THESIS

THE STUDY OF THE WASHING PROBLEMS IN A MODERN POWER LAUNDRY

A Thesis

Submitted to the Faculty of the Massachusetts Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science.

Submitted By

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Acknowledgment

It is fitting that the writer take this opportunity to thank Mr. Robert P. Russell for his hearty cooperation and timely assistance during this work. Many thanks are due the Messrs. McCrillis of the White Star Laundry and Mr. J. W. MacDonald Assistant Superintendent of Buildings at M.I.T. for their generosity and willingness to assist during all periods of the investigation.

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(continued)

Subject:

The Study of the Washing Problems in a Modern Power Laundry.

Objects:

1. To Study the wear of Flat Work (bed linen etc) thru the individual steps in the laundering process, with an aim to lengthen the life of the material.

2. To Study the use of Alkalies and Bleaches with an aim to decide which is the least cloth tendering.

3. To Study the use of the X-Ray in determining the wear to which the material has been subjected.

Introduction:

The difficulty of washing, starching and ironing collars properly in the home gave rise to the opening of a collar laundry in Troy in 1835. This was the beginning of the laundry industry. At first collars alone were sent to the laundry and for years the only collar laundries in the country were located in Troy. The shirt gradually made its appearance in the laundry bundle, and thus it remained up until a comparatively short time ago. There has been a rapid advancement made in the past few years. During the period of from 1914 to 1919 the growth was in excess of 65%, and at the present rate of increase it will have shown a growth of nearly 100%, over the total of 1919, at the time of the next census in 1925. There have been formed clubs with their name as their aim - Billion Dollars in 1930.

This rapid advancement has been due to the fact that science has now fitted itself as the base of the whole industry. Experienced and able men are at the helm of every modern laundry, who are willing to let science substitute the old idea of 'it always has worked' for newer, more efficient and less cloth tendering processes. The laundries hardest problem is to try to live down the deterioration to which the clothes were subjected in the beginning of the industry, and thus to educate the public to the modern power laundry.

Theoretical Aspect:

This phase of the subject will be to study the fibre crystalline structure thru the medium of the X-Ray. Within the last few years it has been shown that cotton fibre is of crystalline structure. The crystals become swollen, depending upon the use of reagents. All phases of this swelling are shown by the X-Ray machine.

Previous Work:

Previous investigation of the action of High Temperature, Sours, Starch, Blues, and Moisture, on fibre (principally cotton).

H. D. Clayton has shown that wool remains more stable at high heat (either moist or dry) than does either cotton or silk. Some cotton fabrics begin to weaken in tensile strength when subjected to 300°F. while others are not affected much below 350°F. If a decrease in breaking strength takes place at 350°F. with unbleached cotton cloth, bleached material begins to weaken at 300°F. Scorches do not become visable until a temperature is reached from 50°F. to 100°F. higher than that at which the cloth begins to weaken.

Clayton carried an investigation with collars giving the cause for holes appearing in semi-soft collars. He came to the conclusion that the exact location of these holes in worn collars is dependent upon the distribution of strain in the wearing and the application of friction to the manufactured article. Furthermore the length of life of webbing cloth is directly proportional to its original strength and inversely proportional to the amount of wear, friction or abuse to which it is subjected. In other words the life of a webbing material possessing a breaking strength of 110# is correspoundingly greater than that of a material breaking at but 80#. This fact is made use of in this investigation. Of course the laundry is not altogether blameless in the matter. Some collars that have been examined through Clayton's work gave positive tests for oxycellulose when boiled in Fehling Solution. This naturally means that collars were weakened and broken down easily. Furthermore, care must be taken to use the proper sour (if oxalic acid is used - rinse well). The ironing temperature must not be too high. At the same time the wearer cannot expect collars to last forever. Whenever a customer complains about wearing out a collar that has had 2 or 3 different laundry marks on it, it may be assumed that the collar has given the wear that the customer may reasonably expect. Occasionally a webbing or duck collar breaks down after but a few periods of wear, in which the wearer has a reason to complain. Unless a positive test for over bleaching is obtained in both the muslin band and the webbing itself, it must then be assumed that the material is in some way defective.

Remembering that the bleacher may over bleach his material just as much as a laundry owner. Clayton founds that collars washed in bulk are subjected to considerable friction of the wheel. During laundering collars washed in nets will be subjected to far less friction since they rub against the other collars in the net, whereas in bulk they also rub against the washer surface.

Clayton's results may be summarized:

1. Holes generally a result of natural wear.

2. That oxycellulose either in the original cloth or introduced during laundering increases the tendency for the holes to develop.

3. Customer may expect 22 periods of wear from a duck or webbing collar.

4. Collars wearing out prematurely are either defective in construction or have been over bleached.

5. Collars show a less tendency to wear in nets.

George H. Johnson has made a summary of the action of acids (sours) on fibres.

H_2So_4:

Concentrated-fibers swell and form gelatenous mass.

Warm-Concentrated-changes the structure by dissolving the fibres.

Hot dilute - very likely to tender.

Cold dilute - very little action, unless dried on the material.

HNO_3:

Hot conc - entirely decomposes.

Cold conc- forms gun cotton.

Dilute - little action, unless dried on the material.

HCI:

Whether concentrated or dilute has less action than any of the mineral acids - unless dried on it.

The above three sours have been used in the laundry process. HNO_3 is now entirely extinct, but the other two are still to be found in a very few places. No mineral acid should be used.

Organic acids (sours) attack to much less extent than do mineral acids. Oxalic, tartaric and citric acids tender the cellulose when dried on it. Boiling formic and acetic acid have considerable tendering capacities - but dilute forms do not show appreciable harm even when allowed to dry on it. Oxalic and acetic are the most widely used sours. Oxalic acid has the great ability of removing rust.

Johnson also states that freezing a wet cotton fabric causes a bursting of the fibres and consequently a great weakening effect. Also that cotton with its hygroscopic moisture driven out is weaker than cotton with its natural moisture retained.

Fuwa has shown that increase of moisture causes increase in strength up to about 12%, beyond this point, however, strength is independent of moisture. Fuwa attributes this to the swelling of the fibres, which in turn causes an increase in fibre to fibre coefficient of friction. He has shown that between 20° to 140°C that the tensile strength decreased practically as a straight linear function. Together with moisture (+ heat) these forces together take the course of the resultant of the separate effects. Baking yarn at 110°C for a period of eight days caused only a slight decrease in tensile strength - while 140°C showed a decrease of 50%.

The Research Laboratory of Applied Chemistry at M.I.T. finds that in eight ordinary launderings, the collar loses 26% of its original strength. Of the 26%, 70% occurs in the washroom and 30% in the finishing department. The washroom loss is attributed to bleaching, rinses sodas and soaps and to the sours and blues. The finishing department loss is attributed to the dryroom, moulder, and hot tube. As a result of this work it was found this loss could be reduced at least 25% of the original 26%. In other words, make the collar lose 19.5% of its original strength instead of 26%. This change can be made without changing the appearance of the collar. Russell recommends that the following process be altered.

1. Lessen Bleach.
2. Change operations following sour and blue.
3. Use neutral starch.
4. Reduce Heat in Dry Room.
5. Alter use of Hot Tube.

(b)

Previous work on Alkalies:

The most recent investigations have been carried on by the Cowles Detergent Co., Manufacturers of the Commercial Alkali Escolite.

The alkali metals combined with the hydroxyl group form our washing alkalies. The principal members of this group are ammonia (NH_3), potassium (K), and sodium (Na).

Ammonium Hydroxide is sometimes used in textile mills as an alkaline assistant in washing with a sodium or or potassium soap. This, however, has been shown, not to increase greatly the activity of the solution. Upon addition of NH_4OH the soap solution becomes thinner in body. NH_4OH is said to have no decisive advantages. The characteristics of this alkali are, that being a gas it has a great penetrating power and the products which it forms in neutralizing acids are practically all soluble in water. On the other hand being easily driven off by heat a temperature such as employed in the washing might readily decompose the NH_3 compounds. Its very disagreeable odor has ruled it out in many instances. The tensile strength of textile fibres are but very slightly impaired by the use of NH_3. The great use of NH_3 would come at low temperatures (lowest volatility) and then driven from the fibres by drying, thence the least amount of tendering. It cannot be used with bronze wash wheels as a compound of copper ammonium is formed which is very destructive to vegetable fibres.

Potassium - This metal is of comparatively high price, the soap of potash is more soluble than the soap of sodium. Potassium soap is not produced in solid form and is therefore less convenient to handle. When using a K soap, K alkalies should also be used because Na alkalies would change the base of the K soap and thus lose the high solubility of the K soap. The compounds of K used as alkalies are the hydroxide and the carbonate. These alkalies neutralize acid dirts, form very soluble compounds, stimulate the colloidal activity of soap and soften the water. The alkali has the decided disadvantage of having to use more (due to molecular weight) to get the same results than for Sodium alkalies. Thus they have greater tendering qualities. These K alkalies are being fast replaced by the cheaper Na alkalies.

Sodium - The alkalies formed from sodium form the greater part of our laundry alkalies and are considered in detail here. Those formed from sodium are: (1) Caustic Soda (2) Soda Ash (3) Bicarbonate of Soda (4) Mixtures of 2 and 3 (5) Trisodium Phosphate (6) Sodium Borate (7) Silicate of Soda (8) Sodium Silico Aluminate. (The following are abstracts from the Cowles Bulletin.)

(1) Caustic Soda: This is the strongest of the alkalies and when used concentrated is very destructive. Application of caustic soda is very seldom found except in modified doses.

(2) Soda Ash: This alkali tends to give a yellowing and graying of the cloth with continued use it becomes destructive.

(3) Bicarbonate of Soda: This is seldom used on account of its low hydroxyl content. Launderers have often been lead to believe that in using a mixture of caustic soda and Bicarbonate the caustic is overcome. This combination is nothing more than to wash with soda ash.

(4) Mixtures of 2 and 3 are called 'modified alkalies" and the result is discussed under Bicarbonate.

(5) Trisodium Phosphate: This alkali has gained some favorable comment probably because of its affinity for hardening materials in water. Its tendency is to soften the water and thus prevent the formation of lime and iron compounds. In buying this alkali the launderer pays for water to the extent of 55%. For this reason it is not an economical alkali.

(6) Sodium Borate: This alkali is less effective than (5) but a very slight bleaching action can be observed with its use. It assists in the retardation of rust.

(7) Silicate of Soda: This alkali has comparatively low cost. The silicate gives a less tendency for the cloth to turn gray or yellow. It is produced in a thick viscous liquid which is hard to handle. It gives a good hydroxyl concentration and when used under the right conditions can be made very satisfactory.

(8) "Escolite:" This alkali is neutralized by two mild mineral acids, alumina and silica. When the alkali is liberated it can be used to greatest advantage in cleaning but cannot be absorbed by the fibres due to the small amount of mineral acid present. Both acid and alkali are in colloidal state in solution. When the water is hot or warm the available alkali is released.

Comparisons of the more important sodium alkalies are given.

Relative Equivalents of Alkali yield.

1# of (8)=2½# (2)=6¼# (4)=6¾# sil soda=10# of (5)=12½ # of (6)

(8) yields amounts of useful alkali about 2½ times that of (2) yet the destructive action is approximately ¼ of (2).

Sample of thread placed in 5% solution of the following alkalies for 142 hours gave:

	Breaking strength/thread	Loss
Orig Thread	4# 6oz	0.0%
(8)	4# 2oz	5.7%
(4)	4# 2oz	5.7%
(1)	3# 2oz	28.6%
(2)	3# 12oz	14.3%

(Note) These data are claims made by the Cowles Detergent Co.

These above percentages were prepared by equivalent strength by weight. Therefore available alkali was 2½ times as much in the case of (8) and (2). (This statement holds for all above and all following tables.)

The Arthur D. Little, Inc. has shown that when boiling with a .1% of (2) and .1% solution of (8) on cotton sheeting

(8) 15% loss (2) 21.15% loss

Also that, 2% solutions for 1 hour at 180°F

(2)=22.1% loss (8) 3% loss

Another independent work (other than Cowles Detergent Co) under average wash room condition and concentrations.

	No of washes	Loss in strength
(8)	50	No loss in strength
(2)	25	11%
(8)	100	4%
(2)	100	13%

On 25 washes (2) is 3 times as great as (8) is at 100 washes despite the fact of 2½ times as great available alkali in (8)

Effect of over doses

Material	No of Washes	Loss
(8)	25	6%
(2)	25	28%
(1)	25	68%
(8)	100	22%
(2)	100	78%
(1)	100	86%

Note: The conc of (1) was 1/3 as conc as (2)

From the Silicate P's and Q's published by the Philadelphia Quartz Company.

"It has long been supposed that silicate and soap mixtures were harder on fabrics than soaps which contained no silicate. A very careful piece of work done in the School of Dyeing at Barmen, by Zanker and Schnable shows the error of this assumption. Cotton yarns washed 200 times in boiling one percent solutions of soap and soap powder with and without silicate show that the fibre washed in the silicate liquors is stronger than that treated with the so called pure products. The first few washings showed an increase of strength, the alkali had a mercerizing action on the fibre, but this was less in the presence of silicate. The same workers found that silicate detergents had a less fading action than soap on the colors of fabrics designated as fast to laundering. After a given number of washes the better appearance was always evident in the fabric from the silicated detergent. Every soap maker knows that the free alkali in a batch of soap can be reduced by adding silicate. The tiny particles of silica which are present in all commercial silicate solutions are able to attach alkali to their surfaces in a way which makes its action much milder than it would otherwise be."

(c) X-Ray Phase of the Subject.

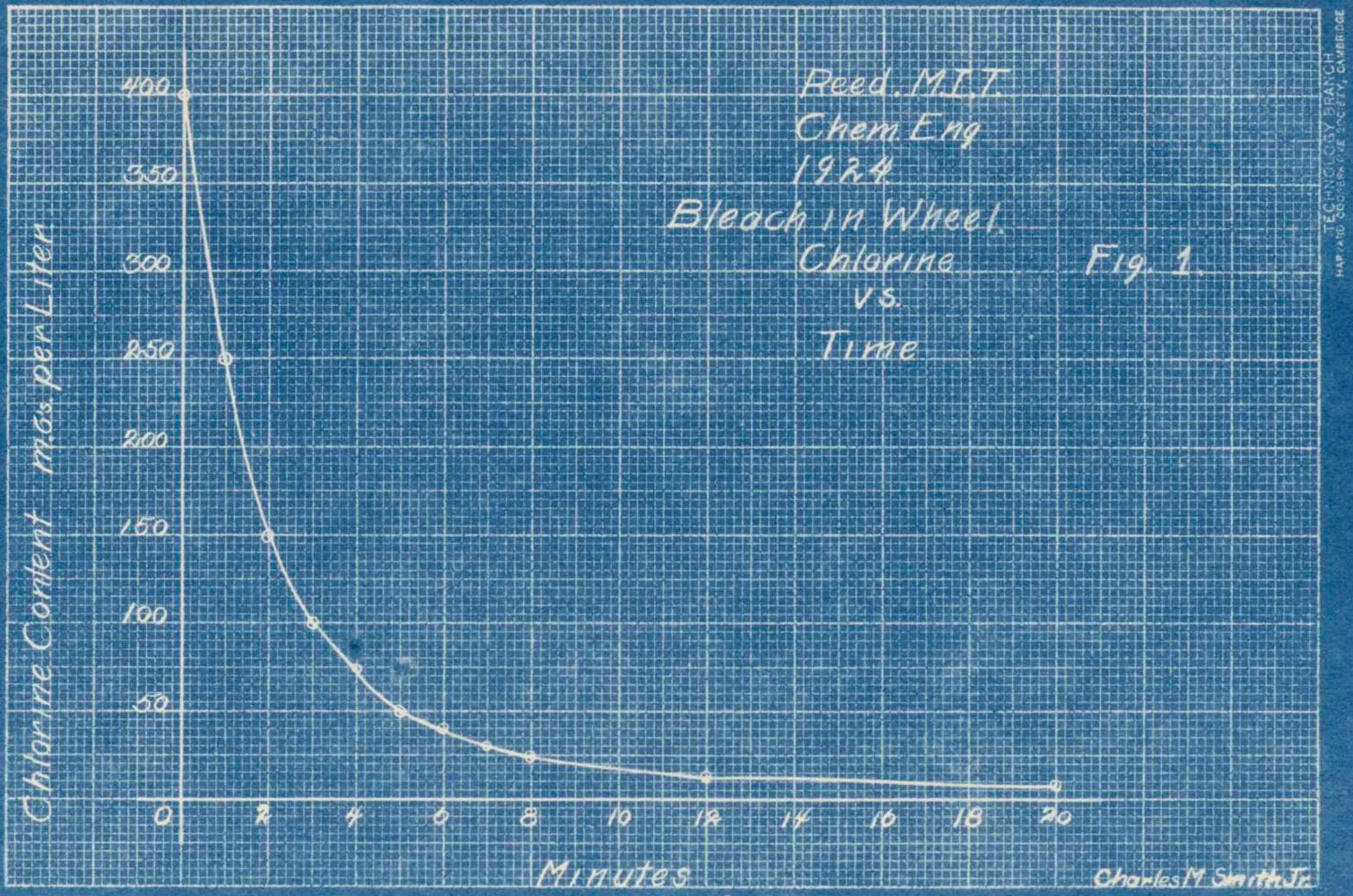
By the use of Laue photograph thru thin metal foils it has been shown that information could be gained in this way concerning the previous history of the sheet. Thus we can tell the size of the individual crystal grains in different preparation from the size of their defraction spots-- the direction of the working can frequently be deduced and the character of its heat treatment suggested. Experiments by M. Polanyi show that there are 2 kinds of fibre: (1) Simple- with parallel packing together of thread like crystals which are always elongated in the same crystallgraphic directions the gliding planes of the atoms are in a single prefered direction; (2) Complex-fibres in which there are more than one direction of fibering or elongating within the same fibre. Cellulose has a predominantly needle like habit, and has been found to yield more or less ideal fibre diagrams.

In many cases X-Ray defraction will be of utmost value not only as a qualitative analysis but for the purpose of semi quantitative estimation. This means of study is particularly useful under the following conditions (1) in an examination of opaque material (2) when the sizes of the individual crystals become indescribably small. Cotton and fibres give powder patterns which the few available data indicate to be identical, thus the crystals of different kinds of Cellulose undoubtly have the same kind of size and shape. Reagents tend to swell this common size and shape dependent on the strength of the solution.

(d) Reed (1924 Chemical Engineering Thesis M.I.T.)

Reed studied the individual steps in the laundering processes. In his investigation laboratory apparatus was used which offered much doubt as to its comparing favorably with actual conditions in practice. Nevertheless his general observations seem to check very well with actual conditions observed in this thesis.

At intervals during 20 minute bleach runs, samples were obtained from the discharge pipe and analysed for oxidizing chlorine content with potassium iodide and standard sodium thio-sulphate solution. Figure Number 1 shows the general decrease in chlorine content with time from an average curve of Reed's 6 runs varying the temperature. Most of the decrease comes within the first 5 minutes. Figures Number 2 shows the wear caused by the individual steps in the laundering process.


Reed. M.I.T.
Chem Eng
1924
Bleach in Wheel.
Chlorine
vs.
Time
Fig. 1.
Chlorine Content mgs. per Liter
400
350
300
250
200
150
100
50
0
2
4
6
8
10
12
14
16
18
20
Minutes
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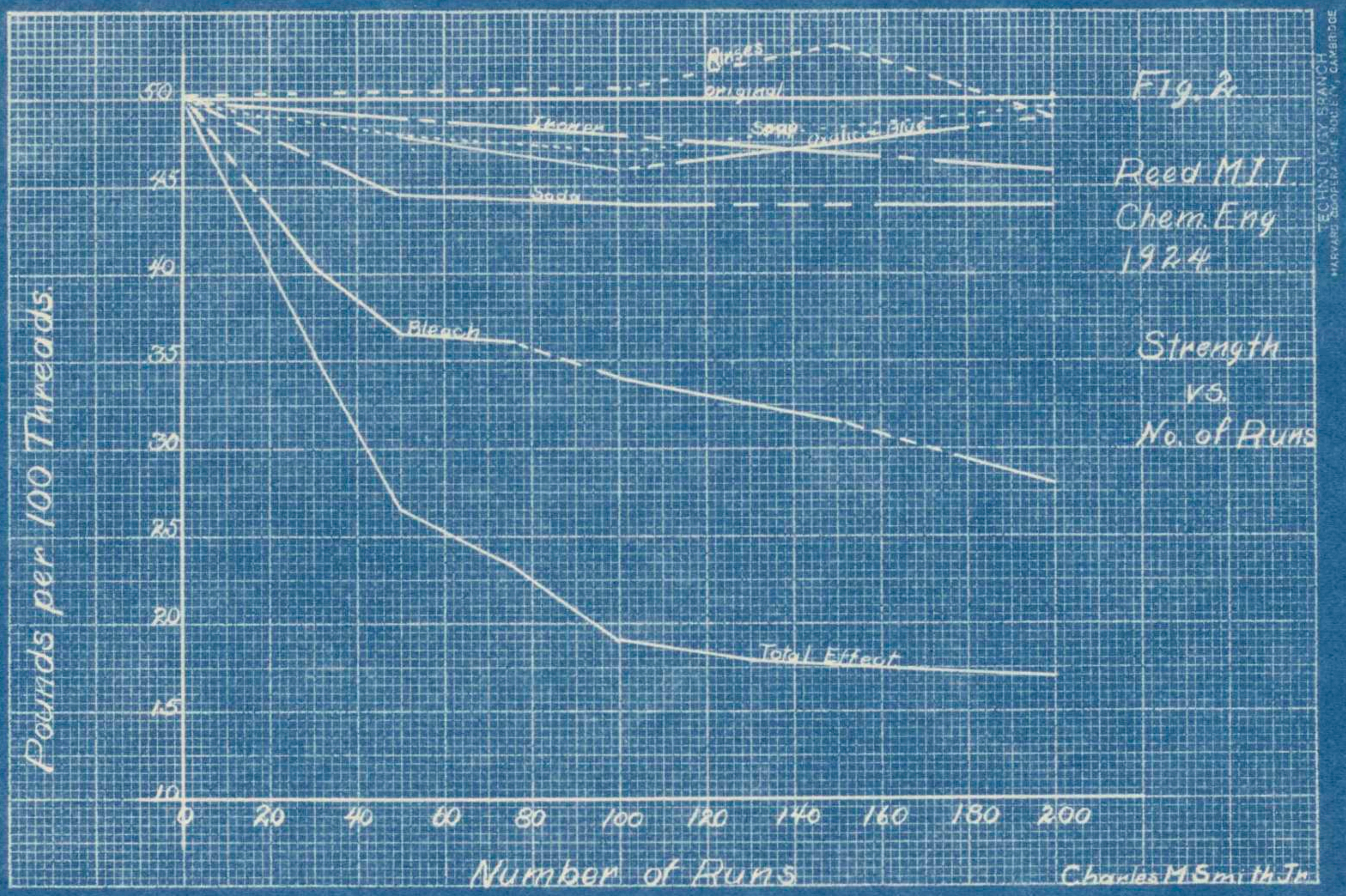
Fig. 2
Reed M.I.T.
Chem. Eng
1924
Strength
vs.
No. of Runs
Pounds per 100 Threads.
Number of Runs
Rinses
Original
Ironer
Soap
Soda
Bleach
Total Effect
50
45
40
35
30
25
20
15
10
0
20
40
60
80
100
120
140
160
180
200
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Reason for Present Investigation:

For the advancement of modern power washroom practice thru the fulfillment of the above mentioned objects.

FLOW SHEET OF F.W. DEPT.

(not table linen)

WHITE STAR LAUNDRY

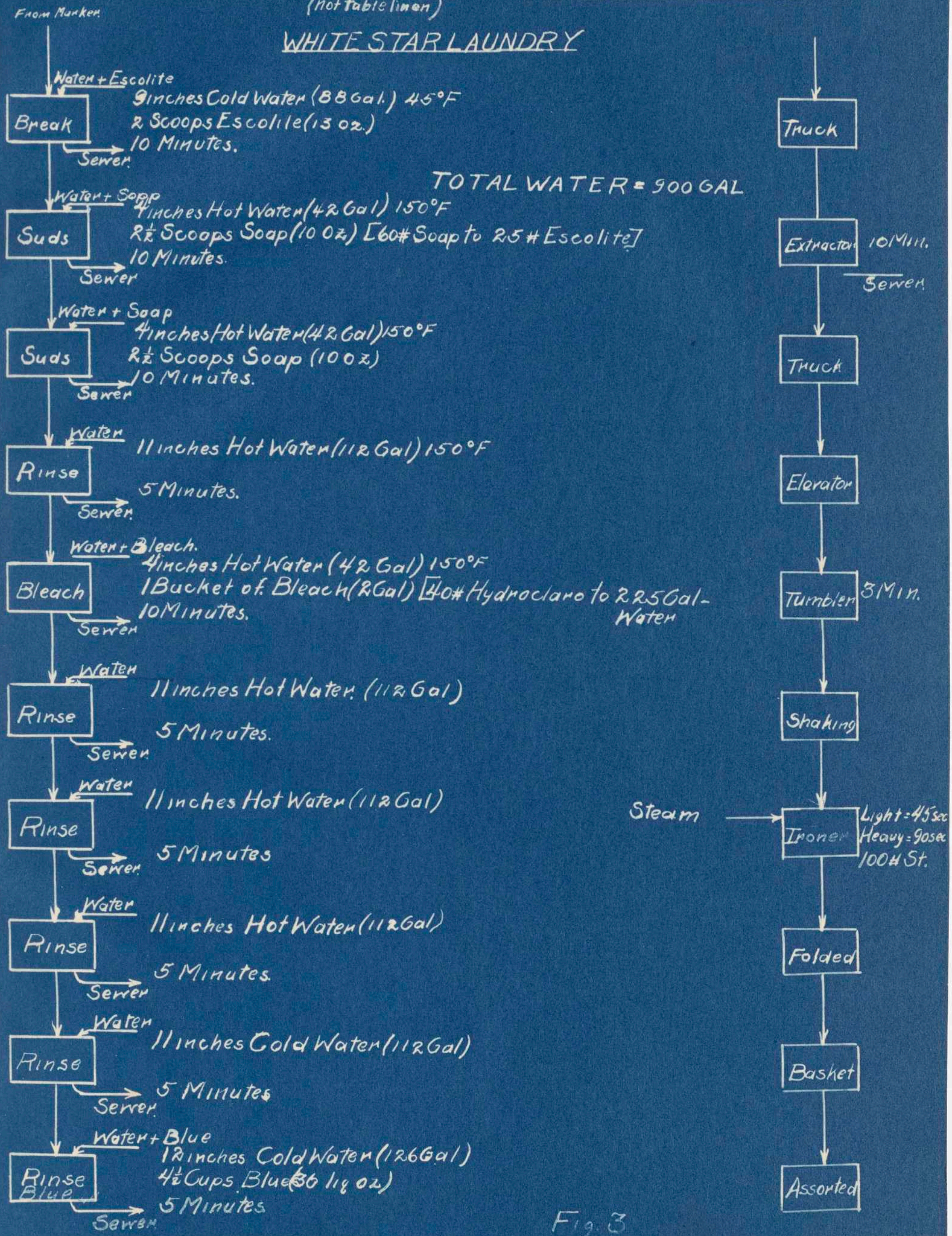


Fig. 3

Experimental Method:

The material used in the investigation was Wamsutta Sheeting. The individual pieces were one yard long by one foot wide. The fills ran with the yard length and perpendicular to the foot width. The warps ran with the foot width and perpendicular to the yard length. Wamsutta Sheeting was sellected as the highest grade cotton sheeting obtainable, and thus the least possible variation in tensile strength throughout the cloth. The material was purchased from Jordan Marsh of Boston.

(a) Proceedure in the White Star Laundry.

Figure Number 3 shows the various steps in the flat-work department of the White Star Laundry. This flow sheet follows the work from the time it leaves the marking room until it reaches the assorting room.

(1) Steps possibly causing wear - From the data gathered on previous work it was observed that any or all of the below steps may assist in causing the wear upon flat work in the laundering process.

1. Soda and Soap.

2. Bleach

3. Blue

4. Rinses

5. Extractor

6. Flat Work Ironer

(2) Method of Attack- From the above six points of possible wear it was observed that problem could be attacked as follows:

That one sample should be run thru the entire process 5 times, another thru 10 times, another thru 15 times, and another thru 20 times, then one sample thru entire process up to extractor 5 times, another thru 10 times, another thru 15 times, and another thru 20 times. In this way thetotal wear of the entire process, the total wear of the extractor and the flat work ironer together, and the total wear of the soap and soda, bleach, blue and rinses collectively, could be obtained. The above experiments were carried on at the White Star Laundry of Brockton, Mass.

The next step in the investigation was to further subdivide the steps so as to determine the percentage of wear caused by the more important of these steps. One sample was run thru the bleaching step 5 times, another 10 times, another 15 times, and another 20 times, a sample thru the cold break, 2 hot suds and one hot rinse 5 times, another 10 times another 15 times and another 20 times. A sample thru 3 hot rinses and 1 cold rinse 5 times, another 10 times, another 15 times, and another 20 times. The above experiments were carried on at the M. I. T. Laundry in Cambridge, Mass.

From these experiments the percentage loss is determined for :

1. Entire Process
2. Extractor and Ironer
3. Bleach
4. Break, Two Hot Suds and One Hot Rinse
5. Rinses and Blue

Thus by a study of the problem in this way we not only get a complete list of the various steps but they also serve as a check upon each other.

The samples thus obtained were stripped and tested on a Scott Machine under constant conditions according to the A.S.T.M.

(a) Outline of Experiment and Key to the Numbers.

O_1	Original Sample No. 1
5EP	Thru Entire Process 5 times
10EP	" " " 10 "
15EP	" " " 15 "
20EP	" " " 20 "
5EX	" " " up to Extractor 5 Times
10EX	" " " " " " 10 "
15EX	" " " " " " 15 "
20Ex	" " " " " " 20 "
5B	" Bleach Run 5 Times
10B	" " " 10 "
15B	" " " 15 "
20B	" " " 20 "
5S	" Cold Break, 2 Hot Suds, 1 Cold Rinse 5 Times
10S	" " " " " " " 10 "
15S	" " " " " " " 15 "
20S	" " " " " " " 20 "
5Ri	" 3 Hot Rinses and 1 Cold Rinse 5 Times.
10Ri	" " " " " " 10 "
15Ri	" " " " " " 15 "
20Ri	" " " " " " 20 "

(b) Testing of Alkalies and Bleaches:

It was observed from the quantitative results obtained by the Research Lab of App Chem and the quala- results so far obtained in this work that the alkalies and the bleaches are the chemicals which should be altered in such a way as to produce less wear on the fabrics while being washed in a laundry. Experiments were carried on in the M.I.T. laundry to ascertain which alkali and which bleach is most advantageous for use in a modern power wash room.

Three commercial alkalies and one combination were tested to give comparative values in their deterioration effect on sheeting. Sample 10E was run thru double the actual concentration 10 times, the same with 10A, 10R and 10Q.

Five commercial bleaches were tested in the same way to give comparative values in their deterioration effect on sheeting. Sample 10H was run thru double the actual concentration 10 times, the same with 10Su, 10W, 10P and 10C.

The samples thus obtained were stripped and tested on a Scott Machine under constant conditions according to the A.S.T.M.

Outline of Experiment and Key to the Numbers

O_2	Original Sample No. 2
10E	Thru Escolite 10 Times.
10A	" Soda Ash 10 Times.
10R	" Russell Combination 10 Times.
10Q	" P. Q. Cleaner 10 Times.
10H	" Hydroclaro Bleach 10 Times.
10Su	" Sunshine Bleach 10 Times.
10W	" White Cross Bleach 10 Times.
10P	" Peroxide (Solozone) Bleach 10 Times.
10C	" Chloride of Lime 10 Times.

X-Ray:

The work on this field has been very limited so that in running experiments of this kind they had to be carried out very blindly 1st trying one set of conditions and then another.

Only two pictures were taken during the thesis run and these should be mentioned here in order that the same mistake will not be made again. As no actual results were obtained the brief outline is included under the Experimental Method.

The 1st picture to be taken was with a Tungsten Tube with 140000 volts. This machine was mechanically rectified on the high potential side. It gives high penetration or Hard X-Rays and the radiation is general or white. The sample was placed 6 centimeters from the plate and was exposed 4 hours. The cloth had been frayed down to a bundle of threads and this bundle had been threaded into a hole an eighth of an inch in diameter in a small piece of lead 3 inches by 2 inches an eighth of an inch thick. The picture when developed showed only a black spot with no crystal defraction. Pictures of this kind are either under or over exposed or the voltage is too great. In this case it had been over exposed (4 hours being too much) and the voltage was no doubt too high.

The next picture was taken with a molybdenum tube. This machine was self-rectified and water cooled. It gives mono-chromatic Kalpha molybdenum rays with a voltage of 43,000. The sample was placed 4½ centimeters from the plate and was exposed 2 hours. The cloth had been frayed down to a bundle of threads and this bundle had been placed across the peep hole and held in place with putty. Thus in this picture the rays passed thru the threads perpendicular to the way the threads ran in the cloth, whereas in the former pictures the rays passed thru parallel to the way the threads ran in the cloth. This picture was also unsuccessful.

It is recommended that the next picture be taken in the former machine with less voltage and less time for exposure using some sort of a filter. Definte recommendations are impossible at this time.

Results (a) (White Star Laundry-with nets)

Sample	Strength in #	Loss Strength in #	%Loss
	Table 1		
Original	58.5	0	0
5EP	57	1.5	2.565
10EP	55.55	2.95	5.125
15EP	53.6	4.9	8.38
20EP	50.9	7.6	13.
	Table 2		
5Ex	57.35	1.15	1.966
10Ex	55.6	2.9	4.96
15Ex	54.5	4.	6.84
20Ex	53.8	4.7	8.04
	Table 3		
5I		.33	.59
10I		.05	.165
15I		.9	1.52
20I		2.9	4.96

Note: I is equivalent to EP-Ex or Extractor and Flat work Ironer.

Results (a) continued. (M.I.T. Laundry-without nets)

Sample	Strength in #	Loss Strength in#	% Loss
	Table 4.		
Original	60.6	0	0
5B	58.5	2.1	3.46
10B	54.6	6	9.9
15B	53.	7.6	12.54
20B	53.	7.6	12.54

Table 5.

Sample	Strength in #	Loss Strength in #	% Loss
5S	57.8	2.8	4.62
10S	55.6	5	8.25
15S	53.8	6.8	11.2
20S	50.8	9.8	16.15

Table 6.

20Ri	58.75	1.85	3.05

Table 7.

5BSRi, or 5Ex		4.9	8.08
10Ex		11.	18.15
15Ex		14.4	23.74
20Ex		19.25	31.74

Table 8.

5EP or 5BSRiI		5.23	8.7
10EP		11.05	18.2
15EP		15.3	25.2
20EP		22.15	36.7

Results (a) continued (Calculated values with nets)

Table 9.

Sample	% Loss
5B	.875
10B	2.51
15B	3.175
20B	3.175

Table 10

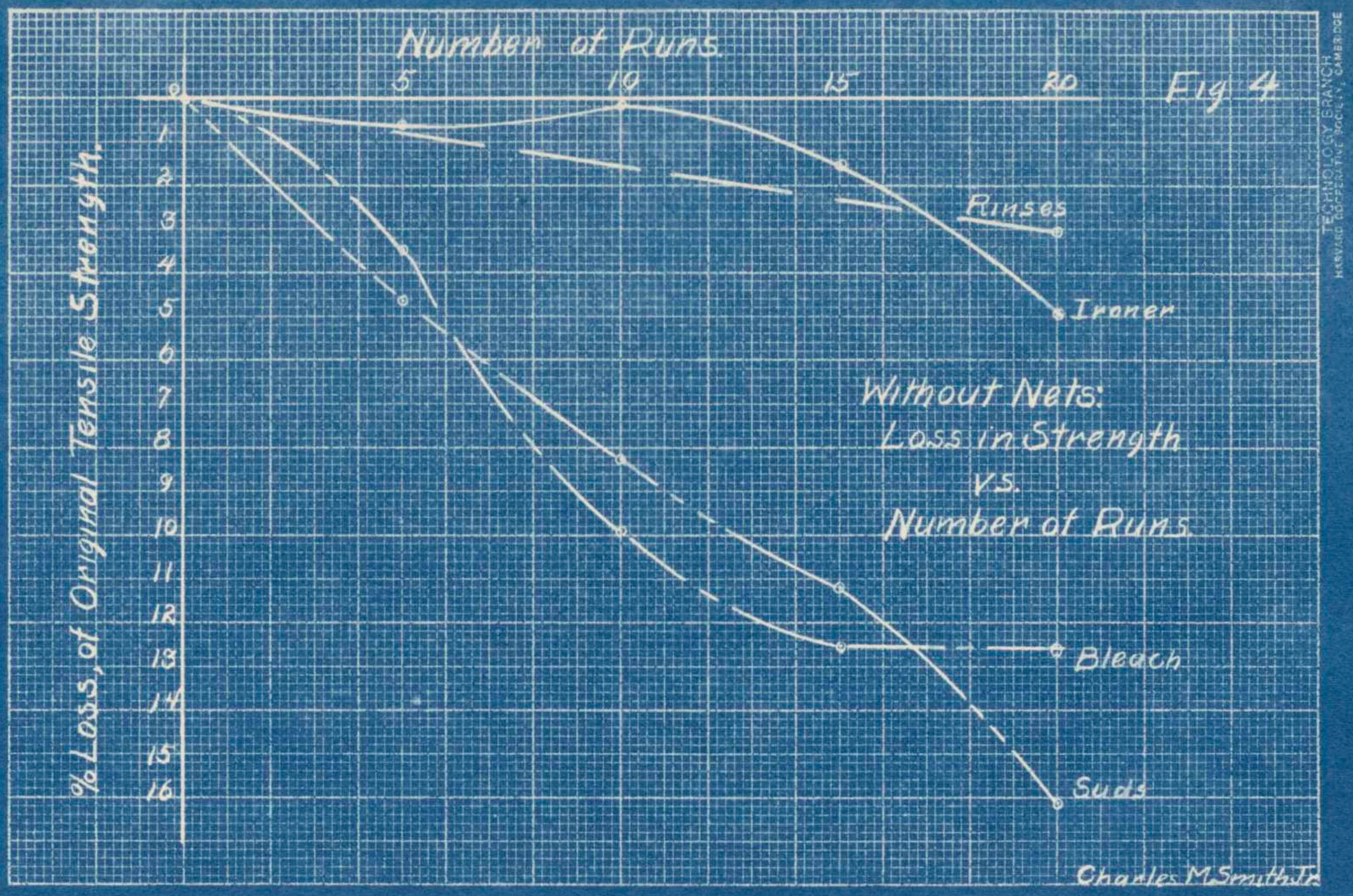
Sample	% Loss
5S	1.18
10S	2.09
15S	2.83
20S	4.08

Table 11 (Repetition of Table 3)

5I	.59
10I	.165
15I	1.52
20I	4.96

Table 12

20Ri	.772



Number of Runs
0
5
10
15
20
Fig 4
% Loss, of Original Tensile Strength.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Rinses
Ironer
Without Nets:
Loss in Strength
vs.
Number of Runs
Bleach
Suds
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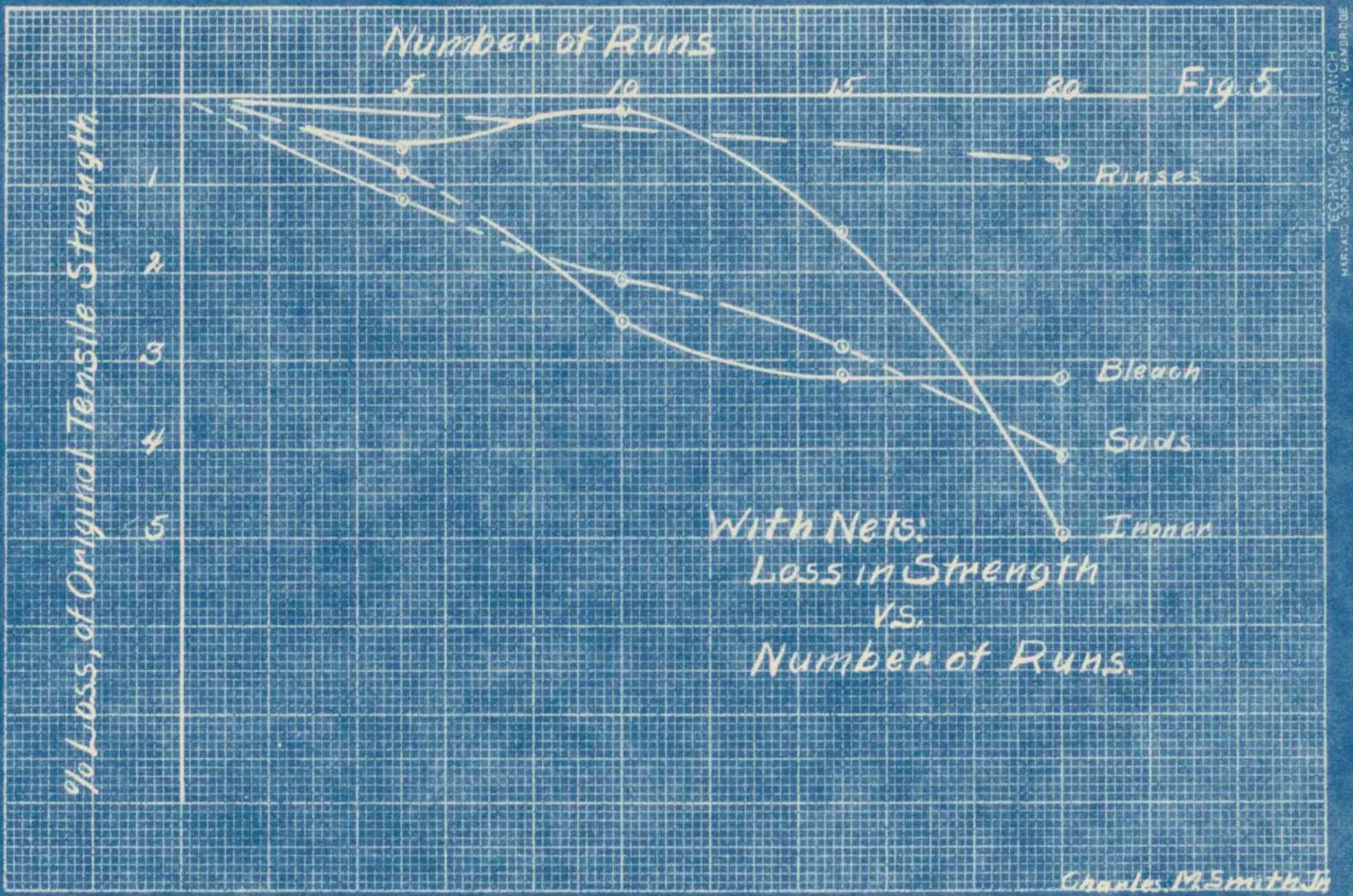
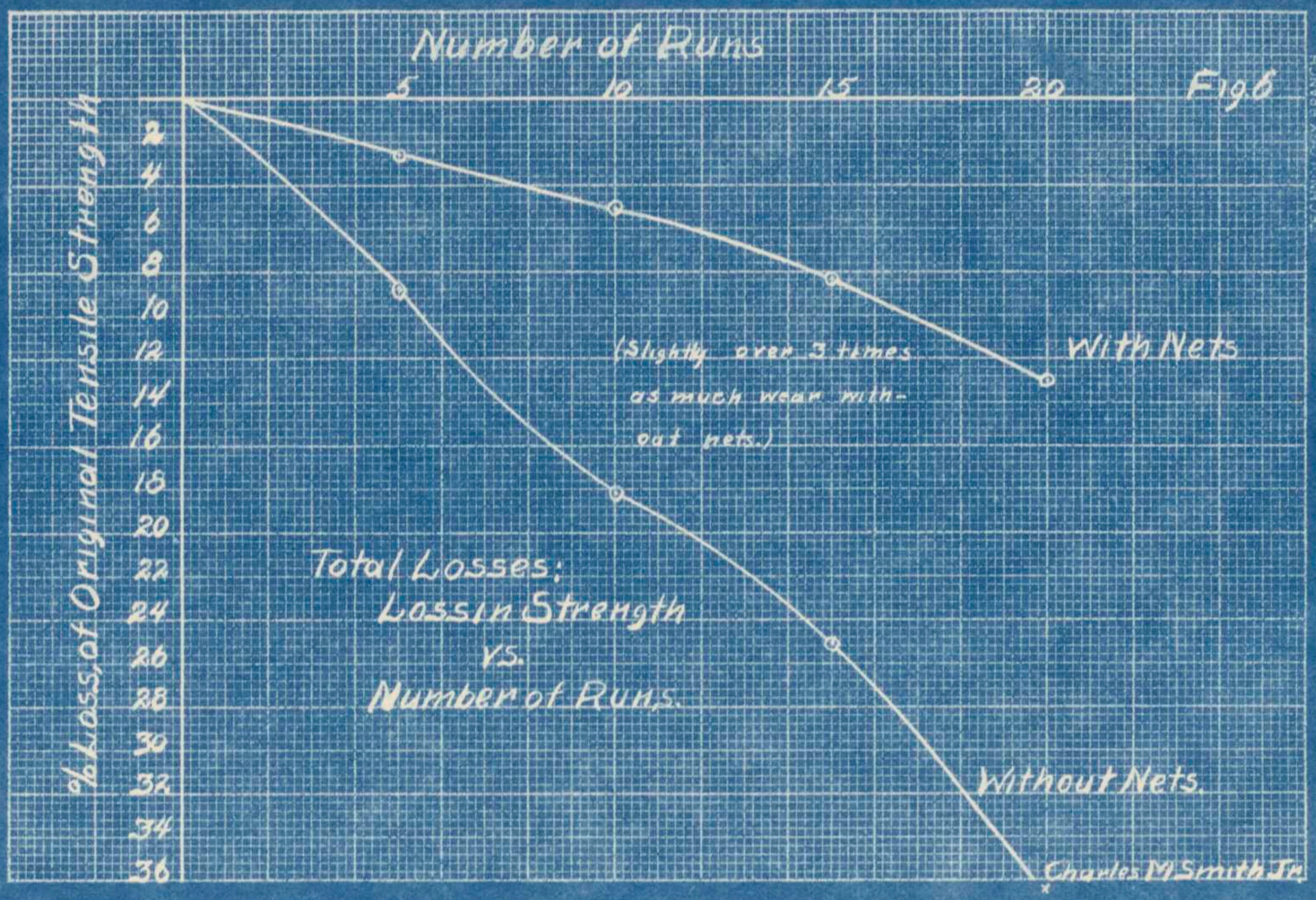
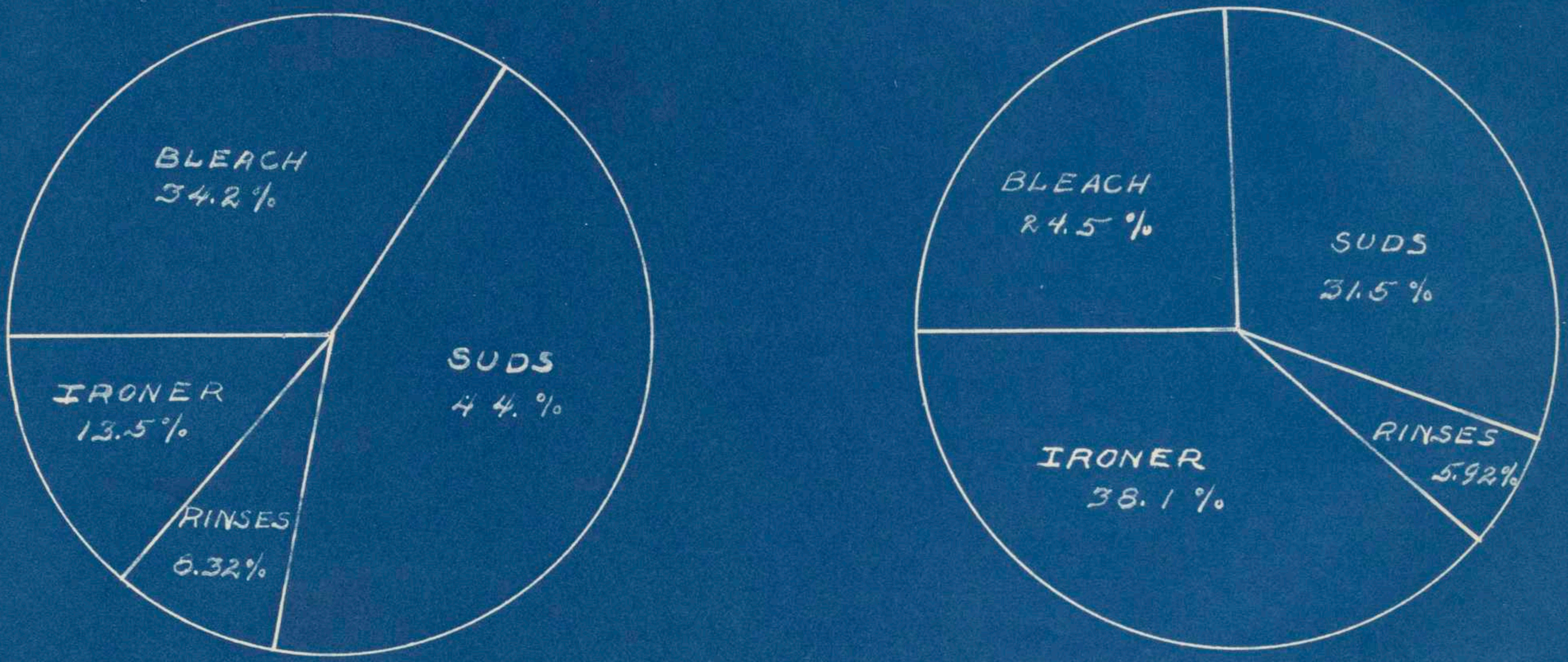

Number of Runs
5
10
15
20
Fig. 5
% Loss, of Original Tensile Strength
1
2
3
4
5
Rinses
Bleach
Suds
Ironer
With Nets:
Loss in Strength
vs.
Number of Runs.
Charles M. Smith Jr.
TECHNOLOGY BRANCH
HARVARD COOPERATIVE SOCIETY, CAMBRIDGE


Number of Runs
5
10
15
20
Fig 6
% Loss, of Original Tensile Strength
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
(Slightly over 3 times as much wear with-out nets.)
With Nets
Total Losses:
Loss in Strength
vs.
Number of Runs.
Without Nets.
Charles M Smith Jr.

CAUSES AND DISTRIBUTION OF LOSSES IN TENSILE STRENGTH IN FLATWORK LAUNDERING

Fig. 7.



TOTAL LOSS 36.7%

WITHOUT NETS

TOTAL LOSS 13%

WITH NETS

Results (b) (M.I.T. Laundry)

Table 13

Alkalies.

Sample	Strength in #	Loss Strength in #	% Loss
Original	58.5	0	0
10Q	57.6	.9	1.54
10E	57.2	1.3	2.22
10R	57.1	1.4	2.39
10A	57.1	1.4	2.39

Table 14

Bleaches

Original	58.5	0	0
10P	56.6	1.9	3.23
10Su	47.9	10.6	18.1
10H	45.1	13.4	22.9
10C	43.7	14.8	25.3
10W	33.5	25.0	42.8

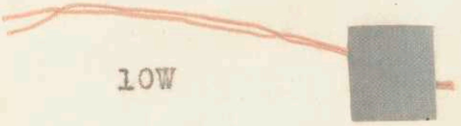
Results (b) continued (M.I.T. Laundry)

Table 15

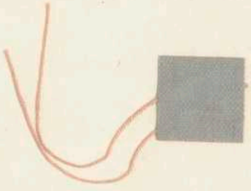
The following are sample hem threads (originally black) which accompanied the bleach samples through the test.

High Cloth Tendering Properties.

10W



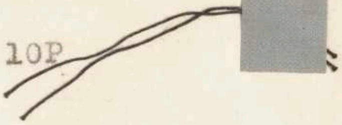
10C



10H

10S

10P



Discussion of Results.

Introduction

It is felt that the value of this investigation lies mainly in the fact that all the work was carried out under actual wash room conditions.

The experiments at the White Star Laundry were followed through exactly as the flow sheet and Method of Investigation indicates. In the process the temperatures, the amount of water, the amount of substances added were carried out in exact routine manner by the washman, so that the results would be absolutely representative of actual conditions. The sheeting was washed in nets at the White Star Laundry.

The experiments at the M.I.T. Laundry which were run as a check on the White Star experiments were carried out under exactly the same conditions. The water used was the same, the temperatures and the concentration were maintained constant. The average number of pounds of clothes per gallon of water were kept constant. Wooden ribbed washers were used in each case. Nets were not used in the M.I.T. Laundry. In this way a figure showing the relative value of the nets in the laundering process could be obtained.

The experiments on the relative merits of the alkalies and bleaches were also run under actual laundry conditions with the exception of the following items. Temperature, time in wash wheel or time of run and concentration of alkali or bleach per gallon of water are the important factors determining the wear upon the fabrics. As the above are the governing variables they were increased over actual conditions so as to get more pronounced results and thus more decidedly fix the relative merits of the alkali or bleach. In washing with the alkalies the temperature was 160°F constantly with each sample instead of 150°F. The concentration was double that of the concentration used at the White Star Laundry. The time of each run was 15 minutes instead of 10 minutes. After ten runs a good rinse was given. In case of the bleaches the temperature was held at 160°F. instead of 150°F. for all except in the case of 10P the temperature was held at 180°F. In the use of 10P the conditions were as adverse as possible. The concentration of the bleach was double that of the concentration used at the White Star Laundry figured on a chlorine content basis. The 10P concentration was slightly more than double. The time of each run was 15 minutes instead of 10 min. After ten runs the samples were given a light sour a hot rinse and a cold rinse.

The measurements in tensile strength taken on the samples run, are the basis of all comparison. Tensile strength testing gives quite variable results estimated to be about 10% variance. For this reason 10 samples were taken from each pice, 5 fills and 5 warps. In Wamsutta Sheeting the warp and fill are very nearly the same so that it amounts to running 10 samples of each piece. In this way a very good average is obtained which cuts the variation to considerably less than 10%.

The conditions under which this investigation was carried out cannot be over stressed. Thus as is observed there is absolutely no laboratory methods or apparatus applied, but only actual washroom conditions, apparatus, and washing equipment are maintained throughout. Thus in this investigation first hand information is obtained and there is no transforming of laboratory data toward an estimate as to what might or ought to happen in the plant.

Discussion (a)

Table 1 shows the wear occuring in the entire process for four different times up to twenty complete runs when nets are used. These four points when plotted (Fig. 6) give practically a straight line with less slope where mercerization tends to take place. From the work of Zanker and Schnabel we might expect a strengthening for these first few runs, but their experiments only included the soap and soda runs. In Table 1 are given the effect of all steps in the process, thus the bleach, rinses, and ironer practically eliminate this strengthening tendency. The same concentration of substances added to the wheel are applicable with or without nets (mainly because the usual laundry concentration is too high) but the nets seem to offer a resistance to the rinses. So with nets, the number of rinses remaining constant, there is a slight tendency to allow this mercerization to take place, thus the slight rise in the curve.

Table 2 offers a check for the same kind of a curve as obtained from Table 1. Here, if plotted, we get a lesser slope for the first few runs than from the Table 1 data. This can easily be explained, in that the ironer step is eliminated, and from Fig 7 we see that this step is the greatest percentage loss (with nets).

Table 3 gives the losses occuring for four different times on the flat work ironer. The loss is slow at first and then increases with great rapidity upon approaching the 20th run. It should be stated that this table of course holds for with or without nets. The extractor causes absolutely no wear if the material is placed in the machine properly, so that no stretching of the garments occur. It was assumed in this investigation that the extractor exhibited no wear, as the wear in this step is entirely dependent upon the extractor man running the individual machine.

Tables 4 and 5 show the losses occuring in the Bleach and Sud runs respectively without nets. It should be remembered that the word Suds in this work refers to four individual steps, namely the cold break, two hot suds and one hot rinse. The reason for no decided gain in strength for the first few washes is that the hot rinse was included in each run, and as no nets were present the mercerizing tendency was practically eliminated. The added effect merely gave a lesser slope than would ordinarily have taken place. It should be noted that this mercerizing or strengthening tendency is not a desired effect, because it only occurs for the first few runs and the more it takes place, the greater is going to be the loss as the runs increase. The bleach and suds curve, (Fig. 4) follow pretty much the same general tendency except toward the twentieth run the bleach seems to have less effect upon the fibre.

Table 6 shows the effect of 20 rinse runs. By one run is meant three hot rinses and one cold rinse. It is seen that the loss is supprisingly low. This small loss is explained by the high level of water used in the rinsing operation. It is thought that the greater the water in the wheel the less wear occuring on the fabric. Had the rinses been run at 4 inches instead of 11 inches the wear would probably have been much greater. For decreasing wear it is needless to increase the water in the suds as the suds themselves offer an insulating property against wear. Where there is no effect as this the wear can be cut to some extent by increasing the amount of water in the wheel.

Tables 8 and 9 explain without nets what tables 1 and 2 have shown with nets. Figure 6 shows that where the rise in the 'with net' curve there is a fall in the 'without net' curve. This is explained by the fact that without nets we are more able to rinse out the mercerizing action caused by the soap and soda. And as stated before, where this tendency has been eliminated or partially so, one should get ultimately relative longer life of the material. Thus in run 20 the quotient we get by dividing the without net loss by the with net loss is less than either of the other three steps. Thus tabulated we get:

Percent Loss

	5EP	10EP	15EP	20EP
Without Nets	8.7	18.2	25.2	36.7
With Nets	2.565	5.125	8.38	13
Quotient	3.39	3.56	3	2.82

So we see that the great tendency is for the cloth to lose less strength when washed in nets, but there is also working a tendency which, as time goes on helps to decrease the loss in the cloth which has been washed without nets, namely better rinsing eliminating the mercerization and causing a slower ultimate decrease in strength. This should not in the least way discourage the use of nets but merely encourage better rinsing when nets are used. The above tabulation also serves to show the relative advantage in using nets. That in 20 washes sheeting loses about 3 times as much figured in percentage of original tensile strength, when washed without nets, as when washed with nets. It should be understood from the above that as more washes are given the value of nets slowly decreases but can be kept surprisingly high by proper regulation of the rinses. From the tabulation it is observed that where mercerization ordinarily takes place there is a slight rise in the quotient and from there on a falling off. This again brings to light the small rise in the 'with net' curve and the slight dip in the 'without net' curve and their relation to the mercerization effect.

Tables 9, 10, 11, 12, are the calculated values for the individual steps in the process when using nets. The same explanations hold for this data as for the with net data. Figure 5 shows that the ironer now becomes the important item, followed by the suds and bleach. Table 11 is merely a repetition of table 3 as the ironer losses are constant with or without nets. And, as the suds and bleach wear decrease when using nets we get the percentages shown on the right of Fig. 7, the ironer constituting the major item.

Discussion (b)

The figures in Tables 13 and 14 are self-explanatory relative to the merits of the different alkalies and bleaches. The conditions which mark the deterioration of the fabric were increased to a degree that makes the relative rank of these brands more pronounced.

Table 13 shows that there is no pronounced difference as far as the effect upon tensile strength of the samples subjected to the four alkalies. There now enters into the case the cost of the individual alkali. It is apparent that 10A is the cheapest. It is gratifying to learn that the L.N.A. is advising a return to 10A when used intelligently, this is suggested from a tensile strength and economic value. Where extremely good water is used, soft and free from scale forming impurities 10A offers an appearance equal to 10E, 10R and 10Q. There is no doubt that silicate greatly helps the appearance of the material under ordinary conditions.

Table 14 shows that as far as the effect upon tensile strength of the samples subjected to the 5 bleaches, 10P holds up decidedly the best. The strength lost by 10P is practically nothing as the very slight decrease in strength can be attributed to the wear received mechanically while in the wheel. This was due to the small amount of water present while bleaching. From the data it seems that 10Su comes next in line, though with considerable loss in comparison with 10P. Closely following are 10H and 10C which remain together as would be expected from their similar composition. Another large drop to 10W, exhibiting the strongest bleach of the lot and very destructive to the fibre.

Table 15 shows the same scale of relation in the samples of bleached threads as was shown in table 13. This gives a slight qualitative idea as to the position the bleaches should take and thus serves as a check upon the tensile strength data.

Conclusions. (a)

1. That in twenty launderings, without nets, the sheeting loses 36.7% of its original tensile strength.

2. That 86.5% of this loss occurs in the wash room and 13.5% occurs in the finishing department.

3. That the distribution of the loss is as follows:

Bleach causes	34.2%
Cold break, 2 Hot Suds and 1 Hot rinse causes	44. %
Rinses and Blue causes	8.3%
Losses occuring in washroom	86.5%
Extractor and Ironer or Finishing Department	13.5%

4. That in twenty launderings with nets the sheeting loses 13% of its original tensile strength.

5. That 61.9% of this loss occurs in the washroom and 38.1% occurs in the finishing department.

6. That the distribution of the loss is as follows:

Bleach	24.5%
Cold break, 2 hot suds, 1 hot rinse causes	31.5%
Rinse and Blue	5.9%
Losses occuring in washroom	61.9%
Extractor and Ironer or Finishing Department	38.1%

7. That in twenty launderings without nets the sheeting loses nearly three times as much strength as does the sheeting washed with nets.

8. That this value of nets in the laundering process increases until somewhere between 5 and 10 runs and then decreases thereafter.

9. That this increase and decrease is due to the mercerization effect.

10. That this mercerization effect is dependent upon the rinses and nets-both the use of nets and few rinses increasing mercerization (initially less loss, finally greater loss in strength). No nets and many rinses decreasing mercerization (initially greater loss, finally less loss in strength)

11. That a balance between these two effects is use of nets and better rinsing.

12. That the less the water in the wheel the greater the mechanical wear.

13. That the extractor causes no wear when the clothes are placed right.

14. That the rinses cause very little comparative wear.

15. That the washroom can approach as a limit

of perfection, clothes worn to a degree of those rinsed to the equivalent number of revolutions of the wheel in the entire process. Thus in this process the rinses alone cause 3% loss (20 runs - without nets). The ideal total loss is about 16% (figured from a ratio of rinse time to total time in washroom - 20 minutes to 70 minutes, and adding the constant ironer loss of 5%). Thus instead of a 36% loss we may work toward a 16% loss. This may possibly be accomplished by increasing the amount of water in various runs (bleach, cold break, and possibly suds) and thus also decreasing the concentration.

16. That in this process the rinses alone cause .8% loss (20 runs - with nets). The ideal total loss is about 8% (figured from a ratio of rinse time to total time in wash room - 20 minutes to 70 minutes, and adding the constant ironer loss of 5%). Thus instead of a 13% loss we may work toward an 8% loss. As there is only a 5% difference between the actual and the ideal, it would hardly prove economical to study the conditions necessary to cut this wear, except thru the increase of water in the bleach run.

Conclusions (b)

1. That so far as tensile strength is concerned 10A holds up as good as the rest, (considering cost and tensile strength alone 10A is the alkali to use)

2. That silicate added to the wheel intelligently usually improves and never mars the appearance of the material.

3. That, if due to local conditions a silicate is necessary, any of the remaining three should assist to the point of satisfaction.

4. That 10P is the least cloth tendering bleach and 10W is the greatest cloth tendering bleach, the others ranging between as shown in results.

Recommendations.

(a) Recommendations to the Plant

1. That nets be used on all washing, as soon as is economically possible.

2. That more water be used in the bleach run even if the amount of bleach liquor added need be increased - it is felt that this, however, would not be called for except to a slight extent. (The bleach run has less water in the wheel than any of the others except the suds.)

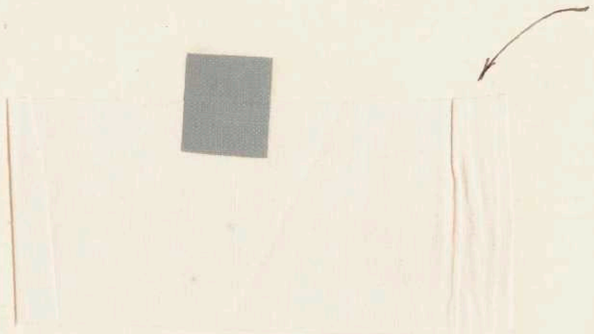
3. That the White Cross Laundry cease using their bleach as soon as practicable, and change to some less cloth tendering bleach.

4. That steps be taken to see if it would be practicable to vary the steam and time in the flat work ironer.

5. That care should be taken to find the cause of, and eliminate the crease effect produced on the flat work ironer. It so happens that if a sample (to be tensile tested) was cut from a part of the cloth that had these wrinkles, they invariably withstood about half the poundage they should. It was first thought that they were merely creases and the tensile machine

was getting hold of only a few threads and not reenforced by the others. This was soon found to be wrong as great care was exercised in placing the sample in the testing machine so as to have the sample perfectly flat. They continued to break exceedingly low. These were eliminated in the computation shown on the data sheet. This crease effect of course greatly reduces the strength in ordinary sheeting thru the laundering process.

Below is a sample of this sort of creasing.



(b) Recommendations for future work.

1. To study the effect of the amount of water in the wash wheel, with an aim to get some relation between the amount of water to the amount of wear.

2. To study the effect of silicate in bleach solution.

3. To study the assumption that suds have an insulating effect against wear. (Possibly the water in the suds should be increased slightly) so to be sure that the low water in the sud run does not cause great wear.

4. To study the X-Ray phase of this subject.

APPENDIX

Data - Tensile Strength

No.	FILLS 1	2	3	4	5	Av.	WARPS 1	2	3	4	5	Av.	Gr.Av.	Compared with
01	59	56	55	55	57	56.4	64	55	58	60	66	60.6	58.5	01
5EP	61	60	48	55	64	57.6	56	58	59	53	56	56.4	57	01
10EP	29"	41"	53	24"	56	54.5	55	51.5	59	59	59	56.6	55.55	01
15EP	58	28"	52	27"	55	55	54.5	56	50	54	35"	53.6	54.3	01
20EP	51	53	50	50	52	51.2	48	49	54	53	49	50.6	50.9	01
5EX	65	52	57	56	59.5	57.9	57	57	58	55	57	56.8	57.35	01
10EX	59.5	59	51	58	60	57.5	54.5	53	47.5#	50	57	53.8	55.6	01
15EX	55	60	55	62	60	57.5	45	58	50	55	50	51.6	54.5	01
20EX	52	59	21"	27"	58	54--	55.0	53	53	50	57	53.6	53.8	01
5B	62	62	60	59	66	61.8	62	61.5	59	56	54	58.5	60.15	01
10B	57	53	63.5	50	61.5	57	52	60	48	56	57	54.6	55.8	01
15B	56	62	62	54	60	58.8	52	54	53	54	52	53	55.9	01
20B	64	61	62	60	59	61.2	56	47	53	57#	56	53.8	57.5	01
5S	61	67	60	67	58	62.6	57	57	59	59	57	57.8	60.2	01
10S	57	60	56	58	60	58.1	57	55	58	51	57	55.6	56.85	01
15S	52	64	57	56	56	57	50	53	49	55	62	53.8	55.4	01
20S	63	61	64	61	60	61.8	49	52	47	52	54	50.8	56.3	01
5Ri	54	62	63	50	61	58	57	55	59	60	58	56.8	57.4	02
10Ri	57	54.5	60	59	58	57.7	57	59	57	61	57	58.2	57.95	02
15Ri	69	60	72	70	68	67.8	51	49	59	59	50	53.6	60.7	02
20Ri	60#	46	55	60	57	58	46#	58	57	61	59	58.75	58.12	02

(continued)

Data - Tensile Strength

	FILLS						WARPS							Compared
No.	1	2	3	4	5	Av.	1	2	3	4	5	Av.	Gr.Av.	with
10E	59	64	62	58	54	59.4	54	55	60	56	50	55	57.2	01
10A	61	62	62	59	50	58.8	51	58	52	59	57	55.4	57.1	01
10R	62	64	62	52	62	60.4	52	52	50	57	58	53.8	57.1	01
10Q	61	60	63	56	52	58.4	58	52	59	58	57	56.8	57.6	02
10H	44	52	37	45	43	44.2	46	45	46	46	47	46	45.1	02
10Su	50	49	48	46	42	47.	50	47	49	48	50	48.8	47.9	02
10W	30	35	30	32	31	31.6	35	35	32	35	30	35.4	33.5	02
10P	60	55	59	57	61	58.4	54	58	54	55	53	54.8	56.6	02
10C	44	50	40	43	46	44.6	47	40	40	42	45	42.8	43.7	02
02	60	58	60	55	60	58.6	61	60	61	56	54	58.4	58.5	02

" This value neglected on account of crease occuring-caused bad break.

This value neglected on account of extremely wide variance.

-- This average assumed

Note: The averages of just the warps were taken where the fills showed large discrepancy.

Analysis of 10Su

Sample of Bleach:

Available Chlorine	6.34 Grams per 100 cc.
Sodium Hydroxide	8.89 grams per 100 cc.
Sodium Carbonate	1.79 grams per 100 cc.

Analysis of 10W

Sample of Bleach:

Available Chlorine	12.65 grams Cl per100cc.
Sodium Hydroxide	11.76 grams per 100cc.
Sodium Carbonate	1.02 grams per 100 cc.

May 19, 1925.

Mr. Robert P. Russell, Divisional Director,
Massachusetts Institute of Technology,
Research Laboratory of Applied Chemistry, Room 2-114,
Cambridge, Mass.

My dear Mr. Russell:-

The following will confirm the statements made to you during the visit of Mr. H. V. King and the writer to your laboratory.

It was pointed out that there is more or less of a fire hazard connected with the use of Solozone in a laundry and that we felt you would get better all-around service with Perborate of Soda. You preferred, however, to use Solozone and stated that the laundries you were working with were equipped to handle this chemical without danger. The most important point is to remember that Sodium Peroxide in contact with moist organic material generally creates combustion.

Solozone, dissolved in water, gives Caustic Soda and Hydrogen Peroxide. We usually add a given quantity of acid first to the water and then dissolve the Solozone. Approximately 1.4 pounds of 66° Be'. Sulphuric Acid are required to neutralize one (1) pound of Solozone. It is always advisable to test the bath in the usual way with litmus paper for alkalinity. The writer suggested that you have the liquor very slightly acid so as to prevent the decomposition of your stock solution. A one day's supply of bleach liquor should be made at a time. This would, of course, be alkalined when added to the washing solution. We suggested that where Hydrogen Peroxide is used in laundry work the temperature be raised gradually to 160° F. starting with a practically cold solution. The speed with which the temperature is raised will depend upon your equipment, etc. It is desirable to avoid iron and copper since both of these metals act as catalysts causing rapid decomposition of the Hydrogen Peroxide. It would be well, therefore, to carefully inspect your equipment. Iron may be painted over with lime which will serve to isolate the metal.

2.

To Mr. Robert P. Russell, Divisional Director,
Massachusetts Institute of Technology,
Cambridge, Mass.

We are sending you today one (1) 40-lb. keg of R. & H. Assistant #2. This compound has given excellent results in washing when used in conjunction with Peroxide.

We would certainly suggest that you test the baths or treating liquorfor active oxygen. This is very apt to be of great help to you in your experiments as under some conditions the bath may decompose too rapidly while under others it may not go down fast enough. Should you have trouble with either extreme, we would appreciate your advising us that we may take steps to assist you.

We hope that if there is any way in which we may be of service that you will not hesitate to so inform us.

Yours very truly,

BLEACHING STATION

T. D. Ainslie
Superintendent.

TDA/HB

Thos. D. Ainslee