4-1-1974

The Effect of Filler Type and Level on Inframike and Moistron Moisture Measurement and Accuray Basis Weight Measurement

Robert G. Tomich
Western Michigan University

THE EFFECT OF FILLER TYPE AND LEVEL ON INFRAMIKE AND MOISTRON MOISTURE MEASUREMENT AND ACCURAY BASIS WEIGHT MEASUREMENT

by

Robert G. Tomich

A Thesis submitted to the
Faculty of the Department of Paper Technology
in partial fulfillment
of the
Degree of Bachelor of Science

Western Micnigan University
Kalamazoo, Michigan
April 1974

ABSTRACT

The following report is a study on the effects of filler type and level on the Inframike, Moistron, and Accuray Basis Weight. Specifically, the effects of clay talc and TiO_2 were investigated at 5%, 10%, and 15% addition levels.

The Inframike was affected linearly by all three filters. The Moistron was not affected by talc and clay, but it was affected in a non-uniform manner by TiO_2. The Accuray was not affected by clay and it was affected linearly by talc and TiO_2.

TABLE OF CONTENTS

INTRODUCTION

The purpose of this paper is to determine the effect, and evaluate the performance, of the Inframike and Moistron moisture gages and the Accuray Basis Weight when varying the level and type of filler in the sheet.

The paper is divided into two main sections: first, a historical background of the instruments and a review of previous experiments is covered; the second part contains an experimental design as suggested by the literature search, the results of the experiment, discussion of results, and conclusions of the experiment.

In the literature search available information on the operation of these instruments back to the late 1950's was covered; the late 1950's was the time when the instruments were first introduced into the industry. Other information relating to these instruments was obtained in an Accuray Operator's Manual and through a previous thesis, which was a performance evaluation of the Inframike and Moistron by David L. Forsman. Most of the information found pertained to the operation of these instruments; that is, a description of the theory behind the instrument and the instrumentation that actually makes it work. No detailed tests conducted on the instruments to evaluate the effect of filler type and level could be found.

HISTORICAL BACKGROUND

Inframike

The Inframike was patented by General Electric, but the patent has since been taken up by Electronic Associates. The Inframike is based on the principle of resonant absorption of infrared energy by water molecules. The resonant absorption phenomenon occurs no matter how the water is mixed--with air, liquid, or solid. The absorption takes place only in several narrow bands of frequency in the near infrared spectral region.[1]

The Inframike alternately projects two narrow bands of radiation onto the paper. One band is absorbed by water, the other is not. The ratio of the backscattered energies of the two bands is dependent on the amount of energy absorbed, which is directly related to the water content in the sheet. The reason for two bands is that changes in the sheet, other than moisture, affect both bands the same way so that the final ratio remains unchanged and is primarily affected by water content. The frequency band absorbed is called the resonant frequency and the frequency just outside this band is referred to as the reference wavelength.[2]

The source of infrared radiation for the Inframike is an incandescent lamp. The radiation is passed through a rotating disk with two filters. One filter passes radiation at the resonant frequency of 1.94 microns wavelength and the other at the reference frequency of 1.8 microns. The radiation is directed into the integrating sphere and onto the paper as a beam about one-half inch in diameter. The reflected radiation from the paper is collected by the integrating sphere and detected by a lead sulfide sensor mounted in the sphere wall.

The Inframike gage itself is designed for a 0 to 12% moisture range, but by using a special amplifier it is good for 0 to 40% moisture. The instrument measures moisture content by primary means and is not dependent on other secondary characteristics of moisture content. The sensing head therefore is mainly affected only by what it is viewing. The gage is unaffected by such things as voltage fluctuations, temperature, type of furnish, pH, brightness, and the degree of beating. It is most affected by basis weight changes, spacing of the gage from the paper, and moisture gradients.

These situations must be taken into consideration if accurate measurements are to be obtained. The instrument should be calibrated for basis weight because the penetration of the radiation into the sheet varies with sheet weight. This brings into consideration the effect of moisture gradients. The gage is primarily affected by the moisture of the paper surface facing it. This would indicate that fillers, if evenly distributed, would not affect the measurement; however, if they migrate to one side of the sheet a gradient is established and the moisture reading will be affected. This effect would change with alterations of the filler level.

The effect of filler on the gage varies with their type and level. Kaolin clay is a material that has infrared absorption bands near those used by the gage. The use of this filler changes the slope of the relationship of meter reading versus moisture content.[3] It would be expected that other fillers having similar infrared absorption bands would also have effects on the same relationship. Clay, on the other hand, showed no effects in the same study by H. W. Hardacker.

The general consensus of the literature regarding this instrument is that it is stable, easy to operate, and accurate when properly calibrated. Of course, in a mill environment with unexpected grade changes or a special order, then a time consuming calibration is not possible. If the effect of the filler and level were known then, the gage reading could be predicted and the necessary controls adjusted.

Moistron

The Moistron Moisture Meter was developed and is produced by Industrial Nucleonics Corporation. The principle of measurement in this meter is A.C. conductivity. The conductivity of the paper changes as the moisture content of the sheet changes. The instrument generates alternating current at specified frequencies. These signals are sent to the Moistron probe which is in contact with the paper.

The Moistron probe is essentially a parallel plate capacitor. It sets up an electronic field which extends into the sheet. A detecting element in the probe is then used to sense the resulting current flow through the sheet. The magnitude of the current is a measure of the impedance of the sheet which is affected by the moisture content.

To compensate for the basis weight and thickness of the paper, the Moistron uses a dual frequency; actually, two frequencies are applied through the probe. When basis weight changes so does the impedance signal of each frequency. The signal changes in the same proportion at each frequency so the basis weight effect is cancelled out when the ratio of the two frequencies is taken. The instrument is not affected by contact pressure, static electricity, or basis weight changes.[4] In one study the Moistron was shown to be sensitive to pH variations.[5] It is possible that at certain levels, with some types of filler, the actual pH of the paper may change, causing a shift in the moisture reading.

As would be indicated by the principle of operation of the instrument, fillers that are electrolytic in nature would affect it. How the gage is affected depends on the electrolytic properties of the fillers. It is possible the effect would change with level changes.

The instrument takes into account many grade variations, but grade parameters such as the percent ash of the sheet will cause the ratio of frequencies to shift.[6] The percent ash can easily be changed by filler variations. Again, as mentioned for the Inframike, the instrument can be calibrated to adjust for grade changes in filler type and level; these changes cannot be compensated for unless the instrument is calibrated. For these occasions it would be vital to know the affect of the filler on the instrument.

Accuray Basis Weight Measurement

The Accuray Beta Gage is manufactured and serviced by the Industrial Nucleonics Corporation. The gage measures the basis weight of the sheet by comparing the amount of radiation through the sheet to the maximum amount of radiation when there is no sheet. The difference is measured and presented in the desired units.

The instrument produces beta rays or electrons from a radioactive source. These rays are directed to the paper toward the radiation detector. Some pass through the sheet and emerge on the other side with enough energy to ionize air or gas. The amount of radiation that does penetrate the sheet depends on the weight per unit area and composition of the sheet. The heavier the sheet the less radiation reaches the detector.

The radiation source is placed below the paper and the ionization or detection chamber is on the other side. Some of the emitted electrons are scattered by the paper, others are trapped, and some are reflected. Those that are transmitted ionize the air or gas in the ionization chamber. A small current flow is produced in the detection chamber by the electrons. The magnitude of the current is directly related to the number of electrons entering the chamber. This number is an inverse function of the mass or basis weight of the sheet.

The beta gage measures the total mass of the sheet. This means:

BASIS WEIGHT = FIBER WEIGHT & COATING AND FILLER WEIGHT & MOISTURE[7]

The Accuray is also able to compute a conditioned weight, which is the weight a sample would have at a specific moisture. Since the gage measures total weight it is always used in conjunction with a moisture meter, usually the Moistron, to eliminate moisture effects.

As has been mentioned before, when beta rays are transmitted to the sheet some are scattered in and some are scattered out. This is taken into account at the time of calibration. The amount and type of filler usually used is also considered. This scattering effect, however, is related to the atomic number of the elements in the sheet. Certain fillers like TiO_2 will cause a high degree of scattering so small changes in its level could cause serious changes in the basis weight reading of the instrument.

It should be mentioned that as filler type and level affect the moisture gage which is used with the Accuray beta gage, the basis weight measurement will be affected correspondingly. To understand how fillers and their level affect the basis weight measurement you must also understand how it affects the moisture gage.

The effects of fillers and their level must be understood before the Inframike and Moistron moisture meters and the Accuray Basis Weight gage can be accurately calibrated. The purpose of the literature review was to suggest procedures to best determine those effects.

EXPERIMENTAL DESIGN

Procedure

The experiment consisted of taking three fillers--talc, clay, and TiO_2--and varying their level of addition 5%, 10%, and 15%; this experiment was conducted on the pilot paper machine at Western Michigan University. The pilot machine is equipped with Industrial Nucleonics Accuray Basis Weight and Moistron moisture gage, along with the Inframike moisture meter. Besides the filler, 2% alum and 1% rosin were added in the beater to aid retention. A 50/50 mixture of bleached hardwood and softwood pulp was used.

The moisture content of the paper was maintained from 4% to 7% and the machine ran 160 pounds per hour of stock, which is equivalent to a fifty pound sheet based on 3,000 sheets.

The fillers were dispersed to a 25% solution on the Cowles mixer; 5%, 10%, and 15% filler based on the use of 160 pounds per hour was metered into the stock line just before the fan pump.

Sample Handling and Test Methods

Two samples were taken from each run. In addition to the nine runs with filler added, a blank run was made at the beginning and end of the trial.

When a sample was to be taken the Accuray was placed in single point position directly behind the scanning head of the Inframike. The paper traveling under the scanning heads was marked with a crayon and simultaneously a reading was taken from the three instruments. The paper that was marked was immediately placed in a plastic bag and the moisture content, ash, and basis weight of the sheet determined.

The ash and moisture were carried out according to standard procedure. The basis weight was determined by cutting a specific area of the marked paper with a template. The sample was dried, weighed, and the basis weight determined.

RESULTS AND DISCUSSION OF RESULTS

The results of the tests conducted and the instrument readings for each run are presented in tabular form. Table I contains the moisture date, Table II the basis weight data.

Following these tables are three graphs. The first two graphs for Inframike and Moistron are plots of percent filler added versus the difference between the instrument and oven dry value. These graphs show the effect the filler type and level have on the instrument. A straight vertical line indicates no effect due to filler additions. The third graph is a plot of percent filler added versus the difference between Accuray basis weight and the measured value.

Moisture Meters

As can be seen in Graph I for the Inframike, all three fillers affected the Inframike. Talc showed the most definite relationship with all four data points indicating a linear relationship. Clay and TiO_2 also show a linear relationship, but the three points obtained with TiO_2 in the sheet do not coincide with the origin or blank run.

In Graph II, for the Moistron, a horizontal line can be seen for talc and clay. This signifies no effect due to those fillers. The line is offset +2.3 from zero (0) deviation, but the blank sample was also 2.3% higher in moisture content than the oven dry sample. This can be compensated for by changing the grade switch on the Accuray to adjust for the +2.3% error. TiO_2 showed no distinct relationship. The points were plotted, but lines could not be drawn to connect them.

From the literature surveyed it was expected that the Inframike would be affected less than the Moistron. This was not indicated in this study. The Moistron showed no effect to clay and talc and an undetermined effect by TiO_2. This indicates the instrument cannot be relied upon when using TiO_2.

The Inframike is affected by all three fillers. Possibly migration of fillers in the sheet causes temperature gradients in the sheet, to which the Inframike is sensitive. These gradients would increase at higher filler levels causing an increased error in the measurement. All three fillers affected the Inframike in such a way.that a calibration curve can be obtained from the data or a graph can be maintained and the error in the instrument reading obtained from it.

Accuray Basis Weight

Graph III is a plot of percent filler added versus the lifference between the Accuray basis weight and the measured value. On graph III it can be seen that clay had no effect on the basis weight. Talc again exhibited a linear relationship with all four data points. The three points obtained with TiO_2 filler added seem to indicate a straight line. There is some doubt to this, however, since the blank or origin is nowhere near the other points and because of the fact that the Moistron was so affected by TiO_2.

The Accuray measures the total weight in the sheet, so when filler is added the Accuray basis weight is going to go up. When filler was added in this experiment the basis weight was adjusted. This way effects caused by adding filler were due to filler properties other than just its mass.

As has been stated previously, clay had very little effect on the Accuray and TiO_2 and clay showed a linear effect with increasing filler content. The effect talc had on the instrument can be determined for various filler levels on the graph. This may not be true for TiO_2 since Moistron errors could have affected the final basis weight measurement.

CONCLUSION

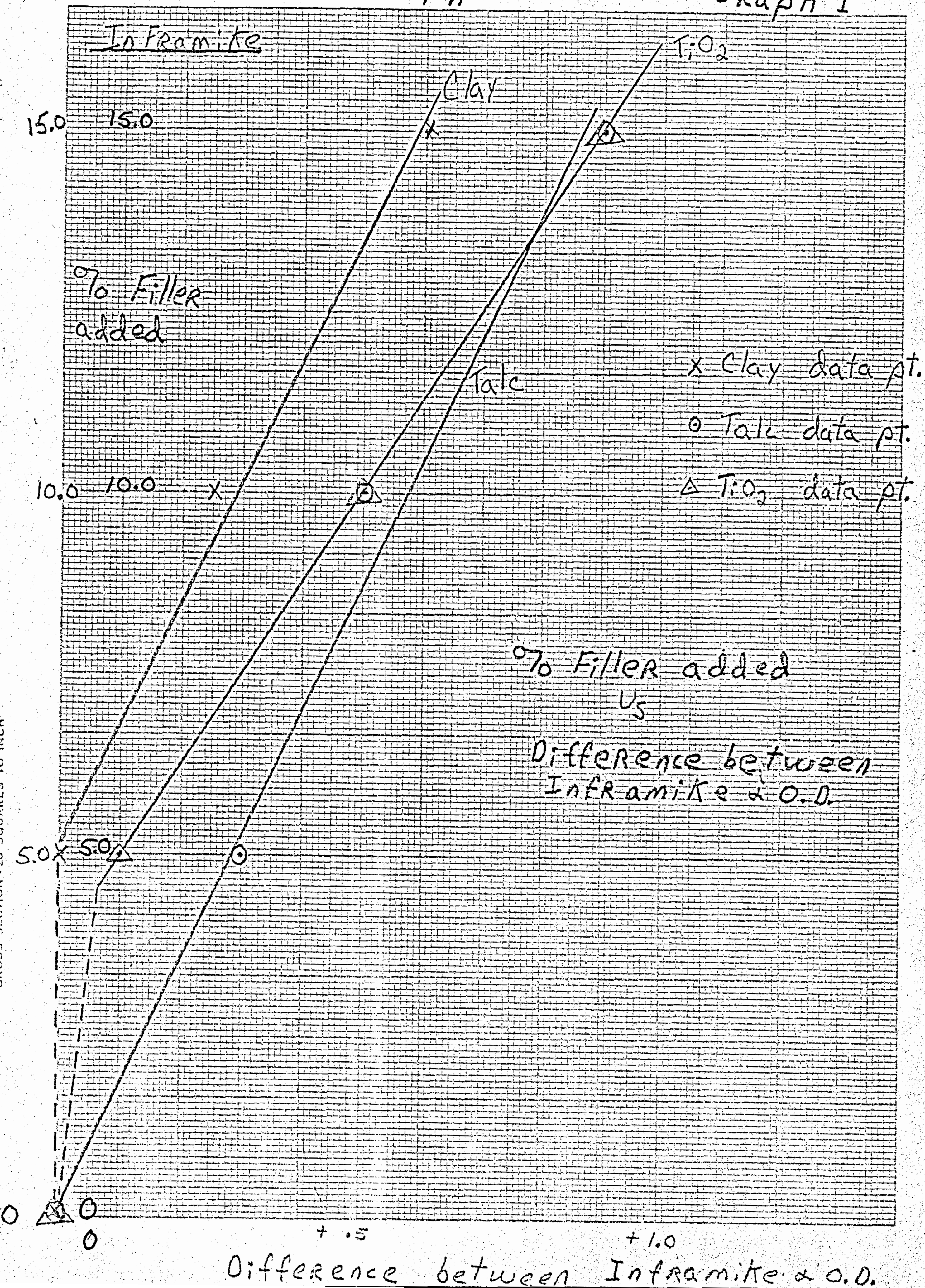
It can be concluded from this study that talc and clay fillers do not have an appreciable effect on the Moistron moisture meter. TiO_2 has an undetermined effect on the electrical properties of the sheet so the gage cannot be trusted when using higher levels of TiO_2.

The Inframike is affected by talc, clay, and TiO_2. The effect is linear and can be predicted to compensate for it.

The Accuray beta gage is not affected by clay, but is affected by talc and TiO_2. The talc and TiO_2 both show a linear relationship between the percent filler added and the difference between instrument value and true value. Therefore the effect these fillers will have can be predicted from graphs with the parameters just given.

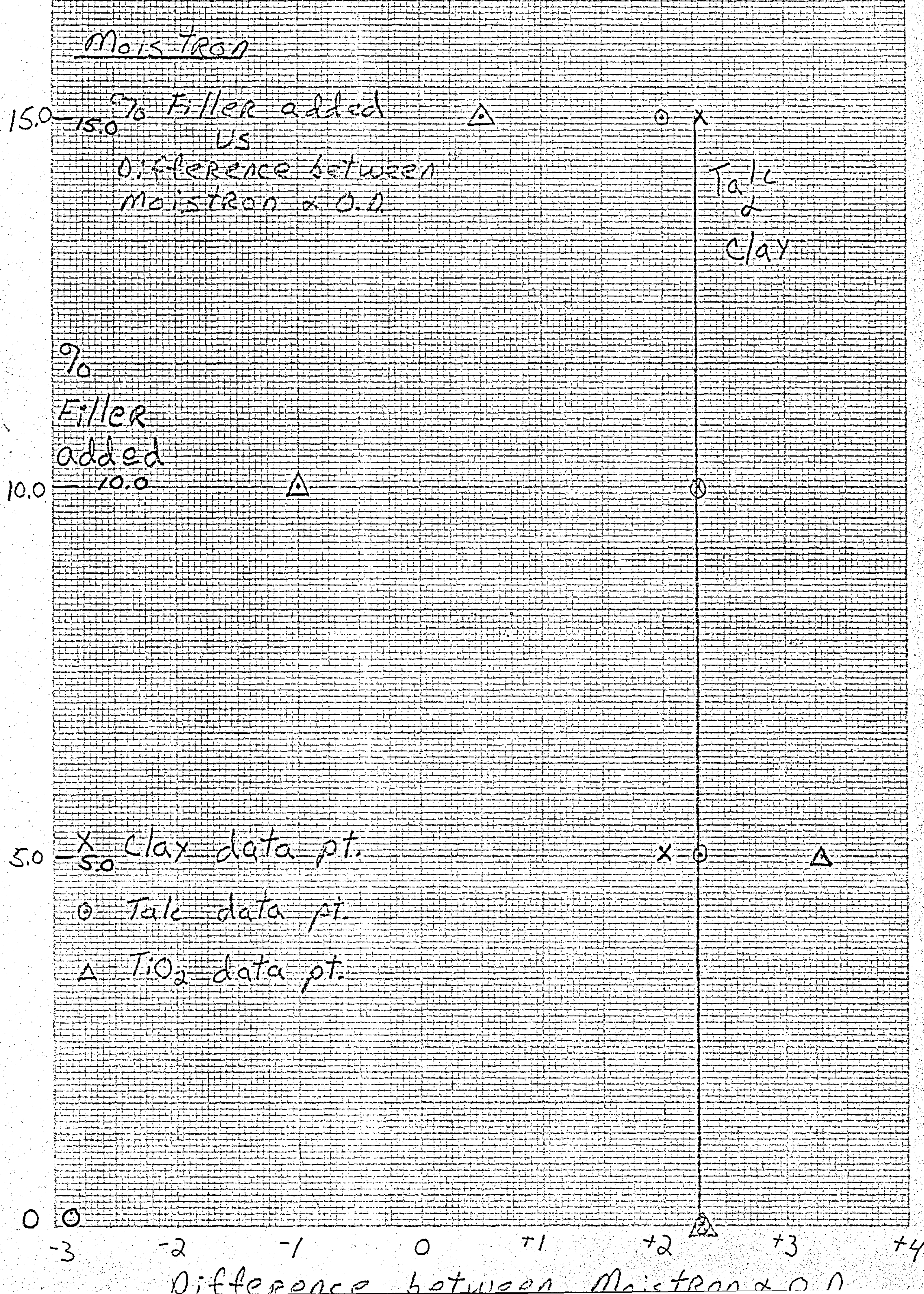
APPENDIXES

Graph I



Inframike
TiO2
Clay
Talc
15.0
15.0
10.0
10.0
5.0
5.0
0
0
% Filler added
x Clay data pt.
⊙ Talc data pt.
△ TiO2 data pt.
% Filler added
Vs
Difference between
Inframike & O.D.
0
+ .5
+ 1.0
Difference between Inframike & O.D.

Graph II



Moistron
% Filler added
vs
Difference between
Moistron & O.D.
15.0
15.0
10.0
10.0
5.0
5.0
0
% Filler added
Talc & Clay
X Clay data pt.
⊙ Talc data pt.
△ TiO2 data pt.
-3
-2
-1
0
+1
+2
+3
+4
Difference between Moistron & O.D.

Graph III

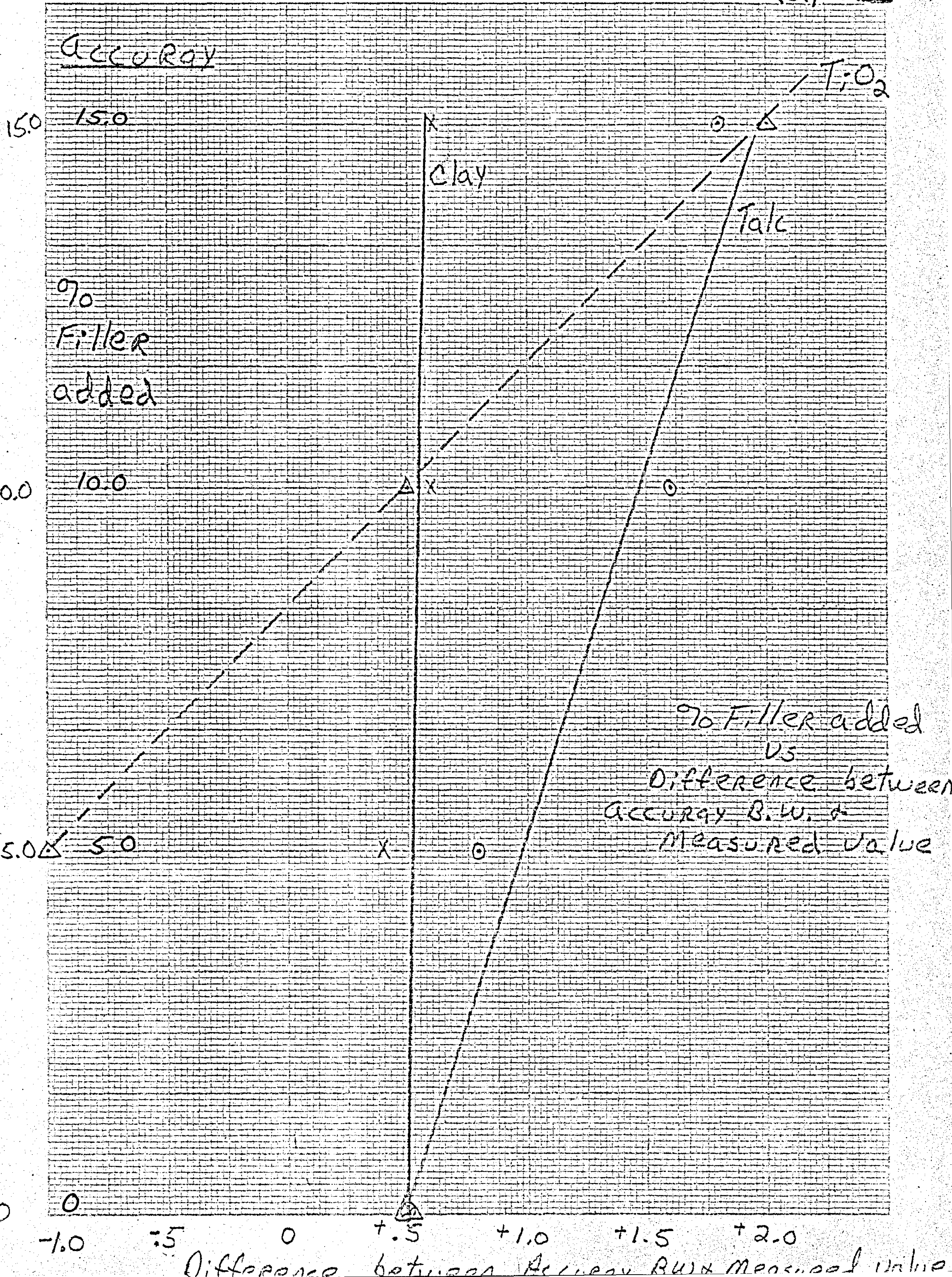

Accuray
TiO_2
15.0
15.0
Clay
Talc
% Filler added
10.0
10.0
% Filler added
vs
Difference between
Accuray B.W. &
Measured Value
5.0
5.0
0
0
-1.0
-.5
0
+.5
+1.0
+1.5
+2.0
Difference between Accuray BW & Measured value

TABLE I

MOISTURE DATA

Sample	Inframike Reading %	Moistron Reading %	Oven Dry %	Difference between Inframike and Oven Dry %	Difference between Moistron and Oven Dry %
Blank	3.8	5.9	3.8	0	+2.1
5% Clay	5.0	6.4	5.0	0	+1.4
10% Clay	4.4	6.5	4.2	+.2	+2.3
15% Clay	4.6	6.3	4.0	+.6	+2.3
5% Talc	4.3	6.3	4.0	+.3	+2.3
10% Talc	4.4	6.2	3.9	+.5	+2.3
15% Talc	4.3	6.7	3.4	+.9	+2.0
5% TiO_2	4.0	5.9	3.9	+.1	+3.3
10% TiO_2	4.9	3.4	4.4	+.5	-1.0
15% TiO_2	4.4	6.1	3.5	+.9	+0.5
Blank	4.1	6.1	4.0	+.1	+2.1

TABLE II

BASIS WEIGHT DATA

Sample	% Ash	Accuray Basis Weight	Measured Basis Weight	Difference Between Accuray Basis Weight and Measured Basis Weight
Blank	.17	52.5	52.0	+ .5
5% Clay	3.9	52.8	52.4	+ .4
10% Clay	8.4	50.7	50.1	+ .6
15% Clay	12.6	53.7	53.1	+ .6
5% Talc	4.1	50.8	50.1	+ .8
10% Talc	8.3	54.2	52.6	+1.6
15% Talc	14.3	55.7	53.9	+1.8
5% TiO_2	4.6	48.9	49.9	-1.0
10% TiO_2	8.2	51.7	51.2	+ .5
15% TiO_2	12.9	53.5	51.5	+2.0
Blank	.20	51.1	50.7	+ .4

FOOTNOTE PAGE

[1]K. W. Hardacker, "Instrumentation Studies XC. Methods of Measuring the Moisture Content of Paper-IV. The General Electric Inframike," Tappi 51 (5), (May, 1968), p. 59A.

[2]Ibid., p. 60A.

[3]Ibid., p. 62A.

[4]Bruce W. Smith, "Scanning Basis Weight and Moisture Gage Systems on Paper Machines," Tappi 43 (3), (March, 1960), p. 228.

[5]Ibid.

[6]David L. Forsman, "Performance Evaluation of the Moistron and Inframike Moisture Gages on the Pilot Plant Machine" (unpublished Bachelor of Science thesis, Western Michigan University, April, 1971), p. 8.

[7]Industrial Nucleonics Corporation. Machine Operators Manual--Accuray Basis Weight and Moisture Measurement and Control System. (Columbus, Ohio: Industrial Nucleonics Corporation), pp. 3-4.

ORIGINAL BIBLIOGRAPHY

Beutler, Arthur J. "An Infrared Backscatter Moisture Cage." Tappi 48 (9), (September, 1965), pp. 490-493.

"Canadian Pulp and Paper Industry Computer System at St. George Keeps Check on Production." Canadian Pulp and Paper Industry, May, 1971, pp. 15-17.

Dyck, A. W. J. "New Developments and Trends in Process Control." American Paper Industry 53 (12), (December, 1971), pp. 26-28, 30-32.

Forsman, David L. "Performance Evaluation of the Moistron and Inframike Moisture Gages on the Pilot Machine." Unpublished Bachelor of Science thesis, Western Michigan University, April, 1971.

Gates, E. R., and Taylor, A. J. "Assessment of the Infrared Technique for Moisture Measurement." Paper Technology 11 (4), pp. 368-74 (T108-14) and pp. 374-77 (T114-17). 1920.

Gavelin, G. "New Swedish Paper Machine Control System." Paper Trade Journal, June, 1972, pp. 36-37.

Grant, R. "Digital and Analog Computers, Their Hardware and How They Work." Paper Trade Journal, January 18, 1971--February 1, 1971, pp. 38-44 and 36-46.

Hardacker, K. W. "Instrumentation Studies XC. Methods of Measuring the Moisture Content of Paper-IV. The General Electric Inframike." Tappi 51 (5), (May, 1968), pp. 59A-68A.

Hazelwood, Eric. "What the Beta Gauge Measures." What are its Limitations?" Paper Trade Journal, August 6, 1973, pp. 33-38.

Industrial Nucleonics Corporation. Machine Operators Manual--Accuray Basis Weight and Moisture Measurement and Control System. Columbus, Ohio: Industrial Nucleonics Corporation.

Lavigne, John R. An Introduction to Paper Industry Instrumentation. San Francisco, California: Miller Freeman Publications, Inc., 1972.

Scrivens, Donald B. "Application of Infrared Moisture Measurement to the Paper Machine." Paper Trade Journal, January 19, 1970, pp. 42-46.

Smith, Bruce W. "Scanning Basis Weight and Moisture Gage Systems on Paper Machines." Tappi 43 (3), (March, 1960), pp. 226-234.

Svenska, Traforskningsinstitut. "Moisture Measurement Methods: Topic of STFI Seminar." Svensk Papperstid, September 15, 1971, pp. 521-527.

SELECTED BIBLIOGRAPHY

Forsman, David L. "Performance Evaluation of the Moistron and Inframike Moisture Gages on the Pilot Plant Machine." Unpublished Bachelor of Science thesis, Western Michigan University, April, 1971.

Hardacker, K. W. "Instrumentation Studies XC. Methods of Measuring the Moisture Content of Paper-IV. The General Electric Inframike." Tappi 51 (5), (May, 1968), pp. 59A-68A.

Hazelwood, Eric. "What the Beta Gage Measures. What are its Limitations?" Paper Trade Journal, August 6, 1973, pp. 33-38.

Industrial Nucleonics Corporation. Maching Operators Manual--Accuray Basis Weight and Moisture Measurement and Control System. Columbus, Ohio: Industrial Nucleonics Corporation.

Lavigne, John R. An Introduction to Paper Industry Instrumentation. San Francisco, California: Miller Freeman Publications, Inc., 1972.

Scrivens, Donald B. "Application of Infrared Moisture Measurement to the Paper Machine." Paper Trade Journal, January 19, 1970, pp. 42-46.

Smith, Bruce W. "Scanning Basis Weight and Moisture Gage Systems on Paper Machines." Tappi 43 (3), (March, 1960), pp. 226-234.