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WORKING GROUP No.10

APPROPRIATE TECHNOLOGY FOR THE MANUFACTURE OF PULP AND PAPER PRODUCTS

UNIVERSAL PULPING

Background Paper

UNIVERSAL PULPING

by

E. S. Prior
UNIDO consultant

Some time ago under the heading of "THE MANY FACES OF A NEW PULPING SYSTEM", an introductory talk on a new development for pulping fibrous structures was given jointly by Hch. Sieger KG, a major corrugated box manufacturer in West Germany and Korru-Tek AG of Switzerland. The idea behind the development was to provide a process that would fit the needs of an independent producer of board in an area of limited wood supplies operated in conjunction with a waste paper mill.

The presentation was greeted with open skepticism - understandably so since there was direct confrontation with almost every known aspect of the pulping processes we live with in modern mills. What was offered was a process system designed around a small, simple, low cost installation, very fast and flexible to be operated with average expertise and producing low pollution levels capable of using all practical sources of fibrous material to produce paper making fiber.

Following the introductory talk, an open demonstration of the pulping method was made using open vessels with no pressure and only boiling temperatures in a hotel room crowded with some 20 observers. The material used for the demonstration was resinous U.S. Southern Pine. Unfortunately, no report was made of this demonstration in the literature later made public.

Even so, a French paper mill executive attending the demonstration remarked: "I have listened, understood and seen - but I do not believe it."

An experienced English mill technician offered a written opinion that the process was not possible based on his experimentation although he did admit that he did not know which chemicals had been used.

Perhaps worse, is the observation of the Chairman of the Board of a great American paper company who commented that no new process could offer enough practical advantage over the present to be of interest.

Most absurdly, it was judged elsewhere as a hoax. Let me say, to lay any doubts to rest, that the rapid efficiency, non-pressure and low temperatures involved have been attested to by Professor Dr. Th. Krause of the "Institut für Makromolekulare Chemie der Technischen Hochschule in Darmstadt" and in open demonstration to 25 members of the "Technischer Ausschuss AG - Packpapier" of West Germany.

We have not made as much progress as we would have liked toward developing and installing a commercial process being limited to a two man working team and the need to develop and/or install laboratory testing, pulping and paper making and other types of equipment on a limited budget, although over a million Deutsch Mark has been invested on the project todate. Additionally, but perhaps most restricting in progress was the need to tread an unknown path where knowledge of other systems offered only limited guidance. Further, it was necessary to subject to proof, however limited, all phases of any pulping system and particularly those dealing with pollution, both air and water.

It is only very recently that we have been able to make the first run of our pulp over an experimental paper machine designed and built by ourselves and our associated engineering company.

A great deal of credit must be given to our principals who have maintained faith, encouragement, advice and positive helpfulness over some difficult periods and to the constructive help and generosity of several suppliers and machine builders.

Initially, I showed and now repeat, photomicrographs of various fiber sources pulped by the process within 30 minutes time without pressure or vacuum, with temperatures not exceeding 100°C. Exhibits 1 - 6 - Pine, Spruce, Bagasse, Straw, Beech, Bamboo. Since that time we have added Kenaf, Coppice Willow, Larch, Rise Husks and Oak.

We have found time and, necessarily so, to touch on the many various elements of pulping which must be considered as fundamental for acceptance of any new process. These I believe you will find interesting and perhaps provocative and on which I will provide details later in this talk.

I would like now to present a typical set of data on testing of the usual pulp profile. Exhibit 7.

These test results were determined by the "Papiertechnische Stiftung" in Munich and give comparable test results with samples of unbleached sulphite pulps taken at random as follows. Exhibits 8 - 12.*

The system is basically acidic in its activation on the binding materials of fibrous structures and in attack on the cellulose components and as shown it appears that strength characteristics can be roughly equated to sulphite pulps. Kappa numbers well under 30 are usual in obtaining full defibrization or the usual recognized state of a full chemical pulp from resinous woods. The correct defibrator and application should permit higher Kappa numbers, yields and strength levels for board pulps.

Exhibit 13 shows the conditions of pulping which, as you will notice, is usually a two step process - one of impregnation and reaction and the other of delignification.

The cooking chemical was drained for recycling to impregnation and reuse. For washing and reduced chemical

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consumption the digester was filled with recycled weak cooking liquor (0.3%) 0 - 1 - twice, raised to 2.5 atu 135°C quickly and the digester blown. The delignification stage is accomplished in a vessel with soft turbulence at 5 - 10% consistency. Drained black liquor can be recycled to save chemical and concentrate solids. With highly resinous woods, depending on pulp purity required, a two step defibrization can be necessary with a short interval between for further delignification. Screening was made over a flat screen using 0.25 mm slits. Screening rejects were in the order of 5%.

This example as stated was drawn from a series of cooks made to simulate utilization of the process in an existing sulphite mill where pressure is necessary. It is anticipated that any existing continuous system based on pressure could be adapted to the new process with operation at reduced pressure and temperatures not exceeding 100°C except for that in blowing at the lowest required pressure. This should provide advantages in reduced corrosion, scaling and maintenance in addition to higher production levels.

Pressure is not necessary, however, and pulping can be accomplished in practically the same time or quicker and easier overall with a non-pressure system. This affords the possibility of unique and relatively inexpensive installation designs. Two possibilities - one showing a very simple batch system utilizing a modified hydrapulper and a continuous system utilizing hot air for reaction temperatures - are illustrated. Exhibits 14 - 15.*

From these examples it is easy to envision economic production units varying from 15 - 100 tons per day well adapted to processing agricultural residues or small wood reserves.

In the continuous system reference is made to the production of animal feed from straw in conjunction with

* to be distributed at the meeting

an alternative production of paper pulp. Preliminary trials have shown that straw cooked by this method utilizing chemical concentrations of only 0.15% can produce an acceptable animal food supplement and extender. Trials leading to the commercial production of feed and paper pulp in this manner are expected to be initiated shortly in an existing nutrition plant utilizing wheat straw in England. Various take-off points are possible to meet the individual requirements of further processing in other locations.

The non-pressure equipment involved comes usually under the heading of light machinery classification and is well within the capabilities of Third World countries to design and produce on a very economic scale.

Although most of our experimental work has been done with flaked wood, trials with crushed chips indicate acceptability so that existing chippers could be utilized.

The black liquor derived from the process approximates a pH of 8.5 at the end of the delignification stage and is of a lightly sweet odor and practically tasteless. The lignin fraction can be precipitated out in a filterable flocculant by acidification to pH 6.0 - 6.5 preferably with alum.

Both the whole black liquor and the decanted clear liquor from the precipitated form have been extensively tested, on a single cook and on a sample in which the black liquor was recycled seven times. Testing was done and extensively reported on by the West German Water Authority "Grosser Erftverband" in Bergheim/Erft.

The liquor was found to be compatible in the processing of ordinary sewage in several ratios without disturbing normal practice in which one part black liquor to three parts urban water provided the ideal combination.

Comparative BOD_5 - COD and permanganate requirement are low as the official reports show. Exhibits 16 - 19.*

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The precipitation affords the opportunity to further concentrate the lignin fraction and recycling of the clear water or as effluent with reduced pollution loads.

The usual turpentine, fatty acids and tall oil fractions are not evident as such in the process, probably due to the low temperatures and short cooking times involved. Foaming in handling has been minimal. The unmodified black liquor from wood can be easily precipitated on the stock fiber with alum and has been found to have properties of high retention and to impart moderate sizing and improved strength properties. Additions have been made up to 15% and since the added color is a natural light tan has not been objectionable. Our past experience in modifying sulphite liquor as a strength additive for radically improving CMT offers hope that further substantial improvement and uses can be found. Black liquor precipitate derived from cooking straw has been found to be readily bleachable with peroxide.

With shredded straw, which is the most easily delignified fibrous structure, the black liquor can be produced in situ after spraying with chemicals in a still relatively dry state and then heated. Follow up with a hardener such as alum plus pressure and drying could provide an inexpensive hardboard in which the straw had produced its own binder.

A further potential is as a fertilizer since the basic chemical used is nitric acid. Authoritative preliminary trials by the University of Bonn ("Landwirtschaftliche Untersuchungs- und Forschungsanstalt") show both high (95%) germination and normal growth rates when applied to barley seeds planted in inert clay. <u>Exhibits 20 - 21.</u>*

Analysis of the black liquor shows a very low percentage of phenols. The possibility exists to modify the cooking chemicals to practically eliminate build-up of metallic

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salts in the soil and since the black liquor is hygroscopic could find potential use as a soil stabilizer. Additionally, it could be anticipated that the nitrogen deficiency normally associated with returning fibrous structures to the soil intact could be reduced.

The possibility of small economic production units offer a variety of local, labor intensive opportunities. For example in England saw mill wood waste could be pulped and the lignin residue with its fertilizing value could be combined with spent mushroom compost to fortify it. Currently, some saw mill waste sells for 2 Pound Sterling per ton leaving a wide margin to produce inexpensive pulp combining what is essentially three low cost waste products to produce upgraded products of considerably higher economic value.

The various fibrous structures as one might expect demand differences in cooking chemical concentration to effect impregnation and activation and subsequently to paper pulp. An approximation for various fibers is as follows. Exhibit 22.

Required chemicals are easily obtained throughout the world and only dilution or solubilizing is necessary for use. Certain substitutions can be made to meet animal feed and the use of black liquor as fertilizer and other potential pollution exigencies. Chemical delivered cost averages 125 Pound Sterling per ton and cost per ton of O.D. pulp can reach 16 Pound Sterling per O.D. ton of fiber of resinous woods with yields of 55 - 65% O.D. Offsetting this, however, are the minimum cost of liquor preparation with reduced investment and recovery costs and the potential usages of the lignin residue as board additive, resin extender and fertilizer etc. in which the value of most of the chemicals or more could be recovered.

Additional advantages in the processing of short fibers such as straw are that generally the nodes are easily pulped eliminating a normally troublesome screening problem and additionally the entire process can be carried through to final bleaching without complete defibering. For example straw pulp produced at 75 brightness as tested by PIRA can have a Schopper Regler of less than 20°. Washing of normally short fibered stock is facilitated through easy drainage and the potential exists to pinpoint control of defibrization to avoid reduction to the ultimate small fiber units characteristic of grass fibrous structures.

I have covered very briefly a broad scope of potential applications and areas for investigation. With my 40 years experience in the industry I would be certainly naive, nay foolish to believe we know all the questions that can arise, let alone the answers. Many of the avenues of knowledge and application to be explored require special training and skills - all require sound fundamental knowledge of the parameters of economics, availability, processing, quality and marketing and, most important, an inquiring, positive mind. We do not see this process in the same vein with today's or tomorrow's great kraft mill installations. What is possible is the challenging opportunity for commercial use in relatively small production units by this hungry world of various fiber sources of small or large availability which presently elude economic pulping or utilization. Additionally, the process is labor intensive and placed at the level of average expertise with expected minimized maintenance problems and should contribute to building a better, more balanced, useful process and pleasant work environment for many areas.

Finally, I offer the thought for those who must work or can only afford to work with short or recycled fibers, which was the area for which this project was first conceived, that future effort can be better spent working more intensively with the chemical companies in building a sheet of paper or board with additives to meet specific requirements using fiber base as a carrier rather than trying to wring the last atom of performance characteristics from the pulp itself. To do this the paper machine must be of a design to exploit the potentials of flexibility now existing and other applications which have received too little consideration todate.

In those broader aspects, we have initiated and come a great distance in development of new concepts for application of solutions and suspensions at the wet end of the paper machine - the distribution of synthetic fibers through the sheet to improve tear and the fortification of pulping waste liquor to give stiffness strength improvement almost equivalent to starch without its drawbacks. We believe our experimental paper machine to be a prototype for future experimental laboratories and for commercial operations in developing countries.

May I in conclusion presume to say here as guests of this great and complex country, India, a final thought for your consideration in a developing world:

SMALL AND SIMPLE IS BEAUTIFUL

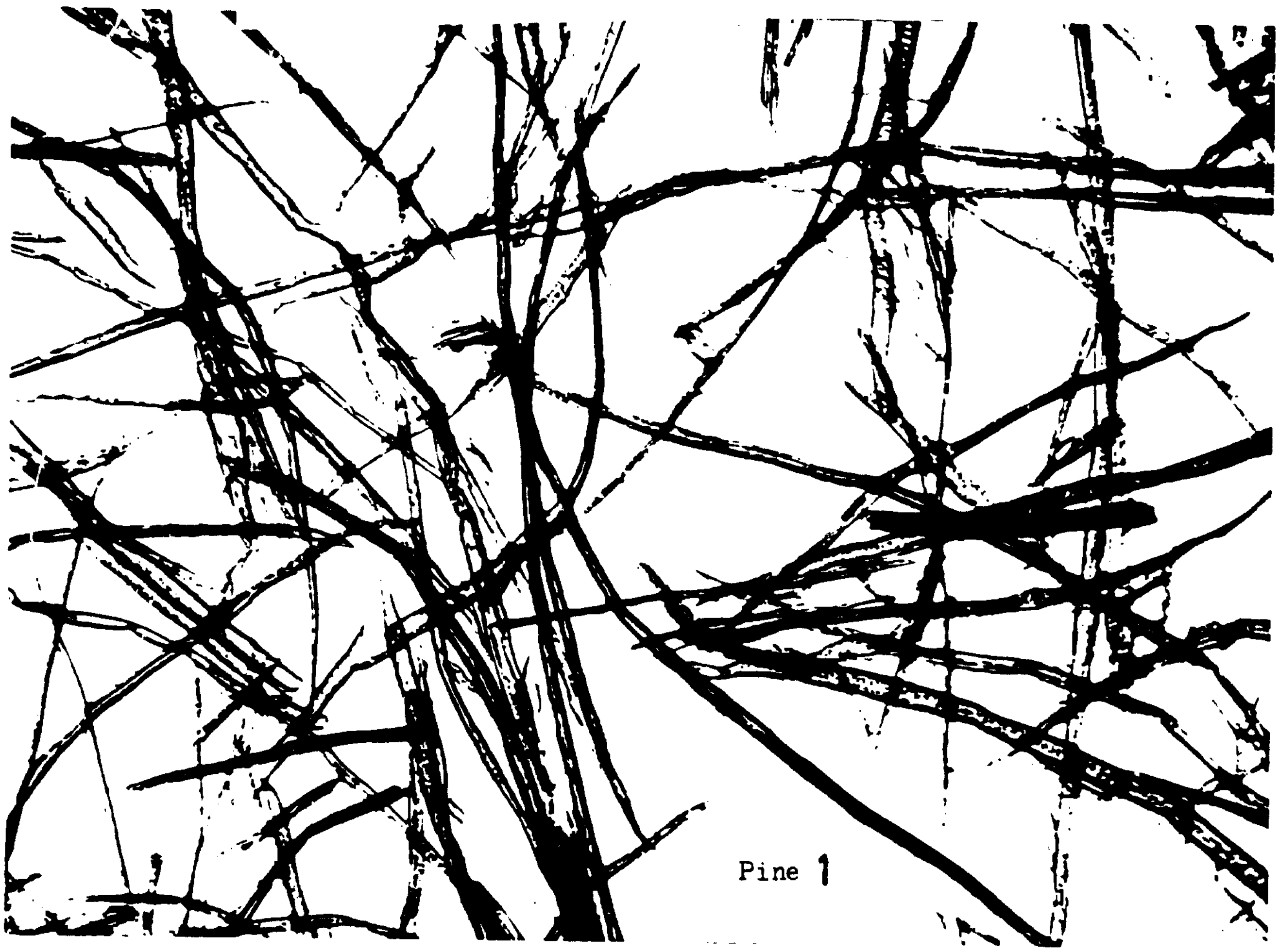
CHOTA AUR SADHARAN SUNDAR HAI

Thank you.

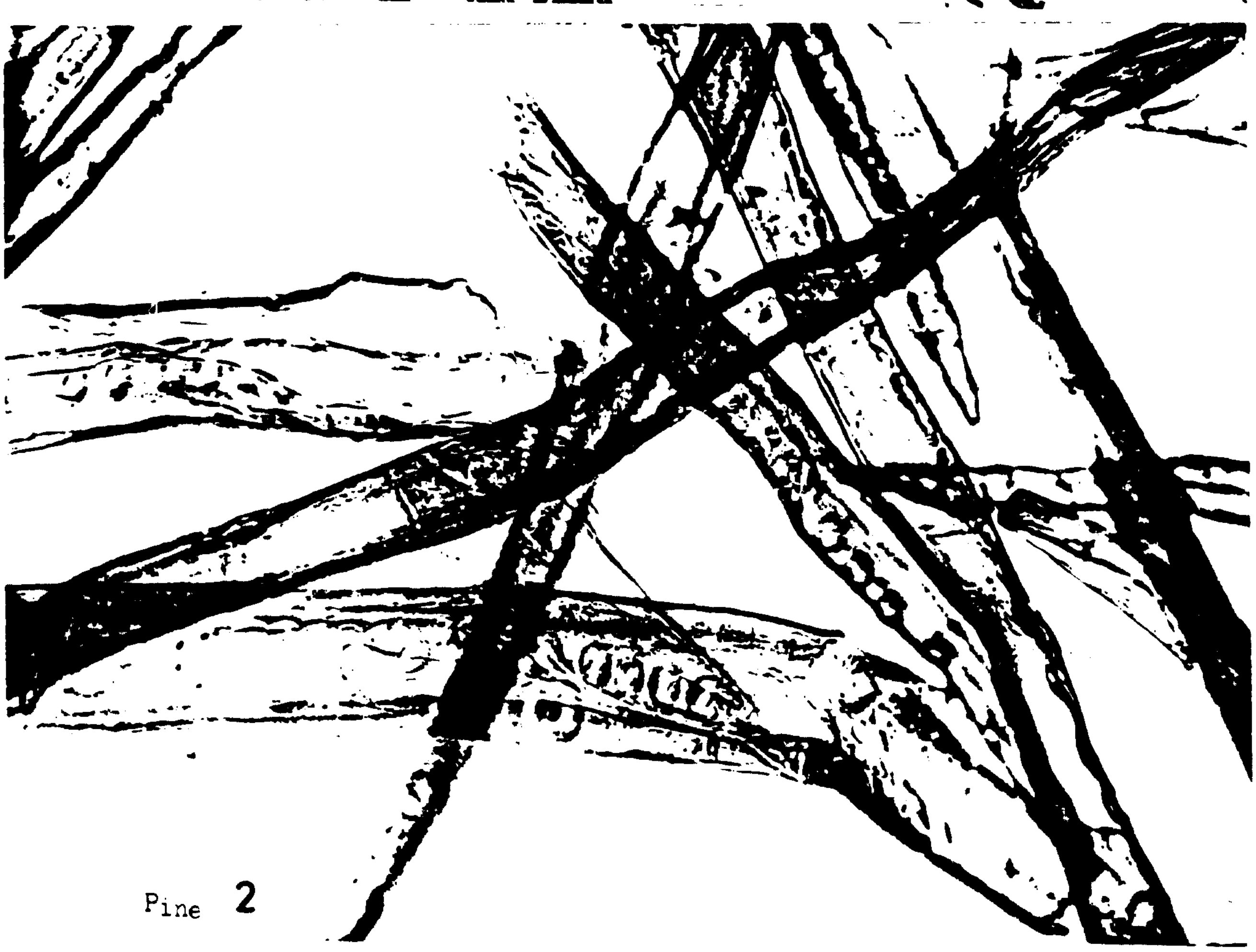
UNIVERSAL PULPING

I

U.S.Southern Pine - 25 Min.Cooking Time



Pine 1

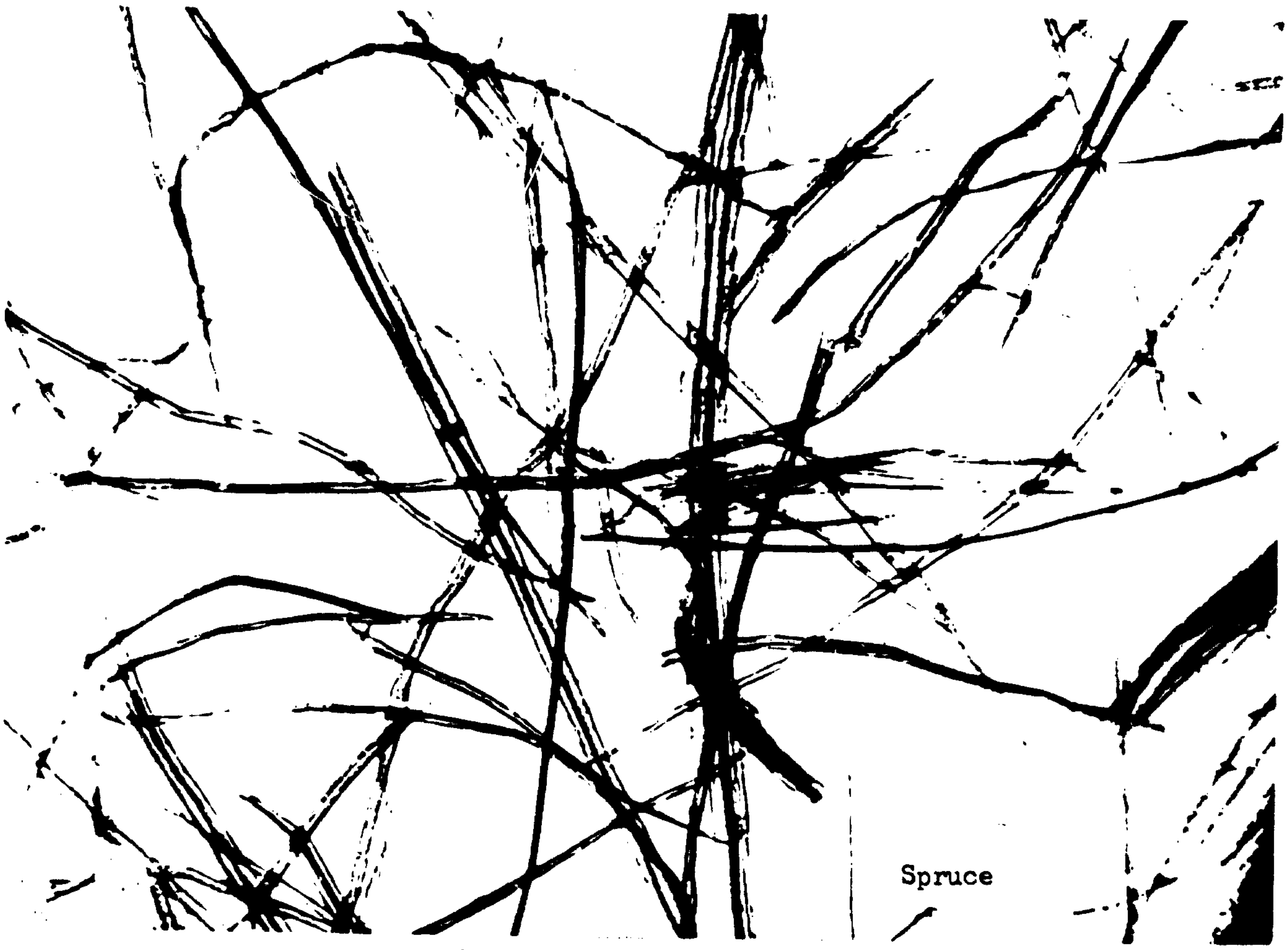


Pine 2

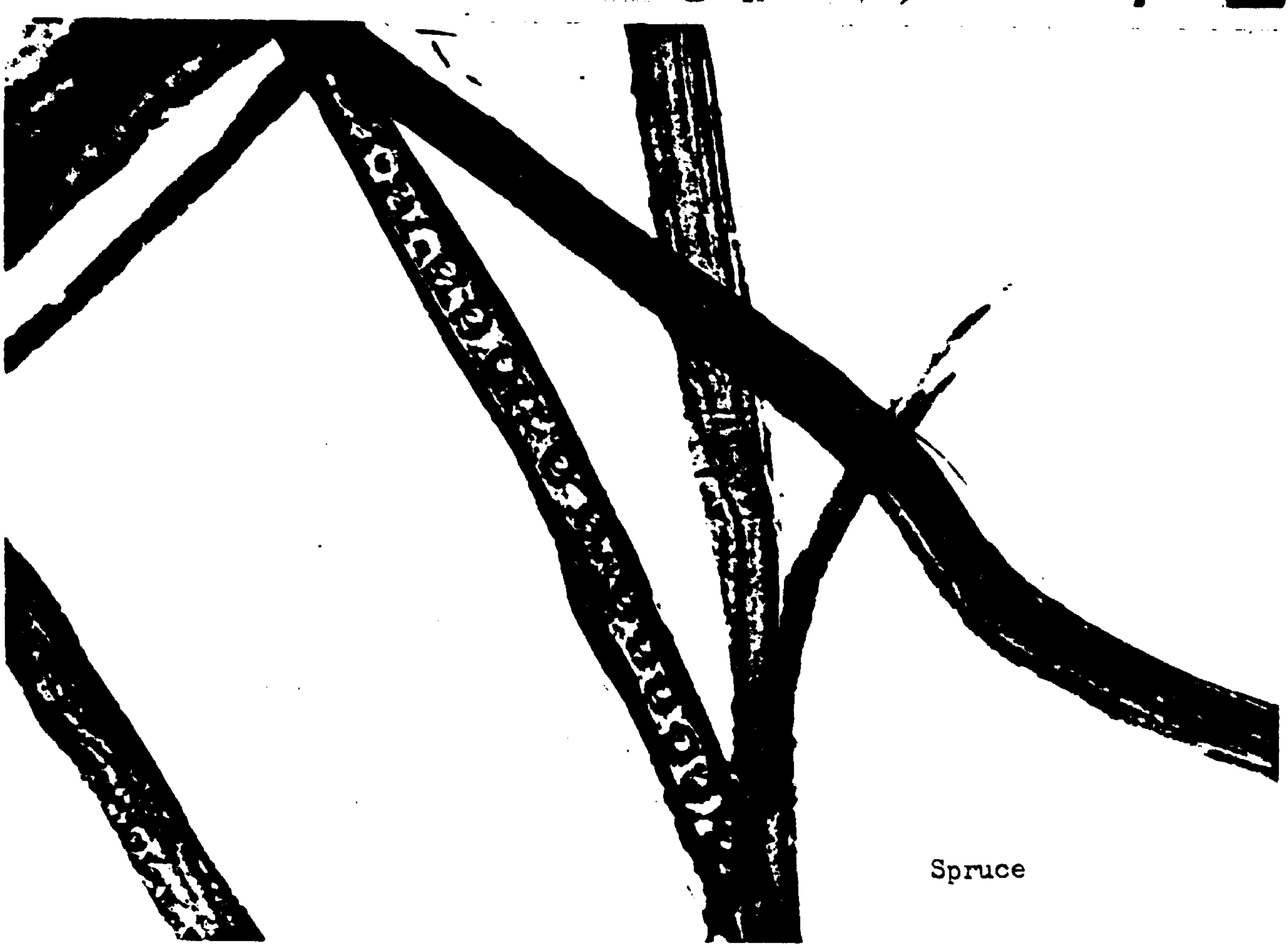
UNIVERSAL PULPING

Spruce - 30 Minutes Cooking Time

2



Spruce

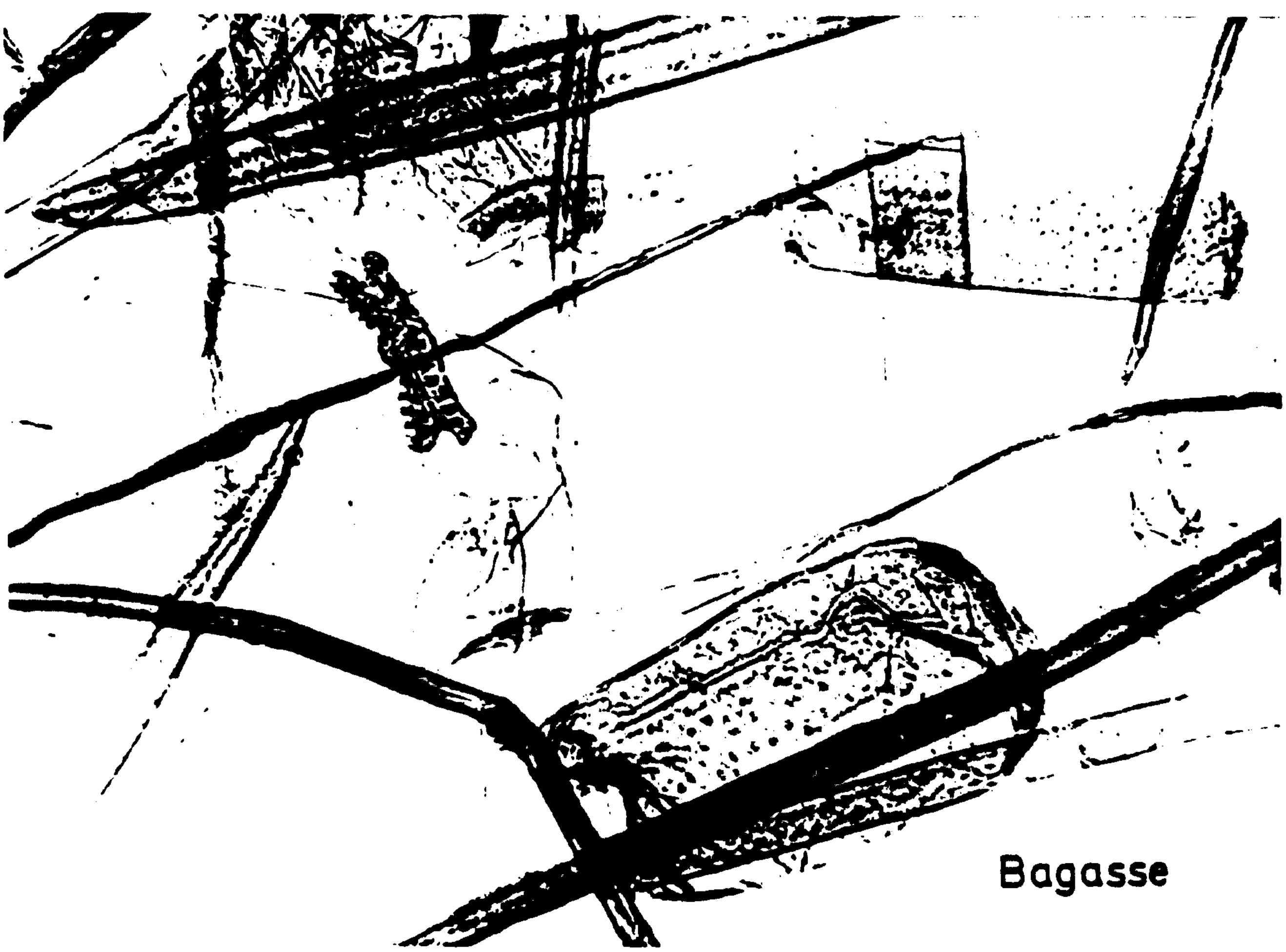


Spruce

UNIVERSAL PULPING

3

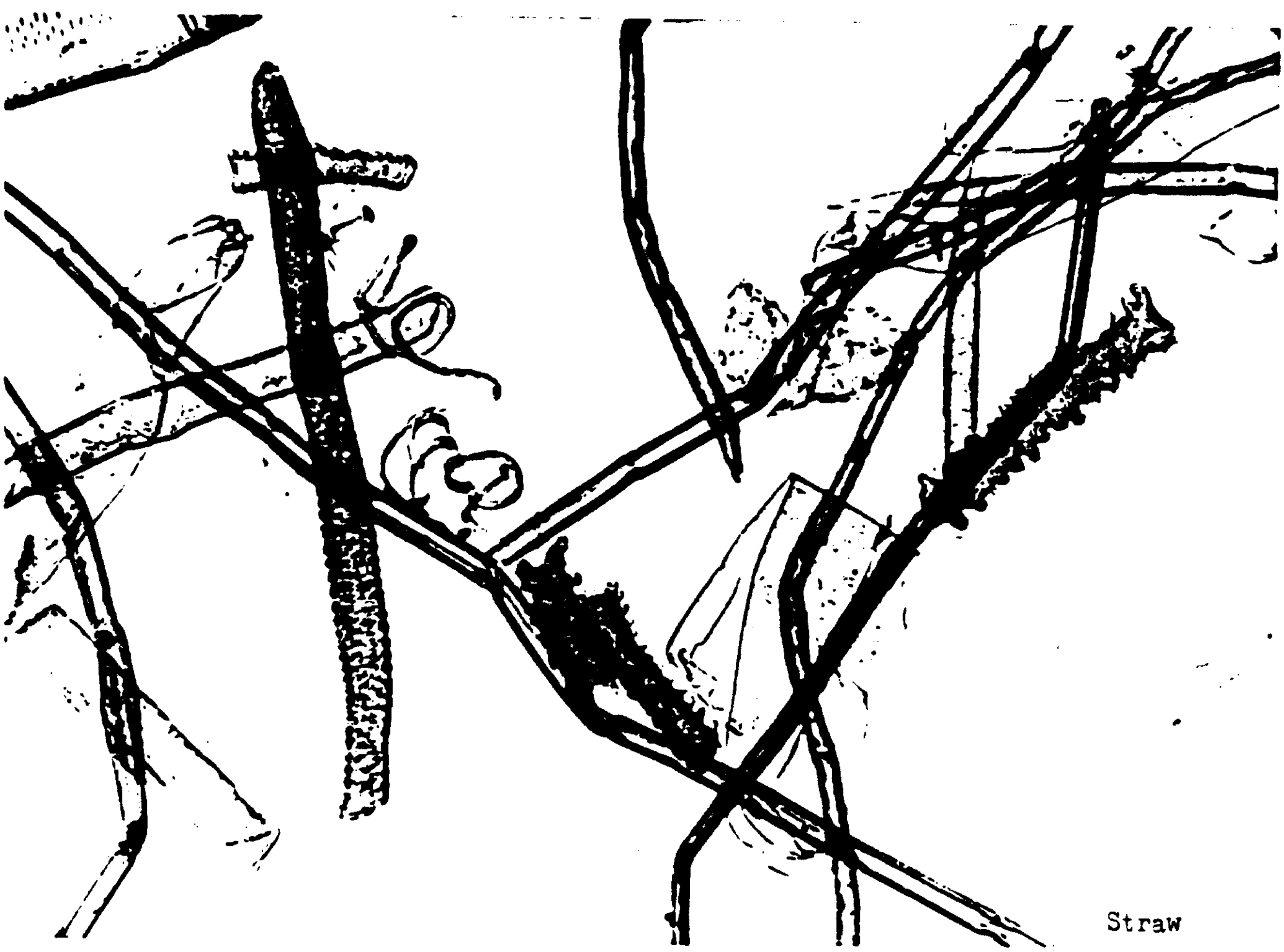
Bagasse - 25 Minutes Cooking Time



U N I V E R S A L   P U L P I N G

4

Wheat Straw - 25 Minutes Cooking Time

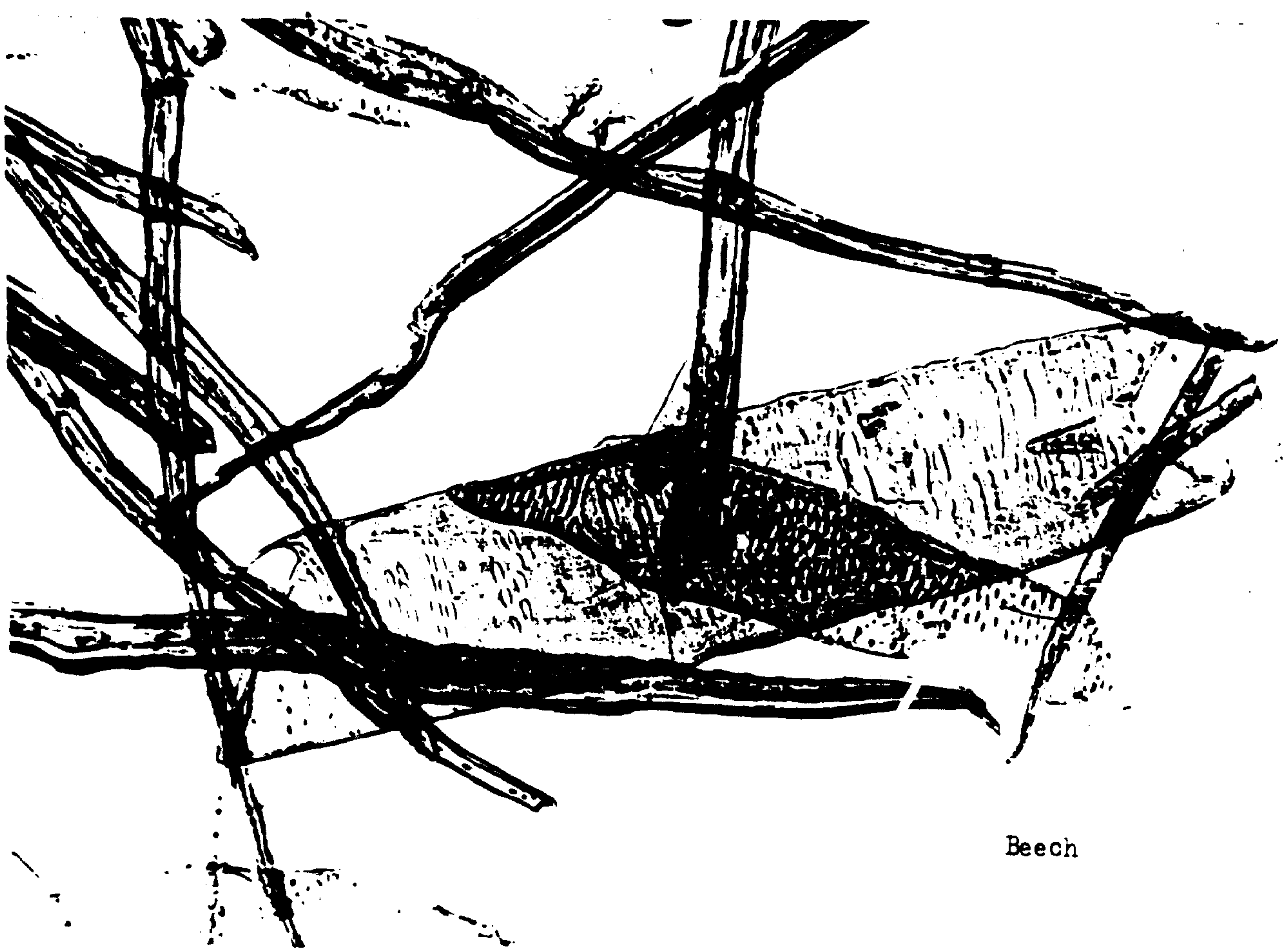


UNIVERSAL PULPING

White Beech - 28 Minutes Cooking Time

5

Beech



Beech

U N I V E R S A L   P U L P I N G

Bamboo - 30 Minutes Cooking Time

6

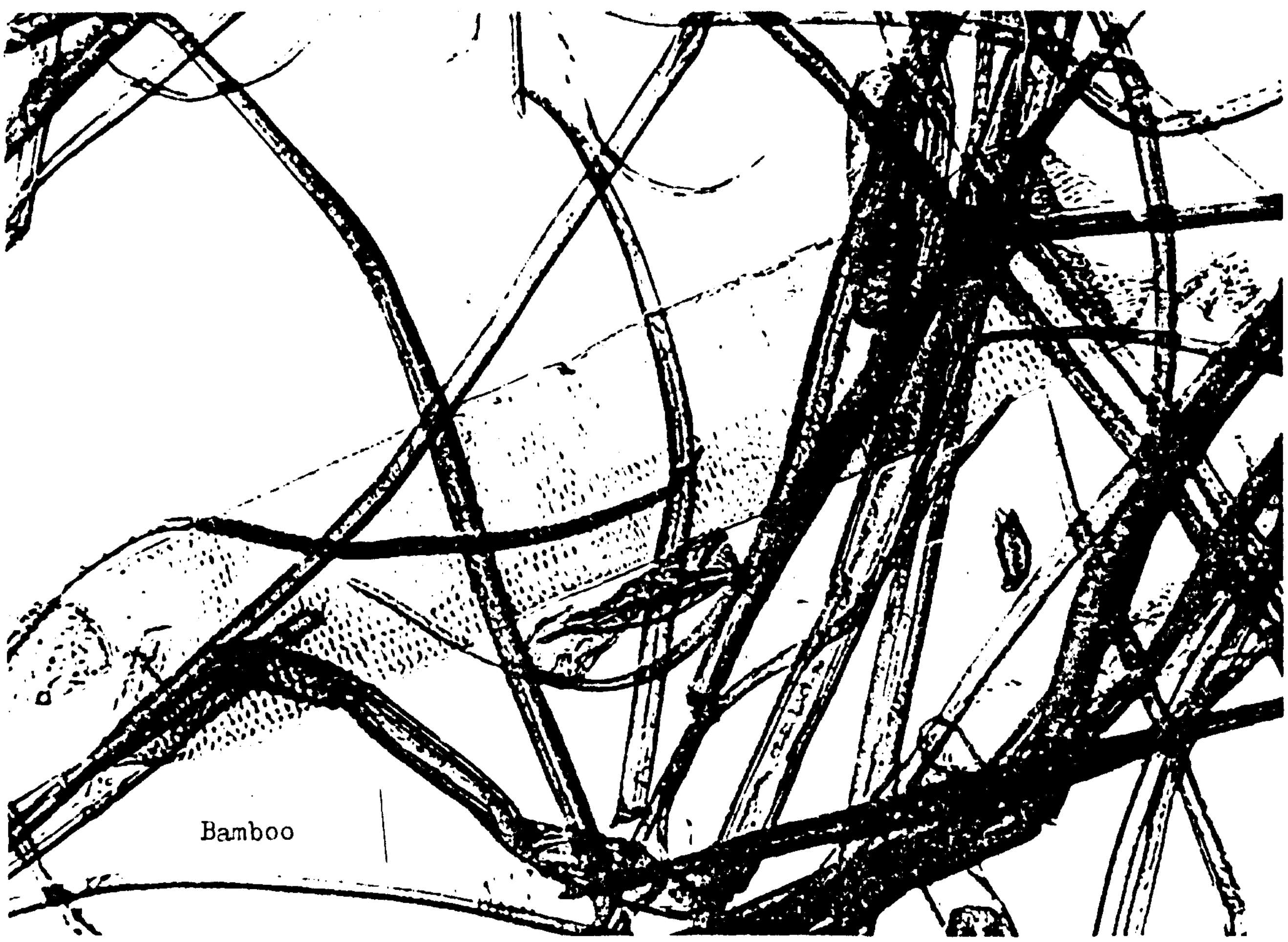


Exhibit No. 7

7

Prüfbericht für Stoffproben

Nr. 5453

Bezeichnung		Zellstoffprobe				
Mahldauer	min	0	5	7	10	13
Mahlgrad	°SR	21	27	39	46	52
Flächengewicht	g/m2	81.7	80.9	78.5	80.0	80.9
Dicke	mm	0.115	0.100	0.094	0.089	0.089
Raumgewicht	kg/dm^3	0.710	0.809	0.835	0.899	0.909
Bruchwiderstand	N	80	88	85	88	98
Reisslänge	m	6660	7400	7360	7480	8240
Berstdruck abs.	kPa	258	360	324	312	380
Berstdruck rel.	kPa	316	444	412	390	470
Weiterreissarbeit n. Brecht-Imset	m	1118	1187	942	922	1109

Test Report on Pulp No. 5453

Test						
Refining	min.	0	5	7	10	13
Freeness	°SR	21	27	39	46	52
Basis Weight	g/m2	81.7	80.9	78.5	80.0	80.9
Caliper	mm	0.115	0.100	0.094	0.089	0.089
Apparent Density	kg/dm^3	0.710	0.809	0.835	0.899	0.909
Elongation	%	1.9	2.9	2.8	2.7	3.2
Tensile	m	6660	7400	7360	7480	8240
Mullen abs.	kPa	258	360	324	312	380
Mullen index	k	316	444	412	390	470
Tear-Brecht-Imset	m	1118	1187	942	922	1109

13

Pulping Conditions

Simulated Use of a Sulphite Digester

Wood	Spruce
Form	Tangential Flakes 0.5-0.6 mm thick
Charge	1.3 kg Atro
Digester	Stationary - circulating
Impregnation Time	15 Minutes
Impregnation Temperature	70 - 75°C
Impregnation Chemical	5%
Cooking Time	15 Minutes
Time to Cooking Temperature	2 Minutes
Cooking Temperature	85 - 95°C
Cooking Chemical	7.5% Concentration
Ratio Liquor to Atro Wood	4 : 1
Pressure	0.5 - 1.5 Atu
Gas off	None
Delignification Stage	20 Minutes
Delignification Temperature	95 - 100°C
Delignification Chemical	0.25% Concentration
Delignification pH	10 → 8.0

COOKING CHEMICAL CONCENTRATIONS

Pine	Flakes	7.5 - 8.5%
Spruce	"	6.5 - 7.5
Beech	"	3.5 - 4.0
Bamboo	"	3.5 - 4.0
Kenaf	Chipped	2.0 - 2.5
Bagasse	Depithed	1.5 - 2.0
Straw	Shredded	1.0 - 1.5
Rice Husks		5.5 - 10.0

B-101

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