The Influence of Beating of Pulp on Fiber Length and Fiber Length Distribution

Rudolf Schmut
Western Michigan University

The Influence of Beating of Pulp on Fiber Length and Fiber Length Distribution.

(Senior Thesis 1951/52, Course No.436 A, Dr.A.Nadelman)

by Rudolf Schmut

Western Michigan College

Pulp and Paper Technology.

Section I - Literature Survey

Section II - Experimental Work

T a b l e o f C o n t e n t s

The Influence of Bea-ting of Pulp on Fiber Length and Fiber Length Distribution,Section I - Literature Survey

1. Introduction

Recent studies and researches assume that certain relations are existing between different properties of pulp - such as between bulk, tearing resistance, bursting strength, tensile strength, freeness, and fiber length index. It has been found furthermore that such relations are different for different types of pulp and that some may even vary from pulp to pulp of the same type.

We need rapid, simple, and accurate methods in stock evaluation. There seem to exist some relations between the fiber length index and some important properties of pulp; now it would be extremely useful to find any definite relations between the mechanical pulping process, respectively the beating process, and fiber characteristics since some of them are very easyly and quickly to determine.

Beating is the mechanical treatment given to papermaking materials suspended in water to mix and prepare them for forming on the paper machine into paper or board of the desired character. A beater consists of a tank or "tub", usually with a partition or "midfeather", and containing a heavy roll revolving against a bedplate. Both roll and bedplate may contain horizontal metal bars set on edge. Pulp or waste papers are put into the tub of the beater and water added so that the mass may circulate and pass between the roll and the bedplate. This

action separates the material and frees the fibers preparatory to further processing. The beater cuts the fibers to a certain length, separates ~~the~~ bundles of fibers ~~existing even in the best pulp~~, brushes or strokes the fibers into greater flexibility, and ~~curbs~~ their ends thus preparing them to form a sheet of paper. Fillers, dyestuffs, and sizing materials may be added to the beater and thus incorporated with the paper stock. Many modifications in design have been developed without changing the basic principles.

The determination of the fiber length index based upon an old method used in papermills, particularly in rag mills, ~~which~~ consists in observing the quantity of fiber ~~caught by the~~ blade drawn through a suspension of fibers in water, ~~the obvious deduction being that the more~~ fiber withdrawn by the blade ~~the longer the fiber must be~~. The fiber length index is defined as ~~one third of~~ the weight of fiber in grams ~~caught in three runs under standard conditions by~~ stainless steel blades ~~in a bronze ring~~ that takes the place of the grid plate in the standard British sheet machine. Theoretical calculations supply strong evidence that the test results are a measure of fiber length; other data indicate that the test results are a function of the average by weight of the square root of the fiber length. The test results have therefore been termed "Fiber Length Index".

The fiber length distribution is defined as the distribution of fibers of various length and size in a pulp. This distribution

can be obtained by means of different mechanical or optical devices.The fiber classification using mechanical devices segregates mechanically a given fibrous sample into a number of separate groups of fibers differing in range of fiber length, such segregation depending solely upon the one factor of fiber length and to be independent of fiber origin,preparation,treatment,width,or other factors,and to determine the relative proportion,by weight,of fiber in each ~~lengthrange group~~ fraction so obtained.

A short historical review may tell that beaters have been used of almost the same kind to refine pulp since 1740. The term "Fiber Length Index" ~~has been~~ was defined and introduced in 1946.Early methods of fiber classification in use since the beginning of this century did not give reproducible results.The major part of the ~~developing~~ development work ~~preparing~~ on the classification apparatus of today ~~has been~~ was done during the past thirty-five years.

The relations mentioned above are:

$V = 0.19\ L + 1.20$ V...bulk,L...Fiber length index

$T = 0.475\ L + 0.65$ T... tear ratio

$B = 40\ L + 30\log(S - 16.5) - 7.1$ B...bursting strength

$M = 3400\ L + 1970\log(S - 18.5) + 3280$ M...breaking length

S...Schopper-Riegler slowness

Description of Apparatus

2. ~~C h a r a c t e r i s t i c s   o f   D e v i c e s   a n d   M e t h o d s   o f   M e a s u r i n g~~

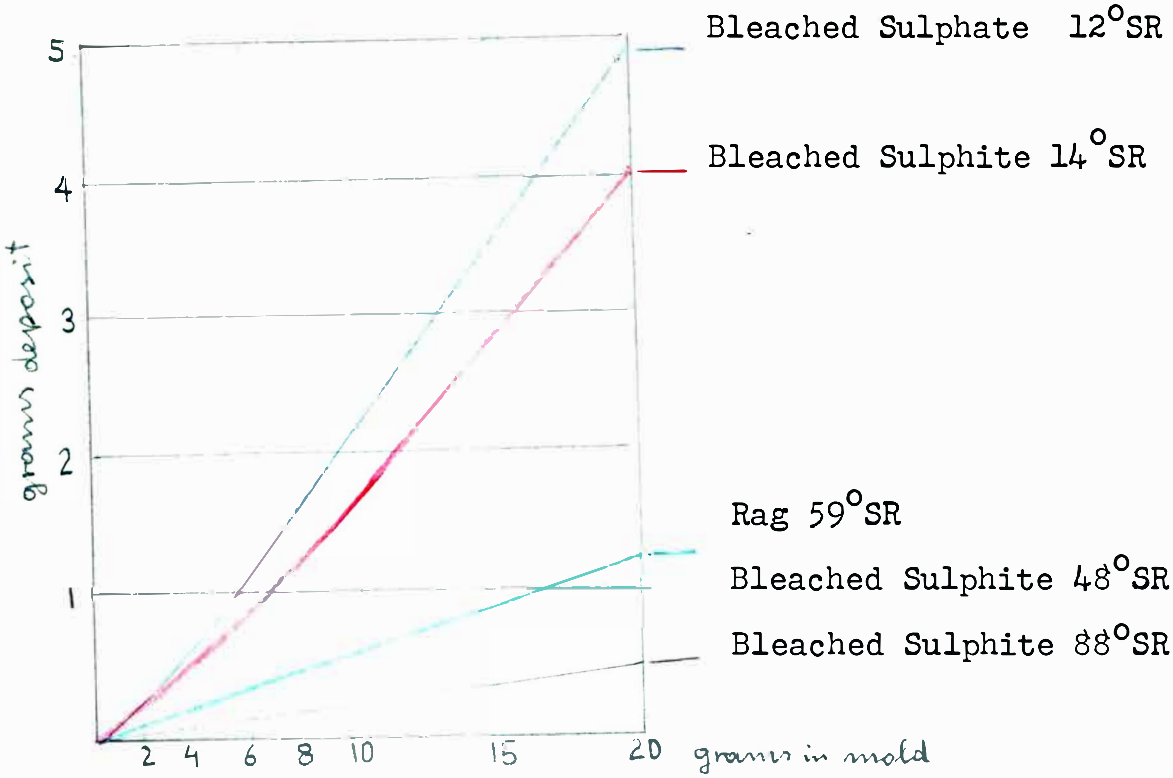
~~a.~~ The report covering the beating process shall state the intervals at which samples were taken and note any departure from the standard procedure. A curve is usually desirable showing the development of the apparent specific gravity and the burst and tear factors plotted against beating time or its logarithm. It is furthermore desirable to cover tensile strength and ~~slowness, resp.~~ freeness, ~~or drainage~~ tests. Pulps are often compared after beating to a maximum burst development or after beating to a definite slowness of 70 or 80 degree Schopper-Riegler or sometimes to a Canadian standard freeness of 500. In other cases it is considered more desirable to ascertain the approximate amount of beating which is equivalent to be given the pulp by the mill for the grade of paper into which it is to be made and to use this degree of beating for comparing or specifying the pulp. The equivalent degree of beating can be established by taking a sample of the unbeaten stock furnish in the mill and drawing curves showing the development of its density, burst, tear, breaking length, and freeness against the time of beating. When the apparent specific gravity of the standard test sheet is plotted against the logarithm of the time of beating, excluding the point of the unbeaten pulp, a straight line should result. The slope of this line gives a measurement of the rate of beating of the pulp, or with a standard pulp, can be used to check the rate of beating of the apparatus.

b. The apparatus to determine the fiber length index is the standard British sheet machine in which a bronze ring with vertical stainless steel blades has replaced the grid plate. Ten grams diluted stock are poured into the rising water; the whole procedure is the same when making a handsheet except that a stirrer without vertical fins is to be used. The blade-grid is removed after drainage and ~~over~~turned into a pan containing some water; all the fibrous material is washed off, and this procedure is to be repeated two times. The collected fibers are filtered, dried and weighed and one third of their weight in grams is the fiber length index. The test can be accelerated by drying fibers and filter paper on a hot plate and an experienced operator can gain results by this quick method within twelve minutes.

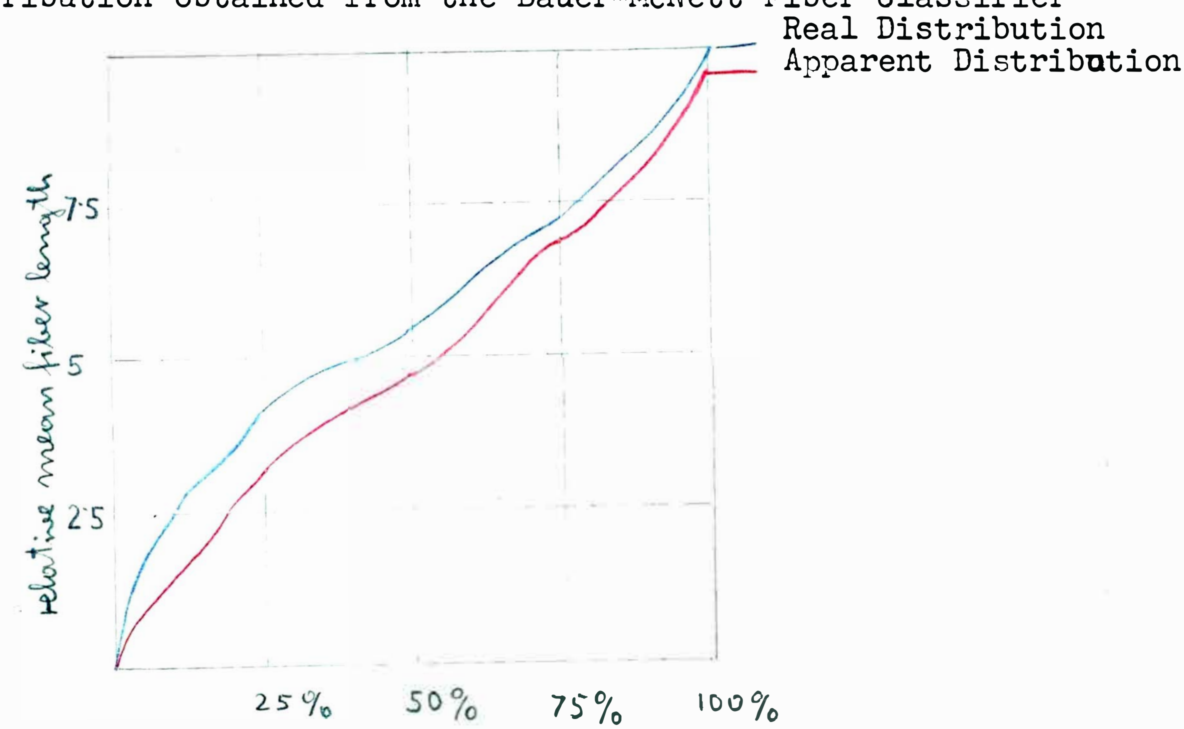
d. There are two methods known for measuring fiber length and fiber length distribution; namely mechanical and optical. Both methods have some disadvantages. They take much time, optical tests need assumptions concerning the relation between the weight of a fiber and its size and length and these weight factors are not above question; optical tests do not take into account fibers under a certain length depending upon the operator and the equipment, they need furthermore trained, skilled operators. The equipment used in optical tests consists of microscope alone or in combination with a microprojector, stains are sometimes used. Mechanical methods depend upon the use of a series of standard

screens.The average length of the fraction caught by the coarsest screen and of the fraction passing the finest screen can not be stated without the use of microscopic methods; it is possible that these values change within the refining process and that a numerical identic distribution contains fibers of other lengths in the first and last fraction at different times of beating or refining.The first screen classifiers used a cascading arrangement of chambers and horizontal screens wherein the flow of liquid was directly depending upon gravity and there was no other reason for agitation than to avoid fiber mats on the screens.Modern classifiers use the same,but modified operations,so that most of the fibers are presented broadside to the screens and avoid passing them at a right angle to the plane of the screen.The principle used is a combination of a high speed flow across the surface of the screen with a much slower flow at right angles through the screen openings.This is obtained by using a hydraulic principle which states that any material swimming in a liquid with high speed tends to turn the main axis parallel to the streamlines.
The Bauer-McNett classifier - used in the experimental part of this thesis - uses four elliptical tanks - the older square tanks caused eddies - with a midfeather parallel to the screen and clockwise rotating cylindrical agitators with small projecting fins.
The high velocity forces the fibers to orientate themselves parallel with the wire and keeps the screen free from a fiber mat.

Relation between weight in sheet mold and weight of deposit(fiber l.i.)



Relation between real fiber length distribution and fiber length distribution obtained from the Bauer-McNett Fiber Classifier



3. General Factors Influencing these Testing Methods

a. Fiber Length Index:

The consistency has no effect if it is below 0.2%; increasing consistency produces increasing fiber length index, as easily can be shown by using the same amount of stock at different consistencies. The weight of fiber has almost no influence except in the case of a very long fiber in which there is a tendency to show longer fibers than there really are existing in the sample. The variation of the weight of the caught fiber is in correspondence with the variation of the total weight of fiber in the sample. An increasing temperature causes an increasing fiber length index, but the effect is neglible below 25°C. A long drainage time - rate of outflow - gives heavier deposits; the test should not be done under such circumstances for theoretical hydraulic considerations. There has not been found yet a systematic or significant effect of the blade cross section although blades with rectangular cross sections seem to collect some higher deposits than blades with sharpened or rounded upper edges. The fiber length index is not dependent upon the type of refining the pulp.

b. Fiber Length Distribution:

A sharper separation is produced if the area of the screen is larger. An decreasing rate of overflow from the constant level tank causes very definitely an increase in the fractions obtained by the coarser screens. The duration of every run should be the same to make the results comparable; an increasing duration produces an increase of fibers in the fractions obtained by the finer screens. Low speed of the agitator has the same effect upon the fiber classification. The weight of the original sample - oven dry basis - must be as close to the prescribed standard weight as possible for the classification seems to result more longer fibers than actually have been in the sample if its weight is more than the standard weight and vice versa. Flexible fibers give higher results in the shorter fractions than rigid fibers. Duplication of results demands an exact duplication in every detail of construction and operation.

4. Physical Testing of Pulp

The physical evaluation of pulp consists of tests dealing with its physical properties. The usual physical evaluation contains tests for Basis weight, thickness, tensile strength and stretch, bursting strength, tearing strength, and moisture content. Some

other tests may be performed if desired or necessary, such as folding endurance, porosity, stiffness, etc. It is, furthermore, necessary to determine freeness or - more convenient but not so accurate - drainage time of pulp. This thesis deals only with the usual strength evaluation and the freeness test, using the standard methods.

5. S u m m a r y

It would be very useful to define the relations between processing of stock and physical properties of pulp in a short and doubtless manner to make the stock evaluation easier by using few, simple, quick and accurate tests. There seems to be evidence that the fiber length index and the fiber length distribution show a way to solve this problem and this thesis tries to deal with some suppositions of that problem.

6. G l o s s a r y

Breaking Length - The length of a strip of paper, cut either in the machine or cross direction, which would break of its own weight when suspended vertically.

$$\frac{\text{Ten.St.per 1" . 13889}}{\text{Weight of a ream25x40-500}} = \text{Br.L.inyards}$$

Bulk - Thickness of a pile of a specified number of sheets under a specific pressure or apparent spec.volume of a sheet of paper when in pile under a definite pressure.

Bursting Strength - The pressure required to rupture a specimen tested in a specified instrument under specified conditions.

Freeness - A measure of the rate with which water drains from a stock suspension through a Fourdrinier machine wire, a wire mesh screen, or a perforated plate. It is also called slowness or wetness according to the type of instrument used in its measurement and the method of reporting results.

Stretch - Extension produced by stretching to the point of rupture.

Tensile Strength - Force parallel to the plane of the specimen required to produce failure in a specimen under standard conditions.

Tear Ratio - Tearing strength in points per pound.

Synonyms (Pay attention to the converting factors): Mullen Test, Pop Test, Bursting Strength Test; Tenacity, Tensile Strength, Breaking Length; Stretch Test, Elongation; Slowness, Freeness, Drainage;

Refer to "Chemistry of Pulp and Papermaking, E.Sutermeister", for conversion factors and interrelationships.

7. Literature References

Bergmann, Stuart I., Length of hardwood fibers and vessel segments. Tappi 32, no.11:494 - 498 (Nov.1949)

Berke, Ralph, Fiber length measurements. Chemist Analyst 28, no.3: 57,59 (Nov.1939)

Biagotti, Enrico, The classification of pulp fibers. Ind.cart.3; no.5:49 - 56 (Aug.1949)

Brainerd, Forrest W., Fractionation of pulp. Paper Trade J. 106, no.16:28,31 (April 21,1938)

Brainerd, Forrest W., A new fiber classifier and its application. Tech.Assoc.Papers 22:205 - 212; discussion 121 - 124 (June 1939)

Brecht, W., Wet classification of fibers in the paper industry; Investigation of a "Plansortierer". Wochbl.Papierfabr.75, no.4:67 - 73; no.5/6:88 - 92 (Aug., Sept./Oct. 1947)

Brown J.D., Studies in classification and refining of groundwood pulp. Pulp Paper Mag.Canada 43, no.2:131 - 140 (Feb.1942)

Butler, W.T., The use of the Bauer-McNett fiber classifier. Pulp Paper Mag.Canada 49, no.3:133 - 136 (Feb.1948)

Campbell, W.B., The cellulose water relationship in papermaking. Forest Service Bull.84:5 (1933); Forests Products Labs.Can.Ottawa

Clarkes, James d'A., The measurement and influence of fiber length. Tech.Assoc.Papers 25:556 - 562 (June 1942)

Cosler, Arthur S., The McNett classifier. Paper Mill 62, no.15:15 - 16 (April 15,1939)

Cosler, Arthur S., Fiber classifier. H.S.Ind.Cart.6, no.2:58 - 59 (Feb.1939)

Heinig,Melburn,Length and width of unbleached sulphate pulp fibers from certain Western woods.Paper Ind.30,no.5:738 - 741 (Aug.1948)

Hertel,K.L.,A method of fiber length analysis using the fibrograph. Textile Research 10,no.12:510 - 525 (Oct.1940)

Holtan,E.N.,Johnston pulp fiber classifier tested.Pulp Paper Mag. Canada 38,no.10:692 (Sept.1937)

Holtan,E.N.,Fiber fractionation as control method for sulphite pulp. Papir I.28,no.15/16:125 - 130;no.17/18:136 - 140 (Sept.18,30 1940)

Hrubesky,C.A.,Fibrous materials testing developments in 1937. Tech.Assoc.Papers 21:311 (June 1938)

Jones,G.D.O.,Proposed standard instrument for classification of papermaking fibers according to length.Paper Trade J.96, no.17:29 - 36 (April 27,1933)

Kress,O.and Brainerd F.W.,Study of wood pulp fractionation.Paper Trade J.98,no.13:35 - 39 (March 29,1934)

Montigny,R.de and Zborowski P.,The rapid measurement of an index of fiber length.Tech.Assoc.Papers 29:220 - 226,226 - 232 (June 1946)

Nickerson,Arno W.,Stock preparation and factors influencing freeness.Paper Mill 61,no.20:21 - 26 (May 14,1938)

Schafer E.R.,and Heinig,Melburn,Further studies on groundwood evaluation.Paper Trade J.93,10:55 - 59 (Sept.3,1931)

Stephenson,J.Newell,Preparation and treatment of wood pulp.Mac Graw Hill,New York 1950

Sutermeister,E.,Chemistry of pulp and paper making.J.Wiley Sons, New York 1941

TAPPI Standards

Witham,G.S.,Modern pulp and paper making.Reinhold Publish.Corp., New York 1942

The Dictionary of Papermaking has been used for preparing the Glossary.More literature references can be found in the Bibliography of Papermaking by C.G.West under the headlines fiber,mechanical process,pulp testing,screenclassification etc.

O u t l i n e   o f   E x p e r i m e n t s

1.Equipment needed

1½lbs.Va lley Iron Work Beater

Standard Sheet Machine and Auxiliary Equipment (Including such as for Determination of the Fiber Length Index)

Bauer McNett Fiber Classifier

TAPPI Standard Desintegrator

Equipment for the Physical Evaluation of Pulp

2.The used pulp is a Canadian bleached kraft pulp from the province of Ontario.

3.Processing will be conducted under TAPPI standard conditions at standard consistency of 1.57%;the samples will be taken at TAPPI standard intervals (0,10,20,..60 minutes)

4.The following tests and procedures will be conducted at each interval:

a.Freeness

b.Fiber Length Index in Duplicate (6runs)

c.Fiber Length Distribution in Triplicate

d.One Set of Handsheets from Pulp as Is for Strength Evaluation

(e.)The balance of pulp will be classified and one set of handsheets each from each fraction of pulp retained on 48,65,100,150 mesh screen will be made for strength evaluation

Rudolf Schmut,December 16,1951

T a b l e   o f   C o n t e n t s

The Influence of Beating of Pulp on Fiber Length and Fiber Length Distribution, Section II - Experimental Work

1. Introduction

The experimental investigations were conducted with the TAPPI standard equipment and under TAPPI standard conditions;Scandinavian bleached kraft pulp from Husum was bea-ten,handsheets were made at each beating interval, their strength properties and some properties of the pulp before and after fractionation were tested,including freeness,fiber length index,fiber length distribution,and the physical strength properties of the pulp as is and of the fractions obtained from the classifier. Results and conclusions seem to furnish some information about the influence of the fiber length of sheets on their physical strength properties,the role certain fractions of fibers play contributing to the strength of the pulp,and the influence of beating on the fiber length index and the fiber length distribution of pulp.

2. Work Performed

Before I enter any detailed discussion I will list all the work done.

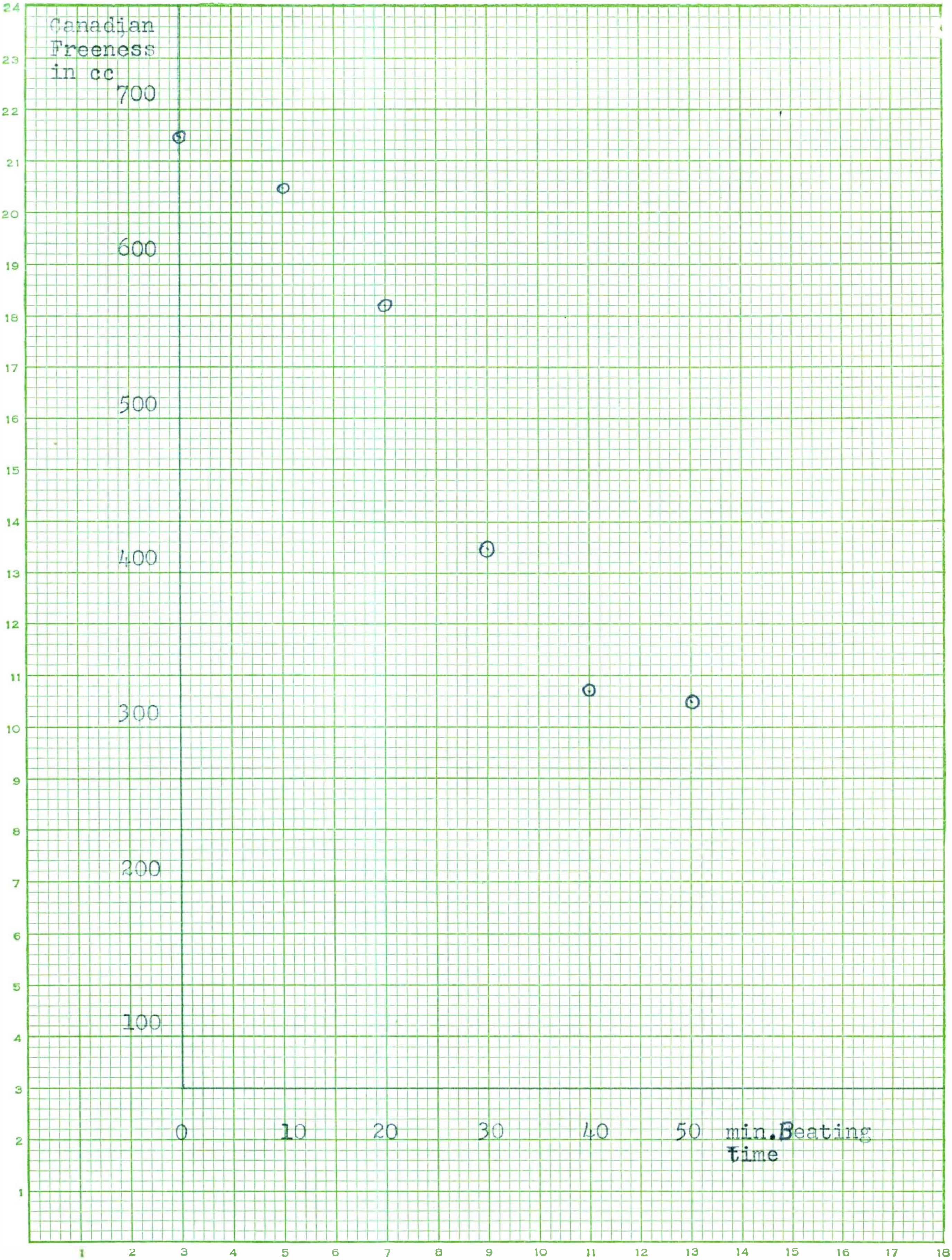
Eight beater runs were made under TAPPI standard conditions;handsheets were formed; the pulp used - Scandinavian bleached kraft pulp - was run through the Bauer-McNett fiber classifier in triplicate to find the fiber

length distribution of each sample, several different screenplates were tried in the classifier in combinations of different sets; the fiber length index of the unclassified pulp was determined in duplicate by means of the fiber length index gridplate; the freeness was determined with the Canadian standard freeness tester; the balance of pulp left after these was run through the classifier to accumulate enough fibrous material of different fiber length - consisting of the four fractions of the Bauer-McNett fiber classifier - from the sample to form handsheets which were evaluated.
The results gotten were compered, computed in tables and a possible significance of some of them will be pointed out in the following pages.

3. Discussion of the Tests and their Results.

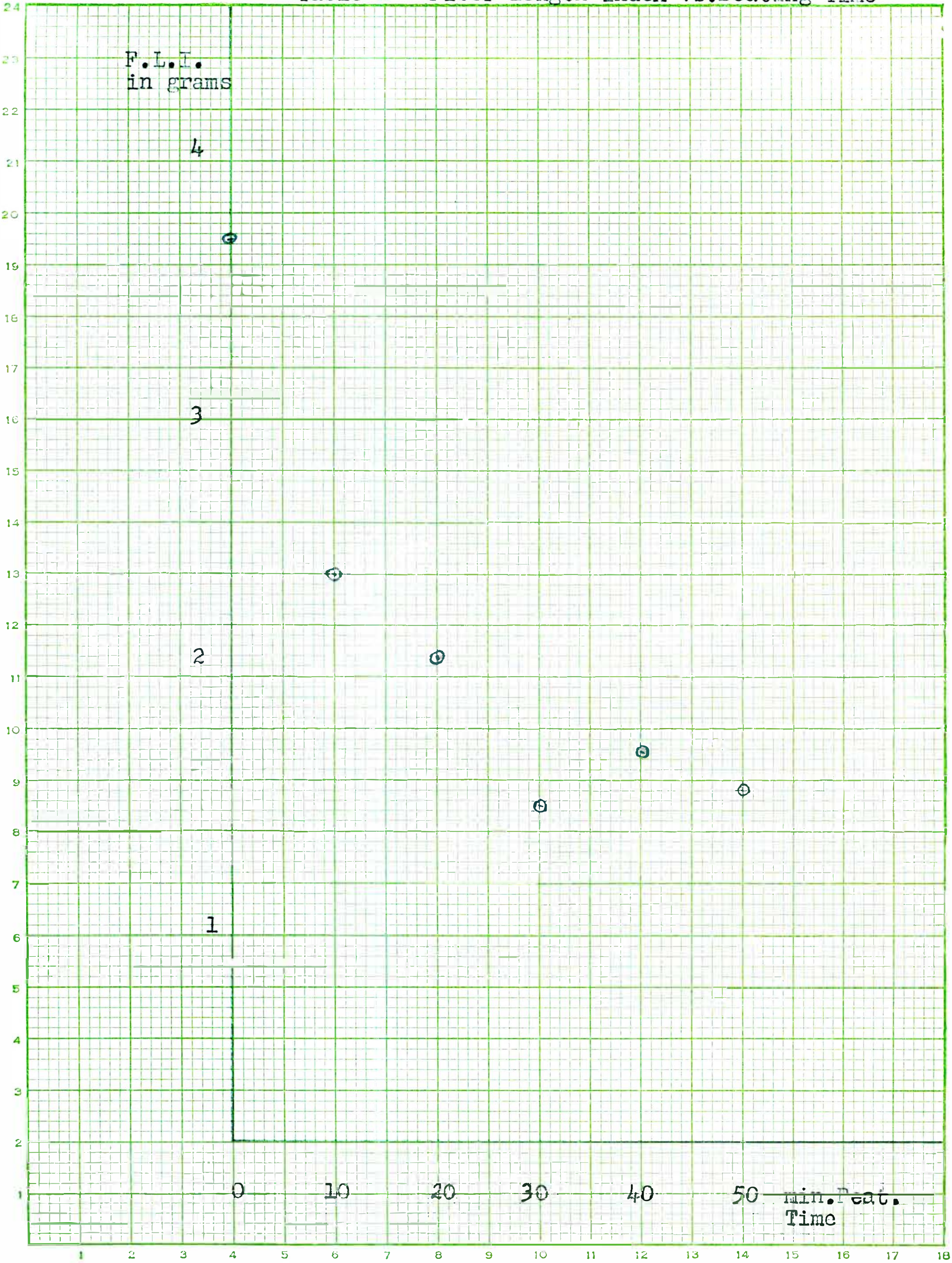
The freeness in cubic centimeters was determined with the Canadian standard freeness tester. The usual results were obtained, as it was to be expected; see table 1 for more details.

Table 1 - Freeness vs.Beating Time



The fiber length index was determined according to the method given on page 5 of the literature survey of this thesis.The determination was done in duplicate and the va-lues obtained in these duplicat tests correspond to a large extent with one another.
The fiber length index drops rapidly at the begin of the beating process and approaches an almost constant level after a beating time of thirty minutes which may indicate that a la-rger amount of cutting is done in the first part of the beating cycle than in the second part.
The highest result found was a fiber length index of 3.705 $\pm$ 0.045 g at zero minutes beating time and the lowest was 1.5 $\pm$ 0 g.at 30 minutes beating time.See table 2 for further details.
Exact duplication of the results obtained is possible if the different determinations are done within some hours; determinations done with the same pulp on different days or within one week's difference show deviations up to 30 percent of the first result although the conditi-ons were carefully checked and duplicated as far as possible.Toxicants were used to prevent any deterioration of the pulp over a storage time of some days.Inasmuch To what extent
these influenced the fiber length index has not been investigated.

Table 2 - Fiber Length Index vs. Beating Time



The fiber length distribution was determined in triplicate at each beating interval;the determinations were done with a Bauer-McNett classifier according to the methods suggested by the manufacturer.The tests correspond to a good extent within experimental limits and are completely reproducable.Outmost care must be taken tu use an exact amount of 10 g o.d.stock.

Several reasons suggested that a screen combination consisting of 20 mesh screen,a 35 ms.,a 65 ms. and a 150 ms. would be most convenient for my work and the experiments, therefore,were standardized on this screen set;I will deal with other screen combinations later in a separate paragraph.

It is highly significant that the fiber length distribution does not show any reasonable changes throughout the whole beating period when the fiber length index dropped, indicating that cutting of fibers was done.The amount of fibrous material retained on the different screens remains a lmost constant and it is interesting to notice that the fiber length distribution of the zero minutes beater run and that of the fifty minutes beater run do not differ more than one percent up or down if compared with one another. The explanation may be that cutting was done to the largest fibers only which were retained on the first screen. This fraction is in size too long to pass through the 20 mesh screen but too short to find any retention on a 10 ms. as testruns showed. - See table 4 screen set 10,20,65,150.

This behavior may give room to the assumption that only fibers of a certain length and above will be cought by beater bars or knives or that fibers must be caught within a certain distance from their ends to be retained on the knife or bar and subsequently to be cut. One publication, previously discussed in my literature survey - De Montigny and Zborowsky, "The Rapid Measurement of an Index of Fiber Length" - mentions such a possibility but does not give any numerical-values. The screen set used as standard in my experiments retains relatively many fibers on the first - coarsest - screen which, therefore, does not present a true sample of long fibers in the fraction retained on it but almost guarantees that only small fibers can pa-ss. The other fractions contain consequently almost exclusively short fibers giving excellent material to test the properties of a very shortfibered pulp. One drawback is tha t a long time is needed to accumulate enough of these shortfibered fractions to form handsheets from them.

Table 3 shows the fiber length distribution obtained through the use of a 20 - 35 - 65 - 150 mesh screen set. This table presents in its upper part the screen combination used at each beating interval and gives in its lower part the fiber length distributions obtained with this set. In horizontal order are the beating intervals of the sample tested a-nd in vertical order is the percentage of the fibrous

material retained on the screens and of the material which passed through all screens and is not accounted for. Efforts to get a more even fiber length distribution were undertaken and the results of these runs are presented in table 4 .Several other screen combinations than the standard combination mentioned above were tried to obtain a more even distribution but none of them gave satisfying results;the amount of time necessary to find an ideal screen set might go far beyond the scope of this paper.
The table shows in its upper part the different screen sets used giving in horizontal order the beating intervals of the tested samples and in vertical order the screens which retained the first,second,third,and fourth fraction. The lower part of the table presents the percentage of fibrous material retained on the different screens and the fibers which passed through the classifier not being accounted for.It gives in horizontal order the beating intervals and in vertical order the percentage of fibrous material retained on the screens or the materialswhich were not accounted for.
The last vertical column deserves special attention because it proves the importance of the time factor to obtain reproducable results.A sample of pulp was beaten forthifty minutes and then run through the classifier for 150 minutes.The fraction retaine on the coarsest screen decreased to 74 percent of its original value and the fraction passing through the classifier without any retention at all

Table 3 - Screens used for the Standard Fractionation in the Bauer-McNett Fiber Classifier

Beater Run (minutes)	0	10	20	30	40	50
Fraction 1	20	20	20	20	20	20
Fraction 2	35	35	35	35	35	35
Fraction 3	65	65	65	65	65	65
Fraction 4	150	150	150	150	150	150

****

Percentage of Fiber retained on the different Screens

Beater Run (minutes)	0	10	20	30	40	50
Fraction 1	66.5	75.3	75.4	71.9	74.8	66.8
Fraction 2	13.3	10.2	8.16	7.85	7.5	12.3
Fraction 3	6.7	6.3	5.2	6.43	6.6	6.76
Fraction 4	3.65	3.5	5.2	1.25	1.4	4.53
Not Acc.for	9.85	4.7	6.04	12.57	9.7	9.61

Table 4 - Screens used in different Combinations in the Bauer-McNett Fiber Classifier

Beater Run (minutes)	0	10	30	50	50	30
Fraction 1	48	48	10	14	14	20
Fraction 2	65	65	20	20	35	48
Fraction 3	100	100	65	65	65	65
Fra-ction 4	150	150	150	150	150	150

****

Percentage of Fiber retained on the different Screen Sets.

Bea-ter Run (minutes)	0	10	20	30	40	50
Fraction 1	81	88.4	0	336	41.6	49.5
Fraction 2	3	0.19	57.6	6.6	39.6	17.5
Fra-ction 3	4	4.2	1.55	39.7	6.3	4.6
Fraction 4	0.6	0.93	0.06	2	3.1	0.05
Not Acc.for	11.4	6.28	2.63	15.7	9.4	28.3 ↑

Comment: The 30 minutes beater run with its figures in the last column was run through the classifier for 150 minutes.

increased to 272 percent of its original value. The other fractions cannot be compared because a 48 ms. had replaced in this run the 35 ms. used in the standard screen combination.

The physical strength evaluation of the pulp as is and of the handsheets formed from the different fractions retained on the classifier seems to indicate that probably complicate relations exist between the original strength of the pulp and the strength contributed to the total strength by the different fractions of long and short fibers contained in this pulp.

The pulp as is shows the usual strength development but the four fractions give unusual curves if plotted against the beating intervals.

It may be concluded that the two shortfibered fractions contribute very little to the folding endurance never exceeding a MIT double fold of 58 as maximum. The two long fibered fractions contribute much to the total folding endurance but reach never the values of the original pulp.

The two shortfibered fractions add an apprciable amount to the tearing strength of the pulp approaching it sometimes closely. The longfibered fractions add much to the tearing strength; it may proove highly significant that the longfibered fractions surpass the tearing strength of the pulp as is up to eighty percent of its original value.

The short fibered fractions pay some contribution to the bursting strength of the pulp as is but stay usually 50-75 percent of its value under the bursting strength of the pulp as is.The long fibered fractions mainly contribute to the bursting strength,approaching the bursting strength of the pulp as is very closely.

The shortfibered fractions add some to the tensile strength of the pulp as is but stay usually about 50 percent under the tensile strength of the original pulp.The long fibered fractions a pproach the tensile strength of the pulp as is closely at some points and the second fraction surpasses it once.

Table 5 gives the strength properties of the pulp as is and the strength propertiies of the four fractions obtained from the Bauer-McNett fiber classifier,using a screenset of 20 - 35 - 65 - 150 mesh,plotted against the beating time.All five curves have been drawn into one diagram to make an easy comparision possible between the different numerical values obtained.A black line indicates the pulp as is,a red line indicates the first fraction (retained on a 20 mesh screen),a blue line the second fraction (retained on a 35 ms.),a green line the third fraction (retained on a 65 ms.) and a dottet red line indicates the fourth fraction (retained on a 150 mesh screen).

Table 5 - Physical Strength Properties

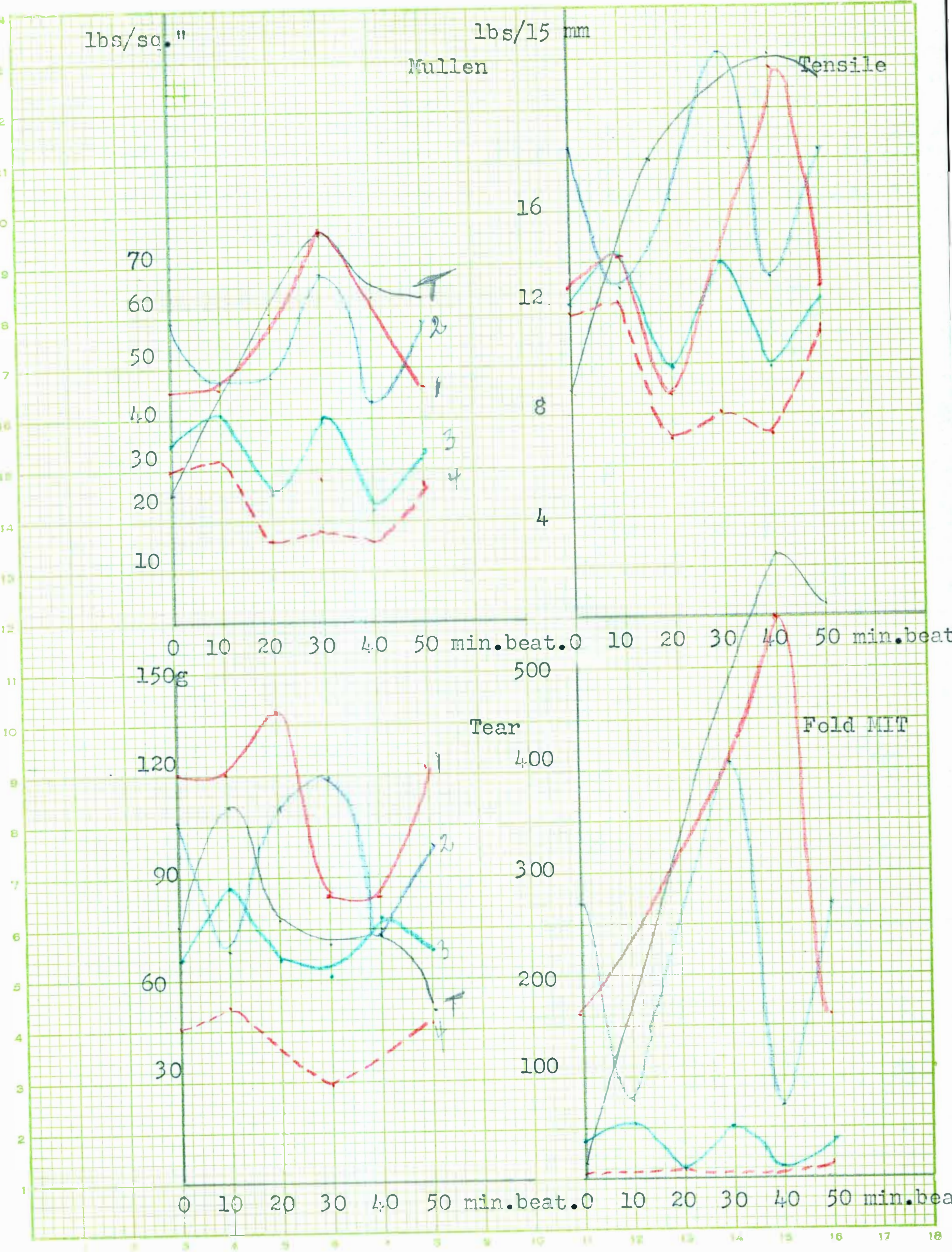


Table 6 shows samples of handsheets made from fibers retained on the different screens.The pulp used for these samples was beaten for ten minutes;the yellowish cast is due to a very high iron content in the water used for all test procedures.

4. Conclusions

Today we have the results of eight fractionations and eight beater runs and determined how much each fraction contributes to the strength characteristics of the total pulp.We found that with exception of tearing resistance no fraction - neither the short nor the long fibers - could surpass the strength of the pulp tested before fractionation.We found,furthermore,that the fiber length index drops with increasing beating time wheras the fiber length distribution remains constant;that permits us to draw tentative conclusions dealing with the nature of the cutting done.

under conditions of the experiment

Table 6 - Samples of handsheets made from fibers retained on 20 - 35 - 65 - 150 mesh screens.

20 mesh

35 mesh

65 mesh

150 mesh

The pulp used was beaten for ten minutes.