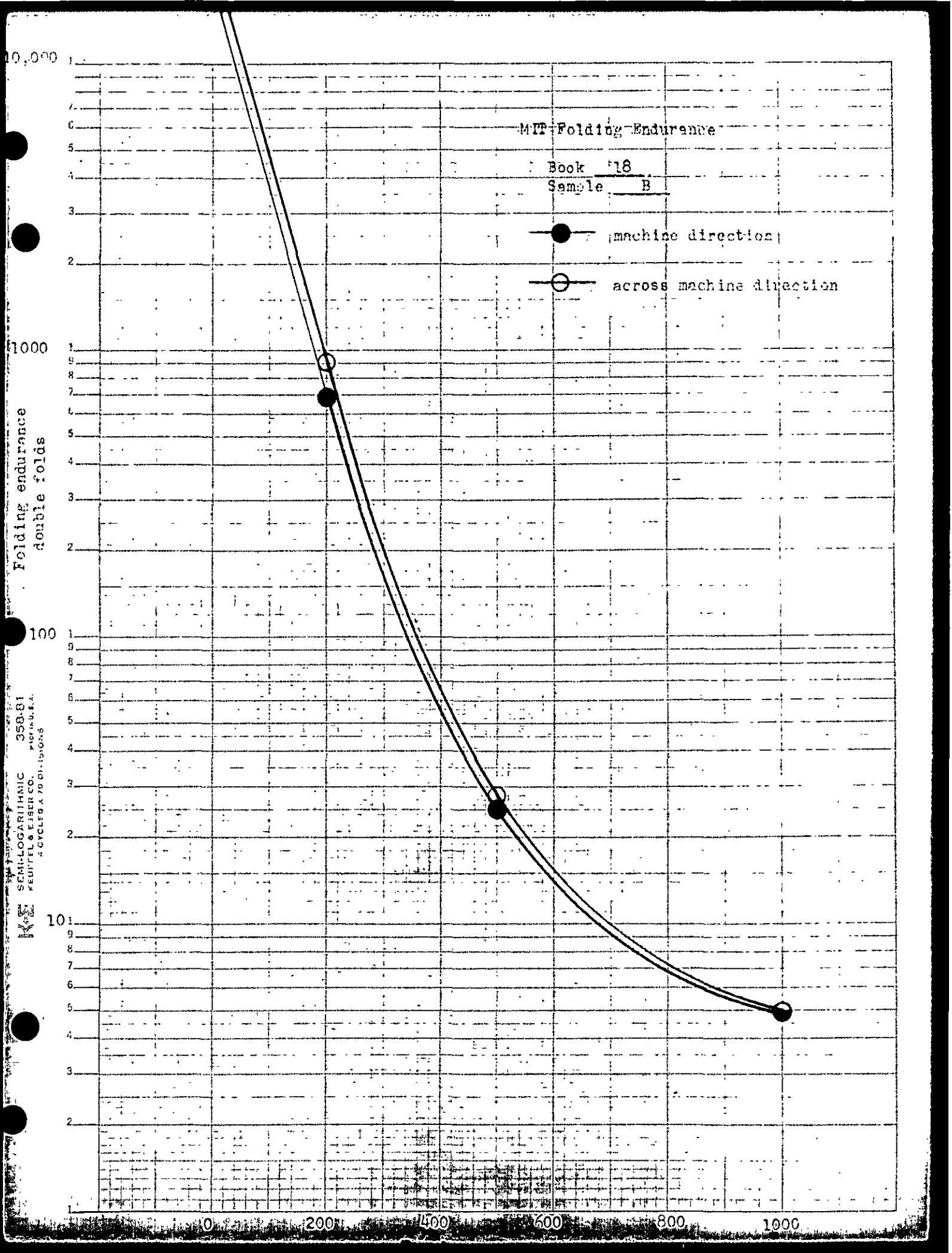
eve/mp

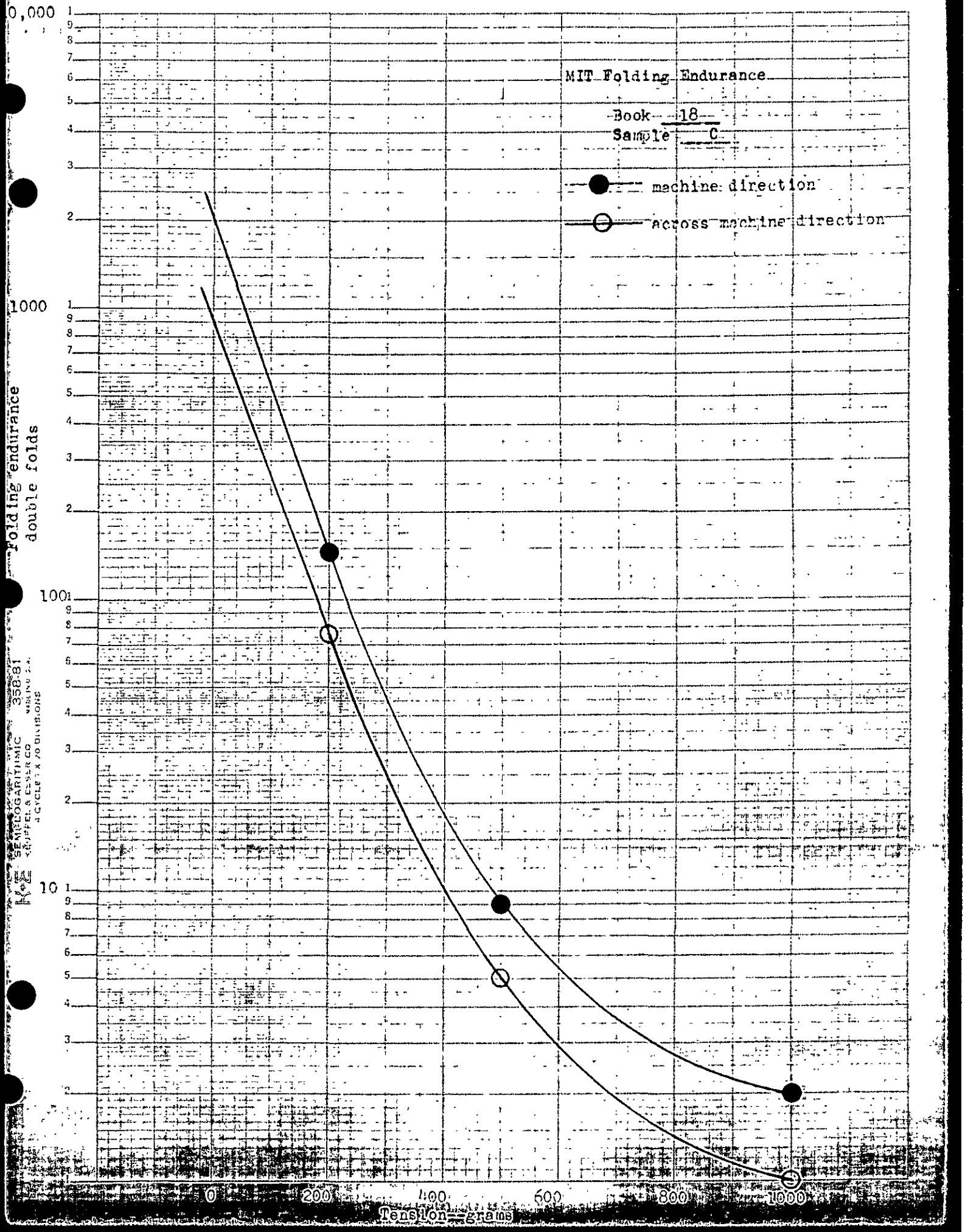

MIT Folding Endurance
Book 4
Sample A
machine direction
across machine direction
Folding endurance
double folds
10,000
1000
100
10
0
200
400
600
800
1000
Tension--grams


MIT Folding Endurance
Book 4
Sample B
machine direction
across machine direction
Folding endurance
double folds
10,000
1000
100
10
0
200
400
600
800
1000
Tension--grams


MIT Folding Endurance
Book 4
Sample C
machine direction
across machine direction
Folding endurance
double folds
10,000
1000
100
10
0
200
400
800
1000
SEMI-LOGARITHMIC 358-81
KEUFFEL & ESSER CO.
4 CYCLES X 70 DIVISIONS


MIT Folding Endurance
Book 18
Sample A
machine direction
across machine direction
folding endurance
double folds
10,000
1000
100
10
0
200
400
600
800
1000
Tension grams


MIT Folding Endurance
Book 18
Sample B
machine direction
across machine direction
Folding endurance
double folds
10,000
1000
100
10
0
200
400
600
800
1000
SEMI-LOGARITHMIC
KEUFFEL & ESSER CO.
358-81
CYCLES X 70 DIVISIONS


MIT Folding Endurance
Book 18
Sample C
machine direction
across machine direction
Folding endurance
double folds
10,000
1000
100
10
0
200
400
600
800
1000
Tension—grams
SEMILOGARITHMIC
358-81
KEUFFEL & ESSER CO
4 CYCLE X 70 DIVISIONS

July 1, 1957
Project 1912 - Report

American Council of Learned Societies
Washington, D.C.

Gentlemen: Attention: Mr. Hellemeyer

I have prepared a report for submission to the American Council of Learned Societies and the Social Science Research Council. I am enclosing herewith two copies of this report, one of which I'll request you to send over to the other co-operating group, for I have had no contact with them whatever. These reports are intended for your files and are not submitted for publication. If either society desires to make public notice of the work, I would appreciate it very much if the responsible member would clear the particular data to be used with me before such publication occurs.

I think I have pulled out of the report the major items of special interest. Much more could be said, but without contributing greatly to the report as it relates to your groups.

The work carried out by The Institute of Paper Chemistry has been extensive and thorough. The charges against our books, which we are absorbing and which do not include any of either my time or my secretary's time, come to better than $4500. This we are glad to contribute to the cause for we are very much interested in any studies which will help to improve our understanding of the lasting qualities of paper.

Sincerely,

Harry F. Lewis
Vice President

Enclosures(2)

Copy to Mr. H. M. Lydenberg

TO THE AMERICAN COUNCIL OF LEARNED SOCIETIES AND THE SOCIAL SCIENCE RESEARCH COUNCIL

The following report describes an experiment set up in the earlier thirties by a joint committee of the American Council of Learned Societies and the Social Science Research Council; the committee was called the Joint Committee on Materials of Research.

The experiment was carried out in the hope that answers to two questions might be forthcoming. The first question was, will a book printed on book paper made from a furnish of highly purified wood pulp, known as Solka pulp, hold up as well under library use as the same weight sheet made of 100% rag stock? The second was, to what extent do such variables as the factors imposed by a geographic location, degree of use, atmospheric conditions, etc. affect the degree of deterioration in books printed on both rag and Solka sheets?

In order to develop this information the Joint Committee on Materials of Research proceeded as follows. The American Council of Learned Societies had in process of publication, with the help of a grant from the New York Times and its President, Adolph S. Ochs, a 20-volume Dictionary of American Biography; the first volume appearing in 1928, the twentieth or last volume in 1937. The printers and publishers of this dictionary were Charles Scribner & Sons of New York. Arrangements were made in 1934 with Scribner to print 25 extra test copies of volume 13, at that time ready to be printed. These test copies differed from the trade volume 13 in that the test volumes were to be printed on two different 100% rag papers and on papers containing 100% of Solka pulp.

Test data on the sheets are provided in an insert entitled "Memorandum About the Paper Stock of this Volume." It must be assumed that the chemical and physical testing procedures reflected in the figures supplied were those in

common use in 1934. To what degree the samples tested were truly representative of the experimental lots of paper is unfortunately not determinable. An attempt was made to check this by getting the original notes of the respective company laboratories but, unfortunately, of the three paper companies only the first, the American Writing Paper Company, is still in operating existence. The Worthy Paper Company Association no longer exists and its records cannot be located. Dill & Collins Paper Company has been bought by the Mead Corporation and its physical facilities converted into warehouse space. Its records could not be obtained.

These 25 test volumes together with the regular volume 13 were sent out to a carefully selected list of libraries distributed widely as to city and country location, sea level and higher elevation, cold and warm and temperate climate. Each library was asked to place the test volume on the shelves with the set and store the trade volume until it was time to call in the experimental volume for testing when the trade volume would replace it. To what degree this condition was followed is difficult to determine. The institutions to which the 25 test volumes were sent include the following:

TABLE I

Copy No.	Location
1	Dartmouth College, Hanover, New Hampshire
2*	Boston Public Library, Boston, Massachusetts
3	Columbia University, New York City
4	The New York Public Library, New York City
5*	The New York Public Library, New York City
6	St. Lawrence University, Canton, New York
7	Library of Congress, Washington, D.C.
8	University of North Carolina, Chapel Hill, North Carolina
9	Public Library, Jacksonville, Florida
10	Howard Memorial Library, New Orleans, Louisiana
11	St. Louis Public Library, St. Louis, Missouri
12	Cincinnati Public Library, Cincinnati, Ohio
13*	Cleveland Public Library, Cleveland, Ohio
14	Carnegie Library, Pittsburgh, Pennsylvania

TABLE I (continued)

Copy No.	Location
15*	John Crerar Library, Chicago, Illinois
16	Iowa State College Library, Ames, Iowa
17	Butte Public Library, Butte, Montana
18	Colorado College Library, Colorado Springs, Colorado
19*	University of Arizona Library, Tucson, Arizona
20	University of Southern California Library, Los Angeles, California
21*	University of California Library, Berkeley, California
22	Seattle Public Library, Seattle, Washington
23*	Toronto Public Library, Toronto, Ontario
24	McGill University Library, Montreal, Quebec, Canada
25	Dalhousie University Library, Halifax, New Brunswick

*Not received by Paper Evaluation Section for testing.

The first section of each book was printed on the same stock as used for the regular trade edition, namely "American Writing Paper," 100% rag, a stock weighing on the basis of a 25"x38" sheet, 60 lb. to 500 sheets, made by the American Writing Paper Company, Holyoke, Massachusetts. This is sample A.

The second section was printed on Worthy Permanent Book, 100% rag, white, a stock weighing on the basis of a 25"x38" sheet, 70 lb. to 500 sheets, made by the Worthy Paper Company Association of West Springfield, Massachusetts. This is sample B.

The third section was printed on "Special Alpha Natural 60 lb. run d-27139, 100% Solka," purified cellulose made by the Brown Company, Portland, Maine, a paper weighing on the basis of a 25"x38" sheet, 60 lb. to 500 sheets made by the Dill & Collins Paper Company, Philadelphia, Pennsylvania. This is sample C.

The above information on the history of the samples was taken from a memorandum which was found in the front of each book.

A description of the three papers is given on the memorandum page reproduced herein as Table II. The sample identification letters A, B, and C which appear on this page were assigned by us for reporting purposes.

TABLE II

MEMORANDUM ABOUT THE PAPER STOCK OF THIS VOLUME
OF THE DICTIONARY OF AMERICAN BIOGRAPHY

This copy of Volume XIII of the Dictionary of American Biography is one of twenty-five run off as a test to determine how various kinds of paper stand up under actual working conditions.

Front matter and pages 1-198 are printed on the same stock as used for the regular trade edition, namely "American Writing Paper," 100% rag, a stock weighing on the basis of a 25"x38" sheet, 60 lb. to 500 sheets, made by the American Writing Paper Company, Holyoke, Massachusetts. The chemical tests of this paper give the following results:

Sample A

Alpha content--before aging		95%
after aging		91.8%
Copper number--before aging		.32%
after aging		.73%
Rosin content		.97%
Total acidity		.018%
pH		6.4
Fold--before aging	*M	74.7
	C	48.5
after aging	M	49.0
	C	39.5

*M--Strips cut with the machine.
C--Strips cut against the machine.

Pages 199-358 are printed on "Worthy Permanent Book, 100% rag, white," a stock weighing on the basis of a 25"x38" sheet, 70 lb. to 500 sheets, made by the Worthy Paper Company Association of West Springfield, Massachusetts. The chemical tests of this paper show the following results:

Sample B

Alpha content--before aging	95.41%
after aging	94.2%
Copper number	.456
Copper number, increase in oven	.0201
pH	6.3
Rosin content	.596%
Folding endurance--not specified loss in oven	5.8%

TABLE II (continued)

Pages 359 to the end of volume are printed on "Special Alpha Natural 60# run d-27139, 100% Solka," purified cellulose made by the Brown Company, Portland, Maine, a paper weighing on the basis of a 25"x38" sheet, 60 lb. to 500 sheets, and made by Dill & Collins Paper Company, Philadelphia, Pennsylvania. Chemical tests of this paper show the following results:

Sample C	Alpha content--before aging	90.7%
	after aging	87.25%
	Copper number--before aging	.92
	after aging	.98
	pH	5.7
	Rosin content	.2%
	Folding--before aging	5.5
	after aging	4.7
	Loss in folding after aging	8 or 85.5%

In addition to the sheets specified above, two sample sheets of each stock are bound at the end of the volume to permit later checking or testing without harming the text.

THE AFTER-USE TEST PROGRAM AND ITS IMPLICATIONS

In April of 1955, or twenty-one years after the test volumes had been sent out to the libraries, The Institute of Paper Chemistry was asked by the last surviving member of the Joint Committee, the former Director of the New York Public Library, H. M. Lydenberg, to test the quality of the paper in those experimental volumes and prepare a final report which could be submitted to co-operating councils as indicative of the completion of the experimental program of the Joint Committee. The Institute of Paper Chemistry agreed to carry out the chemical and physical tests and to prepare a report for submission. This is that report.

On July 15, 1955 a letter was sent out by Mr. Lydenberg to the co-operating libraries asking that the test volumes be sent in to The Institute of Paper Chemistry. Eighteen of the original 25 volumes were returned and the testing of these carried

out. The majority of the volumes not returned apparently could not be spared for one reason or another. One of the test volumes was lost in shipment from the institution to The Institute of Paper Chemistry.

The staff of The Institute of Paper Chemistry has decided against any attempt to publish a scientific report on this experiment for a number of reasons, relating largely to the physical tests on the paper. One is that the paper which was made of 100% Solka pulp was low-grade in its physical properties at the time of its manufacture. It was unfortunate that a better sheet could not have been obtained for this purpose, but in the early thirties the conversion of Solka pulp to a good book paper had not been thoroughly worked out, and, as a result, the physical properties of the test sheet as produced were not representative of what might be expected today of a pulp of that quality. A second reason for this decision is based upon the fact that we have had to accept for the original strength characteristics of the Solka sheet test results which are printed in the book but for which we can get no primary data from the manufacturer. Furthermore, no reproducible physical data are provided for the sheet made by the Worthy Paper Company Association and no description is given for the method of determining the actual value of the folding test in the case of the paper made from the Solka pulp. There are a number of other factors which put a question mark on the justification for attributing any scientific value to the comparison of original and current data. The first two reasons seem to us sufficient to justify the decision to present a generalized report to the two co-operating societies without submission to the scientific literature. However, with this report there are appended the summarized data from all of our tests without specific comment. This deals with that part of the program designated to furnish a convincing answer to the first question, "will a book printed on paper made from Solka pulp hold up as well under library use as the same weight sheet made of 100% rag"?

It should be pointed out that there are some interesting facts which have been developed about the rate of physical deterioration of the paper used in the regular trade volume, as represented by the third of that sheet appearing in the test volume. Likewise, a comparison of the current and original chemical values on this American Writing Paper Company rag sheet (Sample A) and on the sheet made from the Solka pulp (Sample C) seem to have significance. Both points will be stressed later on. Any test results on the second rag sample do not appear to be worth much consideration; it will be included, however, in the appended data sheets.

The results of the physical evaluations of the test papers at The Institute of Paper Chemistry show that the commercial sheet produced by the American Writing Paper Company has survived twenty-two years of heavy use with sufficient residual strength to survive similar use for many more years as measured by Schopper-Riegler folding endurance.

The chemical data likewise show that the Samples A and C have not been lowered more than might have been expected in the period of use. There follows a summary of the averages for all eighteen samples tested with high and low values and spread.

TABLE III

CHEMICAL TESTS ON RAG SHEET A AND SOLKA SHEET C

		% Alpha-Cellulose		pH		Copper Number	
		A	C	A	C	A	C
1.	Original sample	95.0	90.7	6.4	5.7	0.3	0.9
2.	Average (after use)	92.4	87.0	5.1	4.3	1.1	1.6
3.	High	94.7 (22)	90.1 (22)	5.8(22)	4.5 (22)	2.0 (4)	2.3(14)
4.	Low	90.0 (4)	85.0 (4)	4.2(4)	4.0 (14)	0.72(24)	0.89(22)
5.	Spread (1-2)	-2.6	-3.7	-1.3	-1.4	+0.8	+0.7

A. American Writing Paper Rag Sheet C. Dill & Collins Solka Sheet

The numbers in parentheses refer to the test volume numbers (see Table I)

Very small differences exist between the pulp types as the result of twenty-two years of shelf life. One would not be justified in reaching any conclusion other than the fact that rag and Solka sheets have been degraded chemically at about the same average rate; although it should be noted that the chemical purity of the sheet as measured by α-cellulose shows the original purity of the rag sheet to be 4.3% higher than that of the Solka sheet, while the difference after use has increased to 5.4%. In four of the six chemical quality tests the samples from the Seattle Library volume stood highest; in 4 of the 6 the New York Public Library samples stood lowest. The other high quality sheets were from the McGill sample while the other low quality sheets were in the Carnegie Library (Pittsburgh) samples. (Note that higher copper numbers mean lower quality.)

This suffices for any discussion of the changes in strength and composition of the rag and Solka papers.

The remainder of the report will be directed toward the possibility of providing an answer to the second question--"to what extent do such variables as the factors imposed by geographic location, degree of use, atmospheric conditions, etc., affect the degree of deterioration in books printed on rag and Solka sheets"? A quick review of the values for Samples A and C, Tables IV and V show that the greatest changes both physically and chemically have occurred in the books from Columbia University, the New York Public Library, the Pittsburgh Public Library and the University of North Carolina. Minimum degradation has occurred in the books maintained in Seattle, Butte, Colorado College and McGill. It is not easy to pin-point cause and effect, but the books showing the greatest degradation are also the ones in poorest overall shape from excessive use, and the contrary is the case. The Columbia and New York Public Library volumes had received hard enough use to require rebinding. Volumes from the Library of Congress, the Cincinnati Library, the Pittsburgh Carnegie Library, and from the University of North Carolina

TABLE IV

COMPOSITION OF PAPER SAMPLES AFTER USE

		Alpha Cellulose			Starch		Ash			Rosin			Viscosity			Hot Water pH			Cu. No.		
		A	B	C	A	B	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1	Dartmouth College	91.7	90.7	88.1	2.4	0.7	8.0	7.5	8.9	.75	.70	.50	9.1	7.4	9.7	5.1	5.9	4.4	1.0	0.8	1.6
2	Boston Public																				
3	Columbia University	92.8	89.1	87.7	2.4	0.5	8.6	7.0	8.9	.89	.65	.53	5.6	5.9	6.4	4.7	5.2	4.2	1.7	1.5	2.1
4	N.Y. Public	90.0	90.7	35.0	2.4	0.4	8.6	7.8	8.8	.97	.82	.59	5.1	5.2	6.8	4.2	4.8	4.1	2.0	2.0	1.9
5	N.Y. Public																				
6	St. Lawrence U.	91.8	90.1	86.6	3.1	0.9	8.4	7.2	8.6	.69	.60	.46	8.9	7.8	8.7	5.1	5.9	4.4	.88	.74	1.4
7	Library of Congress	91.8	89.5	86.8	3.0	0.8	8.6	7.6	8.8	.77	.71	.49	6.6	6.0	6.8	4.9	5.5	4.2	1.5	1.4	1.8
8	U. of North Carolina	92.4	88.6	86.5	2.7	0.7	8.8	7.3	8.8	.78	.65	.53	7.8	6.9	8.2	5.1	5.7	4.4	1.1	1.2	1.8
9	Jacksonville Public	92.1	88.1	87.6	2.6	0.7	8.5	6.1	8.9	.65	.69	.45	7.6	7.0	7.3	4.7	5.5	4.2	1.1	.95	1.6
10	New Orleans Public	93.1	91.6	86.9	2.6	0.6	8.5	8.3	8.9	.77	.66	.40	8.3	6.9	8.0	5.6	5.8	4.4	.76	.72	1.53
11	St. Louis Public	92.0	89.8	85.7	3.0	0.9	8.7	7.4	8.8	.85	.74	.66	5.7	5.6	6.3	4.7	5.3	4.1	1.4	1.3	1.92
12	Cincinnati Public	92.8	90.0	86.3	3.0	0.9	8.5	7.7	8.8	.81	.76	.54	5.9	6.1	6.4	4.6	5.3	4.2	1.1	1.2	1.86
13	Cleveland Public																				
14	Carnegie Pitts. Public	91.1	91.4	85.4	2.6	0.4	8.7	8.3	8.7	.75	.62	.49	6.6	5.5	6.0	4.6	5.2	4.0	1.6	1.8	2.3
15	Crerar Chi																				
16	Ames	92.0	90.0	85.5	2.5	0.4	8.7	7.4	8.7	.77	.63	.49	7.9	7.3	8.3	5.0	5.8	4.5	1.1	.92	1.44
17	Butte	92.6	91.5	89.2	2.8	0.7	8.7	7.2	8.6	.67	.65	.48	9.1	7.9	11.7	4.9	5.8	4.3	.74	.74	1.09
18	Colorado College	93.9	93.0	88.7	2.9	0.2	8.5	7.8	8.9	.61	.62	.50	8.0	7.6	9.0	5.8	5.7	4.3	.74	.76	1.42
19	Arizona U.																				
20	USC L.A.	92.3	91.4	88.7	2.8	0.4	8.2	8.3	8.8	.71	.64	.49	7.5	9.7	8.3	4.3	4.5	4.3	1.0	1.2	1.54
21	Calif. U. Berkeley																				
22	Seattle Public	94.7	93.2	90.1	3.0	0.8	8.7	8.2	8.9	.85	.73	.55	8.4	7.5	10.3	5.6	5.8	4.5	.85	.87	.89
23	Toronto Public																				
24	McGill Montreal	92.4	91.5	88.0	3.2	0.3	8.5	8.2	8.8	.69	.58	.47	8.1	7.5	9.0	5.8	5.9	4.4	.72	.78	1.38
25	Dalhousie U., N.B.	93.9	92.7	87.9	3.1	0.7	8.[illegible]	7.9	8.7	.71	.61	.48	8.8	8.0	8.8	5.7	5.7	4.3	.81	.72	1.25
	Original Values in 1934 (Table II)	95.0	95.4	90.7						2.7	.60	.20				6.4	6.3	5.7	.32	.46	.92

A--American Writing Paper
100% Rag

B--Worthy Paper Mfg. Association
100% Rag

C--Dill & Collins
100% Solka Pulp

TABLE V

STRENGTH DATA OF PAPER SAMPLES AFTER USE

		A	B	C	Schopper Fold A		B		C		Schopper Tensile A		B		C	
		Basis Weight, lb. 25x38	Basis Weight, lb. 25x38	Basis Weight, lb. 25x38	In	Acr.	In	Acr.	In	Acr.	In	Acr.	In	Acr.	In	Acr.
1	Dartmouth College	56.1	71.2	60.8	14	8	9	9	4	2	16.1	9.1	16.5	11.6	11.5	5.6
	Boston Public															
3	Columbia University				10	8	7	7	3	2	15.9	9.2	16.7	10.6	11.1	5.1
4	N.Y. Public				9	6	7	7	3	2	15.9	9.2	16.0	10.4	10.0	5.4
5	N.Y. Public															
6	St. Lawrence U.				14	8	9	9	3	2	16.7	9.5	17.3	12.0	12.4	5.8
7	Library of Congress				11	7	8	8	3	2	16.4	9.4	17.4	11.6	11.5	5.5
8	U. of North Carolina				9	6	7	7	3	2	16.4	9.5	17.2	11.5	11.5	5.6
9	Jacksonville Public	57.3	71.2	61.6	12	9	8	9	3	2	15.8	8.8	16.5	11.6	12.1	5.7
10	New Orleans Public	56.9	72.5	61.5	12	7	9	9	4	2	16.9	9.5	17.4	11.9	12.5	5.8
11	St. Louis Public				8	8	7	8	3	2	15.6	9.1	17.0	11.9	11.7	5.3
12	Cincinnati Public				12	8	9	9	3	2	16.6	9.7	16.7	11.7	11.9	5.7
13	Cleveland Public															
14	Carnegie Pitts. Public				8	8	8	9	3	1	15.4	9.8	17.0	12.0	12.4	5.4
15	Crerar Chi															
16	Ames	57.3	70.8	57.7	12	7	8	8	3	2	17.0	9.6	17.3	11.7	12.0	5.8
17	Butte				13	9	10	9	5	2	17.0	9.7	17.4	11.8	12.5	5.8
18	Colorado College				14	9	11	10	4	2	16.6	9.5	17.5	12.2	12.7	6.0
19	Arizona U.															
20	USC L.A.	55.4	70.2	61.5	10	8	9	9	4	2	16.6	9.8	17.7	11.8	12.4	5.8
21	Calif. U. Berkeley															
22	Seattle Public	57.5	71.2	58.3	14	8	10	9	5	2	16.9	9.7	17.3	12.0	12.3	5.8
23	Toronto Public															
24	McGill Montreal				13	9	9	9	4	2	16.9	10.0	17.5	12.1	13.0	5.9
25	Dalrousie U., N.B.	55.4	68.8	60.4	15	8	9	9	4	2	16.8	9.8	17.0	12.0	12.2	5.8
	Original Values in 1934 (Table II)				74.7	48.5	--	--	5.5 av.		--	--	--	--	--	--

A--American Writing Paper
100% Rag

B--Worthy Paper Mfg. Association
100% Rag

C--Dill & Collins
100% Solka Pulp

were classified as being in "poor condition." Volumes from Colorado College, McGill, and Dalhousie were in such good condition as to lead to the belief that they had had not too great use. The outside of the Seattle volume on the other hand had evidently been used more than the three just mentioned, but was still in excellent condition.

It should be pointed out that the differences in physical and chemical tests of the worst and the best while not great are significant--particularly chemical tests. The following Table represents a comparison of the tests for the New York Public Library volume (4) as "bad," for the New Orleans volume (10) as "fair to poor," for the Iowa State College volume (16) as "fair to good," and for the Seattle volume (22) as "good." The ratings are by volume appearance, the tests for papers A and C.

	SR Folding Test		Tensile Test		α-Cellulose		pH	
	A	C	A	C	A	C	A	C
N.Y. Public (4)					90.0	85.0	4.2	4.1
Machine	9	3	15.9	11.1				
Across	6	2	8.2	5.1				
New Orleans (10)					93.1	86.9	5.6	4.4
Machine	12	4	16.9	12.5				
Across	7	2	9.5	5.8				
Iowa State (16)					92.0	85.5	5.0	4.5
Machine	12	3	17.0	12.0				
Across	7	2	9.6	5.8				
Seattle Public (22)					94.7	90.1	5.6	4.5
Machine	14	5	16.9	12.3				
Across	8	2	9.7	5.8				
Original (as determined by the manufacturer)	74.7 48.5	5.5 Av.	--	--	95.0	90.7	6.4	5.7

This four-volume comparison places the Seattle volume (22) as showing in general the least amount of degradation by both physical and chemical tests. The New Orleans volume (10) and the Iowa State volume (16) show relatively slight differences but would rate below Seattle, while in a solid last place there is the New York Public Library volume and on all counts by a fairly wide margin. Visual inspection places the Iowa State volume as slightly ahead of the New Orleans volume.

The writer of this report has been in communication with Mr. Lydenberg from time to time over the two-year period. He has also visited the Manuscript Division of the Library of Congress and has read the file which contains the letters dealing with the initiation of this program. It is his recommendation that this report be not published in any official journal. He also recommends that the file be closed.

For the time being the test volumes will be kept at The Institute of Paper Chemistry awaiting advice on their disposition from the co-operating societies.

Harry F. Lewis
Vice President
The Institute of Paper Chemistry

APPENDIX

For those who might be interested the following is a description of the physical and chemical tests employed:

1. Physical Test Methods

The basis weight was determined on samples taken from copy nos. 1, 9, 10, 16, 20, 22 and 25. Schopper fold and Schopper tensile were determined on samples taken from copy nos. 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 18, 20, 22, 24 and 25. The latter includes samples from all books received by the Paper Evaluation Section for testing. The results for these determinations are shown in Table V. The bsis weight determinations were made on unprinted sheets taken from the back of each book. The fold and tensile determinations were made on the printed pages. Ten pages for each sample were used and these were selected at regular page intervals from the various copies. Ten specimens, one from each page, were tested for both directions of the paper.

An average of all the fold data of each sample for the two directions reveals that the folding endurance of Sample A (American Writing Paper, 100% rag) was 62 and now is 10. The folding endurance of Sample B (Worthy Permanent Book, 100% rag) for which no original value was given, now is 9. The folding endurance of Sample C (Solka sheet) was 6 and now is 3. It should be noted that the folding endurance of the American Writing Paper is better now than the original folding endurance of the Solka sheet.

Inasmuch as the original tensile strength values were not given there is no way of telling how much the samples deteriorated with regard to this property over the past 22 years.

2. Folding Tests with the MIT Tester at Reduced Tension

It should be stressed that the tests employed for determining folding endurance are primarily designed for papers of fairly high strength. Just what their significance is on papers of low folding endurance is questionable. As an illustration of this, we ran the folding endurance of the three types of paper on the MIT folding tester at three tensions--the specified tension of 1 kg., a tension of 500 grams and a tension of 200 grams. From the data we extrapolated to zero tension. (In actual use when a sheet page in a book is folded by a careless reader, the tension is likely very low.) The results appear in the following Table for volumes 4 and 18.

	Number of Double Folds to Failure			
Tension	1 kg.	500 g.	200 g.	Extrapolated to 0
Volume 4 (N.Y. Public Library)				
Sample A (American Writing Paper)				
Machine direction	6	32	1031	22,700
Cross machine direction	4	31	774	14,600
Sample B (Worthy Paper Co.)				
Machine direction	4	19	394	7,300
Cross machine direction	4	24	290	2,200
Sample C (Dill & Collins--Solka)				
Machine direction	2	8	70	450
Cross machine direction	1	5	42	260

Tension	Number of Double Folds to Failure 1 kg.	500 g.	200 g.	Extrapolated to 0
Volume 18 (Colorado College)				
Sample A (American Writing Paper)				
Machine direction	6	50	1283	17,400
Cross machine direction	5	34	1032	16,000
Sample B (Worthy Paper Co.)				
Machine direction	5	25	684	17,900
Cross machine direction	5	28	915	22,000
Sample C (Dill & Collins--Solka)				
Machine direction	2	9	148	2,000
Cross machine direction	1	5	76	900

Evidently all three samples still possess residual folding strength for some extended period of intended use. The extrapolated values suggest the need for the development of a special folding test for weak sheets.

3. Chemical Test Methods

1. Alpha cellulose. Method of Bureau of Standards, circa 1930. See Burton, J. O. and Rasch, R. H., Bureau of Standards Journal of Research, No. 6, 603-13 (Jan.-June, 1931).

   The weight of sample was corrected for starch, rosin, and ash. The weight of alpha cellulose was corrected for ash.

   Calculation:

$$\% \alpha = \frac{\text{(wt. of alpha cellulose) - (ash in alpha)}}{\text{(Sample wt. x moisture factor) - (O.D. sample wt.)} \frac{\text{(\% ash, starch \& rosin)}}{100}}$$

2. Starch. Determined colorimetrically with iodine-iodide following water extraction.

3. Ash. Institute Method 610.

4. Rosin. Institute Method 604.

5. Cuprammonium viscosity. Institute Method 420 with the following modifications. (1) The samples were extracted with boiling water in a Waring Blendor and then filtered on a Gooch filter. (2) The samples were then extracted with 95% ethanol, acidified with acetic acid, and finally washed with 95% ethanol. (3) The samples were air dried and fluffed in a Waring Blendor.

6. Hot water pH. Tappi Method T 435 m 52.

7. Copper number. Tappi Method T 430 m.