industrialists made the birth of this prize possible.

Mr. Murdock your name will be remembered by us for years to come as a monument in Japan's pulp and paper history.

Thank you.

~~~~~

**PAPER READ AT THE FIRST SYMPOSIUM OF THE
JAPANESE TECHNICAL ASSOCIATION OF
THE PULP AND PAPER INDUSTRY,
ON 15, JANUARY, 1948.**

Harold R. Murdock

(Head, Pulp & Paper Branch, Forestry Division,
Natural Resources Section)

I am pleased to attend this first symposium of Japanese Technical Association of the Pulp and Paper Industry, an organization which you prefer to call TAPPI. The industry should benefit from your efforts to understand better the basic technical aspects of pulp and paper manufacture. Japan has too few technically trained men, and you are to be congratulated in trying to raise the standards of your profession.

In this introductory talk at the opening of your two day meeting, I wish to discuss some of the more fundamental advances in the chemistry of wood which have taken place in America. I then wish to point out how this knowledge affects the practical process of pulping wood by the sulfite method, which is the main topic for discussion at this meeting. Many of the practical and important improvements which have occurred in the pulp and paper industry have originated from fundamental consideration of the chemistry involved in the process. Basic understanding of scientific facts is vital to progress.

Wood is far from being a uniform material, both physically and chemically. The cellular structure of wood is inseparably linked with the chemistry of its ingredients. Surface properties existing in wood can seriously alter the chemical characteristics. But this talk, because of allotted time, must devote itself to the chemical, rather than the physical, aspect of the subject. The cellulose contained in wood is of primary interest to the pulp industry. The removal of the noncellulose constituents of wood is the essential problem. Consequently, we must know as much possible about the relationship of cellulose in wood to the other ingredients, and understand the chemical behavior of all the ingredients. Variations in the components occur often between hardwoods and softwoods, sapwood and heartwood, and springwood and summerwood. Table II shows these variations as found in loblolly pine and the hardwood species, catalpa. Broad generalizations of the data should not be made but, as shown in the table, pentosans are much higher in hardwoods than in softwoods. On the other hand yellow poplar, a hardwood, has cold and hot water solubilities well below loblolly pine, although the table shows the hardwood,

catalpa, to be much higher in these water solubilities. It is important to know such chemical characteristics of the wood species under consideration in a pulping process.

Holocellulose is the total carbohydrate content of wood after extraction with a solvent. It includes all of the hemicelluloses. Table III shows the actual content of some important pulpwoods, in respect to holocellulose and lignin content. These two substances compose the entire content of solvent extracted wood as is shown by addition of Columns I and III or comparison of Column III with V. By a carefully controlled acid hydrolysis of the holocellulose using 1.3 percent sulfuric acid, some of the weaker hemicelluloses are solubilized to leave a residue (Column IV) which compares well with the Cross and Bevan cellulose shown in Column II. This hydrolysis method is useful for study and identification of the hemicellulose fraction. This fraction is not the entire hemicellulose fractions of the wood, as the Cross and Bevan cellulose contains some of the more resistant hemicelluloses such as pentosans.

Differences between hardwoods and softwoods are also indicated in Table II. The hardwoods have a much higher average holocellulose and hemicellulose content and a definitely lower lignin value than do the softwoods. Table III shows the contents of woodpulp made by the several standard processes. It will be noted that cooking chemicals react differently with the ingredients of wood. Pentosans are particularly high in the alkaline wood pulps, and because of this they give characteristics desired for many purposes as compared to sulfite pulps. In the future it possibly would be practical for woodpulp to be designed for specific uses by proper selection of the pulping process and the operation conditions.

The sulfite pulping process is the subject of our symposium today, so a discussion of the reactions which occur during the sulfite process upon the chief ingredients of wood may interest you. The object of the sulfite process is to produce a maximum yield of nondegraded cellulose with substantially complete removal of the polyuronide hemicelluloses and lignin, and a partial removal of the more resistant hemicelluloses, known as cellulosans. The fundamental reaction is the sulfonation of lignin, to a point of solubilization. The mechanism of this reaction is still not clearly understood, but the best opinions agree that sulfonation occurs in two stages. The first stage is a rapid sulfonation around 70°C which forms an insoluble lignin sulfonic acid, and then further sulfonation until a ratio of sulfur to carbon of 1 to 20 occurs. This product behaves as a strong acid. The lignin sulfonic acid then hydrolyzes in the second stage to soluble substances. The polyuronide hemicelluloses are complexes of pentose groups with hexuronic groups and are believed to be closely associated with lignin. By acid hydrolysis these complex substances appear to split into sugars and uronic acids which are soluble in the cooking solution. The other type of hemicelluloses are much resistant to the conditions of the sulfite process. These short chained polysaccharides called cellulosans are chemically and physically associated with the resistant type celluloses, and survive substantially the conditions of the pulping process so that they are present in the final woodpulp. The physical chemistry entering into the many chemical reactions which occur during the

process can be regulated to a minimum degradation of these cellulosan substances as well as the normal cellulose obtained as pulp.

I have visited most of the sulfite mills in Japan. The control over the various factors entering into intelligent operation of the sulfite digestion process is not impressive. I am convinced that you can make much better pulp and more of it per digester, if you will give consideration to some of the vital principles essential to good sulfite pulp production. The purpose of this meeting is to assist you in this matter, and I will be pleased to answer the questions which arise during the discussion of the cooking charts which are to be presented by representative pulp mills during this symposium.

Table I
AVERAGE ANALYSIS OF COMMERCIAL WOOD PULPS
Percentage over drp pulp

	Unbleached				Bleached		
	Sulfite	Kraft	Soda	Sulfite	Kraft	Soda	Alpha
Ash	0.4	0.8	1.1	0.3	0.7	0.7	0.1
Ether Extraction	0.4	0.4	0.2	0.4	0.2	0.5	0.3
Lignin	1.9	4.2	1.6	0.5	0.1	0.5	0.1
Pentosans	5.1	10.7	19.7	5.4	11.4	18.3	2.9
Cross & Bevan Cellulose	94.7	93.6	95.6	ND	ND	ND	ND
Alpha Cellulose	79.3	77.7	78.7	84.4	82.8	71.1	93.4
Alkali Solubility	22.2	10.1	13.4	20.2	21.5	33.0	6.1
Permanganate Number	13.6	20.8	9.5	1.1	2.4	2.1	0.8
Copper Number	3.1	1.1	0.7	2.6	2.4	3.7	0.4
Viscosity C.P.	84.2	57.1	27.1	24.4	14.6	5.6	24.4

ND: No data available

Table II
ANALYSIS OF LOBLOLLY PINE AND CATALPA
(Stated in Percentage on oven dry (105°C) samples)

	Solubility in		1% NaOH	Pentosans	Lignin	Cellulose
	Cold Water	Hot Water				
Loblolly						
Sapwood						
Springwood	3.28	3.49	11.11	11.59	23.12	53.06
Summerwood	2.18	2.97	11.01	11.12	26.87	61.21
Heartwood						
Springwood	7.50	7.16	18.14	12.77	26.78	53.44
Summerwood	7.64	6.44	21.19	12.12	24.18	52.87
Catalpa						
Sapwood						
Springwood	9.12	12.44	34.45	22.39	23.64	50.37
Summerwood	7.29	10.11	27.97	22.35	18.68	56.49
Heartwood						
Springwood	7.51	11.65	34.27	21.33	24.29	50.38
Summerwood	2.69	5.26	24.15	21.50	19.35	58.45

Table III
CHEMICAL FRACTIONATION OF WOOD

	I	II	III	IV	V	VI
	Holo-cellulose	Cross & Bevan Cellulose	Lignin by H_2SO_4 Method	Hydrolysis of I	Lignin 100 Minus I	Hemi-celluloses I Minus II
White Spruce	73.3	61.2	26.2	61.0	26.7	12.1
Red Spruce	72.9	60.3	26.6	60.5	27.1	12.6
Eastern Hemlock	68.5	56.0	31.5	55.4	31.5	12.5
Balsam Fir	69.9	56.4	30.1	55.3	30.1	13.5
Jack Pine	72.5	58.3	27.2	59.1	27.5	14.2
Aspen	82.5	64.1	17.3	63.7	17.5	18.4
Willow	78.3	61.5	22.0	61.5	21.7	16.8
Maple	76.3	57.9	23.5	57.9	23.7	18.4
White Oak	75.4	59.6	24.1	60.2	24.6	15.8

ON SEMI-SULFITE PROCESS

Shuichi Ichikawa (Oji Paper Co. Ltd.)

This is the report of the researches at the Sakamoto Mill of the Oji Paper Manufacturing Company, Kumamoto Prefecture, Kyushu, under the semi-sulfite process of pines, which was suggested by Mr. Harold R. Murdock, G.H.Q.

This mill is producing 900,000 lbs of pulp per month under the above-mentioned process. The test of this process has shown the necessity of making the total acid as high as possible (more than 5.2% of total acid) and of making the combined acid high (more than 1.4% combined acid), as far as this process is concerned.

Cooking is to be carried out under low temperature (maximum at 125°C) and high pressure (6 kg/cm and more). For treating of pulp, edge runners and stone refiners are used.

The screens are to be of the double system. Better pulp and the worse one are to be separated, and disposed according to the quality of paper. An ordinary beater was used for the beating of pulp. But this must be tested with much care, for the process of beating influences the quality of paper and the bursting strength ratio. The pitch troubles were eliminated by using infusorial earth at the suggestion of Mr. Harold R. Murdock.

The yield of pulp was increased by more than 20%, compared with the normal S.P. The strength of paper was enhanced by 20~40%. As to newsprint, S.P. blending has been reduced from 25% to 20%. Wrapping paper which has 100% of semi-sulfite pulp is 70% stronger than usual wrapping paper. It is now under further investigation, in order that it may be more improved and that it may be used for cement bags, instead of kraft paper.