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The Severity of Refiner Action Upon Pulp Strength Indexes

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Problem Analysis
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Table of Contents

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ABSTRACT

Using the ball mill as the refining tool and five different strength developing materials, an investigation was made of the mechanism of fiber strength development.

The various degrees of refining drasticness were obtained by using each of the five materials, and the burst and tear tests and burst times tear factor were used as the strength indexes for determining the various degrees of refining.

The Severity of Refiner Action upon Pulp Strength Indexes

OBJECTIVE OF THE INVESTIGATION:

The purpose of this investigation was to study the mechanism of fiber strength development by determining the degree of refining severity on the fibers, as applied to the burst and tear strength attributes of paper.

The study was conducted with the ball mill, and five different strength developing refining materials. The materials used were steel balls, porcelain cylinders, porcelain balls, flint pebbles, and golf balls.

The steel balls were chosen to study the extreme fiber cutting effects of this material, whereas, the golf balls were used to indicate the maximum brushing effects as compared to the cutting behavior of the steel balls.

This investigation was not performed to indicate the qualities of the ball mill as a production refiner, but rather as a tool with the various strength developing materials to attain the various types of refining.

This type of investigation is important, as many of today's refiners can drop freeness very quickly, achieving a maximum burst, but tear strength is at an extreme low rendering the paper's overall strength below the acceptable standard. It is important to develop burst to as high a value as possible and still retain a high tear value. It is this retention of tear, while attaining a maximum burst, toward which the investigation was directed.

LITE TURE URVEY:

Upon reviewing the articles found concerning fiber strength development and ball mills, it appears that there has been a fair amount of work done on the refining characteristics of ball and pebble mills. The articles discussed both the refining characteristics, and the construction and maintainance of these refining devices. Most of these articles, however, were directed toward the comparison of the ball mill with other types of refiners rather than toward the development of strength characteristics.

In Stephen Dickhauts article, "Using a Pebble Mill in a Coating Mill," the idea was formulated that the strength of the blows in a refiner depends on the speed of the refiner as well as the size of the pebbles. It is then important to choose the smallest stone that will produce the most contacts to do the refining job necessary.

The use of the tensile times tear and/or burst times tear factor is discussed in John R. and John L. Fanselow's article, Product of Burst and Tear Values as an Index to Fiber and Refiner Evaluation." The use of these two factors is widely used to compare various fibers, the refiners, and refining conditions used to prepare the pulp. The use of these factors will be very valuble in the refining of fibers in the pebble mill. The authors felt that the optimum freeness range where the strength relationships held true was between 600 and 200 CSF. This corresponds to a range of sheet densities of .65g/cc to .80g/cc.

Any values obtained outside this range will not hold true for the burst, tear, and tensile relationships.

F. C. Peterson has done considerable work with ball and pebble mills and has come up with a great deal of interesting data concerning their ability to develop strength in pulps. He has written articles with other authors in this field, and has derived many useful conclusions which will more then benifit the present series of tests. He has found that at the peak of the strength curves, higher burst and tear values may be expected when porcelain balls are used in place of pebbles. This is a result of a decreased degree of cutting action that the porcelain balls exhibit. It was also discovered that a greater length of time was required to reach the peak of the bursting strength curve when porcelain balls were used which was again due to the decreased degree of cutting action as compared to flint pebbles. Another important discovery was that more uniform results may be expected for burst and tear values on duplicate test runs using porcelain balls as compared to flint pebbles. Porcelain balls gave a more constant action because of their more uniform shape as flint pebbles may tend to slide around the bottom. Surface area is another improtant fact to consider when using flint pebbles as smaller pebbles produce higher strength tests. Peterson also discovered that a longer time was necessary to reach maximum burst with porcelain balls than with flint pebbles. An increase in the weight of balls also increases the time required to reach the peak

of the burst curve and a further increase of the weight will decrease the maximum burst obtainable. This same result has been observed with tensile strength as the indicator. The ash content must also be considered as ash will be given off when porcelain balls or cylinders are used as the strength developing material, however, no definite conclusions have been reached as to the amount, as this is dependent upon the hardness of the material.

H. W. Morgan observed many of the conclusions that Peterson arrived at but, he found that the length of time to refine to a particular freeness level was the same for ball and pebble mills, however, the steel ball mill required a greater length of time. He also felt that very little reproduceability was obtainable using any of the strength developing materials.

F. A. Simmons and P. K. Baird arrived at many conclusions directly applicable to industrial use of the ball and pebble mills. They found that the optimum ratio of pulp to pebble to water was 1:54:39, furthermore, if the amount of pulp in these refining devices is decreased, refining time is decreased and the degree of strength development is increased. Included in their conclusions was the fact that increasing the weight of balls used plus a slight decrease in consistency increases the bursting strength.

The above articles represent the bulk of material on this subjest and most of it is directed toward the comparison of

the ball mill with other types of refiners or towards the use of the mill as production refiner. None of these articles investigated the problem of complete strength development, i.e., obtaining a given degree of burst while maintaining a maximum tear. It is this area that I chose to do my work, using the ball mill only as a refining tool to determine the strength values and relationships rather than to exploit the use of the ball mill as a production refiner.

The sources used in compiling the above material can be found in the bibliography at the end of the paper.

P OCEEDURE:

The proceedure followed the one outlined in T.A.P.P.I. 224sm-45 with several exceptions to be discussed below. Three ball jars and one rolling device were used along with five different strength developing materials. Those materials used were steel balls, porcelain balls, porcelain cylinders, flint pebbles, and golf balls. Two pulps were also used; Spruce Falls bleached sulphite and Weyerhauser bleached kraft.

T.A.P.P.I. Standard 224sm-45 recommends 90 grams of oven dry pulp per ball jar which was used in the initial series of tests, however, this weight of pulp required a great length of time to refine. During the later series the pulp weight was decreased to 70 oven dry grams and even to 50 grams to decrease refining time. As the study of consistency changes and its relation to refining time and strength attributes was not being considered, these consistency changes were made without

damaging the results.

The weight of the strength developing materials used were in three cases within T.A.P.P.I. Standards. Steel balls, porcelain cylinders, and porcelain balls all had weights of 4905 grams and where within the standards while golf balls weighed 1761 grams and flint pebbles 4535 grams; both below the required amount. The later two were below standard as their bulk prohibited the addition of further material.

The testing sequence began by weighing out the desired amount of pulp and dispersing it in a British disintegrater for five minutes. The stock and pre-weighed strength developing material were placed in the ball jar and the stock was further diluted to a maximum. The ball mill was placed on the roller and was run for the required number of hours.

When the desired freeness was reached, the pulp was removed from the jar and a Canadian Standard Freeness was taken. The refined pulp was again treated in a British disintegrater for five minutes and handsheets were then made on a Noble and Wood sheet mold, dried, and placed in the humidity room to condition. After these sheets have conditioned at 50% R.H. and 69 degrees Centigrade for two days, they were weighed and tested. Tests were run for both burst and tear with the burst tests run on the Perkins mullen tester and the tear tests on the Elmendorf tear tester. The values obtained on each sheet were corrected to a standard sheet basis weight of 2.80g/sheet.

TABLE 1

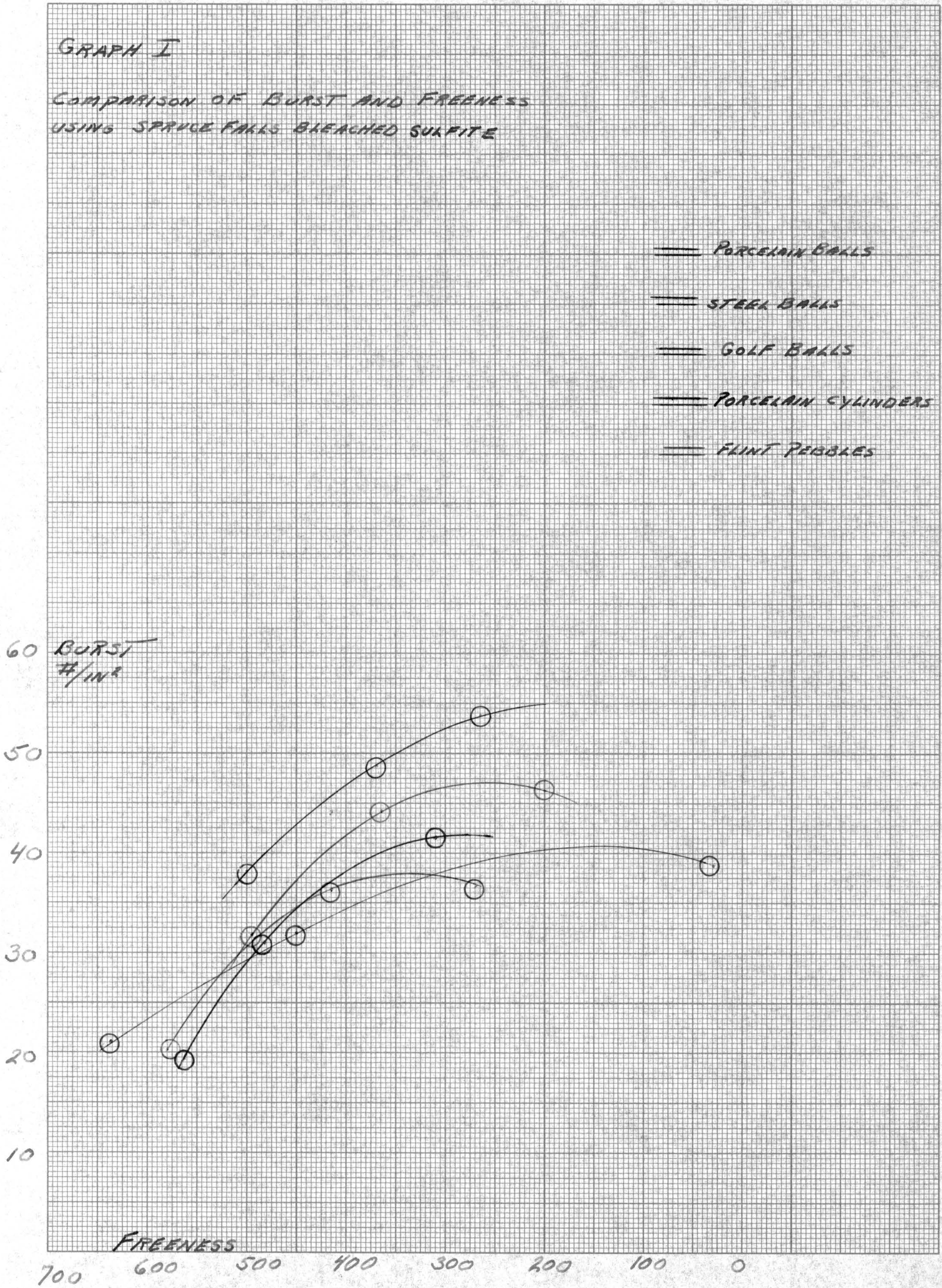
Spruce Falls Bleached Sulfite - Strength Development

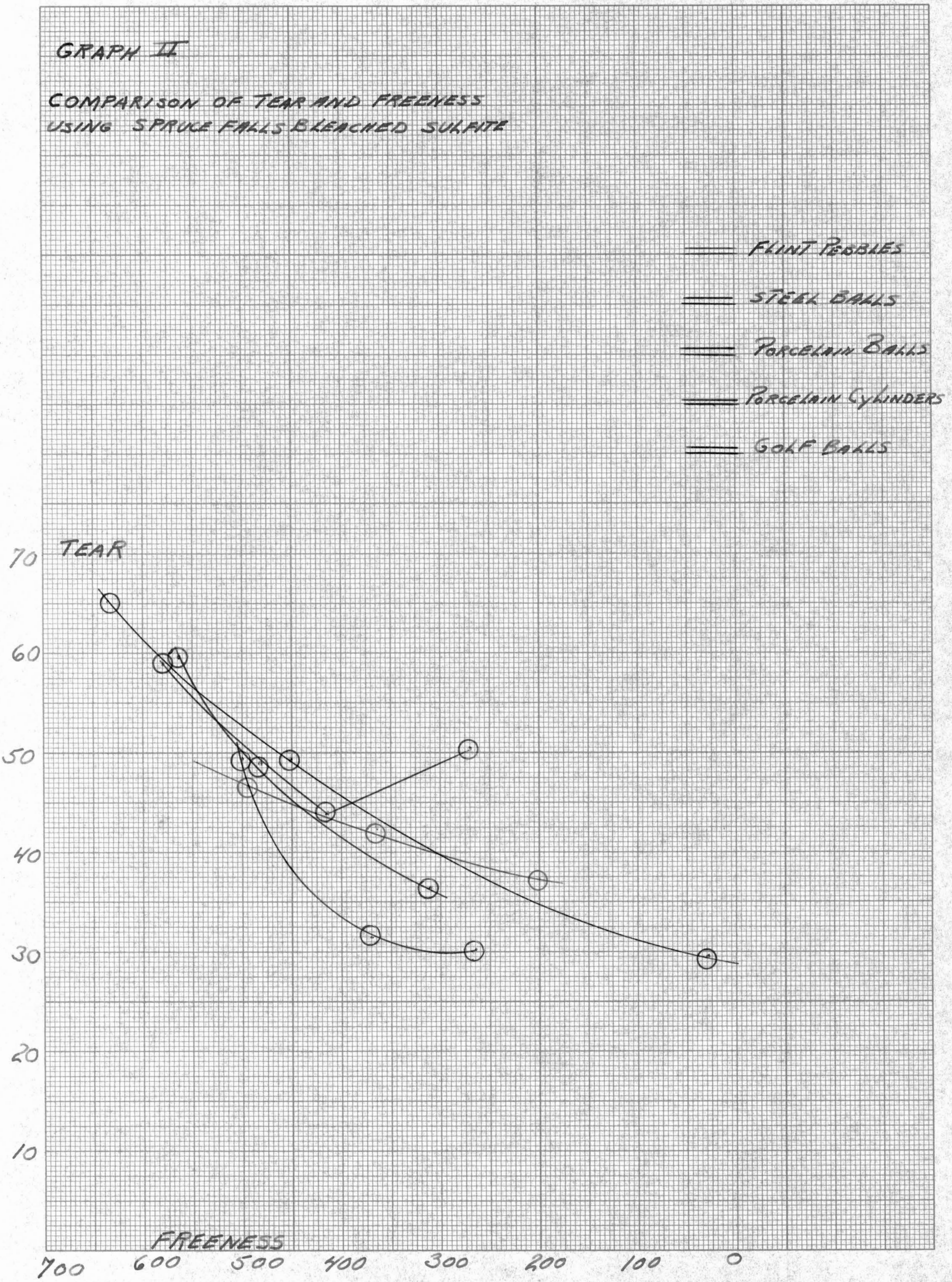
				Approx. Hours To 500 C. S. Freeness
Flint Pebbles				
Freeness	495	365	200	18+
Burst	31.7	44.1	46.2	
Tear	46.6	42.3	37.3	
Burst X Tear	1477	1865	1723	
Steel Balls				
Freeness	500	370	265	4
Burst	38.1	48.6	53.9	
Tear	49.3	31.3	30.1	
Burst X Tear	1878	1521	1622	
Porcelain Cylinders				
Freeness	563	483	310	4½
Burst	19.4	31.0	41.5	
Tear	59.5	48.5	41.2	
Burst X Tear	1154	1504	1710	
Porcelain Balls				
Freeness	580	415	270	13
Burst	20.2	36.2	36.8	
Tear	58.8	43.7	50.4	
Burst X Tear	1188	1582	1855	
Golf Balls				
Freeness	635	450	30	150+
Burst	21.0	32.1	38.9	
Tear	65.1	49.2	29.5	
Burst X Tear	1367	1579	1148	

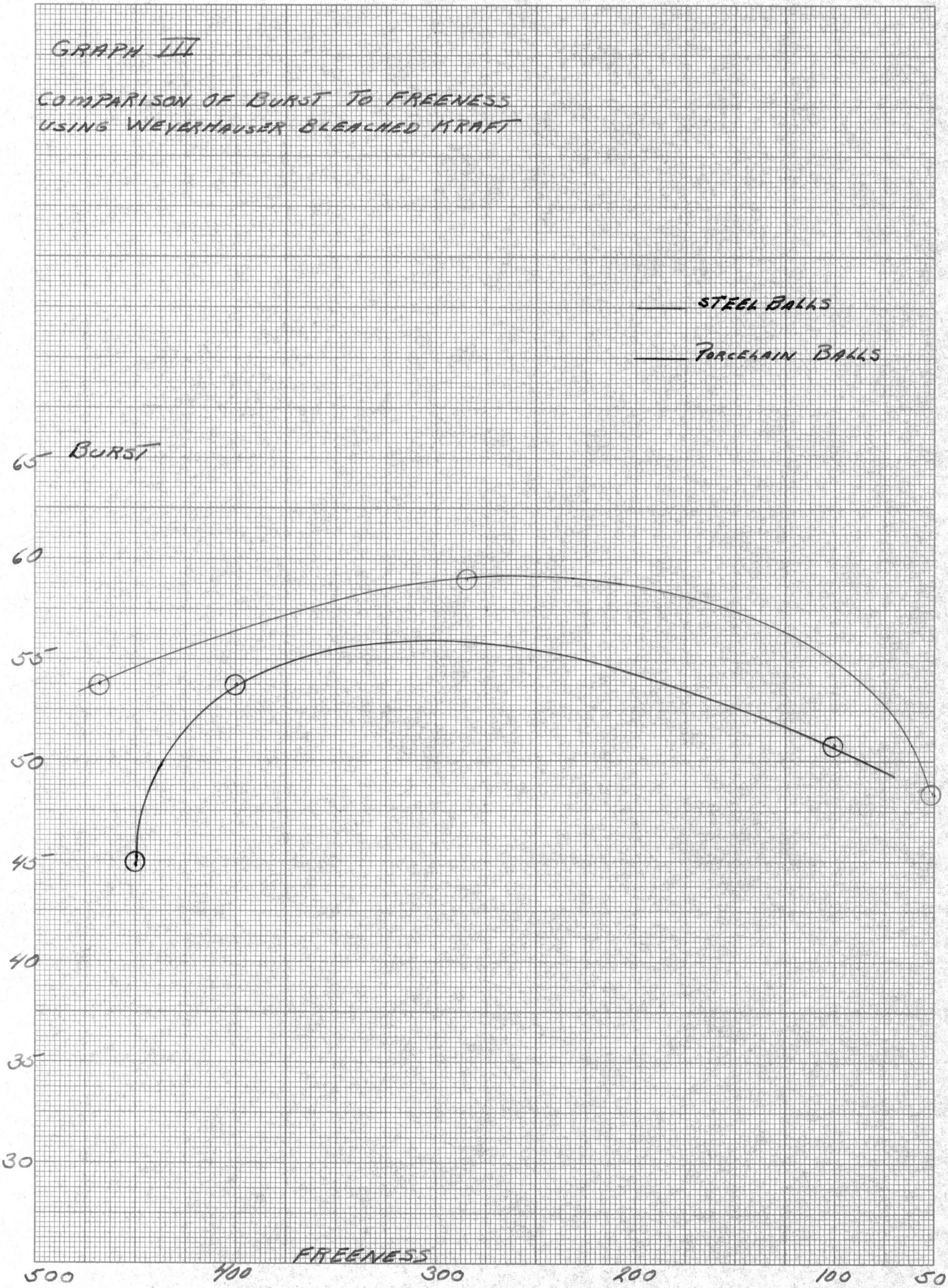
TABLE 2

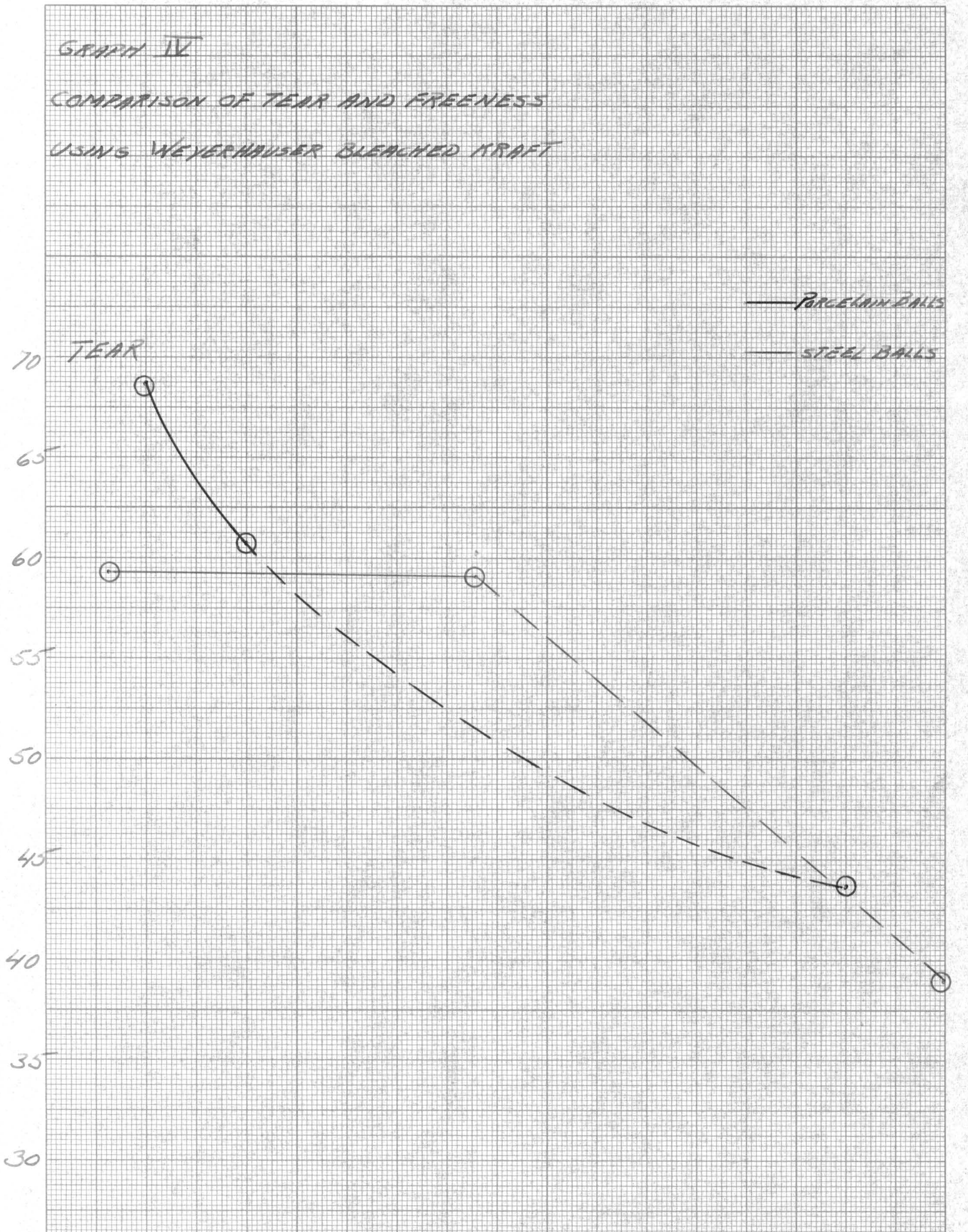
Weyerhauser Bleached Kraft - Strength Development

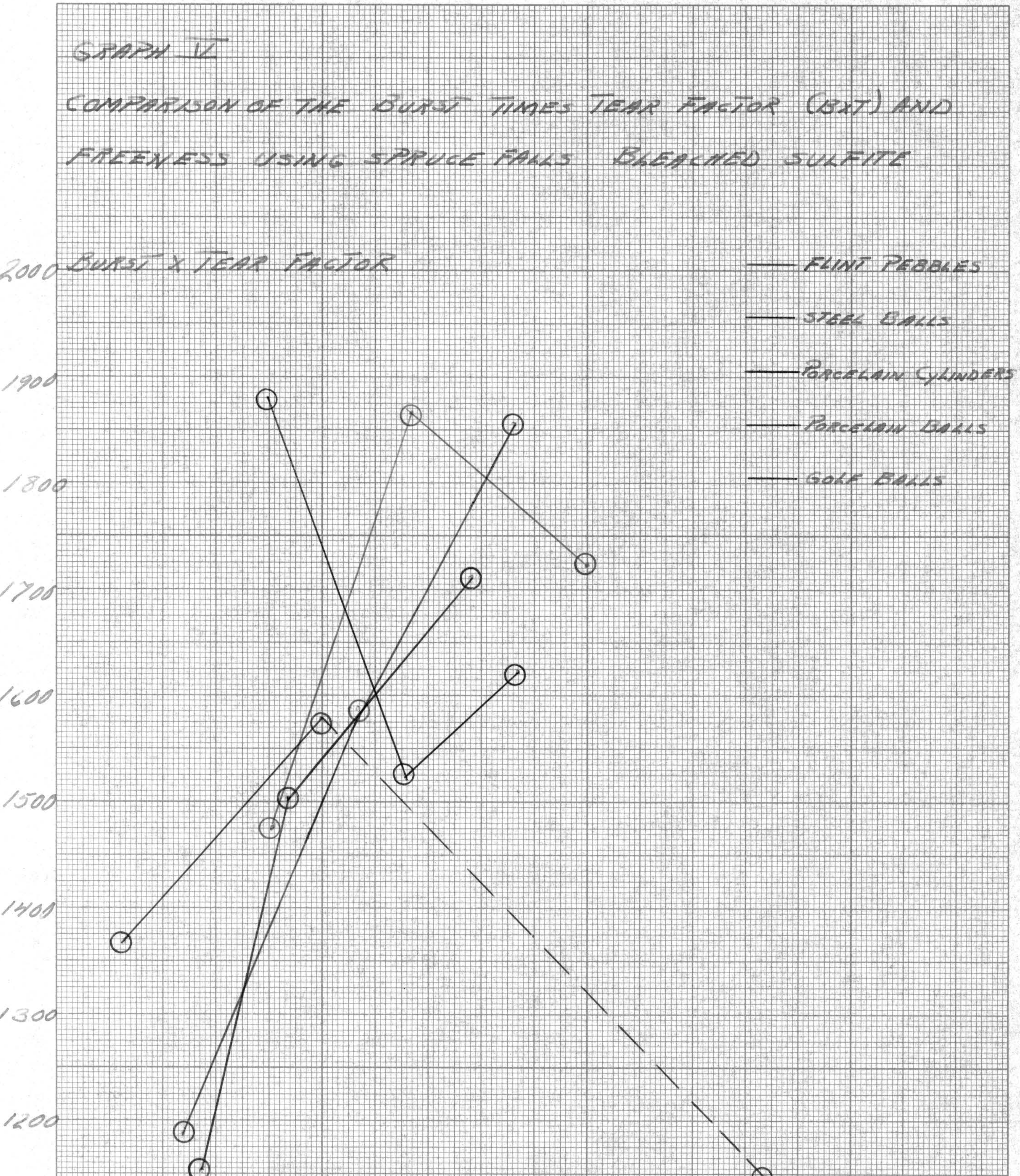
				Approx. Hours To 500 C.S. Freeness
Steel Balls				
Freeness	467	285	50	5
Burst	53.8	59.0	48.3	
Tear	59.3	58.9	39.0	
Burst X Tear	3190	3475	1884	
Porcelain Balls				
Freeness	450	400	100	20
Burst	44.8	53.6	50.8	
Tear	68.7	60.7	43.6	
Burst X Tear	3078	3254	2215	


GRAPH I
COMPARISON OF BURST AND FREENESS
USING SPRUCE FALLS BLEACHED SULFITE
PORCELAIN BALLS
STEEL BALLS
GOLF BALLS
PORCELAIN CYLINDERS
FLINT PEBBLES
BURST
#/IN²
60
50
40
30
20
10
FREENESS
700
600
500
400
300
200
100
0

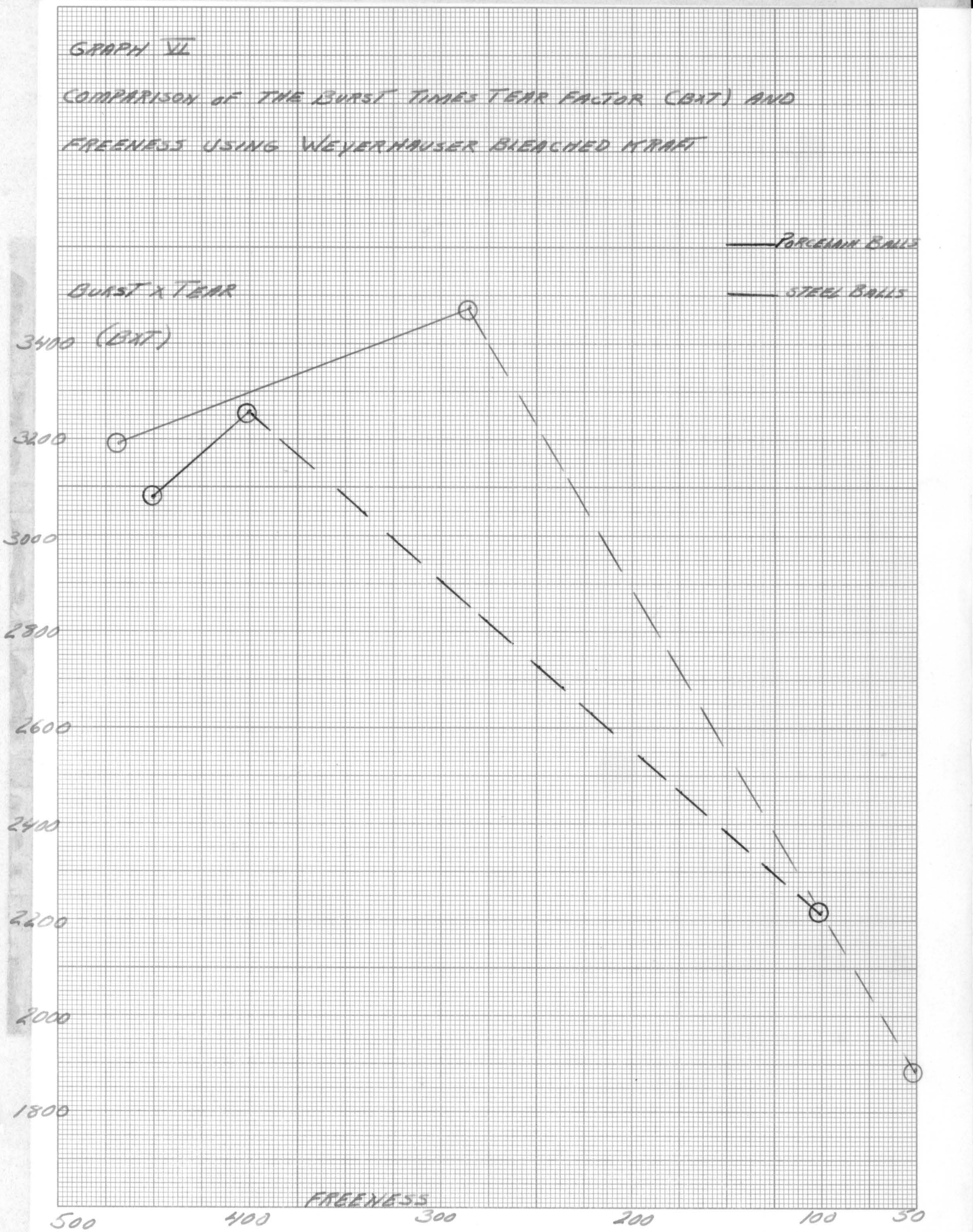

GRAPH II
COMPARISON OF TEAR AND FREENESS
USING SPRUCE FALLS BLEACHED SULFITE
FLINT PEBBLES
STEEL BALLS
PORCELAIN BALLS
PORCELAIN CYLINDERS
GOLF BALLS
TEAR
70
60
50
40
30
20
10
FREENESS
700
600
500
400
300
200
100
0


GRAPH III
COMPARISON OF BURST TO FREENESS
USING WEYERHAUSER BLEACHED KRAFT
STEEL BALLS
PORCELAIN BALLS
BURST
65
60
55
50
45
40
35
30
FREENESS
500
400
300
200
100
50


GRAPH IV
COMPARISON OF TEAR AND FREENESS
USING WEYERHAUSER BLEACHED KRAFT
PORCELAIN BALLS
STEEL BALLS
TEAR
70
65
60
55
50
45
40
35
30
FREENESS
500
400
300
200
100
50



GRAPH VI
COMPARISON OF THE BURST TIMES TEAR FACTOR (BXT) AND
FREENESS USING SPRUCE FALLS BLEACHED SULFITE
BURST X TEAR FACTOR
FLINT PEBBLES
STEEL BALLS
PORCELAIN CYLINDERS
PORCELAIN BALLS
GOLF BALLS
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
FREENESS
700
600
500
400
300
200
100
0



GRAPH VI
COMPARISON OF THE BURST TIMES TEAR FACTOR (BXT) AND
FREENESS USING WEYERHAUSER BLEACHED KRAFT
PORCELAIN BALLS
STEEL BALLS
BURST X TEAR
(BXT)
3400
3200
3000
2800
2600
2400
2200
2000
1800
FREENESS
500
400
300
200
100
50

RESULTS:

The results of this investigation are found in graphs one through six and in tables one and two. For a comparison of the results obtained from the two strength tests, the burst times tear factor was used.

Graphs one and two denote the development of burst and tear using Spruce Falls bleached sulfite. Graph one indicates that the steel balls developed the highest burst followed by flint pebbles and porcelain cylinders. The two lowest burst curves were obtained with porcelain balls and golf balls.

Graph two shows that on the same pulp, steel balls dropped tear by the greatest amount with porcelain cylinders showing the next greatest drop. Flint pebbles showed a drop in tear, however, the overall decrease was not as great as with the former two materials. Procelain balls showed a sharp decrease then increase rendering a conclusion impossible, except that all three of its tear values are above the values obtained with steel balls, flint pebbles, and porcelain cylinders. Golf balls showed a drop in tear of about fifteen points, furthermore, its first two values are above all others obtained at similar freenesses indicating the decreased degree of refining severity as compared to all the other materials. The third value was obtained at a freeness of 30 and was outside the 600-200 freeness range rendering a conclusion impossible.

Comparing these burst and tear results, using the burst times tear factor, indicates that steel balls were the only

material to drop the factor with increased degree of refining while all other materials increased the strength factor with increased degree of refining. Both porcelain cylinders and balls showed high overall strength development with porcelain balls showing the greatest improvement. Flint pebbles showed improvement equal to the porcelain balls, however, the factor dropped off on the last freeness to a value nearly equal to the high achieved by the porcelain cylinders. The golf balls started from the highest factor value and increased slightly only to drop off when the freeness dropped to 30 which is too low to be considered as part of the data.

The same results were obtained using Weyerhauser bleached kraft. Only two strength developing materials were used, steel balls and porcelain cylinders, and they showed the same characteristics as they exhibited with bleached sulfite.

Steel balls developed a higher burst than did the porcelain balls and showed lower values of tear, within the correct freeness range, than did the porcelain balls as is illustrated by graphs three and four.

It is very difficult to draw any conclusions from the burst times tear factors of the bleached kraft because the third factors were taken at too low a freeness to be considered part of the data. The only conclusions can be drawn from the burst and tear graphs which show the steel balls developing the highest burst and lowest tear. These graphs indicate that the steel balls exhibited a greater degree of refining severity than the

porcelain balls.

It is worth noting that the values obtained with the bleached kraft are substanially higher than those obtained with bleached sulfite indicating the higher degree of strength of the kraft pulp.

CONCLU IONS:

It is signifigant that all the materials except steel balls increased strength with increased degree of refining, and that steel balls refined the pulp more drastically than the other materials, thereby decreasing the strength factor.

Graph five denotes the strength developing characteristics of the five materials. As the graph indicates, porcelain balls exhibited the greatest strength developing tendencies as the strength factor increased with increased degree of refining over the entire freeness range.

Porcelain cylinders showed the next best strength improvement followed by the flint pebbles, although the pebbles strength factor dropped off slightly on the third and lowest freeness.

Golf balls also increased in strength over the first two freenesses, but the third freeness was outside the freeness range and no conclusions can be drawn concerning the value of the factor at that point. Golf balls, although not developing overall strength to the highest peak, exhibited the lest degree of refining severity as they developed the highest tear of all the strength developing materials.

Steel balls dropped the strength factor with increased

degree of refining indicating the greatest severity of refining as compared to the other materials. Steel balls also were the only material to drop the strength factor upon increased degree of refining.

It is easily seen from the above data, that the most severe refining was done by the steel balls, while the lest degree of refining drasticness was shown by the golf balls with the other three materials falling in between these two extremes.

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