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Printing with Moisture Setting Inks. The Influence of Varying Degrees of Sizing and Varying Amounts of Hardwood Fibers on The Printability of Bleached Sulphate Sheets

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of Sizing and Varying Amounts of
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of Bleached Sulphate Sheets.

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ABSTRACT

The work on this thesis has been conducted for the purpose of investigating the effect of two variables on the printability of a bleached softwood sulphate sheet, using a moisture setting ink. The two variables are: (1) rosin sizing, (2) furnish, namely, varying amounts of bleached hardwood sulphate fibers.

Handsheets were made in the laboratory with four levels of rosin sizing and increasing amounts of hardwood fibers. The amounts of hardwood fibers ranged from zero to 100 percent with two intermediate percentages.

The calendered handsheets were then printed and visually inspected for quality of printing obtained. Other tests carried out on the sheets were, Carson Curl Size Test, Gurley Softness Test, Bausch and Lomb Opacity, Bekk Smoothness, and Caliper.

The experimental results indicate the following: (1) rosin sizing does not affect printability, when using a moisture setting ink (2) quality of printing varies with varying amounts of hardwood fibers when using a moisture setting ink.

LITERATURE SURVEY

INTRODUCTION

Much work has been done to explore the variables which influence the printability of a sheet of paper. This thesis is limited to the investigation of two variables, namely, varying quantities of hardwood fibers, and varying degrees of rosin sizing. Moisture setting ink will be used in place of conventional oil drying inks in experimentation, in order to obtain new information as to the effect of these two variables on printability.

The literature survey deals with the following subjects:

1. Composition and use of moisture set inks.
2. Fundamentals of printability.
3. Influence of furnish on printability.
4. Influence of sizing on conventional printing as well as on moisture set ink printing.

COMPOSITION AND USE OF MOISTURE SETTING INKS

According to Erikson and Thoma,(8) moisture set ink may be defined as a non-offsetting ink which contains a varnish consisting of a liquid polyglycol as a solvent. The resin dispersed in the solvent represents either a maleic or fumaric acid. This resin when subjected to steam immediately after printing forms a thin, hard surface film. The pigments used in moisture set inks are insoluble in both water and polyglycol.

From this definition one can readily see the difference between an oil base ink which depends upon oxidation for its drying, and a moisture setting ink which dries by precipitation of the resin, due to insolubility in water. The moisture set inks dry

immediately when the surface is exposed and form a hard thin film which prevents offsetting in high speed printing. The precipitated resin has a melting point of about 130 degrees Centigrade, which is higher than the temperature of steam. Although the resin is insoluble in water, its solution in polyglycols has a water tolerance which prevents precipitation on the presses while the paper is being printed. The water tolerance is high enough to prevent precipitation in a room with a relative humidity as high as 80 percent. After the hard film is formed on the printed surface by precipitation the remaining solvent is sorbed by the sheet and the drying is complete.

FUNDAMENTALS OF PRINTABILITY

Printability is that property of a paper which results in printed matter of good quality. This property is not accurately defined at present. It is judged by uniformity of color of the printed areas, contrast between printed and clear areas, legibility of the printed matter, and absence of show through. It is generally believed that the property is related to ink receptivity, uniformity, compressibility, smoothness, and opacity of the paper.[1]

It is easily seen that printability has a broad meaning, resulting in many definitions similar to the one just given. Engelhart[2] states that printability is a property that depends on variables such as: ink, stock, printing process, press, plates, job, atmospheric conditions, and sometimes the condition of the pressman himself. Andella[3] defines printability as that quality in paper that lends itself well to faithful reproduction by possessing the necessary affinity to accept ink from a printing plate and properly "holds" the full color tone values of the halftone

dot structure. Casey[(4)] repeats that printability is not an accurately defined property but is a broad general term referring to the property of a paper which yields printed matter of a good quality. The elements determining the quality of the printing are, the amount of contrast between printed and unprinted areas, the uniformity of solid and halftone areas, the legibility of the printing, the finish of the printed and unprinted areas and the presence or absence of show through.

VARIABLES IN THE STOCK USED

The most important variables affecting printability due to the stock used are, according to Engelhart (loc. cit.): surface smoothness, ink receptivity and affinity, surface strength, chemical reactivity, moisture content and uniformity.

Furthermore, factors such as color, surface reflectance, dimensional stability, body strength, surface abrasiveness and fiber orientation, have to be considered. There are several ways in which the papermaker can control these factors pertaining to printability. Some of these are: furnish used, degree of beating and refining, degree and type of beater sizing used, surface sizing, amount of calendering, type and amount of filler used, speed of the machine and moisture content left in the finished product.

Basically there are two groups of properties that affect printability, namely surface characteristics and internal characteristics. The surface characteristics are particularly important, as the film of ink that is applied in printing is relatively thin compared to the sheet and very seldom comes in contact with the inner part of the sheet.

Smoothness

Generally speaking, one can state, that increasing smoothness improves printability.(2) This is especially true in typographic halftone printing. It is necessary to have a smooth surface if every dot is to leave a clean impression on the surface. At this point smoothness under pressure, or printing smoothness may be introduced. Casey(4) defines printing smoothness as that proportion of the paper which approaches a smooth surface when the paper is subjected to pressure comparable to that which it receives during printing. A sheet of paper has an initial smoothness which is usually determined by one of the conventional smoothness testers without application of pressure in the magnitude applied in printing. One assumes that paper is subjected in printing to pressures ranging from 50 pounds per inch to 1000 pounds per inch.(2) Therefore, it can be realized that a sheet of paper will very readily compress under such tremendous pressures and exhibit a printing smoothness much higher than the initial smoothness. Compressibility and softness might be said to be interrelated. Along with compressibility the property of resiliency is of paramount importance in multicolor printing. Resiliency is the ability of paper to return to its original thickness after being compressed.(5) In multicolor printing, the sheet must return to its original thickness after each imprint if the succeeding colors are to leave impressions that are clear and legible.

Compressibility and resiliency as measured by the Time, Inc., Graphic Arts Laboratory Compressibility Tester may be defined in the following manner:

$$\text{Compressibility (\%)} \quad \frac{\text{Loss in caliper in inches at a given pressure X 100}}{\text{Original caliper in inches}}$$

$$\text{Resiliency (\%)} = \frac{\text{Caliper regained from 1600 P.S.I. of one minute}}{\text{Caliper lost at 1600 p.s.i.}} \times 100$$

Casey[4] states that compressibility and resiliency in combination with smoothness are therefore better indications of good printability than smoothness alone. A compressible, resilient paper, having an initially rough surface will print better than a hard non-resilient paper that is initially smooth.

Ink Receptivity

Ink receptivity is the second characteristic governing printability. If a paper is receptive to the ink being applied, it will leave impressions that have such characteristics as good contrast between printed and unprinted areas, uniformity of solid and halftone areas, and legibility.[4]

The receptivity of ink is usually dependent to a certain extent upon the degree of openness of the sheet.[6] An open sheet will absorb ink more readily than a sheet that is closed by increased density and supercalendering. On the other hand a sheet that has been blackened due to excessive calendering will inhibit the rate of ink absorption.[4] Two extremes may be reached, one in which a sheet is too receptive to ink, forming a gray print and not enough contrast and the other in which the sheet is too hard due to excessive calendering and will not be receptive to ink. The result of a hard non-receptive sheet is usually a mottled, gloss finish and may be subject to offset, whereas, the open porous sheet, if it is too receptive to ink, might be subject to "strike through".[6] Therefore, it is necessary to form a surface that is receptive to ink being applied under pressures ranging from fifty to hundreds of pounds and lasting from 1/10 to 1/500 seconds, depending on press speed.[2]

Ink receptivity is primarily concerned with the transfer of ink to the surface of the paper.(4) It is a function of both ink and paper, and is a property of paper when tested in combination with a particular ink. Even though it is rather difficult to measure ink receptivity, there are methods available to do so. One so-called ink receptivity tests is made by smearing a standard ink on the paper, leaving the ink for a definite period of time, removing the excess ink, and measuring the depth of color. It is best to compare the results with a paper of known ink receptivity. Another method involves printing a weighed strip of paper with an excess of ink, using a solid plate of known area and then blotting the excess ink from the paper, weighing the printed paper again to determine the amount of ink retained. Thus, ink receptivity is best evaluated by the initial resistance of the paper to the break through of the vehicle.

Surface Strength

Surface strength is the third factor that influences printability. It does not physically aid in the deposition of ink as does smoothness and receptivity but it does have a definite effect on the printability of a sheet of paper.(2) If a paper does not have the proper surface bonding it will enhance poor printability by releasing inked fibers from the surface. These loose fibers may fill the plates or contaminate the ink.(4) In our modern high speed printing processes it is of paramount importance that a sheet should have high surface bonding strength because it is a physical law that the "pull" of an ink on paper is increased directly with the speed at which the paper leaves the inked plate.(2)

Furthermore, in multicolor offset printing the colors used

become progressively more tacky and paper with a high surface strength is necessary to withstand both the softening effect of the film of water applied and the tacky inks used plus the increased "pull" inherent in high speed printing. Usually the proper surface bonding can be attained by the proper amount of beating and refining plus the use of proper surface sizing.

Opacity

Opacity is of major importance to printability due to the fact that a sheet with high opacity will, as a rule, be less subject to show-through.[(4)] This is especially important in papers being printed on both sides. Show-through is usually due to two reasons, namely, lack of opacity and lack of resistance to penetration of the ink vehicle. Therefore, a high original opacity is helpful in preventing show-through but is not a guarantee against it, if the paper is not sufficiently resistant to the vehicle of the ink. Change of furnish or addition of titanium dioxide will usually increase the opacity of a sheet.[(2)] Resistance to vehicle can be obtained by proper sizing.

Chemical Reactivity

The chemical reactivity or surface hydrogen ion concentration of a sheet will affect printability in two ways, namely, by retarding the drying of inks, and by destroying the equilibrium necessary in lithography between the fountain solution and the paper.[(2)] Drying oil inks, as a rule, dry most rapidly at a pH value of 5, and as the hydrogen ion concentration increases the drying time decreases.[(4)]

Surface pH is especially important in lithography where the presence of any water soluble materials on the surface of the paper are liable to destroy the rather delicate physicochemical balance which makes the plate-image ink receptive and water repellent, and the non printing areas water receptive.[2] It may also be mentioned, that corrosion of copper, zinc, and other metals used for letter press or gravure plates and cylinders, is increased by improper control of surface pH.

Moisture Content

Moisture content influences almost all other paper characteristics that affect the printability of paper.[4] A one percent moisture change can change the dimensional stability enough to throw a sheet completely out of register.[2] The surface strength of paper will decrease with increased moisture content. The drying time of inks by oxidation increase with increased moisture. Varying amounts of moisture will vary the porosity of a sheet and this in turn will influence the ink receptivity of a sheet. Unless the paper contains five to six percent moisture, static will give the printer trouble on the press which leads to ink "flying" or misting. Adding all these factors together, one can realize the importance of controlled moisture in printing papers.

Uniformity

Casey[4] states that uniformity is the most important property of paper as far as printability is concerned. It is very important that paper be uniform from lot to lot in respect to caliper if uniformity in printing quality is to be expected. Press make-ready must be prepared for paper of a given thickness and any variation from this thickness will give variation in impression, re-

sulting in poor printability.

The other variables, smoothness, ink receptivity, surface strength, opacity, and moisture content must also be uniform from lot to lot, if the same printing results are to be expected without additional, time consuming adjustments on the press or on the inks used.

INFLUENCE OF FURNISH ON PRINTABILITY

Furnish is a mixture of various materials that are blended in the stock suspension from which paper is made.[1] The chief constituent is pulp. Each pulp has its individual characteristics and these pulp characteristics will either make a sheet suitable or unsuitable for printing. This thesis is primarily concerned with two types of pulp, namely a bleached softwood kraft, and a bleached hardwood kraft.

Bleached softwood kraft pulp has fibers with an average length of 3 to 3.5 m.m., has high strength characteristics and as a rule is relatively hard to beat. It is used alone in papers where printing is not of major importance. Very often, it does not yield good printability due to its long resilient fibers and a lack of softness and cushioning effect gained from pulps with short fibers. The fibers of bleached hardwood kraft are, on an average, one third the length of bleached softwood kraft, and papers made from them have a relatively low strength, high bulk, high opacity, high absorbency, and good printability.[1]

In general, a blend of these two pulps gives a satisfactory printing sheet. The softwood kraft furnishes the necessary strength whereas the hardwood kraft furnishes other desirable characteristics,

such as opacity, and resiliency.

INFLUENCE OF SIZING

Sizing is accomplished by the addition of materials to the furnish for paper and board or the surface application of materials to paper and board which increase the resistance of the sheet to penetration by liquids.[1]

The common sizing materials are rosin, wax, glue, starch and latices of thermoplastic polymers. Brakewood[6] states that rosin beater sizing has no effect on printing with oil base inks as oil penetration cannot be inhibited by rosin beater sizing. Sutermeister[7] says that rosin sizing is not a factor of importance in connection with ink receptivity, as printing ink, using an oil base ink, will penetrate a rosin-sized paper as readily as, or even more readily than, an unsized paper. Therefore, it may be concluded that rosin sizing has no effect on the printability or the ink receptivity of a sheet when an oil base ink is used.

Since there seems to be no literature available on the effect of rosin sizing on a glycol base ink, a part of our investigation shall deal with that subject.

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EXPERIMENTAL WORK

INTRODUCTION

The experimental work with moisture setting ink and its printability on bleached sulphate sheets will be carried out in the following sequence: the making of handsheets with varying degrees of rosin sizing and varying amounts of hardwood kraft fibers, the calendering of handsheets, the printing of handsheets on the Vandercook Proof Press using moisture setting inks, and the conducting of other tests such as brightness, opacity, resiliency, smoothness, softness, and consumption of ink in printing.

MAKING OF HANDSHEETS

The pulps used in making the handsheets will be softwood sulphate fibers and hardwood sulphate fibers. These fibers will be beaten individually to a four-hundred milliliter Canadian freeness, and then blended in the desired proportions before being made into handsheets. The following formulations will be made: (1) One hundred percent softwood sulphate, (2) Sixty-seven percent softwood sulphate and thirty-three percent hardwood sulphate, (3) Thirty-three percent softwood sulphate and sixty-seven percent hardwood sulphate, (4) One hundred percent hardwood sulphate.

Besides varying the amount of hardwood fibers, the degree of rosin sizing will also be varied. Each formulation will be made with the following amounts of rosin sizing: (1) No rosin sizing and no alum, (2) No rosin sizing and addition of alum, (3) One percent rosin sizing based on moisture free pulp and

addition of alum, (4) Five percent rosin sizing based on moisture free pulp and addition of alum. The hydrogen ion concentration of the furnish, at 1.57 percent consistency, will be adjusted to 5.5 in the sheets where alum is used.

The sheets will then be made on the Noble and Wood sheet machine. Forty handsheets will be made from each subdivision of the four formulations making a total of six hundred forty handsheets. This number of handsheets will be sufficient to carry out all the desired tests given in the first paragraph, titled, "Experimental Work". The sheets will be pressed and dried on the rotary press and drier, respectively, and conditioned at fifty percent relative humidity at 73°F., before being calendered. After being conditioned, the sheets will have an average weight of 2.63 grams.

CALENDERING OF HANDSHEETS

The sheets, after being conditioned at fifty percent relative humidity at 73° F., will be calendered on a laboratory size calender. This calender is placed in a constant temperature and humidity room at the same conditions as the sheets. Two passes through the calender will be given the sheets after which they will be printed.

PRINTING OF HANDSHEETS

The proof printing will be done on a No. 4 Vandercook Proof Press at the same temperature and humidity conditions as the calendering. All the sheets will be printed identically the same

using a moisture setting ink. The ink will be set by exposing each sheet, immediately after printing, to an atmosphere saturated with water vapor. This will be accomplished by the use of a dessicator. Both solid and halftone plates will be used in printing.

After printing, the sheets will be visually examined and the printability of each sheet will be judged by such characteristics as the amount of contrast between printed and unprinted areas, the uniformity of solid and halftone areas, the legibility of the printing, the finish of the printed areas, and the presence or absence of show-through.

OTHER TESTS

Other tests such as brightness, opacity, resiliency, smoothness, softness, and amount of ink consumed in printing will be carried out on all the handsheets. The tabulated results willobe an average of the five tests conducted on the sheets from each formulation. From these results, conclusions may be made as to which physical and optical characteristics, due to the pulps used, are conducive to good printability and which ones inhibit favorable printability.

EXPERIMENTAL RESULTS

The sixteen formulations of handsheets which were made on the Noble and Wood sheet machine were assigned numbers from one to sixteen. The significance of each number assigned may best be expressed by the following tabulation:

	No size; No alum.	No size; $3\frac{1}{2}$% alum based on moisture free pulp	1% rosin size; $3\frac{1}{2}$% alum, based on moisture free pulp	5% rosin size; $3\frac{1}{2}$% alum based on moisture free pulp
100% Softwood Sulphate 0% Hardwood Sulphate	1	2	3	4
66 1/3% Softwood Sulphate 33 1/3% Hardwood Sulphate	5	6	7	8
33 1/3% Softwood Sulphate 66 1/3% Hardwood Sulphate	9	10	11	12
0% Softwood Sulphate 100% Hardwood Sulphate	13	14	15	16

Table 1: Furnishes Used in Experimentation.

Printing of Handsheets:

Printing of the calendered sheets was done on a Vandercook Proof Press, using a plate containing both solid and halftone areas. The halftone areas consisted of sixty-five and eighty-five line coverage, ranging from five to ninety percent etch. Printing

was done in the conventional manner using a known constant volume of ink on the ink distribution rolls for each formulation printed. Four proofs were printed on each of the sixteen formulations, making a total of sixty-four proofs.

These proofs were then visually inspected with the aid of a microscope. The identity of the formulations were not known during inspection, thereby eliminating biased judgment as to quality of printing. Four quality ratings were chosen, namely, poor, fair, good, and excellent printing. These quality ratings were numbered one through four respectively. Criteria for inspection were: contrast between printed and unprinted areas, uniformity of solid and halftone areas, and legibility of the printing. After inspecting each proof, it was assigned a number with respect to its printing quality. The results of this inspectinn are tabulated as follows:

		No size; no alum	No size; 3½% alum based on o.d.pulp	1% rosin size; 3½% alum, based on o.d.pulp	5% rosin size; 3½% alum, based on o.d.pulp
100% Softwood	Proof 1	2	1	2	1
Sulphate	Proof 2	2	2	1	1
0% Hardwood	Proof 3	1	1	1	1
Sulphate	Proof 4	1	1	1	1
66 1/3% Softwood	Proof 1	1	2	2	1
Sulphate	Proof 2	2	2	2	1
33 1/3% Hardwood	Proof 3	2	2	2	1
Sulphate	Proof 4	2	2	2	1
33 1/3% Softwood	Proof 1	2	3	2	3
Sulphate	Proof 2	3	3	4	3
66 1/3% Hardwood	Proof 3	3	2	3	3
Sulphate	Proof 4	2	2	2	2
0% Softwood	Proof 1	3	4	4	4
Sulphate	Proof 2	3	4	4	4
100% Hardwood	Proof 3	4	4	3	3
Sulphate	Proof 4	4	4	4	4

Table II: Printing Quality of Proofs.

This type of inspection may not be conclusive. It does show, however, a trend of a better quality of printing produced on sheets containing increasing amounts of hardwood sulphate fibers. The most noticeable improvement was experienced on a sheet containing up to two-thirds hardwood sulphate fibers.

A test indicating the absence or presence of "show through" was also carried out. This was done by means of the Photovolt Brightness Test taken on the reverse side of the printed solid area. This brightness reading was subtracted from the initial brightness value of the sheet and the difference was used as a measure of "show through". Minimum "show through" was obtained

on the sheets containing two-thirds hardwood sulphate fibers. These results are illustrated on Figure I.

<u>Carson</u> <u>Curl</u> <u>Size</u> <u>Test:</u>

This test was conducted using both water and di-ethylene glycol as liquids. Di-ethylene glycol was included because it is the solvent most widely used in formulation of moisture setting inks. The rate of curl was measured; it was expressed as time in seconds needed to reach maximum curvature. Averages of at least five tests are presented. When using water, the unsized sheets gave a reading of zero seconds; the sized sheets with one percent and five percent rosin size, gave readings averaging six and twelve seconds respectively. When using di-ethylene glycol as a liquid, the sheets were immediately penetrated and a reading of zero seconds was obtained regardless of the amount of rosin sizing. This indicates that rosin sizing does not prevent penetration of a moisture setting ink into the paper.

The results of the Carson Curl Size Test using water are as follows:

Furnishes / Results in:	No size; no alum. Seconds	No size; $3\frac{1}{2}$% alum based on o.d.pulp Seconds	1% rosin size; $3\frac{1}{2}$% alum, based on o.d.pulp Seconds	5% rosin size; $3\frac{1}{2}$% alum, based on o.d.pulp Seconds
100% Softwood Sulphate 0% Hardwood Sulphate	0	0	4.9	10.9
66 1/3% Softwood Sulphate 33 1/3% Hardwood Sulphate	0	0	6.4	13.6
33 1/3% Softwood Sulphate 66 1/3% Hardwood Sulphate	0	0	6.0	12.9
0% Softwood Sulphate 100% Hardwood Sulphate	0	0	8.2	13.2

Table III: Results of Carson Curl Size Test.

<u>Gurley Softness</u> (Compressibility):

The results of the Gurley Softness Test, also referred to as compressibility, increased at all degrees of sizing with increasing amounts of hardwood sulphate. A maximum was reached at the blend composed of two-thirds hardwood sulphate and one-third softwood sulphate, slightly declining in a one-hundred percent hardwood sulphate sheet.

The results of the Gurley Softness Test are in good agreement with our findings on printing quality. Good compressibility seems to be a major contributing factor to good printability. The results of the Gurley compressibility test are illustrated on

Figure II.

Bekk Smoothness:

Surface smoothness increased at all degrees of rosin sizing from zero to two-thirds hardwood sulphate content in the furnish. A decrease in smoothness was observed on two levels of sizing in one-hundred percent hardwood sulphate sheets. This decrease was not very significant in one of the two cases. Figure III illustrates the change in smoothness with varying amounts of hardwood fiber and varying degrees of rosin sizing.

Opacity:

Opacity increased with increasing amounts of hardwood sulphate in the furnish. There was a trend to higher opacity on the sized sheets. Change of opacity is illustrated in Figure IV.

Caliper:

The caliper of the calendered handsheets formed from four blends of pulp decreased with increasing amounts of hardwood sulphate. Results of the test are illustrated in Figure V.

Conclusions:

Experimental results indicate the following:

1. Varying degrees of rosin sizing do not influence printability. There were no definite trends shown, in the four levels of rosin sizing, as to quality of printing obtained when using a moisture setting ink.
2. Quality of printing varies with varying amounts of hardwood sulphate fibers when using a moisture setting ink. Printing quality improves with addition of hardwood sulphate fibers

ranging from zero to sixty-six and two-thirds percent. Very little improvement was shown beyond this point.

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Figure I

Influence of Furnish on Show Through

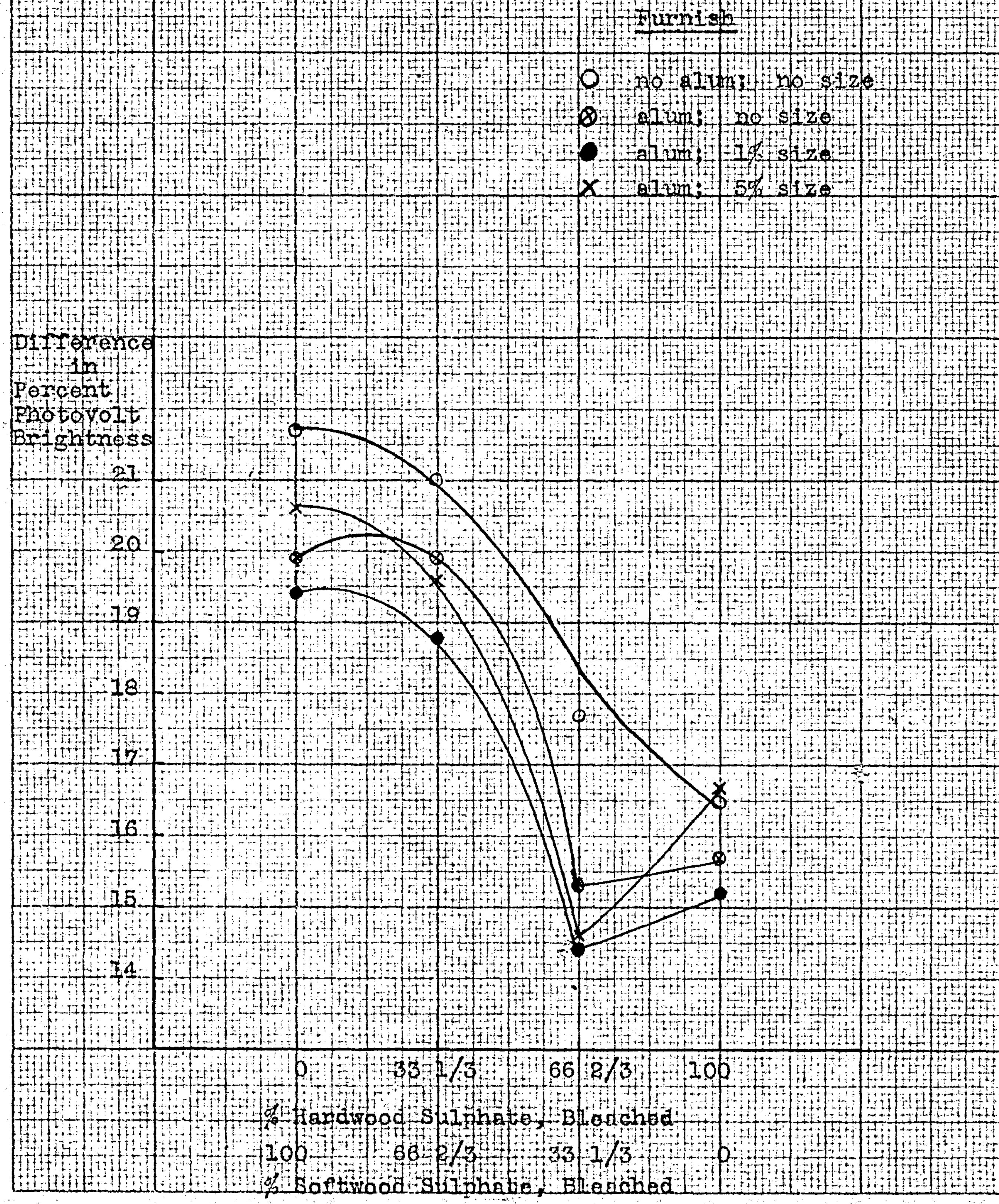

Figure II

Gurley Softness (Compressibility)

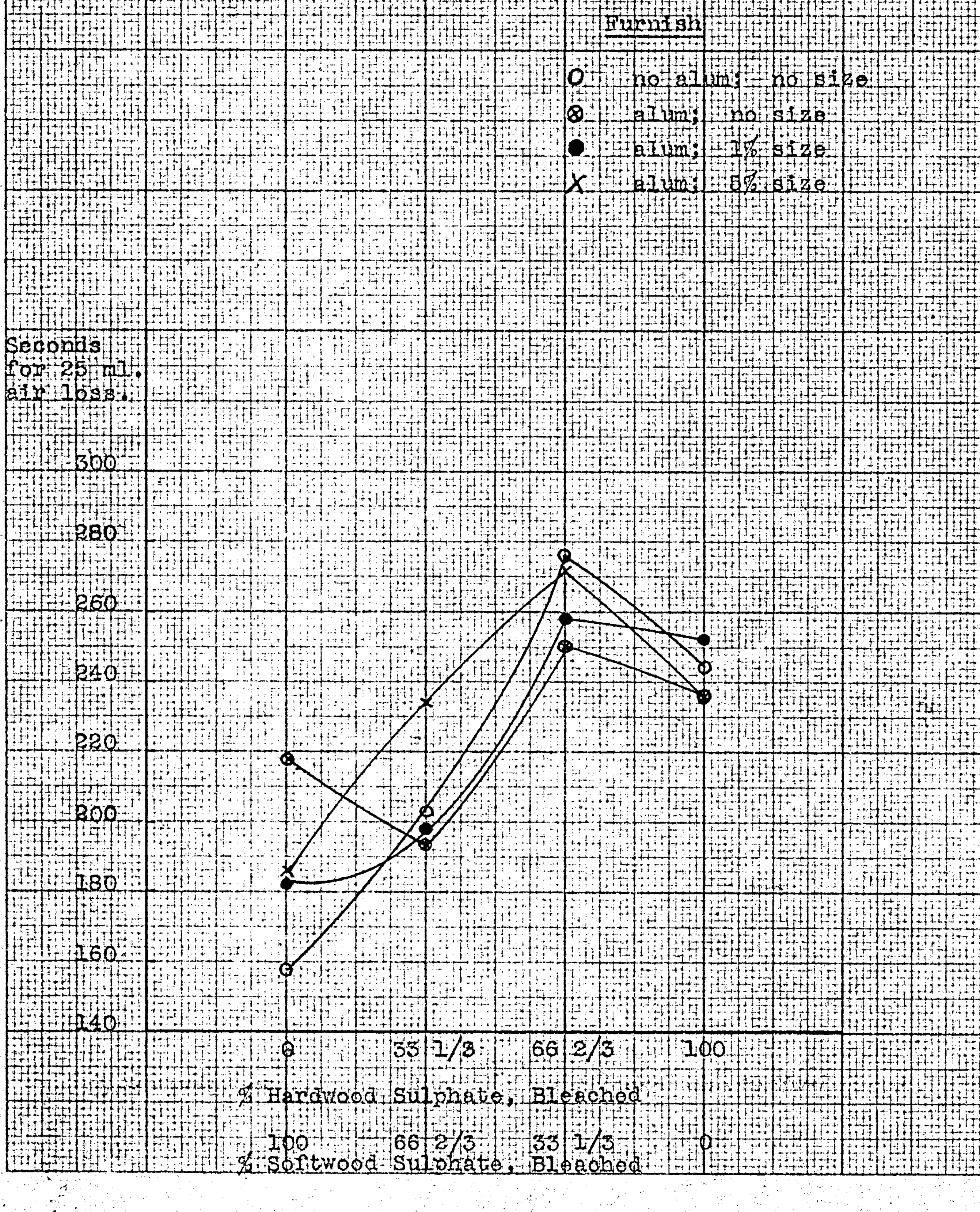

Figure III

Bekk Smoothness

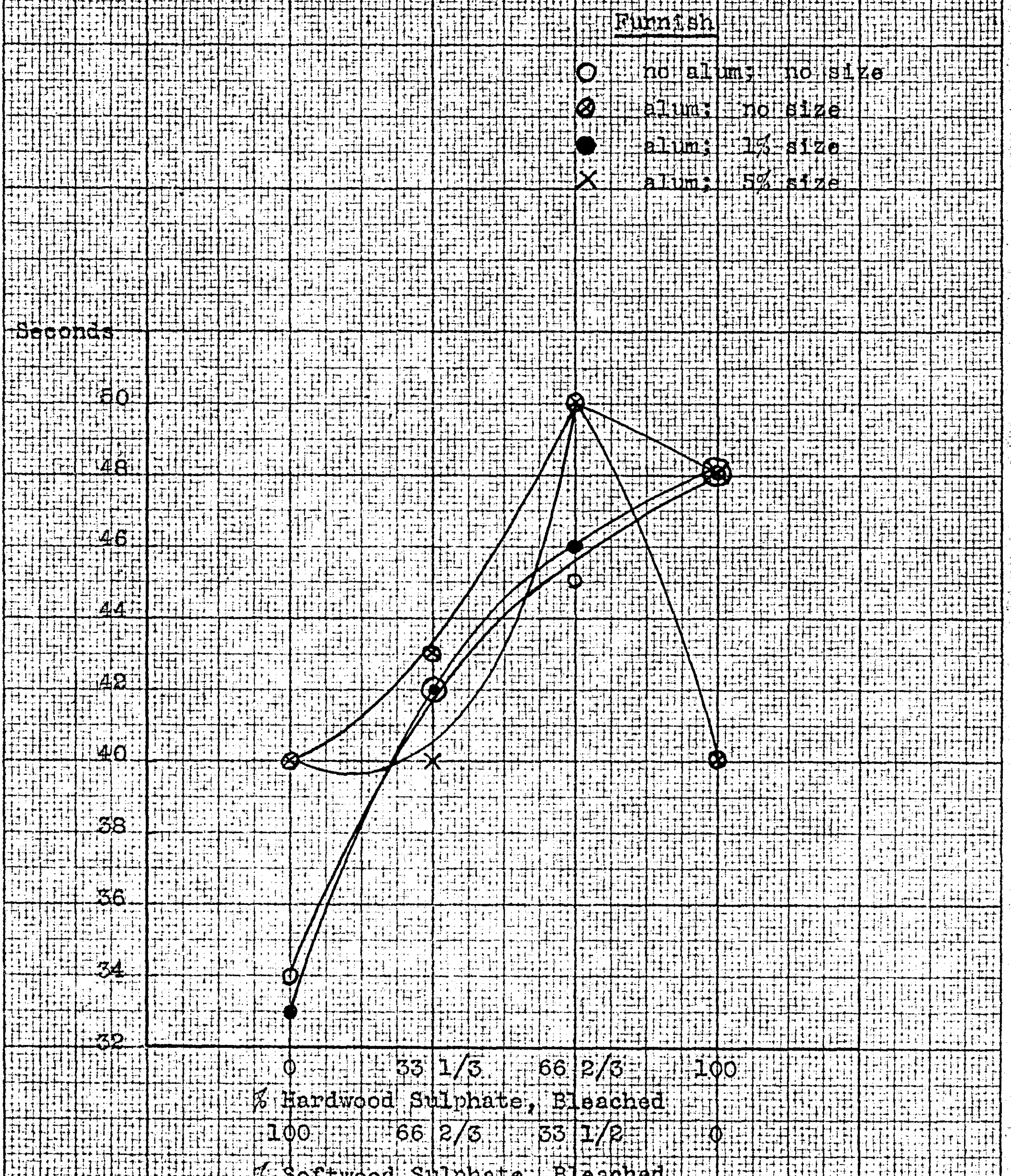

Figure IV

Bausch and Lomb Opacity

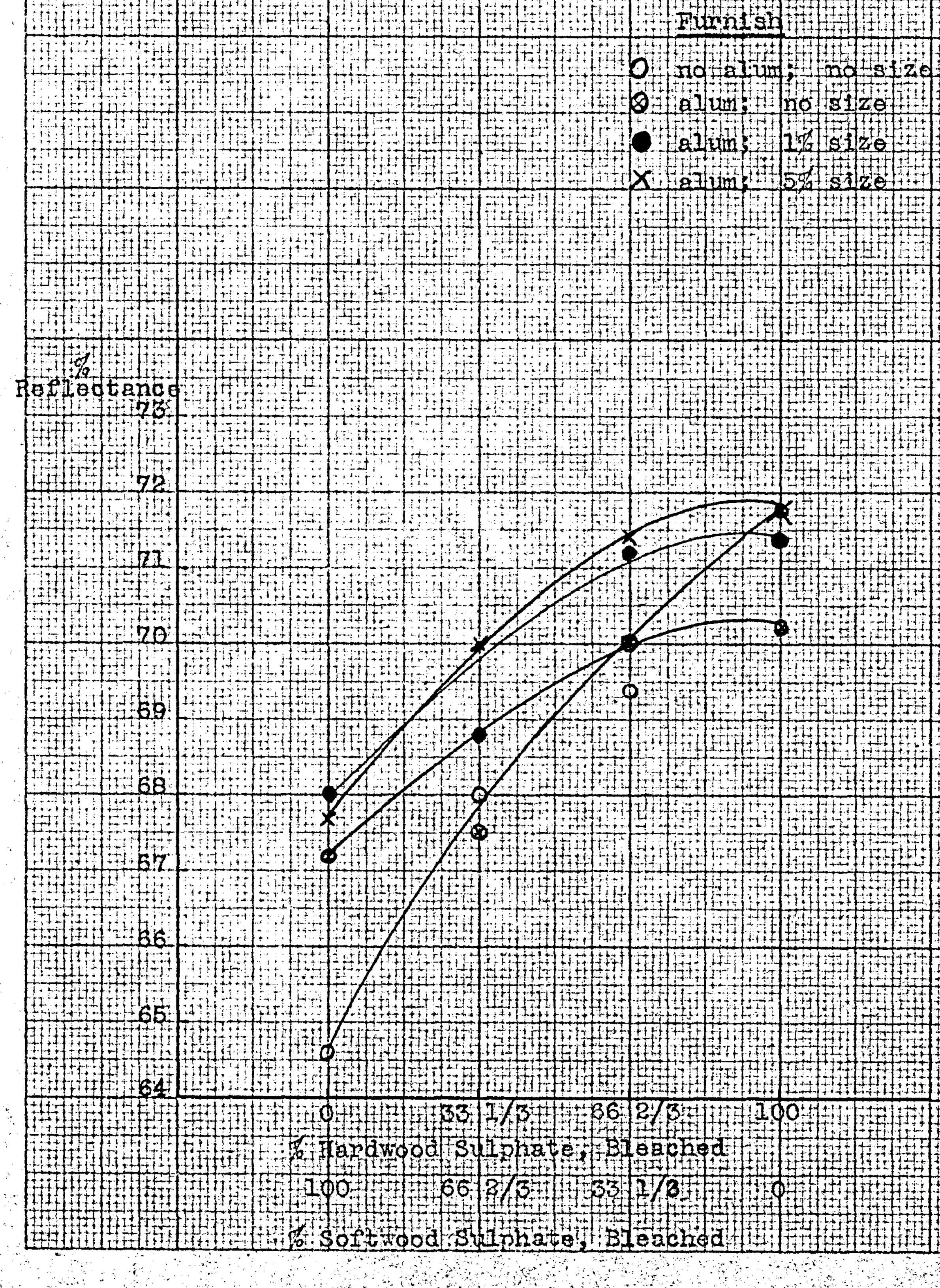

Figure V

Determination of Caliper